No.

ROAD DEVELOPMENT AUTHORITY
MINISTRY OF HIGHWAYS AND ROAD DEVELOPMENT
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

THE DETAILED DESIGN STUDY ON THE OUTER CIRCULAR HIGHWAY TO THE CITY OF COLOMBO

FINAL REPORT
(FOR NORTHERN SECTION 1)

DRAFT TENDER DOCUMENTS

VOLUME III : TECHNICAL SPECIFICATIONS

6 of 10

February 2008

JAPAN INTERNATIONAL COOPERATION AGENCY

Oriental Consultants Company Limited

Pacific Consultants International

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08–017

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VOLUME III - SPECIFICATIONS

CONTENTS

Part 1 – Technical Specifications

SECTION 400 PAVEMENT

SECTION 500 STRUCTURES

SECTION 600 DRAINAGE

SECTION 700 INCIDENTALS

SECTION 800 FACILITIES

SECTION 900 DAYWORKS

SECTION 1000 PROVISIONAL SUM

SECTION 1100 QUALITY MANAGEMENT

SECTION 1200 SITE INVESTIGATIONS FOR EMBANKMENT CONSTRUCTION, BRIDGES & OTHER STRUCTURES AND CUTTINGS

SECTION 1300 TESTS FOR QUALITY CONTROL OF MATERIALS AND WORKS

PART 2 APPENDIX TO SPECIFICATIONS

SECTION 100

PRELIMINARIES

SECTION 101

EQUIVALENT STANDARDS AND CODES

101.1 Specification Intent

The Contractor shall furnish all resources required and complete the specified works according to the Specification. Wherever reference is made to specific standards and codes to be met by the goods and materials to be furnished, and work performed or tested, the provision of the latest current edition or revision of the relevant standards and codes in effect shall apply.

Where such standards and codes are national, or relate to a particular country or region, other authoritative standards which ensure an equal or higher quality than the standards and codes specified will be accepted subject to the Employer's prior review and written approval. Differences between the standards specified and the proposed alternative standards must be fully described in writing by the Contractor and submitted to the Employer at least 28 days prior to the date when the Contractor desires the Employer's approval.

In the event the Employer determines that such proposed deviations do not ensure equal or higher quality, the Contractor shall comply with the standards specified.

101.2 Quality Assurance Plan

The Contractor shall prepare Quality Assurance Plan based on ISO 9000 series (2000 edition) within two month from the date of commencement, for the Engineer’s acceptance before any related work is commenced. The Contractor shall execute the Plan and ensure the performance and the quality of his work. The Contractor shall up-date and add the Plan according to actual requirements for the whole contract period.

The Engineer and the Employer shall check both the contents and the actual performance of the Contractor throughout the contract period.

Hold Points

Quality Assurance Plan and method statements shall indicate “hold points” as follows:

The Contractor’s hold points:

Points where no further work shall proceed without the written approval of a designated person of the Contractor’s management, who shall be named in the Quality Assurance Plan.

The Consultant’s hold points:

Points where no further work shall proceed without the written approval of a designated representative of the Consultant.

The Plan shall include the following items:

- Contractor's organisation, management and document control

  Names, roles, responsibilities and authority of key personnel incl. Quality Assurance Manager, Schedule control manager, Environmental specialist and Managers to control each sub-contractor.

-Contractor's method statements and construction procedures

  Method statements shall include:

  Quality control procedures, quality records, schedule control, sub-contractor plan, office, accommodation and laboratory plans, site layout plans, temporary access roads, temporary drainage, earthworks, soft ground treatment, batching plant and concreting, pre-cast girder construction, bridge construction (in particular piling and foundation works), traffic and utility diversions, asphalt plant and pavement.

101.3 Project Diary

The Contractor shall keep daily record of all significant items relating to the Project and submit it to the Engineer daily (probably by e-mail) in accordance with their Quality assurance plan. The contents are only for information and do not constitute the official documents unless confirmed by writing reasonably later. The required items will be:

- Weather,
- Orders given to the Contractor,
- Important discussions with the Engineer or representative, such as disputes,
- Official visitors and inspections,
- Work or materials rejected and reasons,
- Time of shutting down or resuming work and explanations,
- Work done by the Contractor's forces during the day,
- General purpose of work,
- Account of any time spent by the Contractor's personnel or equipment on disputable items or work,
- Length and cause of any delay,
- Arrival and departure of major equipment and work forces,
- Unusual conditions, if any, such as high water, bridge failures, slides, etc.
- Progress of stakeouts and surveys made,
- When appropriate, daily surveillance of traffic control and its' effectiveness.

For the Pay Item refer section 110.2

101.4 Software for Highway Design

The Engineer has used following software with AutoCAD for highway design. The Contractor shall furnish and use them and be familiar with the usage.

- AutoDesk Civil Design, USA
- AutoDesk Land Desktop, USA

101.5 Costs of Software, Standards and Codes

The costs of software, standards and codes purchased for the Contractor's use shall not be paid separately.

SECTION 102

OFFICES AND LABORATORY FOR THE ENGINEER

102.1 Fixed Charges for Offices and Laboratory for the Engineer

102.1.1 Description

1.1 Accommodation, Offices

The Contractor shall construct (or rent), maintain, and shall provide services and handover all accommodation and offices including their contents, access roads and hard-standings as described in the Appendix 1 (Facilities for the Engineer) to the Specifications for the use of the Engineer.

The Contractor shall prepare and submit detailed plans of offices, laboratory and accommodation (for both the Engineer's and the Contractor's) to get approval from the Engineer, in reasonably advance.

Equipment, furnishings, fittings and supplies shall be located as described in the Appendix to the Specifications and as instructed by the Engineer.

All temporary initial accommodation for the Engineer's local staff and the Engineer's temporary initial offices shall be ready for occupation and use by the Engineer on the date for commencement of the Works.

All other accommodation and offices complete with contents, access roads and hard-standing shall be ready for occupation and use by the Engineer within the time stated in the Appendix to Bid.

The Contractor shall provide garbage collection and disposal locations in the site. All offices and accommodation shall be regularly and properly cleaned for so long as they are required by the Engineer.

All accommodation, offices, their contents, access roads and hard-standings (walls and fences) provided by the Contractor shall be handed over to the Employer and become the property of the Employer at the completion of the Project (except rented ones).

Upon completion of the Contract, all non-consumable items provided shall become the property of the Employer.

1.2 Laboratory

The Contractor shall provide and maintain for the duration of the contract a laboratory complete with all utility services, furniture, equipment, apparatus and fittings for on-site testing of material.

The laboratory, fittings and equipment as approved by the engineer shall be operated by the contractor in accordance with the contract or as directed by the engineer.

The contractor should provide all technicians, labourers etc. in the numbers deemed necessary by the engineer to operate the laboratory as required by the contract.

Personnel once assigned to the laboratory shall not be removed without the prior written approval by the engineer.

Laboratory equipment and apparatus shall be furnished before the start of any work required by their use. Material, equipment and instruments in the laboratory and those used for field testing are to be maintained by the contractor and kept ready in good operating conditions at all times.

Refer Appendix 2 Clause 2.1: Contractors testing laboratory
Appendix 2 Clause 2.2: Laboratory furniture
Appendix 2 Clause 2.3: Laboratory Equipment

1. 3 Survey Equipment

The Contractor shall supply new survey equipment for the exclusive use of the Engineer in accordance with Appendix 2: Clause 1. (Survey and Laboratory Equipment).

Upon completion of the Contract, all non-consumable items provided shall become the property of the Employer.

1.4 Telephone

Telephones described in the Appendix to the Specification shall have a separate connection for the exclusive use of the Engineer. Mobile phones for the Engineer will be included in the Engineer's contract.

1.5 Land for Offices, Accommodation and Other Facilities

The Contractor shall construct the followings on land provided by the Employer:

- The Engineer's main office
- The Engineer's accommodation
- The Contractor's main office.

Where the Contractor leases land for the construction of the other facilities (e.g. The Engineer's portable offices), the Contractor shall ensure the terms of the land lease allow the use of the premises for as long as they are required and shall take into account possible extension or overrun of the Contract period and use of the facilities after the issue of the Defects Liability Certificates. The terms of the lease shall incorporate provisions whereby the Contractor may assign his interests to the Employer.

1.6 Services

The Contractor shall arrange, where possible, for the connection of all facilities to existing water mains, drainage, sewerage and electricity. In circumstances where location of existing services makes such connections impracticable, the Contractor shall provide and operate additional facilities including generators to supply adequate power, pumps, wells or boreholes and/or storage tanks for water supply and shall provide facilities to dispose of sewerage and waste water.

1.7 Rented Premises

Rented offices and housing accommodation, as an alternative to constructing buildings, may be considered by the Engineer in locations conveniently situated along the works. Rents payable shall be at market rates

and shall be subject to approval by the Engineer. The total cost for using the alternative of rented offices and/or accommodation shall be such that there is no extra cost to the Employer compared to the priced items. Where rented accommodation is chosen by the Contractor and approved by the Engineer, the Contractor shall provide and fix those items of furniture, equipment and fittings as listed in Appendices, which the Engineer shall select.

1.8 Relocation of Portable or Mobile Site Office Facilities

During the construction of the Works, the Engineer may direct that a portable or mobile site office facility be moved to another location either within or out of the Right of Way (ROW) limits. If within ROW, the Engineer will advise the Contractor of the required location with consent of the Employer. If out of ROW, the office will be rented one.

In all cases, the Contractor shall disconnect all services, move the office and install in the new location in accordance with the Specification, and reconnect all services. The Contractor shall reinstate the original site to the satisfaction of the Engineer.

The relocation shall be carried out in the shortest possible time and in no case shall services be disconnected or the office moved before all necessary approvals have been gained, and all service connections provided at the new location.

102.1.2 Measurement

Offices for the Engineer shall be measured as the number of each type of office provided.

Furniture for the offices of the Engineer shall be measured as a Provisional Sum (P.S) item.

Provision of temporary hotel accommodation for the Engineer shall be measured and paid under the Provisional Sum for the invoiced cost ordered and approved by the Engineer. No payment will be made under the Provisional Sum for any costs expended by the Contractor after the time for the provision of permanent housing for the Engineer specified in the Appendix to Bid.

Provision of housing for the Engineer will be measured as the number of months (if rented) during which housing is provided to satisfaction of the Engineer. If the Contractor constructs it, it will be measured and paid according to the progress.

Service and maintenance of housing for the Engineer will be measured as the number of months during which they are carried out to the satisfaction of the Engineer.

Survey equipment for the Engineer shall be measured as Provisional Sum (P.S) items.

Stationery for the Engineer shall be measured and paid under the Provisional Sum for the invoiced cost ordered and approved by the Engineer.

Maintenance of the offices for the Engineer will be measured as the number of months during which maintenance is carried out to the satisfaction of the Engineer.

Relocation of portable or mobile site office facility as long as they are required by the Engineer shall be by the number of moves irrespective of the distance moved.

102.1.3 Payment

Payment shall be made upon completion, finishing and occupying of the facility, the procurement, delivery and satisfactory installation, testing and acceptance of equipment item by the engineer and upon the occupation of the facility by the engineer and his staff to the extent that they can properly perform their duties under the contract to the satisfaction of the engineer.

These fixed charges are payable once the identified item, facility or service has been provided by the contractor and accepted by the engineer. In all cases, certification will require that the engineer is satisfied that the contractor has properly discharged his obligation with respect to the item concerned. If it is the opinion of the engineer that this is not the case, then he any delete the item from any payment certificate or reduce the amount certified.

Payment for the provision and equipping of housing for the Engineer shall include all costs including rental, refurbishment, facilities and equipment. Service and maintenance of the housing shall include for the labour, materials and equipment necessary to ensure that they are regularly and properly cleaned, serviced and maintained to the satisfaction of the Engineer.

Payment for the offices of the Engineer shall include for the following items:-

- The acquisition of and payment for land required for the offices, hard standing and access road (if required).
- Provision and erection of the buildings including any necessary foundations.
- Provision of access road, hard standing, fences and gates.
- The connection of telephone, electrical and water services including costs associated with their provision and use.

Payment for the removal of the offices of the Engineer shall include for the following items:-

- The removal of the buildings including any necessary foundations and services (if required).
- The removal of access road, hard standing fences and gates (if required).
- The disconnection of telephone, electrical, sewerage and water services (if required).
- The reinstatement to the satisfaction of the Engineer of the land used for the office, hard standing and access road.

The item ‘Miscellaneous’ provides for discretionary expenditure by the engineer on item relevant to this part of the bill of quantities but not elsewhere covered.

Pay Item	Description	Pay Unit
102.1(1)	Main office: Provide and erect	l.s.
102.1(2)	Portable office: Provide and erect	l.s.
102.1(3)	Provide and Equip Accommodation for Engineer - Type A (4 houses)	mth
102.1(4)	Provide and Equip Accommodation for Engineer - Type B (6 houses)	mth
102.1(5)	Furnish and equip for engineer's office (Main & Portable office)	PS
102.1(6)	Main office: Dismantle and remove	l.s.
102.1(7)	Portable office: Dismantle and remove	l.s.
102.1(8)	Material Testing Laboratory: Provide and erect	l.s.
102.1(9)	Material Testing Laboratory: Furnish and equip	PS
102.1(10)	Material Testing Laboratory: Dismantle and remove	l.s.
102.1(11)	Provide survey equipment	PS
102.1(12)	Provide Electrical Power Supply: CEB connection	l.s.
102.1(13)	Provide Electrical Power Supply: Standby generator	l.s.
102.1(14)	Provide water supply: Domestic water	l.s.
102.1(15)	Provide water supply: Potable water	l.s.
102.1(16)	Provide access roads	l.s.
102.1(17)	Miscellaneous of Section 102.1 (fixed charges)	PS
102.1(18)	Mark-up on item 102.1(17)	percent

102.2 Time-Related Charges for Offices and Laboratory for the Engineer

102.2.1 Description

1 .1 General

Refer the following Appendices for Specification

Refer Appendix 1: Facilities for the Engineer

Appendix 2: 1. Survey equipment

Appendix 2: 2.1 Contractors testing laboratory

Appendix 2: 2.2 Laboratory furniture

Appendix 2: 2.3 Laboratory Equipment

102.2.2 Measurement and Payment

These time-related charges are payable on a monthly or other time-related basis from the time the item, facility or service has been provided by the contractor and accepted by the engineer until the end of the time for completion for the whole of the work or such later time as may be agreed by the engineer to allow any outstanding work to be completed during the defect liability period.

Certification will require that the engineer is satisfied that the contractor has properly discharged his obligation with respect to the time concern. If it is the opinion of the engineer that this is not the case, then he may delete the item from any payment certificate or reduce the amount certified. The item 'Miscellaneous' provides for discretionary expenditure by the engineer on item relevant to this part of the bill of quantities but not elsewhere covered.

Pay Item	Description	Pay Unit
102.2(1)	Service and maintenance: Main office	mth
102.2(2)	Service and maintenance: Portable office	mth
102.2(3)	Service and Maintain Accommodation for Engineer - Type A	mth
102.2(4)	Service and Maintain Accommodation for Engineer - Type B	mth
102.2(5)	Service and maintenance: Engineer's laboratory	mth
102.2(6)	Maintenance of survey equipment	mth
102.2(7)	Service and maintenance: electrical power: CEB	mth
102.2(8)	Operation electrical power: Standby generator	mth
102.2.(9)	Maintain access roads	mth
102.2.(10)	Miscellaneous of Section 102.2 (fixed charges)	PS
102.2(11)	Mark-up on item 102.2(10)	percent

SECTION 103

CONTRACTOR'S SITE ESTABLISHMENT

103.1 Fixed Charges for Contractor's Establishment

103.1.1 Description

1.1 General

The Contractor shall be responsible for acquiring land for the sitting of all his offices, housing, stores, testing laboratory, precasting yards, equipment, plants and workshops and for all temporary works and for the reinstatement of such land on completion of the Contract to the satisfaction of the Engineer and the owners of such land.

The Contractor shall obtain the approval of the Engineer to the sitting of offices, housing, stores, testing laboratory, precasting yards, plants and workshops before such land is acquired and he shall indemnify the Employer against all claims and charges in respect of the occupation, use and reinstatement of the land.

The items shall include:

- Furnish all resources (incl. equipment) required to complete the specified work,
- Establish offices, testing laboratory (as per Appendix 2), housing, workshop and stores for the Contractor,
- Establish precasting yards, crushing , concrete and asphalt plants (Those three plants can be sub-contracted by the Contractor.) for the Contractor,
- Install electrical power supply with sufficient capacity and a standby generator of similar capacity for use exclusively as a backup unit for this purpose,
- Install water supply,
- Provide Access roads,
- Provide Environmental Management Action Plan (EMAP, details in Appendix 5) within 2 month from the commencement of the Work and its up-dating and monitoring according to CEA's requirements and the requirements of Section 114,
- Charges not otherwise itemised

1) The Contractor shall provide, maintain and remove on completion of the works, the offices, testing laboratory including their contents, access roads and hard standing as required by him in order that he may carry out his obligations under the Contract.

2) On completion of the Project, the followings shall become property of the Employer:

- All the buildings of offices, laboratory, housing, workshop and stores with their furniture for the Contractor.

- Electrical power supply system with the standby generator, water supply and the access roads.
- Testing equipment in the laboratory.

The computers, computer peripherals and office equipment purchased by the Contractor for his use will remain as property of the Contractor on completion of the Project.

1.2 Establish Offices

Construct or rent a main Site office or offices of sufficient size for the purposes of the Contract. Electricity, water, telephone, drainage, parking and sanitary facilities to be of standards equivalent to those of the Engineer's offices. The office(s) to be fully equipped, including computer equipment, and furnished to meet the needs of the Contract, including providing the design services required under the Contract.

Comply with the relevant requirements of Clause 34 of the Conditions of Contract.

1.3 Establish Housing

Comply with the relevant requirements of Clause 34 of the Conditions of Contract.

1.4 Establish Workshop

Establish, equip and commission a main Site workshop sufficient for the purposes of the Contract.

1.5 Establish Stores

Establish, equip and commission a store or stores for the safe keeping of spare parts, tyres, fuel and lubricants, cement, paints and such like, all sufficient for the purposes of the Contract.

1.6 Establish Pre-casting Yard

Establish, equip and commission a pre-casting yard for the production of pre-cast concrete items required on the Works, such as kerbs, drain segments, drain cover slabs and the like.

1.7 Establish Asphalt Plant

Install and commission (or sub-contract) a hot-mix asphalt plant of a type to meet the requirements of the Contract and of sufficient capacity to meet the full production needs of the Works. Included in this item shall be the establishment and calibration of a weighbridge for the purpose of weighing asphalt delivery trucks. Payment of this item will be reduced pro rata if the plant provided is not able to meet the full production needs of the Works or if the Contractor procures hot-mix asphalt from third parties.

1.8 Establish Crusher Plant

Install and commission (or sub-contract) a crushing plant or plants of a type to meet the requirements of the Contract and of sufficient capacity to meet the full production needs of the Works. Establishment will include the construction of necessary access roads, installation of necessary utilities and the provision of associated drilling equipment, explosives storage facilities, pumps and the like, all as necessary for the production of the crusher raw feed material. Payment of this item will be reduced pro rata if the plant provided is not able to meet the full production needs of the Works or if the Contractor procures aggregate supplies from third parties.

1.9 Establish concrete batching plant

Install and commission (or sub-contract) a concrete batching plant or plants of a type to meet the requirements of the Contract and of sufficient capacity to meet the full production needs of the Works. Establishment will include the construction of necessary access roads, installation of necessary utilities and the like, all as necessary for the production of the concrete Ready-mix. Payment of this item will be reduced pro rata if the plant provided is not able to meet the full production needs of the Works or if the Contractor procures concrete Ready-mix supplies from third parties.

1.10 Install Electrical Power Supply

Install and commission an electrical power supply of sufficient capacity to meet the full needs of the Contractor's Site establishment. If the supply is taken from the mains, then the Contractor shall supply, install and commission a standby generator of similar capacity for use exclusively as a backup unit for this purpose.

1.11 Install Water Supply

Comply with the requirements of Sub-Clause 34.11 of the Conditions of Contract.

1.12 Provide Access Roads

Construct all-weather access roads to the Contractor's facilities.

1.13 Mobile Phones for the Contractor

- The Contractor shall have adequate numbers of mobile phones (e.g. group package system) for their own use and to communicate with the Engineer and the Employer within 1 month of the date for commencement of the Works.
- The system shall have an operating range which ensures reception throughout the Site.
- The Contractor shall maintain their mobile phones. If they are inoperative for any reason, they shall either be repaired or replaced within 24 hours.
- The Contractor shall pay the cost of the hardware and the communication charges, no separate payment

will be made. (Mobile phones for the Engineer will be included in the Engineer's contract.)

- Upon completion of the Contract, all mobile phones used by the Contractor shall remain the property of the Contractor.

103.1.2 Measurement

Offices, testing laboratory and equipment for the Contractor shall be measured as a lump sum item as indicated in the Bill of Quantities.

Maintenance of the office and laboratory for the Contractor shall be measured as the number of months during which maintenance work is carried

103.1.3 Payment

These Fixed Charges are payable once the identified item, facility or service has been provided by the Contractor and accepted by the Engineer as completed and functioning properly to the extent that the Contractor and his staff can properly perform their duties under the Contract to the satisfaction of the Engineer, and that the Works can start and proceed in a safe and efficient manner.

In all cases, certification will require that the Engineer is satisfied that the Contractor has properly discharged his obligations with respect to the item concerned. If it is the opinion of the Engineer that this is not the case, then he may delete the item from any payment certificate or reduce the amount certified.

- The acquisition and payment of rental on any land required for his offices, laboratory, hard standing and access roads.
- Provision and erection of the buildings, including any necessary foundations, refurbishment, improvement and equipping.
- Provision of access roads, hard standing, fences and gates.
- The connection of telephone, electrical, sewerage and water supply, including costs associated with their provision and use.
- All furniture, stationery and equipment necessary for the proper execution of the work.

Payment for the removal of the offices for the Contractor shall include for:

- The removal of the buildings including any necessary foundations.
- The removal of access roads, hard standing fences and gates.
- The disconnection of telephone, electrical, sewerage and water supply including costs associated with their use.
- The reinstatement to the satisfaction of the Engineer of the land used for the office, laboratory, hard standing and access road.

The item 'Miscellaneous' provides for discretionary expenditure by the engineer on item relevant to this part of the bill of quantities but not elsewhere covered

Pay Item	Description	Pay Unit
103.1(1)	Establish office	l.s.
103.1(2)	Establish housing	l.s.
103.1(3)	Establish workshop	l.s.
103.1(4)	Establish stores	l.s.
103.1(5)	Establish precasting yard	l.s.
103.1(6)	Establish asphalt plant (if applicable)	l.s.
103.1(7)	Establish crusher plant (if applicable)	l.s.
103.1(8)	Establish concrete batching plant (if applicable)	l.s.
103.1(9)	Install electrical power supply	l.s.
103.1(10)	Install water supply	l.s.
103.1(11)	Provide access roads	l.s.
103 .1(12)	Testing Laboratory for the Contractor	l.s.
103.1(13)	Testing Laboratory Equipment for the Contractor	l.s.
103.1(14)	Removal of Site Establishment for the Contractor and Reinstatement of Land	l.s.
103.1(15)	Miscellaneous of Section 103.1 (fixed charges)	PS
103.1(16)	Mark-up on item 103.1(15)	percent

103.2 Time-Related Charges for Contractor's Establishment

103.2.1 Description

The Contractor shall be responsible for maintaining all his Site establishment facilities for the duration of the Contract to a safe, efficient and satisfactory standard such that he may prosecute the Works safely and without hindrance or delay.

1.1 Maintain Asphalt Plant

Included with this item shall be the requirement to recalibrate the weighbridge established with the asphalt plant. This shall be done at six-monthly intervals, or as otherwise directed by the Engineer, by an independent certifying organisation approved by the Engineer.

1.2 Maintain concrete batching plant

Included with this item shall be the requirement to recalibrate the weighbridge established with the concrete batching plant. This shall be done at monthly intervals, or as otherwise directed by the Engineer, by an independent certifying organisation approved by the Engineer.

103.2.2 Measurement and Payment

These Time-Related Charges are payable on a monthly or other time-related basis from the time the item, facility or service has been provided by the Contractor and accepted by the Engineer until the end of the Time for Completion of the whole of the Works, or such later time as may be agreed by the Engineer to allow any outstanding work to be completed during the Defects Liability Period.

Certification will require that the Engineer is satisfied that the Contractor has properly discharged his obligations with respect to the item concerned. If it is the opinion of the Engineer that this is not the case, then he may delete the item from any payment certificate or reduce the amount certified.
Maintenance of the office of the Contractor shall include for the labour, materials and equipment necessary to ensure that they are maintained regularly and properly cleaned
The item 'Miscellaneous' provides for discretionary expenditure by the engineer on item relevant to this part of the bill of quantities but not elsewhere covered

Pay Item	Description	Pay Unit
103.2(1)	Maintain office	mth
103.2(2)	Maintain housing	mth
103.2(3)	Maintain workshop	mth

103.2(4)	Maintain stores	mth
103.2(5)	Maintain precasting yard	mth
103.2(6)	Maintain asphalt plant (if applicable)	mth
103.2(7)	Maintain crusher plant (if applicable)	mth
103.1(8)	Maintain concrete batching plant (if applicable)	mth
103.2(9)	Maintain electrical power supply	mth
103.2(10)	Maintain water supply	mth
103.2(11)	Maintain access road	mth
103.2(12)	Maintenance of Testing Laboratory	mth
103.2(13)	Miscellaneous of Section 103.2 (fixed charge)	PS
103.2(14)	Mark-up on item 103.2 (13)	percent

SECTION 104

STAFF FOR THE ENGINEER

104.1 Time-Related Charges for Staff for the Engineer

104.1.1 Description

- The Contractor shall provide the Engineer with such assistance as is described in the Contract. The Contractor shall provide men equal to the tasks required and maintain continuity of staff.
- Survey assistant shall be experienced in assisting Engineer in survey work. Minimum 5 years experience, 3 (three) Nos. required.
- Draughtsman shall be conversant with civil engineering work and shall have at least five years experience in Auto CAD 2006 or above drafting work.
- Laboratory Technician shall be capable of assisting the Engineer's laboratory staff in testing. Minimum 2 years experience, 2 (two) Nos. for each laboratory.
- House keeper, Office Aide and Labourer shall have minimum 1 year experience,
- The staff provided shall remain in the employ of the Contractor, being seconded to the Engineer only, and the Contractor shall be responsible for all matters concerning their employment.

The Contractor shall ensure, to the extent possible, the continuity of the services of the personnel provided.

104.1.2 Measurement and Payment

Measurement and payment shall be made on monthly basis.

Pay Item	Description	Pay Unit
104.1(1)	Survey Assistant (3 Nose)	Man-mth
104.1(2)	Laboratory Technicians (2 Nose)	Man-mth
104.1(3)	Draughtsman	Man-mth
104.1(4)	House keeper	Man-mth
104.1(5)	Office Aide	Man-mth
104.1(6)	Labourer	Man-mth

SECTION 105

VEHICLES FOR THE ENGINEER

105.1 Fixed Charges for Vehicles for the Engineer

105.1.1 Description

1.1 General

The Contractor shall provide new plain coloured air-conditioned vehicles as described in the Appendix 1, Clause 7 for the exclusive use of the Engineer/the Employer and their representatives for any purpose in connection with the Works. The vehicles shall be licensed and insured for use on the public highway and off-road use with comprehensive insurance cover for any qualified driver authorised by the Engineer/the Employer, together with any authorised passengers and the carriage of goods or samples. The Contractor shall provide a qualified driver holding a valid driver's licence. The Contractor shall provide fuel, oil and maintenance in conformity with the vehicle manufacturer's recommendations and shall clean the vehicles inside and outside as required during the currency of the Contract. A suitable replacement shall be provided for any vehicle out of service. On completion of the Contract, the vehicles shall be handed over to the Employer.

All vehicles shall be delivered and ready for use by the Engineer/the Employer within the time stated in the Appendix to Bid.

The allocation and use of the vehicles provided for the Engineer/the Employer shall be entirely at the discretion of the Engineer/the Employer. Members of the Engineer's/the Employer's staff designated by the Engineer/the Employer, and notified to the Contractor, may at the sole discretion of the Engineer/the Employer, use the vehicles for private purposes. The names and driving licence numbers of such persons or, as the case may be, their private drivers, will be given to the Contractor and the Contractor shall ensure that the vehicles are appropriately insured for such use.

1.2 Access to Major Bridges

The Contractor shall provide adequate access to the major bridges through rivers or waterways for the inspection of the Engineer and the Employer.

105.1.2 Measurement

Vehicles for the Engineer/the Employer shall be measured as the number of each type of vehicle provided.

105.1.3 Payment

These Fixed Charges are payable once the identified item, facility or service has been provided by the Contractor and accepted by the Engineer. In all cases, certification will require that the Engineer is satisfied that the Contractor has properly discharged his obligations with respect to the item concerned. If it is the opinion of the Engineer that this is not the case, then he may delete the item from any payment certificate or reduce the amount certified.

Delayed delivery, except when agreed with the Engineer, shall give rise to a reduction in the payment due the Contractor. For each calendar day of delay for the delivery of each vehicle the amount to be deducted from the payment due for that vehicle will be one thousandth of the sum tendered for that vehicle.

Payment for access to major bridges is deemed to be included here but no separate payment will be made.

Pay Item	Description	Pay Unit
105.1 (1)	Vehicle Type A	Vehicle
105.1 (2)	Vehicle Type B	Vehicle
105.1 (3)	Vehicle Type C	Vehicle
105.1 (4)	Vehicle Type D	Vehicle
105.1 (5)	Motor Cycle (125cc)	nr

105.2 TIME-RELATED CHARGES FOR VEHICLES FOR THE ENGINEER

105.2.1 Description

Refer to the following

Appendix 1, Clause 7: Vehicles for the Engineer

The vehicles shall be licensed and insured for use on the public highway and off-road use with comprehensive insurance cover for any qualified driver authorised by the Engineer/the Employer, together with any authorised passengers and the carriage of goods or samples. The Contractor shall provide a qualified driver holding a valid driver's licence. The Contractor shall provide fuel, oil and maintenance in conformity with the vehicle manufacturer's recommendations and shall clean the vehicles inside and outside as required during the currency of the Contract.

105.2.2 Measurement and Payment

Each vehicle shall have a uniquely numbered, multi-copy, self-carbonising logbook, formatted as one page per week, and identified as belonging to that vehicle. The driver of the vehicle will maintain the log book and record:

- The odometer reading at the start and end of each journey, and
- The origin and destination of each journey, and
- The start time and end time of each journey, and
- In the case of drivers provided by the Contractor :
  - The start and end times of the working day, and
  - The hours worked.

The top (white) copy of the logbook record shall be submitted as supporting documentation for payment. Where the logbook is not correctly completed or there are alterations that cannot be acceptably explained the kilometres in question will not be paid for. The second (pink) copy of the logbook record shall be sent at the end of each week to the Engineer. The third (green) copy of the logbook record shall be retained by the Contractor. The fourth (blue) copy of the logbook record will be retained in the logbook.

Kilometres of use will be measured from the logbook. All the operating costs of the vehicle, including but not limited to fuel, lubricants, servicing, repair, tyres and other consumables, licensing, insurance and the like will be covered by the rates quoted per kilometre.

Notwithstanding the Contractor's working hours noted in Clause 45.2 of the Conditions of Contract, reimbursable driver time will be measured per hour worked or called upon and available to work as recorded in the logbook but subject to the limits of:
07:00 to 18:00 (including 1 hour lunch time) from Monday through Friday and
07:00 to 14:00 on Saturdays.
Overtime (including private and holiday uses) outside these hours, if approved by the Engineer and so noted in the logbook, will also be reimbursable. In all other respects the provisions of Clause 45.2 of the Conditions of Contract shall apply.

These Time-Related Charges are payable on a monthly or other time-related basis from the time the item, facility or service has been provided by the Contractor and accepted by the Engineer until the end of the Time for Completion of the whole of the Works, or such later time as may be agreed by the Engineer to allow any outstanding work to be completed during the Defects Liability Period.

Certification will require that the Engineer is satisfied that the Contractor has properly discharged his obligations with respect to the item concerned. If it is the opinion of the Engineer that this is not the case, then he may delete the item from any payment certificate or reduce the amount certified.

The item 'Miscellaneous' provides for discretionary expenditure by the engineer on item relevant to this part of the bill of quantities but not elsewhere covered

Pay Item	Description	Pay Unit
	Operate Vehicle Type A:	
105.2(1)	From 0 to 40,000 km	Kilometre
105.2(2)	From 40,001 to 80,000 km	Kilometre
105.2(3)	From 80,001 to 120,000 km	Kilometre
105.2(4)	Over 120,000 km	Kilometre
	Operate Vehicle Type B: [summarize all vehicles stated in 105.1(2)]	

105.2(5)	From 0 to 360,000 km (40,000x9)	Kilometre
105.2(6)	From 360,001 to 720,000 km	Kilometre
105.2(7)	From 720,001 to 1,080,000 km	Kilometre
105.2(8)	Over 1,080,000 km	Kilometre
	Operate Vehicle Type C: [summarize all vehicles stated in 105.1(3)]	
105.2(9)	From 0 to 80,000 km (40,000x2)	Kilometre
105.2(10)	From 80,001 to 160,000 km	Kilometre
105.2(11)	From 160,001 to 240,000 km	Kilometre
105.2(12)	Over 240,000 km	Kilometre
	Operate Vehicle Type D: [summarize all vehicles stated in 105.1(4)]	
105.2(13)	From 0 to 200,000 km (40,000 x5)	Kilometre
105.2(14)	From 200,001 to 400,000 km	Kilometre
105.2(15)	From 400,001 to 600,000 km	Kilometre
105.2(16)	Over 600,000 km	Kilometre
	Operate Motor Cycle (125cc) : [summarize all vehicles stated in 105.1(5)]	
105.2(17)	From 0 to 240,000 km (30,000 x 8)	Kilometre
105.2(18)	From 240,001 to 480,000 km	Kilometre
105.2(19)	From 480,001 to720,000 km	Kilometre
105.2(20)	Over 720,000 km	Kilometre
105.2(21)	Provide Driver for Vehicle Type A (1 Nose)	Man-mth
105.2(22)	Provide Driver for Vehicle Type B (9 Nose)	Man-mth
105.2(23)	Provide Driver for Vehicle Type C (2 Nose)	Man-mth
105.2(24)	Provide Driver for Vehicle Type D (5 Nose)	Man-mth
105.2(25)	Overtime - Driver for Vehicle Type A *(input the total number of hours)*	Hour
105.2(26)	Overtime - Driver for Vehicle Type B *(input the total number of hours)*	Hour
105.2(27)	Overtime - Driver for Vehicle Type C *(input the total number of hours)*	Hour
105.2(28)	Overtime - Driver for Vehicle Type D *(input the total number of hours)*	Hour

105.2(29)	Miscellaneous of Section 105.2 *(time-related charges)*	PS
105.2(30)	Mark-up on item 105.2(29)	percent

SECTION 106

TRAFFIC SAFETY AND CONTROL

106.1.1 Description

1.1 General

The Contractor shall manage construction with minimal obstruction to traffic and shall ensure the safety and convenience of the public and property. The Contractor shall follow the safety provisions of all applicable laws, rules, codes and regulations.

1.2 Traffic Safety and Management Proposals

Supplementary to the Programme, in accordance with the requirements of relevant clauses of the Conditions of Contract, the Contractor shall prepare and submit Traffic Safety and Management proposals, which shall be reviewed and updated when the Works are commenced and submitted to the Engineer after consultation with any statutory, police or other authority concerned. The Contractor shall make such changes to his proposals as may be necessary to meet the requirements of the Contract.

Required contents of Traffic Safety and Management Plan:

- Phasing of Works (incl. details of traffic management and diversions).
- Drawings showing traffic management layout, incl.
    1) Position of traffic signs and signals.
    2) Width of lanes.
    3) Working areas.
    4) Crossing roads planning.
- Timing of operations and their permissions.
- Open or Close of affected roads.
- Approved authorities, contact persons, address & Tel. No.

The Contractor shall provide, erect, maintain, reposition and finally remove such traffic signs, lamps, barriers and traffic control signals and such other measures as may be necessitated by the construction of the Works, in accordance with the Motor Traffic Act and its Regulations in force at the time of execution of the Works and Colombo Municipal Councils publication Safety at Roadworks (1991), and Manual on Traffic Control Devices, Part II, Traffic Control Devices for Road Works March 2001 or their latest editions.

Specifically the Contractor shall obtain approval before hauling materials on all public roads from the respective authorities and adequately cover the vehicles by canvas or tarpaulin to avoid spillage of materials on to the roads.

Layout drawings for traffic management schemes are to be prepared using sign layouts as specified above

and submitted for the consent of the Engineer.

The Contractor shall not commence any works which affects the public highway until all traffic management and safety measures necessitated by the Works have been tested, adjusted and are fully operational and approved by the Police and Engineer.

The Contractor shall appoint a "Safety Manager", to act as the Traffic Safety and Control Officer, who shall make all arrangements necessary for traffic safety and control.

The Contractor shall provide and maintain a vehicle for the Safety Manager.

The Contractor is to provide all safety equipment and materials necessary for the safe execution of the Works, the safety of his staff and of traffic and the public having access to Site, and for the Safety Manager to be able to implement all necessary safety practices effectively.

For the Contractor's staff, the safety equipment and materials shall include, but not be limited to, training and educational materials, protective "hard hats", safety shoes, reflective vests, work gloves and the like. For the Site, the safety equipment and materials shall include, but not be limited to, all necessary signs, cones, barricades, lights, road markings and suchlike specified in the Employer's "Manual on Traffic Control Devices" or as otherwise required for the safe execution of the Works.

The Contractor shall keep clean and legible at all times, all traffic signs, road markings, lamps, barriers and traffic control signals and keep records of the inspections and details of all maintenance or replacements. These records shall be submitted weekly to the Engineer. He shall also position, reposition, cover or remove them as necessitated by the progress of the Works.

106.1.2 Measurement

All the costs related to the implementation and execution of the Traffic Safety and Management Plan shall be measured monthly.

106.1.3 Payment

(a) Payment shall include all costs necessary and required for the proper implementation of the Traffic Safety and Management Plan in fully accordance with the requirements of this Specification Section, including updating and submittals.

(b) Payments shall be made monthly according to the Traffic Safety and Management Plan.

(c) The Engineer may at any time withhold payments if (in the opinion of the Engineer) the Traffic Safety and Control is not being provided in due compliance with the requirements and procedures of this Specification Section.

Pay Items		Unit of Measurement
106(1)	Traffic Safety and Control	mth

SECTION 107

TEMPORARY ACCESS AND MAINTENANCE

107.1 Description

1.1 Contractors' Plan and Schedules for Maintenance and Protection of Traffic

The Contractor shall prepare and submit to the Engineer, for review and approval, a complete plan and schedules for implementation and monitoring of the necessary measures that the Contractor shall perform for the maintenance and protection of public traffic, including traffic due to the construction, in the Project area and adjacent area that is being affected during the execution of the Work, and the plan for all the temporary roads to be used by the Contractor for executing the Work.

Special maintenance, which is not included in the Contract but that is defined and ordered by the Engineer to benefit the travelling public, is included in the Provisional Sum of "Pay Item 1001 (7), Existing road repairing as required by the Engineer".

1.2 Temporary Accesses and Diversion Roads during Construction

The Contractor shall construct, maintain, remove and reinstate each temporary access and diversion road during the construction.

(a) Each temporary diversion for traffic shall be made operative in advance of any interference with the existing arrangements and shall be maintained to the required standards.

(b) The Contractor shall design each temporary diversion for traffic, including any temporary structures and remove them as soon as they are no longer required. Elevation of the temporary access shall be proposed by the Contractor and agreed by the Engineer in order that the surrounding houses will not be in worsened flooding conditions. For this purpose、the Contractor shall construct temporary causeways as required.

(c) The Contractor shall propose to construct temporary diversions and shall submit an outline of his proposals to the Engineer for their agreement and consultation with the police.

(d) The Contractor shall submit a formal application to the appropriate authority (Divisional Secretary and each Police) for any statutory orders required to be made or notices required to be published through the Engineer.

(e) The Contractor shall construct the temporary access road along the whole stretch within 12 months from the date of commencement of the contract. The Employer shall give required assistance to achieve the target.

1.3 Maintaining Traffic

(a) The Contractor shall keep the road open to traffic during the Work or provide adequate detour roads as specified or directed. He shall maintain the Work to accommodate traffic.

(b) The Contractor shall construct and maintain all necessary accesses to residents' parking lots,

garages, businesses, residences, farms etc.

(c) The Contractor shall maintain to the satisfaction of the Engineer the carriageway and footwalks of all roads and bridges forming part of the Site in a condition which is at least as good as the condition before the commencement of the Works.

(d) All roads used by the Contractor and those used by the public as diversion routes for traffic due to the Works, shall be considered as part of the Site for the purpose of maintenance. Diversions shall be constructed to the requirements of the RDA and Traffic Police. Diversions will not be permitted without the written approval of RDA and Traffic Police.

(e) The Contractor shall take all precautions to avoid spillage of spoil, earth or any other material on to roads during transportation, and shall remove any such spillage to the satisfaction of the Engineer.

1.4 Maintenance of Existing Roads

Notwithstanding the requirements of Sub-Clauses 29.1 to 30.4 of the Conditions of Contract, the Contractor shall be responsible for maintenance of the existing roads which are being used for their transport of materials and equipment.

The Contractor shall not make the public roads used by them dirty by their equipment and transport vehicles. Adequate washing facilities for the public roads, tires and equipment shall be provided by the Contractor at appropriate locations.

In general, RDA, Provincial Councils and Pradeshiya Sabha (Divisional Secretary) are in charge of the maintenance of the existing roads. They may request the Contractor to make some deposit for the maintenance of the roads being used by the Contractor. The Contractor shall provide required deposit but the payment to the Contractor will be only monthly basis.

1.5 Load Restrictions

The Contractor shall keep load restrictions when hauling equipment or materials on public roads beyond project limits. A special permit does not decrease the Contractor's liability for damage.

(a) Obtain the Engineer's written permission to exceed legal load limits.

(b) Prohibit operating equipment or hauling loads that may damage structures, roadway, or any construction. Hauling materials over any completed work within the project limits must be approved by the Engineer.

1.6 Maintenance during Construction

The Contractor shall maintain the Work during construction until Taking-Over Certificate. Maintenance includes continuous and effective work conducted daily.

(a) The Engineer will notify the Contractor immediately of failure to meet these conditions. If remedy of unsatisfactory maintenance has not started within 24 hours after receiving the notice, the

Engineer will maintain the project. The entire maintenance cost will be deducted from monies due or will be owed by the Contractor.

(b) The Contractor shall maintain previously constructed work when the Contract involves placing material on, or the use of a previously constructed sub grade, base course, pavement, or structure.

107.1.2 Measurement

Temporary access and maintenance shall be measured by lump sum.

Maintaining traffic and existing roads shall be measured on monthly basis, as Maintain of existing roads. Payment shall be according to the progress and monthly basis. The Engineer may at any time withhold payments if (in the opinion of the Engineer) the work herein specified is not being properly provided.

107.1.3 Payment

(a) Payment shall include all costs necessary and required for the proper implementation of the Contractors' Plan and Schedules for Maintenance and Protection of Traffic in fully accordance with the requirements of this Specification Section, including all updating and submittals, supervision, materials, equipment, apparatus and devices, labor, and any other incidental cost.

(b) Neither measurement nor separate payment will be made for furnishing, installing, and maintaining traffic control devices, including temporary fences, services, road works required by the contract for the control and protection of traffic.

(c) All traffic control devices prepared by the Contractor, shall remain being the property of the Contractor, and shall be removed upon completion of the Contract.

(d) Temporary access

Payments shall be made in the following three instalments:

- 20% (twenty percent) upon the issuance of the Engineer's approval to the submitted Plan, and to the mobilization of the Contractor's staff for implementation of the Plan;

- 50% (fifty percent) over the duration of the Contract Construction Period split in partial payments in proportion to this work item progress, upon the Engineer's approval certifying the compliance on the requirements of this Specification Section by the Contractor, and

- 30% (thirty percent) upon the issuance of the Engineer's approval certifying that all the requirements of this Specification Section including those for demobilization have been satisfactorily completed.

Pay Items	Unit of Measurement
107(1) Temporary Access and Maintenance	l.s.
107(2) Maintain Traffic and Existing Roads	mth

SECTION 108

PROJECT SIGN BOARD

108.1 Description

The Contractor shall provide and erect designated number (incl. beginning and end) of project signboards 4 metres wide by 2.2 metres high at locations on or near the site as directed by the Engineer. Wording shall be as shown in the sketch included in the appendix in Sinhala, Tamil and English.

The boards shall be erected with the bottom of the board at a minimum of 2.3 metres above the adjacent ground and clear of motor traffic with posts and struts suitably set in concrete foundations.

Upon completion of the Works or as instructed by the Engineer, the Contractor shall carefully dismantle signboards, formwork, supports and struts and remove from site.

The Contractor shall remove all foundations, dispose of the materials off site and reinstate the ground to the satisfaction of the Engineer. The project signboards shall be erected within 2 weeks of the commencement of the Works.

108.2 Materials

The board shall be galvanised steel, aluminium sheet or 25 mm thick marine (surface-treated) plywood. Lettering in permanent paint and borders to be in black on yellow background.

108.3 Measurement

Project signboards shall be measured as the number provided and erected on site

108.4 Payment

Payment for the project signboard shall include the following items.

- The acquisition of and payment for land required for the erection of the board clear of motor traffic. The Employer shall assist the Contractor for his land acquisition or rent.
- Provision, erection, regular cleaning, maintenance and subsequent removal including concrete foundations.
- Updating the completion date periodically as directed by the Engineer.
- The reinstatement to the satisfaction of the Engineer of the land used for the erection of the board.

Payment for project signboards will be made in the proportion of 80 percent for provision and erection, and 20 percent for the removal of the board and subsequent reinstatement of the land.

Pay items	Unit of Measurement
108(1) Project signboard	Nr

SECTION 109

MONTHLY PROGRESS REPORT

109.1 Description

The requirements established in this Specification Section shall supplement the requirements and provisions stated in Clause 46.1 “Rate of Progress” of the Conditions of Contract, and the Specification Section 112 ”Programme of Work” and the like included in the Contract regarding the reporting requirements.

Before the fifth calendar day of each month, the Contractor shall submit to the Engineer the Report in 12 sets. The Report shall describe all works performed up to and including the last day of the preceding month.

The Report constitutes the fundamental document for the procedure of each progress payment; therefore, the reviewed and approved Report shall be attached to each certificate for progress payment.

Failure of the Contractor to comply with the requirements of this Specification Section shall be considered as a serious default of the Contractor in meeting his contractual obligations. In this case, the Engineer will suspend the procedure for issue of any payment certificate if the relevant Report does not meet the requirements specified herein.

109.2 Requirements for the Report’s Contents

The Report shall include a summarized description of the major activities performed in the month.

The Report shall content, but not be limited to, the following:

- The activities that were completed in the month, including their actual start and completion dates;
- The activities that are currently under progress;
- The time (expressed in calendar days) required to complete each activity that is currently under progress;
- Current and anticipated problems and delaying factors, their effect on the construction schedule, and the proposed corrective actions; and
- Satisfactory evidence to substantiate the completion of such work that was reported as completed but is not apparent to be so to the Engineer.

The Report shall include information and data herein specified. The Engineer, if in his opinion it is necessary to track the progress and/or requirements of the Works, may at any time request the Contractor to include other additional information in the Report.

The Report shall consist basically of the information and data required in all the submittals ordered by each section of the Specifications and the Conditions of Contract, including but not being limited to the following:

- Mobilization, staking-out, photographs and video, etc.
- The Construction photographs and video recording, and other submittals made in the month.
- Drawings Schedule, monitoring of submittals, etc.
- The Programme, the Schedule, the Cash-Flow, etc.
- Safety, traffic control, temporary roads, traffic maintenance and protection, etc.
- Laboratory testing and results, quality control, materials control, etc.
- Environment aspects, etc.
- Aspects related to the Works, submittals, etc. for major items.

109.3 Specific Requirements for the Report

The following items shall specifically be included in the Report:

Quality Control Summary: prepared by the Contractor's Quality Control Manager including a summary of related activities performed in the month, addressing quality control problems, outstanding deficiencies, and shall include a summary of all quality control tests, and test results.

Safety Summary: prepared by the Contractor's Safety Officer including a summary of related activities performed in the month, addressing problems on safety, traffic and environmental control, other restraints and any accident.

Equipment Report: listing in tabular format all equipment on Site since the commencement of work up to the end of the report period, including those of the Contractor, subcontractors and suppliers. The tabulation shall identify the type, make, model, and capacity (if applicable) of equipment, and indicate the date the equipment arrived on site and the date the equipment left the Site. In addition, the listing shall note if the equipment is in operation or not operating. For any equipment not in operation during the report period, the Contractor shall note the period when the equipment was not in operation and the reason for such status.

Work Force Tabulation: listing in tabular format all staff mobilized on Site since the commencement of work up to the end of the report period, including those of the Contractor, subcontractors and suppliers. The listing shall include the names of all personnel, their company affiliation, their position, and nationality.

Updated Schedule and Cash-Flow: showing in the approved bar-chart format for the Schedule (CPM) the progress of the Works referring to the approved Schedule, and the progress of payments as per the updated Cash-Flow Curve ("S" curve), with an attached copy of the Summary Sheet of Payment Certificate corresponding to the Report.

109.4 Progress Photographs

It shall include sufficient number of digital progress photographs (approx. 20-40 photos) with required captions. He shall also supply the digital photograph data for all photographs by Compact Disc/s together with a record in a form acceptable to the Engineer which identifies the date, location and activity to which each photograph relates. These will serve as a permanent record of documentation for the Works.

The Contractor shall print digital photographs in suitable albums of good quality and supply the albums (1 set for the Client, 1 set for the Engineer) as required by the Engineer.

The digital data of the photographs shall be the property of the Employer and no prints from these may be supplied to any persons unless under the written authority of the Employer or the Engineer.

109.5 Video Compact Disks (VCD)

The Contractor shall take videos and supply two (2) No. copies of VCD of approx.30 minute's duration with suitable recorded commentary/subtitles taken by an approved experienced photographer before the start of the Works and at monthly intervals thereafter, all to the direction of the Engineer.

109.6 Measurement and Payment

The rate of the Monthly Progress Report shall include the digital photographs, obtaining colour prints, mounting and supplying albums and VCD.

Pay items	Unit of Measurement
109(1) Monthly Report incl. Photo, VCD	month

SECTION 110

GENERAL OBLIGATIONS

110.1 Fixed Charges for General Obligations

110.1.1 Description

1.1 General

The Contractor shall provide all necessary Insurances, Bonds, Professional Indemnity Insurance, Guarantees and Securities as are required and detailed in the Bid Documents, Conditions of Contract or this Specification.

1.2 Formation of Contract Agreement

All fees and charges, including stamp duty, associated with the preparation and formation of the Contract Agreement in accordance with Sub-Clause 9.1 of the Conditions of Contract.

1.3 Insurances ,Bonds and Securities

The Contractor shall provide all necessary Insurances, Bonds, Professional Indemnity Insurance, Guarantees and Securities as are required and detailed in the Bid Documents, Conditions of Contract or this Specification..

1.4 Scheduling Software

Three original copies of the latest version of the software like "MS Project", "SureTrak Project Manager" (a product of Primavera Systems, website www.Primavera.com) or equivalent. One copy will be retained by the Contractor, one copy will be issued to the Engineer, and one copy will be issued to the Employer. The Engineer's and Employer's copies will remain in their possession upon completion of the Contract.

1.5 Programme of Work

Provision of the programme of work in compliance with Sub-Clause 14.1 of the Conditions of Contract.

1) The programme of work (the "Programme") shall be prepared using the latest version of the scheduling software like "MS Project", "SureTrak Project Manager" or equivalent. In addition, in the case of linear works such as asphalt paving and the like, the Programme shall include "time-chainage" diagrams.
2) The Contractor shall maintain on Site the necessary computing, printing and plotting facilities together with suitably experienced staff to enable the Programme to be reviewed and updated daily and, where necessary, revised.
3) The Programme shall be structured to allow the Contractor and Engineer to appreciate the general progress of the Works, while also providing sufficient detail for the Contractor to control, and the Engineer to monitor, day-to-day progress.

4) The Programme shall clearly identify, at whatever level of detail necessary, the order of procedure of the Works and the interdependencies between the component parts of the Works.
5) The unit of time for the Programme shall be the day and it shall show all rest days and public holidays.
6) Each discrete activity shall be made up of tasks of sufficient detail to identify the individual resources needed for the task.
7) Where there are other contractors on Site, the Contractor shall ensure that his Programme is co-ordinated with their activities.
8) In addition to showing the starting dates, finishing dates, and the duration of activities, the Programme shall show or incorporate, amongst other things:

   (a) The dates by which the Contractor requires further information for design or construction, in accordance with the provisions of the Contract.
   (b) The dates by which the Contractor requires instructions from the Engineer to carry out work described in the Contract as Provisional Sums.
   (c) The dates by which Construction Drawings are to be submitted to the Engineer for approval, and the dates by which such approvals are required.
   (d) The dates by which Construction Drawings are to be submitted to statutory and other authorities for approval, and the dates by which such approvals are required.
   (e) The dates by which requests for approval of materials are to be submitted, and the dates by which such approvals are required.
   (f) The dates by which requests for approval of subcontractors are to be submitted, and the dates by which such approvals are required.
   (g) The dates and periods allowed for the design of important Temporary Works.
   (h) The quantities and productivities used to calculate the duration of all activities.
   (i) Resource histograms showing the daily and cumulative requirements for the major categories of labour, equipment and materials necessary to complete the Works in accordance with the Programme.
   (j) The cost to the Employer of each activity based upon the rates and prices in the Bill of Quantities.
   (k) In the case of a sequential requirement for possession of Site, the areas involved, the dates upon which possession will be required and the expected duration of such possession.
   (l) Those activities whose progress is likely to affect the activities of other contractors.
   (m) Those activities whose progress is dependent upon the progress achieved by other contractors.
   (n) Proper allowance for rain days and any consequent disruption to the Works.
   (o) Proper allowance for any increase in traffic over holiday periods.

9) The Contractor shall submit with the Programme a general description of the arrangements and methods which he proposes to adopt for the execution of the Works so that he complies, inter alia, with the following constraints:

   (a) Colombo- Rathnapura Road (AB010), maximum permissible traffic delay :
      (i) At any one work site = 10 minutes.
      (ii) Over the extent of all work in progress = 20 minutes.
   (b) Malabe- Kaduwela Road (B263), maximum permissible traffic delay :

(i) At any one work site = 10 minutes.
(ii) Over the extent of all work in progress = 15 minutes.

(c) Malabe- Athurugiriya Road (B214), maximum permissible traffic delay :
(i) At any one work site = 10 minutes.
(ii) Over the extent of all work in progress = 15 minutes

(d) Above roads:
(i) Protection, to the satisfaction of the Engineer, of any intermediate pavement layers over which traffic may pass.
(ii) No double lane working.

10) Two copies of the Programme, in both electronic and printed form, and two copies of associated method statements are to be submitted.

11) This version of the Programme, submitted under Sub-Clause 14.1 and consented by the Engineer shall be used as a "Baseline Programme". Any revised Programme shall be presented such that the Engineer can identify the departures from the Baseline Programme and the revised resources necessary to meet the demands of the revised Programme.

1.6 Property Condition Survey

Comply with the requirements of section 205

1.7 Utilities Survey

Comply with the requirements of Sub-Clause 8.3 of the Conditions of Contract.

1.8 Setting-out

Comply with the Specification and the requirements of Sub-Clause 17.2 of the Conditions of Contract.

1.9 Compliance with Statutes and Regulations

Comply with the requirements of Sub-Clause 26.1 of the Conditions of Contract.

1.10 Royalties

Comply with the requirements of Sub-Clause 28.2 of the Conditions of Contract.

1.11 Transport of Contractor's Equipment or Temporary Works

Comply with the requirements of Sub-Clause 30.2 of the Conditions of Contract.

1.12 Head Office Charges

Charges levied by the Contractor's head office to cover the cost of providing and maintaining that part of his head office facilities and staff pertinent to the Contract.

1.13 Site Office Charges

Charges not elsewhere covered arising from the provision and maintenance of the Contractor's Site office facilities.

1.14Clearance of Site on Completion

Comply with the requirements of Sub-Clause 33.1 of the Conditions of Contract

1.15 Charges not Otherwise Itemised

Comply with the requirements of the Contract where not otherwise itemised for payment.

110.1.2 Measurement and Payment

Payment shall be made on submission of the original Insurances, Bonds, Guarantees or Securities or proof of payment of the same, provided that the originals shall be made available to the Engineer within a reasonable time after proof of payment.

In all cases, certification will require that the Engineer is satisfied that the Contractor has properly discharged his obligations with respect to the relevant Clauses or Sub-Clauses of the Conditions of Contract. If it is the opinion of the Engineer that this is not the case, then he may delete the item from any payment certificate.

Pay Item	Description	Pay Unit
110.1(1)	Formation of contract agreement	l.s.
110.1(2)	Performance security	l.s.
110.1(3)	Bank Guarantee for advance payment	l.s.
110.1(4)	Professional Indemnity Insurance for Contractor's Alternative Design for bridges (if applicable)	l.s.
110.1(5)	Scheduling software	l.s.
110.1(6)	Programme of work	l.s.
110.1(7)	Utilities survey	l.s.
110.1(8)	Property condition survey	km
110.1(9)	Clearance of site on completion	l.s.

Payment of the above sums will be certified when the Engineer is satisfied that the Contractor has properly discharged his obligations under the Contract.

Pay Item	Description	Pay Unit
110.1(10)	Setting-out	l.s.
110.1(11)	Compliance with statutes and regulations	l.s.
110.1(12)	Royalties	l.s.

110.1(13)	Transport of Contractor's Equipment of Temporary Works	l.s.
110.1(14)	Head office charges	l.s.
110.1(15)	Site office charges	l.s.

Payment of the above sums will be certified thus :

(a) One third when the value of measured work in the Interim Payment Certificates reaches 30 percent of the amount stated in the Letter of Acceptance.

(b) One third when the value of measured work in the Interim Payment Certificates reaches 60 per cent of the amount stated in the Letter of Acceptance.

(c) The final third on the issue of the Taking-Over Certificate for the whole of the Works.

Pay Item	Description	Pay Unit
110.1(16)	Charges not otherwise itemised	l.s.

One half of the above sum shall be certified for payment when the Engineer is satisfied that the Contractor has demonstrated his ability to discharge his contractual obligations properly. The remaining half of the sum shall be certified for payment once the Taking-Over Certificate for the whole of the Works has been issued.

110.2 TIME-RELATED CHARGES FOR GENERAL OBLIGATIONS

110.2.1 Description

1.1 Scheduling Software

The Contractor shall provide original software program of SureTrak Project Manager to three parties, that is, the Employer, the Engineer and the Contractor. The Engineer's and Employer's programs will remain as their property upon completion of the Contract.

1.2 Revision and Updating of Programme

Comply with the requirements of Sub-Clause 14.2 of the Conditions of Contract which shall include, inter alia :

1) Updating the Programme daily, incorporating all progress and other relevant information known to date.
2) Identifying any problems with regard to adhering to the Programme and determining measures necessary to resolve them.
3) Revising the Programme as instructed by the Engineer in accordance with Sub-Clause 14.2.
4) Providing such supplementary information requested by the Engineer as will enable the Engineer to satisfy himself that the Programme, or any revision thereof, complies with the requirements of the Contract. If the Engineer is not so satisfied then, on receipt of the Engineer's observations, making the modifications necessary to achieve compliance.
5) Once per month, and one week before the monthly progress meeting, submitting to the Engineer two copies of the updated Programme together with two copies of all relevant supporting documentation.
6) Certification will require that the Engineer is satisfied that the Programme in current use accurately reflects the progress of the Works and the timing, sequence and resources needed to complete the Work within the Time for Completion. If it is the opinion of the Engineer that the Programme has not been maintained in such a manner as to allow for the proper control and monitoring of the Works he may delete this item from any payment certificate.

1.3 Cash Flow Estimates

Comply with the requirements of Sub-Clause 14.3 of the Conditions of Contract, which shall include, inter alia :

1) Cash flow estimates shall be submitted at the beginning of each quarter and shall comprise :

   (a) A forecast of the projected value of the Contractor's Monthly Statements for each quarter of each year of the remaining period of the Contract.
   (b) A cumulative "S-curve" of forecast income based on the above projections.

2) The cash flow estimates shall be derived from the Programme through the facility offered by the software to generate cash flow forecasts.

3) Certification will require that the Engineer is satisfied that the cash flow estimate is based upon the Programme in current use, which in turn accurately reflects the progress of the Works and the timing, sequence and resources needed to complete the Works within the Time for Completion. If it is the opinion of the Engineer that this in not the case, he may delete this item from any payment certificate.

1.4 Project Diary

The Contractor shall keep daily record of all significant items relating to the Project and submit it to the Engineer daily (probably by e-mail) in accordance with their Quality assurance plan. The contents are only for information and do not constitute the official documents unless confirmed by writing reasonably later. The required items will be:

- Weather,
- Orders given to the Contractor,
- Important discussions with the Engineer or representative, such as disputes,
- Official visitors and inspections,
- Work or materials rejected and reasons,
- Time of shutting down or resuming work and explanations,
- Work done by the Contractor's forces during the day,
- General purpose of work,
- Account of any time spent by the Contractor's personnel or equipment on disputable items or work,
- Length and cause of any delay,
- Arrival and departure of major equipment and work forces,
- Unusual conditions, if any, such as high water, bridge failures, slides, etc.
- Progress of stakeouts and surveys made,
- When appropriate, daily surveillance of traffic control and its' effectiveness.

1.5 Contractor's Superintendence

Comply with the requirements of Sub-Clause 15.1 of the Conditions of Contract.

1.6 Contractor's Employees

Comply with the requirements of Sub-Clause 16.1 of the Conditions of Contract.

1.7 Care of the Works

Comply with the requirements of Clause 20 of the Conditions of Contract. The general obligations of the Contractor shall include, inter alia, the following :

1) The provision of temporary drainage works such as drains, open channels, banks etc. and the

furnishing and operation of temporary pumps and such other equipment as may be necessary to drain, protect and dewater the Works, and any Temporary Works, adequately. This will be in addition to any permanent drainage works specified and installed, and in addition to any temporary drainage works specifically paid for separately.

2) Care shall be exercised not to allow material in borrow pits to become excessively wet, to keep all completed layers properly drained, to avoid dumps of material on completed layer work that shall inhibit surface drainage or form wet spots under and around dumps, and to protect all parts of the Works against erosion by floods and rain.

3) Material shall not be spread on a layer that is so wet that damage could be caused to the layer during compaction of a subsequent layer when the road is open to traffic.

4) When material is spread out on the road it shall, during wet periods, be given a good cross fall and a light compaction on the surface with a steel-wheeled roller, in order to facilitate run-off during rainy weather.

5) Fill and cut slopes shall be promptly repaired whenever damaged by surface water.

6) Excavations for pipe drains, culverts, service ducts and similar structures shall be adequately protected against possible ingress of water during rainstorms.

7) All completed layer work shall be protected and maintained until the following layer is applied. Maintenance shall include immediate repair of any damage or defects which may occur and shall be repeated as often as necessary to keep the layer intact and in good condition.

8) Before any completed layer is primed or a following layer is constructed thereon, any damage to the existing layer shall be repaired in a manner approved by the Engineer, so that after repair, or reconstruction if necessary, it will conform in all respects to the requirements specified for that layer. All repair work shall be submitted to the Engineer for inspection before covering up.

9) The Contractor shall inform the Engineer of damage or defects to any work before repair or maintenance and the Engineer shall instruct the extent and method of repair. The previously constructed layer shall be thoroughly cleaned of all foreign material and the Contractor shall request its inspection by the Engineer before construction of the following layer or application of a prime coat, surfacing or surface treatment. In the case of all bituminous work in particular the existing layer shall be thoroughly broomed and all dung, clay, and other deleterious material completely removed. Where necessary, the surface shall be sprayed with water before, during and after brooming to remove all foreign material.

1.8 Insurance of the Works

Comply with the requirements of Clauses 21 and 25 of the Conditions of Contract.

1.9 Insurance of Contractor's Equipment

Comply with the requirements of Clauses 21 and 25 of the Conditions of Contract.

1.10 Third Party Insurance

Comply with the requirements of Clauses 23 and 25 of the Conditions of Contract.

1.11 Workmen's Accident Insurance

Comply with the requirements of Clauses 24 and 25 of the Conditions of Contract.

1.12 Avoidance of damage to existing roads

Comply with the requirements of Sub-Clause 30.1 of the Conditions of Contract, which shall include, inter alia, complying with the following maximum permissible gross vehicle weight limitations, as promulgated in Gazette of the Democratic Socialist Republic of Sri Lanka - 1983.06.03 :

(a) No motor vehicle with a 4-wheeled rear axle shall exceed 15,275 kg gross vehicle weight.
(b) No motor vehicle with an 8-wheeled dual rear axle shall exceed 20,000 kg gross vehicle weight.
(c) No articulated or combination vehicle with a 4-wheeled rear axle driving unit and a 4-wheeled axle for the trailer shall exceed 21,000 kg gross vehicle weight.
(d) No articulated or combination vehicle having a lesser number of wheels than (c) above shall exceed 16,500 kg gross vehicle weight.
(e) No articulated or combination vehicle with an 8-wheeled dual axle driving unit and a 4-wheeled axle for the trailer shall exceed 26,500 kg gross vehicle weight.
(f) No articulated or combination vehicle with a 2-wheeled front axle and 4-wheeled rear axle driving unit and a dual axle 8-wheeled trailer shall exceed 27,500 kg gross vehicle weight.
(g) No articulated or combination vehicle with a 2-wheeled front axle and 8-wheeled dual rear axle driving unit and an 8-wheeled dual axle trailer shall exceed 30,500 kg gross vehicle weight.

The above maximum permissible gross vehicle weight limits shall apply to roads categorised by the Employer as Class A and Class B. On all other roads the maximum permissible gross vehicle weight shall be 5,000 kilograms.

If the Contractor wishes to conduct haulage operations on roads other than Class A and B roads, which operations will result in exceeding the specified gross vehicle weight limit of 5,000 kilograms for such roads, he may do so only if :

(i) he has the written permission of the authority responsible for maintaining the road, and
(ii) he has undertaken in writing to maintain and repair the road at his own expense and to the satisfaction of the authority responsible for maintaining the road during his haulage operations, and

(iii) he has undertaken in writing to restore the road at his own expense to its original condition immediately his haulage operations are complete.

1.13 Coordination with Utilities Agencies

The Contractor shall be responsible for dealing with all matters regarding utilities on Site. Where a utility will affect the Works, or be affected by the Works, the Contractor shall be responsible for coordinating with the relevant utility agency to agree and implement all necessary measures for the removal, protection, support, relocation and/or reinstatement, as the case may be, of the utility concerned such that the Works may proceed without hindrance or delay.

Delay of the relocation work beyond the Contractor's responsibility shall be considered as causes of extension of completion time.

1.14 Protection of Utilities

The Contractor shall be responsible for undertaking all necessary utilities removal, protection, support, relocation and reinstatement work himself, the cost of which shall be deemed to be covered by this item. The only exception to this shall be where, with the agreement of the Employer, the responsible utility agency elects to undertake the work, in which case the Employer shall reimburse the utility agency. In such cases, the Contractor may be directed by the Engineer to provide assistance to the utility agency, payment for which shall be made at the applicable rates and prices in the Contract.

Any pipe, cable, conduit or other utility of any nature whatsoever, including underground utilities irrespective of the depth at which they are situated, damaged as a result of the Contractor's operations shall be repaired and reinstated forthwith by the Contractor or by the utility agency concerned, all at the expense of the Contractor and to the satisfaction of the Engineer. The Employer will not be held liable for any delay in completion of the Works which may occur due to damage occurring to utilities in consequence of the Contractor's operations.

1.15 Head Office Charges

Charges levied by the Contractor's head office to cover the cost of providing and maintaining that part of his head office facilities and staff pertinent to the Contract.

1.16 Site Office Charges

Charges not elsewhere covered arising from the provision and maintenance of the Contractor's Site office facilities.

1.17 Charges not otherwise itemised

Comply with the requirements of the Contract where not otherwise itemised for payment.

110.2.1 Payment

Pay Item	Description	Pay Unit
110.2(1)	Scheduling software	l.s.
110.2(2)	Revisions and updating of programme	l.s.
110.2(3)	Cash flow estimates	l.s.
110.2(4)	Project diary	mth
110.2(5)	Contractor's superintendence	l.s.
110.2(6)	Contractor's employees	l.s.
110.2(7)	Coordination with utilities agencies	l.s.
110.2(8)	Professional indemnity insurance	l.s.
110.2(9)	Insurance of the works	l.s.
110.2(10)	Insurance of Contractor's equipment	l.s.
110.2(11)	Third party insurance	l.s.
110.2(12)	Workmen's accident insurance	l.s.
110.2(13)	Head office charges	l.s.
110.2(14)	Site office charges	l.s.
110.2(15)	Charges not otherwise itemised	l.s.

Payment of the above items shall be made on monthly basis in proportion to total months indicated in the Appendix to Tender.

If the Engineer considers the actual completion of each work is different from the total months, he shall calculate the payment in proportion to the actual completion months. Then he shall adjust any previously certified amounts to reflect the recalculation.

The Engineer shall confirm that the Contractor has properly discharged his obligations with respect to the relevant Clause or Sub-Clause of the Conditions of Contract. If the Engineer considers his performance is insufficient, he shall deduct the relevant amount from his certificate.

SECTION 111

CHECK SURVEY

111.1 Description

The Contractor shall, prior to the commencement of any work on Site, carry out a check of the co-ordinates and levels of all permanent ground markers and permanent benchmarks described in the Contract, and provide the results to the Engineer with their position and level in order that they may be checked and revised if necessary.

The Contractor shall provide adequate protection to all permanent ground markers and benchmarks in the site during the contract period.

The Contractor shall identify and bring to the attention of the Engineer any markers (including those of Right of Way (ROW)) that are missing. The missing markers shall be re-instated by the Contractor as per the information provided by the Engineer.

In addition to the above, the Contractor shall, within 28 days of commencing work at any particular location which relates to coordinate on existing roads, carry out detailed surveys and provide the results to the Engineer in order that the designs may be checked and revised if necessary.

111.2 Measurement and Payment

No separate measurement and payment will be made for this work which is deemed to be included in the other items of the Bill of Quantities.

SECTION 112

PROGRAMME OF WORK

112.1 Description

The Contractor shall review, update and submit the programme of work with Monthly Progress Report in accordance with Sub-Clause 14.1 of the Conditions of Contract. The progress of land acquisition and resettlement by the Employer shall be incorporated in the programme.

(a) The programme of work (the "Programme") shall be prepared using the scheduling software Microsoft Project 2000 or other similar software approved by the Engineer. Notwithstanding the above, the software must be capable of fulfilling the requirements described below. The Contractor's programmes shall be submitted with the soft copies to the Engineer from time to time. In addition, in the case of linear works such as asphalt paving and the like, the Programme shall include "time-chainage" diagrams.

(b) The Contractor shall maintain on Site the necessary computing, printing and plotting facilities together with suitably experienced staff to enable the Programme to be reviewed and updated daily and, where necessary, revised.

(c) The Programme shall be structured to allow the Contractor and Engineer to appreciate the general progress of the Works, while also providing sufficient detail for the Contractor to control, and the Engineer to monitor, day-to-day progress against scheduled progress.

(d) The Programme shall be continually updated by the Contractor to include actual progress of the Works.

(e) The Programme shall clearly identify, at whatever level of detail necessary, the order of precedence of the Works, the interdependencies between the component parts of the Works and the critical path.

(f) The unit of time for the Programme shall be the day and it shall show all rest days and public holidays.

(g) Each discrete activity shall be made up of tasks of sufficient detail to identify the individual resources needed for the task.

(h) Where there are other contractors on Site, the Contractor shall ensure that his Programme is coordinated with their activities.

(i) In addition to showing the starting dates, finishing dates, and the duration of activities, the Programme shall show or incorporate, amongst other things:

- The dates and periods allowed for the design of important Temporary Works.
- The quantities and productivities used to calculate the duration of all activities.
- Resource histograms showing the daily and cumulative requirements for the major categories of labour, equipment and materials necessary to complete the Works in accordance with the Programme.

- The cost to the Employer of each activity based upon the rates and prices in the Bill of Quantities.
- In the case of a sequential requirement for possession of Site, the areas involved, the dates upon which possession will be required and the expected duration of such possession. The requirements shall not conflict with the land acquisition programme of the Employer.
- Those activities whose progress is likely to affect the activities of other contractors.
- Those activities whose progress is dependent upon the progress achieved by other contractors.
- Proper allowance for rainy days and any consequent disruption to the Works.
- Proper allowance for any increase in traffic over holiday periods".

(j) Two copies of the Programme, in both electronic and printed form, and two copies of associated method statements are to be submitted.

(k) This version of the Programme, submitted under Sub-Clause 14.1 and after the Engineer's consent to its use is issued, shall be used as a "Baseline Programme". Any revised Programme shall be presented such that the Engineer can identify the departures from the Baseline Programme and the revised resources necessary to meet the demands of the revised Programme.

112.2 Measurement and Payment.

No separate measurement and payment will be made because it is included in Monthly Progress Report (Item 109 (1)). If the Engineer considers the contractor's workmanship of the Programme is insufficient, he may delete the payment from the pay item. For the payment, it will require that the Engineer is satisfied that the Contractor has properly discharged his obligations with respect to the relevant Clauses or Sub-Clause of the Conditions of Contract.

SECTION 113

CONTRACTOR'S DRAWINGS

113.1 Description

The Contractor shall prepare all working drawings that detail required works not included in the Tender Drawings or requested by the Engineer and shall obtain approval from the Engineer. The Contract price includes the cost of furnishing all working drawings.

Requirements and Responsibility of the design are summarized as follows:

Table 113-1 Requirements and Responsibility of Design (Summary)

Description	The Contractor's design responsibility	The Engineer's design responsibility
(1) Highway parts (incl. drainage & soft ground treatment)	**Working drawings** to be prepared.	Detailed Design (**D/D**) prepared in Tender doc.
Additional soil investigation for soft ground	The Contractor is responsible for the planning, execution and reporting of the investigation.	The Engineer shall approve the Contractor's proposal and assist the analysis.
(2) Structural parts Additional soil investigation for foundations	The Contractor is responsible for the planning, execution and reporting of the investigation.	The Engineer shall approve the Contractor's proposal and assist the analysis.
Box culverts & retaining walls	**Working drawings** to be prepared.	**D/D** prepared in Tender doc.
Steel bridges in A1 interchange	**D/D & Working drawings** to be prepared.	Basic Design (**B/D**) prepared in Tender doc.
Concrete bridges in Biyagama	**D/D & Working drawings** to be prepared.	**B/D** prepared in Tender doc.
Kelani River Bridge & Overpass	**Working drawings** to be prepared.	**D/D** prepared in Tender doc.

The Engineer's General Arrangement (GA) drawings of the structures are included in above B/D and D/D, however the Contractor's first step will be preparation and finalisation of the GA drawings based on the additional soil investigations.

Design of permanent works by the Contractor is detailed in Section 120, Design by the Contractor.

This section is to supplement the requirements stated in Sub-Clause 7.2 of the Conditions of Contract, and other relevant clauses related to the submittals by the Contractor.

The drawings that shall be prepared and submitted by the Contractor (hereafter referred as "the Contractor's Drawings") are the following:

(a) Shop Drawings: Drawings prepared by mainly manufacturers to manufacture the products.

(b) Working Drawings: Drawings which have enough detail on them for the Contractor to build the work correctly and for the site dimensions to be true to the drawings. Temporary work drawings are also included.

(c) Other Drawings: These are the drawings and supplemental documents prepared to complement the submitted Shop Drawings or Working Drawings.

(d) Construction Drawings: This is a term used to refer to a complete set of the Shop Drawings, Working Drawings and Other Drawings submitted by the Contractor and already reviewed and approved by the Engineer for their use in the Project, that shall be available at the Site at all times.

(e) As-Built-Drawings: These are the drawings prepared to show in detail all the works actually constructed.

113.2 Requirements

2.1 General

The requirements herein established shall supplement, without detriment to, the requirements and provisions stated in Clause 6 of the General Conditions of Contract for "the Drawings".

Based on the Drawings supplied to the Contractor as stated in Sub-Clause 6.1 "Custody and Supply of Drawings and Documents" of the Conditions of Contract, the Contractor shall prepare all drawings required for the execution of the Works as specified herein.

The Contractor shall be responsible for the following:

- Confirmation and correlation of all incorporated information;
- Accuracy of all dimensions and quantities;
- Information pertaining to the fabrication process and construction method;
- Handling and conservation of all the drawings in good condition during the execution of the work;
- Delays in the submittals; and
- Shop Drawings or Working Drawings prepared by subcontractors, manufacturers, suppliers or distributors, which shall be submitted to the Engineer only by the Contractor.

The Contractor shall provide all the necessary information to substantiate that all materials and/or plants incorporated into the Works, conform to and meet or exceed the requirements of the Specifications and/or the Drawings.

Temporary works

The Contractor shall provide all necessary and/or required drawings, calculations and certifications for all temporary works, which are required or described in the Specifications. He shall obtain "No objection" stamp from the Engineer.

Coordination

The Contractor shall provide followings for his design and drawing preparations at the site office and/or sub-consultant's office:

- Required engineering staff (highways and structures as major categories),
- CAD operators,
- Quantity surveyors,
- Required computers, printers (incl. A-1 size), scanners and other peripherals,
- Required computer design software,
- Reference drawings, books and various design standards (Sri Lanka, BS, AASHTO, Japanese).

About above resources, the Contractor shall submit the proposal and obtain approval from the Engineer, in particular following issues:

- The Contractor's engineers' requirement, experience and organisation (key engineers' CV to be approved),
- Applicable design criteria, design standards and computer software,
- Drawing preparation schedule,
- Submission, revision and those recording system,
- Checking of design calculations, quantities and costs for alternative contractor's designs (Soft ground treatment, steel bridges and concrete bridges).

If additional submittals are required by actions of the Contractor, any delays shall be the Contractor's responsibility.

Failure of the Contractor to comply with the requirements of this Specification Section shall be considered as a serious default of the Contractor in meeting his contractual obligations, resulting in a delay in work progress. In this case, the Engineer shall withhold the relevant payments until the requirements are satisfactorily met and measures to recover the delays are effectively applied by the Contractor and approved by the Engineer.

Unless otherwise specified by the Engineer in accordance with Sub-Clause 6.4 "Delays and Cost of Delay of Drawings" of the Conditions of Contract, the Engineer shall review the Contractor's documents within 21 days from the date on which the Engineer receives them.

If the Engineer finds that the Contractor's document fails to comply with the Specification, he shall give notice to the Contractor (the extent to be stated) within the 21 days. If the Contractor's document so fails to comply, the Contractor shall review, rectify and resubmit with this Sub-Clause, at the Contractor's cost.

As far as above procedure is followed, all time required for review and approval by the Engineer shall not be the basis for any claim, neither for a time extension nor for monetary adjustment.

2.2 Requirements for the Contractor's Drawing Preparation

(a) Contractor's Drawings shall be generally prepared on A-3 paper size (A-1 size as exceptions) and using Auto-CAD 2006 (or latest) in a sheet format previously approved by the Engineer.

(b) Notes shall be written in English.

(c) All dimensions shall be in the metric system.

(d) The Contractor's Drawings shall be stamped "Submitted for Approval for Construction" and shall be signed by the Contractor's responsible engineers.

(e) Unless otherwise instructed by the Engineer, the basic format of the Contractor's Drawings shall be as follows: (refer to Figures 1 and 2)

- There shall be a 3.0 cm margin on the left side of the sheet and a 2.0 cm margin on the other three sides.
- A blank space, 10 cm long and 5 cm wide, shall be left near the lower right-hand corner, for the Engineer's review stamp and comments.
- There shall be a title block, at least 5 cm long and 5 cm wide, in the lower right-hand corner of each sheet. The title block shall show the project number, structure number, the location of the structure, and the contents of the sheet, designer/engineer, sheet number, and revision number.

(f) Design notes, calculations, lists, testing results, reports, descriptions, catalogue cuts, and other non-drawing submittals shall be submitted on A4 size sheets, in lieu of the size mentioned above.

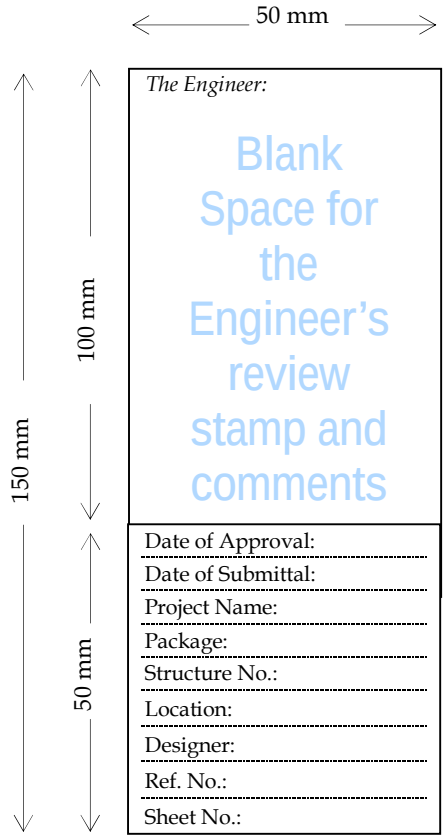
(g) Unless otherwise specified, each submittal of the Contractor's Drawings shall consist of three copies and shall be submitted to the Engineer, one set of which will be returned to the Contractor with revisions, if needed, noted thereon.

(h) Editable electronic files, in the approved application form for the Project, of the Contractor's Drawings subjected to the Engineer's approval shall be provided to the Engineer after issuance of the respective approval.

(i) Submittals without the required signatures and seal will not be accepted and will be returned to the Contractor without action.

Format of the Contractor's Drawings

FIGURE 1



Detail for Blank Space for the Engineer's Review Stamp

FIGURE 2

2.3 Requirements for the Basic Contents of the Contractor's Drawings

(a) Shop Drawings

The Shop Drawings are usually required for manufacturing the products including:

- Bridge expansion joints and shoes,
- Lighting bulbs and poles.

(b) Working Drawings

These shall include, but not be limited to, the following:

- Drawings necessary for preliminary works, such as accommodation, office and laboratory buildings, site and plant layout.
- Cross sections (20 m intervals, will be given to the Contractor).
- Various utility drawings (electricity, telephone and water),
- Temporary access roads (incl. detours) and drainage plans,
- Soft ground treatment details after additional soil investigations, including settlement's monitoring installations, their cross sections, embankment surcharge and trial area details,
- Drainage details incl. ground survey results, inlet and outlet invert levels and grade,
- Bridge foundation and pile details after additional soil investigation,
- Structural steelwork details,
- Detailed reinforcement and bar bending schedules,
- Various facility details,
- Temporary works including formwork, scaffolding and cofferdams,
- Method of construction,
- All drawings, diagrams, illustrations, samples, schedules, testing results, calculations, and other data that are necessary to obtain the Engineer's approval on the drawings.

(c) Other Drawings

The basic requirements defined above for the Shop Drawings and Working Drawings shall apply also to the Other Drawings.

(d) Construction Drawings

The Contractor shall note on the Construction Drawings all changes and deviations from the works shown in the Drawings and the Specifications, and the respective Shop Drawings, Working Drawings, and Other Drawings.

These drawings shall be kept current, as the Works progress and notations shall be made within seven (7) days of the change or deviation.
Upon completion of the Works the complete set of the Construction Drawings shall be stamped "As-Constructed" and signed by the Contractor and shall be so arranged to be used as the base for preparation of the As-Built Drawings.

2.4 Requirements for Submittal

(a) Submittal Schedule

The Submittal Schedule shall be prepared in close relation, and showing solid consistence, with the "Programme to be submitted" specified in Sub-Clause 14.1 of the Conditions of Contract (hereafter referred as "the Programme").

Incorporating in the Programme, the Contractor shall prepare and submit to the Engineer for review and approval, a Submittal Schedule, noting all required information and data required for the Contractor's Drawings to be submitted to the Engineer.

The Submittal Schedule shall be used as the document for monitoring the submittals, and to register the approvals, throughout the period of the Contract.

The Submittal Schedule shall include, but not be limited to, the following:

- A list of the Contractor's Drawings to be submitted in accordance with the main items of the Programme. The captioned list shall be classified by type of drawing (i.e. Shop Drawings, Working Drawings, Other Drawings or As-Built Drawings);
- A bar schedule of the main submittals showing the main work items of the Critical Path as the milestone of each submittal; and
- A list and schedule of the main tests for materials and trials to be subject to approval by the Engineer for the main work items. This list shall include also the submittals of certifications from the suppliers.

(b) Register of Submittals

The register of each submittal shall content the following:

- A description of each submittal and its contents including applicable specification identification;
- Statement if the submittal is for information, or to receive the Engineer's consent or approval;
- The dates of the submittal: Date of submittal to the Engineer and the expected date for return of the submittal;
- In the event that a re-submittal is required, besides the new dates, it shall content the status of the returned submittal (i.e. approved as noted, the comments, or rejected); and
- In the event that a deviation regarding the requirements shown in the Drawings and the Specifications is detected, it shall be clearly stated by the Contractor in the respective submittal.

The Submittal Schedule shall be updated monthly or when required by the Engineer or the Contractor.

The Contractor shall include in his Monthly Progress Report, a summary describing the existing

condition and the progress of his Submittal Schedule.

2.5 Requirements and Procedure for Approval

Submittals of the Contractor's Drawings shall be made according to the priority and approved Submittal Schedule.

1) Design of permanent works by the Employer

Both the Engineer and the Employer shall be responsible for the design. The Contractor shall basically follow the design in consideration of latest site conditions and additional soil investigations.

2) Design of permanent and temporary works by the Contractor:

The drawings shall include all necessary information to allow a verification of conformity with the requirements of the Contract, the Drawings and the Specifications.

Upon receipt of a submittal package by the Engineer, it will be evaluated for completeness and the Contractor will be notified of any deficiencies therein.

The Engineer will review the submitted drawings to determine that general conformity with the design concept and general compliance with the information given in the Drawings and the Specifications have been achieved.

3) Notification of Differing Site Conditions by the Contractor

The Contractor shall notify the Engineer of changes to the Contract resulting from "differing site conditions", extra work, altered work beyond the original Contract or the Employer's actions that change the Contract terms and conditions.

Failure to provide required notice under this Clause constitutes a waiver for any claim resulting from the alleged change.

4) Definition of "Differing Site Conditions"

Subsurface or latent physical conditions at the site that:

(1) Differ materially from those indicated in the Contract.
(2) Differ materially from conditions normally encountered or from those conditions generally recognised as inherent in the nature of the work required.
(3) Present unknown or unusual physical conditions.

5) The Engineer's Response to the Contractor's Notice

The Engineer will provide a written response within 10 calendar days of receiving the notice to:
(1) Confirm the change and, when necessary, direct how the work will proceed, or

(2) Deny any changes and direct how the work will proceed, or

(3) Advise that there is not enough information to decide whether (1) or (2) applies and indicate what additional information is necessary for further review and the date by which it must be received. The Engineer will respond to additional information within 10 calendar days of receipt.

Any Contract adjustments will exclude increased costs or time extensions resulting from the Contractor's failure to provide the requested information.

6) Approval

After review, the Engineer will return one set of submitted drawings to the Contractor. Returned drawings will be stamped with the Engineer's review stamp to indicate the following:

Approved:	The submitted Contractor's Drawings have been reviewed, approved and do not require re-submittal.
Approved as Noted:	The submitted Contractor's Drawings have been reviewed and the Contractor shall incorporate the comments as noted in the drawings. The reviewed Contractor's Drawings do not require re-submittal.
Reviewed and Resubmit:	The submitted Contractor's Drawings require correction or redrawing and shall be resubmitted for review. If the submitted drawings are returned for correction or redrawing, corrections shall be made and the Contractor shall resubmit them in the same manner as the first Submittal. Specific notation shall be made on the resubmitted drawings to indicate the revisions made.
No objection to the design	All drawings for temporary works will be stamped as "No objection to the design".

The Contractor's Drawings that have been evaluated by the Engineer as "Approved as Noted" shall be registered for the update of the Submittals' Schedule and shall form a part of the Construction Drawings that shall be available at the Site at all times.

2.6 Particular Requirements for the As-Built-Drawings

The requirement for completion of the Construction Drawings shall first be satisfied by the Contractor, and approved by the Engineer.

Based on the above condition, the Contractor shall prepare in consultation with the Engineer, the final format to be used for preparation of the As-Built Drawings.

The Contractor shall initially submit 1 set of the As-Built drawings to the Engineer for review, comment and approval.

After all corrections or comments as required by the Engineer have been addressed, and the As-Built Drawings have been approved, the Contractor shall submit to the Engineer the following:

- 5 sets of photo copies with binding, and
- One (1) computer disk copy containing the electronic files of all drawings in an editable version by the approved application for the Project.

2.7 Drawing Copyrights

The rights for using, copying or reproducing, partly or entirely, all or any of the drawings prepared by the Contractor as herein specified, are reserved and belong to the Employer at any time or in any situation.

113.3 Measurement

All the costs related to the preparation, submittals and review of the Contractor's Drawings shall not be measured but paid as a lump sum.

113.4 Payment

(a) Payment shall include all costs necessary and required for the proper preparation of the Contractors' drawings fully in accordance with the requirements of this Specification Section, including all submittals, revision and re-submittals, materials, edition and reproduction, labor, and any other incidental cost.

(b) Payments shall be made in the following three instalments:

- 20% (twenty percent) upon the issuance of the Engineer's approval to the submitted Submittals' Schedule, and to the mobilization of the Contractor's staff and equipment for drawings preparation;
- 65% (sixty five percent) over the duration of the Contract Construction Period split in partial payments in proportion to this work progress, upon the Engineer's approval certifying the compliance on the requirements of this Specification Section by the Contractor, and
- 15% (fifteen percent) upon the issuance of the Engineer's approval certifying that all the requirements of this Specification Section including As-built drawings have been satisfactorily completed.

(c) The Engineer may at any time withhold payments if in the opinion of the Engineer, the contractor fails to prepare and submit the required drawings to the Engineer in time.

Pay Items		Unit of Measurement
113 (1)	Contractor's Drawings	lump sum.

SECTION 114

SAFETY, SECURITY AND PROTECTION OF THE ENVIRONMENT

114.1 Description

1) Laws, Rules and Regulations to be Observed

The Contractor shall observe and comply with the following:

- Sri Lankan laws and Safety and Health Regulations,
- Local laws and ordinances and
- Regulations, orders and decrees of bodies or tribunals having any jurisdiction or authority.

The Contractor shall protect and indemnify the Employer and its representatives against claims or liability originating from violating any of the above items by the following companies or employees of the following companies:

- The Contractor,
- Sub-contractors at any levels,
- Suppliers of materials or services,
- Any others engaged by the Contractor.

The Contractor shall ensure that no Contractor or Sub-contractors employee is required to work in or under conditions that are unsatisfactory, hazardous, or dangerous to health or safety.

2) Cooperation and Duties of Three Parties

All the members of the Client, the Engineer and the Contractor shall cooperate and coordinate for the safety and health in the construction.

A summary of the duties of the three parties and how they are applied is given in the following Table 114.1.

Table 114.1 Duties of Three Parties on Construction Safety

Contractor's duties	Designer's and Consultant's duties	Client's duties
General duties 1. Plan, manage and monitor the construction safety in liaison with sub-contractors. 2. Prepare, develop and implement a written plan and site rules. (Initial plan completed before the construction phase begins.) 3. Give sub-contractors relevant parts of the plan. 4. Make sure suitable welfare facilities are provided from the start and maintained throughout the construction phase. 5. Take reasonable steps to prevent unauthorised access to the site. 6. Prepare and enforce any necessary site rules. 7. Liaise with the Consultant on design (incl. temporary works) carried out during the construction phase. 8. Report to the Consultant with any information relevant to the health and safety incidents. 9. Provide all the workers with suitable health and safety instruction and information. 10. Consult with the workers on health and safety on site. 11. Train own employees regularly and secure the site.	During the design: 1. Avoid foreseeable risks in the construction and eliminate hazards. (Designers are not expected to consider or address risks which cannot be foreseen, and do not require zero risk designs because this is simply impossible.) 2. Designers must not produce designs that cannot be constructed, maintained and used in reasonable safety. 3. Provide adequate information about any significant risks associated with the design. During supervision 1. Ensure that the Contractor is given the sufficient time to prepare safety plan before start of the site works. 2. Monitor whether the construction phase is properly planned, managed and monitored, with adequately resourced competent site management appropriate to the risk and activity. 3. Instruct the Contractor to improve the work if any deficiency was found. 4. Ensure that all sub-contractors are provided with the safety information to carry out their works safely.	1. Check competence and resources of the Contractors and the Consultants. 2. Allow sufficient time for each stage of the project, such as F/S, D/D and construction. 3. Coordinate with residents who may be affected by the project. 4. Coordinate with utility agencies, such as electricity, telephone, water and sewage. 5. Ensure there are suitable management arrangements to ensure the construction work can be carried out safely and without risk to health. (This does not mean managing the work themselves.) 6. Check the contractors have made arrangements for suitable welfare facilities. 7. Check any fixed workplaces (e.g. offices, accommodation, plants, and workshops) will comply with local regulations. 8. Provide pre-construction information to the consultants and the contractors.
Specific Duties 12. Use only licensed operators for heavy equipment (cranes, welding, plant operation etc.) 13. Provide safety equipment and warnings for workers, such as ● Helmets, ● Safety harness, ● Safety shoes, 14. Working at height ● Adequate scaffolds with fences and ladders, 15. Working over or near to water, e.g. bridge work,		

● Buoyancy aids, 16. Lifting operations by cranes ● Use licensed operators and trained workers for lifting, ● Provide movable fence around the working space, ● Avoid unstable loadings and kinked wire ropes, ● Use hook with spring-loaded safety catch, ● Provide warning sign near electric cables, 17. Provide rigid fence at openings and pond areas (prevent from drowning), 18. Provide sufficient lighting facilities during night works. 19. Working in and around excavations ● Provide sufficient soil supports designed by a competent person. 20. Provide guide men near heavy equipment working places. 21. Explosives: prevent injury by flying material. 22. Take care during maintenance of plant and equipment. 23. Take care for natural disaster, like landslides. 24. Provide various warning signs for safety. 25. Provide various safety notifications.		

3) High Risk Activities

The Contractor shall plan, manage and monitor construction work carried out by him or under his control to ensure that it is carried out without risks to safety, security and environment. The high risk activities involve:

(1) Transport and removal of materials and heavy equipment taking account of any risks to the public, e.g. loading/unloading and transport to/from the site,

(2) Nearby high voltage power lines and temporary electrical installations,

(3) Damage and noise to adjacent buildings, e.g. houses, shops, temples and schools.

(4) Stability of temporary and permanent structures, including existing unstable structures,

(5) Falls from high places, scaffoldings and bridges,

(6) At lifting (crane) operations, failure and break of wires,

(7) The maintenance of plants (Crushing, concrete and asphalt) and heavy equipment,

(8) Deep excavations and those in unstable ground conditions,

(9) Work on or near water where there is a risk of falling into water and drowning,

(10) Explosives and spectators

(11) Unauthorised persons' access to the Site,

(12) Children playing around the Site or other vulnerable people nearby, e.g. drowning in sedimentation pits.

(13) Traffic and pedestrians passing through the existing roads in ROW.

4) Security

The Contractor shall:

(1) Protect all project work from any damage, related to performing the work until written acceptance of the Project.

(2) Rebuild, repair, restore and make good all losses, injuries or damage, under the control of the Contractor, at no cost to the Employer.

5) Environment

The Contractor shall:

(1) Maintain the stream flow during the construction of temporary access roads and earth works with provision of adequate drainage facilities.

(2) Provide immediate erosion-control measures to prevent contaminating adjacent streams, or other watercourses, lakes, ponds, or other areas of impounded water.

(3) Use a dike or barrier to separate work areas or pits located in or adjacent to streams from the main stream and to prevent sediment from entering the stream.

(4) Prevent pollution of streams, lakes, ponds and reservoirs with fuels, oils, bitumen, chemical or other harmful materials.

The following definitions shall be referred to for proper interpretation of this Specification Section:

(a) The Contractor's Safety Plan:

The document that shall be prepared and submitted by the Contractor in compliance with the Contract (hereafter referred as "the Safety Plan"). It shall consist of a complete plan for implementation and monitoring of safety measures applied in the Project comprehending the Site and all the related areas such as the construction plants, quarries, roads for material transportation, etc.

(b) The Programme and the Schedule:

As defined in specification Section 112 "Programme of Work".

(c) The Environmental Management Plan (EMP):

The plan for environmental management included in Appendix 4 to the Specifications.

(d) The Environmental Management Action Plan (EMAP):

The Contractor's Plan for Environmental Control and Protection that shall be prepared and submitted by the Contractor in compliance with the Contract (hereafter referred as "the Environmental Management Action Plan (EMAP)"). The Plan shall consist of a complete plan for implementation and monitoring of the necessary measures that the Contractor shall perform to control and protect the environment in the Project area, and any other area within 1 km that is affected by the execution of the Works.

(e) The Traffic Safety and Management Proposals:

As defined in specification Section 106 "Traffic Safety and Control".

114.2 Requirements

2.1 Safety and Security

2.1.1 General

(a) The Safety Plan shall be considered as one of the key-plans composing the Programme prepared, submitted and monitored as described in specification Section 112 "Programme of Work".

(b) The requirements established in this specification Section shall supplement, without detriment to, the requirements and provisions stated in the following clauses of the Conditions of Contract:

- Sub-Clause 19.1 "Safety, Security and Protection of the Environment";
- Sub-Clause 22.1 "Damage to Persons and Property";
- Sub-Clause 23.1 "Third Party Insurance (including Employer's Property)";
- Sub-Clause 23.2 "Amount of Third Party Insurance";
- Sub-Clause 24.1 "Accident or Injury to Workmen";

- Sub-Clause 24.2 "Insurance Against Accident, etc. to Workmen"; and
- Sub-Clause 40.1 "Suspension of Work.

(c) The requirements established in this Specification Section shall also supplement the requirements and provisions stated in the relevant sections of the Specifications and the like regarding safety included in the Contract.

(d) The Contractor shall, as a priority in all his activities, undertakings and endeavors, ensure continuity of the safety measures for the public and all persons directly or indirectly associated with the Works.

(e) The Contractor shall instruct and require the Project Manager, Safety Manager and his Site representative responsible for the Contract execution to be directly accountable in all matters concerning safety.

(f) The Contractor shall comply with all safety and industrial health legislation including, without limitation to, the currently applicable rules and regulation of Sri Lanka and the authorities having jurisdiction on safety.

2.1.2 Contractor's Safety Plan (The Safety Plan)

(a) Incorporating in the Programme, the Contractor shall prepare and submit to the Engineer for review and approval, the Safety Plan that shall be implemented during the work execution, and shall be monitored on a daily basis.

(b) The Safety Plan shall include, but not be limited to, the following:

- **Safety Organizational Structure**:

The organization classified into subdivisions that can be technically and effectively managed, and described in a "Safety Organizational Chart" identifying the subdivisions, responsibilities and tasks of the personnel and supporting staff, all of them engaged solely and specifically for safety issues (including the Contractor's Safety Manager who will be responsible for all safety issues in the Site). Moreover, the criteria for appointment of principal staff shall also be described.

- **Lines of Communication**:

The organizational structure shall show direct lines of communication and reporting among the Safety Manager, Contractor's Project Manager, and the Contractor's Site representative responsible for the Contract execution.

- **Safety Table**:

A table showing the names, addresses, e-mail addresses, and telephone/facsimile numbers of all the personnel named in the "Safety Organization Chart" (this Safety Table shall further be shown in all the Project offices, and distributed among all the Project personnel).

- **Interaction and Communication Procedures**:

The procedures defining the communication system between the Contractor's construction personnel and the safety assurance staff, including radio communication facilities, regular

communication and reporting system. Moreover, the frequency, coverage and intent of site safety meetings shall also be clarified.

- **Safety Training**:

The methods for promoting awareness of site safety and industrial health amongst all persons directly or indirectly associated with the Works. This shall include a program for site publicity and training courses for the workmen both on and off the Site and at all levels of supervision and management, incentive schemes for the promotion of compliance with safety measures and other similar measures. The said program shall be discussed with the Engineer, and shall be applied in a practical and reasonable way that will not affect the normal progress of the work. This shall also include the powers vested in the safety staff which would enable them to take urgent and appropriate and direct action to make safe the Site and prevent unsafe working practices or other infringements on the safety, or statutory regulations.

- **Subcontractors' Safety Plan**:

The means by which safety and industrial health matters and requirements will be communicated to subcontractors of all tiers and their due compliance with safety and all relevant statutory regulations is ensured. This shall also include the procedure for reviewing the safety plan proposed by subcontractors, confirming that it is prepared in due compliance with the statutory regulations and in accordance with the Safety Plan requirements, and the method to incorporate the subcontractors' safety plans into the general Safety Plan.

- **Safety Equipment and Clothing**:

The safety equipment, rescue apparatus and protective clothing which will be required for the Works, including the quantity, source, standards of manufacture, storage provisions and means of ensuring proper utilization by all workmen and staff employed directly or indirectly by the Contractor, and repair to or replacement of damaged equipment. Such equipment shall include, but not be limited to, goggles and other eye protectors, hearing protectors, safety harnesses, safety equipment for working underground and in confined spaces (e.g. sewers, drains, etc), rescue equipment, fire extinguishers, first aid equipment, ropes, hard hats and, where appropriate, associated shock absorbers, chest harnesses.

- **Safety Inspections**:

Safety equipment, scaffolds, guardrails, working platforms, hoists, ladders and other means of access, lifting, lighting, signing, and guarding equipment shall be regularly inspected, tested and maintained and the items below the standards shall be removed from the Site and replaced.

- **Supervision and Auditing**:

The means by which the established safety system will be supervised, monitored and audited by the Safety Manager to ensure due compliance with the principles and objectives of the Safety Plan at all levels of construction. This shall also include the procedure for updating the Safety Plan.

- **Records**:

To be prepared and maintained by the Safety Manager and the staff for safety, and the communication procedures to be adopted by the Safety Manager such that the Engineer, and others

associated with the Works (e.g. subcontractors), are kept fully informed throughout the period of the Contract on matters relating to site safety and industrial health regulations.

- **First Aid and Rescue**:

A description of the operation and equipment of the specified first aid base, the emergency and rescue procedures and their associated equipment. In addition, the method for protection of visitors to the Site shall be stated.

- **Health Hazards**:

An appreciation of the industrial health hazards likely to be associated with the Works and proposals for minimization of the risks associated with such hazards. The way to minimize the effects of climatic exposure (heat, wind and moisture) and noxious substances exposure.

- **Safety regarding Construction Methods**:

Proposals to ensure that construction methods do not compromise the Contractor's commitment to the Safety Plan or his compliance with statutory regulations.

- **First Aid Base**:

A description of the First Aid Base to be established in the Site and maintained until completion of the Work. This shall include a description of the measures to be taken for First Aid and medical services.

- **Others**:

In addition, the following items shall also be included:

- A description of the security norms to be applied in the offices, shops, construction plant, etc.,
- A description of the hygiene measures in eateries, cafeterias, work areas, etc.

2.1.3 Safety Manager

(a) The Contractor shall appoint a Safety Manager whose duties throughout the period of the Contract shall be entirely connected with the Safety activities on the Site.

(b) The Safety Manager shall be bilingual, in accordance with Sub-Clause 16.1 (c) of the Conditions of Contract, and shall be a suitably qualified and experienced person who shall prepare, supervise and monitor the Safety Plan, and shall, in particular but without limitation, carry out auditing of the operation of the Safety Plan in accordance with a rolling program to be submitted, from time to time, to the Engineer for his consent.

(c) The appointment and designation of the Safety Manager shall be subject to the Engineer's approval.

(d) Unless specifically agreed in writing by the Engineer, the Contractor shall not undertake any work on the Site until the Safety Manager has commenced duties on Site.

(e) The Contractor shall not remove the Safety Manager from the Site without the express written permission of the Engineer. Within fourteen (14) days of any such removal, or notice of intent of removal, the Contractor shall nominate a replacement Safety Manager for the Engineer's approval.

(f) The Contractor shall provide the Safety Manager with enough supporting staff in accordance with the staffing levels set out in the Safety Plan. The supporting staff shall include at least one (1) Deputy Safety Manager whose appointment shall be subject to the Engineer's approval. The Deputy Safety Manager shall be capable of assuming the duties and functions of the Safety Manager as contained in the Site Safety Plan whenever necessary.

(g) The Contractor shall empower the Safety Manager and his staff to instruct employees of the Contractor, or of its Subcontractors, of any tiers to cease operations and take urgent and appropriate action to make safe the Site and prevent unsafe working practices or other infringements on the Safety Plan or the statutory regulations.

(h) The Contractor shall ensure that the Safety Manager maintains a daily site diary, comprehensively recording all relevant matters concerning site safety inspections and audits, related incidents and the like. The site diary shall be available at all times for inspection by the Engineer.

2.1.4 Special Requirements for Safety

The Contractor shall duly comply with the following special requirements:

(a) **Safety of Public**:

The Contractor shall be responsible for the safety of the public passing through the Site. All excavations, plant or items of potential danger to the public must be barricaded and sign-posted to the satisfaction of the Engineer, and the Contractor must provide sufficient watchmen to ensure the safety of the public at all times. All existing pedestrian routes shall be maintained in a safe condition unless an alternative route is provided to the satisfaction of the Engineer.

(b) **Availability of Safety-Related Documents**:

The Contractor shall comply with the Engineer's requirements insofar as displaying in each of its site offices, workshops and canteens a copy of such safety and industrial health posters and keeping on the Site copies of safety and industrial health regulations and documents. The minimum regulations and most important documents (selected by the Engineer from the approved Safety Plan) shall be translated into languages which are understood by the operators engaged by the Contractor or subcontractors, and such translations shall be displayed or kept alongside those in Sinhala, Tamil, and English languages.

(c) **Safety Reports**:

The Contractor shall submit regular Safety Reports to the Engineer as a requirement of the Safety Plan. A summary of this report shall be included in each Monthly Progress Report. Safety reports shall comprehensively address all relevant aspects of site safety and industrial health regulations and, in particular, shall report on all site safety audits undertaken during the period covered by the report.

(d) **Safety Information**:

The Contractor shall ensure that safety, rescue and industrial health matters are given a high degree of publicity to all persons regularly or occasionally on the Site. Posters, in Tamil, Sinhala and English, drawing attention to site safety, rescue and industrial health regulations shall be made or obtained from the appropriate sources and shall be displayed prominently in relevant areas of the Site.

(e) **Safety Meetings**:

The Safety Manager of the Contractor shall perform regular safety meetings in accordance with the Safety Plan, with the participation of the Engineer (or a representative delegated by him for the purpose), and representatives of Subcontractors if so requested by the Engineer. All Safety Meetings shall be notified to the Engineer at least 3 days in advance. Minutes of all Safety Meetings shall be taken and sent to the Engineer within three (3) days after the meeting.

(f) **Fire Extinguishers:**

In supplement to the safety equipment stated in the Safety Plan, the Contractor shall provide in particular wall-mounted hand fire extinguishers of all-purpose, nitrogen-pressured, dry chemical type. Moreover, fire extinguishers shall be provided at each Site Offices and the Engineer's offices and accommodations, during the execution of the Works. Individual fire extinguishers shall also be provided in all the vehicles being used in the Project.

(g) **First Aid Base**:

The Contractor shall, at his own expenses, establish and maintain a fully equipped First Aid Base as described in the approved Safety Plan and satisfying the following conditions:

- The First Aid Base shall be located at the Contractor's principal work area and shall consist of a treatment room fitted with a hand wash basin, two treatment couches and sterilizing equipment and lockable cupboards to contain sufficient medical supplies for the Contractor's workforce, the Engineer's site supervisory staff and any visitors to the Site. In addition, six stretchers shall be stored, available for instant use. The first aid base shall contain a recovery room that shall be furnished with six chairs and six footrests. The First Aid post shall be air-conditioned, with cooling capability sufficient to maintain the temperature of the inside of the building at 20 °C.
- A qualified nurse and nurses aid shall be in attendance at the First Aid Base during all times when work is being undertaken on the Site, including work by any Subcontractor and periods when only emergency activities are being undertaken, such as during periods of inclement weather.
- All the costs for First Aid shall be considered as a part of the unit price of the bid, and no additional payment will be made for it.

(h) **Qualified Personnel**:

Suitably qualified personnel shall operate all Construction Plant and equipment used on or around the Site.

(j) **Notification of Accidents:**

The Contractor shall notify the Engineer immediately when any accident occurs whether on site or off site in which the Contractor, his personnel or construction plant, or those of his Subcontractors are directly or indirectly involved and which result in any injuries to any persons. Such initial notification may be verbal and shall be followed by a written comprehensive report within 24 hours after the occurrence of the accident.

(j) Cooperation with the Engineer:

The Contractor shall fully cooperate with the Engineer to prevent accidents and in all safety surveillance carried out by the Engineer or the Employer.

2.2 Environmental Control and Protection

2.2.1 Regulations and Reference Standards

The following regulations of their latest edition shall be applied:

Regulations and Standards:

The current regulations and standards to be applied:

- Central Environmental Authority (CEA) of the Ministry of Environment and Natural Resources (MENR);
- Geological Survey and Mines Bureau (GSMB), in particular construction materials supply;
- Urban Development Authority (UDA) of the Ministry of Urban Development & Sacred Area Development (MUD&SAD); and
- National Housing Development Authority (NHDA) of the Ministry of Housing and Common Amenities (MHCA).

Guidelines:

- JBIC - Guidelines for Confirmation of Environmental and Social Considerations.

2.2.2 General

(a) The "Environmental Management Action Plan (EMAP)" shall be considered as one of the key-plans included in the Section 112 "Programme of Work".

(b) The requirements established in this Specification Section shall supplement, without detriment to, the requirements and provisions stated in the following clauses of the Conditions of Contract:

- Sub-Clause 27.1 "Fossils",
- Sub-Clause 30.4 "Waterborne Traffic",
- Sub-Clause 32.1 "Contractor to Keep Site Clear",
- Sub-Clause 33.1 "Clearance of Site on Completion",
- Sub-Clause 39.1 "Removal of Improper Work, Material or Plant", and
- Sub-Clause 49.2 "Completion of Outstanding Work and Remedying Defects".

(c) The requirements established in this Specification Section shall also supplement the requirements and provisions stated in the relevant sections of the Specifications and the like regarding safety included in the Contract.

(g) Before the application of the measures for environmental protection contained in the "Environmental Control Plan (ECP)" described below, the Contractor shall investigate and clarify sufficiently the details and regulations established by local authorities and pertinent divisions of

the Sri Lanka's Ministry of Environment and Natural Resources (MENR), and shall also obtain their acceptance for the plan.

(h) The Contractor shall be responsible for taking the remedy or mitigation measure(s) required to deal with the environment-related effects of any of his construction or construction-related activities.

(i) When and if an environmental problem arises (such as environmental damage to property and natural resources, ground subsidence, interruption of groundwater flow, surface/ground water contamination, complaints or legal actions by third parties, etc.), the Contractor shall first immediately notify the Engineer thereof; and then, based on the approved ECP, he shall prepare the countermeasures that shall be applied to solve or mitigate the problem, and shall submit them to the Engineer's approval.

2.2.3 Contractor's Plan for Environmental Control and Protection (The Environmental Control Plan)

(a) Incorporating in the Programme, supplementing the Safety Plan and the Traffic Control Plan, the Contractor shall prepare and submit to the Engineer for review and approval, the "Environmental Control Plan" (ECP), based on the "Environmental Management Plan" [Refer to Appendix 4 to the Specifications], that shall be implemented during the work execution, and shall be monitored on a daily basis.

(b) The Environmental Control Plan (ECP) shall include, but not be limited to, the following:

- **Environmental Control Organizational Structure**:

  The organization classified into subdivisions that can be technically and effectively managed, and described in an "Environmental Control Organizational Chart" identifying the subdivisions, responsibilities and tasks of the personnel and supporting staff, all of them engaged solely and specifically for environmental control issues (including the Contractor's Environmental Manager who shall be responsible for all environmental control issues in the Site). Moreover, the criteria for appointment of the principal staff shall also be described.

- **Lines of Communication**:

  The organizational structure shall show direct lines of communication and reporting among the Environmental Manager, Contractor's Project Manager, and the Contractor's authorities responsible for the Contract.

- **Interaction and Communication Procedures:**

  Communication between the Contractor's construction personnel working in areas where the environment will be or is being affected, and the environmental control staff, including regular communication and reporting system. Moreover, the procedures shall also specify the frequency, coverage and intent of site meetings for coordination.

- **Subcontractors' Environmental Management Action Plan (EMAP)**:

  The means by which the EMAP will be communicated to Subcontractors (if any), including also the procedure for reviewing the plan for environmental control proposed by Subcontractors, and

the method to incorporate the Subcontractors' environmental control plans into the Project's EMAP.

- **Inventory of Environmental Impacts**:

  A detailed inventory of the identified environmental impacts that will be caused by executing the Works in accordance with the construction Programme prepared by the Contractor.

- **Methods, Equipment and Supporting Staff for Environmental Control**:

  A detailed and consistent description of the methods to be applied and the equipment and supporting staff to be provided for environmental control, including details for each stage considered during the construction of the Works. The methodology described in the ECP shall cover all the items herein specified, and all applicable requirements of the Sri Lanka standards or the like regarding environmental control.

- **Environmental Control Schedules**:

  Time-bar schedules prepared for each case of environmental control necessity identified in the above- mentioned inventory, including a description of all the main activities for environmental control, dates for commencement and completion of each activity, critical items of the schedule, etc.

- **Environmental Control Inspections**:

  The procedure and schedule for inspections of the environmental control equipment, the compliance of methods, and the performance of the supporting staff.

- **Supervision and Auditing**:

  The means by which the established Environmental Control System will be supervised, monitored and audited by the Environmental Manager to ensure due compliance with the principles and objectives of the ECP. This shall also include the procedure for updating the ECP.

- **Records**:
  To be prepared and maintained by the Environmental Manager and the staff for environmental control, and the communication procedures to be adopted by the Environmental Manager such that the Engineer, and others associated with the Works, are kept fully informed throughout the period of the Contract on matters relating to traffic regulations.

2.2.4 Environmental Manager

(a) The Contractor shall appoint an Environmental Manager per section, whose duties throughout the period of the Contract shall be entirely connected with the Environmental Control activities on the Site.

(b) The Environmental Manager shall be bilingual, in accordance with Clause 16.1 (c) of the Conditions of Contract, and shall be a suitably qualified and experienced person who shall prepare, supervise and monitor the ECP, and shall, in particular but without limitation, carry out auditing of the operation of the ECP in accordance with a rolling programme to be submitted, from time to time, to the Engineer for his consent.

(c) The appointment and designation of the Environmental Manager shall be subject to the Engineer's approval.

(d) Unless specifically agreed in writing by the Engineer, the Contractor shall not undertake any work on the Site, which may affect the environment, until the Environmental Manager has commenced duties on Site and the ECP has been approved by the Engineer.

(e) The Contractor shall not remove the Environmental Manager from the site without the express written permission of the Engineer. Within fourteen (14) days of any such removal, or notice of intent of removal, the Contractor shall nominate a replacement Environmental Manager for the Engineer's approval.

(f) The Contractor shall provide the Environmental Manager with enough supporting staff in accordance with the staffing levels set out in the ECP. The supporting staff shall include at least one (1) Deputy Environmental Manager whose appointment shall be subject to the Engineer's approval. The Deputy Environmental Manager shall be capable of assuming the duties and functions of the Environmental Manager as contained in the ECP whenever necessary.

(g) The Contractor shall ensure that the Environmental Manager maintains a daily site diary comprehensively recording all relevant matters concerning site safety inspections and audits, related incidents and the like. The site diary shall be available at all times for inspection by the Engineer.

2.2.5 Special Requirements for Environmental Control

(a) EMP Monitoring

The Contractor shall perform the monitoring included in the EMP in Volume V: Data Provided by the Employer, of the Bidding Documents.

(b) Air Quality and Dust

1) Control of Air Pollution and Dust Emission

The Contractor shall take necessary action at all times to prevent dust nuisance as a result of his activities on sites*. An air pollution control system shall be installed and shall be operated whenever the equipment and the plant are in operation.

Note: "**Site**" means the place where the Permanent Works are to be executed, including storage and working areas, and to which plant and materials are to be delivered and any other places as may be specified in the Contract as forming part of the Site.

- **Law and Regulations**:

The Contractor shall install any furnaces, boilers, generators, other similar plants (crushing, asphalt and batching plants) and equipment, which use any fuel, in accordance with the Sri Lanka's applicable laws and regulations for environment protection and other relevant legislation because they will produce air, noise and water pollution, vibrations, waste and soil contamination.

- Dust Suppression Measures on the Site:

The Contractor shall implement dust suppression measures that shall include, but not be limited to, the following:

- Cells for Stockpiling:
- Stockpile of sand and aggregate for use in concrete manufacture shall be made accordingly with the applicable Sri Lanka regulations.
- Surfacing of Approaches:

  The areas within the Site where there is a regular movement of vehicles shall have an acceptable hard surface and be kept clear of loose surface material.

- Conveyor Belts:

  Conveyor belts shall be fitted with wind-boards, and conveyor transfer points and hopper discharge areas shall be enclosed to minimize dust emission. All conveyors carrying materials that have the potential to create dust shall be totally enclosed and fitted with belt cleaners.

- Silos:
  Cement and other such fine-grained materials delivered in bulk shall be stored in closed silos fitted with a high-level alarm indicator. The high-level alarm indicators shall be interlocked with the filling line such that in the event of the hopper approaching an overfull condition, an audible alarm will operate, and the pneumatic line to the filling tanker will close.

- Filters or Air Cleaning:

  All air vents on cement silos shall be fitted with suitable “fabric filters” provided with either shaking or pulse-air cleaning mechanism.

  The fabric filter area shall be determined using an air-cloth ratio (filtering velocity) in accordance with standards.

  Weigh hoppers shall be vented to a suitable filter.

  The filter bags in the cement silo dust collector must be thoroughly shaken after cement is blown into the silo to ensure adequate dust collection for subsequent loading.

- Dust Suppression by Water Spraying:

  Effective water sprays shall be used during the delivery and handling of all raw sand and aggregate, and other similar materials, when dust is likely to be created and to dampen all stored materials during dry and windy weather.

  Install adequate dust suppression plant, e.g. water bowser.

  Areas of reclamation shall be completed, including final compaction, as quickly as possible and in conformity with good practice to limit the creation of wind blown dust.

  All the roads within the Project’s Site and all related areas for construction shall be sprayed at least twice a day, and more if necessary to control dust to the satisfaction of the Engineer.

- Tire Cleaning:
  All vehicles shall be properly cleaned (bodies and tires are free of sand and mud) prior to leaving the site areas. For this purpose, necessary cleaning facilities shall be provided in the Site, and the Contractor shall ensure that no water or debris from such cleaning operations is deposited off-site.

- Truck Covers:

  All trucks used for transporting materials to and from the Site shall be covered with canvas tarpaulins or other acceptable type of cover (which shall be properly secured) to prevent debris and/or materials from falling from or being blown off the vehicle(s).

- Wall Protection against Wind:

  Where necessary, and when instructed by the Engineer, walls shall be constructed to avoid the effect of strong winds that could cause the blowing of dust and debris.

- Dust Suppression at Concrete Batching Plant or Crushing Plant:

  Where dusty materials are being discharged to vehicles from a conveying system at a fixed transfer point, a three-sided roofed enclosure with a flexible curtain across the entry shall be provided. Exhaust fans shall be provided for this enclosure and vented to a suitable fabric filter system.

  Any vehicles with an open load carrying area used for moving potentially dust-producing materials shall have properly fitted sides and tailboards. Materials having the potential to create dust shall not be loaded to a level higher than the sides and tail boards, and shall be covered by a clean tarpaulin in good condition. The tarpaulin shall be properly secured and shall extend at least 300 millimetres, or more if necessary, over the edges of the sides and tailboards.

  The Contractor shall frequently clean and water the concrete batching plant and crushing plant sites and ancillary areas to minimize any dust emission.

- Dry mix batching shall be carried out in a totally enclosed area with exhaust to suitable fabric filters.

- Air Pollution Reduction on the Site:

  The Contractor shall not burn debris or other materials on the Site.

  The Contractor shall require that all vehicles, while parked on the site have their engines turned off.

  The Contractor shall check all equipment and machinery on the Site at least weekly and make all necessary corrections and/or repairs to ensure compliance with safety and air pollution requirements.

2) Monitoring of Dust Levels

The Contractor shall carry out dust impact monitoring at all work areas throughout the construction period and in accordance with the approved ECP.

The activities for Monitoring of Dust Levels shall include, but not be limited to, the following:

- **Air Samples and Equipment for Air Quality Control**:

Within two weeks after the date of issue of the Engineer's approval of the ECP, the Contractor shall provide the following:

- Air samplers and associated equipment and shelters for monitoring the suspended dust content.
- A direct reading dust meter capable of reading 1 hour TSP in the range 0.1 - 100 mg/m3.

- **Monitoring Stations**:

- Monitoring stations shall be installed at each location determined in the ECP, as approved by the Engineer, and shall be free from local obstructions or sheltering.
- All the Monitoring Stations shall be provided with suitable access, paved and hard standing, and with a galvanized wire fence and gate.
- The exact location and direction of the monitoring equipment at each monitoring station shall be agreed with the Engineer.

- **Measurements of Dust Levels**:

- The dust levels shall be measured by a method approved by the Monitoring Committee of CEA.
- All samples collected as part of the monitoring programme shall be analyzed in accordance with the standards and current regulations.

- **EMP Monitoring**:

Immediately after the issue of the Engineer's approval of the Monitoring Stations and the methods for dust level measurement, the Contractor shall carry out the EMP monitoring to check the ambient dust levels at each specified monitoring station. The EMP monitoring shall be carried out for a period established in the ECP approved by the Engineer, with measurements to be taken every day at each monitoring station.

- **Monitoring During Work Execution:**

- Impact monitoring shall be carried at each monitoring station for whole contract period with a frequency established in the ECP and approved by the Engineer.
- In the event that the records of monitored dust levels indicate an impact on the air quality evidencing a deteriorating situation, the Engineer, simultaneously with his instructions for improving the dust suppression measures, may require the Contractor to undertake daily impact monitoring at any one or more of the monitoring stations until the results indicate an improving and acceptable level of air quality.
- Monitoring results shall be submitted to the Engineer within one week after completion of the monitoring period.

- Monthly reports shall be analytical and shall provide explanations for any anomaly and problems encountered.

Actions taken in response to the monitoring results shall also be required.

3) Action on Construction Dust Levels

- Where the Engineer determines that the recorded dust levels are significantly greater than the levels established in the baseline survey, the Engineer may direct the Contractor to take effective remedial measures including, but not limited to, reviewing dust sources and modifying working procedures.
- The Contractor shall inform the Engineer of all steps taken. Written reports and proposals for action shall be passed by the Contractor to the Engineer whenever the Engineer determines that air quality monitoring shows that the recorded dust levels are significantly greater than the levels established in the baseline survey.

(c) Water Quality

1) Water Quality Monitoring

- **Law and Regulations**:

The Contractor shall comply with the Sri Lanka legislation and other regulations currently applied in Sri Lanka insofar as they relate to water pollution control and monitoring.

- **Protection of Existing Watercourses**:
  - The Contractor shall ensure that no tools or machinery are washed in any water sources or areas that drain into an existing watercourse, stream, or canal.
  - The Contractor shall ensure that run-off from the construction sites is not deposited directly into any watercourse, stream, or canal.
  - The Contractor shall ensure that chemicals and concrete agitator washings are not deposited in the watercourses.
  - The Contractor shall ensure that all temporary construction facilities are located at least 50 meters away from any water course, stream, or canal.
- Daily Inspection: The Contractor shall daily check all equipment for prevention of oil and/or lubrication leaks and ensure that all equipment oil and lubrication replacements are performed only in maintenance and repair areas.
- **EMP Monitoring**:

The Contractor shall monitor the water quality and compare with the baseline data.

- **Monitoring During Work Execution**:
  - Monitor regularly water quality and runoff from set areas, construction camps, staging areas, labor camps, etc. at least once every month.
  - Monitor water quality according to Environmental Management Action Plan (in Appendix 4) and submit the results to the Engineer within two working days after the tests. Some

tests may take more days to analyse. Those results shall be submitted within eight (8) working days after the tests.

- Monthly reports shall be analytical and shall provide explanations regarding any anomaly or problem encountered.
- The actions taken in response to the monitoring results shall also be described.

(d) Vibration and Noise

1) Control of Emission of Vibration and Noise

- **Law and Regulations**:

The Contractor shall abide by the CEA's regulations (Noise) and Interim standard on Vibration Pollution Control, 4 July 2002, CEA's letter (in Data provided by the Employer).

- **Basic Requirements**:

- The Contractor shall consider noise and vibration caused by blasting and heavy equipment operation as environmental constraints in his design, planning and execution of the Works.
- The Contractor shall at his own expense take all appropriate measures to ensure that works carried out by the Contractor and by his Subcontractors, whether "in" or "off" the Site, will not cause any unnecessary or excessive noise which may disturb local inhabitants.
- The Contractor shall be responsible for repairing any damage caused as a result of vibrations generated from or by the use of his equipment, plant, and machinery.
- Percussive piling will not be permitted without the express permission of the Engineer.
- Without prejudice to the generality of the foregoing, noise level reduction measures shall include, but not be limited to, the following:
- All powered mechanical equipment used in the Works shall be effectively sound reduced using the best techniques available in Sri Lanka in accordance with the current standards.
- Acoustic screens or enclosures shall be provided around any part of the Works located in sensitive areas where according to the ECP from which excessive noise may be generated.
- In general, the equipment shall be selected with due consideration for having lowest noise levels, and ensuring that all equipment is regularly maintained to keep such levels.
- All equipment, engines and motors shall be equipped with proper mufflers.

- **Submittal of Noise Statement**:

- The Contractor shall submit to the Engineer, for review and approval, a "Noise Statement" including full and comprehensive details of all powered mechanical equipment which he proposes to use during the hours of darkness and of his proposed working methods and noise level reduction measures.

- The "Noise Statement" shall include detailed noise calculations to demonstrate the noise generation anticipated by the Contractor.
- The Statement shall also include safety protection measures against noise such as the use of ear plug (or muffs) in noisy areas and rotation and/or working hour limitation for the personnel
- Continuously working in areas of high noise where the permissible noise limit established by the Sri Lanka standards is being exceeded.
- The "Noise Statement" shall be submitted at least fourteen (14) days before the planned start of any work to be undertaken during the hours of darkness.
- No work shall be carried out during the hours of darkness until the Engineer has notified the Contractor in writing of his consent based on the "Noise Statement" submitted in relation to such work.
- Such consent of the Engineer shall not in any event relieve the Contractor of his obligations under the Contract, nor fetter, nor limit neither restrict the Engineer's power to give instructions in accordance with the Contract.

- **Special Condition for Noise Control during Darkness Hours**:

The Contractor shall ensure that noise generated by work carried out by the Contractor and his Subcontractors during hours of darkness does not exceed the maximum permissible noise limits accepted by CEA (the same may vary from time to time and at the sole discretion of the CEA), whether continuously or intermittently. In the event of a breach of this requirement, the Contractor shall immediately re-deploy or adjust the relevant equipment or take other appropriate measures to reduce the noise levels and thereafter maintain them at levels which do not exceed the said limits. Such measures may include, without limitation, the temporary or permanent cessation of use of certain items of equipment.

2) Vibration and Noise Monitoring

- **Vibration Control and Monitoring**:

- The Contractor shall select, use and maintain his plant and equipment, and adopt such methods for construction that the maximum vibration levels, measured on any building or structure outside or within the Site limits, do not exceed the permitted levels specified by the Monitoring Committee of CEA.
- The above are limits for transient vibrations. For continuous or sustained periods of vibrations, the permissible peak particle velocity shall be equal to two thirds of the value given above.
- Vibration Monitoring System:

The Contractor shall establish a system for monitoring vibrations in accordance with the requirements stated by the Monitoring Committee of CEA.

- EMP Monitoring:

The Contractor shall perform the activities for monitoring of vibration quality included in the Baseline Survey prepared by the Consultant in previous stage before tendering.

- Monitoring during Work Execution:

During piling, or any other activity likely to be a source of significant vibration designated by the Engineer, the Contractor shall record vibration levels at locations agreed with the Engineer, at least twice daily. The Engineer may relax the frequency of monitoring if it can be shown that vibration levels are consistent and within specified levels. The monitoring shall be done during the operation of the equipment. The Contractor shall monitor at least six locations shown on the map in the Environmental Management Action Plan (in Appendix 4).

- **Noise Monitoring**:

  - EMP Monitoring:

The Contractor shall perform the activities for monitoring of noise quality included in the Baseline Survey prepared the Consultant in previous stage before tendering.

  - Monitoring Points:

The Contractor shall carry out noise monitoring at such points within the Site, or outside the Site, and at times as shall be determined in the ECP.

  - Methodology:
    The noise monitoring methodology adopted shall conform to the requirements established by the Monitoring Committee of CEA.

- **Reports and Others**:

  - Reports:
    The results of all monitoring shall be reported to the Engineer within 48 hours of any set of readings. In addition the Contractor shall establish detailed records for all sets of vibration and noise monitoring undertaken in the course of work execution. These shall be available for inspection by the Engineer and his representatives at any time during working hours.

  - Other Notes:

    The Contractor shall also note and record the condition of the structure being monitored and any change in condition from the time of the previous round of monitoring.

(e) Waste and Soil Contamination

In order to avoid and to prevent soil contamination by the Works, the Contractor shall:

- Ensure that no earth, rock or debris is deposited on public or private right-of-way as a result of his operations, including any deposits arising from the movement of construction plant or vehicles;
- Provide a wash pit, or a wheel washing and/or vehicle cleaning facility, at the exits from the Site whence excavated material is hauled;

- Provide the entire Site with properly designed temporary drainage system to collect, remove and dispose from the Site all kinds of unnecessary water and waste products found on the Site, including any water, silt or debris washed down from the works by flooding, at a location and in a manner that will not cause pollution or nuisance, and shall not be deposited on land adjacent to the Site.

(f) Other Environmental Aspects

1) Reduction of Construction Operation Impact on Land Communication

The Contractor shall conduct his construction operations to minimize their impact on land communications in and around the areas of construction. Measures to accomplish this requirement shall include, but not be limited to, the following:

- The loading of all trucks used for transporting materials and equipment shall not exceed the legal limits as stipulated by the Sri Lanka's Road Development Authority (RDA).
- The speed for all trucks used for transporting materials and equipment shall not exceed 60 km/hr on highways.
- The transportation of materials and equipment shall be in accordance with all the relevant requirements and regulations.
- Loading and transportation of materials and equipment shall avoid morning and evening rush hours so as not to aggravate the traffic condition on roads in the construction area.
- Proper and sufficient traffic signs shall be installed.
- Drivers shall be properly supervised to ensure their awareness and adherence to regulations.
- Drivers shall be controlled to prevent them from using alcohol and drugs. The Contractor shall stipulate that such usage shall be grounds for termination of employment on the Works.
- Construction materials shall be properly stored.

Even if the Contractor took sufficient precaution, he shall repair the following damages, using the provisional sum:

- All road damage that may occur from the transportation of materials and equipment to and from the Works.
- Coordination with the Ministry of Transport for implementing all necessary repairs and/or restorations.
- Repair of any damage caused by the Contractor to the satisfaction of the Engineer and at no cost to the Employer.

2) Others

The Contractor shall also comply with all current environmental laws and regulations related to the following:

- solid waste disposal;
- liquid waste disposal;

- storage of liquid materials and toxic materials;
- sanitary conditions (water supply, sewerage, etc.);
- sanitary facilities referred to Sub-section 1.6 Services, Section 102, Offices and Laboratory for the Engineer; and
- use of explosives, etc.

114.3 Measurement and Payment

3.1 Measurement

All the costs related to the implementation and execution of Safety, Security and Protection of the Environment shall not be measured but paid as a lump sum.

3.2 Payment for Project Safety and Security

(a) Payment shall include all costs necessary and required for the proper implementation of the Project Safety in fully accordance with the requirements of this Specification Section, including updating and submittals monthly-:

(b) The Engineer may at any time withhold payments if, in his opinion, the Project Safety has not been provided in due compliance with the requirements and procedures of this specification Section.

Pay Items	Unit of Measurement
114(1) Project Safety and Security	mth

3.3 Payment for Environmental Control and Protection

Payment shall be made according to Section 1100, Provisional Sum.

Pay Items	Unit of Measurement
1001 (9) Environmental Control and Protection	Provisional Sum

SECTION 115

CONTROL OF WORKS

115.1 Conformity with Plans and Specifications

The Contractor shall perform and furnish materials in accordance with these specifications and in conformity with lines, levels, grades, cross sections and dimensions shown on plans and working drawings.

When the materials furnished and/or work performed are not totally in conformity with the plans and specifications due to the Contractor's fault but the work done is reasonably acceptable to the Engineer, a determination will be made by the Engineer, whether or not the work will be accepted and remain in place. Where such work is accepted, an appropriate financial adjustment in the Contract Price for such work or materials shall be made by the Engineer.

When the work performed and/or the materials furnished are not in conformity with the plans and specifications and have resulted in an inferior or unsatisfactory product, such work or material shall be removed and replaced or otherwise corrected by and at the expense of the Contractor.

115.2 Setting Out and Construction stakes

The Engineer will show bench marks and reference points to the Contractor as presented in "Data Provided by the Employer".

- The Contractor shall carry out a check of the co-ordinates and levels of all permanent ground markers and permanent bench marks shown in the "Data Provided by the Employer".
- Their position and levels shall be submitted to the Engineer for his checking and revisions.
- The Contractor shall identify and bring to the attention of the Engineer any markers (incl. ROW's) that are missing.
- The Contractor shall check the existing ground levels from time to time and submit the results to the Engineer for his approval.

The Contractor shall perform the checking, necessary calculations and work staking, including:

1) Re-establish survey points and centerlines.
2) Reference control points, when necessary.
3) Run a level circuit to check or re-establish plan benchmarks.
4) Set stakes for construction limits, right-of-way (Markers are provided by the Employer but to be checked by the Contractor.), drainage items, slopes, pavement structure, embankment and subgrade controls, bridge control points for vertical and horizontal alignment of all components and any other stakes necessary to control lines and grades.

The Contractor shall obtain the approval of the Engineer for the above. No work shall begin till such bench marks stakes, setting out points, reference points and all control points of the centre line are certified as correct by the Engineer or his representative.

115.3 Construction Programming

The Contractor shall programme his work so as to reduce as far as is practicable, disruption to all road users during construction of the Works and maintain traffic control measures for the safety of traffic at all times.

115.4 Compaction Equipment

Mechanical equipment shall be used for compacting materials by rolling, tamping and watering the materials (if needed) before compaction. For other operations such as spreading, mixing and shaping, mechanical equipment only or a combination of mechanical equipment (which shall include graders) and manually operated tools and equipment shall be used. The choice of equipment and the procedure of their use shall be subject to the approval of the Engineer, upon his being satisfied on their effectiveness on the basis of trial compactions.

It shall be understood by the Contractor that different type of materials are likely to require different kind of compaction equipment, including successive applications thereof, for achieving the specified degrees of compaction and the Contractor shall keep available a fleet of compaction equipment of the requisite kinds, sizes and numbers.

For compacting along narrow strips e.g. along widening of pavements and in restricted areas e.g. behind bridge abutments, appropriate sized purpose made compacting equipment will be required and the same shall be provided by the Contractor.

All equipment shall be of modern construction by established manufacturers and of proven efficiency and shall be operated and maintained at all times by skilled personnel in a manner acceptable to the Engineer.

115.5 Compaction Trials

For demonstrating the efficacy of mixing and compaction equipment and the working methods proposed to be used by the Contractor for different kinds of materials, the Contractor shall carry out compaction trials before full-scale construction on the road and during construction throughout the course of the contract as required by and in close cooperation with the Engineer. Based on results of compaction trials and construction observation, the Engineer shall reserve the right to direct the use of particular mixing and compaction equipment and methods and disallow the use of others for compacting different kinds of materials in accordance with these Specifications.

115.6 Dispersal of Hauling Equipment

Hauling equipment bringing materials to the site of work shall be dispersed uniformly over the surface of the previously constructed layers in order to avoid rutting and uneven compaction. The materials from hauling equipment shall not be dumped in concentrated heaps but deposited as evenly distributed layers or windrows consistent with the loose thickness to be achieved before compaction. The hauling equipment shall not be allowed on the proposed shoulder areas. Any defects caused by the hauling equipment on shoulder pavement layers shall be remedied by

complete removal down to the Subgrade level and reconstruction as per these Specifications.

115.7 Protection to Newly Constructed Layers

Except as permitted by the Engineer, no traffic other than construction traffic shall be allowed on any earthwork or pavement layer until a surfacing has been applied either as single surface treatment or an asphalt concrete layer or any other surfacing layer. The approval of the Engineer shall be required before traffic is allowed to pass over newly constructed road. Any defects, caused by traffic passing over the construction layers due to the Contractor's fault, shall be remedied in accordance with these Specifications.

115.8 Measurement and Payment

No separate payment shall be made for compliance under this section. Payment shall be deemed to be included in the Contractor's rates.

SECTION 116

CONTROL OF MATERIALS

116.1 Supply Source and Quality Requirements

The Contractor shall use only materials that meet Contract requirements.

- Notify the Engineer of the proposed source of materials to be used prior to their delivery.
- Materials can be conditionally approved at the supply source. Correct, to the satisfaction of the Engineer, or remove materials conditionally approved but that fail to meet Contract requirements. Unless otherwise specified, use new materials for the work.

116.2 Borrow Pits and Quarries

Information regarding the position of Borrow Areas/Pits and Quarries and results of tests carried out on various samples of materials may be available on request, from the Employer. The Contractor shall be deemed to have considered this information, if available and carefully checked the availability of suitable material in sufficient quantities from these sources and other sources during the Tender period. He is deemed to have fully satisfied himself of the quality, suitability and characteristics of the materials and suitability of the plant and the method of working on which he has based his rates. He shall continuously check the availability during the construction.

The Contractor shall be responsible for opening up all quarries and borrow areas and shall organize his method of operations so that only materials of a type and quality approved by the Engineer shall be selected for use in the Works.

The Contractor in his proposal for approval of borrow areas and aggregate quarries, shall describe the route of hauling materials from the borrow areas to the site. He shall obtain the permission to use this route for hauling materials from the Authority of the route. Before commencement of hauling, the Contractor shall inspect the proposed route of hauling with the Engineer and the authority of the route, prepare a report on the condition of the route with necessary photographs and indicating agreed commitments to the authority of the route at the end of hauling period. The contractor shall submit to the Engineer, a copy of this report, before commencing hauling operations.

The Contractor is at liberty to select and use material from his own sources providing the requirements of this section are fully met.

No claims relating to the quantity or quality of material at identified quarry or borrow areas shall be considered by the Employer.

Access Roads to Borrow Pits and Quarries

After award of the Contract, both the Engineer and the Employer will assist the Contractor to obtain the access roads permission from relevant authorities. However, the Contractor shall bear the costs due to non-suitability or non-availability of the access roads for his use.

116.3 Materials for Steel Bridges

Generally all testing is performed within Sri Lanka and witnessed by the Engineer. However, for the steel bridges, the materials and temporary assembling shall be tested and inspected in the

supplier's country. The Contractor shall arrange and conduct the testing at his cost.

- Each lot of structural steel material must come with a certificate of compliance of required tests. Certified mill test reports must be attached to certificates of compliance for all structural materials.
- To ensure delivery of uniform material that meets requirements, the Engineer will accept structural materials mill test reports only from domestic manufacturers or manufacturers with proven plant quality control.
- Quality control is established by submitting detailed written proof or through the Engineer's inspection.

116.4 Storing and Handling Materials

- Store and handle materials to preserve their quality and fitness for the work.
- Transport bulk materials in a manner that prevents loss or segregation after loading and measuring.
- Store material so that they can be easily inspected and retested.
- Obtain approval to store materials and Contractor's plant and equipment on the ROW. Additional storage space is at the Contractor's expense and option. Obtain owner's written permission before storing material on private property. Furnish copies of the permission to the Engineer, if requested.
- Restore storage and plant sites to the original condition at Contractor's expense.

116.5 Unacceptable Materials

All materials not meeting Contract requirements will be rejected. Remove immediately unless the Engineer approves defect corrections.

116.6 Stockpiling of Materials

Unless otherwise permitted by the Engineer, natural soils brought from borrow pits shall not be loaded directly from the borrow area for use in the works but shall first be stockpiled. Such stockpiles shall be tested and approved by the Engineer before the material comprising them may be used in the works.

All materials brought to the Site, which require temporary stockpiling shall be stored carefully at approved locations and in a systematic manner so as to prevent deterioration or mixing of different materials or contamination. Materials which have suffered contamination or deterioration due to improper storage shall not be used in Works and shall be removed from the stock piling area.

The materials shall be free from foreign, organic or any other deleterious substances such as vegetation and perishable matters, or any other substance which in the opinion of the Engineer may affect placing, mixing and compaction of the material or adversely affect the future performance of the Works. Material shall be tested in stockpiles by the Engineer to check suitability for use in the Works.

116.7 Temporary Stockpiling of Materials

Where the work programme is such that materials cannot be placed directly in their required

positions or where mixing of two or more materials is required to meet the requirements of the Specifications, the Engineer may authorize their removal into temporary stockpiles. Such stockpile sites shall be to the Engineer's approval and shall be prepared by suitably clearing, grading and compaction.

The material shall be stockpiled in successive layers of approved thickness over the full stockpile area to the approximate dimensions required by the Engineer.

116.8 Payment

No separate payment shall be made for items under otherwise stated in the Conditions of Contract under this section and payment shall be deemed to be included in the Contractor's rates.

SECTION 117

WORK EXECUTED BY THE EMPLOYER OR OTHER CONTRACTORS

The Employer reserves the right to contract for and perform other work on or near the project work.

- The Contractor shall coordinate with the Engineer and the Employer if any other contractors work within the same project limits.
- The Contractor shall cooperate with the utility owners to remove and rearrange underground or overhead utilities to avoid service interruption or duplicate work by the utility owner.
- The Contractor shall cooperate with other contractors working within the limits of the same project. Conduct work without interrupting or inhibiting the progress or completion of work other contractors working within the same project limits. Any dispute shall be solved through the meeting, where the Employer attends.
- The Contractor shall coordinate and sequence the work with other contractors. Arrange, place and dispose of materials without interfering with the operations of other contractors on the same project.

SECTION 118

REMEDIAL WORK

When upon examination by the Engineer any part of the Works or any plant fails to conform to the Specification requirements, or is at any stage before final acceptance damaged so that it no longer conforms to the requirements of the Specifications, the Engineer may instruct its complete removal and replacement, at the Contractor's expense, with satisfactory work, plant or material. In special cases, the Engineer may instruct the Contractor to apply remedial measures in order to make good any such defects or damage. The actual remedial measures taken shall be entirely at the Contractor's own cost but subject to the Engineer's approval regarding the details thereof.

In particular remedial measures, the Contractor shall ensure that the final product is in full compliance with the Specifications, shall not endanger or damage any other part of the Works and shall be carefully controlled and submitted to the Engineer for examination when completed or at any intermediate stage as may be required.

For the guidance of the Contractor an indication about what may be required in the more common cases of defects or damage is given below, but the Engineer will in no way be bound to approve of or adhere to the measures indicated, as the actual remedial measures will be dictated by the circumstances of each particular case.

118.1 Earthworks

(i) Where a cut slope has been over-excavated, reinstatement by backfilling will not normally be permitted. Either re-trim the entire slope to obtain a uniform slope or construct a stone masonry or a retaining wall in consideration of ROW.

(ii) Where the floor of a cutting has been over excavated it will normally require backfilling and recompaction with approved material (incl. Grade 20 concrete) of higher quality than the cut material. All necessary measures shall be taken to drain ground water that may accumulate in backfilled sections.

(iii) Excess widths of fills will need to be trimmed to the design profile.

(iv) Where erosion has occurred on the surface of cuts or fills, the damage shall be made good by backfilling with suitable material and re-trimming (for fills) or providing drain pipes (into the cut slopes). In more serious fill cases, the slope may have to be cut back and backfilled after benching and compacted to the required standard of compaction with suitable small equipment followed by retrimming. Provision of gabions, stone masonries or retaining walls shall be considered, if necessary.

(v) Over excavation of rock blasting on slopes shall be filled with Grade 20 concrete with 16 mm dowels driven in to the rock, as instructed by the Engineer. Over excavation on the road surface shall be filled with the concrete of same grade, as instructed by the Engineer, in such a way that no

water would be retained on the finished concrete surface. The cost of this work is deemed to be included in the rates for other items of the contract.

118.2 Local Defects in Pavement Layers

(i) Where remedial measures are taken to make good localised defects, the length and width of the area to be repaired by equipment shall be such as to accommodate the full width of the equipment used and of a reasonable length (if necessary, the whole section) to ensure effective repair.

(ii) The depth to which material shall have to be removed will depend on the defect and the type of material. Gravel layers will need to be broken up to a depth of at least 75 mm and crushed stone shall usually need breaking up over its full depth. Asphalt material shall normally require removal for its full depth.

118.3 Concrete

Defective concrete work will normally need the cutting back and complete removal of any weak or honey-combed sections and making good using approved bonding agents to bind fresh concrete to old concrete. Cracks, if permitted to remain, shall be injected with approved compounds and test cores obtained to test the efficacy of the injection process.

118.4 Payment

The Contractor shall undertake remedial work at his own expense. If defects are caused by solely other party's fault, the payment will be made according to the Specification.

SECTION 119

WATER SUPPLY ARRANGEMENTS

The Contractor shall make his own arrangements for the procurement, transportation, storage, distribution and application of water needed for construction and other purposes except where otherwise specified.

Only clean water free from undesirable concentrations of deleterious salts and other materials shall be used. All sources of water used shall be approved by the Engineer.

Mechanically driven and operated water bowsers with effective spray equipment shall be provided at all times to ensure that compaction can proceed without any hold up on account of watering.

119.1 Payment

Payment shall be made according to Pay Items 102 and 103.

SECTION 120

DESIGN BY THE CONTRACTOR

120.1 Scope of the Contractor's Design

Bridges

Within the permanent works, the Contractor shall prepare the detailed design of only the bridge portion listed in Table 120-1 to comply with the design specifications and requirements therein.

TABLE 120-1: Structures to be Designed by the Contractor

Bridge Location	Bridge Type	Total Length	No. of Bridges	Present Design	Required Design
1) A1 Interchange					
Main Line	Steel I-girder	322 m	1	Basic Design	Detailed Design
A1 Interchange Ramp	Steel box-girder	506 m	4	Basic Design	Detailed Design
2) Biyagama					
Main Line	PC I-girder	1,010 m	3	Basic Design	Detailed Design
B214 Interchange Ramp	PC I-girder	408 m	2	Basic Design	Detailed Design
		Alternative design			
Structures with present Basic Design:		Alternative design is acceptable.			
Structures with present Detailed Design:		Alternative design is NOT acceptable.			

Note: In any cases, the total cost of goods and services to be procured from Japan must be no less than 30 % of the total amount of contract and satisfy the STEP loan conditions.

Soft Ground Treatment is detail designed, not necessary to be designed by the Contractor (See details in Soft ground treatment section.).

1.3 Specifications for Detailed Design (D/D) of Bridges

The Contractor's D/D shall comply with the following specifications (Each application of the specification shall be approved by the Engineer.):

(a) Concrete bridges

BS 5400: Steel, Concrete and Composite Bridges,
Part 1: General Statement,
Part 2: Specification for Loads,
Part 4: Code of Practice for Design of Concrete Bridges.
Part 7: Specification for Materials and Workmanship, concrete, reinforcement and Prestressing Tendons,

Other reference specifications: Sri Lanka Bridge Code, Japanese standards and AASHTO.

(b) Steel Bridges

BS 5400: Steel, Concrete and Composite Bridges,
Part 1: General Statement,

Part 2: Specification of Loads,
Part 3: Code of Practice for Design of Steel Bridges,
Part 6: Specification for Materials and Workmanship, Steel
(Part 6 of BS 5400 specifies requirements for the materials, workmanship, handling and erection for the construction of steel bridges, including bolts and nuts.)

Materials of Structural steels shall comply with the requirements of:
BS EN 10025-2: 2004, Hot Rolled Products of Structural Steels
Part 2: Technical Delivery Conditions for Non-Alloy Structural Steels

If the Contractor wants to use other equivalent specifications of the structural steels, such as Sri Lanka's, Japanese and AASHTO's, he shall prove the equivalency and compliance with above BS specifications and get approval from the Engineer.

120.2 Purposes of Design Check by the Engineer

The Engineer's approval of the Contractor's design is required for all structures (including temporary structures), apart from minor structures. The purpose of the approval in principle stage is to enable the Engineer to be satisfied as to:

- Economy of the type and form of structure proposed within the overall scheme concept.
- Its suitability for the environment and sub-soil conditions.
- Its appearance, including the standards of finish to be adopted.
- Adequacy of geotechnical and other investigations.
- Loading and other design or assessment criteria proposed.
- Suitability of the design or assessment methods proposed for use in the final design.
- Application of Design Report prepared by the Engineer and various design specifications, codes and standards.
- Need for consultation with relevant authorities (RDA, Irrigation dept., SLLRDC etc.).
- Provision made for the inspection and maintenance of the structure.
- In the case of repair, strengthening or partial renewal works, the adequacy of the whole and all parts of the structure at all stages of the works to carry the required loading arrangement.

120.3 Definitions for Design Works.

The following definitions and responsibilities will apply for the design works.

"Designer" (for Basic design and Detailed design prepared by the Engineer): the Engineer.

"Designer" (for Detailed design and alternative design prepared by the Contractor or firm of Consulting engineers employed by the Contractor): the Contractor.

"Checker": The qualified engineers or firms of Consulting engineers employed by the Contractor, responsible for the check. The Engineer cannot be employed as checker by the Contractor because of conflict of interest.

"Design Team": the group of engineers employed by the Contractor, responsible for the design or assessment.

"Checking Team": the group of engineers employed by the Contractor, responsible for the check.

120.4 Design Assessment

The design or assessment must comply with the designated specifications. If any variations from or additions to the approved design prove necessary during the design, assessment or check, the Engineer must agree to them before they are implemented. Such variations must be recorded and signed by the Engineer, the Contractor and the Employer.

The Designer shall be responsible for the applicability and accuracy of all computer programmes used and also shall ensure the validity of the programme for each application.

120.5 Design Checking

A Checking Team which may be from the same office but must be independent of the Design Team shall check the design.

120.6 Qualification and Approval Procedure of the Contractor's Designs

(a) Approval of the Design Team

Before commencement of the detailed design, the Contractor shall submit following documents and get approval from the Engineer:

1) Design experience of the design firm or the Design Team (for steel and concrete bridges and soft ground treatment),

2) Detailed design example drawings prepared by the Design Team (for steel and concrete bridges and soft ground treatment),

3) CVs of key design team members (foreign and local),

4) Organisation chart of the design team (in Sri Lanka and abroad, including the number of CAD operators to be employed) and relation with the Contractor,

5) Design criteria, applicable standards and specifications, overall design schedule and

design software programs to be used.

(b) Approval of General Arrangement Drawings

After approval of the Design Team, the Contractor shall submit followings for the Engineer's approval:

1) Location plan,

2) Preliminary General Arrangement drawings (Plan, profile, elevation, typical cross sections, and piles),

3) Relevant parts of the site investigation report (incl. Geotechnical report) and interpretation,

(c) Submission of Detailed Design Drawings

After the General Arrangement drawings approval, the Contractor shall submit the detailed design drawings including followings:

1) NAME OF THE BRIDGE
2) PROPOSED STRUCTURE
(1) Description of Structure,
(2) Structural type
(3) Foundation type,
(4) Span arrangement,
(5) Skew and curve arrangement,
(6) Parapet type,
(7) Proposed arrangements for inspection and maintenance,
(8) Materials and finishes,
(9) Estimated quantities and cost of proposed structures with other structural designs considered and its comparative costs,

3) DESIGN/ASSESSMENT CRITERIA
(1) Live Loading, Headroom
(1)-1 Standards and Specifications applied
(1)-2 HA loading (Normal traffic loading),
(1)-3 HB loading (Abnormal traffic loading),
(1)-4 Footway or footbridge live loading,
(1)-5 Provision for exceptional abnormal loads,
(1)-6 Any special loading not covered above,
(1)-7 Min. headroom provided,
(1)-8 Authorities consulted and any special conditions required,
(2) Proposed departures from standards and methods not covered by standards

4) STRUCTURAL ANALYSIS
(1) Methods of analysis proposed for superstructure, substructure and foundations,
(2) Description and diagram of idealised structure to be used for analysis,
(3) Assumptions intended for calculation of structural element stiffness,
(4) Proposed earth pressure coefficients (ka, ko or kp) to be used in design of earth retaining elements.

5) GROUND CONDITIONS
   (1) Acceptance of interpretative recommendations of the soils report to be used in the design and reasons for any proposed departures,
   (2) Describe foundations fully including the reasons for adoption of allowable and proposed bearing strata and pile load, in which foundations are located. Provision for skin friction effects on piles and for lateral pressures due to compression of underlying strata, etc.
   (3) Differential settlement to be allowed for in design of structure,
   (4) Anticipated ground movements or settlement due to embankment loading, chemical contents, flowing water, measures proposed to deal with these effects as far as they affect the structure,
   (5) Results of test of ground water and any counteraction measures proposed.

6) CHECKING
   (1) Name of proposed Independent Checkers,
   (2) Erection proposals or temporary works for which the Contractor will be required to arrange an independent check
7) DRAWING AND DOCUMENTS
   (1) List of drawings (incl. No.) and documents accompanying the submission.

120.7 Amendments to the design

It is responsibility of the Engineer to inform the Employer of any amendments to the design during construction, which have structural implications. If proposed erection procedure induces different stresses in the completed structure from those anticipated in the design, the changes will need to be approved by the Designer and the Engineer before erection commences.

120.8 Rates in Permanent Works Designed by the Contractor

Where the Contractor designed part(s) of the Permanent Works, the rates and prices in the BOQ shall include for all the obligations and costs associated with the Contractor's design including provision of data and drawings, certificates, awaiting approvals (in principle within 7 days), resubmissions (in principle within 7 days) and modifications and amendment to the Works.

Additionally the rates and prices in the BOQ shall include for the costs of all testing to prove the Contractor's design.

120.9 Rates in Structures Designed by the Contractor

The Contractor shall prepare the detailed design and priced BOQ for the structures defined in Clause 120.1 and get approval from the Engineer.

120.10 Measurement

Bridge Detailed Design

Bridge detailed design for A1 Interchange (Steel I and box-girders) and Biyagama (PC

I-girder) will be in lump sum and measured monthly in proportion to the design progress.

120.11 Payment

Payment for the detailed design prepared by the Contractor shall be paid separately for A1 (steel bridges) and Biyagama (concrete bridges) Interchanges. The payment shall be made monthly in proportion to the design progress.

	Pay Item	Unit of Measurement
120 (1)	Detailed Design for Steel Bridges (incl. alternative design, if applicable)	Lump Sum
120 (2)	Detailed Design for Concrete Bridges (incl. alternative design, if applicable)	Lump Sum

SECTION 200

EARTHWORKS

SECTION 201

CLEARING AND GRUBBING

201.1 Description

The Contractor shall clear, grub, remove and dispose of vegetation and debris within designated limits. Removal of existing structures is designated in Section 202.

201.2 Construction

Clearing and Grubbing:

Where embankment fill is to be constructed, all topsoil shall be removed to an average depth of 200 mm. All surface objects, all trees, including stumps and roots, stumps and roots of previously felled trees, overhanging branches, except those trees and objects that the Engineer directs to be left undisturbed, shall be cleared and grubbed subject to the following provisions:

(a) Mow as required.

(b) Disregard all undisturbed and sound stumps and non-perishable solid objects more than 1 m below subgrade and embankment slopes.

(c) Leave stumps and non-perishable solid objects that extend less than 75 mm above the ground line or low water level when they are outside excavation and embankment areas.

(d) Cut stumps flush or below the final slope line. Holes left by removal of the stumps or roots shall, within one week, be filled with acceptable material and be compacted.

(e) Preserve trees, shrubs, plants and other objects to remain within established limits.

(f) Dispose of material and debris.

(g) Bury disposable material and debris at designated locations with at least 300 mm of cover material.

(h) Obtain written arrangements with property owners and government authorities for disposal locations outside the right-of-way limits.

(i) Remove low-hanging and unsound branches from remaining trees or shrubs. Use proper tree surgery practices to trim tree branches. Trim branches of trees extending over the roadbed to provide a clear height of at least 6 m. Seal the cut or scarred tree or shrub surfaces with an adequate material made for tree surgery.

(j) Where, as a consequence of clearing and grubbing, fill material is required in order to restore the original ground level, it shall be acceptable fill material which shall be compacted to the density prescribed for layers at that depth below finished subgrade. Such replacement of materials shall be considered incidental to clearing and grubbing and shall not be measured for payment. Acceptable fill material for backfilling depressions or excavations shall include brick, stone and concrete debris if approved by the Engineer and

this material shall be compacted in layers to achieve stable backfill to the approval of the Engineer.

Disposal of Cleared Material:

(a) Saleable timber as designated by the Engineer shall be neatly stored in an approved accessible place within or near the right of way as directed and shall be trimmed and staked in accordance with the requirements of the appropriate Government agency to which the timber belongs.

(b) Unsaleable timber may be used by the Contractor for his own purposes in connection with the Contract always provided that he has ascertained and complied with the requirements of the appropriate Government agencies or authorities.

(c) All unsaleable timber except that to be used, and all brushes, stumps, roots, logs and other refuse from the clearing and grubbing operations shall be burned or be disposed by other means approved by the Engineer.

In such cases the Contractor shall be responsible for making the necessary agreements with assistance by the Employer and for paying the resulting expenses.

Piles of material for burning shall be placed either at or near the centre of the cleared area, or in adjacent open spaces where no damage to trees, other vegetation and adjacent property shall occur.

All burning shall be done in conformance with the regulations and at such times and in such a manner as to prevent the fire from spreading to areas adjoining the right of way.

(d) Should the clearing and grubbing be done at a time when burning is not permitted, the Contractor shall pile all material which is to be burned outside the slope lines and, at a time when burning is permitted, he shall return such material to the grade and burn it.

(e) At the end of such operations the roadway and adjacent areas shall be left with a neat and finished appearance. No accumulation of burnt, half burnt or other material shall remain on or adjacent to the right of way.

201.3 Ownership of Timber

All trees or timbers removed by the Clearing and grubbing belong to the former owner or the appropriate government agencies or authority in accordance with the instructions of the Employer. The Contractor shall dispose of unclaimed and unusable materials as directed by the Engineer. The Contractor shall have no ownership rights to the materials.

201.4 Preservation of Property

Existing roads, improvements, facilities, adjacent property, utilities, services, and trees and plants designated for preservation shall be carefully protected from injury or damage, which could result from the Contractor’s operations.

201.5 Measurement

- Clearing and grubbing will be paid for by the square metre.
- Removing of trees and stumps less than 300 mm in girth are classified 201 (1), Clearing and grubbing.
- Neither the work of clearing nor grubbing, disposal sites, material sites, nor imported borrow pit sites shall be paid for when such sites are outside the areas designated for clearing or grubbing. The Contractor is permitted to exercise his own option as to whether he selects to use such disposal sites or borrow pit sites.
- Removal of trees shall be measured in numbers as indicated in the Bill of Quantities.
- The girth of trees to be measured 1 m above the ground.
- Stumps to be measured by taking the average girth at the cut off.

201.6 Payment

This work measured as provided above shall be paid for at the Contract unit prices as detailed below per square metre or as number. The payment shall be full compensation for furnishing all labour, materials, tools, equipment and incidentals necessary to do the work in the designated areas and as specified in these Specifications and the Special Provisions and as directed by the Engineer.

The payment shall include:

- demolition, breaking up, removal and transport,
- tree felling,
- grubbing up and blasting stumps and roots including backfilling and compaction,
- uprooting bushes and small trees,
- disposal of material,
- cutting back trees and bushes,
- sealing services and supplies,
- reinstatement and making good,
- preservation of individual or groups of trees, shrubs and the like.

Pay Items	**Unit of Measurement**
Site Clearing	
201(1) Clearing and grubbing	square metre

Removal

201(2)	Removal of trees 300 mm to 1,000 mm in girth	number
201(3)	Removal of trees 1,000 mm to 2,000 mm in girth	number
201(4)	Removal of trees girth exceeding 2,000 mm	number
201(5)	Removal of stumps and roots of previously felled Trees 300 to 1,000 mm in girth	number
201(6)	Removal of stumps and roots of previously felled Trees 1,000 to 2,000 mm in girth	number
201(7)	Removal of stumps and roots of previously felled Trees in girth exceeding 2,000 mm	number

SECTION 202

REMOVAL OF EXISTING STRUCTURES

202.1 Description

The Contractor shall demolish, remove, dispose of, or salvage buildings, fences, structures, pavements, abandoned pipelines or utilities and other obstructions and backfill cavities. All designated salvable materials should be removed, without unnecessary damage, in sections or pieces which may be readily transported and shall be stored by the Contractor at specified locations.

Prior to the work, the Contractor shall submit his "disposal plan" to the Engineer for approval. The disposal plan may have following two cases, both of which shall be included in the unit price.

Disposal of Materials within the ROW (but outside the embankment areas)

All waste materials (incl. wooden forms), debris or unsuitable and cleared material shall be either burned or buried or appropriately disposed by the methods and at locations approved by the Engineer and within the ROW.

Disposal of Materials outside the ROW

The Contractor shall make all necessary arrangement for the disposal outside the ROW with local government sectors concerned or property owners. The Employer will assist the Contractor to get the permission, however the final responsibility rests on the Contractor.

202.2 Construction Methods

2.1 Items to be Removed and Included works

Removal of existing structures for re-use or remove to store or tip off Site shall include the following items:

(a) Blockwork, stonework, wells, septic tanks, soakage pits, waste water pits and graves.
(b) Paved area and the like.
(c) Brickwork.
(d) Kerbs, channels, edgings, combined drainage and kerb blocks, linear drainage channel systems, fencing, safety fences, safety barriers and pedestrian guardrails and the like.
(e) Copings, string courses and the like.
(f) Cable
(g) Road lighting columns, brackets and wall mountings, traffic signs, gates, stiles, street furniture, road studs and the like.
(h) Feeder pillars, communications cabinets, posts, brackets, signal indicators and the like.
(i) Shelves, racking, frames and the like.

(j) Electronic units and the like.
(k) Chamber covers and frames, gully gratings and frames and the like.
(l) Individual blocks, features or stones.

The work shall include:

(a) Excavation, detensioning, dismantling and extracting.
(b) Cleaning, stacking, protecting and labelling.
(c) Transport and handling.
(d) Disconnecting, removing, disposing of and sealing of existing utility services and supplies (except Items in Section 7.12, Diversion of Utilities)
(e) Backfilling and compaction.
(f) Making good to severed ends of existing walls, hedges, and fencing.
(g) Disposal of material.
(h) Reinstatement and making good.
(i) Storage facilities.

2.2 Bridges, Culverts and other Drainage Structures

Existing structures upon or adjacent to the proposed road shall be removed by the Contractor, as indicated on the Drawings or as required. Where existing bridge structures may be used as a temporary crossing or detour, no part of the removal shall be performed unless otherwise indicated on the Drawings or in the Special Provisions, nor shall the structure be closed or obstructed until the new work is opened to traffic by the Engineer.

Any structure or part of a structure that can be used elsewhere shall be given identification marks to each piece, then carefully dismantled and stored in a designated area or as required by the Engineer. The recovered material shall be the property of the Employer.

The removal of pipes, culverts, chambers and foundations below existing ground levels and above earthworks outlined shall be carried out in accordance with the specification for earthworks. Where these hard objects extend below earthworks outline, the Contractor shall remove them and refill the resulting void. All solid construction shall be broken down and removed to a depth of 0.3 m below carriageway formation and 0.3 m below kerbs and footway construction.

Voids extending below these levels shall be backfilled and compacted with acceptable material or where compaction is impractical, they shall be filled with Grade 7.5/20 concrete.

The Contractor shall agree a method with the Engineer for filling redundant pipes which remain below the levels referred to above. This method shall demonstrate that the fill material can penetrate the full length of the pipe to be grouted or such smaller length as the pipe may be divided up into.

2.3 Extent of Removal

When the Drawings provide for using the existing substructures, or part of same, as permanent parts of the new structure, only those portions indicated on the Drawings to be removed shall be removed. When no such use is contemplated, all portions of the existing structures shall be

completely removed as directed by the Engineer. When the proposed structure is a bridge, and it becomes necessary to remove the portions of the existing structure below ground in order to construct the new work, such removal will be classed as excavation as provided for in Section 501 Excavation and Backfill for Structures.

2.4 Salvaged Materials

When pipe culverts, wooden boxes or other structures with a salvage value are removed, extreme care shall be exercised in their removal and the material involved kept intact without damage. The Contractor shall be held responsible for the satisfactory removal of such structures in a usable condition

Salvaged pipe culverts, wooden boxes or other structures shall be stored at approved accessible points along the project and shall become the property of the former owner. The Contractor shall handover them, get their receipts and forward the receipts to the Engineer. Others shall be disposed of by him.

All material, which is not considered of value by the Engineer, shall be removed from the ROW, or so disposed of upon the ROW as not to constitute an obstruction or a nuisance.

2.5 Buildings

Buildings and dwellings constructed from concrete, steel, brickwork or block-work shall be demolished in a safe fashion. Demolition shall also include the removal of floor slab and foundations. The removal of outbuildings, shelters and timber buildings or dwelling shall be included under Section 201.

202.3 Measurement

Only major quantities of Removal of Existing Structures are listed in the Bill of Quantities.

Removal of existing concrete structures (except items 202 (2), (3) and (4)) shall be measured by cubic metres.

The measurement of masonry, concrete pipe culverts and box culverts shall be by number of removals.

Excavation below these levels and outside these planes will not be measured nor paid for except where the Engineer directs excavations additional to that specified on the Drawings, which shall be measured under the Excavation and Backfill for Structures items.

The measurement for the removal of existing buildings or dwellings shall be determined by building area, and the number of stories high. The area of the building shall be at foundation level, rounded to the nearest square metre.

202.4 Payment

If the Contract contains a separate item for the removal of an existing structure or building then that item shall be payment in full for the removal and disposal of the existing structures as

specified herein.

The payment shall be full compensation for the removal and disposal of the existing structures as specified herein.

Pay Items	Unit of Measurement
202(1) Removal of existing concrete structures	cubic metre
202(2) Removal of existing masonry structures	cubic metre
202(3) Removal of existing building- Floor area	square metre
202(4) Removal of existing pavement	square metre
202(5) Cut of Existing pavement	meter

SECTION 203

EXCAVATION AND EMBANKMENT

203.1 Description

(a) General

Both the Employer (the implementing agency) and the Engineer (the construction supervisor) shall provide sufficient guidance and assistance to the Contractor on the following fields of the construction because these issues will extensively affect the total construction schedule:

1) Arrangement and approval of borrow pits, quarries (incl. blasting) and waste disposal areas.
2) The residents' property survey.
3) Coordination with local agencies and communities (in particular local complaints, utility relocations and road transport for construction).

(b) Video Compact Disk (VCD) and Soil Investigation before Start of the Works

- The Contractor shall record the site conditions with VCD as per Section 100, Preliminaries, before start of the Works.
- The Contractor shall carry out additional soil investigations to determine the construction method of the earthworks according to the Engineer's direction. They will be required before and during the Works from time to time. The cost is included in Provisional sum.

(c) The Contractor shall excavate, haul, dispose of, place and compact specified materials necessary to construct the Project safely. The earthworks will include followings:

- Carriageway, hard shoulder, hard strip, footway, paved area, verge, and side slope;
- Fill on embankment, subgrade, capping (selected subgrade on the upper 200 mm if CBR<15), sub-base material and road base;
- Excavation, removal and disposal of existing road pavement within the limits of construction.
- Excavation for removal of slides, breakages and cave-ins.
- Excavation for new, enlarged or diversion watercourses except where covered under Section 600 Drainage.
- Excavation required in cuts below subgrade level or under embankment below the lowest normal limit of excavation indicated on the Drawings, or below ground line for the removal or replacement of unsuitable material, or below ground line under embankments where benching is required or as otherwise instructed.
- Dewatering, including temporary works such as temporary dykes (or temporary cofferdam as necessary)
- Sub-grade preparation

- Clearing abandoned watercourses;
- Removal of surcharge
- Landscape areas.
- Excavation not specified elsewhere but nonetheless required for a proper execution of the Works.
- Excavation and Backfill for Structures is included in Section 501.
- Removal of Existing Structures is included in Section 202.
- Soft Ground Treatment is included in Section 204.
- Excavation for ditches, channels, berm ditches, drains and flumes is not included in Earthworks but included in Section 600 Drainage.

(c) The Contractor shall employ only equipment and working methods which are suited to the materials to be handled and traversed. He shall be responsible for maintaining the nature of the acceptable material so that when it is placed and compacted, it remains acceptable in accordance with the Contract.

(d) When the excavation reveals a combination of acceptable and unacceptable materials, the Contractor shall carry out the excavation in such a manner that the acceptable materials are excavated separately for use in the Permanent Works without contamination by the unacceptable materials. Classes of fill material required to be deposited separately shall be excavated separately without contamination by other Classes of material.

(e) The Contractor shall make his own arrangements for stockpiling of acceptable material, unacceptable material to be processed, and for the provision of sites for the purpose.

(f) The Contractor shall ensure that he does not adversely affect the stability of excavations or fills by his methods of stockpiling materials, use of plant or siting of temporary buildings or structures.

(g) Excavations for foundations and trenches shall be adequately supported at all times and shall not be battered. The additional work and materials shall be provided by the Contractor. Sheeting and other excavation supports shall be removed as filling proceeds except where they are required to be left in position.

(h) Excavations requiring backfilling shall remain open only for the minimum period necessary.

(i) The Contractor shall keep earthworks free of water including:

- Arranging for the rapid removal of water: -falling on the earthworks, -entering the earthworks from any source.
- Lowering and maintaining by appropriate measures, the water level in excavations, sufficiently to enable the Permanent Works to be constructed.

(j) In carrying out the requirements of sub-Clause (g), the Contractor shall:

- Form and maintain cuttings, embankments and other areas of fill with appropriate falls and gradient and sealed surfaces.

- Provide where necessary temporary watercourses, drains, pumping and the like.
- Discharge accumulated water and groundwater into the permanent outfalls of the drainage system where practicable.
- Provide adequate means for trapping silt on temporary systems discharging into permanent drainage systems.

203.2 Classification, Definitions and Uses of Earthworks Materials - General Classification

2.1 Earthworks materials shall fall into one or other of the following general classifications:

- Acceptable material: material excavated from within the Site or imported on to the Site which meets the requirements of Tables 203-1 and 203-2 for use in the Permanent Works;
- Unacceptable material Class U1 as defined in sub-Clause 2.2 of this Clause: material excavated from within the Site which, unless processed so that it meets the requirements of Tables 203-1 and 203-2 shall not be used in the Permanent Works;
- Unacceptable material Class U2 as defined in sub-Clause 2.3 of this Clause: material excavated from within the Site which shall not be used in the Permanent Works.

TABLE 203-1

Acceptable Earthworks Materials: Classification and Compaction Requirements

Note) mc: moisture content, OMC: Optimum Moisture Content, MCV: Moisture Condition Value

Class and General Material Description	**Material Properties Required for Acceptability**				**Compaction Requirements**
	Property	**Defined and Tested in accordance with:**	**Acceptable Limits within:**		
			Lower	**Upper**	
General Granular Fill Typical Use: **General Fill**					
Any material or combination of materials, 1A: Water graded granular material. 1B: Uniformly graded granular material. 1C: Coarse granular material	Grading	BS 1377: Part 2	Table 203-2	Table 203-2	95% maximum dry density BS1377: Part 4, Heavy compaction test, 4.5kg rammer.
	Uniformity coefficient	Ratio D_{60} to D_{10}	10 (for 1A), 5 (for 1C)	10 (for 1 B)	
	mc	BS 1377: Part 2			
	MCV	Heavy Compaction BS 1377: Part 4			
	Los Angeles coefficient	BS EN 1097-2		50 (for 1C)	
General Cohesive Fill Typical Use: **General Fill**					
Any material or combination of material, 2A: Wet cohesive material, 2B: Dry cohesive material, 2C: Stony cohesive material, 2D: Silty cohesive material	Grading	BS 1377: Part 2	Table 203-2	Table 203-2	95% maximum dry density BS1377: Part 4, Heavy compaction test, 4.5kg rammer.
	Plastic Limit (PL)	BS 1377: Part 2			
	mc	BS1377: Part 2	PL- 4% (for 2A)	PL- 4% (for 2B)	
	MCV	Heavy Compaction BS 1377: Part 4		-	
	Undrained shear strength remoulded material	BS1377: Part 7			
Selected Granular Fill					
	Grading	BS 1377: Part 2	Table 203-2	Table 203-2	
	Uniformity coefficient	Ratio D_{60} to D_{10}	10 (for 6A),	10 (for 6C)	
	Plasticity index	BS1377: Part 2	Non plastic		
	Los Angeles coefficient	BS EN 1097-2		50 (for 6B & 6C)	
	mc	BS1377: Part 2			

TABLE 203-1 (cont'd)

Class and General Material Description	Material Properties Required for Acceptability				Compaction Requirements
	Property	Defined and Tested in accordance with:	Acceptable Limits within:		
			Lower	Upper	
Selected Granular Fill					
Recycled aggregate 6F1: Selected granular material (fine grading for capping), 6F2: Selected granular material (coarse grading for capping), Natural and crushed aggregate 6H: Selected granular material (Backfilling for drainage)	Grading	BS1377: Part 2	Table 203-2	Table 203-2	
	Optimum mc	BS1377: Part 4 (vibrating hammer method)			
	mc	BS1377: Part 2	Optimum mc - 2% (for 6F1 & 6F2)	Optimum mc (for 6F1 & 6F2)	
	Los Angeles coefficient	BS EN 1097-2		60 (for 6F1), 50 (for 6F2 & 6H)	
	Plasticity index	BS 598: Part 102		2.0 % (for 6F1) Non-plastic (for 6H)	
	Bitumen content	BS 598: Part 102		2.0 % (for 6F1 & 6F2)	
Selected Granular Fill Typical Use: **Fill to structures**					
6N: Selected well graded granular material 6P: Selected granular material	Grading	BS 1377: Part2	Table 203-2	Table 203-2	95% maximum dry density BS 1377: Part 4 Heavy compaction test, 4.5kg rammer or Vibrating hammer method (for granular material)
	Uniformity coefficient	Ratio D_{60} to D_{10}	10 (for 6N), 5 (for 6P)		
	Los Angeles coefficient	BS EN 1097-2		40 (for 6N), 60 (for 6P)	
	Undrained shear parameters (c & ϕ)	BS 1377: Part 7			
	Effective angle of internal friction (ϕ ') and effective cohesion (c')	BS 1377: Part 7			
	Permeability				
	mc	BS 1377: Part 2			
	MCV	Heavy Compaction BS 1377: Part 4			

TABLE 203-1 (cont'd)

Class and General Material Description	Material Properties Required for Acceptability				Compaction Requirements
	Property	Defined and Tested in accordance with:	Acceptable Limits within:		
			Lower	Upper	
Selected Cohesive Fill Typical Use: **Fill to structures**					
7A: Selected Cohesive material	Grading	BS1377: Part 2	Table 203-2	Table 203-2	95% maximum dry density BS1377: Part 4 Heavy compaction test, 4.5kg rammer or Vibrating Hammer method (for granular material)
	mc	BS1377: Part 2			
	MCV	Heavy Compaction BS 1377: Part 4			
	Undrained shear parameters (c & ϕ)	BS 1377: Part 7			
	Effective angle of internal friction (ϕ ') and effective cohesion (c')	BS 1377: Part 7			
	Liquid limit	BS 1377: Part 2		45	
	Plasticity Index	BS 1377: Part 2		25	

TABLE 203-2 Grading Requirements for Acceptable Earthwork Materials

Class	% by Mass Passing the Size Shown																	
	Size (mm), BS Series													Size (microns), BS series				
	500	300	125	90	75	37.5	20	10	6.3	5	3.35	2	1.18	600	300	150	63	2
1. General granular fill																		
General fill (Rock fill)																		
1A. Well graded granular material		100	95-100														<15	
1B. Uniformly graded granular material			100														<15	
1C. Coarse granular material	100		10-95											0-25			<15	
2. General cohesive fill																		
General fill																		
2A. Wet cohesive material			100									80-100					15-100	
2B. Dry cohesive material			100									80-100					15-100	
2C. Stony cohesive material			100									15-80					15-80	
2D. Silty cohesive material			100														80-100	0-20
6. Selected granular fill																		
6A. Below water, Selected well graded granular material	100							0-100		0-85				0-45			0-5	
6B. Starter layer, Selected coarse granular material	100		0-10															
6C. Starter layer, Selected uniformly graded granular material			100			0-100			0-100		0-35	0-10		0-2				
6F1. Capping, Selected granular material (fine grading)					100	75-100		40-95		30-85				10-50			<15	
6F2. Capping, Selected granular material (coarse grading)			100	80-100	65-100	45-100		15-60		10-45				0-25			0-12	
6H. Selected granular material (backfilling for drain)							100			60-100			15-45	0-25		0-5		
6N. Fill to structures, Selected well graded granular material					100												<15	
6P. Fill to structures, Selected granular material					100												<15	
7. Selected cohesive fill																		
7A. Fill to structures, Selected cohesive material					100												15-100	

Source) Specification for Highway Works, the Highways Agency, UK, 2007.

2.2 Unacceptable material Class U1 shall be:

(a) Material which does not comply with the permitted constituents and material properties of Tables 203.1 and 203.2 for acceptable material;

(b) Material, or constituents of materials, composed of the following:

- Peat, materials from swamps, marshes and bogs;
- Logs, stumps, and perished material;
- Clay having a liquid limit determined in accordance with BS1377: Part 2, exceeding 90 or plasticity index determined in accordance with BS 1377: Part 2, exceeding 65.

2.3 Unacceptable material Class U2

Unacceptable material Class U2 shall be material having hazardous chemical or physical properties requiring special measures for its excavation, handling, storing, transportation, deposition and disposal.

2.4 Unacceptable material

Unacceptable material may be processed by mechanical, chemical or other means to render the material acceptable for use in the Permanent Works in accordance with the requirements of Table 203-1.

2.5 Soil Acceptable for Fills

Soil acceptable for fill shall include all acceptable materials excavated in accordance with the Specification, which are not otherwise specified as hard rock, boulders, unsuitable soil, road pavement excavation, slipped material from slopes, or subgrade replacement. They can be excavated with bulldozer, excavator, loader, grader and ripper (tractor power 400 HP with reasonable ripping output).

2.6 Hard Rock

Hard rock is defined as all materials which, in the opinion of the Engineer, require blasting, or the use of metal wedges and sledgehammers, or the use of compressed air drilling for its removal and which cannot be extracted by ripping with a tractor power of at least 400 HP, with a new single rear mounted heavy duty ripper. Hard rock shall not include boulders less than 1 (one) cu.m. in size.

2.7 Boulders

Boulders shall comprise solid pieces of rock that are weathered on all faces (boulders) that are between 0.25 cu.m. and 1 cu.m. in volume. Boulders that exceed the stated volume shall be classified as Hard Rock.

Measurement of boulders will be taken as the maximum dimension along the longest axis of the

boulder (length) multiplied by the area of a circle of a circumference equal to the measured girth of the boulder at its widest point.

2.8 Selected Fill for Embankment

Selected fill for embankments consists of:

- Selected material,
- Drainage layer
- Porous backfill
- Permeable backfill

in Table 203-1 for classification and Table 203-2 for grading requirements.

2.9 Stabilisation

Stabilisation shall mean the spreading of cement or lime or both on a layer of deposited or intact granular or cohesive material, and the subsequent process of pulverising and mixing followed by appropriate compaction to form the whole or a constituent layer of a capping.

2.10 Use of Fill Materials

In addition to any grading requirements the maximum particle size of any fill material shall be no more than 2/3 of the compacted layer thickness except that cobbles having an equivalent diameter of more than 150 mm shall not be deposited beneath verges or central reserves within 1.3 m of the finished surface.

2.11 Capping Layer or Subgrade with Selected Material

The material used for Embankment Construction in the Top 200 mm Layer (Subgrade) shall be granular fill or cohesive fill which shall not include highly plastic clay, silts, peat or any soil that is contaminated with top soil, vegetables or other unsuitable materials. The capping layer shall conform to the requirements of Classes 6F1, 6F2 or other stabilised ones in Tables 203-1 and 203-2.

203.3 Construction

3.1 Forming of Cuttings and Cutting Slopes

(a) Office Work

Considerable office work shall be done before field work starts. The Contractor shall check the Cross section drawings before and during the Works and up-date working drawings for slope cutting, embankment and soft ground treatment.

(b) Rock cross sections

- When rock is encountered, the rock area shall be cross-sectioned as soon as the overburden has been removed. The demarcation between rock and earth should be agreed between the Engineer and the Contractor.
- Rock sections shall be taken at the stations where original cross sections were taken, plus any additional sections that will be needed to arrive at the correct volume of rock excavation.
- Broken rocks shall be moved endways or sideways sufficiently to expose an area of at least one-half the width of the cut so that a true section can be taken. After sectioning this half, the remaining half shall be exposed for sectioning in a similar manner.

(c) Slope stakes

- Where rocks are encountered, the Contractor shall set new slope stakes on the top of the rocks, using the typical grade shown on the typical cross sections.
- The Contractor shall design the transition parts between the soil and rocks, so that the two cutting surfaces and the steps are smoothly and neatly connected.
- When water seepage is observed at the cutting section (at the rock or soil), the Contractor shall provide adequate measures (like horizontal drain) in consultation with the Engineer.

(d) Blasting

Where pre-split blasting is required or permitted, it shall comply with relevant clauses and any other requirements. Full details of the methods and arrangements to be adopted shall be made available to the Engineer before commencement of drilling operation.

3.2 Common Excavation

The Contractor shall:

- Excavate and use or dispose of all material encountered including soft rock not otherwise classified.
- Clear, grub and remove topsoil before beginning excavation, grading and embankment operations.
- Finish excavation and embankment surfaces smooth and uniform.
- Obtain the Engineer's approval before wasting excavation material.
- Excavate and perform embankment operations without disturbing material outside staked construction limits.
- Dispose of surplus or unacceptable excavated material. Obtain written arrangement with property owners and governmental authorities for disposal locations outside the Right-of-Way limits.
- Use suitable surplus material to widen embankments and flatten slopes within the Right-of-Way subject to the Engineer's approval.
- Cover rocks and boulders with at least 300 mm of embankment material.
- Place no excess or unacceptable material in wetland.
- Form natural and rounded slopes at borrow pits.

- Remove and dispose of pavement and base courses under Clearing and Grubbing.

Dewatering:

The Contractor shall keep earthworks free of water including:

(a) Remove quickly water shedding on to the earthworks.

(b) Stop water entering the earthworks from any source.

(c) Lower and maintain the water level sufficiently low to enable the excavation works, with appropriate measures like pumping.

Pumping etc.:

The Contractor shall:

(a) Form and maintain cutting, embankments and other area of fill with appropriate falls and gradient and sealed surface.

(b) Provide where necessary temporary watercourses, drains, pumping and the like.

(c) Discharge accumulated water and groundwater into the permanent outfalls of the drainage system where practicable.

(d) Provide adequate means for trapping silt on temporary systems discharging into permanent drainage systems.

Replacement of soft ground:

For replacement of Soft ground, the procedure will be as follows:

(a) Lower the water level with adequate water pumps as low as possible, including temporary works such as temporary dykes (or temporary cofferdam as necessary).

(b) Excavate the Softground (incl. Peat) for replacement and dispose of the material to the designated locations (The Contractor shall search the locations with assistance by the Employer.)

(c) Place rock in one or two layers at the bottom of the excavation, depending on the conditions.

(d) Fill the granular materials (from quarry; see 204.2, 2.1 Gravel) on the bottom rocks and compact up to required densities until reaching the required level.

3.3 Rock and Boulder Excavation

The Contractor shall excavate the rock and boulder to the lines and levels estimated and designed in the drawings. The Contractor shall choose most effective method for the excavation, such as blasting, compressed air drilling and ripping. It shall include all boulders and detached stones with a volume of 0.25 cu.m or more. The Contractor shall get required permission for blasting from relevant agencies, including Central Environmental Agency (CEA), with assistance by the Employer and shall meet their requirements.

Excavate material classified as rock to a depth between 150-300 mm below the subgrade top level.

- Shape the rock surface to drain.
- Backfill to subgrade under Embankment.
- Pre-split rock slopes when specified. Plan diameter, spacing and loading pre-split holes to produce a neat break. Drill pre-split holes to the full depth of the ledge.
- Demonstrate to the Engineer with a 30-m test section that diameter, spacing and loading will produce an acceptable back slope. Continue pre-splitting if the back slope is acceptable. Establish another test section until satisfactory results are obtained.
- Handle and load explosives to manufacturer's recommendation.

Vibration by machines, Explosives and Blasting for Excavation

(a) Interim Standards on Vibration Pollution Control by Central Environmental Authority (CEA) in Sri Lanka, dated 4 July 2002, Ref. No.07/05/67/2K2- CoV. Some extracts are presented below:

- The Contractor shall follow Maximum allowable Vibration in PPV (mm/sec.) for the operation of Machinery, Construction Activities and Vehicle Movement Traffic.

Category of the structure of the building (ISO 4866:1990E):

Type 3:

Single and two-story houses 6 buildings made of lighter construction like bricks.

Category of structure	Type of vibration	Frequency of vibration (Hz)	Vibration in PPV (mm/sec)
Type 3	Continuous	0-10	1.0
		10-50	2.0
		Over 50	4.0
	Intermittent	0-10	2.0
		10-50	4.0
		Over 50	8.0

Note) PPV: Peak Particle Velocity

- Vibration for Blasting Activities.

Category of structure	Type of vibration	Type of Blasting	Ground vibration in PPV (mm/sec)	Air blast over pressure (dB(L))
Type 3	Impulsive	Multi bore hole with delay detonators	5.0	115

Trial blasting shall be made under supervision of CEA. For example, in STDP ADB section, following blasting was approved by CEA:

Dia. of drilling for blasting: 76 mm,

Drilling depth: 8 m (max) & 6 m (average),

No. of blasting holes: 10 holes.

- Vibration for the Inconvenience of the Occupants in Buildings, see the standards.
- To satisfy above requirements, if relocation of residents outside the ROW is required, the Contractor shall relocate them to appropriate places at the Contractor's own cost before start of the operation.

(b) Quarry for rock material shall be carefully selected in consultation with Geological Survey & Mines Bureau (GS & MB). Licenses for all borrow pits and quarry sites shall be obtained from GS & MB together with the required clearances/permits from the CEA/relevant authority, whenever required.

(c) Crusher operations by the Contractor shall be approved by both CEA and relevant local authorities prior to commencement of the operation.

(d) Routes for transport of quarry and borrow materials by the Contractor shall be agreed by relevant traffic authorities.

3.4 Borrow Excavation

The Contractor shall provide borrow material meeting specifications from off the Right-of-Way or from outside excavation limits.

- Make arrangements and pay all costs involved in procuring borrow. Permit the Engineer to check the quality and quantity of the borrow materials before entering the contract with the supplier.
- The Engineer may have identified certain borrow areas outside the ROW which are expected to provide material in compliance with the Specification. It is the Contractor's responsibility to satisfy himself that the quantity and quality of material available in such areas meets the requirements of the Specification for use in the Works. No claims in this respect, nor regarding any licensing arrangements, shall be considered by the Employer.
- Use suitable and available common and rock excavation before using borrow excavation. Obtain approval to use borrow in lieu of on-site excavation. Grade borrow areas uniformly to drain.

3.5 Unsuitable (or Unacceptable) Excavation

Excavation will be considered unsuitable if it contains deposits of saturated or unsaturated soil mixtures or organic matter (including peat) unacceptable for embankment material by the opinion of the Engineer.

- When the removal of unsuitable material for replacement is needed up to 3-6 m or more deep, the Contractor shall provide sufficient protection for the surrounding buildings, structures and wells so that they won't be affected by the ground water lowering caused by the replacement.

- Remove unsuitable material found in the subgrade. Excavate to the specified or directed depth. Backfill and compact under Clause 3.6 Embankment.
- Dispose of material that cannot be properly stabilised and compacted under Clause 3.6 Embankment.
- The Contractor shall make his own arrangements for stockpiling of unacceptable material to be processed and disposed.
- The Contractor shall utilise the excavated peat as much as possible for topsoil and minor fillings. The excessive quantities of peat shall be disposed of in and out of ROW where the Engineer and the Employer approved.

3.6 Embankment

The Contractor shall:

- Control embankment work not to worsen the flood conditions in the site and protect the embankment during the flood time. (Excavation and Backfill for Structures are specified in Section 501.)
- Provide adequate drainage facilities (both temporary and permanent) not to make any ponding.
- Place rocks and other solid materials in embankment areas other than those designated for placing or driving piling.
- Where Softground treatment is required, the Contractor shall refer to Section 204 Soft Ground Treatment and related drawings.
- To limit the build up of pore water pressure in the underlying formation, where countermeasures for soft ground treatment are to be provided in locations marked on the Soil Plan and Profile Drawings, the rate of construction of embankments above natural ground level in these locations shall be designed by the Engineer.
- Bench when placing embankment on hillsides or against existing embankment with slopes steeper than 1 to 6. Bench continuously in loose lifts of less than 300 mm. Ensure benching can accommodate placing and compacting equipment. Begin all horizontal cuts at the intersection of the ground line and the vertical side of the previous bench. Step existing slopes to keep the embankment from wedging against structures. Compact excavation from benching with the new embankment material.
- Remove all organic matter where embankment is placed when natural ground is within 1.5 m of the subgrade. Scarify the cleared surface to a minimum depth of 150 mm. Compact to specified embankment density. Discard all remaining sod thoroughly before constructing embankment where the natural ground is greater than 1.5 m below subgrade.
- Scarify existing roadways containing granular material within 1 m of the subgrade to a depth of 150 mm. Compact to specified embankment density.

- Compact embankment without applying excessive pressure against structures.
- Place fill adjacent to the end bent of a bridge only to the bottom of the back-wall until the superstructure is in place. Place embankment simultaneously on both sides of a concrete wall or box-type structure.
- Place and spread roadway embankment in uniform horizontal layers of less than 225 mm compacted measurement. Compact to specified density before placing next layer. Obtain approval to increase layer thickness. Maintain proper moisture content to achieve the required density and stability.
- Place rock embankments in layers equal to the average rock dimension. Restrict maximum rock dimension to 1 m. Distribute spalls and finer rock fragments to level and smooth each layer. Place succeeding layers not to damage previously completed layers. Dump rock on the layer being constructed and push into place. Do not construct rock layers within 600 mm of finished subgrade.
- On completion of the layer of rock fill mentioned above, the compaction shall be carried out with an 8-tonne vibratory roller. This procedure shall be continued until all layers of rock fill are completed and there is no visible movement of the rock fill under the compacting roller.
- Place at least 600 mm of compacted embankment over structures before placing rock.
- Compact layers in embankment areas, other than rock, to at least 95% of the maximum density. Increase or decrease moisture content of material to meet the specified density.
- Use nuclear density and moisture gages for checking field density.

3.7 Subgrade Preparation

The Contractor shall shape and compact subgrade before placing a sub base course.

- The Contractor shall shape subgrade for its full width to required grade and cross section. Scarify the top 150 mm of the subgrade and increase or decrease moisture content to achieve specified density and stability.
- Compact the top 200 mm thick of subgrade to a dry density equal to at least 95 % of the maximum dry density as determined by BS1377: Part 4: 1990 (BS Heavy compaction test, 4.5 kg rammer) at a moisture content as required by the compaction equipment. Compact the lower layers up to 93 % of the maximum dry density.
- Selected Subgrade Materials and Capping Layers These materials are required to provide sufficient cover (D=500 mm) on weak subgrades. A minimum CBR of 15 % is specified at above conditions of 2).
- Stabilise the subgrade to allow placing a sub base material without rutting or displacing the roadbed.
- Ensure the finished subgrade surface is smooth and conforms to prescribed elevations before constructing the sub base course. Limit the maximum variation from the subgrade to the

prescribed elevation within +20 mm and -30 mm. Correct all finished sections damaged during construction operations.

3.8 Compaction of Fills

(a) General

Compaction shall be end-product as required for the Class of fill in Table 203-1, using plant appropriate to the Class of fill and the site conditions.

(b) End-product Compaction

The Contractor shall at least 7 days before commencement of end-product compaction make available the following to the Engineer:

- The values of maximum dry density and the optimum moisture content obtained in accordance with BS 1377: Part 4 using the 4.5 kg rammer method.
- A graph of density plotted against moisture content from which each of maximum dry density and optimum moisture content were determined.
- Fill compacted to end-product requirements shall have a field dry density equal to or greater than the percentage designated by the Engineer.
- The field dry density shall be measured in accordance with BS 1377: Part 9, except that nuclear methods shall only be used. Where nuclear methods are used, the gauge shall be calibrated in accordance with BS 1377: Part 9.

203.4 Measurement

4.1 Excavation

- All required and accepted excavation shall be measured in its original position after clearing, grubbing and topsoil removal. The volume is determined in cubic metres by the average end area method as computed from the original and final cross sections of required and completed work.
- Measurement of rock excavated to a depth below subgrade level as required in Clause 3.3. Construction methods shall be computed on the basis of excavation to the specified minimum depth below subgrade level only and no over break shall be included.
- Interim payment may be made on measured volumes of required excavation actually executed, before final shaping, provided the Contractor's intention to complete the work is clear.

4.2 Embankment

- Embankment shall be measured in cu. m from cross sections measured and produced by the Contractor and agreed by the Engineer. The volume to be measured will be the net volume of required and accepted embankment including capping, actually constructed and completed in

accordance with the Specification, the lines, levels, grades, and cross section shown on the Drawings or as directed by the Engineer.

- The cross section to be used for volume calculation shall be the area bounded by the subgrade (below base and sub-base) the side slopes or inside panel lines and the ground line surveyed immediately after Clearing and Grubbing is completed and approved.
- No account shall be taken of benching of the ground beneath the embankment. In cases where the embankment foundation is soft and where the ground is likely to settle appreciably under the weight of the embankment the extra volume of embankment required due to settlement shall be included.

Embankment Measurement for Settlement

The latter volume will be measured as soon as the subgrade is finally graded, re-shaped, compacted and accepted, before the spreading of sub-base or base. The work of reshaping and grading necessitated by settlement of up to 75 mm will not be measured nor separately paid for. For measurement of the volume that has settled below original ground level, special settlement platforms shall be placed by the Contractor. Prior to the commencement of embankment construction, they shall be placed on the centre line at approximately 50 m intervals or as necessary. The additional end area shall be taken as a rectangle, the length of which shall be the distance from toe to toe of the embankment, as measured on cross section sheets, at the original ground level, and the height of which shall be 80% of the measured settlement of the platform. The measured settlement of each plat form shall be used for all cross sections within a distance equal to half the platform spacing. The platforms shall be constructed in such a way that they will settle with the embankment, with vertical posts such that levels may be taken without excavation. The platforms shall be furnished and placed at the expense of the Contractor.

- Topsoil placed on side slopes shall not be included in the volume of embankment fill.
- Where the Engineer directs the excavation and replacement of unsuitable material below ground level under the embankment, the original ground shall be taken as the level to which excavation have been made.
- The final volume of embankment fill to be measured for payment shall include the voids for pipe culverts, and the inlets and outlets of culverts.
- Where the Engineer directs the counter embankment beside the embankment to stabilise it, this material shall be measured for payment.
- Deduction from the measured volume shall be made for the following where they lie within the measured volume:
  1) Bridges
  2) Porous backfill material
  3) Sand blankets and other special materials, where separately measured and paid for.
- Where work is directed by the Engineer to be performed under Clause 203.1 of this Section 203, it shall be measured and paid under Daywork pursuant to Sub-Clause 52.4 of the

Conditions of Contract. Where in the opinion of the Engineer, the rates in the Daywork schedule in the Bill of Quantities do not apply, new Daywork rates shall be fixed pursuant to Sub-Clause 52.2 of the Conditions of Contract.

203.5 Payment

5.1 Excavation

The quantities of roadway excavation measured as specified above will be paid for at the Contract unit prices per cubic metre for the various types as detailed below. Such prices shall include:

- Excavation and ripping
- Blasting, splitting, breaking, drilling and the like,
- Relocation of residents due to blasting
- Upholding the sides,
- Keeping earthworks free of water,
- Dewatering with pumps, and construction of temporary dykes or cofferdams
- Forming and trimming side slopes, benchings and berms,
- Additional excavation the Contractor may require for working space, timbering,
- Formwork or other temporary works and its subsequent backfilling.
- Taking precautions to avoid damage to property, structures, drains, sewers, services, instrumentation and the like.
- Loading into transport,
- Multiple handling of material,
- Haulage, deposition and compaction in temporary stockpiles include provision of sites for stockpiles,
- Haulage to its final destination and satisfactory disposal of all roadway excavation,
- Quantities of Slips and slides materials include:

  1) Slips and slides which take place after the Contractor's ground survey and deemed as natural phenomena.

  2) Slips and slides which take place even if the Contractor followed the Drawings.

  If the Contractor caused the Slips and slides due to lack of their reasonable caution, it won't be measured for payment.

- Furnishing all labour, materials, tools, equipment and incidentals to complete the work.

The above prices and payment shall be full compensation for all work involved in performing the roadway excavation completely as shown on the plans and as specified in these Specifications and the Special Provisions and as directed by the Engineer.

5.2 Embankment

This work measured as provided above shall be paid for at the relevant Contract unit prices per cu. m. or sq.m as detailed below. Payment shall be full compensation for performing the work (including construction of capping layers and subgrade), furnishing the materials and providing all labour, equipment, tools and incidentals necessary to do the work.

The settlement monitoring devices are included in Section 204 Soft Ground Treatment.

Pay Items		Unit of Measurement
Excavation		
203(1)	Excavation- Classified Material for Reuse (Excavation/Loading/Transport)	cubic metre
203(2)	Excavation- Soft Rock for Reuse (Excavation/Loading/Transport)	cubic metre
203(3)	Excavation- Hard Rock for Reuse (Excavation/Loading/Transport)	cubic metre
203(4)	Excavation- Unsuitable Material for Disposal (Excavation/Loading/Transport/Placing & Spreading)	cubic metre
203(4)-1	Excavation of Slips or Slides	cubic metre
Embankment and Other Areas of Filling		
203(5)	Fill for Road-bed of Embankment - Using excavated soil in other part (Placing and Spreading/Compaction)	cubic metre
203 (6)	Fill for Road-bed of Embankment - Using excavated Soft rock in other part (Placing and Spreading/Compaction)	cubic metre
203 (7)	Fill for Road-bed of Embankment - Using excavated Hard rock in other part (Placing and Spreading/Compaction)	cubic metre
203 (8)	Fill for Road-bed of Embankment - Using borrow material (Excavation/Loading/Transport/Placing & Spreading/Compaction)	cubic metre
203 (9)	Fill for Soft Soil Excavated Place - Using quarry material (Loading/Transport/Placing & Spreading/Compaction)	cubic metre
203 (10)	Slope formation - Cut slope	square metre
203 (11)	Slope formation - Filling slope	square metre
203 (12)	Filling Road Bed by Selected Material (Excavation/Loading/Transport/Placing & Spreading/Compaction)	cubic metre

SECTION 204

SOFT GROUND TREATMENT

204.1 Description

General

In the Northern section-1, most of the embankment sections need soft ground treatment. The Engineer prepared the Detailed Design (D/D). However, due to uncertainties of soft soil mechanism, both the Engineer and the Contractor have to cooperate to achieve the target of within 15 cm residual settlement after 3 years from acceptance of the respective sections of the pavement works.

Soft Ground Treatment in the Northern Section-1

In the D/D, the Engineer designed following eight types of Soft Ground Treatment (SGT):

SGT Type-A:	Gravel mat (0.5 m thick).
SGT Type-B:	Gravel mat (0.5 m thick) with one layer of geotextile.
SGT Type-C:	Gravel mat (0.5 m thick) with one layer of geotextile and band drains.
SGT Type-D:	Gravel mat (0.5 m thick) with one layer of geotextile and Gravel Compaction Pile (GCP).
SGT Type-E:	Gravel mat (0.5 m thick), band drains and Gravel Compaction Pile (GCP).
SGT Type-F:	Gravel mat (0.5 m thick) with one layer of geotextile, band drains and Gravel Compaction Pile (GCP).
SGT Type-G:	Gravel mat (0.5 m thick) with one layer of geotextile and Gravel Compaction Pile (GCP, whole areas).
SGT Type-H	Replacement with compacted gravel by excavation.

Note:
To keep the Gravel mat min.0.5 m in thickness, some additional quantities due to compression by upper embankment load should be considered.

Responsibilities in the Soft Ground Treatment

Due to uncertainties of the soil behaviour, the responsibilities of each work are briefly distributed as follows:

Description of responsibility	The Contractor	The Engineer	The Employer
Inspection of the site	*		
Review of D/D	*		
Planning, execution and reporting of additional soil investigation	*		
Working drawing preparation after site inspection (referring to D/D and additional soil investigation)	*		
Trial area planning and proposal submission	*		
Evaluation and decision of the Contractor's proposal on trial		*	
Trial area execution and monitoring	*		
Trial area analysis and decision		*	
Planning and proposal on soft ground treatment as permanent works	*		
Evaluation and decision of the Contractor's proposal on permanent works		*	
Execution, monitoring and its data processing of the permanent works of the treatment (during the construction)	*		
Stability failure of the embankment	* (if the Contractor has not followed the design, Specification and Engineer's instruction)	* (if the Contractor has strictly followed the design, Specification and Engineer's instruction)	* (if there are unforeseen site/ ground conditions)
Analysis and decision of the treatment (during the construction)		*	
Evaluation of the target (within 15 cm in 3 years) at the end of the construction period		*	
Check the settlement (one month before the end of defect liability period)	*		
Analysis and evaluation of the target (by the end of defect liability period)		*	
Inspection and evaluation of the target (3 years after the work completion)			*

- Any unforeseen issues will be discussed among the above three parties.
- The embankment shall be designed to have a short and long term factor of safety of 1.20 and 1.25 respectively.

Testing and Criteria of Soft Ground Treatment

The Contractor shall supply and install the testing equipment, as well as test and monitor the soft ground treatment as part of the Works during and after the treatment. The embankment shall be constructed by the Contractor according to the contract documents and latest boring data obtained by the Contractor during construction period so that any continued settlement at the road centre after a period of 3 years following the acceptance of the paving is within 15 cm. In this regard, settlement predictions shall be prepared by the Contractor based on reliable theory, soil data, actual observations and the like and submitted to the Engineer for acceptance. If the predicted settlement for 3 years based on monitored data exceeds 15 cm, the Contractor shall immediately report to the Engineer and discuss the solution.

If any unusual movement or failure is anticipated, the Contractor shall immediately report to the Engineer and discuss the solution. If the ground conditions differ from those expected from his interpretation of the ground investigation reports, the Contractor shall do the same.

204.2 Materials

2.1 Gravel

Gravel to be used for the gravel mat and Gravel Compaction Pile (GCP) shall be crushed stone, suitably graded for high permeability and shall be free from clay, lumps of dirt, organic matter or any other deleterious matter. The material for gravel mat and Gravel Compaction Pile (GCP) shall meet the grading requirements in Table 204-1 of the Specification. Samples of gravel shall be submitted by the Contractor to the Engineer for approval.

Table 204-1
Grading Requirement for Gravel Mat and Gravel Compaction Material

	Gravel Mat and Gravel Compaction Pile
BS Test Sieve (mm)	Percentage by Mass Passing the Sieve
50	100
37.5	85-100
20.0	50-80
5.0	15-40
2.0	5-25
0.063	0-5

Compacted earth work materials for replacement shall meet each requirement in Table 203-2:

Class 6. Selected granular fill

Class 6A. Below water, Selected well graded granular material
Class 6B. Starter layer, Selected coarse granular material
Class 6C. Starter layer, Selected uniformly graded granular material

Samples of gravel for replacement shall be submitted by the Contractor to the Engineer for approval.

2.2 Geotextile

Geotextile has two kinds, woven and non woven. The Contractor shall study and select the required characteristics of the product and propose to the Engineer for acceptance.

Geotextile shall UV-stabilized and made of polypropylene yarns either woven with different or same strength for both warp and weft directions. The geotextile shall be tested in accordance with ISO 10319 or equivalent and requirements in Section 606.

The Permeability (vertical: ISO 11058, water head of 50 mm) for separation geotextile, shall not be less than 85 litre/m^2/s. End parts shall have sufficient allowance for pulling due to settlement.

2.3 Band Drain

The drain shall consist of a continuous band-shaped core enclosed in a filter jacket.

The core shall form a three-dimensional open labyrinth structure. The filter jacket shall be a non-woven polyester fabric or similar with effective opening size not bigger than 80 μm and minimum filter velocity of 6.5 x 10^{-4} m/sec. The drain shall have a minimum water discharge capacity of 40 x 10^{-6} m^3/sec after being compressed under 300 to 350 kN/m2, and minimum filter strength of 8 KN/m to withstand the installation stress.

2.4 Surcharge

Surcharge is shown in the typical cross section for Soft Ground Treatment (Surcharge). The materials for surcharge shall conform to Section 203.2.

204.3 Construction Methods

3.1 Replacement of Unacceptable Soil (Peat) (if Peat is included in the excavated soils: SGT Type-H)

Referring to the results of additional soil investigation and the Engineer's instructions, the Contractor shall construct the trial areas of Soft ground treatment, in particular replacement of Unacceptable material (Peat) in a safe way. Approximate maximum distributed depth of peat for replacement is about 6 m.

In addition to soft ground treatment, the Contractor shall prepare the adequate excavation equipment for the estimated depth and shall demonstrate the Work and check the performance for acceptance of the Engineer.

1) Replacement filling below the water table - rockfill under water

- Where replacement filling is to be constructed from below the water table level, rockfill shall be deposited in successive layers of a thickness determined by the size of rock and depth of water, to a height of 300 mm above the surrounding water level.
- Each layer shall be constructed starting at one end of the filling under construction and placing the rock by means of a bulldozer in such a manner that the larger rock shall be placed, and the spaces between the layer, filled with finer material to form a dense interlocking and stable layer.
- The maximum size of rock shall be 125-500 mm. The rockfill shall be blinded with a layer of 40 mm graded aggregate sufficient to fill all voids in the upper layer of the rockfill.
- Rockfill shall be compacted by heavy vibratory rollers (minimum weight of 8 tonnes) until there is no visible movement of the rockfill under the equipment.

3.2 Embankment Construction (SGT Type-A thru H)

1) Embankment construction above the water table: pioneer layer on soft unstable ground

- Where embankment filling is to be constructed over very wet or soft ground that displays excessive movement under normal compaction equipment and haulage trucks, thereby precluding the effective compaction of the bottom layer, the Engineer may direct that a pioneer layer (Sandy soil) be constructed on the unstable ground. This layer shall be constructed by end dumping and spreading successive loads of soil suitable for embankment construction in a uniform layer of thickness sufficient to provide a stable working platform. This layer shall be suitably compacted and shall be 0.5 meter high from original natural ground level for the construction of further embankment layers which shall be compacted to a controlled density.
- Light hauling equipment shall be used to place the material, and the layer shall be compacted by the use of compaction equipment that will provide the most effective compaction without over-stressing the roadbed. Pioneer layers need not necessarily be compacted to a controlled density.

- The compacted volume of material used may be determined on the basis of 70 % of the loose volume in trucks as an alternative to taking cross sections before and after construction in case it is difficult to take cross sections.

- Pioneer layers shall be paid by:
  Pay Item 203 (9): Fill for soft soil excavated place – Using quarry material in Section 203**.**

3.3 Gravel Mat (SGT Type A thru H) and Gravel Compaction Pile (GCP) (SGT Type D thru G)

(a) If directed by the Engineer, a temporary earth dyke shall be formed around the work area to protect the drains, filling materials and other related works from water.

Surface settlement plates with vertical rods shall be installed at 20 cm above the gravel mat bottom level in such a way that the top of the base plate is horizontal. Before placing any embankment material, the Engineer will inspect the completed installation and take initial elevations on the top of the base plate and the top of the rod. Subsequently a 40 cm thick layer of gravel shall be placed on the settlement plate. As the embankment construction progresses, the rods shall be extended as necessary.

The settlement plates shall be installed so as to check not only vertical but also horizontal movement.

The work shall also include the installation and maintenance of other settlement monitoring and measuring devices as required by the Engineer. Prior to loading the soil, the Engineer instruct the Contractor of an additional 0.5m deep and 1m width of gravel to be placed at the toe of the gravel mat, which to be removed after settlement is completed.

(b) Unless otherwise approved by the Engineer, the method of construction of Gravel Compaction Piles shall be as given below:

i) The Contractor shall form Gravel Compaction Pile (GCP) in existing natural soils by filling gravel with vibro replacement or vibro displacement in the manner and in the areas as given below.

Gravel piles will be installed by driving a casing pipe with a special device at its lower end to form a sand/gravel plug using pile-driving equipment. When it has penetrated into the required depth by vibration, the inside of the pipe is filled with gravel through the upper hopper on the pipe top. The upper end of the pipe is then closed, and compressed air is applied inside the pipe while it is raised to certain height from the ground level and the gravel inside will be expelled out of the pipe end simultaneously.

Casing pipe shall be penetrated again with compaction of the gravel in the ground by further vibration. After the vibration has attained its required compaction degree and its required diameter of the gravel compaction pile, the casing will be raised to expel the remaining gravel out of the casing pipe. Same penetration accompanying with vibration for compaction work will be repeated until the whole gravel compaction pile is completed to the required ground level.

Completion of each GCP shall be checked and accepted by the Engineer at site. On completion of all vertical GCP to the diameter and spacing specified by the Engineer, a horizontal layer of geotextile (if necessary, strength of geotextile will vary depending on the locations) and suitable gravel shall be spread over the area to the depth instructed by the Engineer.

When the abutments of viaducts and box culverts are located on the soft ground, the soft ground shall be treated with the following procedure:

1) Compacted sandy soil for embankment construction to the height of 500 mm from initial natural ground level shall be provided for supporting installation machinery.
2) GCP shall be carried out as shown in the drawings.
3) After the GCP, it shall be left for more than one to three months to stabilise the existing treated ground and recovering of its strength shall be confirmed before embankment work.
4) Then preload shall be placed up to designed road level.
5) Leave the preload for more than one month with monitoring the settlement of the ground.
6) Submit the settlement monitoring data to the Engineer for his review and approval of the preload removal.
7) After the Engineer's approval on the removal, remove the preload.
8) Construct the abutments and box culverts.

GCP often causes noise, vibration and heaving of the surrounding ground. Therefore the Contractor shall monitor them continuously at the GCP sites and the surrounding areas. When the Engineer find the negative impact is serious, the Contractor shall take immediate action, such as suspension of the work, introduction of low noise and low vibration machines and provision of ditches around the GCP sites, depending on the circumstances of the site. The GCP shall reach at least the firm clayey soil layer or medium dense sand layer.

ii) Geotextile material shall be installed at the specified location in the arrangement as shown on the plans or as otherwise directed by the Engineer. The geotextile shall have sufficient additional width in the end to cope with the pulling due to the settlement.

The ground surface where the geotextile will be laid shall be cleared from all sharp stumps, stones, etc, that could cause puncture or tear to the fabric.

The ground surface shall be flat and level. Unevenness of the ground surface shall not be more than 10 cm and inclination across the road shall not be more than 5 %. The geotextile shall be overlapped by at least 500 mm and shall not be pegged at the edge.

The gravel mat placement after the installation of geotextile shall be in such a way so that the fabric will not be partially overstretched. The gravel shall be well distributed in a layer not thicker than 50 cm, and the distribution of gravel shall be carried out in one direction without any alteration, starting from one point. Non woven type geotextile shall be pegged at the edges of the embankment width. While woven geotextile shall be wrapped at the effective road width to form an effective anchorage as directed by the Engineer.

iii) To limit the build up of pore water pressure in the underlying formation where countermeasures for soft ground treatment are to be provided in

locations marked on the Soil Plan and Profile Drawings, the rate of construction of embankments above natural ground level in these locations shall be designed by the Contractor and agreed by the Engineer.

3.4 Geotextile (SGT Type-B thru D, F and G)

The applicable location, material, strength, number of layers and method of construction of the geotextile which may include separator shall be proposed by the Contractor, referring to the Soil Profile drawings, and shall conform to Section 606.

3.5 Band Drains (SGT Type-C, E and F)

(a) This work shall consist of the installation of a system of vertical band drains and a horizontal gravel mat so as to accelerate settlement and improve the subsoil in areas of soft ground as shown on the drawings or as directed by the Engineer.

Prior to the commencement of the work, subsoil investigations as approved by the Engineer shall be carried out by the Contractor, and the Contractor shall submit his proposal for the vertical drain system including a complete description of the band drain material, type, capacity, calculations and work method, which shall demonstrate the capability of the drain to meet the requirements stated hereinafter. The proposal shall be based on the available subsoil data and on the results of the soil investigation required under the Contract. The proposal shall be approved by the Engineer before commencement of the work. The work shall be carried out in close conformity with the requirements, which will be established by the Engineer after the results of the soil investigation are available.

(b) Compacted sandy soil for embankment construction to the height of 500 mm from initial natural ground level shall be provided for supporting installation machinery.

(c) Drains shall be installed with approved equipment to the specified depth and spacing and arrangement as shown on the plans or as otherwise directed by Engineer.

(d) The gravel mat shall be laid to form the horizontal gravel drain.

(e) A geotextile shall be placed over the gravel mat as a separator, if required by the Engineer.
The drains installation equipment shall be the type, which will cause a minimum disturbance to the subsoil during the installation operation. Constant load or constant rate of advancement method or the so-called ‘static’ method is preferred. Vibrator, falling weight impact hammers, and jetting will not be allowed unless otherwise approved by the Engineer and restricted only for assistance in penetration in areas where the design depths cannot be achieved by static method.

The drains shall be installed using a mandrel or steel sleeve that will be advanced through the soil to the required depth. The mandrel shall protect the drain material from tears, cuts and abrasions during installation and shall be withdrawn after installation of the drain. The mandrel shall be rectangular or rhombic in shape with appropriate cross sectional area.

(f) Prior to the installation, the Contractor shall submit details of the sequence and method of installation to the Engineer for review and approval.

The equipment shall be carefully checked for plumbness prior to the advancing of each drain. Drains that are out of their proper location by more than 150 mm, drains that are damaged in construction, and drains that are improperly completed shall not be accepted, and no compensation will be allowed for any materials furnished or for any works performed on such drains.

During installation of the drains, the Contractor shall provide suitable means for determining the depth of the drain at any given time. Joins or connections in the drain material shall be made in an approved workmanlike manner so as to ensure continuity of the material. Minimum length of overlap in the join shall be 300 mm. The drain material shall be cut neatly at its upper end and there shall be a 300 mm top cutting of tip length of drain material protruding above the working ground at each installation.

3.6 Surcharge (SGT Type-A thru G)

Surcharge as determined by the Contractor and as agreed by the Engineer shall be placed for the sections specified in the drawings, except for the sections for which the treatment Type H (Replacement by Excavation) are applied.

Before shaping the subgrade and placing a sub base course after completion of leaving period (more than six months in principle) for consolidation settlement, if top level of surcharge is higher than bottom level of selected fill (subgrade), such extra surcharge shall be removed.

For the construction of the surcharge, the Contractor shall conform to 3.6 and 3.8 under Section 203.3.

3.7 Instrumentation and Monitoring

The Contractor shall provide and install various instruments for soft ground treatment monitoring as directed by the Engineer. The monitoring shall be done at the sections which are approved by the Engineer in about 50 m interval along the longitudinal alignment of the road. Monitoring shall be carried out where the ground conditions are the worst at the section of about 50 m interval, and be started before construction of embankment and continued to the end of construction period. The instrumentation and monitoring shall include for:

1) Instruments for soft ground treatment monitoring

2) Tubing or cabling
3) Recording water levels
4) Cleaning and keeping hole free of harmful materials,
5) Connections and joints,
6) Sand and gravel filters
7) Removing contaminated water,
8) Recording data and monitoring, and supplying one copy to the Engineer,
9) Proving correct functioning,
10) Bedding and required fencing

3.8 Testing of Soft Ground Treatment

3.8.1 Test to be carried out

The following tests or alternatives shall be carried out at the positions and frequency agreed by the Engineer.

1) **Penetration Tests**
The static cone penetration test (CPT), the standard penetration test (SPT) or Dynamic Cone Penetration (DCP) tests shall be carried out, as per Sec 1200.

3) **Unconfined compression tests for clayey soils**
Sampling and testing shall be carried out in clayey soils. Then unconfined test values can be correlated to DCP-CBR as defined in TRL UK Road Note 31 (1993) and such values can be used to determine the bearing capacity of such strata.

3.8.2 Trial Areas

- The purpose of carrying out of trial embankment is to confirm the performance of all soft ground treatment methods. It is to the benefits of the Contractor to initiate the trials.
- GCP is designed at soft ground with very soft peat and clay. The Contractor shall carry out the trial construction, check the efficiency, schedule and costs and evaluate the performance especially at the area where very soft peat is distributed at ground surface.
- Works on the trial areas are part of Permanent Works of each work item. Therefore, each work item includes the trial areas and the works on the trial areas will be measured for payment, using each Pay Item.
- Trial areas are to be treated and tested. The trial areas, which meet the performance requirements, may form part of the Permanent Works. If they did not meet the requirements due to the Contractor's fault, they shall not form the Permanent Works. The failed areas in the Permanent work site shall be reinstated at the Contractor's own expense until satisfaction of the Engineer.
- Equipment and materials used in trial areas shall be identical to those proposed for the Permanent Works.
- Trial area location shall be proposed by the Contractor for acceptance of the Engineer or otherwise instructed by the Engineer.

3.8.3 Records and Reports

- Complete records of plant, equipment and materials shall be maintained during all soft ground treatment operations.
- Records shall be made available to the Engineer, including all information identified in Table 204-2.
- All records pertaining to a particular day's operations shall be made available to the Engineer at the start of the following day's operation.
- The Contractor shall prepare Special reports on soft ground treatment using adequate computer software, from time to time, in coordination with the Engineer. The reports shall include:
    1) Slope stability analysis,
    2) Embankment and settlement analysis,
    3) Performance of soft ground treatment incl. lateral movement and water table,
    4) All results of instrumentation, monitoring and tests

Table 204-2 Records and Reports - Information Required

Soft Ground Treatment	In situ Testing
For each column/area treated: Date Contract title Area identification Ground level at commencement Ground level at completion	For each area tested: Date Contract title Area identification Test position, co-ordinates and level Method of test used All information required by appropriate BS standard test procedure Water table Other
Material used Approximate column diameter Bottom and top level of penetration / installation of each treatment point Vibratory power consumption during operation	
Material consumption/installation volume during treatment work Jetting pressure (where applicable) Duration of penetration Obstructions and delays No. and type of tests carried out	

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204.4 Measurement

The measurement of pioneer layer shall be the cubic meters and as per Sub Clause 3.2.

Gravel Compaction Pile (GCP) will be measured by the linear meter for the diameter as given in the Pay Item Description. The GCP shall include:

- Trial areas,
- Demonstrations,
- Site control, observations, records and reports,
- Additional gravel required due to penetration into surrounding ground.

Vertical band drains will be measured by the linear metre for the size as given in the Pay Item Description. Measurement will not be made for joints. The pay item shall include the cost for equipment establishment, bringing, erecting, setting up, moving, dismantling and removing from the site on completion.

The quantity of gravel mat will be measured by cubic metres as one pay item, irrespective of the depth of gravel instructed by the Engineer.

Geotextile (strength varies) shall be measured by square metres for area covered plus some allowance for pulling by settlement. Overlaps will not be measured.

The excavation of unsuitable material for disposal and fill for soft soil excavated locations shall be measured as per Section 203.

Measurement for fill of surcharge and excavation of excess surcharge shall be carried out as per measurement for Pay Item 203 (8) and 203 (1), respectively.

Measurement for preload and removal of preload shall be carried out as per measurement for Pay Item 204 (12).

Quantities for Trial areas are included in all the Pay Items of Section 204. Therefore no separate measurement will be made for the payment.

Instrumentation, monitoring and testing will be measured by Lump sum according to progress.

Any other costs related to soft ground treatment will be deemed to be included in the Contract unit price for the pay items given below in paragraph 204.5.

Additional soil investigation is included in Pay Item 1001 (6) of Provisional Sum.

204.5 Payment

The work measured as provided above will be paid for at the Contract price per unit of measurement for the item listed below, which price and payment will be full compensation for furnishing and placing all materials, and for all labour, equipment and other incidentals necessary to complete the work in accordance with the Drawings, Specifications and as directed by the Engineer.

Quantities for trial areas are included in each Pay Item.

Payment for fill of surcharge and excavation of excess surcharge shall be carried out as per Pay Item 203 (8) and 203 (1), respectively.

Payment for preload and removal of preload shall be carried out as per measurement for Pay Item 204 (12).

Payment for excavation of unsuitable material for disposal and fill for soft soil

excavated locations shall be carried out as per Section 203.

Pay Items	Unit of Measurement
204(1) Geotextile (Tensile Strength 100/50)	sq.m
204(2) Geotextile (Tensile Strength 200/50)	sq.m
204(3) Geotextile (Tensile Strength 300/50)	sq.m
204(4) Geotextile (Tensile Strength 400/50)	sq.m
204(5) Geotextile (Tensile Strength 600/50)	sq.m
204(6) Geotextile (Tensile Strength 800/100)	sq.m
204(7) Band Drains	metre
204(8) Compacted Sandy Soil ((Excavation/Loading/Transportation/ Placing & Spreading/Compaction)	cubic metre
204(8)-1 Pioneer Layer	cubic meter
204(9) Gravel Mat (Excavation/Loading/Transportation/ Placing & Spreading/Compaction)	cubic metre
204(10) Gravel Compaction Pile (GCP), (700 mm in diameter, gravel size max. 50 mm)	meter
204(11) Instrumentation, Monitoring and Testing	lump sum
204(12) Preloading	cubic metre

Geotextile for separator, please refer to Pay Item 606 (1) Geotextile (9.5 KN/m) under Section 606.

SECTION 205

PROPERTY CONDITION SURVEY

205.1 Description

With assistance of the Employer, the Contractor shall survey the road right of way, locate and identify all properties within or adjacent to the right of way that do not require demolition but may be damaged by the Contractor's operations. Location shall include position and dimensions in relation to the right of way. Identification shall include the nature of the property, the type of construction, the owner and, if different, the occupant, and shall include a photograph or photographs of the property sufficient to define its type, physical and structural condition.

Such surveys may be conducted, at the Engineer's direction, both before, during and after the Works have passed any given property. The findings of such surveys shall be used in evaluating representations, if any, from property owners or occupants regarding allegations of damage to their property arising from the Contractor's operations.

205.2 Measurement and Payment

Measurement

Measurement shall be by the kilometre of road fully surveyed to the Engineer's satisfaction, as measured along the centre line. "Fully surveyed" shall mean that all the houses along both sides of the road have been surveyed. Less complete surveys will be measured on a pro-rata basis.

Payment

Separate payment will be made for surveys conducted before, during and after the Works have passed the point of survey. The Contract unit rate specified for the work concerned shall be full compensation for furnishing all labour, materials, tools, equipment and incidentals necessary to complete all the work required by the Contract and as directed by the Engineer.

Pay Item		Unit of Measurement
205(1)	Property Condition Survey	km

SECTION 206

EXPLOSIVES AND BLASTING OPERATIONS

206.1 Description

This work shall consist of handling, transport, storing, and use of explosives for carrying out blasting operations in the formation of roads, preparation of foundations of structures or for production of aggregates, according to these specifications and as approved by the Engineer.

These specifications shall be read in conjunction with the Mines and Mineral Act Explosives Act and other regulations issued from time to time by the Controller of Explosives.

206.2 Materials

All explosives used shall be of approved manufacture and of Non-electric and electric type with delay elements and shall belong to the following categories.

Initiating Explosives (non electric and electric)

Low Explosives

High Explosives

Stemming materials

(a) Initiating Explosives

These shall consist of non-electric detonators, safety fuse (firing cord), detonating fuse & electric detonators with delay elements and ignitor cords, used to initiate the main charge.

(b) Low Explosives

Low explosives are mixtures of potassium nitrate or sodium nitrate, charcoal and sulphur in suitable proportions manufactured to have a granular form with coarse, medium or fine grains, glazed with graphite, usually referred to as black blasting powder.

(c) High Explosives

High explosives shall be gelatines, gelignites, dynamites in powder form, all of which contain nitroglycerine as sensitizers, or Ammonium Nitrate or slurries based on Tri-Nitro Toluene (TNT) or mixtures of Ammonium Nitrate and fuel oil (ANFO).

(d) Stemming Material

Material for stemming shall be quarry fines or sand.

206.3 Blasting Operations and the Required Personnel

(a) The contractor shall have on his blasting site whenever electric detonator blasting operations are

taking place, a qualified mining Engineer (shot firers) fully experienced in mining work and he shall design and supervise the field work.

(b) Choice of Explosives

In the choice of explosives, in addition to job requirements, consideration shall be given to the following factors.

(i) Type of rock including geological features such as strength of rock mass and presence of fractures, fissures etc.

(ii) Degree of fragmentation desired

(iii) Number, size and depth of drill hole

(iv) Ground vibrations, noise, air blast pressure, fly rock and proximity to buildings and other structures

(c) Safety precautions and other pre-blast operational engineering aspects

The following technical considerations shall be implemented prior to commencing blasting operations.

(i) Obtaining relevant licences under the prevailing Acts and Regulations such as Mines & Mineral Act and National Environmental Act, if necessary.

(ii) Appointing mining engineers (shot firers) for electric detonator blasting crews.

(iii) Appointing monitoring groups to monitor blasting effects such as ground vibration, air blast over pressure etc.

(iv) Mapping of buildings and structures, which are situated within 400 m circles from the proposed blasting area with GPS coordinates.

(v) Conducting pre-blast surveying activities of structures and buildings which are situated within 400m distances from the blasting area (this distance may change subject to the existing environmental and technical considerations) and preparation of technical reports for each and every building and structure.

(d) Conduct of blasting activities

(i) Initiation by Firing Cord (safety fuse)

Normally the standard plain detonator shall be used to initiate the main charges.

To prepare the capped fuse, the fuse shall be cut straight across with a sharp knife. The detonator shall then be slipped over the freshly cut end of the fuse so that “the mixture” and fuse are in

contact. The detonator shall then be crimped gently but securely with approved crimpers. Force shall not be used when inserting the fuse into the detonator. The part of the detonator containing the detonating mixture shall not be crimped. The ends of the fuse shall not be allowed to be damp or contact oil or grease. When capped fuses are to be used in wet conditions the junction between the fuse and the detonator shall be well coated with a water proofing or cap sealing compound. Sufficient length of free end of the fuse shall be left so that ample time is available to fire all the boreholes charges and to enable the workmen to get away to a safe place.

Preparation of the capped fuse shall not be done at or close to the face of the rock. This shall be done at a safe place immediately before the commencement of charging the shot holes.

(ii) Initiation by Detonating Fuse

Detonating fuse shall be used in large scale excavation or quarry work to initiate high explosives. A plain detonator or an electric detonator shall be attached to the detonating fuse with adhesive tape, or string, firmly so that it points towards the explosive charge. Delay or short delay detonators shall be used if a method of delay firing is employed. When fixing the detonating fuse to the primer cartridge, sufficient length of the detonating fuse shall be in contact with detonating cord. The free ends of the detonating cord from the shot holes shall be firmly fixed to a main cord using adhesive tape, string or thin wire. At least 50mm of the branch lines shall be in contact with the main cord at the joint.

(iii) Initiation by Electric Detonators

Electric detonators shall be used for initiating explosives when electric shot fixing is adopted. Firing shall be done only with blasting machines, approved by the Engineer. Use of mains for Mains firing shall not be permitted. The primer shall be prepared by making a hole in the cartridge with an aluminium or brass pricker and inserting the detonator until it is completely buried in the explosive. The leading wires shall then be hitched round the cartridge to prevent the detonator from being withdrawn. All electrical connections shall be made with clean wires well twisted together. Care shall be taken to ensure that the insulation of leading wires, connecting wires and cables is not damaged due to rough handling. All joints shall be well insulated. The bared ends of the leading wires shall be well protected to prevent contact with any conductors. Electric shot firing shall not be carried out if a thunderstorm is imminent. The number of shots to be fired shall not exceed the recommendation of the manufacturer of blasting machines.

(e) Charging Boreholes

When the structure of the rock is distributed and irregular small diameter short boreholes shall be used. The faces shall be worked in steps of benches by blasting with short vertical holes of 1-5 metre in depth, drilled in a line parallel to the face. The horizontal distance from the bottom of the borehole to the face shall be always less than the depth of the borehole. The diameter of the boreholes shall normally be 25 to 50 mm. Special gelatine of 80% strength or as recommended for this type of work shall be used. The borehole shall be cleaned out with compressed air or other

approved method. The cartridges of explosives shall then be inserted into the borehole one at a time and pressed with a wooden rod. The primer cartridge shall then be pushed until it rests against the main charge.

Metal rods shall never be used to charge boreholes. No drill or metal equipment of any kind shall be introduced into the hole once explosives have been inserted. After loading the explosives, stemming shall be inserted. Material for stemming shall be quarry fines or sand which shall be gently tamped for the first few inches from the bottom. Pressure shall be gradually increased for tamping so that the stemming is firmly packed in the hole. During tamping the leading wires of the detonators, safety fuse or detonating cord shall be held taut onto one side of the borehole to prevent damage to wire or fuse.

In quarrying operations, small diameter long boreholes charged with a high explosive and fired at a predetermined pattern using shot delay detonators shall be used to produce well-fragmented rock and reduce ground vibrations.

(f) Preparations for firing

(i) When using Detonating Cord

(a) All connections between lines of detonating cord shall be made at points where the core load is known to be dry. Where the ends have been, or may be, exposed to wet conditions, connections shall be made at least 500 mm from the ends, and the excess folded over and secured to the main line.

(b) The connection between branch lines and the part of the main lines carrying the incoming detonation waves shall be made firmly, e.g. by taping or by slip-proof knots, to the satisfaction of the Engineer. Care shall be taken that branch lines do not loop back and cross over the main lines before entering the hole.

(c) Lines of detonating cord shall be laid or hung in straight lines or smooth curves, without excessive slack or tension and shall be kept at least 200 mm apart. For core loads over 12.5 g/m, greater separation may be required, and the manufacturers' instructions shall be followed.

(d) When detonating relays are used to achieve the desired delay pattern, the manufacturers' instructions for the type in use shall be followed. Care shall be taken to ensure that detonating relays are properly connected to ensure protection.

(e) The full length of the detonator shall be firmly taped to the line of detonating core, with the base of the detonator pointing in the desired direction of detonation in the cord.

(f) To ensure that the desired delay pattern is achieved, the manufacturers' recommendations on the required separation between detonators and / or detonating relays, and adjacent lines of cord shall be followed.

(ii) When using Fuse and Plain Detonators

(a) The method of lighting the fuses shall be decided at the planning stage, after consideration has been given to the number of fuses, the burning time of the fuses, and the time required to come to safety after the last fuse has been lit.

(b) Where fuses are lit individually by the shot firer, fuse lighters shall be used. It is desirable that a second person shall control the time which has elapsed from the lighting of the first fuse.

(c) Where igniter cord is used in conjunction with fuse, the delay pattern shall be drawn up so that all the fuses are burning in the holes before the first charge detonates.

(iii) When using Electric Detonators

(a) All detonators used in a blast shall be of the same electrical sensitivity and be produced by the same manufacturer.

(b) The choice of detonator type, shot firing cable, connecting wire, connecting system (series, series/parallel etc.) and firing device (exploder, etc.) shall be made at the planning stage of the blast.

(c) All connections in the shot firing circuit shall be clean, tight and insulated from contact with each other and the ground. The type of insulation shall be chosen after consideration of local conditions, i.e. presence of water, conducting rock and firing voltage. The insulation to the ground shall be checked if the conditions are found difficult.

(d) Only instruments approved by the Engineer shall be used at the blast site for checking circuit values.

(e) The resistance of the firing circuit shall be measured and the result shall be consistent with the calculated value in accordance with the number and type of detonators. In the case of series/parallel connection, the resistance of each circuit shall be balanced to the limits appropriate for the exploder and the detonators being used.

(f) The shot firing cable shall be checked visually for mechanical damage before every blast. It shall also be checked for correct open and closed circuit resistance before it is connected to the detonator circuits.

(g) Exploders and testing equipment shall be regularly tested for correct performance. The intervals between tests shall be decided after consideration of the local factors, but the tests shall always be carried out if the exploder and/or tester equipment have been subjected to abnormal conditions, or following a misfire.

(h) The means for controlling the discharge of the electrical energy into the firing circuit shall always be under the control of the shot firer.

(iv) When using other methods

The manufacturers' instructions shall be followed at all times. Where any doubt exists, advice shall be sought at the planning stage.

(g) Precautions before and after firing

(i) The shot firer shall determine the danger area for the blast being fired, having regard to the type of operation and to local conditions, e.g. visibility. He shall be responsible for checking that the danger area is clear of all personnel before going to the place of safety from which the blast is to be fired.

(ii) Sentries shall be posted to guard all possible entries to the danger area, where it is large and/or not completely visible from the shot firer's place of safety. Sentries shall carry an unmistakable form of identification e.g. red flags and shall prohibit entry into their sector of the danger area until the shot firer has checked that it is clear and has relieved him of his duty.

(iii) The post-firing examination of the blast area shall not be undertaken before sufficient time has elapsed to allow for the dilution of the shot firing fumes to a safe level. The time required shall be decided after consideration of the local conditions.

(iv) The shot firer's duty shall include an examination of the blasting site, and this shall be completed before work is resumed. This examination shall include inspections for;

- dangerous rock conditions,
- presence of undetonated explosives and / or accessories in the rock pile,
- presence of undetonated explosives and / or accessories in blast holes,
- abnormal appearance of the blast, which could suggest that not all the blast holes had detonated correctly.

(v) In many types of blasting work, a considerable accumulation of empty cases can be built up during the charging operation. The cases shall first be checked for freedom from explosives material, and then destroyed by burning on the surface, preferably after the blast has been fired. The burning operation shall preferably take place at a designated site removed from the charged boreholes, explosives materials, or explosives stores, and in accordance with manufacturer's instructions.

(h) Secondary Blasting

Secondary blasting in quarries shall be done either by pop shooting or plaster shooting to reduce

the size of boulders, produced from the primary blast, to smaller size for easy handling.

(i) Dealing with misfires

(i) General

(a) No attempt shall be made to fire a hole or holes which have misfired before a very careful examination of the conditions has been made.

(b) All normal rules detailed in Section 206.3(h) "Precautions before and after firing" shall be observed when firing misfired holes.

(c) When misfires occur, action shall be divided into two parts. The first is dealing with the immediate situation. The second is an analysis of why the misfire occurred, and what can be done to prevent repetition. Consideration shall always be given to seek qualified professional assistance in the second phase, and also in the first phase if the misfire has resulted in a specially difficult situation, in the opinion of the Engineer.

(d) Where the charge could be damaged by water, or where the hole cannot be safely fired, the charge shall be retrieved. In horizontal holes, this is most easily done by washing the charge out. In vertical holes, it may as a last resort be necessary to fire a succession of short small diameter holes or plaster shots to dislodge the rock, and recover the explosives from the rock. Great care shall be taken that the holes drilled for this purpose are angled away from the charge at least 300 mm away from the misfired hole and parallel to it.

(ii) When using Plain Detonators

(a) If a misfire occurs, no person shall be allowed to reach the area until a specified period has lapsed. The specified period shall not be less than one hour. After the period has lapsed the exposed fuse shall be examined. If it is found that the fuse has burnt only along part of its length, the stemming shall be carefully washed out and a new primer cartridge inserted and fired. No attempt shall be made to remove the explosive from the borehole. No metal objects shall be used to remove the stemming.

(b) Where the fuses are accessible, they shall be trimmed and the holes fired.

(c) Where the fuses are inaccessible or damaged, the principles detailed in 206.3 (c) shall be observed.

(iii) When using Electric Detonators

(a) If a misfire occurs in electric shot firing a time lapse of at least fifteen minutes shall be allowed before any person is allowed to approach the misfire.

(b) After this time, where the detonator leads are accessible, the individual assemblies shall be checked for continuity. If the test gives a positive result, the hole/s can be fired. It is advisable

to use another, tested, exploder and the cable shall be examined carefully for faults before the attempt to fire is made.

(c) Where the leads are inaccessible or where the test for continuity gives negative results, the hole/s shall be reprimed. The stemming shall be washed out with water, and new primers inserted. This method shall be used only if the main charge will not be seriously affected by the water used to remove the stemming. No attempt shall be made to dig out the stemming from the hole.

(j) Warning to Residents and Traffic

Adequate warning shall be given to neighbouring residents before blasting operations are carried out. A siren shall be sounded and men with red flags posted, on all roads at close proximity to the quarry, to warn traffic, as approved by the Engineer.

206.4 Safety in Handling, Transport and Storage

(i) Explosives, detonators, detonating fuse etc., shall not be stored except in a proper magazine which is clean, dry, well ventilated, well locked and approved by the Controller of explosives.

(ii) Explosives and detonators shall be stored separately either in separate magazines or in a separate compartment of the magazine. Detonating fuse shall be stored with explosives and not with detonators.

(iii) Smoking, matches or open light shall not be allowed in or near the magazine or while handling explosives and detonators. A permanent notice board in Sinhala, Tamil and English warning "NO SMOKING" shall be displayed in a prominent place near the magazine.

(iv) Only wooden tools shall be used to open cases of explosives. No metal tools shall be kept in the magazine or used. Cases shall not be opened inside the magazine.

(v) Cases of explosives shall be handled with care and shall not be dropped, pushed or slid in a rough manner.

(vi) When a case has been opened its contents shall be used before opening other cases.

(vii) Explosives and detonators shall be issued in the sequence of manufacturing dates marked on the boxes.

(viii) Primer cartridge shall not be made in the magazine.

(ix) Explosives shall not be transported with any other materials, particularly with tools or inflammable liquids.

(x) Whenever possible, explosives and detonators shall be transported in separate vehicle or conveyed by

different men. If both have to be carried in the same vehicle they shall be placed in separate compartments.

(xi) When transporting, the explosives shall be kept furthest from the engine. Explosives shall not be carried in the driver's cabin.

(xii) Loading and unloading of explosives to the vehicle shall be done as gently as possible.

(xiii) No explosives or detonators shall be transported without a valid transport pass.

(xiv) Only the essential quantity of explosives and detonators shall be transported to the blasting site. Explosives and detonators shall be kept apart until they are used.

(xv) A monthly return of explosives indicating the quantity of each kind of explosives used, the quantity of rock blasted, opening and closing stock balances shall be sent to the Engineer and to the responsible authority for the district in which the explosives are kept.

206.5 Tests and Standards of Acceptance

The materials and the work shall follow BS 5607:1998, Code of practice for the safe use of explosives in the construction industry

206.6 Measurement and Payment

This work item shall include preliminary site trials of blasting. No separate measurement will be made for the payment because this item is included in Pay Item 203 (3), Excavation - Hard rock for reuse.

SECTION 300

SUB-BASE AND BASE COURSES

SECTION 300

ROAD PAVEMENTS - GENERAL

300.1 Description

The road pavement shall consist of the following layers:

- Wearing course,
- Binder course,
- Base course,
- Subbase course,

The Contractor shall construct the pavement in accordance with the Drawings and following guidelines:

- Overseas Road Note 31, A Guide to the Structural Design of Bitumen-surfaced Roads in Tropical and Sub-tropical countries, Transport Research Laboratory (TRL), UK, 1993.
- Overseas Road Note 19, "A Guide to the Design of Hot Mix Asphalt in Tropical and Sub-tropical countries", Transport Research Laboratory (TRL), UK, Nov. 2002.
- Mix Design Methods for Asphalt Concrete (MS-2), American Asphalt Institute.
- AASHTO Guide for Design of Pavement Structures, AASHTO.

300.2 Pavement Construction

The Contractor shall have regard to the nature of those materials and of the subgrade or any capping and the need to protect them from deterioration due to the ingress of water, the adverse effects of weather and the use of construction plant. The Contractor shall programme the laying and compaction of the subbase and the subsequent pavement courses and take such other steps as may be considered necessary, to afford protection to the base, subbase and subgrade.

300.3 Horizontal Alignment

The edge of the pavement and all other parallel alignments shall be correct within a tolerance of 25 mm therefrom.

300.4 Surface Levels of Pavement Courses

The level of any point on the constructed surface of the pavement courses shall be the design level subject to the appropriate tolerances stated in TABLE 300-1.

TABLE 300-1: Tolerances in Surface Levels of Pavement

Description	Tolerance
Wearing course	± 6 mm
Binder course	± 6 mm
Base course	+ 15 mm, -10 mm
Subbase course	+ 10, - 30 mm
Subgrade	+10, - 30 mm

300.5 Surface Regularity

The longitudinal regularity of the surfaces of wearing, binder and base courses shall be such that such that the number of surface irregularities is within the relevant limits stated in TABLE 300-2.

TABLE 300-2: Maximum Permitted No. of Surface Irregularities

Description	No. of Surface Irregularities (in each lane of carriageway & shoulders) for each irregularity limit	
Irregularity Limits	4 mm	7 mm
Pave. Length	300 m	300 m
OCH main road	20 No.	2 No.
Other roads	40 No.	4 No.

An irregularity is a variation of not less than 4 mm or not less than 7 mm of the profile of the road surface as measured by the rolling straight-edge set at 4 mm or 7 mm as appropriate. No irregularity exceeding 10 mm shall be permitted.

Pavements shall be measured transversely for irregularities at regular intervals by a 3 m long straight-edge placed at right angles to the centre line of the road. The maximum allowable difference between the pavement surface and the straight-edge shall be 3 mm.

300.6 Rectification

Where any pavement area does not comply with the Specification for regularity, surface tolerance, thickness, texture depth, material properties or compaction, the full extent of the area which does not comply with the Specification shall be made good and the surface of the pavement shall be rectified.

SECTION 301

SUB-BASE

301.1 Description

This work shall consist of furnishing, placing and compacting sub-base material on a prepared and accepted subgrade in accordance with the Specification and the lines, levels, grades, dimensions and cross sections shown on the Drawings and as required by the Engineer.

301.2 Materials

2.1

Materials for sub base shall be free from vegetable matter and lumps or ball of clay and the material shall conform to the requirements for Types I, II or III as specified below.

(a) Type I material shall be natural or artificial mixture of hard durable particles of mineral aggregate, meeting the following requirements:

Grading: The grading shall conform to grading envelopes A, B, C or D in Table 301-1. The fraction passing the 75μm sieve shall be not greater than two thirds of the fraction passing the 425μm sieve.

Plasticity: The portion passing the 425μm sieve shall, if it is plastic,

Under flexible pavement:

LL<40,

PI<12,

Percentage of Wear: The coarse part of the material sampled and tested in accordance with AASHTO test method T96 shall have: Percentage of wear<50. The Aggregate Impact Value (AIV) when tested according to BS 812-112:1990(1995): AIV<35.

Soundness: The material shall not include any fraction that breaks up when alternately wetted and dried.

The 4 day soaked CBR value at 98% maximum dry density in accordance with BS 1377: Part 4 (Heavy Compaction): CBR after soaking>30.

(b) Type II material shall be material having the same basic characteristics as Type I except that the grading shall conform to grading envelopes E or F in Table 301-1 and: LL<40, PI<12.

There will be no requirement for the percentage of wear given by AASHTO Test method T 96.

(c) Type III material shall be a soil aggregate material satisfying, in general, the plasticity, and liquid limit requirements for Type I and shall have a 4 days soaked CBR value: CBR after soaking>30, when compacted to 98% of maximum dry density as determined by BS 1377-4:1990 (Heavy compaction test, 4.5kg rammer).

2.2 Method of Selection

The material for sub-base shall be the type indicated on the Drawings. If no type is indicated on the Drawings, the Contractor may select material of Type I, II or III, subject to the approval of the Engineer.

TABLE 301-1: Grading Requirements for Soil Aggregate Material

BS Sieve Sizes		Percentage by weight passing BS Sieves					
		Type I and Type III				Type II	
mm	µm	Grade A	Grade B	Grade C	Grade D	Grade E	Grade F
50		100	100	-	-	-	-
28		-	75 - 95	100	100	100	100
10		30 - 65	40 - 75	50 - 85	60 - 100	-	-
2		15 - 40	20 - 45	25 - 50	40 - 70	40 - 100	55 - 100
	425	8 - 20	15 - 30	15 - 30	25 - 45	20 - 50	30 - 70
	75	2 - 8	5 - 20	5 - 15	5 - 20	6 - 20	8 - 25

301.3 Method of Construction

3.1 Preparation of Subgrade

Before construction of sub-base, the earth work, topsoil, grassing, side ditches and drains for the section concerned shall be completed so that the section of embankment already constructed will be protected against erosion.

The subgrade shall be shaped and compacted in conformity with the provisions of Section 203, and completed for at least 150 m ahead of the placing of sub-base course material. Notwithstanding any earlier approval of subgrade, any damage to or deterioration of subgrade shall be made good before sub-base is laid.

3.2 Spreading Sub-base

Sub-base shall be spread in layers, with compacted thickness up to the designed subbase, as shown in the Drawings, subject to the type of roller to be used and the approval of the Engineer. The layers shall be as nearly equal in thickness as possible and compacted to the required density throughout the layer from top to bottom. Care shall be taken to prevent segregation of the material into fine and coarse parts.

3.3 Sprinkling, Rolling and Compacting

Immediately after each layer has been spread and shaped satisfactorily, each layer shall be thoroughly compacted with suitable and adequate compaction equipment approved by the Engineer. Rolling operations shall begin from the outer edge of roadbed toward the centre, gradually in a longitudinal direction; except on super elevated curves, where rolling shall begin at the low side

and progress toward the high side. Sub-base of sandy material shall be compacted by use of vibrating equipment.

Each layer shall be compacted to at least 98% of the maximum dry density as determined by BS 1377-4:1990 (Heavy compaction test, 4.5kg rammer). Frequencies of tests are given in the Section 1100. Quality Control Tests and Frequencies.

Sub-base material which does not contain sufficient moisture to be compacted in accordance with the requirements of this section shall be sprinkled with water as directed by the Engineer.

During construction of sub-base, the Contractor shall ensure the sub-base already spread and rolled is properly drained.

Sub-base material containing excess moisture shall be dried prior to or during compaction. Drying of wet material shall be performed by methods approved by the Engineer.

The surface tolerance is specified in Section 300.

301.4 Measurement

Sub-base as described in this section will be measured by the cubic metre of material compacted in place and accepted. Measurements shall be based on the cross section of the sub-base shown on the Drawings and actual length measured horizontally along the centre line of the surface of the road.

301.5 Payment

This work measured as provided above shall be paid for at the Contract unit price per cubic metre for sub-base as detailed below. The payment shall be full compensation for furnishing all materials, hauling, placing, compacting, sprinkling, finishing, shaping and testing and for all labour, equipment, tools and other incidentals necessary to complete the work specified.

Pay items	**Unit of Measurement**
301(1) Sub Base Course	cubic metre
301(2) Sub Base Course for Rigid Pavement	cubic metre

SECTION 302

AGGREGATE BASE

302.1 Description

This work shall consist of a base, composed of crushed aggregate material placed and compacted on a prepared and accepted subgrade, sub-base or other base course in accordance with the Specification and the lines, levels, grades, dimensions and cross sections shown on the Drawings and as required by the Engineer.

302.2 Materials

2.1 The materials shall meet the requirements for sub-base provided for in Section 301, Type I, Grade A or B except where otherwise herein indicated. The portion of aggregate passing the 425μm sieve shall be non-plastic. The material shall conform with the grading requirements listed in Table 301-1, Section 301. The material shall have a 4 day soaked CBR value, at 98% of maximum dry density in accordance with BS 1377: Part 4 Heavy compaction as indicated on the Drawings or, if not indicated, not less than 80 (CBR after 4 day soaking>80). The course part of the material sampled and tested in accordance with AASHTO test method T96 shall have a percentage of wear not greater than 40 (Percent of Wear<40). If no grading is indicated on the Drawings, grading A or B from Table 301-1 shall be used. The AIV when tested according to BS812-112: 1990 (1995) shall not exceed 30 (AIV<30).

2.2 Crushed Aggregate

Crushed aggregate shall consist of hard durable particles or fragments of rock or gravel crushed to the required size, and a filler of sand or other finely divided mineral matter. When the aggregate is produced from crushed rock, it shall be from a quarry approved in writing by the Engineer, and crushed and screened to achieve the required grading. When produced from gravel, not less than 50% by weight of the coarse aggregate shall be particles having at least one fractured face and, if necessary to meet this requirement or to eliminate an excess of filler, the gravel shall be screened before crushing.

302.3 Construction Methods

3.1 Preparation of Subgrade or Sub-base

The Subgrade or Sub-base shall be shaped and compacted in conformity with the provisions of Section 203, and Section 301, and completed for at least 50m ahead of the placing of the base course material.

3.2 Spreading Base

Base shall be spread in layers with compacted thickness up to the designed thickness, as shown in the Drawings, subject to the type of roller to be used and the approval of the Engineer. The layers shall be as nearly equal in thickness as possible. Care shall be taken to prevent segregation of the

material into coarse and fine parts.

Where the material for shoulders is the same as that used for the base course, the material shall be evenly spread in layers, as specified, for the full width of the roadbed and the base course and the shoulders constructed simultaneously.

Where the shoulders are not of the same material as the base course, then prior to spreading the aggregate base, a partial width of shoulder, not less than 0.7m wide, shall be constructed to the elevation of the top of each uncompacted layer being placed and the inside edge made as straight as practicable. After the partial completion of the shoulders, the aggregate shall be spread upon the subgrade or preceding layer, and against the previously formed shoulders, in layers of uniform thickness, as specified, to give the required compacted depth shown on the Drawings. The material deposited on the subgrade or previous layer may be spread and shaped by any method, which will not cause the segregation of the coarse and fine particles. When directed by the Engineer, areas of segregated coarse or fine material shall be remixed or removed and replaced with well-graded material.

When the base course is spread contiguous to concrete kerbs or gutters, extreme care shall be exercised not to damage the kerbs or gutters. Any damage to kerbs or gutters by the Contractor, shall warrant the removal and replacement of the kerbs or gutters.

3.3 Sprinkling, Rolling and Compacting

Immediately after each layer has been spread and shaped satisfactorily, each layer shall be thoroughly compacted with suitable and adequate compaction equipment approved by the Engineer.

Rolling operations shall begin along the edges and overlap the shoulder at least 0.7 m or as close to the outer edge of the shoulder as practicable where a full width roadbed base course is specified on the Drawings, and progress toward the centre, gradually in a longitudinal direction. On super elevated curves, rolling shall begin at the low side and progress toward the high side. The rolling operation shall continue until all roller marks are eliminated, and the course is thoroughly compacted.

Each layer shall be compacted to at least 98% of the maximum dry density as determined by BS1377-4: 1990 (Heavy compaction test, 4.5 kg rammer). Density of the compacted base course shall be determined by BS1377-4: 1990, Test 15.

Frequencies of tests are given in the Section 8 . Quality Control Tests and Frequencies.

Base course material which does not contain sufficient moisture to be compacted in accordance with the requirements of this Section shall be sprinkled with water. The Contractor shall supply the necessary water at his own expense. Base course material containing excess moisture shall be dried prior to or during compaction. Drying of wet material shall be performed by methods approved by the Engineer.

The final shaping and rolling of the shoulders to the full width shall be made after the base course is completed.

3.4 Surface Tolerance

Surface tolerance is specified in Section 300.

302.4 Measurement

This item shall be measured as the number of square metres or cubic metres of material complete in place and accepted. Surface measurements shall be based on the nominal width of the base course at the top surface of the base course shown on the Drawings and the actual length measured horizontally along the centreline of the surface of the road. Volume measurements shall be the cross section shown on the Drawings.

302.5 Payment

This work measured as provided above shall be paid for at the Contract unit price per cubic metre or square metre for Aggregate Base as detailed below. The payment shall be full compensation for furnishing all materials, hauling, placing, compacting, sprinkling, finishing, shaping and testing and for all labour, equipment, tools and other incidentals necessary to complete the work.

Pay Items	Unit of Measurement
302(1) Aggregate Road Base	cubic metre

(Sections 303, 304 and 305 are not used.)

SECTION 306

ASPHALTIC MATERIALS

306.1 Description

This section specifies the asphaltic materials to be used in the work.

306.2 Materials

2.1

Materials shall be of the type specified in the Special Provision or shown on the Drawings. If the material to be used is not specifically designated, the type used shall be approved in writing by the Engineer. In general, materials shall meet the requirements for one of the following types.

2.2 Asphalt Cement

Asphalt cement shall conform to the requirements (for the appropriate grade) of BS 3690-1: 1989 (1997) Standard Specification for Asphalt Bitumen or AASHTO M20:2000. Asphalt Bitumen shall be intended when material is referred to as "straight run bitumen", "penetration grade bitumen" or by its penetration value (as for example 60-70 or 80-100 pen).

306.3 Materials Requirements

3.1 Methods of Storage and Handling

Asphaltic material shall be handled and stored with due regard for safety and in such a way that at the time of use in the work material conforms to the Specification. In particular, emulsified asphalt shall be handled with care and not subjected to mechanical shocks or extremes of temperature likely to cause separation of the asphalt. Emulsified asphalt showing signs of separation shall not be used.

3.2 Application of Asphaltic Material Quantities

Ceylon Petroleum Corporation is the sole agency in Sri Lanka to supply asphalt cement materials in Sri Lanka. The Contractor shall order the required asphalt cement quantities through the Corporation without delay on a yearly basis. If the required quantity appears to be not available in the Corporation, the Contractor shall take immediate measures, e.g. import from abroad. If the Contractor failed to order the required quantities from the Corporation in time or failed to take immediate measures, e.g. importing from abroad, the Contractor cannot make any claims on delays and cost caused by the same and he will be held responsible for such delays.

306.4 Measurement

No separate measurement shall be made because Asphaltic materials are considered to be included in asphaltic base and pavement.

306.5 Payment

No separate payment shall be made because Asphaltic materials are considered to be included in asphaltic base and pavement.

(Section 307 is not used.)

SECTION 308

ASPHALT BOUND BASE

308.1 Description

This work shall consist of a course composed of asphaltic bound base constructed on a prepared and accepted subgrade, sub base or other base course in accordance with these Specifications and the lines, levels, grades, dimensions and cross sections shown on the Drawings and as required by the Engineer.

308.2 Materials

2.1 Aggregates shall conform to the requirements for crushed rock or crushed gravel, in Section 302 except that the grading shall be as shown in Table 308-1.

TABLE 308-1 Grading Requirements

Aggregate Grading BS Size		Type of Aggregate % by weight passing
mm	µm	Crushed Rock
50		100
37.5		95 - 100
28		75 - 90
14		60 - 75
3.35		30 - 45
	75	3 - 8
Asphalt Binder		% by weight of total mixture as found by analysis
		3.0 - 4.0

2.2 Asphaltic materials shall conform to the requirements of Section 306. In the absence of any requirement or permission to the contrary, asphalt cement of 60-70 penetration shall be used.

2.3 Filler shall comply with the requirements of Section 406 Clause 2.5 of the Specifications.

2.4 Preparations of Materials shall be carried out according to the requirements of Section 401.

2.5 The optimum bitumen contents shall be determined in accordance with Marshall Test (ASTM D.1559) so as to obtain a bituminous mixture meeting the following requirements:

Stability: 5.5 KN (Minimum)
Flow: 2-5 mm
Air void in total mix: 3-7 %

308.3 Construction Methods

3.1 Construction methods shall conform to the requirements of Section 401 and relevant clauses of Section 406, Asphalt Concrete Surfacing. However the diameter of the core cut shall be 150 mm. The density of the Asphalt Bound Base shall be not less than 92 % of the theoretical maximum density as per AASHTO T 209-99.

Thickness and Surface Tolerance

The thickness and surface tolerances are shown in Section 300.

308.4 Measurement

The quantity measured for payment shall be the number of cubic metres or square metres completed to the width and thickness shown on the Drawings and accepted in the completed base course.

308.5 Payment

The quantities measured as provided above, shall be paid for at the Contract unit price per unit of measurement as listed below that is shown in the Bill of Quantities or on the Drawings. The prices and payments shall be full compensation for furnishing and placing all materials including all labour, equipment, tools and incidentals necessary to complete the work.

Pay items shall be:		**Unit of Measurement**
308(1)	Asphalt bound base	cubic metre
308(2)	Asphalt bound regulating base course ….mm thick	square metre

(Section 309 is not used.)

SECTION 310

SHOULDERS

310.1 Description

This work shall consist of:

(a) The provision of material for, and construction of, shoulders to the lines, grades, levels, dimensions and cross section shown on the Drawings and as required by the Engineer but not including bituminous surfacing or grassing.

(b) The scarifying trimming and shaping the existing shoulders and reconditioning of the whole by addition, if necessary, of approved materials to form a shoulder to the lines, levels, grades, dimensions and cross sections shown on the Drawings and as required by the Engineer.

310.2 Material

(a) New Shoulders

Materials shall satisfy the appropriate requirements for the cross section in the drawings.

Sub-base materials shall be Type I and have grading A or B with the provision that the plasticity index shall not be greater than 11 (PI<11) and the liquid limit not greater than 35 (LL<35).

Where the design of the shoulder cross section includes sufficient protection at the outer edge to prevent erosion of the naturally well grassed embankment, and where at the same time the longitudinal grade of the road is less than 3 percent, the material shall conform to the requirements of Section 301 sub-base material Type I but plasticity index shall be not less than 5 and not more than 16 (5<PI<16), and the liquid limit shall be not greater than 35 (LL<35).

The material shall be a well graded aggregate of maximum size 37.5 mm and not more than 30 percent passing the 75 μm sieve. Plasticity index shall be not less than 5 and not more than 16 (5<PI<16), and the liquid limit shall be not greater than 35 (LL<35). The material shall be free of organic matter.

All material shall conform to any other requirements indicated on the cross sections on the Drawings or in the Special Provisions.

(b) Scarifying Trimming and Shaping of existing shoulder Additional materials shall conform to the requirements for classified earth set forth in Section 203 of the Specification and having a CBR of 25%, a plasticity index ranging from 4-15 and liquid limit not exceeding 40.

310.3 Construction Methods

(a) Wearing course, Binder course, Base course, Subbase course and capping layer (selected material) shall be extended to the shoulder and the rounding parts according to the Drawings. The road

surface must be constructed with a camber so that it sheds rainwater quickly. The top of the shoulders should be impermeable.

(b) Shoulders shall be processed and compacted in layers not exceeding 0.2 m thickness before compaction. The drainage course shall be compacted to 95 % of maximum dry density as determined by BS 1377- 4:1990 (Heavy compaction test, 4.5 kg rammer) and other courses to 98 % of maximum dry density as determined by BS 1377 - 4:1990 (Heavy compaction test, 4.5 kg rammer).

(c) After compaction the shoulder shall be trimmed to the cross section dimensions shown and shall conform to the required levels, slopes and cross section. The average thickness of each course shall not be less than the thickness shown on the Drawings and the accuracy of the surface shall be such that water drains away from the road over the surface freely and evenly without forming channels.

(d) The existing shoulder shall be scarified trimmed and shaped using a blade grader, with the addition if necessary, of suitable material to the lines, level, grades and dimensions, shown on the Drawings, or as ordered by the Engineer.

(e) On completion of scarifying trimming and shaping the shoulders shall be compacted by rolling as directed by the Engineer.

310.4 Measurement

The construction of shoulders shall not be measured as pay items of shoulders but as combination of the following pay items:

- Wearing course,
- Binder course,
- Base course,
- Subbase course,
- Subgrade (Embankment incl. capping layers).

310.5 Payment

The payment for shoulders shall be made using each component pay items, no separate payment by shoulder pay items.

SECTION 400

PAVEMENT

SECTION 401

ASPHALT PAVEMENT CONSTRUCTION - GENERAL

401.1 Description

1.1 General

For general requirements on asphalt pavement, Section 300, Road pavements-General shall be referred.

This work shall cover the general requirements that are applicable to all types of asphaltic bound bases and surfacing irrespective of gradation of mineral aggregate, type and amount of asphaltic material or use. Deviations from these general requirements are indicated in the specific requirements as set forth in the respective sections.

The work shall consist of one or more courses of plant-mixed asphaltic mixtures constructed on a prepared and accepted subgrade, sub-base, base course or other roadbed in accordance with the Specification and the specific requirements of the Contract and in conformity with the required lines, levels, grades dimensions and cross sections.

1.2 Composition of Mixtures

The asphaltic mix shall be composed of coarse mineral aggregate, fine mineral aggregate and filler. The several mineral constituents shall be sized, uniformly graded and combined in such that the resulting blend meets the grading requirements for the specific type under the Contract. To such composite blended aggregate shall be added asphalt with the percentage limits set in the Specification for the specific type.

401.2 Plant and Equipment

2.1 Mixing plant used by the Contractor shall be a modern type batching plant and shall have the capacity sufficient to supply the paver on the road continuously when spreading the asphaltic mix at normal speed and required thickness. The plant shall be able to heat the aggregate and the binder to the appropriate temperatures given in the tables and before coating the aggregate shall be adequately dried.

The plant shall be so designed, coordinated and operated so that the materials, including any added filler, shall be weighed or measured into the mixer and mixed in such a manner that the premix on discharge from the mixer is uniform in composition and all particles of the aggregate are completely coated.

The Contractor shall provide and have at hand not less than ten 25 kg standard weights for frequent testing of all weighing scales on the mixing plant. The plant shall, if situated in urban areas or required by the Contract, be equipped with a dust collector so

constructed as to waste or return uniformly to the elevator all or any part of the material collected.

The Contractor shall provide a field laboratory for testing of all materials used in Asphaltic mix design and testing.

Safety equipment - Adequate and safe stairways to the mixer platform and guarded ladders to other plant units shall be placed at all points required for accessibility to plant operations. All gears, pulleys, chains, sprockets and other dangerous moving parts shall be thoroughly guarded. Ample and unobstructed space shall be provided on the mixing platform. A clear and unobstructed passage shall be maintained at all times in and around the truck loading space. This space shall be kept free from drippings from the mixing platform. Flexible pipe connections carrying hot asphalt shall be shielded.

The mixing plant and all equipment necessary to operate the plant will be inspected by the Engineer for approval. The Contractor shall calibrate the plant periodically up to the satisfactory conditions.

2.2 Temperature limits for Asphaltic Mixtures

The asphaltic material shall be heated to the temperature as set forth in the tables. The heating system shall be so designed as to avoid overheating. The mixture shall be delivered to site within 10 °C of the temperature set in the job-mix formula.

401.3 Construction Methods

3.1 Weather Limitation

Asphaltic mixtures shall be placed only when the surface is dry, when rain is not forecast prepared roadbed is in a satisfactory condition; provided, however that the Engineer may permit, in case of sudden rain the placing of mixture then in transit from the plant, if laid at proper temperature and if the road bed is free from pools of water. Such permission shall in no way relax the requirements for quality and smoothness of surface.

3.2 Progress of Work

No work shall be performed when there is insufficient hauling, spreading or finishing equipment, or Labour, to ensure progress at a rate not less than 60% of the capacity of the mixing plant.

3.3 Hauling Trucks

Trucks for hauling asphaltic mixtures shall have tight, clean and smooth metal beds that have been sprayed with soapy water, thinned fuel oil, paraffin oil, or lime solution to

prevent the mixture from adhering to the beds. The amount of sprayed fluid shall however be kept to the practical minimum. Each load shall be covered with a canvas or other suitable material of such size as to protect the mixture from the weather. Any truck causing excessive segregation of material by its spring suspension or other contributing factors, or that shows oil leaks in detrimental amounts or that causes undue delays shall upon direction of the Engineer be removed from the work until such conditions are corrected. When necessary, in order that the mixture shall be delivered to the site within the specified temperature range, a properly fastened insulating cover shall be used. Loading and Transporting shall be such that spreading, compacting and finishing shall all be carried out during daylight hours unless satisfactory illumination is provided by the Contractor.

The Contractor shall provide adequate weighing bridges and maintain with the calibration. Each vehicle shall be weighed after each loading at the mixer and a record shall be kept of the gross weight, tare and net weight as well as time of despatch of each load.

3.4 Pavers

The equipment for spreading and finishing shall be approved mechanical; self powered pavers, capable of spreading and finishing the mixture true to the lines, grades, levels, dimensions and cross sections. The pavers shall be equipped with hoppers and distributing screws of the reversing type to place the mixture evenly in front of adjustable steering devices and shall have reverse as well as forward travelling speeds. Pavers shall also be equipped with vibrating screeds furnished with suitable burners or heaters.

The pavers shall maintain trueness of grade and confine the edges of the pavement to true lines without the use of stationery side forms. The equipment shall include blending or joint levelling devices for smoothing and adjusting longitudinal joints between lanes. The assembly shall be adjustable to give the cross section shape prescribed and shall be so designed and operated as to place the thickness or weight per square metre of material required.

The mixture after spreading and initial tamping by the paver shall have a smooth surface free of distortions caused by dragging, tearing or gouging.

If, during construction, it is found that the spreading and finishing equipment in operation leaves in the pavement surface tracks or indented areas or other objectionable irregularities that are not satisfactorily corrected by scheduled operations, the use of such equipment shall be discontinued and other satisfactory spreading and finishing equipment shall be provided by the Contractor forthwith. A fully trained and experienced operator shall be in direct charge of the paver. Material remaining in hoppers, conveying and spreading mechanisms, tampers and screeds shall be cleaned off at the

end of each working day. Narrow strips remaining alongside paver work shall be hand laid and rolled at the same time as the paver laid work, and allowance shall be made for extra compaction of hand-laid strips. Any defects in the finished surface shall immediately be rectified before any rolling takes place and there must be no unnecessary scattering back by hand of material on paver laid work.

3.5 Rollers

a) General

The type of roller or roller combination to be used shall be nominated by the Contractor for the approval of the Engineer prior to the commencement of work. Irrespective of the type of roller or roller combination, the Contractor shall supply evidence that the roller or roller combination shall have a compaction capacity not less than 1.5 times the spreading capacity of the paver. During construction should this compaction capacity not be met, an additional and appropriate roller shall be provided immediately to meet this requirement.

b) Procedure

Rolling of the mix shall consist of six separate operations as follows:-

- transverse joint
- longitudinal joint
- outside edge
- initial or breakdown rolling
- second or intermediate rolling
- finish or final rolling

The first rolling of all joints and edges, the initial or breakdown rolling and the final or finish rolling shall all be done with the steel wheeled tandem rollers. The second or intermediate rolling shall be done with the pneumatic tyred roller except on small operations as noted above.

The speed of the rollers shall not exceed 4 kilometres per hour for steel wheeled rollers and 6 kilometres per hour for pneumatic tyred rollers and shall be at all times slow enough to avoid displacement of the hot mixture.

3.6 Non Vibratory Rollers

Roller Requirements

Generally with each paver, two steel wheeled tandem rollers and one pneumatic tyred roller will be required, except that on projects involving a total of less than 500 tons of material the minimum requirement will be one tandem roller. All rollers shall be self propelled, capable of being reversed without backlash and equipped with power steering, dual controls allowing operation from the right or left side, water tanks, sprinkler systems and coco-mats to ensure even wetting of rollers or tyres. The Contractor shall supply to the Engineer for each type of roller a calibration chart showing the relationship between depth of ballast and weight and giving the tare weight of the roller. Each roller shall be in good condition and worked by a competent and experienced operator.

Steel wheeled tandem roller shall weigh not less than 8 metric tons and each tandem roller used for final compaction (finish rolling) shall have at least one roller capable of applying a minimum load of 33 N/mm of roller width.

Pneumatic tyred rollers shall be of an approved type having not less than seven wheels smooth tread compactor tyres of equal size and construction capable of operating at inflation pressures up to 850 kN per square metre. Wheels shall be equally spaced along both axle lines and arranged so that tyres on one axle line track midway between those on the other with an overlap. Each type shall be kept inflated to the specified operating pressure such that the pressure difference between any two tyres shall not exceed 35 kN per square metre. Means shall be provided for checking and adjusting the tyre pressures on the job at all times. For each size and type of tyre used the Contractor shall supply to the Engineer charts or tabulations showing the relationship between wheel load, inflation pressure and tyre contact pressure, width and area. Each roller shall be equipped with means of adjusting its total weight by ballasting so that the load per wheel can be varied from 15 N to 25 N. In operation the tyre inflation pressure and the wheel load shall be adjusted, as required by the Engineer, to meet the requirements of each particular application. In general the compaction of any course with a pneumatic tired roller shall be accomplished with contact pressure as high as the material will support.

3.7 Vibratory Rollers

Roller Requirements - Generally rollers shall be self propelled tandem rollers, capable of being reversed without backlash, be equipped with water tanks, sprinkler systems which wet the tyres evenly, and an automatic vibration control which cuts out the vibratory system before the machine comes to a halt.

The minimum operating weight of the roller shall be 3 tons and minimum drum width 0.75 m, the minimum linear drum applied force 33 N/mm and the minimum frequency of vibration 4000 r.p.m. (67 Hz) operating on both wheels.

Where the contractor wishes to use a roller or roller combination which meets most but not all of the above requirements, the Engineer may approve the use of such rollers provided they meet the compaction capacity as specified in Clauses 3.5 through 3.7 and compact to the density and surface tolerances specified in Section 300 of the Specification.

3.8 Preparation of Existing Surface

Where local irregularities in the existing surface would otherwise result in a course more than 75 mm thick after compaction, the surface shall be regulated using an asphaltic mixture to be approved by the Engineer, and thoroughly tamped or rolled. The mixture used shall be as follows:

a) Binder Course as per Section 406 – up to 55mm thick

b) Asphalt Bound base as per Section 308– between 55 mm to 100 mm thick

c) Layers of (b) & (a) – Above 100 mm thick

Approval of the Engineer

The thickness of the regulating course required and the materials to be used shall be as shown on the drawings or otherwise agreed with and to the approval of the Engineer. Where the existing roadbed is broken or in the opinion of the Engineer shows instability, the unstable material shall be removed and disposed of as directed by the Engineer and be replaced with the same mixture as specified for the next course, compacted to the standard and elevation of the adjacent surface.

Where the existing surface course is stabilized or asphaltic or Portland cement concrete, and the edges have become eroded, disintegrated, or broken the edges shall be trimmed back as directed by the Engineer. The debris shall be removed and disposed of, and the space backfilled with an asphaltic mixture or with gravel or similar approved material as directed and then compacted.

The surface upon which the mixture is to be placed shall be swept thoroughly and cleaned of all loose dirt and other objectionable material immediately before spreading the mixture.

Before spreading the mixture upon a Portland cement concrete surface all longitudinal and transverse joints shall be cleaned out and filled with an approved sand asphalt mix. Cracks shall be similarly treated as directed by the Engineer. Wherever possible the cleaning out shall be to a depth of 40 mm or more and the sand asphalt shall be thoroughly compacted in joints and cracks to a level not more than 3mm below the surface. A tack coat shall then be applied to the surface.

3.9 Spreading and Finishing

Upon arrival at the point of use, the temperature of the mixture shall be checked in both the hauling truck and in the paver hopper and recorded. The mixture shall be spread and struck off to the grade, elevation and cross section shape intended, either over the entire width or over such partial width as may be practicable. The mixture shall be laid upon an approved surface and only when weather conditions are considered suitable by the Engineer.

In narrow base widening, deep or irregular sections, turnouts or driveways where it is impractical to spread and finish the mixture by use of a paver, the Contractor shall use approved spreading equipment or acceptable hand methods as directed by the Engineer.

On areas where in the opinion of the Engineer, the use of spreading equipment is considered impractical the mixture shall be dumped on steel boards then spread, raked and laid by hand to provide the correct weight or uniform thickness of material without segregation.

The Contractor shall provide suitable means for keeping all small tools clean and free accumulations of asphaltic material. He shall provide and have ready for use at all times enough tarpaulins or covers, as may be directed by the Engineer, for use in any emergency such as rain, chilling wind, or unavoidable delay, for the purpose of covering or protecting any material that may have been dumped and not spread.

For macadam recipe mixes the maximum thickness of any compacted layer shall not exceed those given in BS 4987

3.10 Compaction of Mixtures

General - Immediately after the mixture has been spread and struck off, the surface shall be checked and any inequalities adjusted. The mixture shall then be thoroughly and uniformly compacted by rolling. Each course shall be rolled as soon after being placed as the material will support the roller without undue displacement or cracking.

Rolling shall start longitudinally at the sides and proceed toward the centre of the pavement except that on super elevated curves rolling shall begin at the low side and progress toward the high side. Successive trips of the roller shall overlap by at least one-half of the width of the roller and alternate trips shall not terminate at the same point. For initial rolling the drive roller should be nearest the paver. Any displacements occurring as a result of reversing the direction of the roller or from any other cause shall at once be corrected with rakes and fresh mixture where required. Care shall be exercised in rolling not to displace the line and grade of the edges.

Rolling shall progress continuously as may be necessary to obtain uniform compaction

while the mixture is in a workable condition and until all roller marks are eliminated.

To prevent adhesion of mixture to the roller, the wheels shall be kept properly moistened, but excess water will not be permitted.

Heavy equipment or rollers shall not be permitted to stand on the finished surface until it has thoroughly cooled or set.

Any petroleum products dropped or spilled from the vehicles or equipment employed by the Contractor upon any portion of the pavement under construction is cause for the removal and replacement of the contaminated pavement by the Contractor at no Client's cost.

Along kerbs, headers, manholes and similar structures and at all places not accessible to the roller, compaction shall be secured by means of hot hand tampers or with mechanical tampers giving equivalent compaction. Each hand tamper shall weigh not less than 10 kg and shall have a tamping face area of not more than 0.03 square metres.

The surface of the after compaction shall be smooth and true to the established crown and grade within the tolerance specified. Any mixture that becomes loose and broken, mixed with dirt or which is defective in any way, shall be removed and replaced with fresh hot mixture, which shall be compacted immediately to conform to the surrounding area. Any area of one square metre or more showing an excess or deficiency of asphaltic material shall be removed and replaced. All high spots, high joints, depressions, and honeycombs shall be adjusted and corrected as directed by the Engineer.

3.11 Joints

Both longitudinal and lateral joints in successive courses shall be staggered so as not to be one above the other. Longitudinal joints shall be arranged so that the longitudinal joint in the top course shall be at the location of the line dividing the traffic lanes. Lateral joints shall be staggered a minimum of 250 mm and shall be straight.

Longitudinal and transverse joints shall be made in a careful manner so that well bonded and sealed joints are provided for the full depth of the course. No mixture shall be placed against previously rolled material unless the edge is vertical or has been cut back to a vertical face. A brush coat of hot asphalt shall be applied just before additional is placed against the previously rolled material.

Spreading shall be as nearly continuous as possible and rollers shall pass over the unprotected end of freshly laid mixture only when authorised by the Engineer. In all such cases provision shall be made for a properly bonded and sealed joint with the new surface for the full depth of the course as specified above. Before placing mixtures against them, all contact surfaces of kerbs, gutters, headers, manholes, etc, shall be given a thin,

uniform coating of hot asphalt and the joints between these structures and the surface mixture shall be effectively sealed by the subsequent spreading, finishing and compaction operations.

3.12 Surface Test of the Pavement

(a) ***Surface Tolerances and Irregularities***:
As specified in Section 300.4.

(b) ***Surface Testing***:

- Tests for conformity with the specified surface tolerances shall be made immediately after initial compaction, and variations shall be corrected by removing or adding material as may be necessary. Rolling shall then be continued as specified. After final rolling, the smoothness of the course shall be checked again and any irregularity of the surface exceeding the above limits and any area defective in texture, compaction or composition shall be corrected as directed by the Engineer.
- Acceptance of surface course shall be based on the results of sampling and testing of at least 5 samples per each control strip for monitoring the compaction degree and surface course thickness (by extracting cores). The frequency of measurements might be increased or reduced at the Engineer's discretion.
- In addition, within 14 days after completion of paving work for the surface course, the roughness of the surface after final rolling shall be measured. For this purpose the Contractor shall provide a full set of portable roughometer similar or equivalent to a Multi-purpose Profiling System (including all the necessary devises, hardware and software) for calculation of the International Roughness Index (IRI) (AASHTO PP37 or ASTM E950). Defective areas on 0.1-kilometer segments with IRI values greater than 2.00 m/km shall not be accepted.

401.4 Measurement and Payment

No separate payment will be made for compliance to this part of the Specification.

SECTION 402

PRIME COAT

402.1 Description

A prime coat is a thin layer of bitumen sprayed onto the aggregate base course to give adhesion between the base and the subsequent binder course. This work shall consist of the careful cleaning of the surface to be primed and furnishing and applying asphaltic material in accordance with the Specification to the area shown on the Drawings and as directed by the Engineer.

402.2 Materials

2.1 Asphaltic Material

Prime coat shall be low viscosity, medium curing cutback bitumen such as MC-30 and MC-70.

2.2 Blotting Material

Blotting material shall be coarse sand or crushed stone conforming to the grading given in Table 402-1. The grading shall be determined by the sieve analysis test. It shall clean and dry and free of lumps of clay and other deleterious matter.

Table 402-1 Grading of Coarse sand or Crushed Stone used for Sand Sealing and as Blotting (blinding) Material

Sieve Size		% Passing
mm	micron	
9.5		100
4.5		85 - 100
2.36		50 - 95
1.18		25 - 80
	600	10 - 40
	300	0 - 15
	150	0 - 5
	75	0 - 2

402.3 Construction Methods

3.1 Weather Limitations

Prime coat shall be applied at a time when the surface to be treated is dry or slightly damp, when the ambient temperature is above 13°C and rising, or above 16 °C if falling and when the weather is dry.

3.2 Equipment

(a) Application to Large Areas

The equipment used by the Contractor shall include a power broom and blower or both, a self powered pressure asphaltic material distributor, and, when necessary, equipment for heating asphaltic material.

The distributor shall have pneumatic tyres of such width and number that the load produced on the road surface shall not exceed 1200 kg per mm of tyre width, and shall be so designed, equipped, maintained, and operated that asphaltic material at even heat may be uniformly distributed on variable widths of surface up to 5 metres at readily determined and controlled rates of from 1.0 litres per square metre with uniform pressure and with an allowable variation from any specified rate not to exceed 0.1 litre per square metre. Distributor equipment shall include an instrument for measuring the speed of travel accurately at low speeds, the rate of flow of asphaltic material through the nozzles, the temperature of the contents of the tank and the pressure. These instruments shall be so located that the operator can easily read them whilst operating the distributor.

Distributors shall be equipped with a separate power unit for the pump and full circulation spray bars. The spray bar on the distributor shall be controlled by a man riding at the rear of the distributor in such a position that operation of all sprays is in his full view.

Before commencing the spraying, the lateral spray of bitumen shall be checked at least once a month by carrying out Depot tray tests as per BS 1707: 89.

(b) Application to Small Areas

The equipment shall be to the approval of the Engineer but shall generally conform to the following:

The equipment used shall be capable of applying the asphalt material within the specified temperature range and concentration in accordance with Table 402-2 and Clause 3.4 respectively.

The distributor shall either have pneumatic tyres and be of such weight so as not to damage the surface to be treated or shall be kept clear of the surface.

(c) Supplementary general requirements for (a) and (b)

The tanks of distributors shall be fitted with accurately calibrated dipsticks or contents gauges.

All measuring equipment on the distributor shall have been recently calibrated and an accurate and satisfactory record of such calibration shall be supplied to the Engineer.

If, after beginning the work, the distribution of asphaltic material is found to be in error the distributor shall be withdrawn from the work and calibrated in a manner satisfactory to the Engineer before proceeding with the work.

The Engineer may require such tests as he considers necessary to check the performance of the distributor. As and when directed by the Engineer, the Contractor, shall make the distributor and its equipment available for field testing and shall supply any assistance required for this purpose. Any distributor which does not operate satisfactorily or conform to the requirements of the Specification in all respects may be rejected by the Engineer for further use on the road.

3.3 Surface Cleaning

Immediately before applying the asphalt material all loose dirt and other objectionable material shall be removed from the surface with a power broom and blower or both as required. Such cleaning shall continue until the entire surface shows a pattern of exposed large particles well wedged together and free from dust. When so ordered by the Engineer a light application of water shall be made just before the application of asphaltic material.

3.4 Application of Asphaltic Material

Asphaltic material shall be applied by means of a distributor at the rate or rates directed by the Engineer, which will usually be from 1.0 litre per square metre and at a temperature within the range called for in Table 402-1 for the particular material being used. Any prescribed application shall be divided into two applications when necessary to prevent asphalt flowing off the surface and additional asphaltic material shall be applied where surface conditions indicate it to be necessary, if the Engineer so directs. No further courses shall be applied until the prime coat set and the solvent evaporated.

When so directed, the prime coat shall be applied in lanes of approximately one half or less of the width of the completed surface. A lane of prime coat shall be applied, allowed to penetrate not less than 4 hours, then covered with blotting material if required and opened to traffic before asphaltic material is applied to the adjacent lane. In covering the first treated lane, a strip at least 200mm wide shall be left uncovered where the two lanes join, to permit a slight overlap of the asphaltic material.

The surfaces kerbs of structures and trees adjacent to the areas being treated shall be

protected in such a manner as to prevent their being spattered or marred. No asphaltic material shall be discharged into a burrow pit or gutter.

TABLE 402-2 SPRAYING TEMPERATURES FOR ASPHALT

Type Grade Cutbacks	Grade (approx.)	Temperatures (whirling spray jet)
R.C or M.C	30	50 - 60
	70	65 - 80
	250	95 - 115
	800	115 - 135
	3000	135 - 155
Emulsions ambient temperature or hotter as necessary for uniform spraying and satisfactory penetration.		
Asphalt cement	60 - 70 pen	165 - 185
	80 - 100 pen	160 - 175

Note: slot jet distributors should allow a lower spray temperature

3.5 Maintenance and Opening to Traffic

Traffic shall not be permitted on the primed surface until the asphaltic material has penetrated and dried and, in the opinion of the Engineer, will not be picked up by traffic. Where the Engineer deems it impracticable to detour traffic, the Contractor shall spread the minimum quantity, as determined by the Engineer, of blotting material necessary to avoid picking up, and traffic shall be allowed to use areas so treated. Any areas containing an excess or deficiency of priming material shall be corrected by the addition of sand or asphalt as directed by the Engineer. Such corrections of faulty work shall be rectified before the asphalt concrete is laid.

402.4 Measurement

The quantity of asphaltic material measured for payment shall be the number of litres or asphaltic material used as directed in the accepted work, measured in accordance with Section 306.

The quantity of blotting material shall not be measured for payment

402.5 Payment

This work measured as provided above, shall be paid for at the Contract unit price per unit of measurement, for each of the items listed below that is shown in the Bill of Quantities. The prices and payment shall be full compensation for preparation of the surface and furnishing and placing the materials including blotting material, all labour, equipment, tools and incidentals necessary to complete the work prescribed in this section.

Pay Items	Unit of Measurement
402 (1) Prime Coat	litre

SECTION 403

TACK COAT

403.1 Description

This work shall consist of furnishing and applying asphaltic material to a previously prepared roadbed, in accordance with the Specification and to the width and area required by the Engineer.

403.2 Materials

Asphaltic material shall be Catonic Rapid Setting (CRS-1, CRS-2) or Catonic Slow Setting (CSS-1) as per AASHTO M59-01.

403.3 Construction Methods

3.1 Equipment

The equipment shall be as specified in Section 402 Prime Coat.

3.2 Cleaning Site

When, in the opinion of the Engineer, it is necessary, the width of surface to be treated shall be cleaned with a power broom or power blower to remove loose dirt and other objectionable material. The surface to be treated shall be dry.

3.3 Application of Asphaltic Material

Immediately after cleaning of the surface, asphaltic material shall be applied by means of a distributor at the rate directed by the Engineer, but not to exceed 0.75 litres per square metre and at the temperature within the range called for in Section 402 for the particular material being used. The tack coat shall be applied only when the surface is dry except with the permission of the Engineer.

The surfaces of kerbs and/or structures and trees adjacent to the areas being treated shall be protected in such a manner as to prevent their being spattered or marred. No asphaltic material shall be discharged into a borrow pit or gutter. The Engineer may direct that emulsions shall be diluted with clean water in order to control the rate of spread.

The surface course shall not be placed over the tack coat until it is in a proper condition of tackiness to receive it. Tack coat shall be applied only so far in advance of surface course placement as is necessary to obtain this proper condition of tackiness. Until the surface course is placed, the Contractor shall protect the tack coat from damage.

403.4 Measurement

The quantity of asphaltic material measured for payment shall be the number of litres or tonnes of asphaltic material used as directed in the accepted work, measured in accordance with Section 306.

403.5 Payment

This work measured as provided above, shall be paid for at the Contract price per unit of measurement, respectively for each of the items shown in the Bill of Quantities. The prices and payment shall be full compensation for furnishing and placing the materials, including all labour, equipment, tools, and including incidentals necessary to complete the work.

Pay Items		Unit of Measurement
403 (1)	Tack Coat	litre

SECTION 404

ASPHALTIC SEAL COAT AND ASPHALTIC SURFACE TREATMENT

404.1 Description

1.1

Asphaltic Seal Coat shall consist of a light application of asphaltic material with or without cover aggregate to a previously constructed asphaltic road surface in accordance with the Specification and to the area shown on the Drawings and as directed by the Engineer. It may be applied to either new or old asphaltic pavements to seal surface voids or applied to surface treatments to increase aggregate retention, prevent dusting and provide a uniform dark colour.

1.2

Asphaltic Surface Treatment shall consist of Double Bituminous Surface Treatment (OBST) and Single Bituminous Surface Treatment (SBST) to a primed non-asphaltic surface or to a previously constructed asphaltic surface in accordance with the Specification and to the area shown on the Drawings and as directed by the Engineer. Further guidance in the use of asphalt surface treatment may be obtained by inspection of the UK Transport Research Laboratory – Overseas Road Note 03.

404.2 Materials

2.1 Asphaltic Materials

Asphaltic materials shall be of the types and grades indicated in the Special Provisions or elsewhere in the Contract documents and shall conform to the requirements of Section 306.

2.2 Asphalt Additive

Adhesion and Anti-stripping Agent shall be added to the Asphaltic material where so specified in the Contract documents or when the Engineer so directs or approves. The additive shall be of a type approved by the Engineer and the required percentage of additive shall be thoroughly mixed with the asphaltic material in accordance with the manufacturer's instructions or as directed by the Engineer for such time as is necessary to produce a homogeneous mixture.

2.3 Aggregates for Bituminous Surface Treatment

For single bituminous surface treatment the cover aggregate shall be nominal 20 mm, 14 mm or 10 mm size chippings as specified in the Special Provisions or as directed by the Engineer.

For double bituminous surface treatment the cover aggregate for the first application of

asphaltic material and coverage aggregate shall be nominal 20 mm size chippings, and the cover aggregate for the second application of asphaltic material and cover aggregate shall be nominal 10 mm size chippings, or as specified in the Special Provisions.

Cover aggregates shall be screened crushed stone or crushed gravel and shall comprise clean, dry, hard, tough, sound, angular and cubical chippings free from vegetative and other organic matter, dust clay and other deleterious substances. Cover aggregates shall conform to the following physical and mechanical quality requirements:

(a) The estimated coated area shall be not less than 95% when tested in accordance with AASHTO Test Method T 182, using the asphaltic material intended for the job and tested with additive if so specified. When testing aggregates in accordance with AASHTO Test Method T 182 the temperature of the water and tray of binder shall be increased from 25 degrees to 40 °C, so as to reflect the expected temperature of the road surface during the treatment.

(b) The Los Angeles abrasion value shall be not more than 40 when tested in accordance with AASHTO test T 96 and the Aggregate Impact Value when tested in accordance with BS 812 not more than 30.

(c) The weighted average weight loss in the sodium sulphate soundness test (5 cycles) AASHTO Test Method T 104, shall be not more than 12%.

(d) The flakiness index when tested in accordance with BS 812 shall be not more than 35.

(e) The gradation shall conform to the appropriate envelope in the following Table 404-1.

TABLE 404-1: Grading Requirements for Cover Aggregate For Asphaltic Surface Treatment And Asphaltic Seal Coat

BS Sieve	NOMINAL SIZES % by weight passing BS Sieve			
mm	20	14	10	5
28	100			
20	85 - 100	100		
14	0 - 40	85 - 100	100	
10	0 - 7	0 - 40	85 - 100	100
6.3	-	0 - 7	0 - 35	85 - 100
5.0	-	-	0 - 10	-
3.35	-	-	-	0 - 35
2.36	0 - 2	0 - 2	0 - 2	0 - 10

Blotting material shall be clean, dry sand or stone dust approved by the Engineer, and shall be free from vegetative and other organic matter and clay.

When so indicated elsewhere in the Contract documents or ordered by the Engineer aggregates shall be pre-coated with approved pre-coating material to improve the adhesion to the asphalt.

2.4 Pre-coated Aggregate

Pre-coating material shall be thinly and evenly applied by means of a fine pressure spray to a moving stream of aggregate or by mixing with the aggregate in an approved mixing plant so that all particles are fully coated but do not contain excess material. The coating shall be such that no material will drip from a particle of aggregate suspended between the fingers.

Aggregate shall not contain moisture sufficient to cause uneven distribution of the pre-coating material. It shall not be used in the work unless the pre-coating material has adhered effectively to the aggregate.

Pre-coating of aggregate shall not be carried out when rain is imminent unless the aggregate is adequately covered or unless the mixing of an adhesion agent in the pre-coating material has been authorised by the Engineer.

In areas subject to dusty conditions, pre-coated aggregate shall not be stockpiled for any period longer than is necessary for moisture to dry out. When there is a visible coating of dust on the particles the Engineer may direct that portions of the stockpiles be pre-coated again.

2.5 Stockpiling of Aggregates

Stockpiling of aggregates will be permitted only, where agreed by the Engineer. A separate be made for each nominal size of aggregate at each location.

The site of the stockpile shall be cleared of all vegetation and debris, graded and drained, and where the Engineer deems it necessary, the area shall be surfaced with a 100 mm layer of approved stone or rock. The costs for such kind of work shall not be paid separately, and shall be deemed included in the price and rates introduced in the Bill of Quantities for the main item.

Unless otherwise approved by the Engineer each stockpile shall be built at least two meters high by tipping in layers not more than one metre deep over the whole area of the stock-pile. The Contractor shall supply any planking or other material required in connection with movement of vehicles over and about the stockpiles. The bottom 50 mm layer of aggregate or any contaminated aggregate shall not be used in the work.

TABLE 404-2: Approximate Quantities of Materials For Surface Treatments and Seal Coats Per Square Metre

Nominal size of Aggregate (mm)	RATE OF APPLICATION	
	Kilograms Aggregate	Litres Asphaltic Material
20	20 - 30	1.2 - 2.2
14	12 - 18	0.9 - 1.5
10	8 - 12	0.7 - 1.2
5	5 - 8	0.4 - 0.8
None (fog Seal)	none	0.2 - 0.5

Notes:

1) The quantities shown above are a guide only and will vary considerably according to the type and condition of the surface, the grading, type, shape and absorbency of the aggregate, the weather conditions and the traffic.
2) The asphaltic material may be asphalt cement cut back asphalt or emulsified asphalt as specified elsewhere in the Contract documents. For seal coats, the Engineer may direct that emulsions shall be diluted with clean water in order to control the rate of application.
3) In the case of multiple surface treatments a considerable variation of the quantities shown above for asphaltic materials may be found necessary or desirable. The first application of asphalt may be reduced and subsequent applications increased if this provides a better result.
4) The actual quantities to be used in the work shall be as directed by the Engineer.

404.3 Construction methods

3.1 Equipment

The Contractor shall supply all the plant and equipment necessary for carrying out the work in accordance with the Specification and shall supply details of the make, model capacity, weight and such other details of the plant and equipment as may be required by the Engineer.

For seal coats without cover aggregate, the Contractor shall include a power broom and a self-powered asphaltic material pressure distributor as per the equipment for the works, and when necessary, equipment for heating asphaltic material shall be also included.

For seal coats with aggregate, and surface treatments, the equipment shall include a power broom or a power blower or both, a drag broom, a self-powered asphaltic material pressure distributor, a self-propelled pneumatic tyred roller, aggregate spreading equipment an adequate number of trucks and, when necessary, equipment for heating asphaltic material. A steel wheeled roller may be used only when so authorised by the Engineer.

In addition, when coated aggregates, asphalt additives or rubberised asphaltic materials are specified, approved mixing plant shall be provided for the particular application.

Plant and equipment shall comply with the following requirements:

(a) The asphaltic Material Distributor shall conform to the requirements of Section 402 Clause 3.2.

(b) The Power Broom shall be a rotary broom, towed or self-propelled, specifically designed for sweeping road surfaces.

(c) The Drag Broom shall be capable of distributing unevenly spread aggregate without distributing the particles freshly bedded in the binder.

(d) The Pneumatic Tyred Roller shall conform to the requirements of Section 401 Clause 3.6.

(e) The Steel Wheeled Roller, where this type is permitted shall have a load per mm width of roller of between 250 and 450 kilograms.

(f) The Aggregate Spreader shall be approved mechanical equipment capable of spreading a uniform layer of cover aggregate of the specified size in accordance with Clause 3.5.

(g) Motor trucks shall be suitable in number and performance for the application of aggregate in accordance with Clause 2.5.

(h) Heating Equipment where permitted shall be capable of producing uniform heating to the required temperature without damage to the asphaltic material. An approved instrument for temperature measurement in Celsius with an accuracy of + or - 3% shall be provided. Means shall be provided to drain completely the heating tank or tanks. Suitable fire-fighting equipment and material shall be conveniently available to the heating equipment at all times when heating is in progress.

3.2 Weather Limitations and Control of Work

No spraying shall be carried out on a wet pavement, while rain appears imminent or during high winds

The Engineer may order work to cease temporarily on account of adverse weather, unsatisfactory condition of materials, equipment or pavement or any conditions which he considers may affect the work adversely.

3.3 Cleaning and Preparation of Surface

Prior to the application of Binder, loose dirt and other objectionable material shall be removed from the surface by means of the power broom or blower or both. If this does not provide a uniformly clean surface, additional sweeping shall be done by hand, using stiff bass or similar brooms. Sweeping shall extend at least 0.2m beyond each edge of the area to be sprayed.

Adherent patches of objectionable material shall be removed from the surface by steel scraper or other approved method and where the Engineer so directs the scraped area shall be washed down with water and hand brooms.

No application of asphaltic material shall be undertaken until the pavement has been cleaned to the satisfaction of the Engineer. This shall apply to the second application as

well as the first.

Where a prime coat has been applied to the surface, any area in which the prime coat has been insufficiently applied or is defective in any way shall be reprimed as directed by the Engineer. A period of at least 48 hours or such longer period as may be necessary for the primer to become completely dry shall elapse before any further asphaltic material is applied.

Before application of the asphaltic material any necessary preliminary patching of the surface of the road shall have been completed to the satisfaction of the Engineer.

3.4 Application of Asphaltic Material

The uniform application of asphaltic material at the rate specified or ordered shall be made by means of the distributor except that where the use of the distributor is not practicable for the application to small areas, the Engineer may approve the application by means of hand spray equipment attached to the distributor.

Application temperature shall be within the range called for in Table 402-1, for the particular asphaltic material being used, except that for rubberised asphaltic materials a higher temperature of application may be specified or directed by the Engineer. When an adhesion agent has been added to the asphaltic material the whole of the material in the distributor shall be circulated for at least fifteen minutes or such greater time as may be necessary to achieve a homogeneous mixture at uniform temperature.

Quantities of asphaltic materials in excess of requirements shall not be heated, nor shall such materials be held at temperatures within the range of application temperatures for periods in excess of ten hours. Any asphaltic material which has been heated for an excessive period of time or which has been overheated shall be rejected.

The area to be sprayed with asphaltic material at any time shall be limited to that which can be covered with aggregate at the specified rate. Liquid asphalts shall be covered by aggregate immediately after spraying.

When so directed the asphaltic material shall be applied in lanes of approximately one-half or less of the width of the completed surface and when so applied there shall be a slight overlap of asphaltic material along the adjoining edges of lanes. In the case of multiple surface treatments succeeding courses shall have the asphalt joint offset by approximately 0.15m from the joint of the preceding application.

During, all applications, iron work in the road and the surface of adjacent structures and trees shall be protected in such manner as to prevent their being spattered or marred.

Except for seal coats without cover aggregate, suitable paper shall be spread on the surface for a sufficient distance back from the ends of each application so that flow through the nozzles may be started and stopped on the paper and so that all nozzles will

operate properly over the entire length being treated. Paper so used shall be immediately removed and disposed of in a manner satisfactory to the Engineer.

The distributor shall commence moving at a sufficient distance in advance of the start of the application to ensure that the road speed for correct application is attained at the commencement of spraying and shall maintain this speed until passed the finishing point of the application.

Provision shall be made for 10 percent or such other percentages as may be determined by the Engineer, of the rated capacity of the distributor tank to be retained in the tank at the completion of each run so as to avoid air entrainment within the delivery system and provide for any minor excess in the rate of application.

After each application, the quantity of material sprayed shall be checked against the area covered, and any necessary adjustments shall be made to ensure that the specified or ordered rate of application is maintained in subsequent runs.

Spraying shall cease immediately if any defect develops in the spraying equipment and it shall not recommence until the fault has been rectified.

3.5 Application of Cover Aggregate

Before the asphaltic material is applied, sufficient cover aggregate shall be in trucks at the site of the work to provide the full cover for the area to be sprayed. The application of the aggregate shall proceed immediately after application of asphaltic material commences and shall be completed within one minute of the completion of spraying or such smaller period of time as the Engineer shall direct.

The aggregate shall be spread uniformly over the asphaltic material by means of the approved aggregate spreader at the rate specified or as ordered by the Engineer. Any bare or insufficiently covered areas shall be re-run by the mechanical spreader or covered by hand as necessary to give uniform and complete coverage. Any aggregate spread in excess of the rate specified or ordered shall be scattered and evenly distributed on the road or otherwise removed and stockpiled as directed by the Engineer.

3.6 Rolling and Brooming

Immediately after spreading to the satisfaction of the Engineer, the aggregate shall be rolled with one or more pneumatic tyred rollers or, if permitted by the Engineer, by approved steel wheeled rollers, until the aggregate is firmly embedded in the asphaltic material. Where required to ensure an even distribution of aggregate the surface shall be drag broomed after the initial rolling except that if the drag broom has any tendency to dislodge aggregate particles bedded in the binder the Engineer may direct that drag brooming be deferred or eliminated, and that light hand brooming be substituted. Rolling shall be continued, for as long as is necessary to ensure thorough incorporation of the aggregate into the binder or as directed by the Engineer.

3.7 Control of Traffic

The Contractor shall take all necessary precautions to protect the work from damage until such time as the seal coat or surface treatment has developed sufficient strength to carry normal traffic without disturbance of the aggregate. Where it is necessary to allow early use of the new work to facilitate the movement of traffic, vehicles may be allowed to run on the work after rolling is completed provided that vehicles are controlled to such slow speeds that no displacement of aggregate occurs.

The Contractor shall take all necessary steps to avoid or minimise delays and inconvenience to road users during the course of the work. Where adequate detours or side-tracks are available, traffic shall be temporarily diverted while the work is in progress. Adequate signs, signals, barriers and lamps for the warning and guidance of traffic shall be provided at all times during the course of the work.

No traffic shall be permitted to pass the working area during the application of asphaltic material nor shall traffic be permitted to encroach upon the edge of asphaltic material until such time as it is covered with aggregate.

The Contractor shall take all reasonable precautions to protect traffic against damage or disfigurement by construction equipment, tools and material, splashes and smirches of asphalt or other construction materials and shall be responsible for any claims arising from such damage or disfigurement.

404.4 Measurement

The quantities of aggregate or pre-coated aggregate measured for payment shall be the number of square metres used as directed in the accepted work.

The quantities of materials used as directed shall be those calculated from the specified or authorised area in the work. If the rate of application is less than that specified or altered, and is accepted by the Engineer, the actual quantities shall be as the basis of payment.

404.5 Payment

The quantities, measured as provided above shall be paid for at the Contract unit price per unit of measurement, respectively, for each of the items listed below that is shown in the Bill of Quantities. The prices and payment shall be full compensation for furnishing, and placing all materials, including all labour, equipment, tools and incidentals necessary to complete the work.

Where defective work is corrected or additives used which have not been specified or ordered by the Engineer, no payments will be made in respect of extra work or materials in excess of the quantities specified or ordered.

Payment shall include for the removal by sweeping of any contamination of the first

application by trafficking prior to the second application.

Pay Items		Unit of Measurement
404(l)	Double Bituminous Surface	square metre
404(2)	Single Bituminous Surface	square metre

(Section 405 is not used.)

SECTION 406

ASPHALT CONCRETE SURFACING

406.1 Description

1.1 General

This work shall consist of a surfacing of dense graded asphaltic concrete constructed on a prepared base in accordance with the Specification and the lines, levels, grades, dimensions and cross section shown on the Drawings and as required by the Engineer.

All the provisions in Section 300, "Road Pavements - General" and Section 401, "Asphalt Pavement Construction - General" shall form a part of the Specification unless otherwise stated.

The surfacing shall consist of one or two layers of the thickness shown on the Drawings. The top layer shall be denoted as the wearing course and the lower layer as the binder course. Mixes shall be designed according to the "Marshall Method Mix Design" Asphalt Institute Manual - No 2, MS-2.

1.2 General Composition of the Mixture

The mixture shall consist of mineral aggregate, and filler if needed, coated with asphalt cement. The total mineral aggregate shall have a job mix grading within the limits set in Table 406-1, even allowing for tolerances or conform to that given in BS 594: Part 1.

In exceptional cases the Engineer's approval may be given to grading outside the limits specified in Table 406-1.

The ratio of total material passing the 75 µm sieve to asphalt by weight shall not exceed 1.5 to 1.0, nor be less than 1.0 to 1.0.

In addition to meeting the requirements of the job mix formula in Clause 1.3, laboratory samples shall be prepared using 75 blows. The samples shall be of approved material to the gradation and asphalt content stated and shall have the following characteristics:

- Marshall Stability: not less than 9.0 kN.
- Marshall Flow (0.25mm): not less than 8 and not more than 16
- The ratio Marshall Stability (kN)/Marshall Flow (0.25mm): not less than 0.55
- Air Voids in Mix (VIM), binder course: 4% to 7%
- Air Voids in Mix (VIM), wearing course: 3% to 5%
- Voids in Mineral Aggregate (VMA) Greater than 13 %

- The asphalt contents on the "Wet" or right-hand increasing side of the VMA curve shall be avoided.
- The air Voids in total Mix (VIM) at refusal density as per TRL UK Road Notes 19 and 31 for high traffic and severe sites (slow moving heavy traffic) shall not be less than 2.5 % and 3.0 %, respectively.

The selected job mix shall be from one of the classifications listed below:

TABLE 406-1: GRADING FOR ASPHALT SURFACING

Mix Classification Course			**1**	**2**	**3**
Thickness mm			**Binder**	**Wearing**	**Wearing**
		Max	**75**	**75**	**75**
		Min	**35**	**35**	**40**
			Total % by weight passing including filler		
Sieve size (mm)	Sieve size (micron)				
28			100	100	100
20			90 - 100	85-100	93-100
10			58 - 75	65-94	59-94
5			37 - 52	46-74	38-69
2.36			21 - 38	35-58	25-48
1.18			15 - 33	26-48	20-40
	600		10 - 26	18-38	15-32
	300		6 - 20	11-28	10-23
	150		2 - 10	7-20	4-15
	75		1 - 5	3 - 12	3-12
Asphalt content (%)			4.0 – 6.5	4.0-6.0	4.5-6.5

1.3 Job Mix

Before starting work, the Contractor shall submit to the Engineer in writing, a proposed job-mix formula for the mixture to be supplied for the project. The formula so submitted shall stipulate for the mixture a single percentage of aggregate passing each required sieve size a single definite temperature at which the mixture is to be emptied from the mixer, and, for mixtures to be laid hot, a single definite temperature at which the mixture is to be delivered on the road, all of which shall fall within the ranges of the general composition and temperature limits.

All mixture furnished to site shall fall within the ranges of tolerance given below:

- Passing sieves 10mm and larger ±5%
- Passing sieves between 10mm and 75µm ±4%
- Passing 75 µm sieve ±1.5%
- Asphalt ±0.3%

- Temperature of mixture when emptied from mixer ±10°C
- Temperature of mixture at delivery on road ±10° C

Each day samples of the materials and mixture shall be taken and tested as specified in the following British Standards or as the Engineer considers necessary for checking the required uniformity of the mixture.

- Binders	BS 76 and BS 3690	}	or equivalent ASTM
- Aggregates	BS 812, BS 594 and BS 1047	}	or AASHTO tests
- Coated macadam	BS 598	}	

When unsatisfactory results or changed conditions make it necessary, the Contractor shall submit a new job-mix formula to the Engineer for approval.

Should a change in a material be encountered or should a change in a source of material be made, a new job formula shall be submitted and approved before the mixture containing the new material is delivered. Materials will be rejected if they are found to have void or asphalt content greater or less than the specified range.

406.2 Materials

2.1 Asphaltic Materials

Asphaltic Materials shall conform to the requirements of Section 306. In the absence of any requirement or permission to the contrary, asphalt cement of 60-70 penetration shall be used for binder course and wearing.

2.2 Asphalt Additive

The provisions of Section 404 -2 Clause 2.2 shall apply.

2.3 Coarse Mineral Aggregate

Coarse aggregate is material substantially retained on the 5 mm BS test sieve (Definition in BS 812) and shall be crushed rock, or crushed gravel. Only one type of coarse aggregate shall be used except by written permission from the Engineer.

Crushed rock, and crushed gavel shall consist of clean, tough, durable material free from vegetable matter, soft particles, and other objectionable matter. When gravel is used the clay and silt content shall not exceed 1% by mass of the coarse aggregate when determined in accordance with the sedimentation or decantation methods given in BS 812.

Crushed rock shall be one or more of the types listed below as classified in BS 812. The Contractor shall if required by the Engineer, inform him of the group or groups to which

the aggregate belongs.

- Granite group
- Basalt group
- Gabbro group
- Porphyro group
- Quartzite group
- Hornfels group
- Gritstone group
- Limestone group

If it is proposed to use an aggregate of another type other than the groups above, the Contractor shall submit all the details to the Engineer for his approval.

Coarse Aggregates shall comply with the following;

- Aggregate Impact Value when tested in accordance with BS 812 of not more than 30 % (AIV<30).
- Los Angels Abrasion Value as determined by AASHTO test method T96 of not more than 40 % (LAAV<40).
- Flakiness Index when tested in accordance with BS 812 Part 105.1 shall not exceed 35 % (Flakiness Index<35).
- Water absorption of the aggregate shall not be more than 2 %.
- When subject to Coating and Stripping Test AASHTO test method T182, the aggregates shall have a coated area of not less than 95%.
- The loss on the Sodium sulphate soundness test (5 cycles, AASHTO T-104) shall not exceed 12 %.

The materials shall conform to the requirements of Table 406-1 of the Specification with the additional requirements noted below.

2.4 Fine Mineral Aggregate

The portion of the aggregate passing a 5 mm BS test sieve (BS 812) shall be known as fine mineral aggregate, and shall consist of natural sand, crushed stone aggregate, or a combination if stated in the Special Provisions. Fine aggregate shall be composed of clean, hard durable particles, rough surfaced and angular, free from vegetable soft particles, clay balls or other objectionable material. Crushed stone aggregate shall be produced from stone meeting the requirements for coarse mineral aggregate in Clause 2.3.

When sand is used the clay and silt content shall not exceed 3% by mass of the fine aggregate when determined in accordance with sedimentation or decantation methods given in BS 812.

2.5 Mineral Filler

Mineral filler when required shall consist of lime-stone dust, dolomite dust or similar rock dust, Portland cement, hydrated lime, silica cement or other mineral matter from sources approved by the Engineer. It shall be free from foreign or other deleterious material. It shall be dry and free from lumps and when tested by means of laboratory sieves shall meet the following grading requirements.

B.S Sieve (micron)	Percentage by Weight Passing
600	100
300	95 - 100
75	75 -100

Mineral filler shall be considered to include any mineral dust naturally present in the asphalt.

2.6 Fine Mineral Aggregates

The fine mineral aggregates shall have a Sand Equivalent of not less than 50 as determined by AASHTO Test Method T 176.

2.7 Mixture

The asphalt shall be extracted from samples in accordance with AASHTO Test Method T 164. After concentration of the extracted asphalt solvent solution to approximately 200 millilitres the contained mineral particles shall be removed in a centrifuge. This removal shall be considered satisfactory when the ash content (by ignition) of the recovered asphalt is not greater than 1% by weight. The asphalt shall be recovered from the solution in accordance with AASHTO Test Method T 170.

Asphalt recovered from samples shall have a penetration of at least 70% of the penetration of the asphalt cement before mixing and ductility of at least 400 mm when tested in accordance with AASHTO Test Methods T 49 and T 51, respectively. Frequencies of tests are given in the Section 1100 Quality Management.

406.3 Construction Method

3.1 Construction methods shall conform to the requirements of Section 401 of the Specification subject to the following modifications.

(a) The asphalt material shall be mixed, transported and laid in accordance with BS 594: Part 2. Heating of asphalt materials - Asphalt cement shall be heated to a temperature between 140°C and 170 °C. The Engineer will approve the exact temperature.

(b) Heating of mineral aggregates - The mineral aggregates shall be heated to a temperature between 150 °C and 170 °C.

(c) Heating of mixture: The mixture shall be delivered from the mixer at a temperature between the absolute limits of 135 °C and 170 °C even allowing for tolerances.

(d) Delivery of mixture: The mixture shall be delivered on the road at approximately a range of ± 10°C of the mean temperature of the job mix formula giving due account of compaction temperatures.

(e) Compaction: The mixture shall be compacted at a temperature above 105 °C. The density of all samples taken from the compacted surface course shall be not less than 97% of the Marshall Density of the mixture sampled at the plant appropriate to the location.

(f) Pavement Samples:

- The Contractor shall take samples of uncompacted material from the paver as near to where the cores are to be taken as is practicable from the paver augers in accordance with BS 598: Part 100, Clause 6.3 or equivalent AASHTO or ASTM tests.

  For each uncompacted sample, the compositional analysis shall be carried out in accordance with BS 598: Part 102 or equivalent AASHTO or ASTM tests.

- The Contractor shall after final rolling and before opening the surface to traffic, cut samples from the finished work for testing. Samples shall be not less than 250mm square, except that for measurement of the field density only, cores with a minimum diameter of 100 mm cut by an approved coring machine will be acceptable. Samples shall be taken of the mixture for the full depth of the course from the locations directed by the Engineer.

For each core, the bulk density shall be determined in accordance with the procedure in BS 598: Part 104, Clause 4 or equivalent AASHTO or ASTM tests. Next, the maximum density shall be determined from the pair of the cores in accordance with BS DD228: 1996 or equivalent AASHTO or ASTM tests. One sample for density measurement shall be taken for each day or fraction of a day that the plant operates or if the output exceeds 100 tonnes per day then at the rate of one per 100 tonnes or part thereof.

Samples for analysis and other tests shall be taken from the surface course when the Engineer so directs and shall in any case be taken whenever a change is made in the job-mix formula. Where samples have been taken, fresh material shall be placed, thoroughly compacted and finished to the satisfaction of the Engineer.

Transfer of refusal density mix design to compaction trials

A minimum of three trial lengths shall be constructed with bitumen contents at the laboratory optimum for refusal density and at 0.5 % above and at 0.5 % below the optimum.

A minimum of 93 % and a mean value of 95 % of the standard Percentage Refusal Density shall be taken as the density on completion of compaction of the layer.

If the mix is laid to refusal density, the compacted layer thickness shall be 2.5 to 4 times the maximum aggregate particle size to obtain satisfactory workability.

3.2 Control and Testing

(a) Unless specified otherwise in the Special Provisions, the Contractor shall provide adequate laboratory accommodation and all the equipment required for sampling and for each of the following tests:

- Grading analysis of aggregates and filler.
- Flakiness and Elongation Index of course aggregates.
- Sand Equivalent of aggregates
- Bulk specific gravity of mixed aggregates
- Compacted density of mixed aggregates
- Compacted density of mix (Marshall Density)
- Marshall Stability and Flow
- Density of compacted surface course.
- Asphalt extraction

The Contractor shall be responsible for this sampling and testing and shall provide an adequate number of skilled assistants to do this work. The Engineer may provide an adequate number of skilled assistants to do this work. The Engineer may however from time to time decide to take the samples and or carry out the test himself. The Contractor shall keep records of all his tests and copies of these records shall be sent to the Engineer continuously.

(b) The Contractor shall provide the Engineer with the following results and records of tests carried out on each day's production together with the exact location of each day's production in the finished work.

- Temperature of mix when sampled at the mixing plant and on the road.
- Density of laboratory - compacted mix (Marshall Density)
- Compacted density and percentage compaction of surface course.
- Marshall Stability and Flow
- Asphalt content and aggregate grading of mix
- Air voids in mix

(c) Compliance Requirements

When determined in accordance with BS 598: Part 102, the uncompacted sample:

- The asphalt content on analysis shall be higher or equal to than 4.5% but lower or equal to 7.0%.
- The aggregate grading shall not differ from that given in BS 594: Part 1.

3.3 Surface Tests

(a) Visual Inspection

Immediately after the pavement compaction completed, inspect the surface if any aggregate segregation or bleeding or hair cracking takes place. If the skid resistance seems insufficient, a surface dressing shall be provided.

(b) Horizontal Alignments and Surface Irregularity

As specified in Section 303.3 and 303.4 in Section 300, Road Pavements – General.

3.4 Rectification

The Contractor shall make good and rectify the surface of the pavement where any pavement area does not comply with the Specification for regularity, surface tolerance, thickness, texture depth, material properties or compaction, to the full extent of the area at his own cost.

3.5 Protection of the Pavement

Sections of the newly finished work shall be protected from traffic of any kind until the mixture has cooled to 50 °C. Traffic shall not normally be permitted on the newly laid surface less than 6 hours after completion of the pavement except with the approval of the Engineer.

406.4 Measurement

Asphalt concrete surfacing shall be measured by number of tonnes furnished, spread, compacted, completed and accepted in the asphalt pavement.Deficiencies in thickness of the wearing course shall, unless and overlay is constructed at the Contractor's expense, result in a proportion only of the binder and wearing courses tonnes measured for payment. Proportions shall be determined in accordance with the thickness deficiencies described below.

Thickness of asphalt concrete wearing course shall be determined by average calliper measurement of cores, rounded upward to the nearest mm.

Paved sections to be measured separately shall consist of each 100 lin. m section in each traffic lane. The last section in each traffic lane shall be 100 m plus the fractional part of 100 m remaining. Other areas such as intersections, entrances, crossovers, ramps, etc. shall be measured as one section and the thickness of each shall be determined separately. Small irregular unit areas may be included as part of another section.

One core shall be taken from each section by the Contractor at approved locations and in the presence of the Engineer. When the measurement of the core from any paved section is not deficient by more than 5 mm from the specified thickness, the core will be deemed to be of the specified thickness as shown on the Drawings.

When the measurement of the core from any paved section is deficient by more than 5 mm but not more than 15 mm, 2 additional cores spaced at not less than 25 m and as decided by the Engineer shall be taken and used together with the first core to determine the average thickness of such section.

When the measurement of the core from any paved section is less than the specified thickness by more than 15 mm, the average thickness of such section shall be determined by taking additional cores at not less than 5 m intervals parallel to the centreline in each direction from the affected location until, in each direction, a core is taken which is not deficient by more than 20 mm. Exploratory cores for deficient thickness will not be used in average thickness determinations.

Any deficiencies in the total thickness of wearing courses shall be subject to a proportional reduction in the tonnes of binder and wearing courses measured for payment. Alternatively, the Contractor shall construct all at his own expense, a wearing course overlay, if practical in the judgement of the Engineer. Any such overlay shall be a minimum of 40 mm compacted thickness and to the specified standard of the course it is overlaying.

Table 406-2 Deficiency in Thickness of Binder and Wearing Courses

% Deficiency in Thickness as Determined by Cores	Portion of Binder & Wearing Course Tonnes Measured for Payment
0.0 to 10.0	100 %
10.1 to 20.0	80 %
20.1 to 30.0	60 %
31.1 to 40.0	40 %

406.5 Payment

Payment for asphaltic concrete surfacing will be made at contract unit rate for the item as measured above. The price shall be full compensation for furnishing all materials, for mixing and placing of the mixed material and for providing all plant, machinery, equipment, tools, labour and incidentals necessary to complete the work to these specifications.

Pay Item	Unit of Measurement
406(1) Asphalt Concrete Binder Course	tonnes
406(2) Asphalt Concrete Wearing Course	tonnes

(Section 407 is not used.)

SECTION 408

PORTLAND CEMENT CONCRETE PAVEMENT

408.1. Description

1.1 General

This work shall consist of constructing a Portland cement concrete pavement with or without reinforcement, on a prepared and accepted subgrade or sub base in accordance with the Specification and in conformity with the lines, levels, grades, dimensions and cross sections shown on the Drawings. Portland cement concrete shall consist of a mixture of Portland cement, fine aggregate, coarse aggregate and water, with or without admixture.

1.2 The following items shall conform with Section 500 Clauses of the Specification.

(a) Quality of Concrete
(b) Trial Mixes
(c) Sampling and Testing

408.2. Materials

2.1 The following items shall conform with Section 500 Clauses 2 of the Specification.

(a) Portland Cement
(b) Water
(c) Admixtures
(d) Aggregates
(e) Reinforcement
(f) Jointing materials

2.2 Sub-base Materials

Granular material conforming to AASHTO Standard Specification M155 shall be used immediately beneath the concrete pavement. The material shall be compacted to 98% of BS 1377- 4: 1990, (Heavy compaction test, 4.5 kg rammer).

408.3. Equipment and Tools

3.1 The following shall conform with Section 501 Clause 3 of the Specification.

(a) Batching Plant and Equipment
(b) Mixers

(c) Batching and Transporting Materials
(d) Mixing of Concrete
(e) Curing Agents

3.2 Finishing Equipment

a) Finishing Machine **-** The finishing machine shall be of the screeding and trowelling type equipped with two independently operated screeds, designed and operated to strike off the concrete. It shall be fully and accurately adjustable for loss of crown or other dis-arrangement due to wear.

(b) Vibrators – Vibrators for full width vibration of concrete paving slabs, may be either the surface pan type or the internal type. They may be attached to the spreader finisher. They shall not come in contact with the joint, load transfer devices, subgrade or side forms. The frequency of the surface vibrators shall not be less than 3500 impulse per minute and for the internal type not less than 5000 impulse per minute.

3.3 Joint Cutting Saw

The mechanical saw for cutting joints shall be adequately powered to cut rapidly with a water cooled diamond edge saw blade or an abrasive wheel to the depth required. When sawing of joints is carried out the Contractor shall keep a stand-by power saw on the project.

3.4 Forms

Straight side forms shall be metal forms having a thickness of at least 5 mm and have a depth equal to the prescribed edge thickness of the pavement slab.

Curved forms shall be of the radius called for on the Drawings and acceptable flexible forms shall be installed with that radius.

Built up forms with horizontal joints shall not be used. Forms shall be free from kinks, bends or warps. Forms shall not deflect more than 6 mm when tested as a simple beam with a span of 3 metres under a load equal to that which the finisher or other construction equipment will exert on them. The base width of forms shall at least equal the effective height. The top of the form shall not vary from a three metre straight edge by more than 3mm at any point and the side by more than 6mm at any point.

The forms shall contain provision for locking together tightly the ends of abutting form sections and for secure setting.

408.4. Construction Methods

4.1 Preparation of Subgrade or Sub-base

Where the materials in the existing subgrade conform to the requirements of AASHTO Standard Specification M 155 the roadbed shall be prepared to receive the pavement.

Where the existing subgrade materials do not conform to the requirements of AASHTO Standard Specification M 155 the Engineer shall instruct the Contractor to import such materials from borrow or other excavation to form a substantial granular sub-base. Laying this sub-base shall be carried out as specified in Section 301 Clause 3 with materials as specified in Clause 2.2.

Before forms are set and paving operations are begun, the roadbed within the proposed pavement lines shall have been graded and compacted to proper line and surface elevation, any sub base course, or other preliminary work including compaction shall have been completed, all structures shall have been brought to proper grade and alignment and the roadbed shall have been trimmed approximately to correct elevation for a width extending at least 0.6 m beyond each edge of the proposed concrete pavement. Generally sufficient roadbed shall have been trimmed and approved to permit forms to be set for at least two days concreting ahead of the point where concrete is being placed.

4.2 Setting Forms

(a) Base support - the roadbed under the forms shall be compacted and cut to grade so that the forms, when set, shall be uniformly and adequately supported for their entire length and at the specified elevations. Roadbed found to be below established grade at the form line shall be filled to grade in lifts of 10mm or less for 0.5 m on each side of the base of the forms, and thoroughly re-rolled or tamped. Imperfections and variations above grade shall be corrected by tamping or by cutting to the degree required.

(b) Advance setting - Forms shall have been set, checked and approved by the Engineer for at least half the length of pavement to be concreted in a particular day before concreting shall commence on that day. Unless prior approval has been obtained from the Engineer for concreting short sections, the length of formwork set checked and approved by the Engineer shall not be less than 150m at the time of commencement of concreting on any one day.

(c) Staking forms - Forms shall be staked into place with three or more pins for each 3m section, one pin being placed near each end of the section. Form sections shall be tightly locked, free from play or movement in any direction. The forms shall not deviate from true line by more than 6mm at any point. Forms shall be cleaned and oiled prior to the placing of concrete.

(d) Grade and alignment - The alignment and grade elevations of the forms shall be checked and the necessary corrections made by the Contractor immediately before and after placing the concrete. When any form has been disturbed or any roadbed has become unstable, the form shall be reset and re-checked.

4.3 Condition of Roadbed

The roadbed shall be checked for conformity with the crown and elevation shown on the Drawings by means of a tooth bed template riding on the side forms. If necessary material shall be removed or added, as required to bring all portions of the roadbed to the correct elevation. It shall then be compacted thoroughly and again checked with the template. Concrete shall not be placed on any portion of the roadbed which has not been checked and approved by the Engineer.

4.4 Limitations of Mixing

No concrete shall be mixed, placed or finished when the natural light is insufficient unless an adequate and approved artificial fighting system is operated.

Concrete shall be mixed only in amounts required for current use.

The Contractor shall be responsible for producing a concrete of the required consistency. Should it prove impracticable to finish centrally mixed concrete properly before it has become too stiff, the Engineer may require that the concrete be mixed at the site of the work.

4.5 Placing Concrete

Concrete shall be placed only on a roadbed that has been prepared as specified in Clause 4.3. No concrete shall be placed around structures until they have been brought to the required grade and alignment nor until expansion joint material has been placed around them.

Unless truck mixers, truck agitators and other approved hauling equipment are equipped with means for discharge of concrete without segregation of the materials, the concrete shall be unloaded into a bucket, which shall be lifted over the roadbed and the concrete deposited there from in such a way as to prevent segregation or recompaction of the materials.

The concrete shall be distributed so as to require as little rehandling as possible and so that when the layer is consolidated and finished the thickness required will be provided with the surface at no point below the required elevation.

Unless otherwise directed by the Engineer, spreading shall be accomplished by the use of a mechanical concrete spreader of a type and design approved by the Engineer. Hand spreading at joints shall be done with shovels, not with rakes. Workmen with earth or other foreign material on their boots or shoes shall not walk in the freshly mixed concrete.

Placing shall be continuous between transverse joints.

The concrete shall be thoroughly consolidated against and along the faces of all forms by means of vibrators inserted in the concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the roadbed, or a side form. In no case shall the vibrator be operated longer than 30 seconds in any one location.

Where concrete is to be placed adjoining a previously constructed concrete slab, the Contractor shall carry out any work the Engineer deems necessary to provide a good joint including drilling and grouting load transfer bars into the existing slab.

Should any concrete materials fall on or be worked into the surface of a completed slab, they shall be removed immediately by approved methods to the full satisfaction of the Engineer.

Concrete shall be deposited as near to expansion and contraction joints as possible without disturbing them, but shall not be dumped from the discharge bucket on to a joint assembly.

Except at construction joints, concrete shall be shovelled against both sides of the joint simultaneously, maintaining equal pressure on both sides. It shall be deposited to a height of approximately 50mm more than the depth of the joint and shall be vibrated so that all honeycomb and voids are prevented. The vibrator shall be inserted in the concrete and worked along the full length and both sides of the joint.

The reinforcement shall be placed on the bottom layer and the second and upper layer of concrete shall be placed before initial set of the bottom layer has occurred. Displacement of the reinforcement during subsequent concreting shall be prevented.

4.6 Initial Strike- off and Placement of Reinforcement

The bottom layer of concrete shall be struck off for the full width true to crown at the required distance below the finished surface elevation for placement of reinforcement or for placement of a top layer of the required thickness.

The striking-off shall be accomplished by use of the finishing machine, unless the use of hand methods is specifically authorised by the Engineer at specific locations such as changes in width, or in case of emergencies.

Wire-fabric or bar-mat reinforcement shall be laid on the surface of the bottom layer of concrete. Equal clearance shall be provided on each side of the slab, successive sheets shall be lapped as called for on the Drawings, and the reinforcement shall extend to within 50mm of transverse expansion and contraction joints, but shall not extend across the joints. It shall be continuous without interruption at emergency construction joints. At laps, the sheets shall be wired or slipped together firmly at intervals of not more than 1 metre.

The reinforcement when placed, shall be free from dirt or other foreign matter, and shall not be so rusted as to impair bond of the steel with the concrete.

Cross bars or bar mats shall be overlapped at least 100 mm.

4.7 Joints

Joints shall be of the designs shown on the Drawings and shall be constructed where called for on the Drawings or directed by the Engineer. Before any joint materials are set in place, the roadbed at those locations shall have been approved by the Engineer.

A strip of the preformed expansion joint filler shall be placed around each structure which extends into or through the pavement before concrete is placed.

(a) Traverse expansion joints - the material for a traverse expansion joint shall be assembled off the roadbed, and placed into position as a unit.

Each assembly shall consist of an installing bar or approved substitute, preformed joint filler of the required dimensions, a protective metal cap of at least 2.5 mm thick material having flanges not less than 35 mm deep, dowel bars of the required size and length assembled at the required locations, dowel bar sleeves and an approved auxiliary spacing and supporting element for the dowel bars, located at or near the ends of the bars.

The installing bar shall be of substantial metal plate cut to the required depth and crown of the slab and having a length 10 mm less than the required length of the joint. It shall be slotted from the bottom as necessary to permit removal. Suitable means shall be provided on the bar for facilitating its removal.

The protective metal cap may be either a separate component or a part of the installing bar. The installing bars and protective caps shall be cleaned and oiled before use.
One end of each dowel bar shall be thoroughly coated with a brush coat of asphalt MC-2 or other material adequate in the opinion of the Engineer to prevent the concrete from bonding to that portion of the dowel. A dowel sleeve shall be placed on the coated end of each dowel.

The supporting element shall be of such design and construction as to hold the dowels in the correct alignment, both vertically and horizontally, subject to a tolerance of not more 1.0 mm in 100 mm.

When assembled, the top of the installing bar shall be about 5 mm above the top of the preformed filler, the filler shall be vertical when the dowel bars are level the face of the filler shall be in a plane at right angles to the centre line of the road, subject to a tolerance of not more than 5mm in the width of a traffic lane, and the dowels shall be parallel to each other and at right angles to the face of the filler.

The joint assembly shall be placed so that the installing bar is on the side of the filler remote from pouring operations. The top of the filler shall be 10 mm below the required concrete surface, and the bottom shall rest on or extend slightly into the roadbed. The filler shall be in a vertical position. The assembly shall be staked into position throughout construction. The assembly and its installation shall have been approved by the Engineer before any concrete is placed against it

The stakes shall be of a cross section and length satisfactory to the Engineer. Stakes of channel of U-shaped metal shall be of material of not less than 1.5 mm thick. They shall be 0.4 m in length, or longer if necessary to provide proper stability of the assembly.

(b) Transverse contraction joints - Transverse contraction joints shall consist of planes of weakness created by forming or cutting grooves in the surface of the pavement and when shown on the Drawings shall include load transfer dowel-bar assemblies.

Planes of weakness - Grooves for planes of weakness shall be sawn in the concrete after its initial set or under exceptional circumstances and only with the permission of the Engineer, be formed in the soft concrete after brooming and just before the initial set. Grooves shall be at right angles to the centre line of the pavement and shall be true to line, subject to a tolerance of 5 mm in the width of the slab.

When formed grooves are approved by the Engineer they shall be made by depressing an approved tool or device into the soft concrete. The tool or device shall remain in place until the concrete has attained its initial set and then be removed with out disturbing the adjacent concrete. The width and depth shall be as shown on the Drawings.

When the Drawings call for sawn contraction joints to be 18m or more apart, all joints shall be sawn before uncontrolled shrinkage cracking takes place but not until the concrete has hardened to the extent that tearing and ravelling is not excessive, usually 4 to 24 hours after placing. When the Drawings call for sawn joints to be less than 18m apart, it may be found impossible to saw all joints before uncontrolled cracking takes place. In this case part of the joints generally 18m to 30m apart, shall be sawn before

uncontrolled cracking takes place and the intermediate joints before the end of the curing period or shortly thereafter. The spacing of joints that must be sawn early will depend on several factors but shall be at such intervals as will prevent uncontrolled cracking. All contraction joints in lanes adjacent to previously constructed lanes shall be sawn before uncontrolled cracking occurs. If extreme conditions exist which make it impracticable to prevent erratic cracking by early sawing, the contraction joint groove shall be formed prior to initial set of concrete as provided above.

Al sawn joints shall be 40 mm deep. When 18 m or more apart they shall be not less than 12 mm in width and when less than 18 m apart shall be the width of the conventional saw blade.

Any procedure for sawing joints that result in premature and uncontrolled cracking shall be revised immediately by adjusting the sequence of cutting the joints or the time interval involved between the placing of the concrete or the removal of the curing medium and cutting of the joints.

Load Transfer Assemblies - Each assembly for a transverse contraction joint shall consist of dowel bars without sleeves and an approved auxiliary spacing and supporting element. It may also include an installing plate at the option of the Contractor.

One end of each dowel shall be thoroughly coated with a brush coat of Asphalt MC-2 or other material adequate in the opinion of the Engineer to prevent the concrete from bonding to that portion of the dowel.

The supporting element shall be of such design and construction as to hold the dowels in correct alignment both vertically and horizontally, subject to a tolerance of not more than 1.0 mm in 100 mm.

The assembly shall be placed into position so that the dowels are parallel to the centre line and shall be staked into position in such a way as to hold the assembly securely in portion throughout construction. The assembly and its installation shall have been approved by the Engineer before any concrete is placed against it.

(c) Longitudinal Joints - Longitudinal joints shall be constructed in conformity with the details shown on the Drawings. Planes of weakness shall be created by forming or cutting grooves in the surface of the pavement in accordance with the applicable provisions of Clause 4.7 (b).

Tie bars across longitudinal joints shall be placed perpendicular to the joint and shall be rigidly secured by approved chairs or other supports to prevent displacement.

The bars shall not be painted or coated with asphalt or other material. When adjacent

lanes of pavement are constructed separately, steel side forms shall be used which will form a keyway along the construction joint. Tie bars may be bent at right angles against the form of the first lane constructed and straightened into final position before the concrete of the adjacent lane is poured.

(d) Transverse construction joints - Transverse construction joints shall be keyed joints formed by placing installing bars or suitable bulkhead material so that a vertical face with approved key is formed or shall be butt joints formed with suitable material so that a vertical face is formed with no key. No tie bars will be necessary when key joints are formed but dowel bars of the same dimensions and at the same spacing as for construction joints will be necessary at all butt joints. Wire fabric or bar mat reinforcement shall extend across both keyed and butt joints.

Transverse construction joints shall be constructed when there is an interruption of more than 30 minutes in the concreting operations. No transverse joint shall be constructed within 3m of an expansion joint, construction joint, or plane of weakness. If sufficient concrete has not been mixed at the time of interruption to form a slab at least 3 m long the excess concrete back to the last preceding joint shall be removed and disposed of as directed by the Engineer.

4.8 Final Strike-Off, Consolidation and Finishing

(a) Machine Finishing - As soon as the concrete in the top layer has been placed, it shall be struck off and screeded by an approved finishing machine to the grades and cross sections shown on the Drawings and to a level slightly above grade so that when properly consolidated and finished the surface of the pavement will be at the exact level and grade indicated on the Drawings and free from porous areas. The machine shall go over each area of pavement as many times and at such interval as necessary to give the proper compaction and to leave a surface of uniform texture, true to grade and cross section. Excessive operation over a given area shall be avoided. The tops of the forms shall be kept clean by an effective device attached to the machine and the travel of the machine on the form shall be maintained true without lift, wobble or other variation tending to affect the precision finish.

During the first pass of the finishing machine a uniform ridge of concrete shall be ahead of the front screed for its entire length. Except when making a construction joint, the finishing machine shall not be operated beyond that point where the above described ridge can be maintained ahead of the front screed.

At transverse joints, the finishing machine shall be moved forward until the front screed is approximately 0.2 m from the joint. Segregated coarse shall be removed from both sides and off the joint.

The front screed shall be lifted and brought directly over the joint, set upon it, and the forward motion of the finishing machine shall be resumed. When the second screed is close enough to permit the excess motor in front of it to flow over the joint, it shall be lifted and carried over the joint. Thereafter, the finishing machine may run over the joint without filing the screeds, provided there is no segregated coarse aggregate immediately between the joint and the screed or on top of the joint.

After concrete has been placed on both sides of the joint and struck off, the installing bar or channel cap shall be slowly and carefully withdrawn. After the installing bar or channel cap is completely withdrawn, the concrete shall be carefully spaded and additional freshly mixed concrete worked into any depressions left by the removal of the installing bar.

(b) Hand finishing - Where the width of slab changes, hand methods may be used for strike off and consolidation, subject to the approval of the Engineer. In case of breakdown or other emergency the Engineer may authorize the use of hand methods until repairs can be made.

An approved portable screed shall be provided for use. The screed shall be at least 0.6 m longer than the width of the slab to be struck off and consolidated. It shall be of approved shape, sufficiently rigid to retain its shape and constructed either of metal or of other material shod with metal. (If necessary, a second screed shall be provided for striking off the bottom layer of concrete).

Consolidation shall be attained by raising and dropping the screed in successive positions until the required compaction and reduction of surface voids is secured.

The screed shall then be placed on the forms and slid along them, without lifting, in a combined longitudinal and transverse shearing motion moving always in the direction in which the work is progressing, If necessary this shall be repeated until the surface is of uniform texture to grade and contour, and free from porous areas.

(c) Floating - After the concrete has been struck off and consolidated, it shall be further smoothed, trued and consolidated by means of a longitudinal power float of a suitable design approved by the Engineer. Care shall be exercised to start floating operation at the proper time. In this operation, the longitudinal float shall be worked with a sawing motion, while held in a floating position parallel to the road centre line, and passes gradually from one side of the pavement to the other. Movements ahead along the centre line of the road shall be in successive advances of not more than one half the length of the float.

(d) Straight-edging and surface correction - After the longitudinal floating has been

completed and the excess water removed, but while the concrete is still plastic, the surface of the concrete shall be tested for trueness with a 3m straight edge. The straight edge shall be held in contact with the surface in successive positions parallel to the road centre line and the whole area gone over from one side of the slab to the other. Advance along the road shall be in successive stages of not more than one half the length of the straight edge. Any depressions found shall be immediately filled with freshly mixed concrete and any high areas shall be cut down and the surface shall be struck off, consolidated and re-finished. Special attention shall be given to ensure that the surface across joints fully meets the requirements for smoothness. The straight edge testing and refloating shall continue until the entire surface is found to be free from observable departures from the straight edge and the slab has the required grade and crown.

(e) Brooming - As soon as surplus water has risen to the surface, the pavement shall be given a broomed finish.

Brooms shall be of a quality, size and construction satisfactory to the Engineer. Any course or long bristles which cause irregularities or deep corrugations shall be trimmed or entirely cut off. When worn or otherwise unsatisfactory, the brooms shall be replaced.

The broom shall be drawn from one edge to the other, with strokes slightly over lapping, in such a way as to corrugate the surface uniformly to a depth of not more than 2 mm. Brooming shall be completed before the concrete is in such condition that the surface is torn or unduly roughened by the brooming. The broomed surface shall be free from rough areas, porous areas, irregularities or depressions, and of an appearance satisfactory to the Engineer.

(f) Edging at forms and joints - After brooming, but before the concrete has taken its initial set, the edges of the pavement along, each side of each slab, and on each side of transverse expansion joints, planes of weakness except when sawed transverse construction joints, and emergency construction joints shall be worked with an approved tool and rounded to a radius of 5 mm. A well defined and continuous radius shall be produced and a smooth, dense mortar finish obtained. The surface of the slab shall not be unduly disturbed by tilting of the tool during use.

At all transverse joints and tool marks appearing on the slab adjacent to the joint shall be removed completely.

All joints shall be tested with a straight edge before the concrete has set, and correction be made if one side of the joint is higher than the other or if they are higher or lower than the adjacent slabs.

4.9 Surface Requirements

After the concrete has hardened sufficiently, the surface shall be given a further test for trueness using an approved 3 m straight edge laid on the surface in successive positions overlapping 1.5 m, over the whole surface and particularly at joints. Any portion of the surface when tested in the longitudinal direction, which shows a variation or departure from the testing edge of more than 3.5 mm but not exceeding 7.0 mm shall be marked and immediately ground down with an approved grinding tool until the variation does not exceed 3.5 mm.

Whenever the variation or departure from the testing edge is more than 7.0 mm the pavement shall be removed and replaced. Such removal shall be of the full depth and width of the slab and at least 3 m long.

4.10 Curing

As soon after brooming and edging as is practicable without marring the surface, the concrete shall be cured by one of the methods prescribed below.

The concreting operation shall be suspended whenever the supply of water is insufficient for both curing and concreting or whenever an adequate supply of other curing materials is not on hand at the site.

Curing materials shall be weighted down in a manner satisfactory to the Engineer so that displacement is effectively prevented. Should a portion of the slab become exposed at any time during the curing period it shall be re-covered immediately to the full satisfaction of the Engineer.

The concrete shall not be left exposed between stages of curing. Immediately after final finishing, the concrete shall be cured for not less than 72 hours.

The surface of the concrete shall be covered with two layers of burlap, or with two mats of cotton, a layer of sand or other approved highly absorptive material. This covering may be either left in place for at least 72 hours or may, after 12 hours, be removed and replaced with paper. Throughout the 72 hour period, the covering shall be continuously kept damp by spraying. Salt or brackish water shall not be used. If approved by the Engineer paper may be placed on the surface immediately after final finishing and left in place for not less than 72 hours.

When the use of an approved membrane curing compound is called for in the Contract this shall be in accordance, with AASHTO Standard Specification M 148 and be Type 2.

It shall be applied to the finished surface by means of an approved automatic spraying machine as soon as the free water has disappeared. The spraying machine shall be self-propelled and shall ride on the side forms of previously constructed pavement

straddling the newly paved lane. The machine shall be equipped with spraying nozzles which can be controlled and operated so as to completely and uniformly cover the pavement surface with the required amount of curing compound. The curing compound in the storage drum being used for the spraying operation shall be thoroughly and continuously agitated during the application. Spraying shall be sufficient to produce a fine spray and cover the surface thoroughly and completely with a uniform film. Spray equipment shall be maintained in first class mechanical condition and the spray nozzle shall be provided with an adequate wind guard.

The curing compound shall be applied with an overlapping coverage which will give a 2 coat application at coverage of not more than 4 square metres per litre for both coats. The application of curing compound by hand operated pressure sprayers will be permitted only on odd widths or shapes of slabs and on concrete surfaces exposed by the removal of forms as authorized by the Engineer. When application is made by hand operated sprayers the second coat shall be applied in a direction approximately at right angles to the direction of the first coat. The compound shall form a uniform continuous coherent film that shall not check, crack or peek and shall be free from pin holes or other imperfections. If discontinuities, pin holes or abrasions exist, an additional coat shall be applied within thirty minutes to the affected areas. Concrete surfaces which are subjected to heavy rainfall within three hours after the curing compound has been applied shall be re-sprayed by the method and the coverage specified above, at no additional cost to the Employer. Necessary precautions shall be taken to ensure proper curing at the joints, and that none of the curing compound enters joints which are to be sealed with joint sealing compounds. Rope of moistened paper, fibre or other suitable material shall be used to seal the top of the joint opening and the concrete in the region of the joint shall be sprayed with curing compound immediately after the rope seal is installed. Other methods of curing the concrete and the joints may be used when approved by the Engineer. Approved stand-by facilities or approved alternative methods for curing concrete pavement shall be provided at a readily accessible location at the site of the work for use in event of mechanical failure of the spraying equipment or any other conditions which may prevent correct application of the membrane curing compound at the proper time. In the event of a failure of' the regular spraying equipment, the paving operation shall be stopped, and the stand by or alternative curing method shall be used only on the remaining portion of the paving already placed. Concrete surfaces to which membrane curing compounds have been applied shall be adequately protected for the duration of the entire curing period from pedestrian and vehicular traffic, except as required for joint sawing operations and surface tests and from any other cause which will disrupt the continuity of the membrane.

The curing membrane so formed shall be maintained intact for a period of not less than 14 days. The entire surface shall be protected from the effects of solar radiation and in addition by the use of frames covered with material with heat and light rain reflecting properties. Each frame shall be erected immediately after completion of spraying of the

area to be covered by the frame, and in such a manner that the concrete surface is undisturbed. The surface shall be inspected regularly to ascertain the earliest time at which it is able to withstand the operation of spreading sand without deformation or disruption of the curing membrane, whereupon the frames shall be removed and sand shall be sprayed, without delay to a thickness of at least 30mm and wetted immediately. Other moisture retaining material may be used in place of sand subject to the approval of the Engineer.

Whatever material is used it shall be kept continuously moist for not less than 72 hours and to a degree which will ensure that 100% humidity is maintained adjacent to the concrete surface. If sand or alternative material, is removed within 14 days of the casting operation care shall be taken to avoid damaging the curing membrane whilst so doing.

Concrete liable to be affected by running water shall be adequately protected from damage during the setting, period.

Upon removal of the side forms, the sides of the slabs exposed shall be protected immediately to provide a curing treatment equal to that provided for the surface.

It is essential to the soundness and effectiveness of the finished pavement that curing of the concrete is satisfactorily performed and the Contractor shall observe the requirements of the Specification carefully and expeditiously.

4.11 Removing Forms

Forms shall not be removed until the freshly placed concrete has set for at least 12 hours, except any auxiliary forms used temporarily in widened areas. The forms shall be removed carefully so as to avoid damage to the pavement.

As soon as the forms are removed, the ends of all expansion joints shall be cleaned of concrete and the full width of the filler exposed for the full depth of the slab. Any areas showing a minor degree of honeycomb shall be patched up with mortar, composed of one part cement and two parts of fine aggregates by weight. Where the Engineer considers that a major degree of honeycomb is present, the work shall be considered defective and shall be removed and replaced at the expense of the Contractor. The portion removed shall be for the full depth and width of the slab and at least 3 m long.

4.12 Protection of Pavement

The Contractor shall erect and maintain suitable barricades and shall employ watchmen to exclude all traffic from the newly constructed pavement until opened for use. These barriers shall be arranged so as not to interfere with public traffic on any lane intended to

be kept open and necessary signs and lights shall be maintained by the Contractor clearly indicating any lanes open to the public. Where as shown on the Drawings it is necessary to provide for traffic across the pavement the Contractor shall, at his own expense, construct suitable and substantial crossings to bridge the concrete.

Where any stipulated public traffic lane is contiguous with the slab or lane being placed, the Contractor shall provide, erect, and subsequently remove a substantial temporary guard fence along the prescribed dividing line, which shall be maintained there until the slab is opened to traffic.

The Contractor's plan of operation shall be such as to obviate any need for encroachment on the public lane.

Any part of the pavement damaged by traffic or other cause prior to its final acceptance shall be repaired or replaced by, and at the expense of, the Contractor in a manner satisfactory to the Engineer.

4.13 Sealing Joints

Before the pavement is opened to traffic, and as soon after the curing period as is practical, all joints, both longitudinal and transverse, shall be filled with the material approved for use as seal.

The joint faces shall be clean and the surface dry when the seal is applied. Material for seal applied hot shall be stirred sufficiently during heating so that localized overheating does not occur.

The sealing material shall be poured into each joint opening to conform to the details shown on the Drawings or as directed by the Engineer. The pouring shall be done in such a manner that the material will not be spilled on the exposed surfaces of the concrete. Any excess material on the surface of the concrete pavement shall be removed immediately and pavement surface cleaned.

When required to prevent tackiness or pick-up under traffic, the exposed surface of the seal material shall be dusted with an approved material. Other methods of preventing pick-up under traffic may be used when approved by the Engineer.

Poured joint-sealing materials shall not be placed when the air temperature in the shade is less than 10 degree C except with the approval of the Engineer.

4.14 Opening of Traffic

The new work shall not be opened to traffic until so authorized by the Engineer.

4.15 Finishing Shoulders

Shoulders shall be constructed in accordance with the details shown on the Drawings and as specified in the relevant Sections of the Specification.

The construction, shaping and other treatment of the shoulders shall follow the completion of the pavement as closely as possible.

408.5. Measurement

a) Tolerance in Pavement Thickness

The pavement shall be of the thickness shown on the Drawings. The Engineer will require two cores to be taken from each 500 m of slabs, and measured in accordance with AASHTO Test Method T 148 to determine the average thickness of the pavement for each kilometre of slab or fraction thereof. Edge measurements may also be considered if the Engineer so elects.

Where the Engineer considers that the cores taken do not indicate fairly the actual thickness of pavement he may request that additional cores and measurements are taken. Such cores shall be taken at intervals of not less than 100 m. The additional information so obtained shall be used in determining what adjustments to the Contract unit price are required.

The unit price of concrete pavement in the Bill of Quantities shall include for all costs incurred in coring and measuring cores and making good the holes with concrete of the specified quality.

As soon as practicable after coring is completed, the pavement shall be reinstated by filling in the core holes as directed by the Engineer

b) Area

The area of Portland cement concrete pavement to be paid for shall be the number of square metres completed, accepted and measured in place. The width from outside to outside of completed pavement, as shown on the Drawings. The length will be the actual length measured along the centre line of the riding surface.

Areas constructed to less than the required thickness will be adjusted in the manner set out in the following paragraph and the adjusted areas paid for at the unit rate shown in the Bill of Quantities. No adjustment will be made for pavement constructed to a thickness greater than specified.

Areas of pavement deficient by 3.5 mm or less in thickness will be accepted and paid for at the unit rate in the Bill of Quantities. Areas of pavement deficient by between 3.5 and 15.0 mm in thickness will be reduced proportionately by the ratio of the deficient thickness to the specified thickness. Areas 15 mm or more deficient in thickness will not be included for payment except where such areas have been removed and replaced by pavement meeting the Specification.

Where widths of constructed pavement prove to be greater than those specified, the widths, as shown on the Drawings or as directed by the Engineer, shall be used when calculating areas of pavement. When widths of constructed pavement prove to be less than those specified the areas to be included for payment will be calculated using the widths as constructed and accepted by the Engineer.

c) Granular Sub-base Material

The volume of granular sub-base material under the pavement shall be the number of cubic metres compacted in place to the required thickness and accepted by the Engineer.

d) Waterproof Membrane

An underlay shall be used to provide a waterproof membrane between the concrete slab and the sub-base. Where an overlap of underlay material is necessary this shall be at least 300mm. Water shall be not allowed to pond on the membrane which shall be completely water-proof when the concrete is laid. In unreinforced concrete slabs, where tied warping joints are substituted for contraction joints only plastic sheeting 125μm thick shall be used.

e) Reinforcement

Steel reinforcement incorporated in the pavement will be measured in accordance with Sub-clause 5.2.4 of this Specification.

408.6. Payment

Portland cement concrete pavement measured as provided above shall be paid for at the Contract unit price per square metre of specified thickness shown in the Bill of Quantities.

High early strength cement concrete pavement when specified by the Engineer shall be paid for at the Contract unit price per square metre of high early strength cement concrete pavement of the specified thickness shown in the Bill of Quantifies.

The above rates shall include full compensation for furnishing all aggregates and cement, for mixing, placing, screeding, finishing, curing and protecting concrete, for furnishing

placing and removing forms and tie bar shields, placing all materials including dowels, tie-bar, joint assemblies etc, and the work of subgrade preparation and all labour, equipment tools and incidentals necessary to complete the work..

Granular sub-base material measured as provided above will be paid for as described in Section 301 of the Specification.

Subgrade paper measured as provided above will be paid for at the Contract unit price as shown in the Bill of Quantities. The rate shall be full compensation for furnishing and placing such paper inclusive of labour, equipment tools and incidentals necessary for its proper installation.

Reinforcement for Portland cement concrete pavement measured as provided above shall be paid for at the Contract unit price per metric ton shown in the Bill of Quantities. The price shall include full compensation for furnishing and placing all steel reinforcement complete in place and for all labour, materials, tools, equipment and incidentals necessary to complete the installation of the steel as shown on the drawings or as directed by the Engineer.

Partial payment for reinforcement delivered and properly stored at the Site will be allowed at 75% of the invoice price of such reinforcement when accepted at the Site.

The prices to be inserted by the Contractor in the Bill of Quantities shall include for preparing, cutting, packing, transporting and testing cylinders and cores required by the Engineer, including pavement reinstatement.

Pay Items	**Unit of Measurement**
408(1) Portland cement concrete pavement 225 mm thick	square metre
408(2) High early strength Portland cement concrete pavement of ( ) mm thickness	square metre
408(3) Waterproof membrane	square metre
408(4) Reinforcement steel	tonne

SECTION 500

STRUCTURES

SECTION 501

EXCAVATION AND BACKFILL FOR STRUCTURES

501.1 Description

The Contractor shall remove or excavate materials to construct foundations for bridges, box culverts, retaining walls and major structures, other than pipe culverts. The work shall include constructing and removing cofferdams and sheeting, pumping, de-watering and bailing, backfilling of completed structures, disposal of excavated materials. Storm sewers and pipes shall be excavated and backfilled in accordance with Section 601 Reinforced Concrete Culvert Pipe, and measurement and payment will be in accordance with that Section.

In general, Section 200 Earthworks shall be applied. In particular to structure excavation, pockets of soft soil or loose rock shall be removed and the resulting voids shall be filled with blinding concrete. If surcharge for box culverts and soft ground treatment for bridge abutments are required on the drawings, the Contractor shall provide them before structure excavation.

Backfill all spaces not occupied by abutments, piers, or other permanent work with earth up to the surface of the surrounding ground, with sufficient allowance for settlement. Backfill materials shall be at least similar to the surrounding ground in quality. Compact all backfill to the density of the surrounding ground, and neatly grade its top surface.

Saturated soil without organic material, which was produced by structure excavation, can be used for other embankment after drying. Saturated or unsaturated soil with organic material shall not be used for other embankment, however that can be used for flattening existing slopes and voids, otherwise that shall be disposed of at the approved location by the Engineer.

501.2 Materials

2.1 Rubble Mound under Foundation

Rubble mound shall be placed after the excavation for structure foundation to provide level foundation. Material for rubble mount shall consist of suitably graded sand, gravel, or stone as shown on the Drawings or as required by the Engineer.

2.2 Levelling Concrete for Foundation

Levelling Concrete shall conform to the general requirements of Section 503. Concrete to be placed under water shall conform to the requirements of Section 503. The concrete to be used as foundation fill in dry excavations shall be made with aggregate and cement, and shall be mixed and placed, in accordance with Section 503 except that minimum cement content may be 250 kilograms per cubic metre.

2.3 Backfill Materials

Backfill shall be material approved by the Engineer. It shall be obtained from the structure excavation if such material is approved by the Engineer as suitable. Any additional material needed shall be obtained from roadway or borrow excavation unless otherwise agreed by the Engineer.

Backfill behind abutment wall and box culvert wall shall meet the requirement of Section 513, Pay Item 513 (11) Dry Stone Masonry.

501.3 Construction Methods

3.1 Clearing

Prior to starting excavation operations in any area, all necessary clearing and grubbing shall have been completed to the satisfaction of the Engineer.

3.2 Excavation

The Contractor shall notify the Engineer sufficiently in advance of the beginning of any excavation so that cross section elevations and measurement may be taken of the undisturbed ground. The natural ground adjacent to the structure after clearing and grubbing shall not be disturbed without permission of the Engineer.

Trenches and foundation pits for structures and structure footings and under-drains shall be excavated to the lines, grades and elevations shown on the Drawings or as stated by the Engineer. The elevations of the bottoms of the footings shown on the Drawings are approximate only and the Engineer may order in writing such changes in the dimension or elevations of footings as may be deemed necessary to secure a satisfactory foundation.

Boulders, logs and other objectionable material encountered in excavation shall be removed.

After each excavation is completed the Contractor shall notify the Engineer to that effect and no footing, bedding material or structure shall be placed until the Engineer has approved the depth of excavation and the character of the foundation material.

Rock and other hard foundation material shall be cleared of all loose material and cut to a firm surface, either levelled, stepped or serrated, as specified or shown on the Drawings or directed by the Engineer. All seams and crevices shall be cleared out and grouted with Portland Cement grout at the time the footing is placed.

All loose and disintegrated rock and thin strata shall be removed. When the footing is to rest on material other than rock, special care shall be taken not to disturb the bottom of the excavation, and excavation to final grade shall be deferred until just before the footing is to be placed. When, in the opinion of the Engineer, the foundation material is soft,

contains organic matter, or is otherwise unsuitable, the Contractor shall remove the unsuitable material and insert foundation fill material or concrete as specified or shown on the Drawings or directed by the Engineer. If foundation fill material is required it shall be placed and compacted in layers not more than 0.20m loose thickness or as directed by the Engineer. The degree of compaction shall conform to that of paragraph 3 of Sub-clause 3.6 Backfilling, Section 501.

All excavation surfaces and surfaces of backfill material against which concrete is to be placed shall be smooth and firm and true to line and level.

3.3 Disposal of Excavated Material

All excavated material shall be classified by the Contractor in accordance with Section 200: Earthworks and material except Unsuitable Material shall be utilized as backfill or embankment. The surplus material shall not be temporarily placed within a stream area or identified detention areas. It shall be finally disposed of in such a manner as not to obstruct the stream or drainage paths nor otherwise impair the efficiency or appearance of the works nor is it to endanger the partly finished structure. The disposal shall meet the environmental regulations.

Excavated material suitable for use as backfill may be deposited by the Contractor in storage piles at points convenient for re-handling of the material during the backfilling operation.

Excavated material shall be deposited in such places and in such a manner as not to cause damage to highways, services or property either within or outside the right of way and so as to cause no impediment to the drainage of the site or surrounding area. The location of storage piles shall be subject to the approval of the Engineer who may require that the survey centre line and the transverse or hub line of any part of the structure be kept free of obstruction.

3.4 Cofferdam and Caisson

(a) The term "cofferdam" denotes any temporary or removable structure, constructed to hold the surrounding earth, water, or both, out of the excavation, whether such structure is constructed of earth, timber, steel, concrete or any combination of these. The term includes earth dykes, timber cribs, sheet piling, removable steel shells and all bracing; and it shall be understood to include excavation enclosed by pumping wells and well points. The cost of cofferdams is always to be included as part of the bid price for the structure.

(b) The term "caisson" denotes a permanent part of the substructure so constructed as to sink gradually into place as material is excavated within the area protected by its sidewalls

(c) When no provision for caisson is shown in the Drawings it shall be the intent of the Contract that suitable cofferdams shall be provided for all excavations where cofferdams

may be necessary in order to control water or to preclude sliding and caving of the walls of the excavation.

(d) The contractor shall submit upon request Drawings showing his proposed method of cofferdam and/or caisson construction. Approval of the Drawings by the Engineer will not in any way relieve the Contractor of the responsibility for the adequacy of the design for strength and stability or for the safety of the people working therein.

(e) The interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction and removal of any required forms and the inspection of the interior and to permit pumping outside the forms.

(f) If practicable cofferdams shall be so designed that no cross bracing shall be left in place. If this is not practicable bracing left in place shall be of structural steel. The end of such structural members that would be exposed when the structure is completed shall be boxed back at least 150mm behind the concrete face. The resulting holes shall be completely filled with concrete.

(g) In general sheet-piling cofferdams shall extend well below the bottom of the footing and shall be well braced and as watertight as practicable.

(h) When foundation piles are to be driven inside a cofferdam and it is judged impracticable to de-water the cofferdam before placing a concrete seal, the excavation may be extended below the designed level to a depth sufficient to allow for swell of the material during pile driving operations. Any material that rises to a level above the design level shall be removed.

(i) Where it is possible to de-water the cofferdam the foundation material shall be removed to exact grade after the foundation piles are driven.

(j) Where the Engineer directs excavation additional to that specified in the Drawings, the additional excavation will be paid for under Item 501(1).

In all other cases, backfilling in a foundation to compensate for excavation, which has been extended beyond the grades and lines shown on the Drawings, shall be at the expense of the Contractor.

Backfilling shall be with concrete or foundation fill material as indicated on the Drawings or in the Special Provisions or as directed by the Engineer.

If no material is indicated, backfilling shall be concrete of the same grade as required for the structure to be constructed in the excavation.

Unless otherwise permitted no excavation shall be made outside of caissons or cribs or cofferdams or sheet piling and the natural stream bed adjacent to the structure shall not be disturbed without permission from the Engineer. If any excavation or dredging is made at the site of the structure before caissons, cribs, or cofferdams are in place, the Contractor shall, after the foundation is in place, backfill all such excavation to the original ground surface or stream bed with material satisfactory to the Engineer.

Material deposited within the stream area from foundations or other excavations or from the filling of cofferdams shall be removed and the stream area freed from obstruction.

(k) Caissons and cofferdams which tilt or move laterally during construction shall be corrected as necessary at the expense of the Contractor.

(l) Unless otherwise provided cofferdams shall be removed after the completion of the substructure. The removal shall be effected in such a manner as not to disturb or damage the finished work. The Engineer may order the Contractor to leave any part or the whole of the cofferdam in place.

(m) When conditions are encountered which in the opinion of the Engineer, render it impracticable to de-water the foundation before placing the footing, the Engineer may require the construction of a concrete foundation or seal of such dimensions as he may consider necessary and of such thickness as to resist any possible uplift. The Concrete for such seal shall be placed as shown in the Drawings or required by the Engineer. The foundation shall then be de-watered and the footing placed. When weighted cribs are used and the weight is used to overcome part of the hydrostatic pressure acting against the bottom of the foundation seal, special anchorages such as dowels or keys shall be provided to transfer the entire weight of the crib to the foundation seal.

When a foundation seal is placed under water, the cofferdam shall be vented at low water as directed.

Cofferdams shall be constructed so as to protect newly cast concrete from sudden rising of the water and to prevent damage to the foundation by erosion.

3.5 Pumping and Bailing

Pumping and bailing from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of the movement of water through or alongside any concrete being placed. No pumping or bailing will be permitted during the placing of concrete or for a period of at least 24 hours thereafter unless it is done from a suitable sump separated from the concrete work by a watertight wall. The wall shall be extended so far below the bottom of the sump that no material from the concrete can penetrate into the well. The design of this sump shall be to the Engineer's satisfaction.

Pumping or bailing to de-water a sealed cofferdam shall not be started until at least 36 hours after final set of concrete in the bottom seal.

Excavations shall be as dry as possible prior to and during placing concrete. Placing concrete under water will only be permitted if indicated on the Drawings or permitted by the Engineer.

3.6 Backfilling

Before backfilling, the Contractor shall confirm that the soft ground at bridge abutments

and box culverts are properly treated according to the Specification.

All spaces excavated under this Specification and not occupied by the permanent structure shall be backfilled. Backfilled material shall be free from large lumps, wood and other deleterious material.

Backfill not within the embankment area shall be placed in layers not more than 0.25m in depth (loose measurement) and shall meet the compaction requirements in Section 200 Earthworks.

Backfill within the embankment areas shall be made with approved material placed in uniform layers not to exceed 0.20m in depth (loose measurement) and each layer shall be constructed in accordance with Section 203 Excavation and Embankment except that mechanical tampers may be used for compaction, or as specified in the Special Provisions. Each layer shall be compacted to obtain 95% of the maximum dry density of the material as determined by BS1377 Part 4: 1990 (Heavy compaction test, 4.5 kg rammer). Unless otherwise specified hand tamping will not be accepted.

In placing embankment backfill the material shall be placed in so far as possible to approximately the same height on both sides of the structure.

If conditions require backfilling appreciably higher on one side, the additional material on the higher side shall not be placed until permission is given by the Engineer nor until the Engineer is satisfied that the structure has enough strength to withstand any pressure created.

Backfill shall not be placed behind the walls of bridges or box culverts until the top slab or superstructure has been placed for the required time and not less than three days and shall be carried up simultaneously behind opposite abutments or side walls.

No backfilling shall be placed against any structure until permission has been given by the Engineer. Jetting of fill or other hydraulic methods involving, or likely to involve, liquid or semi liquid pressure shall be prohibited.

Adequate provision shall be made for drainage and to allow for porous backfill material to be supplied and placed in accordance with Section 513.

501.4 Measurement

The volume of excavation shall be measured in cubic metres of undisturbed material.

The quantity of excavation and backfill for structures shall include excavation for:

- All structures except pipe culverts and sewers.
- The volume of the solid to be bounded on the bottom of the footing or base of structure (for rubble mound and levelling concrete).

- On the top by the surface of the ground after other excavation, embankment and clearing and grubbing have been completed.
- On the sides of the footings by cutting line shown in the Drawings.

Excavations outside this area for working space or the Contractors temporary works will not be measured.

Excavation and backfill below these levels and outside these plan outlines will not be measured nor paid for, except as allowed for in Clause 3.4 (j)

Excavation and backfill shall be the undisturbed volume excavated, measured and described above.

Backfill with concrete including concrete seals where directed by the Engineer shall be measured separately as the volume of concrete accepted and within the plan outline and top and bottom surfaces required. Concrete placed to backfill excavation beyond the excavation required will not be measured. The plan outline referred to is the required excavation plan outline.

Excavation for pipe culverts and drainage will not be measured under this section but in accordance with Section 600. In the case of structures for which a lump sum bid is called for the volume of excavation will not be measured as a separate item and the cost shall be included in the lump sum.

501.5 Payment

This work measured as provided above shall be paid for at the relevant Contract unit prices per cubic metre for "Excavation and Backfill for Structures" or "Aggregate Backfill for Structures" or "Concrete Backfill for Structures". The payment shall be full compensation for all work described in this Section 203 of the Technical Specifications including excavation and backfill including compaction; sinking all Caisson; constructing and removing all cofferdams; all de-watering, pumping and bailing; and for furnishing all materials, labour equipment, tools, sheeting, bracing, cofferdams, pumps, drills, explosives and incidentals necessary to complete the work.

No direct payment will be made for filling or backfilling around structures, payment for the backfilling and compacting of those areas which were removed as structural excavation shall be included in the unit prices bid for "Excavation and Backfill for Structures" and will not be paid for. In areas where clearing and grubbing is shown on the Drawings, the clearing and grubbing will be paid for at the price bid for "Clearing and Grubbing" in accordance with the requirements of Section 201.

Pay Item		Unit of Measurement
501(1)	Excavation- Classified Material for Re-use	cubic metre
501(4)	Excavation- Soft Rock for Re-use	cubic metre

501(7)	Excavation of Unsuitable material for disposal	cubic metre
501(10)	Structure Backfill	cubic metre
501(30)	Rubble Foundation	cubic metre

SECTION 502

PILING

502.1 Description

Piles shall be driven precast reinforced concrete or bored piles furnished and installed in accordance with this Specifications and in conformity with the requirements on the Drawings or elsewhere in the Contract documents.

Bored piles shall be socketed to a minimum of one (1) pile diameter into sound bearing stratum, unless otherwise stated in the Drawing of the contract.

British Standards have been specified as standards for materials and workmanship.

However the contractor may employ materials manufactured to other internationally - accepted standards or Sri Lankan standards subject to Engineer's approval, which shall require submission of full documentation including test certificates for properties required by the relevant British Standard, carried out at an ISO 9001 - accredited laboratory by suitably qualified people.

Workmanship standards may be substituted with internationally-accepted workmanship standards not in conflict with the provisions of BS 5400 Parts 4, 7, 8 and 9.2 subject to the Engineer's approval.

1.1 General

The Contractor shall carry out the works in accordance with a method statement, which has been submitted to, and approved by, the Engineer. This method statement shall include as appropriate under-reaming or driving, the length or set to be obtained, details of the constituent materials of any drilling fluid used for stabilisation, the method of inspection, details of the concrete mix, the minimum time between the completion of one pile and the commencement of the next, and the pattern of construction.

The Contractor shall submit to the Engineer a programme of his proposed sequence and timing for driving or boring piles having regard to the avoidance of damage to adjacent piles or unfilled pile excavations. Piling shall not commence until approval of the Engineer has been obtained.

The Contractor shall report immediately to the Engineer any circumstance, which indicates that in the Contractor's opinion the ground conditions differ from those expected from his interpretation of the site investigation reports.

Each pile shall be marked in such a manner that it can be identified with the records of manufacture such as date of casting, the cement type, concrete grade, element length, the prestressing force where appropriate, etc.

1.2 Tolerances in Pile installation

Piles shall be installed within the following maximum permitted tolerances.

- Position: 75mm in either direction at cut-off level
- Verticality: 1 in 75 deviation from the vertical
- Rake: 1 in 25 deviation from the specified rake up to 1:6 and 1 in 15 for piles raking more than 1:6

No method of forcible correction will be permitted.

The Contractor shall ensure that damage does not occur to completed piles through his method of working.

502.2 Precast Piles

2.1 Materials

2.1.1 Precast Reinforced Concrete Piles

(a) ***General:***
Piles shall be constructed with the details shown on the Drawings. The concrete shall be proportioned, mixed and placed in accordance with the provisions of Section 503 Portland Cement Concrete Structure. Reinforcement shall comply with the provisions of Section 504 Reinforcement for Structures. Main reinforcing bars shall be supplied in one complete length and should this prove impracticable separate lengths shall be effectively spliced by a method approved by the Engineer.

(b) ***Tolerances in Pile dimensions:***
The cross sectional dimensions of the pile shall be not less than those specified and shall not exceed them by more than 6 mm. Each face of a pile shall not deviate by more than 6 mm from any straight line 3 m long joining two points on that face. Nor shall the centre of area of the pile any cross section along its length deviate more than 1/500 of the pile length from a line joining the centres of area at the ends of the pile. Where a pile is less than 3 m long the permitted deviation from straightness shall be reduced below 6 mm on a pro-rata basis in accordance with the actual length.

The head of a pile element or the end of the pile upon which the hammer acts shall be square to the pile axis within a tolerance of 1 in 150.

(c) ***Formwork:***
Forms for precast concrete piles shall conform to the general requirements for concrete formwork as described in Section 503 Forms shall be accessible for compacting the concrete. Side forms may be removed at any time not less than 24 hours after completion of the placing of concrete but the entire pile shall remain supported for at least 7 days and shall not be subjected to any handling stress until the concrete has been in place for 21 days or such reduced time as the Engineer may decide as a result of tests.

(d) ***Reinforcement:***
Reinforcement shall be in accordance with the provisions set out in Section 504 and positioned as shown on the Drawings.

(e) ***Pile Shoes:***
Pile shoes (a high-grade cast-iron point on the foot of a precast pile) shall be provided as shown on the Drawings. Pile shoes shall be free from sand, honeycombing or porous places, air holes or other defects. Straps shall be of mild steel or wrought iron cast into the base and shall run continuously through it. All shoes shall be fitted to the reinforcement as shown on the Drawings.

(f) ***Casting:***
The piles shall be cast in a horizontal position. Special care shall be taken to place the concrete so as to produce a pile free from any air pockets, honeycombing or other defect.

Concrete shall be placed continuously and shall be compacted by vibrating or by other means satisfactory to the Engineer. The forms shall be slightly overfilled, the surplus concrete screeded off, and the top surfaces finished to a uniform, even texture similar to that produced by the forms.

(g) ***Finish:***
When removed from the forms piles shall present true, smooth, even surfaces free from any surface blemishes, and true to the dimensions shown on the Drawings.

(h) ***Curing:***
Concrete piles shall be covered with wet burlap immediately after placing is completed and shall be kept continuously wet for at least 7 days.

(i) ***Handling:***
When raising or transporting precast concrete piles, the Contractor shall provide slings and other equipment necessary to prevent any appreciable bending of the pile or cracking of the concrete. No concrete pile shall be lifted otherwise than by slinging from the lifting holes, the positions of which shall be as directed or approved by the Engineer. Piles damaged in handling or driving shall be replaced.

Concrete piles shall be so handled at all times to prevent breaking or chipping the edges.

Piles shall not be driven until 28 days have elapsed from the time of casting or such reduced time as the Engineer may decide as a result of tests.

2.2 Construction Methods

2.2.1 Preparation for Driving

(a) Preparing piles

Provide collars, bands, cushion or other devices to protect piles against splitting and brooming.

(b) Splicing Piles:

Full-length piles shall be used where practicable. In exceptional circumstances and only with the Engineer's approval splicing of piles will be permitted. The method of splicing shall be as shown on the Drawings or as approved by the Engineer.

2.2.2 Handling, Pitching and Driving

(a) **General**:

The main setting out for the piles is to be completed prior to commencement of piling. Secondary or individual pile setting out is to be completed and agreed not less than 8 hours prior to commencing work on the piles concerned. All main setting out points, lines, stations and the like are to be maintained safe and undisturbed. Piles shall be pitched accurately in the positions and driven to the lines shown on the Drawings or fixed by the Engineer. Piles deflected from the vertical or proper line shall, where ordered by the Engineer, be withdrawn and re-pitched until the proper line is obtained. No forcible method of correction of the position or line of any pile will be permitted.

Any pile damaged by reason of improper driving or driven out of its proper location or driven below the elevation fixed by the Drawings or by the Engineer, shall be corrected at the Contractor's expense by one of the following methods approved by the Engineer for the pile in question.

The pile shall be withdrawn and replaced by a new and if necessary longer pile. Any holes from which piles are withdrawn shall be packed with approved non-plastic material before re-driving takes place. The compensating piles shall be driven to replace the defective or low pile as instructed by the Engineer.

Raking Piles -All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down again. Raking piles shall be driven accurately to the rake shown on the Drawings. The pile frame employed for the driving of the batter piles shall have leads capable of adjustment to the required angle. When piles have to be driven below the level of the bottom of the leads, extension leads shall be fitted except where the use of a follower is specifically permitted by the Engineer.

(b) ***Driving Equipment***:

Before any piling work is commenced the Contractor shall submit to the Engineer full details of the pile driving equipment and the method of carrying out the work he intends to use. Protect the head of concrete piles by a pile cushion when the nature of the driving is such as to unduly injure them. Prohibit the use of wood, wire rope, or asbestos hammer cushions.

Equip single-action diesel hammers with a device to determine hammer stroke during pile driving operations. Equip double-action diesel hammers with a bounce chamber pressure gage mounted near ground level so as to be easily read. Provide a correlation chart of bounce chamber pressure and delivered hammer energy.

Inspect the hammer cushion after every 100 hours of pile driving.

(c) ***Driving:***

Piles shall be supported in line and position with leads while being driven. Pile driver leads shall be constructed so as to afford freedom of movement of the hammer, and they shall be held firmly in position to ensure rigid lateral support to the pile during driving. Flying leads will not be permitted. Except where piles are driven through water, the leads shall be of sufficient length to make the use of a follower unnecessary, and shall be so designed as to permit the proper placing of batter piles. Drive concrete piles after 21 days of casting.

Drive piles at a penetration rate of not less than 2.5 mm per blow at the required bearing value.

A detailed and accurate record of the driving of all piles shall be kept by the Engineer and the Contractor shall give every assistance to the Engineer in keeping this record which will include the following: pile numbers, positions, types, sizes, actual lengths, temporary compression, dates driven, lengths in footings, penetration under final blows of the hammer, striking energy of the hammer, lengths extended, lengths cut off and final pay lengths.

(d) ***Bearing Values:***

Piles shall be driven to a bearing value not less than that shown on the Drawings. The Engineer will specify the penetration and the Contractor shall drive the piles to the penetration specified but if the Engineer is not satisfied that the desired bearing value has been attained the Contractor shall carry on driving until such desired value is attained.

(e) ***Cut off and Extension:***

Concrete piles shall be cut off at such elevation that they will extend into the cap or footing as indicated on the Drawings. Reinforced concrete piles may be cast the full length of the reinforcing bars, provided that the concrete is cut off to expose the steel as shown on the Drawings after the piles have been driven.

(f) ***Lengthening:***

Any provision for lengthening piles incorporated at the time of manufacture shall be designed by the Engineer to resist all stresses to which it may be subjected.

If no provision for lengthening piles was incorporated at the time of manufacture, any method for lengthening shall be such that the extended pile including any joints is capable of taking safely the stresses during driving and under load.

(g) ***Set:***

The set shall be measured and recorded for each pile at the completion of driving.

When a set is being measured, the following requirements shall be met.

- The exposed part of the pile shall be in good condition without damage or distortion.
- The helmet, dolly and any packing shall be in sound condition.

- The hammer blow shall be in line with the pile axis and the impact surfaces shall be flat and at right angles to the pile and hammer axis.
- The hammer shall be in good condition, delivering adequate energy per blow, and operating correctly.
- The temporary compression of the pile shall be recorded.

The set shall be recorded either as the penetration in millimetres per 10 blows or as the number of blows required to produce a penetration of 25 mm.

(h) ***Driving sequence and risen piles:***

Piles shall be driven in a sequence to minimise any detrimental effects of heave and lateral displacement of the ground. The sequence and method of piling including pre-boring shall limit uplift and lateral movement so that the final position of each pile is within the specified tolerances.

If records and measurements show that piles have been laterally displaced so as to be outside the permitted tolerance or damaged, the Contractor shall provide the measures to enable the piles to comply with the Specification.

502.3 Bored Cast in Place Piles

3.1 Materials

Piles shall be constructed in accordance with the details shown on the Drawings. The concrete shall be proportioned, mixed and placed in accordance with the provisions of Section 503 Portland Cement Concrete Structures. Reinforcement shall comply with the provision of Section 504 Reinforcement for Structures.

3.2 Excavation

Whenever possible, excavations shall be carried out in the dry. In stable soils lining may be omitted if agreed by the Engineer. In soils liable to flow into the borehole, a temporary lining or drilling mud, such as bentonite suspension may be used instead of casings, must be used. The bottom of the casing shall be kept sufficiently below the boring to prevent the inflow of soil and the subsequent formation of cavities in the surrounding ground.

Excavation shall not be exposed to the atmosphere longer than is necessary and shall be covered at all times when work is not in progress. The Contractor shall take all precautions necessary to prevent the ingress of surface water or foreign matter.

3.3 Casings

Temporary casing or drilling fluid shall be provided where necessary to ensure stability of the pile boring during boring, placing of reinforcement and concreting operations. Casings shall be watertight steel tubes. Before concreting, any permanent casings shall be clean and undamaged.

3.4 Drilling Fluid

When the use of drilling fluid has been approved by the Engineer for maintaining the stability of a boring, the level of the fluid in the boring shall be such as to achieve stability. An adequate temporary casing shall be used in conjunction with this method to ensure stability of the strata near ground level until concrete has been placed. The fluid level shall be maintained at a level not less than 1m above the level of external ground water.

Bentonite as supplied to the Site and before mixing, shall be of a quality that shall accord with Publication 163 "Drilling Fluid materials" of the Engineering Equipment and Materials Users Association, UK or the equivalent. A certificate shall be obtained by the Contractor from the manufacturer showing the properties of each consignment of bentonite delivered to the Site. This certificate shall be made available to the Engineer on Request. The properties to be given by the manufacturer are the apparent viscosity range (in centipoise) and the gel strength range (N/m2) for solids in water.

Where the use of bentonite is approved, it shall be mixed thoroughly with clean fresh water to make a suspension, which will maintain the stability of the boring/excavation for the period, necessary to place concrete and to complete construction. If water for the Works is not available from a water company's supply, the Contractor shall ensure that the water complies with the guidance given in BS 3148. Water from the sea or tidal rivers shall not be used.

Where saline or chemically contaminated ground water occurs, special precautions shall be taken to modify the drilling fluid or pre-hydrate the bentonite in fresh water so as to render it suitable in all respects for the construction of the Works.

In the event of a rapid or sustained loss of drilling fluid from the pile boring, the boring shall be backfilled without delay and the instructions of the Engineer shall be obtained before excavation at that location is resumed.

Pumping from a boring other than under controlled concrete placement shall not be permitted without the approval of the Engineer.

3.5 Drilling fluid and soil tests

The frequency of testing drilling fluid and the method and procedure of sampling shall be proposed by the Contractor and agreed by the Engineer before the commencement of the work. The measuring device shall be calibrated to read within 0.01g/ml. For average soil conditions the results shall generally be within the ranges stated in Table 502-1.

When required by the Engineer, the Contractor shall take from the pile boring undisturbed soiled samples in compliance with BS 5930. Such samples shall be tested in an approved laboratory.

TABLE 502-1: Tests and Compliance values for Support Fluid

Property to be measured	Test method and apparatus	API RP 13 Section	Compliance values measured at 20 deg. C	
			As supplied to pile	Samples from pile prior to placing concrete
Density	Mud balance	1	Less than 1.10 g/ml	Less than 1.15 g/ml
Fluid loss (30 minute test)	Low temperature test fluid loss	3	Less than 40 ml	Less than 60ml
Viscosity	Marsh cone	2	30 to 70 seconds	Less than 90 seconds
Shear strength (10 min. gel strength)	Fan viscometer	2	4 to 40 N/m2	4 to 40 N/m2
Sand content	Sand screen test	4	Less than 2 %	Less than 2 %
pH	Electrical pH meter to BS 3145; range pH 7 to 14	-	9.5 to 10.8	9.5 to 11.7

3.6 Stability of pile bore

Where boring takes place through unstable water bearing strata, the process of excavation and the support fluid and depth of temporary casing where employed shall be such that soil from outside the area of the pile is not drawn into the pile section and cavities are not created outside the temporary casing as it is advanced

Where a support fluid is used for maintaining the stability of a bore, an adequate temporary casing shall be used in conjunction with the support fluid so as to ensure stability of the strata near ground level until concrete has been placed. During construction the level of drilling fluid in the pile excavation shall be maintained within the cased or stable bore so that it is not less than 2m above the level of external standing groundwater at all times.

3.7 Continuity of Construction

The pile shall be bored and the concrete shall be placed as soon as possible after placement of reinforcing steel cage.

The time period during which each pile is excavated and the concrete is placed shall not exceed 12 hours. The time period shall start when excavation below the temporary lining tubes commences. Where the construction sequence is such that the time period of 12 hours will be exceeded even if no delays are taken into account, a realistic time period during which the pile is excavated and concrete placed shall be stated in the Contractor's method statement.

The Contractor shall advise on the likely effect of this extended pile construction period on the performance and capacity of the pile.

3.8 Inspection

Each pile bore, which does not contain standing water or support fluid, shall be inspected

from the ground surface prior to concrete being placed in it to ensure the base is clean. Adequate means of lighting, measuring tapes and a means of measuring verticality shall be used. For piles of 750 mm diameter or larger and where manned inspection of the pile base is required by the Engineer, equipment shall be provided by the Contractor to enable his representatives to descend into the bore for the purpose of inspection. The Contractor shall provide all necessary facilities to enable an inspection of any pile excavation to be made including facilities to check the depth, verticality and position. The full requirements of BS 8008 shall be followed.

The Contractor shall designate a Supervisor to supervise each inspection. The Supervisor shall have a copy of BS 8008 and shall ensure that every person involved in the descent of piles is familiar with its requirements.

3.9 Cleanliness of pile bases

On completion of boring loose, disturbed or softened soil shall be removed from the bore using appropriate methods, which shall be designed to clean while at the same time minimizing ground disturbance below the pile bases. Water or support fluid shall be maintained at such levels throughout and following the cleaning operation so that stability of the bore is preserved.

- Clean the excavation base so as to achieve less than 1% of sand weight in the bentonite.
- Verify the dimensions and alignment of each excavation.
- Measure final excavation depth after final cleaning.

At all times when the pile head is unattended, the bore shall be clearly marked and fenced off so as not to cause a safety hazard.

3.10 Reinforcement

Reinforcement shall be in accordance with Section 504.

Reinforcement shall be maintained in its correct position during concreting of the pile. Where it is made up into cages, they shall be sufficiently rigid to enable them to be handled without damage.

The number of joints in longitudinal steel bars shall be kept to a minimum. Joints in steel reinforcement shall be such that the full strength of each bar is effective across the joint and shall be made so that there is no detrimental displacement of the reinforcement during the construction of the pile.

Reinforcement shall be maintained in its correct position during concreting of the pile, to allow a vertical tolerance of +150/-50 mm on the level of the reinforcement projecting above the final cut off level. Where reinforcement is made up into cages, they shall be

sufficiently rigid to enable them to be handled, placed and concreted without damage. If the cage is to be welded together, welding shall be carried out to the requirements Section 504.

Unless otherwise specified, reinforcement shall extend to the base of the pile or to at least 3m below the bottom of the temporary casing, whichever is the lesser.

Spacers shall be designed and manufactured using strong and durable materials which shall not lead to corrosion of the reinforcement or spalling of the concrete cover. The details of the means by which the Contractor plans to ensure the correct cover to and position of the reinforcement shall be submitted for approval.

3.11 Concrete

Cement materials, aggregate, admixtures and water shall be in accordance with Section 503.

3.12 Workability of concrete

Workability measured at the time of discharge into the pile bore shall be in accordance with the limits shown in Table 502-2.

TABLE 502-2: Piling Mix Workability

Pilling Mix	Workability		Typical conditions of use (The concrete and aggregate size must be compatible with the reinforcement spacing)
	Target Flow mm	Slump Range mm	
A	Not applicable	75-150	Placed into water-free unlined or permanently lined bore of 600 mm diameter or over, or where casting level lies below temporary casing; reinforcement spaced at 100 mm centres or greater, leaving ample room for free movement of concrete between bars.
B	Target flow 500±50	Slump* 100-250	Where reinforcement is spaced at less than 100 mm centres; where cut-off level of concrete is within temporary casing; where pile bore is water-free and the diameter is less than 600mm.
C	Target flow 550±50	Slump* 150 or more	Where concrete is to be placed by tremie under water or support fluid or by pumping or by continuous flight auger.

Note: *The slump test method is not suited to these very high workabilities and the flow test is to be preferred.

3.13 Compaction

Internal vibrators shall not be used to compact concrete.

3.14 Placing concrete in dry borings

Before placing concrete, check final bore depth to ensure that the structural strength of the concrete placed in all piles is not impaired through grout loss, segregation or bleeding.

The method of placing shall be such as to ensure that the concrete or grout in its final position is dense and homogeneous. Concrete shall be introduced into the pile via a hopper and suitable length of rigid delivery tube to ensure that the concrete falls vertically and centrally down the shaft. The tube shall be at least 3 m long.

3.15 Placing concrete under water or support fluid

Before placing concrete, check final bore depth to ensure there is no accumulation of silt or other material at the base of the boring, and the Contractor shall ensure that heavily contaminated support fluid, which could impair the free flow of concrete from the tremie pipe, has not accumulated in the bottom of the hole.

A sample of support fluid shall be taken from the top and bottom of the boring using an appropriate device. The fluid shall be prepared, sampled and tested as stated in the Contractor's submission.

If tests show the fluid does not comply with the limits stated by the Contractor for the particular type of support fluid, the fluid shall be wholly or partly replaced as appropriate before concrete is placed.

Concrete to be placed under water or support fluid shall be placed by tremie in one continuous operation and shall not be discharged freely into the water or support fluid. Pumping of concrete may be used where appropriate. The bottom end of the tremie must be square to the axis of the tremie and its circumference must be continuous. The tremie must be fully charged with concrete before it is lifted off the base of the pile.

The concrete shall be of high workability and cement content in accordance with Section 503 and Table 502-2 Mix C.

The concrete shall be placed in a manner that will not cause segregation of the mix.

The depths to the surface of the concrete shall be measured and the length of the tremie tubes recorded at regular intervals corresponding to the placing of each batch of concrete. The depths measured and volumes placed shall be plotted immediately on a graph and compared with the theoretical relationship of depth against volume.

The hopper and pipe of the tremie shall be clean and watertight throughout. The pipe shall extend to the base of the bore and a sliding plug or barrier shall be placed in the pipe to prevent direct contact between the first charge of concrete in the tremie and the water or support fluid. The pipe shall at all times penetrate the concrete which has

previously been placed with a minimum embedment of 2 m and shall not be withdrawn from the concrete until completion of concreting. A sufficient quantity of concrete shall be maintained within the pipe to ensure that the pressure from it exceeds that from the water or support fluid. The internal diameter of the pipe of the tremie shall not be less than 150-200 mm or six times the maximum aggregate size. It shall be so designed that external projections are minimized, allowing the tremie to pass within reinforcing cages without causing damage. The internal face of the pipe of the tremie shall be free from projections.

3.16 Extraction of casing

3.16.1 Workability of concrete

Temporary casings shall be extracted while the concrete within them remains sufficiently workable to ensure that the concrete is not lifted. During extraction the motion of the casing shall be maintained in an axial direction relative to the pile.

3.16.2 Concrete level

When the casing is being extracted, a sufficient quantity of concrete shall be maintained within it to ensure that pressure from external water, support fluid or soil is exceeded and that the pile is neither reduced in section nor contaminated..

The concrete level within a temporary casing in a dry bore may be topped up where necessary during the course of casing extraction so that the base of the casing is always below the concrete surface until the casting of the pile has been completed.

Adequate precautions shall be taken in all cases where excess heads of water or support fluid could occur as the casing is withdrawn because of the displacement of water or fluid by the concrete as it flows into its final position against the walls of the pile bore. Where two or more discontinuous lengths of casing (double casing) are used in the construction the Contractor's method of working shall produce piles to their full designed cross-sections. The depth to the average levels of the concrete surface of the pile shall be measured before and after each temporary casing is removed. These measurements shall be recorded on the pile record.

3.17 Pile head casting level tolerances

For piles cast in dry bores using temporary casing and without the use of a permanent casing, pile heads shall be cast to a level above the specified cut-off so that, after trimming, a sound concrete connection with the pile can be made. The casting level shall be above the cut-off level and within the tolerance shown in Table 502-3 but shall not be above the commencing surface level. No pile shall be cast with its cut-off level below standing water level unless appropriate measures are taken to prevent inflow of water causing segregation of the concrete as temporary casing is extracted.

TABLE 502-3: Casting Tolerance above Cut-off Level for Piles cast in Dry Bores using Temporary Casing and without the use of Permanent Lining

Cut-off distance below commencing surface, H, m +	Casting tolerance above cut-off level, m
0.15 - 10.00	0.3 + H/12 + C/8 where C = length of temporary casing below the commencing surface*

+ Beyond H = 10 m. the casting tolerance applying to H = 10 m shall apply.
* If H is greater than C. then this tolerance is no longer applicable and the tolerances in Table 502-4 will apply.

For piles cast in dry bores within permanent lining tubes or permanent casings to where their cut-off levels are in stable ground below the base of any casing used, pile heads shall be cast to a level above the specified cut-off so that, after trimming, a sound concrete connection with the pile can be made. The casting level shall be above the cut-off level and within the tolerance shown in Table 502-4 but shall not be above the commencing surface level.

TABLE 502-4: Casting Tolerance above Cut-off Level for Piles cast in Dry Bores within Permanent Lining tubes or Permanent casings, or where their Cut-off Levels are in Stable Ground below the Base of any Casing used

Cut-off distance below commencing surface, H, m +	Casting tolerance above cut-off level, m
0.15 - 10.00	0.3 + H/10

+ Beyond H = 10 m, the casting tolerance applying to H = 10 m shall apply.

For piles cast under water or support fluid, the pile heads shall be cast to a level above the specified cut-off so that, after trimming to remove all debris and contaminated concrete, a sound concrete connection with the pile can be made. The casting level shall be above the cut-off level and within the tolerance shown in Table 502-5, but shall not be above the commencing surface level. Cut-off levels may be specified below the standing groundwater level, and where this condition applies the borehole fluid level shall not be reduced below the standing groundwater level until the concrete has set.

Where either support fluid or water is mixed in the ground by the drilling equipment to assist with the installation of temporary casings the casting level shall be coincident with the commencing surface.

TABLE 502-5: Casting Tolerance above Cut-off Level for Piles cast under Water or Support Fluid*

Cut-off distance below commencing surface, H, m +	Casting tolerance above cut-off level, m
0.15 - 10.00	1.0 + H/12 + C/8 where C = length of temporary casing below the commencing surface*

+ Beyond H = 10 m, the casting tolerance applying to H = 10 m shall apply.
* In cases where a pile is cast so that the cut-off is within a permanent lining tube, the appropriate tolerance is given by deletion of the casing term C/8 in the table.

3.18 Temporary backfilling above pile casting level

After each pile has been cast, any empty bore remaining shall be carefully backfilled as soon as possible with inert spoil.

3.19 Cutting off pile heads

When cutting off and trimming piles to the specified cut-off level, the Contractor shall take care to avoid shattering or otherwise damaging the rest of the pile. Any cracked or defective concrete shall be cut away and the pile repaired in a manner to provide a full and sound section at the cut-off level.

502.4 Pile Records

A record of all piles installed shall be kept by the Contractor and a signed copy of the record of the work done each day shall be given to the Engineer within 24 hours.

The record shall consist of the information listed in Table 502-6.

On completion of piling the Contractor shall deliver to the Engineer a schedule recording the final toe levels of all piles to Mean Sea Level.

502.5 Integrity Testing of Piles

Where integrity-testing is called for, the following method, subject to Engineer approval shall be adopted:

- Sonic logging method.

The procedure and equipment shall conform with the provisions of the Institution of Civil Engineers Specifications for Piling and Embedded retaining walls, 1996 and to the Engineer's requirements.

TABLE 502-6: Piling Records

All Piles	Driven Precast Concrete and Steel Piles	Bored Cast-in-Place Concrete Piles
- Date - Contract identification number - Pile identification number - Pile type - Working load - Ground level at commencement of operations - Working platform level - Pile toe level - Details of any obstructions, delays or other interruptions to the sequence of work including times - Cut-off level - Head level of completed pile - Ground heave - Grade of concrete - Water/cement ratio	- Cross-sectional dimensions - Total length of preformed pile - Driven length of preformed pile Time of commencement and completion of driving or re-driving Sequence of driving groups - Final set - Sections and joints used - Type, weight, drop and mechanical condition of hammer used - Number, type and condition of the packing on the pile head - Type and condition of the dolly in the helmet - For a single acting hammer the final drop - For a double acting hammer, the final frequency of blows - The set taken at intervals during the last 3 m of driving required - Details of any interruptions of driving - Details of re-driving	- Diameter of completed pile - Diameter of any enlarged base - Length of temporary casing - Length of permanent casing - Length of finished pile including any enlarged base - Type of boring - Time of commencement of boring - Time of completion of boring - Details of soil strata penetrated - Details of soil samples taken and - insitu tests carried out - Details of any interruption in boring - Standing ground water level and water strikes during boring - Method of placing concrete - Concrete mix details - Nominal maximum aggregate size - Cement content - Type and quantity of admixtures - Measured slumps & Target flow - Batch times - Time of commencement of concrete pour - Time of completion of concrete pour - Volume of concrete placed in enlarged base - Volume of concrete placed in pile shaft - Reinforcement details - Number, type and size of main reinforcement bars - Type, size and pitch or spacing of helical binding or link bars - Length of individual reinforcement cages - Total reinforcement length of pile

Notes:

- All levels shall be to Mean Sea Level Datum.
- The 24-hour clock shall be used.
- For any pile not completed in the working day the date shall be entered in the records together with the times of commencement and completion.
- For driving operations not using a piling hammer, equivalent information to that required on type, weight, drop etc., of hammer, packing and dolly shall be provided.
- The final set of each pile shall be recorded as the penetration in mm per 10 blows or the number of blows required to produce a penetration of 25 mm.

502.6 Static Load Testing of Piles

(a) General

The design and construction of the load application system shall be satisfactory for the required test. These details shall be made available prior to the commencement of testing.

(b) Boring or driving record

For each preliminary pile which is to be tested, a detailed record of the conditions experienced during boring or of the progress during driving, shall be made available daily, not later than noon on the next working day.

(c) Concrete test cubes

Four test cubes shall be made from the concrete used in the preliminary test pile and from the concrete used for building up a working pile.

The pile test shall not be started until the strength of the cubes taken from the pile exceeds twice the average direct stress in any pile section under the maximum required test load.

(d) Supervision

The setting-up of pile testing equipment shall be carried out under competent supervision and the equipment shall be checked to ensure that the setting-up is satisfactory before the commencement of load application.

(e) Compression tests

Compression test shall be carried out using kent ledge, tension piles or specially constructed anchorage.

(f) Test procedure

Proof load test procedure (working compression piles)

Design Verification Load (DVL) is defined as "a load which will be substituted for the specified working load for the purpose of a test and which may be applied to an isolated or single loaded pile at the time of testing in the given conditions of the site."

Following each application of an increment of load, the load shall be maintained at the specified value for not less than the period shown in Table 502-7 and until the measured rate of settlement in a period of 30 minutes is less than 0.5% of the current cumulative settlement which has occurred, subject to a minimum settlement rate of 0.05 mm in 30 minutes. The rate of settlement shall be calculated from the slope of the line obtained by plotting values of settlement versus time and drawing a smooth curve through the point.

Table 502-7: Minimum Loading Times for Pile Test

Load	Minimum Time of Load Holding Load
25% DVL	30 minutes
50% DVL	30 minutes
75% DVL	30 minutes
100% DVL	6 hours
75% DVL	10 minutes
50% DVL	10 minutes
25% DVL	10 minutes
0	1 hour
100% DVL	1 hour
100% DVL+25% SWL	1 hour
100% DVL+50% SWL	6 hours
100% DVL+25% SWL	10 minutes
100% DVL	10 minutes
75% DVL	10 minutes
50% DVL	10 minutes
25% DVL	10 minutes
0	1 hour

DVL: Design Verification Load, SWL: Specified Working Load.

Each stage of unloading shall proceed after the expiry of the period shown in Table 502-7 For any period when the load is constant, time and settlement shall be recorded immediately on reaching the load, at not more than 5 minutes intervals up to 15 minutes, at approximately 15 minutes intervals up to one hour, at 30 minute intervals between 1 hour and 4 hours, and 1 hour intervals between 4 hours and 12 hours after the application of the increment of load.

502.7 High Strain Dynamic Pile Test

High Strain Dynamic Pile Test using Driving Analyser or similar device shall have the capability to evaluate the bearing capacity and other essential properties of the pile in place. Qualified personnel from the specialised testing company are required to conduct the tests. The testing company engaged for the test shall be ISO 9002 certified or accredited by well established engineering institution.

A pile in the pile group for every bridge/retaining wall with piled foundation shall be selected by the Engineer for the test. All the test piles shall be constructed at an earliest opportunity and subject them to the test.

The test piles shall be properly protected from damage in the course of performing the tests.

502.8 Measurement

The items shall include:

- Establishment, movement and operation of pile driving equipment,

- Establishment, movement and operation of bored piling equipment,
- Precast piles,
- In situ concrete,
- Formwork,
- Reinforcement,
- Taking observations, maintaining the boring or driving record and concreting or grouting record of each pile and supplying one copy to the Engineer.
- Cutting off pile head to required level, exposing reinforcement and bending projecting reinforcement.
- Sonic logging and Loading tests.

The unit of measurement for the furnishing of all types of driven piles will be the furnished length of piles in metres as specified on the Drawings. Where driven piles are extended the furnished length shall be the total length in metres furnished as instructed by the Engineer.

The unit of measurement for driving piles will be linear metres of driven pile measured from tip to the existing ground level or the level of the underside of the pile cap or ground beam (ignoring any blinding layer) whichever is the lower.

The unit of measurement for test piles will be linear metre of test piles furnished as directed by the Engineer.

The unit of measurement for bored or driven cast-in- place piles will be linear metres of bored or cast in-situ pile, measured from tip to cut-off. Empty bore will not be measured.

Load tests on driven or bored piles will be measured by number completed and accepted by the Engineer. Integrity testing on bored piles will be measured by number completed as ordered by the Engineer.

502.9 Payment

The furnishing of all types of driven piles measured as provided above shall be paid for at the Contract unit price per pile for the specified length as detailed below. The payment shall be full compensation for all materials, including reinforcement, formwork, concrete, pile shoes, labour, tools and equipment, and other incidentals necessary to complete the work.

The furnishing for lengthening of driven piles measured as provided above shall be paid for at the Contract unit price per linear metre of pile as detailed below. The payment shall be full compensation for stripping the pile head, splicing, welding couplers, all materials including reinforcement, formwork, concrete, labour, tools and equipment and other

incidentals necessary to complete the work.

Driving piles measured as provided above shall be paid for at the Contract unit price per linear metre of driven pile as detailed below. The payment shall be full compensation for bringing driving equipment to site, moving equipment from pile to pile, driving piles, removing driving equipment from site on completion, stripping pile heads, labour, tools and equipment and other incidentals necessary to complete the work.

Precast reinforced concrete piles or bored cast-in-place piles measured as provided above shall be paid for at the Contract unit price per linear metre of constructed pile as detailed below. The payment shall be full compensation for all materials including concrete, reinforcement, casing, boring, jetting, bringing equipment to site and removing on completion, moving equipment from pile to pile, empty bore, labour, tools and equipment and other incidentals necessary to complete the work.

Load tests measured as provided above shall be paid for at the Contract unit price per test as detailed below. The payment shall be full compensation for carrying out the test loading, all equipment, kentledge, tension piles, labour, tools and other incidentals necessary to complete the test.

The Integrity testing of piles shall be measured as provided above shall be paid for at the Contract unit price per test as detailed below. The payment shall be full compensation for carrying out the test, all equipment, labour, tools and other incidentals necessary to complete the test.

Pay Item		**Unit of Measurement**
502(1)	Bored piles 1000 mm dia.	metre
502(2)	Bored Piles 1500 mm dia.	metre
502(3)	Sonic Logging Test for Pile Integrity	number
502(4)	Static Load Test of Pile	number

SECTION 503

PORTLAND CEMENT CONCRETE STRUCTURES

503.1 Description

1.1 General

The Contractor shall furnish, place, finish and cure concrete bridges, box culverts with headwalls/wing walls, retaining walls and miscellaneous structures including but not limited to, falsework, forms, cofferdams, shoring, water control systems, detour and temporary bridges.

This work shall consist of the construction of all or portions of structures of Portland cement concrete, of the required grade or grades with or without reinforcement, and with or without admixture, constructed in accordance with the Specification and the lines, levels, grades and dimensions shown on the Drawings and as required by the Engineer.

Portland cement concrete shall consist of a mixture of Portland cement, water and coarse and fine aggregate with or without admixture.

British Standards have been specified as the standards for materials and workmanship

However the Contractor may employ materials manufactured to other internationally-accepted standards or Sri Lankan standards subject to Engineer's approval, which shall require submission of full documentation including test certificates for properties required by the relevant British Standard, carried out at an ISO 9001 - accredited laboratory by suitably qualified people.

Workmanship standards may be substituted with internationally-accepted workmanship standards not in conflict with the provisions of BS 5400 Parts 4, 7, 8 and 9.2, subject to the Engineer's approval.

1.2 Quality of Concrete

(a) **Grades of concrete**:
the grade of concrete to be used in each part of the structure shall be described on the Drawings or in the Pay Items.

(b) For each grade of concrete the specified characteristic strength in N/mm2 shall be as set out in Table 503-1.

(c) The class of concrete shall be defined by its grade followed by the maximum size aggregate allowed.

TABLE 503-1: Grades of Concrete

Grade	Characteristic Strength (N/mm2)
15	15
20	20
25	25
30	30
40	40
50	50
60	60

(d) Cement Content & water cement ratio - The minimum quantity of cement permitted will be as set out in Table 503-2 even though the strength of mixes containing these quantities may exceed the minimum required for the particular grades. The Contractor will design the concrete mixes and submit his proposals for the approval of the Engineer.

TABLE 503-2: Minimum Cement Content (Kg/m3) and Maximum Water/Cement Ratio Required to Ensure Durability of Concrete

Environment	Prestressed Concrete					Reinforced Concrete					Plain Concrete				
	Nominal maximum size of aggregate (mm)				Max. free water/ cement ratio	Nominal maximum size of aggregate (mm)				Max. free water/ cement ratio	Nominal maximum size of aggregate (mm)				Max. free water/ cement ratio
	40	20	14	10		40	20	14	10		40	20	14	10	
Concrete surfaces exposed to (i) Abrasive action by sea water (ii) water with pH<= 4.5 Rank: Extreme	320	350	370	400	0.45	325	350	375	390	0.45	325	350	375	390	0.50
Concrete surfaces directly affected by sea water spray Rank: Very Severe	300	325	350	375	0.45	300	325	350	375	0.45	300	325	350	375	0.50
Concrete surfaces exposed to: (i) driving rain (ii) alternate wetting and drying Rank: Severe	300	325	350	375	0.50	300	325	350	375	0.50	275	300	325	350	0.50
Concrete surfaces above ground level and fully sheltered against all of the following: (i) rain (ii) sea water spray Concrete surfaces permanently saturated by water with pH > 4.5 Rank: Moderate	300	325	350	375	0.50	275	300	325	350	0.50	250	275	300	325	0.50

The cement content shall not exceed 550 kg/m3 unless agreed by the Engineer; however, no price adjustment shall be allowed for exceeding the required tolerances.

(e) Buried concrete exposed to sulphates

The minimum cement content (kg/m3) and maximum water/cement ratio for buried concrete in aggressive subsoil shall be based on the provisions of BS 5328-1:1997 and the Specification for Highway Works with Notes for Guidance in "Manual of Contract Documents for Highway Works", HMSO, May 2001, referred to as UKSHW in the following Paragraphs. The bridge foundations shall be considered as requiring a high performance level to UKSHW

(f) The target strength shall exceed the specified characteristic strength by at least the "current margin". The "current margin" for the mix design shall be 10 N/sq.mm for concrete of Grade 15 or 15.0 N/sq.mm for concrete of Grade 20 or above may be used if approved by the Engineer.

However, when the specified characteristic strength approaches the maximum possible strength of concrete made with a particular aggregate, a smaller margin of not less than 5 N/sq.mm for concrete of Grade 15 or 7.5 N/sq.mm for Grade 20 or above may be used if approved by the Engineer.

(g) Grading of aggregates - the grading of the aggregates shall be within the limits specified in Clause 2.4. Once the appropriate grading have been determined and approved they shall not be varied without the permission of the Engineer.

(h) Workability - The concrete shall be of suitable workability for full compaction to be obtained. The workability of concrete shall be as shown in Table 503-3. The slump shall be measured in accordance with BS 1881.

(i) The Chloride and Sulphate contents shall conform to values shown in Table 503-4.

TABLE 503-3: Workability of Vibrated Concrete

Use of Concrete	Nominal Slump	Permitted Deviation
Reinforced Concrete in slabs, beams, walls, precast components and columns	75 mm	± 25
Reinforced Concrete in slabs, beams, walls, precast components and columns containing congested reinforcement	125 mm	± 25
In-situ concrete piles	125 mm	± 25

TABLE 503-4: Maximum Chloride and Sulphate Contents in Concrete from all Sources (i.e. From Cement, Aggregate, Water And Additives)

Type or Use of cement	Maximum total Chloride content expressed as Chloride ions by mass of cement	Maximum total acid soluble sulphate content expressed as SO3 by mass of cement
Prestressed concrete or steam cured reinforced concrete	0.1 %	4 %
Concrete made with Sulphate resisting Portland cement to BS 4027	0.2 %	4 %
All other	0.3 %	4 %

1.3 Trial Mixes

The Contractor shall prepare trial mixes having workability, strength, and surface finish criteria, to satisfy the Engineer regarding these qualities. The trial mixes shall be made and compacted in the presence of the Engineer; using the same type of plant and equipment as will be used for the works. The concreting plant and means of transport employed to make the trial mix and to transport them representative distances shall be similar to the corresponding plant and transport to be used in the Works.

From each trial mix, test cubes shall be taken as follows. For each mix a set of six cubes shall be made from each of three consecutive batches. Three from each set of six shall be tested at an age of 28 days and three at an earlier age approved by the Engineer. The cubes shall be made, cured, stored, transported and tested in compression in accordance with BS 1881. The tests shall be carried out in a laboratory approved by the Engineer.

From the same mix as that from which the test cubes are made, the workability of the concrete shall be determined by the Slump Test in accordance with BS 1881 or other method approved by the Engineer. The remainder of the mix shall be cast in a wooden mould and compacted. After 24 hours the sides of the mould shall be struck and the surface examined in order to satisfy the Engineer that an acceptable surface can be obtained with this mix

A trial mix for a particular grade shall be accepted when the average strength of the nine cubes, tested at 28 days exceeds the specified characteristic strength by the current margin minus 3.5 N/sq.mm. In addition the consistency shall be to the satisfaction of the Engineer.

The characteristic strength of the various classes of concrete shall be determined as soon as the first 30 test results of each class become available.

The characteristic strength shall be calculated by the equation:

$X0 = X - kS$

Where:

X0 : characteristic strength,

X: mean or average of the series of results

The value of k shall be taken as 1.64.

S: standard deviation given by the equation:

$S = \{ \sum (Xi . X) 2 / (N . 1) \} .$

Where Xi ; the individual result, N: the total number of results.

When a proposed mix has been approved, no variations shall be made in the mix proportions, or in the type, size, grading zone or source of any of the constituents without the consent of the Engineer who may require further trial mixes to be made before any such variation is approved. Until the results of trial mixes for a particular grade have been approved by the Engineer, no concrete of the relevant grade shall be placed in the works.

When the Contractor intends to purchase factory-made precast concrete units, trial mixes may be dispensed with provided that evidence is given to satisfy the Engineer that the factory regularly produces concrete, which complies with the Specification. The evidence shall include details of mix proportions, water-cement ratios, slump and strengths obtained at 28 days.

1.4 Sampling and Testing

The Contractor shall take samples of the concrete for testing.

Unless otherwise requested by the Engineer, cube tests shall be made at the rate of 1 set of three cubes per 10 cu.m of concrete. The times of day at which samples are taken shall be chosen at random. At least one set of three cubes shall be taken on each day that a particular grade is used. Frequencies of tests are given in the Section 1100 - Quality Management.

The procedure for sampling and making cubes and testing shall be carried out strictly in the manner described in BS 1881. In addition, the Engineer may order at his own discretion, additional samples of concrete to be cured at the job site, in order to verify actual strengths obtained.

When the difference between the results divided by their mean exceeding 15%, the test result shall be deemed invalid.

For cubes tested at an age of 28 days the cube strength shall conform to the following requirements:

(a) The average strength determined from any group of four consecutive test results shall exceed the specified characteristic strength by at least 0.5 times the "current margin".

(b) Each individual test result shall be greater than 85% of the specified characteristic strength.

The "current margin" shall be taken as two thirds of the specified characteristic strength for concrete up to Grade 15, or 15 N/sq.mm for concrete of Grade 20 or above.

If the average strength of any group of four consecutive test results fails to meet the first requirement (a), then all concrete mixed in all batches from the first batch to the last batch from which samples were taken to make the test cubes, together with all the intervening batches shall be deemed not to comply with the strength requirements.

If only one test result fails to meet the second requirement (b), then that result may be considered to represent only the particular batch of concrete from which those cubes were taken.

The Contractor shall take such remedial action as the Engineer may order, including the removal of the relevant concrete, and shall, before proceeding with the concreting, submit for the Engineer's approval details of the action proposed to ensure that the concrete complies with the requirements of the Specification.

(c) The Contractor shall submit to the Engineer statistical analysis of concrete strength results on weekly basis for each concrete grade.

(d) If the test results did not meet above requirements, the Contractor shall take required action to improve the strength parameters by changing the mix design or so, subject to the acceptance of the Engineer.

503.2 Materials

2.1 Portland Cement

Cement shall conform to the provisions of the following British Standards:

- BS 12 Ordinary Portland Cement (ordinary and rapid hardening)
- BS 146 Portland - blast furnace cement
- BS 4027 Sulphate-resisting Portland cement
- BS 1370 Low heat Portland cement

The Contractor shall provide test certificates issued by an ISO 9001's accredited laboratory for each consignment or lot intended for use on works to enable the Engineer to satisfy himself that the consignment or lot material conforms to the relevant British Standard.

The Contractor shall provide suitable means of storing and protecting the cement against dampness. Fully covered storage areas with floors protected from rising dampness shall be provided. Bagged or bulk cement which has become partially set or which contains lumps of caked cement shall be rejected. The use of cement reclaimed from discarded or used bags will not be permitted.

2.2 Water

The water used in mixing or curing concrete shall be tested by methods described in BS 3148. All water shall be clean and free from salt, oil or acid, vegetable or other substance injurious to the finished product.

Sources of water shall be maintained at such a depth and the water shall be withdrawn in

such a manner as to exclude silt, mud, grass or other foreign materials. Water from the sea or tidal rivers shall not be used.

Potable water supplied by the National Water Supply and Drainage Board shall normally be acceptable.

2.3 Admixtures

Admixtures shall not be used without the written approval of the Engineer. The Contractor shall submit technical data of any admixtures he proposes to use to the Engineer at least 28 days prior to the date of placing orders for such giving particulars of the structure on which he intends to use such admixtures.

Admixtures containing Calcium Chloride in any form are not permitted.

2.4 Aggregate

Unless otherwise specified or agreed by the Engineer aggregate shall comply with the requirements of BS 882, (aggregates from natural sources for concrete, including granolithic).

2.4.1 Fine Aggregate

The grading of fine aggregate when determined by a test according to BS 882 shall be within the limits of one of the grading zones given in Table 503-5.

The fine aggregate shall be described as fine aggregate of the grading zone into which it falls - e.g. BS 882, Grading Zone C, M, F or Overall.

TABLE 503-5: Grading Limits for Fine Aggregate

Sieve Size	Percentage by mass passing BS Sieve			
	Overall limits	Additional limits for grading		
		C	M	F
10.00 mm	100	-	-	-
5.00 mm	89 to 100	-	-	-
2.36 mm	60 to 100	60 to 100	65 to 100	80 to 100
1.18 mm	30 to 100	30 to 90	45 to 100	70 to 100
600 µm	15 to 100	15 to 54	25 to 80	55 to 100
300 µm	5 to 70	5 to 40	5 to 48	5 to 70
150 µm	0 to 15[1]	-	-	-

[1]: Increased to 20 % for crushed rock fines, except when they are used for heavy duty floors

Note: Individual sands may comply with the requirements of more than one grading. Alternatively, some sands may satisfy the overall limits but may not fall within any one of the additional limits C, M or F. In this case and where sands do not comply with the above table an agreed grading envelope may also be used provided that the supplier can satisfy the Engineer that such materials can produce concrete of the required quality.

2.4.2 Coarse Aggregate

The grading of coarse aggregate, when determined by a test according to BS 882 shall be within the limits of one of the grading given in Table 503-6 and the nominal maximum size of aggregate shall be 40mm, 20mm, 14mm or 10mm as specified.

TABLE 503-6: Grading Limits for Coarse Aggregate

Sieve Size (mm)	Percentage by mass passing BS Sieve for nominal sizes, Single-sized aggregate				
	40 mm	20 mm	14 mm	10 mm	5 mm
50	100	-	-	-	-
37.5	85 to 100	100	-	-	-
20.0	0 to 25	85 to 100	100	-	-
14.0	-	0 to 70	85 to 100	100	-
10.0	0 to 5	0 to 25	0 to 50	85 to 100	100
5.0	-	0 to 5	0 to 10	0 to 25	45 to 100
2.36	-	-	-	0 to 5	0 to 30

The maximum size of aggregate to be used shall be not larger than a quarter of the least dimension of the member in which it is to be used or be at least 5 mm smaller than the minimum space between reinforcing bars in the member which ever is the lesser.

Chloride and Sulphate levels shall be as shown in Table 503-4.

For the control of Alkali-Silica reaction non-reactive aggregates shall be used. Provided they are not contaminated with opal, tridymite or cristobiline or contain more than 20 % (by weight) of chert, flint or chalcedony. The following types of aggregate are considered to be non-reactive Dolerite, Dolomite, Feldspar, Gneiss, Granite, Limestone, Schist and Tuff. On no occasion shall the amount of equivalent sodium oxide exceed 3.0 kg in any cubic metre of concrete. No separate payment shall be made for the referred testing, and it shall be deemed to be included in the rates and prices introduced in the main item for concrete preparation.

The Engineer will permit hand broken stone to be used as coarse aggregate for Grade 15 concrete.

The scope of the project requires the excavation of large quantities of Soft and Hard rock. In addition large quantities of rock is required to be used for replacement of the soft ground treatment areas and for producing coarse and fine aggregates for concrete structures, road sub base, base courses and asphalt pavement.

The installation of crushing plants with adequate production capacity is critical to the project. Furthermore, the supply of large quantity of natural river sand is limited on the project. Fine aggregates will have to be produced from the rock, which may require the use of special crushers and screens. Rock spoil and soil overburden materials can be used

for embankment fill.

All aggregates shall be stored in such a way that they shall be kept free from contact with deleterious matter. Aggregates of different sizes shall be stored separately and in such a way as to avoid segregation in each stockpile.

The Contractor shall provide copies of the results of routine control tests carried out by the aggregate producer and obtain the Engineer's approval prior to placing orders.

2.5 Reinforcement

All reinforcement shall comply with the requirements of Section 504.

2.6 Waterstops

Waterstops shall be manufactured by the extrusion of an Elastomeric plastic compound consisting of virgin polyvinyl chloride will meet the following performance requirements:

-	Tensile Strength	12.2 MPa (Min)
-	Elongation at break	250 % (Min)
-	Water soluble matter content	0.15 % (Max)
-	Softness number	38 to 80

503.3 Equipment and Tools

3.1 General

Equipment and tools necessary for handling material and performing the work, and satisfactory to the Engineer as to design, capacity and mechanical condition, shall be at the site of work before work is started.

If any equipment is not maintained in full working order or if the equipment as used by the Contractor proves inadequate to obtain the results prescribed, such equipment shall be improved or other satisfactory equipment substituted or added at the direction of the Engineer.

3.2 Batching Plant and Equipment

(a) General - All material in the mix shall be proportioned wholly by weight. The batching plant shall include bins, weighing hoppers, and scales for the fine aggregate and for each separate size of coarse aggregate. If cement is used in bulk, a bin, hopper and scales for the cement shall be included. The container shall be watertight.

Provisions satisfactory to the Engineer shall be made for batching other components of the mix, at the batching plant or at the mixer as may be necessary. The batching plant

may be either of stationary or of mobile type. It shall always be properly levelled within the accuracy required for the proper operation of the weighing mechanisms.

(b) Bins and hoppers - Bins with adequate separate compartments for fine aggregate and for each required size of coarse aggregate shall be provided in the batching plant. Each compartment shall discharge efficiently and freely into the weighing hopper. Means of control shall be provided so that as the quantity desired in the weighing hopper is being approached, the material may be added slowly and shut off with precision. A port or other opening for removing an overload of the several materials from the hopper shall be provided.

Weighing hoppers shall be constructed so as to discharge fully.

(c) Scales - The scales for weighing aggregates and cement shall be of either the beam type or the spring less -dial type. They shall be accurate within one half of 1% under operating conditions throughout the range of use. Ten 25-kilogram weights shall be available for checking accuracy.

All exposed fulcrums, clevises, and similarly working parts of scales shall be kept clean. When beam type scales are used, provision shall be made for indicating to the operator that the required load in the weighing hopper is being approached. The device shall indicate at least the last 100 kilograms of load and up to 25 kilograms overload. All weighing and indicating devices shall be in full view of the operator while charging the hopper and he shall have convenient access to all controls.

Cement may be measured by weight, or in standard sacks considered to weigh 50 kilograms net. When measured by weight, satisfactory scales and hopper shall be provided together with a boot or other approved device to transfer the cement from the weighing hopper. Satisfactory methods of handling shall be employed.

Control of batching

All measuring equipment shall be maintained in a clean and serviceable condition. The Contractor shall check over the range in use when set up at each site and shall maintain thereafter. The Contractor shall calibrate the equipment periodically and as directed by the Engineer.

- The quantity of water adjusted for the free moisture content of the aggregate shall be measured.
- The batch weight of aggregate shall be adjusted to allow for the free moisture content of the aggregate being used. The accuracy (weight) of equipment for each batch shall fall within the following limits:
- Cement: + 3 % of quantity of cement,
- Water: + 3 % quantity of water,
- Aggregate: + 3 % of total quantity,

- Admixture: + 5 %

The mixer shall comply with BS 1305 where applicable.

3.3 Mixers

(a) General - All concrete shall be mixed in batch mixers manufactured in accordance with BS 1305 or tested in accordance with BS 3963. It may be mixed at the site of construction, at a central plant or in transit. Each mixer shall have attached to it in a prominent place a manufacturer's plate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of the mixing drum.

(b) Mixers at site of construction - Mixers at the site shall be approved drum-type capable of combining the aggregate, cement and water into a thoroughly mixed and uniform mass within the specified mixing period and of discharging the mixture without segregation. The mixer shall be equipped with a suitable charging hopper, water storage, and a water-measuring device, accurate within 1%. Controls shall be so arranged that the water can be applied only while the mixer is being charged.

The discharge lever shall lock automatically until the batch has been mixed the required time after all materials are in the mixer. Suitable equipment for discharging the concrete in the form shall be provided. The mixer shall be cleaned at suitable intervals. The pick-up and throw over blades in the drum shall be replaced when they have lost 10% of their depth.

(c) Central Plant Mixers - These mixers shall be of approved drum type capable of combining the aggregate, cement and water into a thoroughly mixed and uniform mass within the specified mixing period and of discharging the mixture without segregation. Central plant mixers shall be equipped with an acceptable timing device that will not permit the batch to be discharged until the specified mixing time has elapsed. The water system for a central mixer shall be either a calibrated measuring tank or a meter and shall not necessarily be an integral part of the mixer.

The mixers shall be cleaned at suitable intervals. They shall be examined daily for changes in interior condition. The pick-up and throw over blades in the drum shall be replaced when they have lost 10% of their depth.

(d) Truck or transit mixers - These shall be equipped with electrically actuated counters by which the number of revolutions of the drum or blades may readily be verified and the counters shall be actuated at the commencement of mixing operations at designated mixing speeds. The mixer shall be capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity.

Except when intended for use exclusively as agitators, truck mixers shall be provided with a water-measuring device to measure accurately the quantity of water for each batch. The delivered amount of water shall be within plus or minus 1% of the indicated amount.

(e) Hot Weather Concreting - The Contractor shall make the necessary arrangements, regarding the equipment and materials at the site, to maintain the temperature of the concrete mixture between 10°C and 30°C.

During hot weather the Contractor shall ensure that the constituent of the concrete are sufficiently cool to prevent the concrete from stiffening in the interval between its discharge from the mixer and compaction in its final position.

3.4 Batching and Transporting Materials

For mixing at site of construction, aggregates shall be transported from the batching plant to the mixer in batch boxes, vehicle bodies, or other containers adequate in design and construction to carry properly the batch required. Partitions separating batches shall be adequate and effective to prevent spilling from one compartment to another while in transit or while being dumped.

Cement in original shipping containers may be transported on top of the aggregates. The number of sacks of cement required for each batch shall be placed on the aggregates for that batch. Sacked cement shall be emptied into the aggregates prior to dumping into the mixer.

Batches shall be delivered to the mixer separately and intact. Each batch container shall be dumped cleanly into the mixer without loss of cement or mixing or spilling of material from one batch compartment into another.

3.5 Mixing Concrete

(a) Mixing at Site of Construction - The amount of admixture to be added, if any, shall be approved by the Engineer.

Job-site mixers shall be operated at a drum speed of not less than 15 nor more than 20 revolutions per minute. The batched materials shall be so charged into the drum that a portion of the water shall enter in advance of the cement and aggregates and the water shall continue to flow into the drum for a minimum time of 5 seconds after all the cement and aggregates are in the drum. Mixing time shall be measured from the time all materials except water are in the drum and shall in the case of mixers having a capacity of 1 cubic metre or less not be less than 50 seconds nor more than 70 seconds. In the case of dual drum mixers, the mixing time shall not include transfer time. The contents of an individual mixer drum shall be removed before a succeeding batch is added to the drum. Any concrete mixed less than the specified minimum time shall be discarded and disposed of by the Contractor at his own expense.

The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity in cubic metres as shown on the manufacturer's guaranteed capacity standard rating plate on the mixer; except that an overload up to 20% above the mixer's nominal capacity will be permitted provided concrete test data for strength, segregation, and uniform consistency are satisfactory, and provided no spillage of concrete takes place.

Re-tempering concrete by adding water or by other means will not be permitted. Concrete, which is not of the required consistency at the time of placement, shall not be used.

(b) Central Plant Mixing - In addition to the requirements of Clause 3.5(a) central plant mixers which have a capacity of not less than 2 cubic metres nor more than 5 cubic metres and mixers having a capacity greater than 5 cubic metres may permit a minimum mixing time of 90 seconds and 120 seconds respectively; provided a mixing analysis and tests of the job materials indicates that such produced concrete is equivalent in strength and uniformly to that attained as stated in the preceding paragraphs.

Mixed concrete shall be transported from the central mixing plant to the site of work in agitator trucks, or upon written permission of the Engineer, in non-agitator trucks. Delivery of concrete shall be so regulated that placing is at a continuous rate unless delayed by the placing operations. The intervals between deliveries of batches shall not be so great as to allow the concrete in place to harden partially, and in no case shall such an interval exceed 30 minutes.

Agitator trucks - Unless otherwise permitted in writing by the Engineer the agitator truck shall have a watertight revolving drum suitably mounted and shall be capable of transporting and discharging the concrete without segregation. The agitating speed of the drum shall not be less than two or more than six revolutions per minute. The volume of mixed concrete permitted in the drum shall not exceed the manufacturers rating nor exceed 80% the gross volume of the drum.

Gross volume of agitator bodies expressed in cubic metres shall be supplied by the mixer manufacturer.

Concrete, when deposited, shall have a temperature of not more than 32°C. It shall be compacted in its final position within 45 minutes of discharge from the mixer unless carried out in purpose-made agitator, operating continuously, when the time shall be within 2 hours of the introduction of cement to the mix and within 45 minutes of discharge from the agitator.

No concrete shall be mixed, placed, or finished when the natural light is insufficient unless an adequate and approved artificial lighting system is operated.

Concrete shall be mixed only in amounts required for current use. The Contractor shall be responsible for producing a concrete of the required consistency. Should it prove impracticable to finish centrally mixed concrete properly before it has become too stiff, the Engineer may require that the concrete be mixed at the site of the work.

3.6 Formwork

Formwork shall include all temporary or permanent moulds for forming the concrete. All formwork shall be of wood or metal and shall be built mortar-tight and rigid enough to maintain the concrete in position during placing, compaction, setting and hardening.

Formwork for exposed surfaces shall be made of dressed timber of uniform thickness

with or without a form liner of an approved type or shall be of metal sufficiently rigid in self with no surface blemish that will impair the quality of the concrete surface finish. No rusty or bent metal forms shall be used. Formwork shall be chamfered on all sharp edges and shall be given a bevel in the case of projections.

Rough timber may be used for surfaces that will not be exposed in the finished structure.

All timber shall be sound, free from warps and twists sap, shakes, large or loose knots, wavy edges or other defects affecting the strength or appearance of the finished structure.

The shape, strength, rigidity, water-tightness and surface smoothness of re-used formwork shall be maintained at all times. Any warped or bulged timber must be re-sized before being re-used. Formwork, which is unsatisfactory in any respect, shall not be re-used.

Internal ties, where permitted, shall be so arranged as to allow their removal to a depth of at least 25 mm from the concrete face without injury to the concrete. No permanently embedded metal shall have less than 25 mm cover to the finished concrete surface.

Formwork shall be so constructed that easy cleaning out of any extraneous material inside the formwork can be achieved without disturbing formwork already checked and approved by the Engineer.

Formwork shall be treated with approved non-staining oil or saturated with water at the discretion of the Engineer before placing concrete. Form oil will only be used after the approval of the Engineer has been given.

The Engineer may require trials to be carried out before approval is given for the use of particular form oil, to ascertain that the form oil proposed by the Contractor will not discolour or injure the finished concrete face in any way.

Trial panels when required in the contract and before commencing concreting, the Contractor shall prepare a trial panel of size and surface finish acceptable to the Engineer. The panel shall be filled with the proposed concrete mix compacted by the method to be used in the works. As soon as practicable after compaction, the forms shall be removed to enable the Engineer to check the surface finish and compaction achieved.

3.7 Surface Finishes for Concrete (Formed Surfaces)

Formwork shall be capable of producing the following finishes as required in the Works:

Class F1 No extra requirement, for unexposed formed surfaces.

Class F2: For normally exposed formed surfaces:

The irregularities in the finish shall be no greater than those obtained from the use of wrought thickness square edged boards arranged in a uniform pattern. The finish is

intended to be left as struck but imperfections such as fins and surface discolouration shall be made good to the satisfaction of the Engineer.

Class F3: Very costly and should only be used for small areas:

The resulting finish shall be smooth and of uniform texture and appearance. The formwork lining shall leave no stain on the concrete and shall be so jointed and fixed to its backing that it imparts no blemishes. It shall be of the same type and obtained from only one source throughout any one structure. The Contractor shall make good any imperfections in the finish to the complete satisfaction of the engineer. Internal ties and embedded metal parts will not be allowed.

Class F4: Appropriate for large areas required having a first-class appearance:

The requirements of Class F4 are as for Class F3 except that internal metal ties and embedded metal parts will be permitted. The ties shall however be positioned only in rebates or in other positions as described in the Contract or as agreed by the Engineer.

Permanently exposed concrete surfaces to Classes F2, F3 and F4 shall be protected from rust marks and stains of any kind.

Unless otherwise described in the Contract, all formwork joints for exposed surfaces of concrete finishes Classes F2, F3 and F4 shall form a regular pattern agreed by the Engineer with horizontal and vertical lines continuous throughout each structure and all construction joints shall coincide with these horizontal or vertical lines.

3.8 Scaffolding and Settlement

The Contractor shall at first check the soil bearing capacity and design the safe scaffolding and false work. If overloading, it will affect the stability as well as load-carrying capacity. Differential settlement is often a problem where heavy loads are applied to scaffolds resting on uncompacted soils. A scaffold tower 9 m high which settles 25 mm on one side can move 150 mm at the top. Settlement puts stress on braces, tie-ins and frame joints. Heavy loads should be placed symmetrically on the platform to ensure that soil settlement is uniform.

The scaffold structure must be capable of carrying the loads to be applied. Both light-duty and heavy-duty frames are available on the market. Light-duty frames should not be used where heavy loads will be involved. If the load-carrying capacity of the frames is not known, consult the manufacturer or supplier and obtain the load capacity of the scaffold frame system. The load-carrying capacity of frames usually varies with the height of the towers.

Detailed calculations and drawings including camber shall be submitted to the Engineer for his consent prior to loading.

Scaffolds that cannot be founded on solid footings must be supported by ample piling,

which shall be spaced, driven and removed in a manner approved by the Engineer.

3.9 Curing Agents

(a) Burlap - The burlap used for curing shall be made from jute or hemp and at the time of using shall be in good condition, free from dirt, clay or other substances, which interfere with its absorptive quality. It shall not contain any substance, which would have a deleterious effect on the concrete. Burlap shall be of such quality that it will absorb water readily when dipped or sprayed and shall weigh not less than 240 grams per square metre.

(b) Sand - Sand shall be clean and free from clay balls or any other deleterious matter.

(c) Liquid membrane forming compounds - Liquid membrane forming compounds shall conform to the requirements of BS 7542: 1992 or AASHTO Standard Specification M148 Type 2.

3.10 Release Agents

Release agents for formwork shall be to the approval of the Engineer. Where a concrete surface is to be permanently exposed, only one agent shall be used throughout the entire area. Release agents shall be applied evenly and shall not be permitted to come into contact with reinforcement, prestressing tendons and anchorages. Where the concrete is to receive an applied finish the release agent shall be compatible.

3.11 Compacting Equipment

High frequency internal vibrators of either the pneumatic electric or hydraulic type shall be used for compacting concrete in all structures and where practicable in precast units. The vibrators shall be of a type approved by the Engineer with a minimum frequency of 3500 impulses per minute and shall be capable of visibly affecting a properly designed concrete with a 20mm slump over a circular area of 450 mm radius.

Before the casting starts the Contractor shall have at the site, besides the necessary number of various vibrators required for a casting, at least one complete set of spare vibrators.

503.4 Construction Methods

4.1 General

The Contractor shall maintain an adequate number of trained and experienced supervisors and foremen at the site to supervise and control the work. All construction, other than concrete, shall conform to the requirements prescribed in other Sections of the Specification for the several items of work entering into the complete structure.

4.2 Foundations

Preparation of foundations shall conform to the details as shown on the Drawings and in accordance with the requirements of Section 501: Excavation and Backfill for Structures. The elevations of the bottoms of footings as shown on the Drawings are approximately only and the Engineer may order further excavation as necessary to obtain satisfactory foundations.

Pile foundations shall be constructed in accordance with the provisions set out in Section 502 and as shown on the Drawings.

4.3 Temporary Works

The Contractor shall construct and remove temporary facilities employed by the Contractor in the execution of the Work, including but not limited to,

- Falsework,
- Forms,
- Cofferdams,
- Shoring,
- Water control systems,
- Temporary bridges.

The Contractor shall perform the following activities:

(a) General

- The Contractor shall design the temporary works and provide working drawings with design calculations and supporting data in sufficient detail to permit a structural review of the proposed design of a temporary work.
- Include such data as the sequence and rate of concrete placement.
- Furnish copies of the drawings 30 days in advance of work for review, revision and approval.
- Start the construction only after the drawings have been approved.
- Construct temporary works in conformance with the approved working drawings. Verify the quality of the materials and work employed are consistent within the design.
- Remove all temporary works (except specified to remain) upon completion of their use.
- Restore the area to its original or planned condition and clean of all debris.

(b) Falsework and Forms

- Furnish rigid and strong falsework and forms to safely support all loads imposed and produce the lines and grades indicated.
- Make the required surface texture with forms and provide uniformity of colour of formed surfaces.
- Limit loads of falsework onto other structures to those permitted in each design.
- Construct falsework and set grades that allow for anticipated settlement and deflection, provide the vertical alignment and camber indicated for the permanent structure, permit minor adjustments during the placement of concrete or structural steel and allow for the gradual release of the falsework.
- Provide for accurate measurement of falsework settlement during the placing and curing of the concrete.
- For post-tensioned I- and box-girders, release underside falsework only after the prestressing steel has been tensioned.
- Remove forms or falsework only after the concrete attains the specified compressive strength and 7 days after placing the concrete.
- Release falsework supporting any span of a continuous or rigid frame bridge after the structural concrete in the entire span attains the specified compressive strength.
- Remove supports in such a manner as to avoid overstressing the concrete or damaging its surface and to permit the structure to uniformly and gradually take the stresses resulting from its own mass.

(c) Cofferdams and Shoring

- Construct cofferdams to adequate depths to ensure stability and to adequate heights to seal off all water.
- Control the ingress of water so that footing concrete can be placed in the dry.
- Construct shoring to support all loads imposed and to comply with applicable safety regulations.

(d) Temporary Water Control System

- Submit shop drawings and working drawings, in accordance with the requirements and procedure stated in Specification Section 113, for temporary water control systems, dikes, bypass channels, flumes and other surface water diversion works and cut-off walls and pumping systems, including wellpoint and deep-well systems used to prevent water from entering excavations or structures.

(e) Temporary Bridges

- Construct, maintain and remove temporary bridges so as not to endanger the work or the public.

4.4 Reinforcement

The Engineer shall inspect and approve all reinforcement in place in accordance with the requirements of Section 504 "Reinforcement for Structures", before concrete is placed. An experienced steel fixer shall be present while all concrete is placed to ensure that no reinforcement becomes displaced during placing and if it does, to reposition such reinforcement before proceeding further.

4.5 Placing Concrete

(a) General - All concrete shall be placed within the times specified in Clause 3.5. Concrete shall be placed in such a manner as to avoid segregation and the displacement of reinforcing bars and shall be spread in horizontal layers where practicable. Concrete shall be placed where necessary inside forms by hand shovels and in no instance shall vibrators be so manipulated to transport concrete inside formwork. Care shall be taken to prevent mortar from spattering on forms and reinforcing steel and from drying ahead of the final covering with concrete. Where spattering has occurred the forms and steel shall be cleaned with wire brushes or scrapers before concrete is placed around steel or in forms. Troughs, pipes or short chutes used as aids in placing concrete shall be positioned in such a manner that segregation of the concrete will not occur. All chutes, troughs, and pipes shall be kept clean and free from coating of hardened concrete or mortar.

Concrete shall be thoroughly compacted by vibration, unless otherwise agreed by the Engineer, during the operation of placing, and thoroughly worked around the reinforcement, tendons or duct formers, around embedded fixtures and into corners of the formwork to form a solid mass free of voids. When vibrators are used to compact the concrete, vibration shall be applied continuously during the placing of each batch of concrete until the expulsion of air has practically ceased and in a manner that does not promote segregation of the ingredients.

Particular care shall be taken when concreting bridge decks of substantial thickness to avoid layering of concrete, and the whole thickness shall be placed in one pass. In deck slabs where void formers are used, adequate means to prevent flotation shall be employed and care taken to ensure adequate compaction of the concrete placed beneath the void formers.

Vibration shall not be applied by way of the reinforcement. Where vibrators of the immersion type are used, contact with reinforcement and all inserts shall be avoided as far as is practicable.

Concrete shall not be subject to disturbance between 4 hours and 24 hours after compaction, except with the agreement of the Engineer. Wherever vibration has to be applied externally, the design of formwork and disposition of vibrators shall ensure efficient compaction and the avoidance of surface blemishes.

There shall be no excess water on the top surface on completion of compaction.

Concrete shall not be dropped freely over a vertical distance of more than 1.20 metres.

Concrete shall be placed continuously throughout each section of the structure or between joints if shown on the Drawings or as directed by the Engineer. If, in an emergency it is necessary to stop placing concrete before a section is completed, bulkheads shall be placed as the Engineer may direct and the resulting joint shall be deemed a construction joint, the treatment for which is given in Clause 4.5(g).

- If concreting will continue more than 1 hour, the Contractor shall submit the pouring plan indicating the sequence of concreting in layers. The sequence shall be planned to avoid any cold joints.
- The Contractor shall stop placement of concrete under conditions of threatening rain unless protection is provided.

(b) Concrete Columns - Concrete in columns or bents shall be placed in one continuous operation unless otherwise permitted by the Engineer.

(c) Concrete Slab and Girder Spans - Concrete in T-Beam or deck girder spans having spans of 12 metres or less shall be placed in one continuous operation unless otherwise stated on the Drawings. Concrete preferably shall be deposited by beginning at the centre of the span and working towards the ends.

Concrete in slab spans shall be placed in one continuous operation and in one layer for each span, unless otherwise stated on the Drawings.

Concrete in girders spanning more than 12 metres may be placed in two operations; the first operation being the placing of concrete in the girder stems to the bottom of the slab haunches or the bottom of the slab whichever is applicable. The top surface of the previously placed concrete shall be jetted with air or water to remove laitance and all loose material and no further roughening shall be carried out. A period of at least 24 hours shall elapse between the completion of placing concrete in the girder and the commencement of placing concrete in the slab. The Contractor shall check all falsework for shrinkage and settlement and shall tighten all wedges to ensure minimum deflection of all formwork.

(d) Walls, Piers, etc - Where walls, piers, columns, struts, posts and other such structural members allow horizontal construction joints, concrete shall not be placed on top of other concrete which has not been allowed to set for 12 hours or more.

Work shall not be discontinued within 450 mm of the top of any face, unless provision has been made for a coping less than 450 mm thick, in which case, if permitted by the Engineer, the construction joint may be made at the underside of the coping.

(e) Culverts - The slabs of box culverts shall be placed for their full depth in one layer and allowed to set not less than 12 hours before any additional work is done on them. For

culverts of exceptional length under high embankment details of construction joints are shown on the Drawings. The entire length of slabs between indicated construction joints shall be placed for their full depth or layer and allowed to set for not less than 12 hours before any additional work is done on these lengths.

Before concrete is placed in sidewalls, bottom slabs shall be cleaned of all shavings, sticks, sawdust and other extraneous material.

The Contractor shall submit to the Engineer for approval his proposals for pouring culvert walls before commencing culvert construction. Concrete shall not be placed in layers more than one metre high relative to the concrete already placed. Deposition shall proceed in a systematic manner.

(f) Depositing Concrete Under Water - Concrete shall not be deposited in water except with the approval of the Engineer and with his immediate supervision and in this case the method of placing shall be by tremie and as defined below.

Concrete deposited in water shall contain 10% by weight extra cement to that approved by the Engineer for the grade of concrete used. To prevent segregation, it shall be carefully placed in a compact mass, in its final position, by means of a tremie tube or pipe, or a bottom dump bucket and shall not be disturbed after being deposited. Special care must be exercised to maintain still water at the point of deposit. Concrete shall not be placed in running water. The method of depositing concrete shall be so regulated as to produce approximately horizontal surfaces.

Concrete seals shall be placed in one continuous operation. When a tremie tube or pipe is used it shall consist of a tube or pipe not less than 250mm in diameter. All joints in the tube shall be watertight. The means of supporting the tremie tube shall be such as to permit free movement of the discharge end over the entire top of the concrete and to permit it being lowered rapidly when necessary to choke off or retard the flow. The tremie tube shall be filled by a method that will prevent washing out of the concrete. The discharge end shall be completely submerged in concrete at all times and the tremie shall be kept full.

When concrete is placed with a bottom dump bucket, the bucket shall have a capacity of not less than one half cubic metre and the top of the bucket shall be open. The bottom door shall open freely downward and outward when tripped. The bucket shall be completely filled and slowly lowered to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited and when empty be withdrawn slowly until well above the concrete. The slump of the concrete used shall be maintained between 100 and 200 mm.

Dewatering shall proceed only when the concrete seal is considered strong enough to withstand any pressures to be exerted upon it. This time will be decided by the Engineer.

All laitance or other unsatisfactory material shall be removed from the exposed surface

by scraping, jetting, chipping or by other means, which will not injure the seal unduly.

(g) Construction Joints - a concreting schedule shall be prepared for each structure detailing the locations of construction joint on this concreting schedule, and it shall be submitted to the Engineer for review and approval. These locations shall not be altered, unless in case of emergency, when construction joints shall be positioned as directed by the Engineer.

At horizontal construction joints, gauge strips 20 to 30 mm square shall be placed inside the forms along all exposed surfaces to give the joints straight lines. Before placing fresh concrete, the surfaces of all construction joints shall be hammered with a sharp hand tool until the aggregate is exposed, cleaned and a small quantity of neat cement slurry added. At the same time forms shall be checked to see that they are tight against the concrete already in place. Concrete in substructures shall be placed in such manner that all horizontal construction joints will be truly horizontal.

Where vertical construction joints are necessary, reinforcing bars shall extend across the joint in such a manner as to make the structure monolithic. Special care shall be taken to avoid construction joints through wing walls.

(h) Precast Concrete Units - When the method of manufacture has been approved, no further changes shall be made without the approval of the Engineer

The Contractor shall inform the Engineer in advance of the date of commencement of manufacture and casting of each type of unit.

A copy of all 28-day cube test results relating to the work shall be sent to the Engineer as soon as they become available.

(i) Concrete shall not be subject to disturbance between 4 hours and 24 hours after compaction except that re-compaction of the upper layers of deep lifts to prevent or annul settlement cracking may be carried out.

4.6 Curing

All concrete surfaces shall be kept wet for at least 7 days after placing. Bridge deck and footwalk slabs shall be covered with wet burlap immediately after final finishing of the surface. This material shall remain in place for the full curing period or may be removed and replaced with sand when the concrete has hardened sufficiently to prevent marring. In both cases the materials shall be kept thoroughly wet for the entire curing period. All other surfaces if not protected by forms shall be kept thoroughly wet, either by sprinkling or by the use of wet burlap until the end of the curing period. If timber forms are allowed to remain in place during the curing period, they shall be kept moist at all times to prevent the opening of joints.

The Contractor's proposals for the use of liquid membrane curing compound shall be subject to the approval of the Engineer.

4.7 Removal of Formwork and Falsework

(a) Time of removal : The minimum period before striking forms shall be as shown in Table 503-7 subject to mandatory Engineer's approval. The Engineer's approval shall not relieve the Contractor of responsibility for the safety of the work. Blocks and bracing shall be removed at the same time as the forms and in no case shall any portion of the forms be left in the concrete.

TABLE 503-7: Minimum Period before Striking Formwork

Vertical forms to Abutments, wing walls, columns, beams and similar components	24 hours
Soffit forms to deck slabs	4 days
Props to deck slabs	21 days
Soffit formwork to beams	9 days
Props to beams	21 days

Forms used on exposed vertical faces shall remain in place for periods, which shall be determined by the Engineer.

Falsework and forms under slabs, beams, girders and arches shall remain in place for 21 days after the day on which placing of concrete was completed. When high early strength cement is used, forms for all structures may be removed after less than 14 days but only with the written approval of the Engineer who will decide the time for removal as a result of tests. Formwork and falsework for the whole of suspended span bridges and other special structures shall remain in place until such time as the Engineer will decide after all concrete has been poured.

(b) Patching - As soon as the forms are removed, all wire or metal devices used for securing the formwork which project from or appear on the surface of the finished concrete shall be removed or cut back at least 25mm from the finished surface of the concrete. All holes and pockets so formed shall be filled with cement mortar mixed in the same proportions as the fine aggregate to cement of the concrete mix used for that particular section of the structure, after the surface to be patched has been thoroughly cleaned and wetted to receive the patch.

(c) Cause for rejection - Excessive honeycombing shall be sufficient to cause rejection of portions of the structure containing this honeycombing. The Contractor, on receipt of written orders from the Engineer, shall remove and rebuild such portions of the structure to Engineer's requirements.

4.8 Finishing Concrete

All concrete surfaces exposed in the completed work shall comply with the requirements as specified below except where the Drawings indicate otherwise.

(a) Concrete Decks - Immediately after placing concrete, concrete decks shall be struck off templates to provide proper crowns and shall be finished smooth to the correct levels. Finish shall be slightly but uniformly roughened by brooming.

(b) Kerb and Foot walk Surface - Exposed faces of kerbs and foot-walks shall be finished true to lines and grades. The kerb surface shall be wood floated to a smooth but not slippery finish. Foot-walk surfaces shall be slightly but uniformly roughened by brooming.

(c) Bridge Bearing Shelves, Pile Caps, and Tops of Walls - Exposed faces shall be struck off with a straight edge and floated to true grade with a steel trowel using firm pressure to produce a dense, smooth uniform surface free from trowel marks. Under no circumstances will the use of mortar topping for concrete surfaces be permitted.

(d) Cavities

Clean and saturate with water all cavities produced by form ties and all other holes, broken corners or edges and other defects, then fill with required mortar.

4.9 Dimensional Tolerances

4.9.1 General

Where tolerances for individual components and associated dimensions are not specified on the Drawings, deviations from established lines, grades and dimensions in the completed work shall not exceed the herein provided..

4.9.2 Dimensional Tolerances

The tolerances given in Table 503-8 are to cover strength durability and fit of prefabricated elements and cast-in-situ elements.

TABLE 503-8: Dimensional Tolerances

Description	Tolerance (mm)
Cross-sectional dimension of members and thickness of slabs	+10, -3
Length of members, length and width of slabs:	
- dimension up to 18 m	$\pm$ 6
- dimension 18 m and over	1 in 3000
Clear cover to reinforcement	+6, -3
Fitments for prefabricated elements	1 in 1000
Girder anchorages (including dimensions between anchorages on adjacent piers), cored holes, handrail anchorages and other embedded items	$\pm$ 5

4.9.3 Positional Tolerances

Positional tolerances listed in Table 503-9 refer to the departure of any point, plane or

component of a structure from its correct position within the layout of the structure as shown on the Drawings.

TABLE 503-9: Positional Tolerances

Description	Tolerance (mm)
Level of footings	± 20
Level other than footings	± 5
Horizontal location, where tolerance on fit is not applicable	± 25

4.9.4 Relative Position

Relative tolerances refer to departures from linearity or planarity in any part of the structure. Tolerances are measured as the departure of any point in a line or surface from the remainder of that line or surface.

Departure may be sudden (e.g. misfit at joint in formwork) or gradual (e.g. a wobble in a surface). Tolerance on gradual departure is the value calculated by multiplying the overall length of the line or surface under consideration by the factor given in Table 503-10.

TABLE 503-10: Relative Tolerances

Description	Tolerance	
	Factor	Max. (mm)
Exposed edge:		
- gradual departure	0.001	-
Exposed surface:		
- gradual departure	0.004	10
- sudden departure	-	3

4.10 Loading

No superstructure load shall be placed upon finished bents, piers, or abutments until the Engineer so directs but in no case shall any load of any kind be placed until the Contractor has completed curing. The Contractor shall not place any temporary loads on deck slabs.

Bridge deck slabs shall be opened to traffic only when so directed by the Engineer and generally not sooner than 28 days after the placing of the concrete has been completed.

4.11 Backfill to Structures

All spaces which have been excavated and the volumes of which are not occupied by the concrete structure shall be backfilled and compacted with acceptable material in

accordance with the provisions of Sub-section 501.2 Materials 2.3 "Backfill Materials" or as directed by the Engineer.

4.12 Cleaning Up

Upon completion of structure and before final acceptance, the Contractor shall remove all falsework, piling etc, down to 0.5 metres below the finished ground line. Excavated, or useless materials, rubbish etc, shall be removed from the site and the site shall be left in a neat and presentable condition satisfactory to the Engineer.

4.13 Waterstops

Waterstops where used shall form continuous watertight joints.

503.5 Proportioning by Volume

Volume batching of concrete is not permitted for structural concrete.

Where permitted concrete may be volume-batched in the proportions given in Table 503-11, Fine and Coarse Aggregate complying with the grading limits of Tables 503-5 and 503-6 shall be measured using gauge boxes of suitable internal dimensions such as 400 x 350 x 250 mm which is 0.035 m3 and corresponds to the volume of a bag of cement weighing 50 kg.

TABLE 503-11: Standard Volumetric Mixes

Specified Mix	Equivalent Grade where specified	Quantities Per 50kg Bag Of Cement		
		Fine Aggregate (m3)	Coarse Aggregate (m3)	Approx. water content in litres
1: 1: 2	30	0.035 1 box	0.070 2 boxes	21
1: 1.5: 3	25	0.053 1.5 boxes	0.105 3 boxes	23
1: 2: 4	20	0.070 2 boxes	0.140 4 boxes	25
1: 3: 6	10	0.105 3 boxes	0.210 6 boxes	32
1: 4: 8	-	0.140 4 boxes	0.280 8 boxes	32

Note:
- The internal dimensions of boxes for measuring aggregate shall be 400 mm x 350 mm x 250 mm high.
- If gauging boxes are allowed to be used for cement, this box shall be 400 mm x 350 mm x 250 mm high to account for bulking.

Standard volumetric mixes of materials given in Table 503-11 are based on the dry loose volumes of each grading of aggregate used. Aggregates must not be shaken, rammed or heaped in the boxes during batching and a suitable allowance, determined by tests, must be made for bulking of damp material.

503.6 Measurement

Concrete shall be measured by the number of cubic metres of the several classes complete in place and accepted. In computing quantities the dimensions used shall be those shown on the Drawings or ordered in writing by the Engineer but the measurement shall not include any concrete used for the construction of temporary works. No deduction from the measured quantity shall be made for:

- Holes, ducts, pockets, sockets and the like not exceeding 0.15 cubic metres each in volume,
- Reinforcement,
- Individual fillets, chamfers, splays, drips, rebates, recesses, grooves and the like of 100 mm total girth or less when measured over the faces in contact with the formwork.

Measurement for Precast I-girder concrete is not included here but included in the I-girder.

503.7 Payment

The concrete structures for bridges and box culverts shall include following items but shall not be measured for payment separately (These are deemed to be included in the concrete costs.):

- Falsework,
- Forms,
- Cofferdams,
- Shoring,
- Water control systems,
- Detour and temporary bridges (including its maintenance),
- Mix design,
- Trial mixes,
- Admixtures and additives.

Reinforcing steel is included in Section 504, Reinforcement. Concrete and reinforcing steel for Prestressed box girders, Precast prestressed I- girders and their cross beams shall be measured and paid according to Section 505, Prestressed Concrete.

Concrete work measured as provided above for the grade or grades of concrete specified, shall be paid for at the Contract unit price per cubic metre for concrete as detailed below.

The payment shall be full compensation for furnishing, testing, placing and curing all

materials, including labour, tools, equipment, etc., incidental thereto including the provision and construction of drainage falls and systems and weep holes, the forming of holes, pockets and sockets and the like not exceeding 0.15 cubic metres each in volume, forming construction joints and unformed surfaces.

Separate payment will not be made for testing of concrete mixes the cost of which shall be included in the rate for concrete works.

Pay Item		Unit of Measurement
503(1)	Concrete Grade 15 for Levelling Concrete	cubic metres
503(2)	Concrete Grade 30 for Abutment, Pier	cubic metres
503(3)	Concrete Grade 30 for Sidewalk Kerb for Overpass Bridge	cubic metres
503(4)	Concrete Grade 30 for Parapet, Sidewalk, Kerb	cubic metres
503(5)	Concrete Grade 30 for Approach Slab	cubic metres
503(6)	Concrete Grade 35 for Cross beam	cubic metres
503(7)	Concrete Grade 35 for Deck Slab	cubic metres
503(8)	Concrete Grade 50 for Box Girder	cubic metres
503(9)	Concrete Grade 30 for Box Culvert	cubic metres
503(10)	Concrete Grade 30 for Retaining wall	cubic metres
503(11)	Concrete Grade 40 for Abutment, Pier	cubic metre
503(12)	Concrete Grade 40 for Approach Slab	cubic metre
503(13)	Concrete Grade 30 for Cross Beam of PC-I Girder	cubic metre
503(14)	Concrete Grade 40 for Cross Beam of PC-I Girder	cubic metre
503(15)	Concrete Grade 30 for Deck Slab	cubic metre
503(16)	Concrete Grade 40 for Deck Slab	cubic metre
503(17)	Concrete Grade 40 for Parapet, Sidewalk, Kerb	cubic metre

SECTION 504

REINFORCEMENT FOR STRUCTURES

504.1 Description

This work shall consist of supplying, cutting and bending and fixing reinforcement bars of the grade, type and size in accordance with the Specification, and in conformity with the requirements shown on the Drawings.

British Standards have been specified as standards for materials and workmanship.

However the Contractor may employ materials manufactured to other internationally - accepted standards or Sri Lankan standards subject to Engineer's approval, which shall require submission of full documentation including test certificates for properties required by the relevant British Standard, carried out at an ISO 9001 - accredited laboratory by suitably qualified people.

Workmanship standards may be substituted with internationally-accepted workmanship standards not in conflict with the provisions of BS 5400 Parts 4, 7, 8 and 9.2 subject to the Engineer's approval.

504.2 Materials

All steel reinforcement specified shall comply with BS 4449 or BS 4483 and shall be cut and bent in compliance with BS 8666. The Contractor shall provide test certificates issued by an ISO 9001-accredited laboratory for each consignment or lot intended for use on works to enable the Engineer to satisfy himself that the consignment or lot material conforms with the relevant British Standard.

2.1 Steel Reinforcement Bar

Hot rolled mild steel bars shall conform to the provisions of BS 4449 and hot rolled high yield bars shall conform to the requirements of BS 4449 except that no bar shall contain a flash weld.

Frequencies of tests are given in the Section 1100, Quality Management.

The deformed bars can be classified as either Type 1 or Type 2. Type 2 deformed bars shall be used for all reinforced concrete structures.

Type 1*:* is a plain square twisted bar or a plain chamfered square twisted bar with a pitch or twist not greater than 18 times the normal size of the bar.

Type 2*:* is a bar with transverse continuous helical ribs. The spacing between the ribs shall not exceed 800mm. The mean area of ribs per unit length shall, when projected on a plan

normal to the axis of the bar, be not less than 0.15 sq.m/m greater than the core of

the bar.

2.2 Hard Drawn Steel Wire and Wire Mesh

Hard drawn mild steel wire shall conform to the requirements of BS 4482.

2.3 Steel Fabric

Steel fabric reinforcement shall conform to the requirements of BS 4483. The steel fabric shall be delivered to the site in flat mats.

2.4 Binding Wire

Reinforcement binding wire shall be best black annealed mild steel wire, approximately 1.6 mm in diameter

504.3 Construction Methods

3.1 Protection and Storage

Reinforcement for structures shall be handled and stored in a manner that will prevent bending out of the desired shape and the unnecessary accumulation of dirt, oil and paint. When placed in the work it shall be free from dirt, oil, grease, paint, millscale and loose or thick rust or any other substance that could be shown to adversely affect the steel or concrete chemically or reduce the bond.

3.2 Cutting and Bending

Bars shall be cut and bent cold to the dimensions indicated and with equipment and methods approved by the Engineer and in conformity with the provisions of BS 8666.

3.3 Placing, Supporting and Fastening

All bar reinforcement shall be placed, supported and secured before the beginning of concreting operations. The reinforcement shall be checked and approved by the Engineer before placement of concrete. The relationship between the minimum spacing of bars and the maximum size of aggregate shall be as follows unless otherwise stated by the Engineer. The minimum clear distance between two bars in a beam or column shall not be less than the diameter of the bars or 25 mm or the largest size of aggregate plus 10 mm whichever is the greatest. For bars in pairs or bundles, the equivalent diameter shall be adopted. Laying or driving bars into the concrete after placement will not be permitted.

- Use deformed reinforcing bars. Plain bars may be used for spirals and ties.
- Place and secure steel reinforcement in position. Tie bars at all intersections around the

perimeter of each mat and not less than 600 mm centers or at every intersection, whichever is greater.

- Support reinforcing steel in its proper position by using precast concrete blocks, wire, chairs, supplementary bars, or other approved devices and to maintain the distance between the reinforcing steel and the formed surface or the top surface of deck slabs within 6 mm of that specified.

- Provide precast concrete blocks having a comparable compressive strength, colour and texture to that of the concrete in which they are to be embedded with an embedded wire for securing the block. Maximum size of the face of blocks in contact with forms is 50 mm by 50 mm. Wire ties shall be securely tied and folded so that they do not project beyond the planes formed by the reinforcing bars.

- Adjust or relocate non-prestressed reinforcement used in post-tensioned concrete during the installation of Prestressing ducts or tendons to provide planned clearances to the Prestressing tendons, anchorages and stressing equipment.

- Substitute different size reinforcing bars only with the Engineer's approval.

- The adequacy of the supports and ties to secure the reinforcement properly shall be subject to the approval of the Engineer.

3.4 Surface Condition

Until immediately before concrete is placed around it, reinforcement shall be free from mud, oil, paint, retarder, release agent, loose rust, loose mill scale, grease or any other substance that can be shown to have an adverse chemical effect on the steel or concrete, or to reduce bond between the steel and the concrete.

3.5 Anchorage, Splicing and Joints

Anchorage, splicing and joints shall be made only where shown on the Drawings, except in the case additional laps or splice bars are required and the Engineer's approval has been obtained. If additional lap splices are used, the additional weight occasioned by such lap splices will not be included in the measurement of reinforcement for payment.

Welding and mechanical joints are specified in Clause 3.6 and 3.7, respectively.

Maximum length of one reinforcement bar is 12 m on the Drawings. Splices shall be staggered as much as possible. If not shown on the Drawings, the length of lapped splices shall be no less than 36 times the bar diameter.

In lapped splices, the bars shall be placed and wired in such a manner as to maintain the minimum distance to the surface of the concrete shown on the Drawings.

3.6 Welded Splices

Welded splices shall be used only if specified on the Drawings, or if approved by the Engineer. Welding shall conform to the Structural Welding Code, Reinforcing Steel, AWS D1.4 of the American Welding Society and applicable special provisions.

Welding of reinforcement steel will be allowed if the chemical composition of the steel exceeds the percentages shown herein.

If welding is permitted by the Engineer, the Contractor shall mobilize welders' staff that is currently certified (subjected to the Engineer's approval). Moreover, Contractor shall submit the statement for construction and drawings showing in detail each weld, testing method of each weld (e.g. using magnetic particle, radiography, or other non-destructive inspection techniques).

Reinforcing Steel Components

Chemical Composition	Percent
Carbon (C)	0.30
Manganese (MA)	1.50
Carbon Equivalent (C.E.)	0.55

3.7 Mechanical Coupler Splices

Splices made with mechanical couplers shall be used only if detailed on the Drawings, or previously approved by the Engineer in lieu of welding. Such couplers shall develop in tension or compression, as required, at least 125 percent of the specific yield strength of the bar.

When requested by the Engineer, up to two field splices out of each 100, or portion thereof, placed in the work and chosen at random by the Engineer, shall be removed by the Contractor and tested with 125 percent of the specified yield strength by the Engineer.

3.8 Splicing of Mesh or Mats

Sheets of mesh or bar mat reinforcement shall be spliced by overlapping each other sufficiently to maintain a uniform strength and shall be securely fastened at the ends and edges. The edge lap shall not be less than one mesh in width plus 50 mm.

504.4 Measurement

The items shall include cleaning, cutting, bending and binding of reinforcement. (Reinforcing steels and Prestress tendons for Prestressed concrete are included in Section 505, Prestressed Concrete.) The computed weight shall not include wire mesh or clips, wire, separators, chairs and other material used in fastening the reinforcement in place.

No measurement shall be made for the mass of splices.

The quantity of reinforcement to be measured under this Section shall be the computed weight in tonnes of material used and accepted as shown on the Drawings provided that the quantity shall not include the reinforcement in any item of work the basis of payment for which includes the reinforcement. In computing the weight to be measured, the theoretical weights of bars of the cross section shown on the Drawings or authorised, shall be used. These weights are given in the following table (Mass of Steel bars according to BS 4449):

Nominal Dia.	6mm	8mm	10mm	12mm	16mm	20mm	25mm	32mm	40mm
Weight in kg/m	0.222	0.395	0.616	0.888	1.579	2.466	3.854	6.313	9.864

504.5 Payment

This work measured as provided above, shall be paid for at the Contract unit price per tonne of reinforcement for the particular Bill Item listed below. The payment shall be full compensation for furnishing, fabricating, splicing and placing of the reinforcing steel, including all incidental work, materials required and for all labour, equipment and tools.

The splicing shall not be measured for payment.

Reinforcing steel for Prestressed concrete shall be measured and paid according to Section 505, Prestressed Concrete.

Pay Item		Unit of Measurement
504(1)	High Yield Steel bar Grade 460	tonne

SECTION 505

PRESTRESSED CONCRETE

505.1 Description

1.1 General

This work shall consist of the furnishing, placing, and tensioning prestressing tendons for:

- Precast I-girders (Grade 50 concrete, Longitudinal prestressing),
- Box girders (Grade 50, cast-in-place concrete, Longitudinal prestressing).
- Cross Beams for I-girders and Box girders (Grade 35, cast-in-place concrete, Transversal prestressing), It shall be in accordance with the details shown on the Drawings and as specified herein, also the work shall conform to the applicable requirements of Section 503, Concrete Structures of the Specification.

British Standards have been specified as standards for materials and workmanship.

However the Contractor may employ materials manufactured to other internationally - accepted standards or Sri Lankan standards, they are subject to Engineer's approval, which shall require submission of full documentation including test certificates for properties required by the relevant British Standard, carried out at an ISO 9001 - accredited laboratory by suitably qualified people.

Workmanship standards may be substituted with internationally - accepted workmanship standards not in conflict with the provisions of BS 5400 Parts 4, 7, 8 and 9.2, subject to the Engineer's approval.

1.2 Definitions

Post tensioning is defined as any method of prestressing concrete in which the tension reinforcement is tensioned after the concrete is placed.

Pre-tensioning is defined as any method of prestressing concrete in which the tension reinforcement is tensioned before the concrete is placed.

505.2 Materials

2.1 General Materials

Applicable clauses in the following sections shall be referred for general materials:

Section/Clause	Materials
- Section 503 Concrete Structures	Concretes in general
- Section 504 Reinforcement	Reinforcement in general
- Section 503 Concrete Structures, Clause 2.1	Portland Cement
- Section 503 Concrete Structures, Clause 2.2	Water
- Section 503 Concrete Structures, Clause 2.3	Admixtures
- Section 503 Concrete Structures, Clause 2.4	Aggregates

2.2 Prestressing Tendons

(a) Chemical analysis of Prestressing tendons shall be submitted for the Engineer's approval. Prestressing tendons with less impurity of phosphorus and sulphur are preferable.

(b) Steel Wire for prestressed concrete shall conform to the requirements of BS 5896.

(c) Seven-Wire Strand for prestressed concrete shall be stress-relieved strands that conform to the requirements of BS 5896, Relaxation Class 2.

(d) Twelve-Wire Strand for prestressed concrete shall conform to the requirements of BS 5896, Relaxation Class 2.

(e) Cold Worked High Tensile Alloy Bar shall conform to the requirements of BS 4486.

2.3 Duct

The duct shall form an airtight and watertight barrier to the tendons and shall be fabricated from corrugated galvanized sheet steel or semi-rigid conduit. The minimum manufactured wall thickness of ducting shall be 2 mm. The contractor shall provide evidence of testing to demonstrate the following requirements:

(a) Wall thickness of ducts after tensioning of the tendons shall be not less than 1.5 mm.

(b) The duct shall transmit full bond strength from tendons to the surrounding concrete over a length no greater than 40 duct diameters.

Vents providing an air passage of at least 20 mm internal diameter shall be provided at the anchorages and in the troughs and crests and beyond each intermediate crest in the direction of flow of the grout at the point where the duct is one half diameter lower than the crest, (but no further than 1 m from the crest), The maximum spacing of the vents shall be 12 m unless otherwise decided by the Engineer.

2.4 Anchorages

Anchorages shall be tested in accordance with BS4447.

2.5 Grout

The following requirements shall be complied:

2.5.1 Fluidity

When tested by the methods specified in Table 505-2, the fluidity of the grout shall meet the criteria given in Table 505-1. Additionally, the fluidity (flow cone passage time) at outlets shall not vary from that of the injected grout by more than 20 %.

2.5.2 Bleeding

When tested by the method referred to in Table 505-2, the bleeding for common grout shall be less than 2% of the initial volume of the grout and the average of 4 successive results shall be less than 1 %. The water shall be reabsorbed by the grout during the 24 hours after mixing. For special grout, there shall be no bleeding.

2.5.3 Strength

The compressive strength of 100 mm cubes made of the grout shall exceed 27 N/mm2 at 7 days. Cubes shall be made, cured and tested in accordance with BS 1881

2.5.4 Volume Change

The volume change assessed may be either an increase or decrease. When tested in accordance with the method referred to in Table 505-2, the volume change of common grout shall be within the range -1% to + 5%. For grouts containing expanding agents there shall be no decrease in volume. For special grout the volume change shall be between zero and + 5%.

2.5.5 Sieve Test

The grout shall contain no lumps. This shall be verified by testing as referred to in Table 505-2.

2.5.6 Sedimentation Test

When tested by the method referred to in Table 505-2, the grout shall not exhibit variation in density in excess of 10% within a single test sample.

2.5.7 Testing of Grout

General, Suitability and acceptance tests for the properties of grout shall be determined in accordance with the Concrete Society Technical Report 47 "Durable Bonded Post-Tensioned Concrete Bridges". The testing requirements are summarised in Table 505-2.

TABLE 505-1: Test Requirements for Fluidity of Grout

Test Method	Immediately after mixing	At the end of the injection period subject to a minimum of 30 minutes after mixing	At duct outlet
Cone	< 25 s (see note)	< 25 s (see note)	> 10 s

* Mixing time shall be measured from the time when all of the materials are in the mixer. For special grout, the minimum time shall be 90 minutes.
Note:
For grouts prepared in some mixers which have a high shear mixing action, the upper limits given here may be increased to 50 s. The mixer and these limits shall be subject to the approval of the Engineer.

TABLE 505-2: Minimum Test Requirements for Grout

Suitability Testing	
Fluidity	Sampled immediately after mixing, one test. Common grout: after estimated time to grout duct or minimum of 30 min. Special grout: after 90 min two tests averaged in both cases.
Bleed, Volume Change, Sedimentation, Strength	Each sampled immediately after mixing, 3 tests averaged.
Acceptance Testing	
Fluidity	Sampled immediately after mixing, one test from mixer. After flow through duct, one test from each anchorage outlet. On completion, one test from the mixer.
Bleed, Volume change, Strength	Two tests per day, one of which shall be from grout after flow through duct, taken from end anchorage outlet, the other from the mixer.
Sedimentation	One test per day for common grout, or one test per pre-bagged supplied batch (by manufacturer's reference number); subject to a minimum of one test per continuous grouting operation.

2.5.8 Admixtures

General

Admixtures shall be used where required to achieve a low water/cement ration and impart good fluidity, minimum bleed and volume stability or expansion to the grout to comply with sub Clause 2.5.

Types

Admixtures are divided into two types, expanding and non-expanding and they may be used to obtain the required grout performance.

Chemical Composition

Admixtures shall not contain substances in quantities (e. g. Aluminium) which will adversely affect the grout or the corrosion protection of the prestressing steel.

Corrosion

Grout admixtures shall not cause the grout to promote corrosion of the prestressing steel and associated accessories by rusting, pitting, stress corrosion or hydrogen embrittlement.

505.3 Construction Methods

3.1 General

The Contractor shall select a system that provides the magnitude and distribution of prestressing force and ultimate strength without exceeding allowable temporary stresses. Perform the prestressing by post-tensioning method.

Planning, Prestressing and Erection

The Contractor shall submit for the approval of the Engineer a detailed method statement, at least 4 weeks prior to use in any trials or in the works, covering:

- Proposed materials,
- Ducts,
- Anchorage,
- Vent arrangements,
- Personnel,
- Equipment,
- Grouting procedures,
- Erection method
- Quality Control

When full scale trials are required, these shall be commenced at least 56 days before the planned commencement of fixing ducts for prestressing for the permanent works.

3.2 Formwork for Prestressed Concrete

Formwork for prestressed concrete shall be of a type provided with removable side forms that allows the concrete member to deform during prestressing operation. The bottom portions of the moulds should be prevented from adhering to the concrete and the sides should be designed so as to permit striking without affecting the stability of the remaining formwork. Where a number of units are made in line, they shall be free to slide in the direction of their length and thus permit transfer of the prestressing force to the concrete along the whole line.

3.3 Placing Ducts

(a) Duct Systems

The system of ducts, duct connections, drains, transitions to anchorages and caps for anchors shall form a complete encapsulation for the tendons which is resistant to the ingress of air and water. The system shall be fully compatible with the prestressing anchorages, couplers and other details.

(b) Duct Assembly Verification test

Each complete duct system including, vents, anchorages, anchorage caps, and where appropriate couplers and their connections, shall be air - pressure tested before concreting. Testing pressure of 0.01 N/mm2 shall demonstrate that the system is undamaged and has been correctly assembled. The testing shall demonstrate that a loss of pressure no greater than 10 % occurs after 5 min. Local deformation of the duct at supports shall be avoided.

3.4 Prestressing Tendons

(a) Handling, Storage, Surface, Straightness and Cutting

- Prestressing tendons shall be handled in a way so that mechanical damage, work hardening or heating is avoided.
- All prestressing tendons shall be stored clear of the ground and protected from the weather, from splashes from any other materials, and from splashes from the cutting operation of an oxy-acetylene torch or arc welding processes in the vicinity.
- Prestressing tendons shall never after the manufacture be subjected to any welding operation, or heat treatment or mechanical coating such as galvanising.
- Prestressing tendons shall be clean and free from pitting loose rust and loose scale at the time of incorporation in the work.
- Wire and Strands shall be in coils of sufficiently large diameter to ensure that the strand pays out straight.
- All cutting of wire, strand or bar shall be carried out by tools approved by the Engineer.

These can be either:

- a high-speed abrasive cutting wheel, friction saw or any other mechanical method at not less than one diameter from the anchor, or
- an oxy-acetylene cutting flame, using excess oxygen to ensure a cutting rather than a melting action, not less than 75 mm from the anchor. The temperature of the tendon adjacent to the anchor shall be not greater than 200 °C.

(b) Positioning of Tendons and Ducts

Tendons and ducts shall be accurately placed and maintained in position both vertically and horizontally as shown on the Drawings or approved by the Engineer. Unless otherwise shown on the Drawings the tolerance in the location of the centre line of sheath or duct shall be + 5 mm.

3.5 Anchorage Assemblies

(a) The Contractor shall set and hold anchorage devices or block-out templates for anchorages with their axes parallel to the axis of the tendon and anchor plates perpendicular to the tendon.

(b) The Engineer has the right to test one anchorage for each span or in the case of single span bridges, two anchorages. For each anchorage system used in the works, the characteristic value for anchorage efficiency shall be not less than 90%.

(c) Anchorages to be incorporated in the works shall be handled and used strictly in accordance with the manufacturer's instructions and recommendations.

(d) Anchorages shall be the correct type for prestressing system used, and shall be rigidly fixed true to alignment in the formwork so that they cannot move during concreting operations. The Contractor shall submit the results of the material tests carried out by the manufacturer, for the approval of the Engineer.

(e) Anchorage components shall be transported, handled and stored with such care that any damage mechanical or corrosive, is prevented. This is especially important for the gripping and securing system of the anchorages. If extended storage of the components in excess of three months becomes necessary, protective materials such as correctly formulated oil; grease or other corrosion-preventing material shall be used.

(f) Any damaged or corroded components will be rejected by the Engineer.

3.6 Prestressing Tendons - Tensioning

3.6.1 General

All wires, strands or bars stressed in one operation shall be taken, from the same parcel. Each cable shall be tagged with its number from which the coil numbers of the steel used can be identified. Cables shall not be kinked or twisted. Individual wires and strands for which extensions are to be measured shall be readily identifiable at each end of the member. No strand that has become untwisted shall be used.

3.6.2 Tensioning Apparatus

The tensioning apparatus shall meet the following general requirements.

(a) The means of attachment of the tendon to the jack or tensioning device shall be safe and secure.

(b) Wires or strands to be stressed simultaneously shall be approximately of equal length between anchorage points at the datum of load and extension measurement. The degree of variation shall be small compared with the expected extension.

(c) The tensioning apparatus shall be such that a controlled total force is imposed gradually and no dangerous secondary stresses are induced in the tendons, anchorage or concrete.

(d) The force in the tendons during tensioning shall be measured by direct-reading load cells or obtained indirectly from gauges fitted in the hydraulic system to determine the pressure in the jacks. Facilities shall be provided for the measurement of the extension of the tendon and of any movement of the tendon in the gripping devices. The load-measuring device shall be calibrated to accuracy within +2% and checked at intervals to the approval of the Engineer.

Elongation of the tendon shall be measured to accuracy within 2% or 2mm, whichever is the more accurate.

(e) The tensioning equipment shall be calibrated before the tensioning operation and at intervals to the approval of the Engineer.

3.6.3 Post-Tensioning Method

Stressing shall be applied to produce the stress required in the wires immediately after the anchorage as shown on the Drawings or as directed by the Engineer. Suitable allowances shall be made for friction in the jacks and cable ducts and for slip and yield in the grips or anchorage.

The tensioning process shall be conducted so that the tension being applied and the elongation may be measured at all times. A record shall be kept for gauge pressures or load cell readings and elongations at all times and the minimum age in hours of the concrete unit at the stressing took place. Copies of these records shall be supplied to the Engineer. Prestressing forces shall not be applied to the concrete unit until it has attained strength as specified above for the pre-tensioning method.

Where wires, stands or bars in a tendon are not stressed simultaneously, the use of spacers shall be in accordance with the recommendation of the system manufacturer or as specified in the Drawings.

3.6.4 Jacks for Prestressing

(a) Jacks for tensioning tendons shall be hydraulically operated and capable of providing a slow uniform increase of load. Each jack shall be equipped with an appropriate pressure gauge capable of indicating the hydraulic pressure at all times during the stressing operation. A calibration chart certified by the manufacturer of the jacks showing the relationship between gauge readings and force on the ram shall be made available on the Site by the Contractor. Additionally, the jacks should carry a calibration certificate, not older than 6 month, issued by an approved independent authority.

(b) Adequacy of Jacks. It shall be verified that the type of jacks employed corresponds to the prestressing system used, and to the dimensions of the tendons. It shall also be verified that the jacks have the necessary stroke for the stressing of the tendons.

(c) Testing of jacks and load measuring equipment

- The internal friction of the jacks must be tested by means of adequate load cells or dynamometers, or by means of another jack of the same type, of the force recorded is affected by this friction. Friction tests within jacks must be executed under condition similar to those of the actual tensioning operations.
- Calibration of dynamometer, load cells and pressure gauges must be made by a laboratory with the necessary equipment and must be certified.
- Intermediate test on equipment may be made on Site by means of calibrated master equipment, which is not used in the tensioning operations.
- Visual inspection of the load measuring equipment must be undertaken frequently so that abnormality can be detected at the earliest possible stage. If any incident has occurred during transport, handling or tensioning, which may have caused shock, the equipment must be recalibrated.

3.6.5 Tensioning Operations

(a) Friction tests before start of full scale tensioning operations

- Before full scale tensioning operations start, friction tests shall be carried out on at least 3 tendons.
- The tendons to be used shall be selected and specified by the Engineer and they may have to be released and re-tensioned.
- From the test, the mean value of the frictional coefficient and its standard deviation, so established, shall be used for the prestressing calculation on each tendon.
- Furthermore, the apparent modulus of elasticity of the tendons shall be computed on the basis of extensions and frictional coefficient.

(b) Preparation of full scale tensioning

- Before tensioning is carried out the Contractor shall submit to the Engineer the proposed stressing programme inclusive of the theoretical force and extension of each tendon. The Engineer shall check this programme for its agreement with the design assumption and if satisfied, shall give his approval.
- Similarly he shall approve the test results for the compressive strength of the concrete, which shall be at least 36.0 N/mm2, before any tensioning commences.

(c) Tensioning procedure

- The tensioning operations must comply with the prestressing programme approved by the Engineer in advance. Operating crews must be especially trained for the use of particular type of equipment, and always shall exert every possible effort to obtain the theoretical values for force and extension.
- The extension shall be measured to accuracy of 1 mm, between a fixed point at the anchorage or concrete surface and a mark on the tendon, and compared with the theoretical extensions of the calculation.

- The tensioning force shall be applied in predetermined increments and corresponding extensions shall be recorded. By this method the reading after application of 15% to 20% of the force, presumed to have removed the slack from the tendon, shall be termed the "Zero-Reading".
- As tensioning progress an "as measured" force extension line shall be drawn on a theoretical tensioning graph, previously prepared in the prestressing log. Tensioning shall be considered satisfactory completed if and when the "as measured" line intersects the theoretical line for the maximum force-extension relationship between the two controlling values of the standard deviation.
- If the standard deviation limitation is exceeded or if any abnormalities occur during tensioning, the operation shall be halted and the Engineer called for guidance.
- When tensioning has been satisfactorily completed, the tendons shall be anchored in strict accordance with the procedure characteristic of the prestressing system. If anchoring results in a slip of tendon the slip shall be measured and recorded. If the slip exceeds the maximum permissible value of the tendon must be completely released and tensioning repeated. In any event, the maximum slip of the tendons during anchorage shall not exceed 5mm.

(d) Recording of observations approval

All data observed during the tensioning operations must be recorded immediately in the tensioning log. The tendons shall be kept in such a condition that they may be

re - stressed. i.e. they shall not be cut, nor must the duct be grouted, until final approval of the tensioning has been given by the Engineer.

The deflector in contract with the tendon shall, where possible have a radius of not more than 50 times the diameter of the tendon, and the total angle of deflection shall not exceed 15 degrees. Where the radius is less than 50 times the diameter of the tendon the angle of deflection exceeds 15 degrees, the loss of strength of the tendon shall be determined by test and due allowance made.

Tensioning shall be carried out in such a manner that the stress in the tendon increases at a gradual and steady rate.

After the tendons have been anchored, the force exerted by the tensioning apparatus shall be decreased gradually and steadily so as to avoid shock to the tendons or the anchorage. Unless otherwise agreed by the Engineer, tendons shall not be cut less than 3 days after grouting. Immediately after anchoring, the stresses in the prestressing tendons shall not exceed 70% of their ultimate tensile strength. During stressing the value shall not exceed 80%.

3.7 Grouting

(a) Planning and Trials

The Contractor shall undertake full-scale trial of the grout mix and of the grouting operations as required in the Specification for duct installation, testing, concreting, grouting and any other associated problems to ensure that grout fills the ducts and surrounds the prestressing steel.

The Contractor shall submit a detailed method statement, at least 4 weeks prior to use in any trials or in the works, covering proposed material, ducts, anchorage and vent arrangements, personnel, equipment, grouting procedures and quality control for the Engineer's approval.

(b) Grouting Equipment

Grouting equipment shall consist of a mixer, a storage reservoir and a pump with all necessary connection hoses, valves, measuring devices for water, dry materials, admixtures and testing equipment.

(c) Mixing of Grout

All materials shall be batched by mass except the mixing water and liquid admixtures which may be batched by mass or by volume. The water/cement ratio shall be as low as possible consistent with the necessary workability and not exceed 0.45 by weight unless otherwise agreed by the Engineer.

(d) Injecting Grout

- A check shall be made to ensure that the ducts, vents, inlets and outlets are capable of accepting injection of the grout. This check shall be achieved by blowing through the system with dry, oil-free air and testing each vent in turn.
- Any water in the ducts shall be removed before grouting operations commence.
- Grouting of the ducts shall be carried out within 28 days of installation of the tendons or as soon as is practicable thereafter, in which case additional measures shall be taken to avoid corrosion of the prestressing steel.
- Grout injection shall not result in more than 10 m of duct being grouted per minute.
- The method of injecting grout shall ensure filling of the ducts and that the tendons are surrounded by grout. Grout shall be allowed to flow from each vent and the remote end of the duct until its fluidity is visually equivalent to that of the grout being injected.
- Following this, a further 5 litters of grout at each vent shall be vented into a clean receptacle and then discarded. The opening shall be firmly closed. All vents shall be closed in a similar manner one after another in the direction of the flow except that at intermediate crests the vents immediately downstream shall be closed before their associated crest vent.
- The injection tubes shall then be sealed off under pressure of 0.5 N/sq.mm being maintained for at least one minutes.

- The filled ducts shall not be subjected to shock or vibration for at least 24 hours from the time of grouting.
- When the grout has set, the grout vents shall be reopened and left open.
- The Contractor shall keep full records of grouting for each duct in accordance with the certification scheme requirements for the post-tensioning systems.
- Copies of these records shall be supplied to the Engineer within 24 hours of completing grouting to each duct.
- On completion of grouting, grout vents shall be positively sealed and waterproofed.

3.8 Precast Prestressed Concrete Construction

The term "precast" applies to a concrete unit cast on Site but not in its final position.

(a) Shop Drawings and Working Drawings

The Contractor shall provide shop drawings and working drawings, in accordance with the requirements and procedure stated in Specification Section 113, for precast members.

- Include in the drawings the erection method of the members.
- Cast members only after the referred drawings are approved.

(b) Precasting

The Contractor shall monitor the quality of the concrete when casting in an established yard.

- Perform test for materials and strength with Section 503 Concrete Structures.
- Construct the precast yard with sufficient ground bearing strength, if manufacturing on the Site.

Allowable Variations of Dimension

For all precast prestressed I-girders, the length, cross section dimensions and straightness of precast concrete shall be measured at 28±2 days after casting. Unless otherwise stated the allowable dimensional variations shall not exceed the following:

	Length	**Variation**
-	Up to 3m	±6 mm
-	3 to 4.5m	±9 mm
-	4.5 to 6m	±12 mm
-	Additional for every subsequent 6 m	±6 mm

Cross Section (each direction)

-	Up to 500mm	±6 mm
-	500 to 750mm	±9 mm
-	Additional for every subsequent	±3 mm

250 mm

Straightness or Bow (deviation from intended line)

- Up to 3m ±6 mm
- 3 to 6m ±9 mm
- 6 to 12m ±12 mm
- Additional for every subsequent 6 m ±6 mm

Marking of Prestressed Members

Each prestressed member is to be uniquely and permanently marked so as to show its type, date of casting and reinforcement in a location to be agreed with the Engineer.

Where the Engineer requires tests to be carried out, no unit to which the tests relate shall be dispatched to site until the tests have been satisfactorily complete.

(c) Storage

When members are stored, they shall be firmly supported only at the designated points.

(d) Handling and Transport

Precast prestressed concrete shall not be moved from the casting position until the concrete has attained a compressive strength of 80% of the specified 28day strength, nor transported until it has developed as strength of 90% of the specified 28 day strength.

Extreme care shall be exercised in handling, moving and placing precast prestressed concrete members. Precast girders and slabs shall be transported in an upright position. The points of support and directions of the reactions with respect to the member shall be approximately the same during transportation and storage as when the member is in its final position.

Members shall be lifted or supported only at points described in the Drawings or otherwise agreed with the Engineer and shall be handled and placed without impact.

Any unit considered by the Engineer to have become substandard shall be rejected and replaced at the Contractor's expense by an acceptable unit.

(e) Assembly and erection

Prior to assembly and erection, the Contractor shall prepare the method of statement and obtain approval from the Engineer.

In a composite slab bridge where precast beams are laid side by side with minimal gaps to form a deck:

- The width of the deck soffit shall be within ±25mm of that shown on the Drawings.
- In adjacent spans, the continuity of line of the outside beams shall be maintained;

- the alignment of transverse holes shall permit the reinforcement or prestressing tendons to be placed without distortion.

The in-situ concrete slab in composite slab bridges shall be placed in such a sequence that the advancing edge of freshly deposited concrete over the full width of the deck, between longitudinal construction joints, is approximately parallel to the deck supports. Precast beams shall be prevented from moving laterally during the placing of the in-situ concrete.

(f) Structural Connections

Unless otherwise agreed by the Engineer, the composition and water/cement ratio of the in-situ concrete or mortar used in any connection and in the packing of joints shall be in accordance with the assembly instructions.

Levelling devices shall only be released or removed with the Engineer's approval.

(g) Protection

At all stages of construction, precast concrete units shall be properly protected to prevent damage to permanently exposed concrete surfaces, especially decorative features.

The Contractor shall provide all equipment necessary for the construction and the prestressing. Prestressing shall be done with approved jacking equipment.

A graph or table showing the calibration shall be furnished to the Engineer. The accuracy of all measuring equipment shall be checked to the satisfaction of the Engineer at the start of each day it is to be used, whenever the equipment is moved to another jack.
The Contractor shall comply satisfactorily with all of the requirements herein established. Prestressed concrete shall be formed, stressed, placed, cured and protected at shop, manufacturing plants and locations approved by the Engineer, where the fabrication of such members shall be properly inspected and controlled.

505.4 Measurement

(a) PC-I Girders (precast, post tensioning)

The units of measurement for PC-I girders shall be number of the girders fabricated, accepted and erected according to the specification. The length of the girder shall be the measurement along the centre line.

Fabrication; Pay Item 505 (1) through (6)
Fabrication of PC-I girders shall include:
1) Mix design and admixtures
2) Formwork, reinforcement, prestress tendons, concrete
3) Placing concrete and curing
4) Prestressing and testing
5) Grouting internal tendons.

Erection; Pay Item 505 (7) through (12)

Erection of PC-I girders shall include:

(a) Transport and erection with adequate equipment

(b) Cross Beam for I-Girder

The unit of measurement for Pay Item 505 (13), Pre-stressing Strand:1S21.8 for cross beam of I-Girder shall be kg. The work shall include:

1) Placing prestress tendons,
2) Prestressing and testing
3) Grouting internal tendons.

(Concrete and reinforcement will be measured by Pay Items 503 and 504.)

(c) Box Girder

The unit of measurement for;

Pay item 505 (14) Prestressing Strand 12S15.2 for the Box Girder Longitudinal PC Cable, and Pay Item 505 (15), Prestressing Strand 1S28.6 for Box Girder Transverse PC Cable, shall be kg. The work shall include:

1) Placing prestress tendons,
2) Prestressing and testing,
3) Grouting internal tendons

(Concrete, reinforcement and others will be measured by Pay Items 503, 504, 510, 511 and513.)

(d) Lengths of tendons shall be measured along the line of the tendon between the out side faces of those parts of the anchorage units cast into the concrete.

505.5 Payment

The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items of the Bill of Quantities listed herein.

Payment will be full compensation for the work prescribed in this section, and for furnishing all labour, materials, tests, tools, equipment and any incidentals to complete the work as shown on the Drawings, as required by these Specifications, and/or as directed by the Engineer.

5.1 Precast Prestressed Concrete I-Girders

Payment shall include, but be limited to, the following:

- Mix design,
- Trial mixes,
- Concrete Grade 50 for prestressed concrete I-girders
- Reinforcement for prestressed concrete I-girders,

- Prestressing Tendons, tendon ducts and anchorages for prestressed concrete I-girders,
- Formwork with camber,
- Holes, ducts, pockets and the like,
- Mixing and placing concrete,
- Curing and protection,
- Marking members for identification and delivery in matching sequence,
- Temporary bracing or stays to prevent displacement, and lifting devices,
- Prestressing with anchorages and jacks,
- Taking observations and compiling a record of stressing and grouting operations and supplying one copy to the Engineer,
- Calculation in respect of the required jacking force and extension,
- Flushing-out of ducts, grouting and testing.
- All the operations, equipment, materials and incidentals for fabrication, hauling, erection and installation in place, testing, etc. required until the work is completed and accepted.

5.2 Box girders and Cross Beams for both I-girders and Box girders

(a) Prestressing tendons for Box girders and Cross beams

Payment shall include, but be limited to, the following:

- Prestressing tendons, tendon ducts and anchorages,
- Prestressing with anchorages and jacks,
- Taking observations and compiling a record of stressing and grouting operations and supplying one copy to the Engineer,
- Calculation in respect of the required jacking force and extension,
- Flushing-out of ducts, grouting and testing.
- All the operations, equipment, materials and incidentals required for installing and prestressing tendons for the girders until the work is completed and accepted.

Pay Item		Unit of Measurement
Fabrication of PC-I Girder		
505(1)	PC Girder Fabrication – 14.000 m long	number
505(2)	PC Girder Fabrication – 15.500 m long	number

505(3)	PC Girder Fabrication – 16.000 m long	number
505(4)	PC Girder Fabrication – 16.500 m long	number
505(5)	PC Girder Fabrication – 17.600 m long	number
505(6)	PC Girder Fabrication – 18.000 m long	number
505(7)	PC Girder Fabrication – 21.000 m long	number
505(8)	PC Girder Fabrication – 22.000 m long	number
505(9)	PC Girder Fabrication – 22.500 m long	number
505(10)	PC Girder Fabrication – 25.000 m long	number
505(11)	PC Girder Fabrication – 29.500 m long	number
505(12)	PC Girder Fabrication – 35.000 m long	number
505(13)	PC Girder Fabrication – 35.500 m long	number
505(14)	PC Girder Fabrication – 35.750 m long	number

Erection of PC-I Girder

505(15)	PC Girder Erection – 14.000 m long	number
505(16)	PC Girder Erection – 15.500 m long	number
505(17)	PC Girder Erection – 16.000 m long	number
505(18)	PC Girder Erection – 16.500 m long	number
505(19)	PC Girder Erection – 17.600 m long	number
505(20)	PC Girder Erection – 18.000 m long	number
505(21)	PC Girder Erection – 21.000 m long	number
505(22)	PC Girder Erection – 22.000 m long	number
505(23)	PC Girder Erection – 22.500 m long	number
505(24)	PC Girder Erection – 25.000 m long	number
505(25)	PC Girder Erection – 29.500 m long	number
505(26)	PC Girder Erection – 35.000 m long	number
505(27)	PC Girder Erection – 35.500 m long	number
505(28)	PC Girder Erection – 35.750 m long	number
505(29)	PC Girder Erection – 35.500 m long by erection girder	number
505(29)-1	PC Girder Erection – 35.000 m long by erection girder	number
505(29)-2	PC Girder Erection – 29.500 m long by erection girder	number
505(29)-3	PC Girder Erection – 25.000 m long by erection girder	number
505(29)-4	PC Girder Erection – 22.500 m long by erection girder	number
505(29)-5	PC Girder Erection – 22.000 m long by erection girder	number
505(29)-6	PC Girder Erection – 21.000 m long by erection girder	number

505(30)	Pre-Stressing Strand 1S21.8 for Cross Beam of I Girder	Kg

SECTION 506

CAISSON (WELL) FOUNDATIONS FOR STRUCTURES

506.1 Description

This work shall consist of the construction of wells, taking them down to the indicated levels by open dredging of the soil and other materials or by pneumatic sinking, plugging the bottom and filling the inside in accordance with the Specification and the requirements of the Drawings or other Contract documents.

506.2 Materials

The well cylinders shall be of reinforced concrete as indicated on the Drawings. The concrete shall be proportioned, mixed and placed in accordance with the provisions of Section 503 Portland Cement Concrete Structures. Reinforcement shall comply with the provisions of Section 504 Reinforcement for Structures.

506.3 Construction Methods

The dimensions and shape of the well shall be strictly in conformity with the Drawings. The well kerb shall be placed truly in position and level and it may be precast or cast in–situ. Construct the well on the firm foundation to ensure stability, not to produce differential settlement nor tilting. Make right or reset the well tilted or moved laterally during the excavation.

When the kerb is to be laid on dry beds, the site shall be excavated up to 0.30 metres above the sub-soil water table before the cutting edge is placed.

For wells, which are to be pitched in water, an earth or sand island where possible shall be constructed and the kerb placed or cast on this island. In case of any deep or fast flowing water where an island may not be possible, the kerb may be precast, floated and lowered in its final position with the help of necessary equipment.

The well shall be built in one straight line from bottom to top, the work being checked carefully by means approved by the Engineer.

The section of the well built up above the adjoining bed level shall in the first stage not be more than 2 metres, and in the subsequent stages it shall not exceed the diameter of the well. The height of the well shall be calibrated by marking a gauge on the outer periphery of the well in the form of a 100 mm wide mark every 200 mm. Every metre shall be marked in black paint. The gauge shall start with zero at the bottom of the cutting edge. After sinking of a stage is completed any damaged portion of the top cylinder shall be properly repaired before the next cylinder is placed.

506.4 Sinking

The well shall be sunk by excavating material uniformly from inside the dredge hole.

Sinking or loading the well with kentledge shall be commenced only after any repair in the cylinder has been cured for at least 48 hours or as specified in the Drawings. Kentledge shall be placed in an orderly and safe manner and in such a way that it does not interfere with the excavation or damage the well.

Blasting, as a means to penetrate layers of boulders and the like, will be allowed only with the written permission of the Engineer and shall not damage the caisson edge.

Dewatering of the well may not be used as a means for sinking the well, without written permission of the Engineer.

Water jetting may be employed for well sinking wherever necessary.

When the wells have to be sunk close to each other and the distance between them is not greater than the diameter of the wells, the Contractor shall check the distance and the inclination and plan the overall sinking and the method shall be approved by the Engineer before hand. The excessive excavation shall be avoided and the excavated soil shall be disposed as soon as possible.

In sinking dumb-bell or Double D shaped wells the excavation in both dredge holes should be carried out consecutively and equally to facilitate even sinking.

All wells on which sinking is in progress shall be sunk to sufficient depth below the designed scour level before the seasonal floods. Further, they shall be temporarily filled and plugged before the onset of the floods so that they do not suffer any tilt or shift.

All necessary precautions shall be taken against any possible damage to the foundations of existing structures in the vicinity of the wells, prior to commencement of dredging from inside the well.

The dredged material shall not be allowed to accumulate over the well. It shall be dumped, as far away from the well as possible and then continuously and simultaneously removed.

In cases where the river flows along one edge of the well being sunk, the dredged material shall be dumped out from the site.

A very deep sump shall not be made below the well kerb, as it entails the risk of jumping (sudden sinking) of the well, or caving in of the soils. The depth of sump shall not exceed 1.0 m below the level of the cutting edge without the written permission of the Engineer.

In all cases where gas is expected including alluvium impregnated with decayed vegetable matter, the use of Day Safety Lamps shall be compulsory.

Unless otherwise specified the tilt of any well shall not exceed 1 in 80 and the shift shall not be more than 5% of the outside diameter of the circular well or of the maximum outside dimension of the well for any other shape subject to a maximum of 150 mm.

Bells or under-reams shall be excavated from virgin material and be free from loose crumbs of soils. If the wells are to be seated on hard rock strata, the cutting edge shall be embedded into a suitable depth in the rock strata. The Contractor shall arrange that the well can be inspected in a dry condition whenever it is possible with the bottom of the well clearly visible.

506.5 Filling the Well

No concreting may be started before the Engineer has approved the excavation.

If the bottom has been benched the benched area shall be filled in with concrete so the well is evenly seated on good hard rock.

When concrete can be placed in a dry excavation, it shall be discharged through a funnel with a length of tube so that the concrete is not segregated, or by means of an auger. When concreting under water an efficient tremie technique shall be used as described in Section 503 Portland Cement Concrete Structures.

The fill materials of the well shall be as described in the Drawings.

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506.6 Measurement

The measurement for cutting edge under the kerb shall be in tons based on the net weight of metal used in the cutting edge.

The unit of measurement of the cylinder will be the length of the cylinder in metres furnished and placed as instructed by the Engineer. Excavation in rock shall be paid for separately in cubic metres. The quantity of concrete plugging and sand filling if any shall be in cubic metres.

Reinforcement except for reinforcement in cylinder shall be measured in tons.

506.7 Payment

The price for cutting edge shall be full compensation for furnishing and placing the cutting edge.

The price for cylinders shall include furnishing cylinders, sinking of the well including the cost of all labour, tools and plant and other operations required, such as formation of island dewatering, excavation and bailing out material, providing and placing kentledge on top of the well and removing same, sand filling and contingencies warranting provision of temporary top plug in the event of floods being expected at site making further sinking not possible, and also other incidental works to sink the well to the level shown on the Drawings, or ordered by the Engineer. It shall also include all means, used for removal of obstacles from under the cutting edge of the well. The rate shall be applicable for all types of soils except rock.

Excavation in rock shall include all cost of labour, tools and equipment required to excavate and bailing out the material. The rate for concrete and sand filling shall include cost of all labour, materials, tools and plant required to complete the work as specified here in above and as shown on the Drawings.

The price for reinforcement shall include all works as described in Section 504 Reinforcements for Structures, and the measuring of the quantity shall be in accordance with said Section.

Pay Items shall be:		**Unit of Measurement**
506(1)	Cutting edge	tonne
506(2)	Provide and sink concrete cylinder	metre
506(3)	Rock excavation	cubic metre
506(4)	Concrete Fill	cubic metre

506(5)	Sand Fill	cubic metre
506(6)	Reinforcement	tonne

SECTION 507

STRUCTURAL STEELWORK

507.1 Description

The Contractor shall furnish, fabricate and erect steel structures and structural steel elements of other structures.

- Detailed design for the steel structures shall comply with:
  Section 120, Design by the Contractor.
- The surface preparation and corrosion protection of structural steelwork shall comply with:

  Section 508, Protection of Steelwork against Corrosion.
- The Contractor shall refer to:
  Section 510, Bridge Expansion Joints and
  Section 511, Bridge Bearings.

Requirements for Materials, Workmanship, Inspection and Testing, Handling, Transport and Erection, Supply, Measurement and Weighing of Structural Steelwork shall comply with the Specification Clauses (including its amendment) of:

BS 5400, Steel, Concrete and Composite Bridges,
Part 6 (1999): Specification for Materials and Workmanship, Steel.

507.2 Materials

2.1 Structural Steels with designated standard

Structural steels shall comply with the requirements of:

BS EN 10025-2: 2004, Hot Rolled Products of Structural Steels,
Part 2, Technical Delivery Conditions for Non-Alloy Structural Steels

2.2 Structural Steels with other Specifications

If the Contractor wants to use structural steels complying with the requirements of other specifications, he shall prove the equivalence and compliance with above designated standards.

2.3 Approval before Order

(a) All steels
Before placing any order of the steel materials, the Contractor shall submit followings to prove the steel quality and to get the Engineer's approval:

1) Sample steels including bolts, nuts and washers,
2) Grades of steels, Mill certificates, certificates of test results, testing location and source of material,
3) Relevant specifications

Before shipping of the steel, the Contractor shall ensure the lot number appears on the shipping package and a certification notes date and location of all testing.

(b) Bolts, nuts and washers

Unless otherwise specified by the Engineer, if high strength friction grip bolts, nuts and washers are used, they shall comply with the requirements of BS 4395 (Bolts, nuts and washers).

The Contractor shall furnish:

- Rotational capacity test results,
- Bolt and nut coating thickness, when applicable.
- Proof load test results for bolts and nuts,
- Marking on the surface to identify the grade, manufacturer, type and class.
- Black bolts shall be oily to the touch when delivered and installed.

If tension control bolts, nuts and washers are used, they shall comply with "Society of Steel Construction of Japan - Document JSS II-09-1996, Sets of Torshear Type High Strength Bolt, Hexagon Nut and Plain Washers for Structural Joints".

(c) Welding Consumables

Welding consumables in metal-arc welding shall comply with requirements of BS 5135 and recommendations given in BS EN 1011-1.

507.3 Construction

The Contractor shall comply with BS 5400, Part 6, Clauses from 4 to 7 (in the end) for construction of the structural steelworks. Only the list of the clauses is presented here:

Related clauses of BS 5400, Part 6:

4. Workmanship
   - 4.1 Interchangeability of Parts
   - 4.2 Fabrication Tolerances
   - 4.3 Preparation of Edges, Ends and surfaces
   - 4.4 Bolts, Nuts and Washers
   - 4.5 Holes for Rivets and Bolts
   - 4.6 Rivets and Riveting
   - 4.7 Welding
   - 4.8 Bending and Pressing
   - 4.9 Straightening and Flattering
   - 4.10 Forging
   - 4.11 Tie Rods
   - 4.12 Parallel Barrel Drifts
   - 4.13 Pins and Pin Holes
   - 4.14 Camber
   - 4.15 Marking for Erection
   - 4.16 Rectification of Surface Defects and Edge Laminations
5. Inspection and Testing
   - 5.1 General
   - 5.2 Testing of Structural Steel
   - 5.3 Surface Defects and Edge Laminations
   - 5,4 Procedure Trials
   - 5.5 Production Tests
   - 5.6 Checking of Deviations in Rolled and Built-up Sections
   - 5.7 Checking of Alignment at Joints
   - 5.8 Inspection and Testing of Rivets
   - 5.9 Temporary Erection at Contractor's Works
6. Handling, Transport and Erection
   - 6.1 handling and Stacking
   - 6.2 Packing for Transport

6.3 Erection
7. Supply, Measurement and Weighing
7.1 Computed Weights
7.2 Weighbridge Weights
7.3 Numbers of Site Rivets, Bolts and Nuts and Service Bolts

In addition, following clauses of requirements are added, referring to AASHTO's "Guide Specifications for Highway Construction", Division 800 Structures, Section 811 Steel Structures.

3.1 Documentation

(a) Notice of Beginning of Work
The Contractor shall provide written notice thirty (30) calendar days before work begins at the mill or shop. He shall begin work only after receiving the Engineer's notice.

(b) Inspection
- Structural steel will be inspected at the fabrication site.
- Furnish copies of all mill orders and certified mill test reports.
- Include the chemical analysis and mechanical test results for each grade of steel used in the work. Certificates of compliance may be furnished in place of mill test reports for materials normally not supplied with mill test reports.
- Include the Charpy V-notch impact test results in certified mill test reports for steels with specified impact values.
- Furnish copies of mill orders when the order is placed.
- Furnish certified mill test reports and certificates of compliance before beginning fabrication. Ensure the certificate of compliance carries the manufacturer's signature and that the material meets specifications.
- Make material available for examination. Provide free access at all times to any portion of the fabrication site.

3.2 Working Drawings

- The Contractor's working drawings shall be based on the contract drawings, unless otherwise instructed by the Engineer.
- Approval of working drawings by the Engineer covers only the requirements for strength and detail. No responsibility for errors in dimensions is assumed.
- Begin work only after working drawings are approved. Approval does not relieve the Contractor of Contract requirements.

(a) Shop Drawings
- Submit copies of detailed shop drawings for approval at least thirty (30) calendar days before starting the work to allow time for review and correction by the Contractor.
- Ensure shop drawings fully detail dimensions and sizes of structure components, all associated parts and connections.
- Where specific orientation of plates is required, show the direction of rolling of plates.
- Identify steel grade of each piece on working drawings.

(b) Erection Drawings
- Submit drawings that completely illustrate the proposed method of erection.
- Show details of all falsework bent, bracing, guys, deadmen, lifting devices and attachments to the bridge members.
- Show erection sequence, location of cranes and barges, crane capacities, location of lifting points on the bridge members and weights of the members.
- Ensure the drawings completely detail all anticipated phases and conditions during

erection.
- Furnish calculations showing that factored resistances are not exceeded and that member capacities and final geometry will be correct.

(c) Camber Diagram
- Furnish a fabricator-prepared diagram showing the camber at each panel point for trusses or arch ribs, at field splices and fractions of span length (quarter points minimum) for continuous beam and girders or rigid frames.
- Include calculated cambers to be used in the structure's preassembly.

3.3 Fabrication

Identifying Steel during Fabrication
- Ensure the system of assembly-marking for individual pieces and cutting instructions to the shop maintains the identity of the original piece.
- Furnish material taken from stock that is identifiable by heat number and mill test reports, subject to approval.
- During fabrication, up to the point of assembling, ensure that each member clearly displays its specification.
- Ensure all steel pieces are grade-marked by low stress-type steel die stamping or by a firmly attached tag.
- Furnish an affidavit certifying the steel identification was maintained throughout fabrication, as requested.

3.4 Storing Materials

- Store structural steel, plain or fabricated, on platforms, skids, or other supports minimum of 300 mm above the ground.
- Keep steel free from dirt, grease, and other foreign matter and protect it from corrosion.

3.5 Plates

Direction of Rolling

Cut and fabricate steel plates for main members; splice plates for flanges and main tension members so the primary direction of rolling is parallel to the main tensile and/or compressive stresses.

3.6 Fit of Stiffeners

- Mill or grind end-bearing stiffener for girders and stiffeners supporting concentrated loads to bear (either milled, ground or on weldable steel in compression areas of flanges, welded as specified the flange.
- Ensure intermediate stiffeners that do not support concentrated loads fit tightly against the compression flange.

3.7 Abutting Joints

Mill or saw cut abutting ends in compression members of truss and column to provide a square joint and uniform bearing. Maximum opening in unfaced joints is 10 mm.

3.8 Facing Bearing Surfaces

Ensure the surface finish for bearing, base plates and other bearing surfaces that contact each other or concrete.

3.9 Straightening Material

- Straighten plates, angles, other shapes and built-up members without fracturing or injuring the metal. Use mechanical means to straighten distorted members by applying limited, localized heat.
- Maximum heat for straightening is 650 degree C. Measure temperature using temperature-indicating liquids or bimetal thermometers. Material heated in excess of the specified limits will be rejected unless testing verifies material.
- Ensure parts to be heat-straightened are free of stress and external forces, including stresses from mechanical means used to apply the heat.
- Straightened pieces showing evidence of fracture will be rejected.

3.10 Bolt Holes for High-Strength Bolts and Unfinished Bolts

- Standard hole size for bolts M24 and smaller is the bolt diameter plus 2 mm. For bolts M27 and larger, the standard hole size is a bolt diameter plus 3 mm.
- When specified, enlarged or slotted holes are allowed for high-strength bolts.

3.11 Curved Girders

Flanges of curved, welded girders may be cut to the radii specified or curved by applying heat as specified in succeeding Subsections. Ensure that the radii are not less than allowed.

3.12 Heat Curving Rolled Beams and Welded Girders

Prohibit heat curving of steels manufactured to a specified minimum yield point greater than 345 MPa.

3.13 Assembly

(a) Bolting

- Clean metal contact surfaces before assembling.
- Assemble the member before drilling, reaming or bolting.
- Remove all burrs and shavings and ensure the member is free from twists, bends and other deformations.

(b) Welded Connections

Ensure that surfaces and edges to be welded are smooth, uniform, clean and free of defects, subject to the approval of the Engineer. Metal-arc welding shall comply with the requirements of BS 5135.

(c) Preassembly of Field Connections

- Preassemble field connections of main members of trusses, arches, continuous beams, plate girders, bents, towers and rigid frames prior to erection as necessary to verify the geometry of the completed structure or unit and to verify or prepare field splices.
- Ensure accurate geometry; propose and appropriate preassembly method for approval by the Engineer.
- Provide a method and details of assembly consistent with the erection procedure shown on the Contractor-prepared and Engineer-approved erection plans and camber diagrams.
- As a minimum, provide a preassembly procedure consisting of assembling three contiguous panels accurately adjusted for line and camber.
- Provide progressive assemblies consisting of at least one section or panel of the

previous assembly (repositioned if necessary and adequately pinned to ensure accurate alignment), plus two or more sections or panels added at the advancing end.

(d) Match Marking

Match mark connecting parts preassembled in the shop to ensure proper fit in the field. Provide a diagram that shows such marks.

(e) Connections Using Unfinished, Turned or Ribbed Bolts

When specified, furnish unfinished, turned, or ribbed bolts conforming to the requirements for carbon and alloy steel externally threaded metric fasteners.

3.14 Connections Using High-Strength Friction Grip Bolts and Tension Control Bolts

Use High-strength bolts in holes that conform to the requirements.

(a) Bolted Parts

Use steel for all material within the grip of the bolt. Prohibit use of compressible material such as gaskets or insulation within the grip. Ensure that bolted steel parts fit solidly together after the bolts are tightened.

(b) Surface Conditions

At the time of assembly, ensure that all joint surfaces, including surfaces adjacent to the bolt head and nut, are free of scale, except tight mill scale and free of dirt or other foreign material.

(c) Installation

Use a bolt-tension measuring device at the job site to perform the rotational capacity test. The device shall be calibrated before the test and the certificate shall be submitted and approved by the Engineer.

If tension control bolts, nuts and washers are used, they shall comply with “Society of Steel Construction of Japan - Document JSS II-09-1996, Sets of Torshear Type High Strength Bolt, Hexagon Nut and Plain Washers for Structural Joints”.

Use of Tension control bolts, nuts and washers shall be as given in BS 4604: Parts 1 & 2.

3.15 Welding

Ensure that welding, welder qualifications and prequalification of weld details and inspection of welds shall comply with BS 5135 and the requirements of BS 5400, Part 1.

3.16 Handling and Storing Materials

- Store material on skids.
- Keep storage area clean and properly drained.
- Support stored girders and beams upright with long members to prevent damage from deflection.
- Inventory material received against the shipping lists and report shortage or damage promptly in writing.
- The Contractor shall be responsible for damaged or lost material.

3.17 Expansion Joints and Bearings

The Contractor shall refer to Section 510, Bridge Expansion Joints and Section 511, Bridge Bearings. Verify substructure dimensions and elevations before ordering superstructure materials for staged construction projects.

3.18 Trial Erection at the place of Fabrication

- Follow erection procedures as detailed in the submitted erection drawings and methods.
- If any damages occurred, repair them at the Contractor's expense.
- Prepare and submit revised erection drawings detailing all proposed deviations.
- Recalculate and submit erection stresses that differ from the planned method.
- Document changes in stresses or in behaviour for the temporary and final structures.
- Provide additional material required to keep both the temporary and final stresses within the allowable limits used in design.
- Provide temporary bracing or stiffening devices to accommodate handling stresses in individual members or segments of the structure during erection.
- Support segments of the structure to produce the proper alignment and camber in the completed structure.
- Install frames and diagonal bracing to provide stability and ensure correct geometry.
- Provide all required temporary bracing.

3.19 Permanent erection

- Assemble using match-marks. Ensure parts are not damaged or distorted.
- Clean bearing surfaces and surfaces to be in permanent contact before assembly.
- Fill minimum one-half of the holes in splices and field connections with bolts and cylindrical erection pins (half-bolts and half-pins) before installing and tightening the balance of high-strength bolts.
- Fill three-fourths of the holes in splices and connections carrying traffic during erection.
- Fitting-up bolts may be the same high-strength bolts used in the installation.
- Ensure other fitting-up bolts are of the same nominal diameter and that cylindrical erection pins are 0.75 mm larger.

3.20 Pin Connections

- Furnish pilot and driving nuts in driving pins.
- Drive pins to take full bearing.
- Tighten pin nuts and bur the thread at the face of the nut with a pointed tool.

3.21 Misfits

Correct minor misfits by a minor amount of reaming, cutting grinding, and chipping. Errors in shop fabrication or deformation resulting from handling and transporting will be cause for rejection.

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507.4 Measurement

(a) Fabrication and Erection of Steelwork

The measurement shall be made in three stages for each structure (Steel I-girders and box-girders):

1) Fabrication of structural steelwork: tonne
2) Trial erection of structural steelwork: tonne
3) Permanent erection of structural steelwork: tonne

The measurement shall be the computed mass of the finished member comprising
- Transportation (incl. import and duties)
- Plates (incl. deck panels of box girders),
- Bracing and external diaphragms,
- Rolled sections,
- Shear connectors,
- Stiffeners,
- Cleats,
- Packs,
- Splice plates and all fittings,

without allowance for tolerances for rolling margin and other permissible deviations from standard masses or nominal dimensions.

Exclusion
The masses of welds, bolts, nuts, washers, rivets and protective coatings shall be excluded from the measurement.

No deduction shall be made for notches, cope holes, bolt and rivet holes, and the like, which are each less than 0.03 sq. m.

The computed mass of rolled steel and iron shall be determined from the dimensions briefly shown on the Drawings on the following basis:

(a) Rolled or cast steel, 7,850 kg/cu.m
(b) Cast iron, 7,210 kg/cu.m

Main members and deck panels shall be inclusive of:
- Connectors,
- Stiffeners,
- Internal diaphragms and
- Other integral components.

(b) Fabrication of Steelwork

The items for fabrication shall include for:

a. Examining and checking for segregation, laminations, cracks and surface flaws and carrying out any remedial measures required by the Engineer in respect of such defects.
b. Cutting, marking off, drilling, notching, machining, treatment of outside arrises, smoothing to slopes, form fitting, end and edge preparation and cambering.
c. Riveting, bolting, assembling and pre-heating.
d. Welds, packing plates, rivets, bolts (incl. holding down bolts), nuts and washers required to fabricate and to complete the erection and installation on Site, together with spares and service bolts, drifts, draw up cleats and the like.
e. Pre-production procedural trials.
f. Welder approval trials and provision of certificates.
g. Allowance for rolling margins, over-runs and other permissible deviations.
h. Checking of deviations in plate panels and rolled and built-up sections and of alignment at joints, including taking measurements and observations and recording and supplying one copy of the records to the Engineer.
i. Preparation and supply of marked erection drawings, marking members for identification and delivery in matching sequence.

j. In the case of weathering steel blast cleaning after fabrication.

(c) Trial Erection at the Place of Fabrication

The items for trial erection shall include for:

1) Temporary bracing or stays to prevent displacement including the provision and removal of temporary attachments.
2) Proving dimensions, cambers and profiles and alignment at joints.
3) Match-marking members as required for permanent erection.
4) Dismantling.
5) Modifications and refitting of members as a result of the trial erection.
6) Bolts, nuts, washers, sockets, base plates, anchorage assemblies, drilling or forming holes and pockets and casting in.

(d) Permanent Erection

The items for permanent erection shall include for:

a. Temporary bracing or stays to prevent displacement including the provision and removal of temporary attachments.
b. Welder approval trials and provision of certificates.
c. Procedural trials.
d. Permanent bolted, riveted and welded connections including the provision of preheat and shelters for welding.
e. Checking of deviations in plate panels and rolled and built-up sections and of alignment at joints, including taking measurements and observations and recording and supplying one copy of the records to the Engineer.
f. Drilling or forming holes and pockets and casting in bars, sockets, base plates and anchorage assemblies.
g. Adhesives and epoxy or polyester mortar, bedding mortar or grout.

507.5 Payment

Pay Item		Unit of Measurement
507 (1)	Fabrication for Steel I-girder	tonne
507 (2)	Fabrication for Steel box-girder	tonne
507 (3)	Trial Erection for Steel I-girder	tonne
507 (4)	Trial Erection for Steel box-girder	tonne
507 (5)	Permanent Erection for Steel I-girder	tonne
507 (6)	Permanent Erection for Steel box-girder	tonne

Section 508

PROTECTION OF STEELWORK AGAINST CORROSION

508.1 Description

The Contractor shall prepare surface and apply paint to specified surfaces of steelwork. At the same time, the Contractor shall provide protective devices so as not to damage the steelwork, facilities and traffic. Waste material shall be disposed, as directed by the Engineer.

Surface preparation and protection against corrosion of steelwork shall be carried out as appropriate to the design and method of fabrication of the components and the paint manufacturers' recommendations.

The Contractor shall follow item numbers and descriptions of paints contained in the "Manual of Paints for Structural Steelwork" which is included in standard BD 35 of UK and summarised as follows:

Table 508.1 Requirements for Steel Bridges Surface Preparation and Protective Systems

Surface preparation			**Protective systems**
(i) Bridge steelwork, fabrication stage			
Area Description	**Method**	**Surface Preparation by Blast Cleaning (as per BS 7079)**	**Type and Minimum total dry film thickness (mdft) of the paint system**
Area A **Exterior** main surfaces, including shop welds	Blast clean with chilled cast iron grit or aluminium oxide grit	**Sa3**, Medium profile	I: for Ready Access, II: for Difficult Access, both **300 microns**
Area B **Interior** of box girder surfaces, except Area C, but including shop welds	Blast clean with metallic abrasive	**Sa2½**, Medium profile	III: **200 microns**
Area C **Contact surfaces** of parent material at high strength friction grip and tension control bolted joints	Blast clean with chilled cast iron grit or aluminium oxide grit	**Sa3**, Medium profile	Thermally sprayed metal coating: aluminium metal spray
Area D High strength friction grip and tension control bolted joints. Contact and outer surfaces of joint material	Blast clean with chilled cast iron grit or aluminium oxide grit	**Sa3**, Medium profile	Contact surfaces: Thermally sprayed metal coating: aluminium metal spray. Outer surfaces: I: for Ready Access, II: for Difficult Access, both **300 microns**

(ii) Bridge steelwork, erection stage			
Area Description	**Method**	**Surface Preparation by Blast Cleaning (as per BS 7079)**	**Type and Minimum total dry film thickness (mdft) of the paint system**
Area E Exterior surfaces of site welds and weld affected areas	Remove slag, wire brush, wet clean and blast clean as Area A	**Sa3**, Medium profile	I: for Ready Access, II: for Difficult Access, both **300 microns**
Area F Interior surfaces of site welds and weld affected areas	Remove slag, wire brush and wet clean	**Sa2**	1st Coat: Zinc or ferrous based phosphate solution followed by Type III (as 2nd and 3rd Coats)

Note:

1) Types I, II and III: Refer to UK's Standard Specification, Series 1900, Protection of Steelwork.
2) Surface preparation, Sa2, Sa2½ and Sa3: Refer to BS 7079.

This work shall, consist of unless otherwise provided in the Contract, the preparation of the metal surfaces, the application, protection and drying of the paint coating and the supplying of all tools, tackle, scaffolding, labour and materials necessary for the entire work.

508.2 Materials

The Contractor shall provide coating surface preparation, application of prime coat and finish coat thickness and colour, as specified.

508.3 Construction

3.1 Surface Preparation – General requirements

3.1.1 Shop and Site Work

a) Before blast cleaning or abrading steel surfaces or before over coating, painted or galvanized surfaces, contamination by oil or grease shall be removed by wet cleaning the affected areas.

b) Clean water, which does not leave harmful residues on the surface, shall be used for cleaning and rinsing.

c) Cleaning agents approved by the Engineer shall be used.

d) Surface preparation shall be continued until the required standard has been achieved.

e) Weld spatter shall be removed from accessible areas, which are to be galvanized or protected, by metal spray or paint. Firmly adhering weld spatter in the heat-affected zone shall be removed before blast cleaning.

f) After dry surface preparation of internal surfaces and before any wet cleaning, all dust and debris shall be removed from accessible areas by sweeping and vacuum cleaning.

g) Immediately before application of each coat of paint, the Contractor shall ensure that the surfaces:

i) meet the required standard of preparation;
ii) are free from harmful residues, including mortar, concrete dust, grit and paint degradation products;
iii) are free from detrimental contamination;
iv) are free from moisture detrimental to the coating to be applied.

h) Joints, plies and fasteners shall be sealed in compliance with Clauses 3.3.2(m) and (n).

i) Coats, of paint shall be free embedded metallic or other foreign particles including metallic dust. Deposits of adherent matter on metallic coatings or painted surfaces shall be cleaned off immediately they occur. Coatings damaged in the process shall be restored.

j) Final shop coats on external surfaces shall be wet cleaned on site.

3.2 Surface Preparation – Materials and Methods

3.2.1 Dry Blast Cleaning in the Shops

a) Unless otherwise described chilled cast iron grit abrasive complying with BS EN ISO 11124-2 or steel shot of not less than 40 Hardness Rockwell C and complying with the size requirements of BS EN ISO 11124-3 shall be used.

Abrasive grades shall not exceed the following:

Profile (see Clause 3.6, a):		Fine	Medium	Coarse
Chilled cast iron grit	:	G12	G17	G4
Steel shot	:	S170	S330	S390

b) The particle size of any abrasive in plant or equipment shall not exceed the maximum for the relevant grade as specified above.

c) Before the start of blast cleaning and during blast cleaning the Contractor shall ensure that the abrasive is free from matter, which could leave detrimental contamination, as defined in Clause 3.6 a) on the surface to be coated.

3.2.2 Abrading in the Shops or on Site

a) Any encrusted foreign matter or paint which may be difficult to remove by abrading alone shall, with the Engineer's approval be dislodged by scraping, aided by hand or power wire-brushing. This work shall be completed before abrading the areas so affected.

b) Abrading shall be carried out using abrasive paper or other material or a flexible abrasive disc mounted on a power driven flexible pad, or a power driven arbour or spindle-mounted flexible abrasive flap wheel. Abrading tools may be used to remove weld spatter. Subject to the Engineer's approval, wet abrading may be employed for the preparation of finishes over sound undercoats, over unsound systems over galvanizing, or galvanizing.

c) All equipment including tools, abrasive sheets, abrasive discs and abrasive wheels shall be of a type, capacity and in condition, approved by the Engineer. The speed of revolution shall be as approved by the Engineer.

d) A burnished appearance caused by polishing in of paint, rust or dirt will not be

acceptable.

e) Areas of previously corroded steel or unsound metal coatings, except galvanizing, which have been prepared by abrading down to bright steel (without mill scale and usually not rusty) or bright (ditto) metal coating, and blast cleaning where appropriate, shall be protected by the primer and next two coats of paint before any cleaning down or preparation of adjacent surfaces.

3.2.3 Wet Cleaning in the Shops or on Site

a) Wet cleaning shall be carried out by scrubbing with a stiff bristled brush using water and a cleaning agent. Immediately after cleaning, the surfaces shall be thoroughly rinsed.

3.2.4 Dry Cleaning in the Shops or on Site

Surface shall be cleaned by scrubbing with a dry stiff-bristled brush.

3.2.5 Dry Blast Cleaning on Site

Metallic abrasives shall comply with Clause 3.2.1, 3.2.2 and 3.2.3 of this Clause. Metallic grit abrasive shall be used for dry blast cleaning of relatively small areas on site which are to be metal sprayed, such as at site welds, at areas prepared to clean steel or areas where a metal spray is to be restored, as indicated in Clause 3.7, c). The Contractor shall ensure that grade and particle shape of non-metallic abrasives are adequate for the purpose intended. Non-metallic abrasives shall not be recycled.

3.2.6 Wet Blast Cleaning on Site

a) Unless otherwise agreed with the Engineer a low-pressure air/water/abrasive system shall be used. The air/water pressure at the nozzle shall not exceed 7.0 kgf.cm² and shall be fully adjustable below this level. The system shall incorporate a mechanical metering device remote controlled by the operator from the nozzle to enable him to regulate from zero to maximum the quantity of non-metallic abrasive being fed into the air/water mixture. During abrasive cleaning, the air, water and abrasive shall be thoroughly mixed and this mixture shall be projected on to the surface to be cleaned through a single bore nozzle or tube. The use of an inhibitor during wet blast cleaning or washing will not be permitted.

b) Within 60 minutes of wet blast cleaning, the whole of the cleaned surface shall be thoroughly washed using the blast cleaning equipment with air and water. Any further deposits of abrasive on already rinsed surfaces shall be removed in similar manner also within 60 minutes of being deposited. All accumulated deposits of abrasive and debris on other parts of the structure shall be removed by the same method before the end of the working day. After washing the surface, the surface shall be free from all particles of dust and debris. Tests for freedom from detrimental contamination shall be made after the washing.

3.2.7 Combined Wet/Dry Blast Cleaning on Site

a) Wet blasting cleaning using the low pressure air/water/ abrasive system in compliance with Clause 3.2.6, a) and b) shall be followed, at an interval approved by the Engineer, by dry blast cleaning in compliance with Clause 3.2.5, of all the previously wet blast cleaned areas.

b) The specified standard of surface preparation shall have been achieved in full, initially by

wet blast cleaning and washing, before any later dry blast cleaning of the same areas to remove flash rusting or to restore the required standard of surface preparation.

3.2.8 Other Requirements

When surface preparation is to be carried out by dry blast cleaning and, on adjacent surfaces, by wet cleaning and or abrading, then unless otherwise agreed or required by the Engineer, the wet cleaning and any abrading shall be carried out first.

When combined wet/dry blast cleaning has been specified instead of dry blast cleaning only, the above sequence may be received. On completion of the wet blast cleaning part of the process, the areas to be abraded shall be cleaned in compliance with Clause 3.2.3, a) except that for rinsing, the wet blast cleaning equipment may be used. The dry abrading shall be carried out after any wet blast cleaning part of the process, and dry abrading shall be carried out after any wet abrading required and final rinsing. Any prepared dry metal surface shall be protected from the effects of any further wet method of surface preparation by the application of the next two coats of paint including stripe coats.

3.2.9 Grinding After Surface Preparation in the Shops or on Site

Grinding wheels and discs shall be of the size, shape and grade of coarseness appropriate to the particular operation. The speed of revolution shall be ass approved by the Engineer.

3.3 Procedures for Treatment at Joints

3.3.1 Fasteners, Joint material and Parent Material in Joints, Before Assembly or Welding, in the Workshop or on Site

Fasteners, Including Bolts, Nuts and Washers

a) Surfaces of uncoated fasteners shall be free from all but traces of oil or grease before assembly.

b) Unless otherwise described, threaded fasteners at joints in hot dip galvanized steelwork or in hot dip galvanized steelwork, which is to be painted, shall be hot dip galvanized. Hot dip galvanized fasteners, which are to be painted, shall be treated with an adhesion promoter before assembly.

c) Metal coatings on surfaces of fasteners which are to be painted shall be:

   i) free from all traces of oil and grease and then treated with an adhesion promoter: or
   ii) treated at the same time as the parent material where fasteners are already assembled in compliance with sub-Clause 3.3.2, j).

   Fasteners excluding those in ii) above shall be pressure-rinsed with water and allowed to dry before assembly or packing for delivery at least one hour and not more than four hours after satisfactory application of an adhesion promoter.

d) Fasteners, which have become difficult to tighten because of corrosion shall be replaced.

Joint Material and Parent Material in Joints

e) The standard of initial blast cleaning of joint material and parent material in joints shall be at least equal to that for the parent material. Before a joint is made on site, contact surfaces shall be restored to Sa2½ quality or to sound metal coating.

At Joints Made with High Strength Friction Grip and Tension Control Bolts

f) In steelwork painted only overall:

The blast primer applied to the parent material shall be taken 10 mm to 15 mm inside the perimeter of the joints. The outer surfaces and edges of site joint material may, at the option of the Contractor, also be given a coat of the blast primer.

g) In steelwork with thermally sprayed metal coating at joints only and painted overall:

Unless otherwise described, the thermally sprayed metal coating shall be applied to the contact surfaces of the joints and to the outer surfaces and edges of joint material. The thermally sprayed metal coating on the contact surfaces of the parent material shall be taken 10 mm to 15 mm outside the perimeter of the joints. The blast primer applied to the parent material shall be taken 10 mm to 15 mm inside the perimeter of the joints. The thermally sprayed metal coating on the outer surfaces and edges of site joint material shall be given a coat of aluminium epoxy sealer (two-pack).

h) In steelwork with thermally sprayed metal coating overall and sealed only or painted overall:

Unless otherwise described, the thermally sprayed metal coating shall be applied to the contact surfaces of the joints and to the outer surfaces and edges of joint material. The sealer applied to the parent material shall be taken 10 mm to 15 mm inside the perimeter of the joints. The thermally sprayed metal coating on outer surfaces and edges of site joint material shall be given a aluminium epoxy (two-pack) sealer.

i) In steelwork hot dip galvanized only or hot dip galvanized and painted overall:

All material at joints shall be hot dip galvanized. When an adhesion promoter and a first undercoat are applied before a joint is made, they shall be taken 10 mm to 15 mm inside perimeter of the joint; these coats shall also be applied to edges and outer surfaces if the joint material.

j) The thickness of a protective paint coat applied to the outer surfaces of joint material prior to assembly of any high strength friction grip (HSFG) or tension control bolted joints shall not exceed 20 microns dry film thickness (dft).

At Non Friction Bolted Joints

k) At workshop joints in all steelwork other than in hot dip galvanized steelwork, the blast primer alone or thermally sprayed metal coating plus sealer shall be applied initially to parent and joint material. Immediately before assembly of a joint which is to be painted, the first undercoat shall be applied to the contact surfaces and the joint made while the paint is wet.

l) At site joints in all steelwork other than in hot dip galvanized steelwork unless otherwise described, all surfaces except those of fasteners, shall receive in the workshop the workshop protective system, which is applied to the parent material.

m) At all joints in hot dip galvanized steel work, an adhesion promoter and workshop coats may be applied to the joint material before or after workshop joints are made. When hot dip galvanized steelwork is painted on site, an adhesion promoter and paint shall be applied to joint material after the joint has been made.

At Welded Joints

n) At workshop and site joints in all steelwork, surfaces to be welded shall be restored to Sa2½ quality or bright steel and shall be free of any protective or other coating immediately prior to welding.

3.3.2 Parent Material, Workshop Treatment Adjacent to Joints which are to be Assembled or Welded Later on Site

At HSFG and Tension Control Bolted Joints

a) The paint coats, with the exception of the primer or first coat of paint, shall be stepped back at 30 mm intervals commencing 10 mm from the perimeter of the joints.

At Non Friction Bolted Joints

b) Unless otherwise described, workshop paint coats are not required to be stepped back.

At Welded Joints

c) Thermally sprayed metal coating shall be kept clear of the weld by a distance of at least 15 times the thickness of the steel in the area to be welded, with a maximum of 300 mm from the joint. The restricted area shall be masked during metal spraying. Hot dip galvanizing shall be removed a minimum of 5 mm back from the edges of weld areas. Paint coats shall be stepped back at 30 mm intervals commencing at least 100 mm from the joint, or from the edge of the thermally sprayed metal coating, starting with the 2nd coat of paint.

At Completed Joints

d) Within 14 days of a joint completed, exposed surfaces of parent and joint material shall be prepared in compliance with Clauses 3.3.2, e) to i) and fasteners in compliance with Clause 3.3.2, j) to I).

At Bolted Joints

e) In steelwork painted only overall, blast cleaned only or primed surfaces shall be prepared by dry blast cleaning to restore or provide the required standard of surface preparation, for workshop or site work as appropriate.

f) In steelwork thermally sprayed metal coating at joints only, and painted overall, primed or sealed thermally sprayed metal coatings shall be prepared by dry blast cleaning to restore the surfaces to the required standard.

g) In steelwork with thermally sprayed metal coating overall, and sealed only or painted overall, thermally sprayed metal coatings shall be prepared as described in Clause 3.3.2, f).

h) In steelwork hot dip galvanized only or hot dip galvanized and painted overall, the surface shall be free from contamination detrimental to paint coats by wet cleaning.

At Welded Joints

i) In all steelwork, welds shall be prepared by the methods and to the required standards for workshop or site work as appropriate. Surfaces of areas adjacent to the weld shall be similarly prepared. For site welds in hot dip galvanized steelwork, surfaces shall be

treated in accordance with Clause 3.4, j).

Surfaces of Fasteners

j) Uncoated and temporarily coated fasteners shall be free from all but traces of oil and grease and blast cleaned to Sa2½ quality, Medium profile, before painting.

k) Metal-coated fasteners, which have been treated with an adhesion promoter before assembly shall be dry cleaned after final surface preparation of the joint and then painted.

l) Fasteners, which are to receive thermally sprayed metal coating after assembly shall be blast cleaned to Sa3 quality, medium profile, with chilled cast iron grit, cast steel grit or aluminium oxide.

Sealing at Joints or Plies

m) Bolted joints or built-up sections shall be free from any water, which has penetrated the plies.

When drying out has been completed or when surfaces are dry after surface preparation, fine gaps around the perimeter of joints or along plies shall be sealed by successive application of undercoat paint. All wider gaps shall be sealed with a proprietary sealant compatible with the paint approved by the Engineer.

Sealing of Gaps at Nibs of Load Indicating Fasteners of Washers

n) Gaps shall be sealed by brush application of primer and successive undercoats, of the types used on adjacent areas.

3.4 Procedures for Treatment at Areas of Mechanical Damage or Other Surface Defects

a) Score marks, other surface defects and indentations in the surface of a steel substrate or of a metal coating shall be treated by abrading or grinding to bright steel or bright metal coating, to produce a surface without sharp edges or abrupt change in contour. Damage to unprepared surfaces shall be treated before blast cleaning. A blast cleaning profile shall be restored on areas to be thermally metal sprayed but not necessarily areas to be painted only. Other surface defects in the steel substrate, including fissures caused by the removal of 'hackles' or inclusions described in Clause 3.8, c) shall be similarly treated subject to the approval of the Engineer.

b) In the case of damage to paint coatings only, surface preparation shall be by blast cleaning or abrading. The paint coatings shall then be restored.

c) When a two-pack Epoxy paint system is restored over a steel substrate prepared by abrading, the adhesion of the first paint coat to the substrate shall be checked in accordance with 'BS EN ISO 4624, BS 3900-E10' or BS EN 22063 Annex A method 1.

d) When an area of thermally sprayed metal coating is to be restored after surface preparation by abrading or grinding, any affected thermally sprayed metal coating or exposed steel substrate shall be dry blast cleaned immediately before further application of thermally sprayed metal coating.

e) In the workshop, a damaged thermally sprayed metal coating, together with any damaged sealer or paint coats, shall be restored.

f) On site, with the exception of the small areas, relative to the size of the component,

permitted under Clause g) of this Clause, a damaged thermally sprayed metal coating, together with any damaged sealer or paint coats shall be restored but with a minimum thickness of 150 microns of thermally sprayed metal coating.

g) On site, small areas of isolated damaged, as agreed with the Engineer, in a thermally sprayed metal coating plus paint system, need not to be restored; after surface preparation in compliance with sub-Clause a) of this Clause, the thermally sprayed metal coating shall be replaced by 100 microns of the first undercoats, omitting the sealer. Adjacent paint coats, excluding the sealer shall then be restored over the repaired area.

h) In the workshop, in the case of hot dip galvanizing only, small isolated areas of up to 40 mm² and not exceeding 0.5 % of the total surface area of the component, whichever is the lesser, may after surface preparation, be repaired with low meting point zinc alloy, providing that exceed 0.5 % of the total surface area of the component. Components with damaged areas greater than the above limits shall be regalvanized.

i) All repair work shall only be undertaken when agreed by the Engineer and shall be to his approval; otherwise the component shall be regalvanized.

j) On site, surfaces of hot dip galvanized components found to have minor damage, as agreed with the Engineer, shall be prepared in accordance with sub-Clause h) of this Clause and coated with zinc-rich primer of 75 microns "mdft", complying with BS 4652 Type 2 or 3. Alternatively the components shall be regalvanized.

k) In all cases where paint coats only are to be restored, or thermally sprayed metal coatings replaced or restored, or hot dip galvanizing is to be replaced by paint, the edges of paint coatings or metal coating adjacent to the affected area shall be bevelled back into sound paint or metal coating. This work shall be carried out before any final blast cleaning described in sub-Clause d) of this Clause.

l) An adhesion promoter applied outside the areas to be overcoated shall be removed immediately by wet cleaning.

m) In the workshop exposure and overcoating times shall not exceed those specified in Clause 3.13.

On site, unless otherwise agreed by the Engineer, overcoating shall be started immediately after surface preparation of the affected area and before any deterioration in the standard of the prepared surface occurs, and continued as soon as each coat is dry enough for overcoating.

3.5 Procedures for Treatment of Local Failure in Protective Coatings

a) In the workshop, failed paint coatings and failed thermally sprayed metal coating shall be restored. Abrading down to sound paint only is permissible. If a thermally sprayed metal coating is damaged or reduced to less than 80 % of the specified minimum thickness during abrading, it shall be restored.

b) On site, failed paint coating and thermally sprayed metal coatings shall be restored except that:

i) abrading down to sound paint or to bright steel, or
ii) blast cleaning with metallic abrasive,

are permissible methods of surface preparation when restoring paint systems over a steel substrate.

c) In the shops, and on site, hot dip galvanized components showing signs of failure, e.g. blisters and rust of the coating shall be regalvanized.

d) In the workshop and on site, failed paint coatings over hot dip galvanizing shall be restored. Surface preparation shall be by abrading. Areas of sound hot dip galvanizing exposed through a pint system shall be abraded only as necessary to ensure satisfactory application of an adhesion promoter and paint. If the hot dip galvanizing is damaged or reduced to less than 80 % of the specified minimum thickness during abrading, the component shall be regalvanized.

e) In all cases of local failure, the extent of the failure and the required surface preparation, including extent of initial wet or dry cleaning down, shall be agreed with the Engineer. Restoration of protective coatings shall not be started until the standard of surface preparation, including the cleanliness of surface, has been accepted by the Engineer.

f) Clauses 3.4, c), d), k), i) and m) shall be complied with

3.6 Workmanship Standards for the Surface Preparation of Steel by Blast Cleaning, Abrading, Grinding and Cleaning

a) The surface profile to be achieved by blast cleaning, either 'Fine' "Medium" or 'Coarse' as appropriate, shall be within the limits set by the Surface Profile Comparator for the Assessment of Abrasive Blast Cleaned Surfaces, conforming to BS EN ISO 8503-1, BS 7079-C1.

b) Blast Cleaned surfaces shall be virtually free from sharp spikes of parent metal defined as 'rogue peaks' formed by the impact of abrasive particles and which project above the blast cleaning profile. Any 'rogue peaks' which would be detrimental to the protective system shall be removed.

c) 'Hackles' and inclusions caused by the rolling process, visible after blast cleaning, which would be detrimental to the protective system, shall be removed. Affected surfaces shall be prepared by grinding or abrading to bright steel in compliance with Clause 3.4, a). Sharp edges shall be rounded. If thermally sprayed metal coating is to be applied the surfaces shall then be blast cleaned.

d) Steel surfaces to be prepared by any of the methods described in the Contract shall be such that after surface preparation the surfaces are free from detrimental contamination.

e) Surface preparation by blast cleaning shall be to one or more of the following standards of visual cleanliness:

(i) Sa3 in 'BS EN ISO 8501-1, BS 7079-A1'
(ii) Sa2½ in 'BS EN ISO 8501-1, BS 7079-A1'
(iii) Sa2 in 'BS EN ISO 8501-1, BS 7079-A1'

f) Additionally, after surface preparation by blast cleaning to Sa3 or Sa½ quality, the surface profile shall be virtually free from embedded abrasive particles when viewed through a 10X illuminated magnifying glass. Surfaces assessed as unsatisfactory in this respect by the Engineer shall be blast cleaned again with fresh abrasive. Another abrasive complying with the Specification may be used if necessary.

g) 'Harmful residues' or 'detrimental contamination:'

Surfaces shall be deemed to be free from 'harmful residues' or 'detrimental contamination' after surface preparation when any such remaining matter will not reduce

the required durability of the specified protective system.

h) "Bright steel':

Surfaces free from defects or prepared to this standard by grinding or abrading shall have an overall bright appearance.

3.7 Workmanship Standards for the Surface Preparation of Coated Steelwork by Blast Cleaning, Abrading Grinding and Cleaning

a) Before overcoating, surfaces shall be free from:

(i) any visible gloss
(ii) any unsound paint down to sound paint
(iii) any unsound paint down to Sa3 or Sa2½ quality steel
(iv) any unsound paint down to bright steel
(v) any unsound paint down to sound metal coating
(vi) any unsound paint down to bright metal coating
(vii) any unsound metal coating down to sound metal coating
(viii) any unsound metal coating down to bright metal coating
(ix) any unsound metal coating down to Sa3 or Sa2½ quality steel
(x) any unsound metal coating down to bright steel
(xi) detrimental contaminations

b) Definitions of terms used in describing the above standards of workmanship are as follows:

(i) Sa3 or Sa2½ quality, as in sub-Clause 3.6, e)
(ii) 'bright steel', as in sub-Clause 3.6, h)
(iii) 'free from detrimental contamination', as in Clause 3.6, g)
(iv) 'bright mental coating' resulting from abrading a metal coating whose surfaces are free from all corrosion products and of bright appearance overall
(v) 'unsound metal coating', a metal coating showing signs of disruption, inadequate adhesion or penetration by rust or other corrosion products
(vi) 'sound metal coating', a metal coating which complies with clause 3.10, b) including such a metal coating which has been blast cleaned but which has a reduced thickness in accordance with sub-Clause 3.5, a)
(vii) 'unsound paint', paint showing signs of disruption, rusting, having inadequate adhesion or covering rust scale, loose rust, loose mill scale or other detrimental products.
(viii) 'sound paint', paint which is sound down to a metal substrate.

c) Definitions of terms used in Clauses 3.3, 3.4 and 3.5 are as follows;

When 'clean steel' is exposed through a metal spray coating during remedial surface preparation, remnants of sound aluminium metal spray coating may, subject to the agreement of the Engineer, be retained in a blast cleaning profile; also, subject to the agreement of the Engineer, traces of zinc metal may remain occluded within the surface of a blast cleaning profile after the removal of a zinc metal spray.

3.8 Paint and Similar Protective Coatings

a) The term paint shall be deemed to refer to protective coatings in general.

b) All paints permitted for use in the Works are listed in the Manual of Paints for Structural Steelwork which is included in BD 35 and which also contains details of

the quality assurance scheme for paints and similar protective coatings.

c) All paints shall be supplied in sealed containers of not more than 25 litres capacity and these shall be used in order of date of manufacture and batch number. Each container shall have a completely removable lid and be clearly marked on the side to show the name of the manufacturer, registered description of the material (including purpose, e.g. whether primer, undercoat or finish), colour. Item No., paint manufacturer's reference number, batch number and date of manufacture. Where date of manufacture is coded, the Contractor shall provide the Engineer with the code key. In addition paints shall be supplied in sealed containers of no greater than 5 litre capacity for testing purposes.

d) The Contractor shall ensure that the properties of the paints he has selected are suitable for the atmospheric conditions in the workshops and on site, including temperature and humidity, and that he is able to apply the paints satisfactorily to all parts of the structure in these conditions.

e) Unless otherwise described, all paints forming any one protective system or overlapping system, shall be obtained from the same manufacturer, as named by the Contractor in the form attached in the Appendix. Unless the source of supply entered in Appendix is rejected by the Engineer, it shall not be changed once the Appendix has been submitted for approval.

3.9 Testing of Paints

Provision of Samples

a) Unless otherwise described, the Contractor shall provide unopened 5 litre samples, known as "A" samples, for quality assurance purposes, for each type of paint to be used for the Works. In addition the Contractor shall supply at least 500 ml samples, know as "B" samples, for application control purposes.

'A' Samples

b) 'A' samples are required in all cases where more than 1000 litres of any one coat of paint is to be applied to road-bridge and gantry steelwork. 'A' samples are not required for footbridge steelwork. For two-pack systems, separate samples of the base and activator shall be despatched by the Contractor to the testing authority.

c) The first 'A' samples shall be taken from the first representative batch of each type of paint delivered to the fabricators workshop or to site.

d) Additional 'A' samples of the paints subject to testing under sub-Clause b) of this Clause shall be provided by the Contractor depending on the weight of structural steelwork in the Works in accordance with the following:

(i) 500 tonnes to 1000 tonnes: one set of samples;

(ii) over 1000 tonnes a further set of samples for each part of or whole 1000 tonnes.

The Contractor shall also provide an 'A' sample;

(iii) of any replacement batch of paint subject to testing under sub-Clause b) of

this Clause;

(iv) returned paint described in Clause 3.12, d)

(v) when the paint in the opinion of the Engineer, is showing unsatisfactory application characteristics under Clause 3.13

e) Immediately after selection by the Engineer, the 'A' samples shall be dispatched by the Contractor to the testing authority in accordance with the Engineer's instructions.

f) Paint shall be supplied in sufficient time to allow for sampling and testing before the start of application.

g) Unless permitted by the Engineer, painting except for procedure trails, shall not start until the 'A' sample from the paint to be applied has been tested and confirmed by the Engineer as being satisfactory for use.

'B' Samples

h) The Contractor shall take 'B' samples when instructed by the Engineer, and only under his supervision. The samples shall be taken from painters' kettle or from nozzles of airless spray guns directly into clean, new 500 ml tins, which shall be filled, then sealed and handed to the Engineer. Immediately after selection the 'B' samples shall be despatched by the Contractor to the testing authority in accordance together with the Appendix form.

Provision of 500 ml Tins, Packing and Transport of 'A' and 'B' Samples

i) The Contractor shall provide 500 ml tins with lids clips, for 'B' samples at the start of painting or before any procedure trials required by Clause 3.14. The quantity supplied shall be sufficient to avoid any delay in taking 'B' samples throughout the work.

j) The Contractor shall ensure that the lids of all tins of sample paint are securely clipped down when they are dispatched for testing.

3.10 Metal Coatings

Hot Dip Galvanized Coatings

a) Hot dip galvanized coatings shall, unless otherwise described, complying with BS EN ISO 1461 and with the following:

i) Inhibited hydrochloric acid with a strength not exceeding 18 % and within a temperature range of 15 ^{0} C to 25 ^{0} C or inhibited sulphuric acid with a strength not exceeding 18 % and within a temperature range of 60 ^{0} C to 80 ^{0} C shall be used for pickling.

ii) Components shall not be immersed in the pickling acid longer than is necessary (as stated in BS EN ISO 1461) for cleaning the surfaces prior to hot dip galvanizing.

iii) The surfaces of components to be hot dip galvanized shall be dried before immersion in the molten zinc.

iv) When an aqueous flux is to be used, all traces of acid shall be washed off immediately after pickling.

v) Hot dip galvanized coatings shall be relatively smooth, continuous and free from flux staining.

vi) Detrimental surface contamination of hot dip galvanized coatings, which are to be painted, shall be removed by wet cleaning in compliance with Clause 3.2.3, a). Surfaces to be painted shall not receive chromate passivation treatment.

vii) Vent holes drilled in hollow sections prior to hot dip galvanizing shall be plugged after hot dip galvanizing and before any painting.

Thermally Sprayed Metal Coatings

b) Thermally sprayed metal coatings shall, unless otherwise described, comply with BS EN 22063 and with the following.

i) Aluminium coating shall be of a material with minimum quality in accordance with type A1 99.5 (1050A) of ISO 209: Part 1. Zinc coating shall have a composition in accordance with type Zn 99.99 of ISO 752.

ii) The thickness of the coating shall be not less than 100 microns.

(iii) The strength of adhesion of thermally sprayed metal coatings shall not be less than the following:

Aluminium	50 kgf/cm^2
Zinc	50 kgf/cm^2

(iv) Thermally sprayed metal coatings shall be applied continuously over each 0.5 m2 per gun or the area of the component whichever is the lesser until the specified thickness has been achieved.

(v) The application of thermally sprayed metal in separate layers shall not be permitted.

(vi) All surfaces to be thermally metal sprayed, including that of the reference panel having equivalent hardness to that of the parent material, shall be blast cleaned with chilled iron grit or high carbon cast-steel grit with a hardness value greater than 650 HV, or aluminium oxide with hardness value greater than 9 Mohs, and the standard shall be Sa3 quality, medium profile..

Sherardized Coatings

c) Sherardized coatings shall, unless otherwise described, comply with Class 1. Table 1 of BS 4921.

Electroplated Coatings

d) Electroplated coatings shall, unless otherwise specified, comply with BS 3382-1 and BS 3382-2. Additionally BS 3382-1 and BS 3382-2 shall be deemed to cover the electroplating of components up to and including 36 mm in diameter. Electroplated surfaces, which are to be painted, shall not receive chromate passivation treatment.

Other Requirements

e) When a metal coating is required on only part of a component, it shall be applied before the rest of the component receives paint.

f) Electroplated items under torque or tension conditions shall be stress relieved by heat

treatment at appropriate temperature and time to prevent failure by hydrogen embrittlement.

3.11 Testing of Metal Spray Coatings

a) At the start of the Works, and subsequently at intervals specified by the Engineer (with the exception of coatings on steel in bearings, curved surfaces, repairs to mechanical damage, local failure of thermally sprayed metal coating at site joints or areas restored on site), the Contractor shall demonstrate by means of a tensile test in accordance with BS EN 22063, that the minimum adhesion requirement is being attained as detailed in sub-Clause 3.10, b), (iii).

b) The tensile tests shall be carried out initially on flat panels 150 mm x 150 mm x 6 mm, which are of the same grade of steel as the parent material and which before blast cleaning had the same surface condition. The panels shall be blast cleaned and thermally metal sprayed together with the parent material to the same standard and using the same technique.

c) The Contractor shall ensure that adhesion tests have been carried out satisfactorily before any further work continues.

d) If the adhesion requirement on any test panel is not met, the Contractor shall carry out a further test on the parent material adjacent to the panel position. In the case of adhesion failure on the steelwork itself by either method of test, unsound thermally sprayed metal coating shall be restored and the test repeated.

e) If more than two locale areas of faulty adhesion occur on any one component, the whole of the thermally sprayed metal coating on the component shall be considered as having failed, and it shall be restored. Clause 3.13.1, d) is not acceptable in the case of adhesion failure.

3.12 Storage Requirement and Keeping Periods for Paints

a) On delivery to the workshop or site, paint shall be unloaded directly into one or more secure paint stores which shall be located approximately within 100 metres of the painting area. Insulation and means of heating and ventilating shall be provided as necessary to maintain the temperature of paint stores between 5^{o}C and 27^{o}C.

   If at any time or place paint in tins, painters' kettles or airless spray containers is allowed to reach temperatures outside the 5^{o}C and 27^{o}C limits or the paint manufacturer's recommended storage temperature, the paint shall be discarded and not used in the Works. Two pack products which produce an exothermic reaction when mixed, may be allowed to exceed the specified higher temperature limit. The Contractor shall also implement any additional storage restrictions recommended by the paint manufacturer.

b) Unless expected in accordance with sub clause d) of this Clause, paint which has not been used within the shelf life recommended by the manufacturer or within 18 months of the date of manufacture, whichever is the lesser, shall be discarded or returned to the manufacturer and not used in the Works.

c) Chemically or moisture cured paints shall not be used after the expiry of the pot life stipulated by the paint manufacturer. They shall be discarded on expiry of the pot life or at the end of each working day/night whichever is the less.

d) Exceptionally, components of two-pack epoxy paints may have their keeping period extended to 24 months provided that the Contractor returns the paints to the paint manufacturer and ascertains that the manufacturer examines the contents of each tin and reconstitute the paints as necessary so that such paints are equal in all respects to the paint described in the Specification. The Contractor shall provide a Certificate of Conformity confirming that such

paints have been inspected and where necessary reconstituted and conform in all respect to the Specification.

e) Each tin of reconstituted paint returned to the workshop or site by the manufacturer shall have an additional label affixed stating "Extended Shelf Life to (date)". The previous date marking shall remain and not be obscured. Agreement by the Engineer to extended keeping periods for certain paint does not relieve the Contractor of his responsibilities. Testing in compliance with Clause 3.9 shall apply to reconstituted paints.

3.13 Application of Paint

3.13.1 General

a) Paint shall be supplied from the Contractor's paint store to the painters ready for application. The only adjustment of formulation is permitted as described in clause 3.14, d). In exceptional circumstances, any addition of solvent necessary to improve application shall be advised and if possible carried out by the paint manufacturer, preferably in the paint process plant with adequate equipment and controlled measurements.

b) Paint shall be applied only to surfaces, that have been prepared and cleaned as described in this section.

c) Unless otherwise described, a coat of paint in a system shall be applied by one of the following methods:
   (i) brush (B)
   (ii) Airless spray (AS)
   (iii) Air assisted spray

d) Paint shall not be applied under the following conditions:

   (i) when the Dew Point is reached and/or when the ambient temperature falls below 5 deg. C or the relative humidity rises above 80 % in an enclosed workshop or 90 % on site;
   (ii) during rain, fog, mist or in a dust laden atmosphere;
   (iii) when the amount of moisture likely to be deposited on the surface by condensation or rain before or after painting, may have a harmful effect on the paint;
   (iv) when wind-borne dust may have a harmful effect on the paint.

e) All workshop painting of steelwork shall be carried out in a fully enclosed workshop unless otherwise agreed by the Engineer.

f) Before starting the procedure trials described in clause 3.14 and as required by the Engineer, the Contractor shall furnish the Engineer with details of the overall wet film thickness for each coat he proposes to apply. He shall also provide information as to the total amount of paint that he expects to use for each coat of each system for which procedure trials are required. The calculation of the amount of paint to be used shall be based on the volume solids plus an allowance for waste.

g) The following requirements of paint film thickness shall apply:

   (i) Wet film thickness gauges shall be used where practicable to check that the wet film thickness is not less than:

   {Minimum dry film thickness ("mdft") / Volume solids %} x 100

(ii) During the application of a paint system, the Contractor shall ensure that the progressive total thickness of the applied coats will allow the specified minimum total dft of the system to be attained without exceeding, overall, the proposed wet film thicknesses referred to in sub clause (i) of this clause by more than 20 %.

(iii) In no case shall the total dry film thickness of a paint system or the "mdft" of the last undercoat and finish be less than the specified in Appendix of Paint System Sheets.

(iv) The local dry film thickness for any primer shall not exceed the specified "mdft" by more than 30 % and for other paints by more than 75 %.

h) Each coat of paint of a specified system shall have satisfactory adhesion as demonstrated by an adhesion test approved by the Engineer.

i) Each applied specified paint coat shall be free from defects, including cratering, pin-holing, blistering, rivelling, sagging, bittiness, dry spray and cissing etc. The presence of these defects shall be determined by unaided visual assessment. The presence of pin holing or porosity shall be determined by low or high-voltage detectors (at corners, bolted joints and welds pin-holing shall be exempted). The finished system shall have an even and uniform appearance with no defect and the finishing paint in visually sensitive areas shall be from the same batch.

j) The gloss level of the finishing coat shall be established before the procedure trials. A painted tin plate reference panel, 150 mm x 100 mm, shall be provided by the Contractor for this purpose.

k) All successive coats in a system including the stripe coats shall be contrasting colours to aid identification.

l) Two-pack chemically cured paints shall not be applied when the steel or ambient temperatures are below those advised by the paint manufacturer, nor shall such paints be applied when the temperature is likely to fall below the advised temperatures during the period.

3.13.2 Stripe Coats

a) Stripe coats shall be applied to all welds and all fasteners including washers and to all external corners except those of RHS. The first stripe coat, using second undercoat paint, shall be applied over the primer, sealer or Item 155. When a second stripe coat is specified, it shall be separated from the first stripe coat by an undercoat. The first stripe coat on fasteners treated with Item 155 shall be applied by brush: other stripe coats may be applied by brush or airless spray as appropriate.

Note:
Item 155 in BD 35:
Description: 'T' wash,
Coat Type: Adhesion promoter for hot dip galvanized steel,
Build: LB (Low Build, dft: below 50 micron),
Applied by: B (Brush),

A solvent shall be used to remove final traces of grease from fasteners before treatment with Item 155.

The Contractor shall enter the details of the stripe coats he has selected in Appendix Form, Paint System Sheet giving the Item No., colour and method of application.

b) Square solid infill bars shall, after the second undercoat has been applied, be given an extra coat of first undercoat in lieu of stripe coats.

3.13.3 Exposure Times for Prepared Steel Surfaces and for Metal Coatings.
Exposure Times and Treatment of Item 155 and Over coating Times for Paints

a) Clean steel prepared by dry blast cleaning or bright steel prepared by abrading or by grinding shall be primed within 4 hours.

b) Clean steel prepared by wet blast cleaning only, shall be primed within 4 hours of being dry enough for painting.

c) Clean steel prepared by combined wet/dry blast cleaning shall be primed within 4 hours of dry blast cleaning.

d) Steel or steel work blast primed at the mills or in the workshop shall be overcoated within 8 weeks. The primed surfaces shall only be exposed outside for a maximum of 2 weeks of the 8 week period. Prepared surfaces affected by detrimental contamination or corrosion shall be restored before overcoating.

e) Workshop steelwork, which has been thermally metal sprayed, shall be primed and sealed within 4 hours. The next coat shall be applied within 72 hours.

f) Workshop prepared steel surfaces, unsealed thermally sprayed metal coating and undercoats, except final workshop undercoat, shall not be exposed outside.

g) Shop prepared steel surfaces, unsealed metal spray coatings and undercoats, except final shop undercoat, shall be exposed outside.

h) All surfaces treated with Item 155, except those of fasteners which have been treated in compliance with Clause 3.3.2, c), shall, after initial drying, be wet cleaned in compliance with Clause 3.2.3, a) taking care not to remove adhering Item 155, and allowed to dry before over coating. The first coat of paint shall be applied within 48 hours of the surfaces treated with Item 155 being first dry enough for painting over.

i) When hot dip galvanized steel is to be protected by a paint system, Item 155 shall be applied not later than 14 days after delivery to site.

j) When hot dip galvanized steel is to be erected in a Marine environment and is to be protected by a paint system, Item 155 and the workshop coats shall be applied within 7 days after hot dip galvanizing.

k) A first workshop undercoat shall be overcoated within 72 hours. Unless otherwise agreed with the Engineer, further workshop coats shall be applied within 72-hour intervals per coat.

l) The application of sealant in gaps in compliance with Clause 3.3.2, m) may be carried out either before or after application, as appropriate, of the first coat of paint to be applied to the completed joints or assembled plies.

m) Prepared steel surfaces and thermally sprayed metal coatings which have been restored, also paint coats and hot dip galvanizing which have been prepared after surface damage or deterioration shall be overcoated with the sealer primer or first undercoat as appropriate before the surfaces have been affected by moisture and in any case within 4 hours.

n) On site, steel surfaces and thermally sprayed metal coatings shall be primed or sealed within 4 hours and shall have the following coat applied within 72 hours unless otherwise agreed with the Engineer. The next coat shall be applied within a further 72 hours unless otherwise agreed with the Engineer.

o) On site, shop applied paint coats on clean steel or metal coating shall be over coated within 7 days. Subsequent coats of paint shall be applied within 7 days of applying the previous coat unless otherwise agreed with the Engineer.

3.14 Procedure Trials

a) Unless otherwise described the Contractor shall carry out shop and site procedure trials of the protective system when more than 50 litres of any coat of paint are to be applied to Difficult Access' road –bridge and gantry steelwork.

Procedure trials are not required for footbridges.

Procedure trails are not required for system applied to joints or for galvanizing only. The procedure trials shall be completed at least ten days before the start of application of the systems on the main steelwork. The trails shall be carried out with the labour and equipment to be used for the work.

b) The Contractor shall provide for the shop trials, samples of steel from 2 sq.m. to 10 sq.m. representing the main steel work, galvanized when necessary as required by the Engineer. The Contractor shall demonstrate his ability to carry out blast cleaning, to apply metal spray coatings described in Appendix 6 and the paints he has selected. He shall provide sufficient paint for the trails.

c) Metal spray application and painting of the main steelwork shall not be started in the shops or on site until procedure trails have been completed to the satisfaction of the Engineer.

d) Any adjustment to the registered paint formulations shown to be required by the trials, other than an adjustment to the solvent shall be agreed with the Engineer and made at the paint manufacturer's works.

e) Unless otherwise agreed by the Engineer, the Contractor shall carry out further procedure trials whenever he employs replacement skilled labour or proposes to use equipment of a different type.

3.15 Storage and Transport of Steel and Fabricated Steelwork.

a) Steel awaiting fabrication for the Works and uncoated steelwork shall be adequately protected from contaminants liable to cause heavy rusting and possibly pitting of the surfaces

b) Steelwork shall not be loaded for transport until the paint system is sufficiently hard for handling.

c) During storage, steelwork shall be kept clear of the ground and shall be laid out or stacked so as to prevent water or dirt accumulating on or against any of the surfaces. Suitable packings shall be placed between layers of stacked steelwork. When cover is provided, it shall be ventilated sufficiently to keep condensation to a minimum.

d) Components weighing less than one tone shall be kept in a storage area away from their erection point in order to minimise damage to protective coatings.

e) Lengths of parapet and individual steel lighting columns and masts shall be supported on timber, and precautions taken to prevent damage to their protective coatings and ingress of water. They shall only be positioned adjacent to their erection point immediately before erection. If the planned erection time is delayed by more than 72 hours, the components shall be returned to the storage area.

f) If in the opinion of the Engineer, damage to coatings is excessive, or may be difficult to deal with satisfactorily after erection, the Contractor shall restore the coating before erection.

3.16 Surface in Contact with Concrete

a) Unless otherwise described, thermally sprayed metal coating and all workshop paint coats shall be returned 25 mm into the concrete/steelwork contract area.

b) Where aluminum metal spray, which has been sealed only, is returned into the contact area, it shall be given a coat of Item 110 of 30 microns "mdft", not later than 48 hours before concreting. Application of the paint outside the contract area shall be prevented, by masking if necessary.

c) Hot dip galvanized coatings shall be applied overall. Unless other wise described, concrete may come into direct contact with the hot dip galvanized surfaces.

Note:
Item 110 in BD 35:

Description:	Zinc Phosphate Epoxy (two-pack),
Coat Type:	Blast Primer/sealer,
Build:	LB (Low Build, dft: below 50 micron),
Applied by:	B (Brush, to small areas only) or AS (Apply by airless spray).

3.17 Appendix 508: Paint System Sheets

a) During the detailed design of steel structures, the Contractor shall submit for approval a copy of Appendix 508.1 through 508.5, Paint System Sheets, of which he shall have completed for each paint system.

b) After the Engineer's written approval, the approved Paint System Sheets shall be used for the checking of the paint system.

3.18 Access and Lighting

a) Access for inspection by the Engineer shall be provided and erected by the Contractor. The access shall be agreed with the Engineer as being adequate in all respects for inspection purposes.

b) Manual surface preparation and coating application work shall not be carried our when light intensity at the workface is less than 500 lux. When the natural light intensity falls below this level, the Contractor shall install and maintain temporary lighting which shall provide a minimum light intensity of 500 lux over at least 1.0 sq.m. at the workface during the work and also for inspection when required by the Engineer.

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508.4 Measurement

The measurement for painting shall be the surface area to be painted. The surface area is calculated as follows:

1) I-girder: Exterior surfaces and contact surfaces separately.
2) Box-girder: Exterior and Interior surfaces and contact surfaces separately.

Painting will be categorised into two:

1) Painting in fabrication stage,
2) Painting in permanent erection stage.

508.5 Payment

The work measured as provided above shall be paid for at the Contract unit price per square metre and shall be full compensation for the preparation of the metal surface prior to and between coat and applying the surface protection including all labour, plant equipment, samples, testing tools and incidentals necessary to complete the work prescribed in the contract.

Pay item	Unit of Measurement
1) Fabrication stage	
508 (1) Painting (Exterior, t=300 microns)	square metre
508 (2) Painting (Interior of box girders, t=200 microns)	square metre
508 (3) Thermal Spray for Contact Surface	square metre
2) Permanent erection stage	
508 (4) Painting for Exterior Surfaces of Contact Surface (t=300 microns)	square metre
508 (5) Painting for Interior Surfaces of Contact Surface (t=200 microns)	square metre

APPENDIX 508.1

PAINT SYSTEM SHEETS - BRIDGE STEEL SUPERSTRUCTURE

1. Surface Preparation. Bridge steelwork, fabrication stage.

All exterior main surfaces, including shop welds and 50 mm edge strip on the top surface of the top flange of the main beams to be blast clean with chilled cast iron grit to clean steel, 1st Quality Medium profile.

The top surface of the top flange of the main beams (except 50 mm edge strip) and stud shear connectors to be blast cleaned with chilled cast iron grit to bare steel (blast cleaned or abraded).

Interfaces (including those on packer plates) at High-Strength Friction Grip (HSFG) bolted connections to be blast cleaned with chilled cast iron grit to 1st Quality, Medium profile and to receive the aluminium metal spray until erection is complete.

2. Surface Preparation. Bridge Steelwork, erection stage.

After erection and after final tightening of HSFG bolts, all exterior main surfaces should be thoroughly washed to the approval of the engineer before applying the site paint system, which will include the 1st and 2nd shop coats to HSFG areas before applying the site coats.

Surfaces of site welds and weld-affected areas shall be wire brush, wet clean or blast clean to 1st Quality, Medium, profile to remove slag, prior to the application of the complete corrosion protection system.

3. Application Instructions:

a) All surfaces to receive protective coatings, except the top surface of the top flange of the main beams with shear connectors.
b) The method of application to be entered on the Paint System Sheet to this Appendix by the Contractor's paint supplier.
c) All work is to be to the approval of the Engineer

4. Fasteners

Unless otherwise specified on the drawings, bolts, nuts and washers in bridge steelwork shall be supplied zinc plated.

5. Paint Suppliers

Paints for any one system shall be obtained from the same manufacturer.

APPENDIX 508.2

PAINT SYSTEM SHEET - STEEL PARAPETS AND PEDESTRIAN GUARDRAIL

1. Surface Preparation.

All surfaces, subject to accessibility will be pickled for galvanising all in accordance with Section 508, Clause 3.10 of the Specification.

2. Protective Systems

Metal coating – Galvanising

1st Coat:	"T" wash
2nd Coat:	Zinc Phosphate Undercoat
3rd Coat:	MIO AR Undercoat
4th Coat:	MIO AR Finish, medium grey
Minimum total dry film thickness:	200 μm.
Colour of Finish:	Medium Grey 00A 90 BS4800

All in accordance with Section 508 of the specification. For parapets, the "T" wash, the 2nd and 3rd coats shall be applied in the shops; the 4th coat may be applied in the shops or on site at the Contractor's opinion. If the full corrosion protection system is applied in the shops the contractor is to ensure that the painted items have adequate protection during transit to minimise damage.

For corrosion protection system for pedestrian guardrails on footways refer to the fabrication drawing.

APPENDIX 508.3

PAINT SYSTEM SHEET - BEARINGS

1. Surface Preparation.

Area A: Exterior surfaces, except wearing surfaces but including a 25 mm return on surfaces of the top bearing plates and base plates in contact with grout or mortar.

Method: Blast clean with chilled grit iron.
Standard: Clean steel, 1st Quality, Medium profile.

Area B: Central area of the top bearing plate and spreader base plate surfaces in contact with grout or mortar.

Method: Blast clean with metallic abrasive.
Standard: Clean steel, 2nd Quality, Medium profile.

Area C: Area of top bearing plates or base plates in contact with structural steel components

Method: As Area A
Standard: As Area A

Area D: Exposed shop fasteners in components to be coated after assembly.

Method: As Area A.
Standard: As Area A

Area E: Concealed shop fasteners

Method: No requirement
Standard: No requirement

Area F: Site fasteners for fixing bearings to piers or abutments and for fixing bridge components to bearings. Restore metal coating as necessary to original standard of cleanliness.

2. Protective Systems

Area A: Aluminium metal spray minimum thickness 150 μm.

1st Coat Aluminium Epoxy Sealer (2 pack)
B. Application rate: 0.05 to 0.07 1/m

2nd Coat MIO Epoxy Primer (2 pack), B or AS "mdft" 50μm.

3rd Coat MIO Epoxy Undercoat/Finish (2 Pack), B or AS “mdft” 50μm
Minimum combined dry film thickness for 2nd and 3rd coats 115μm.
Additional coats for bearings for steel or concrete bridge beams.

Over Area A

4th Coat: MIO Epoxy Undercoat/Finish, (2 pack), B or AS “mdft” 50μm.

5th Coat: MIO Epoxy Undercoat/Finish, (2 pack), B or AS "mdft" 50µm.

Minimum total dry film thickness for paint system 225µm.

Colour to match finish or main steelwork.

Aluminium metal spray plus Aluminium Epoxy Sealer (2 pack) only, are required on interfaces of machined surfaces of spreader base plate and of bearing.

Area B: MIO Epoxy Primer (2 pack) "mdft" 50µm.

Area C: Aluminium metal spray minimum thickness 150µm.

1st Coat: Aluminium Epoxy Sealer (2 pack) B. Application rate: 0.05 to 0.07 l/m.

2nd Coat: MIO Epoxy Primer (2 pack), B or AS "mdft" 50µm.

3rd Coat: MIO Epoxy Undercoat/Finish (2 Pack), B or AS "mdft" 50µm.

Minimum combined dry film thickness for 2nd and 3rd coats 115µm.

Area D: As area A

Area E: Fasteners unprotected by grease shall be zinc electroplated.

Area F; Metal Coating: Zinc electroplating.

1st Coat: "T" wash

2nd Coat: Epoxy Primer (2 pack), B or AS. "mdft" 50µm

3rd Coat: MIO Epoxy Undercoat/Finish (2 pack), B or AS "mdft" 50µm.

5th Coat: MIO Epoxy Undercoat/Finish (2 pack), B or AS "mdft" 50µm.

Minimum total dry film thickness 225µm.

Alternative 4th and 5th coats As Area A

3. Application Instructions.

Areas A, B or C and D

The aluminium metal spray and 1st, 2nd and 3rd coats shall be applied by the bearing manufacturer at his works.

Area A

The 4th and 5th coats shall be applied by the bearing manufacturer at his work.

Area F

"T" Wash shall be applied on site, either before or after erection, to surfaces to be painted. "T" wash coming into contact with adjacent paint coats shall be removed

immediately.

The remaining site coats shall be applied to exposed surfaces after erection.

Stripe coats for bearings only: (stripe coats are not required for bearing site fasteners).

A 1st stripe coat of undercoat shall be applied over the MIO Epoxy Primer by the bearing manufacturer.

A 2nd stripe coat of last undercoat shall be applied on site. MIO Epoxy coats shall be contrasting colours, e.g. medium grey, dark grey.

4. Paint Suppliers

Paints for any one system shall be obtained from the same manufacturer.

APPENDIX 508.4

PAINT SYSTEM SHEETS - PAINT DATA SHEETS

Manufacturer :

Registered Description :

Brand Name and Reference No :

Consistency and Method of Application :

Weight per 5 Litres (kg) :

Volume Solids % :

Manufacturer's Minimum
Dry Film Thickness Range
Recommended lower "mdft" :
Recommended upper "mdft" :

Full Application Instructions :

Flash Point :

Dry Times at 20°C Surface dry :
Hard dry :
Overcoating :

Cleaning Solvent :

Effect on Drying Times of
Temperatures below 20°C :

Manufacturer's Application Restrictions,
e.g. for Temperatures or Humidity :

Manufacturer's General Recommendation :

APPENDIX 508.5

PAINT SYSTEM SHEETS - PAINT SAMPLE ANALYSIS REPORT

From: Laboratory Name :

To :

Name :

Address :

Telephone confirmation :

Contract Title :

Bridge Name and/or No :

Samples Despatched from :

Despatch Date on :

Samples Received at :

Paint Manufacturer :

Satisfactory Samples

Sample No.	Reference No.	Batch No.

Unsatisfactory Samples and Technical Comment

Sample No.	Reference No.	Batch No.

Signed: Date:

(Section 509 is not used.)

SECTION 510

BRIDGE EXPANSION JOINTS

510.1 Description

The Contractor shall furnish and install bridge expansion joints and sealing of gaps in bridge deck. This work shall consist of furnishing and installing pre-moulded and flexible expansion joints and sealing materials, in accordance with the manufacturer's recommendations. Expansion joints shall have good riding quality and skid resistance and shall not cause a hazard to any class of road user.

Expansion joints in bridge decks shall be capable of sustaining the loads and movements without damage to the surfacing or supporting structure. The same joint system, seal or sealant shall continue across the full width of the deck including footway, verge, hard strip, hard shoulder and central reserve. Different joint systems shall not be combined at one end of a deck.

The locations and types of expansion joints are as given in the Drawings. The manufacturer is to be made aware of the location of the expansion joints.

Expansion joints shall be constructed to provide absolute freedom of movement through a movement range consistent with the design.

510.2 Materials

2.1 Asphaltic Plug

The joint shall be constructed in layers using a mixture of flexible bituminous material and aggregate to provide not only a homogeneous expansion medium but also the running surface at carriageway level. This material shall be used for minor bridges (overpass bridges).

The aggregate classification and grading curve shall be in accordance with BS 812: 1975, Parts 101 and 102: 1984 and Part 103.1: 1985. The water absorption, impact, crushing and abrasion properties of the aggregates shall be in accordance with BS 812: Parts 1 and 2: 1975.

2.2 Reinforced Elastomeric Expansion Joint

Reinforced Elastomeric expansion joints are prefabricated units which span the deck joint gap and are in either an elastonomer or elastomer reinforced with metal plates. This material shall be used for major bridges (other than Overpass bridges).

2.3 Dowel Bars

The dowel bars shall be of stainless steel made from either Type 304 S 31 or 316 S 33 and

Grade 250 or 460 to BS 6744.

For expansion joints, a closely fitting cap 100mm long consisting of waterproofing cardboard or suitable synthetic material shall be placed over one end of each dowel bar.

2.4 Bedding Mortar

Bedding mortar shall be chloride free, shrinkage-compensating grout and shall have a minimum strength of not less than 50 N/mm2 at 28 days. The thickness of grout shall be not less than 12 mm or more than 25 mm. It shall be mixed, applied and cured in accordance with the manufacturer's recommendation.

510.3 Construction Methods

3.1 Shop Drawings and Working Drawings

Prepare calculations showing joint settings for installation before installing joint in any bridge deck. Submit shop drawings and working drawings, in accordance with the requirements and procedure stated in Specification Section 113, showing the installation procedure and joint using proprietary joint systems. Submit shop drawings for approval. Work on the deck joint seal before the drawings are approved is not permitted.

3.2 Storage and Preparation

Expansion joint material delivered to the bridge site shall be stored under cover, on platforms above the surface of the ground. It shall be protected at all times from damage and when placed it shall be free from dirt, oil, grease or other foreign substances.

The pre-moulded material shall be used in as large pieces as possible. Small areas of square metre or less shall be made of one piece. The material shall be cut to a clean pure edge with a sharp tool. Rougher ragged edges will not be permitted. The material shall be placed so that it will be securely held in the form and well fastened to one face of the concrete. Care must be taken to ensure straight lines at the joint.

3.3 Installation of Expansion Joints

3.3.1 Asphaltic Plug

- Expansion gap shall be covered with masking strip (hardboard or plywood) with wood fillet engaging in expansion gap with sufficient clearance to allow for thermal movements.
- Surfacing laid over the joint
- Saw cut each side of the masking strip
- Surfacing and masking strip removed and exposed concrete prepared and cleaned. Sawn edges primed with waterproof sealer.

- Install joint material.

3.3.2 Reinforced Elastomeric Joint

- The positioning of holding down bolts and anchorage system shall be checked for accuracy before the casting of concrete commences. Templates or shuttering shall be fixed to box out the concrete for the joint and to locate holding down bolts or anchorage pockets. Threaded parts shall be protected from damage, kept clean and free from rust.
- Where the surfacing and bridge deck waterproofing are to be removed to accommodate the bridge joint these shall be cut to a clean straight line for the full depth of the surfacing without damage to the concrete substrate.
- Before installation of the joint, the concrete surfaces shall be free from laitance, sound, clean and comply with the manufacturer's requirements.
- The expansion joint and the bridge deck waterproofing shall be formed so that a watertight seal is provided. Where prefabricated units are used, the seal between each unit shall be made watertight and in addition a secondary waterproofing system in the form of a continuous membrane shall be installed.
- The gap width shall be set, in relation to the prevailing deck temperature, with the joint gap sides parallel. Seals which are not held in metal runners shall remain in compression for the full range of joint movement.
- Expansion joints shall be of uniform width and straight alignment and shall be accurately set and finished and aligned with the finished surface.
- During the placing and hardening of the bedding and bonding materials, movement between the joint and the substrate shall be prevented.
- Before vehicles traffic the joints, temporary cover capable of withstanding vehicular loading shall be provided over expansion joints during and after their installation as appropriate for protection and shall remain in place until the Engineer permits their removal.

3.3.3 Sealing of Gaps

- Joint filler board and sealant shall be compatible.
- Gunned or poured sealants shall be placed when the temperature of the structure is such that any movements which may take place will not cause the strain in the sealant to exceed the maximum value recommended by the manufacturer.
- Immediately before sealing, the Contractor shall ensure that the sides of the joint gap are clean, dry and free from loose material. Any concrete projections into the gap shall be removed.

- All seals shall, where practicable, be poured or fixed in one continuous length. Where required, a joint in a seal shall be located and formed in accordance with the manufacturer's instructions.
- Where gunned or poured sealants are visible, the concrete shall be masked on either side of the joint with suitable tape prior to the placement of the sealant to prevent its adherence to the exposed concrete surface. The tape shall not stain the concrete surface.

510.4 Measurement

The quantity of expansion joint measured for payment shall be the number of linear metres complete in place and accepted.

510.5 Payment

This work measured as provided above for the particular item specified shall be paid for at the Contract unit price for the particular unit of measurement for the item. The payment shall be full compensation for furnishing and placing all materials including all labour, tools, equipment and incidentals necessary to complete the work prescribed. Payment for dowel shall be full compensation for furnishing and placing all materials including end caps and slip sleeves, labour, tools, equipment and incidentals necessary to complete the work prescribed.

Pay Item		Unit of Measurement
510(1)	Expansion joint Type-Asphaltic Plug	metre
510(2)	Expansion joint Elastomeric Type for 50 mm gap	metre
510(3)	Expansion joint Elastomeric Type for 75 mm gap	metre
510(4)	Expansion joint Elastomeric Type for 100 mm gap	metre

SECTION 511

BRIDGE BEARINGS

511.1 Description

The Contractor shall furnish and install bridge bearings. This work shall consist of furnishing and installing bridge bearings in accordance with the manufacturer's recommendations.

The locations and types of bridge bearings are as given in the Drawings. The manufacturer is to be made aware of the location.

511.2 Materials - Elastomeric Bearing

Elastomeric bearings as herein specified shall include plain bearings (consisting of Elastomer only) and laminated bearings (consisting of layers of Elastomer restrained at their interfaces by bonded laminates).

The Elastomeric bearings shall conform to the requirements of BS 5400:Part 9: Section 9.2.

The Contractor shall furnish to the Engineer a certification by the manufacturer that the elastomeric in the elastomeric bearing pads to be furnished conforms to all of the requirements of the Specification. The certification shall be supported by a certified copy of the results of tests, performed by the manufacturer upon samples of Elastomeric to be used in the pads covering all requirements.

511.3 Construction Methods

The Contractor shall submit shop drawings and working drawings, in accordance with the requirements and procedure stated in Specification Section 113,, manufacture and test bearings.

- The bearings shall be supplied and installed in compliance with the Specification Clauses of BS 5400:Part 9: Section 9.1 for Design of Bearings in Highway Bridges.
- The bearing pads shall be installed to the appropriate sitting as directed by the Engineer. When they are set on thin beds of neat cement grout, the grout shall be allowed to harden before the beams are erected.
- Elastomeric bearings without external load places can be place directly on a concrete or steel surface provided that it is flat to within tolerance of 0.005 of the nominal dimension for others.
- Use grout or other directed means to correct any lack of parallelism between the top of the bearing and the underside of the girder that exceeds 0.01 radians.

- The bearing shall be maintained in their correct position during the placing of the bridge deck. After the deck has been completed each bearing and the area around it, shall be left clean.

511.4 Measurement

The quantity of bridge bearings shall be the number of each type, size and thickness of pad completed in place and accepted.

511.5 Payment

This work measured as provided above for the particular item specified shall be paid for at the Contract unit price for the particular unit of measurement for the item. The payment shall be full compensation for furnishing and placing all materials including all labour, tools, equipment and incidentals necessary to complete the work prescribed.

Pay Item		Unit of Measurement
511(1)	Bearing for I-Girder (Fixed - 560x310x44)	number
511(2)	Bearing for I-Girder (Fixed - 360x260x36)	number
511(3)	Bearing for I-Girder (Fixed - 410x310x40)	number
511(4)	Bearing for Ix Girder (Free - 560x360x56)	number
511(5)	Bearing for I-Girder (Free - 560x360x62)	number
511(6)	Bearing for I-Girder (Free - 410x310x50)	number
511(7)	Bearing for I-Girder (Free - 560x 310x56)	number
511(8)	Elastomeric enclosed by steel plates type 800 kN, Mov.	number
511(9)	Elastomeric enclosed by steel plates type 1,250 kN, Fix.	number
511(10)	Elastomeric enclosed by steel plates type 1,250 kN, Mov.	number
511(11)	Elastomeric enclosed by steel plates type 3,500 kN, Fix.	number
511(12)	Elastomeric enclosed by steel plates type 2,000 kN, Mov.	number
511(13)	Elastomeric enclosed by steel plates type 4,000 kN, Fix.	number

(Section 512 is not used.)

SECTION 513

MISCELLANEOUS ITEMS FOR STRUCTURES

513.1 Description

This work shall consist of furnishing miscellaneous items as indicated on the Drawings, which are not covered elsewhere in the Specification. Included are such items as rainwater inlets, dowel bars, nameplates, cover slabs and other incidental items, not specified elsewhere.

513.2 Materials

- Concrete shall conform to the requirements of Section 503 of the Specification.
- Reinforcement, where required, shall conform to the requirements of Section 504 of the Specification.
- Filter Layer (Geotextile 9.5 kN/m) behind the Box culverts shall conform to Section 606 Geotextile.

Other material shall comply with relevant sections of the Specifications, British Standards and the Drawings.

513.3 Construction Methods

Construction methods and installation of the items shall be in accordance with the Specification or manufactures instruction and be to the satisfaction of the Engineer.

Following mesh fences will be installed to prevent objects from falling down.
Pay Item 513 (6): Bridge Mesh Fence (Type-1) for Overpass Bridges,
Pay Item 513 (7): Bridge Mesh Fence (Type-2) for Highway Bridges,
Pay Item 513 (9): Bridge Mesh Fence (Type-3) before Highway bridges, along the Highway, L=20 m in the left side only.

Pay Items 513(11) Dry Stone Lining and 513(12) Filter Layer (Geotextile, 9.5 kN/m) will be used for backfill drainage material behind bridge abutment wall and box culvert wall.
Pay Items 513(15) Water Stop-
Water stop shall be PVC Dump Bell type, 150 mm wide. For construction joints formed in box culverts, water stop shall be installed along the joint between adjacent sections of concrete.
Pay Item 513 (19) – Precast Concrete Barrier as detailed in drawing No. K13-22 shall be constructed at Highway Bridge No. 14 at the location shown. Levelling concrete, 10 mm thick will be required for its installation.

513.4 Measurement

Miscellaneous structures will be measured for payment by the number of each item or length in metres or weight in kilograms, as indicated in the Special Provisions and the Bill of Quantities, completed and accepted in place.

513.5 Payment

This work measured as provided will be paid for at the Contract unit price for each particular item, such price and payment constituting full compensation for all material, tools, equipment and incidentals needed to complete the work. The complete work includes work associated with the item and indicated in the Drawing or elsewhere in the Special Provisions, if not specifically mentioned in an item of the Bill of Quantities.

Pay Item	Unit of Measurement
513(1) RC Panel for I Girder Slab	Sq. metre
513(2) RC Panel for Side Walk of Overpass bridge	Sq. metre
513(3) Bridge Catch Basin	number
513(4) Bridge Drainage pipe PVC 200 mm dia.	metre
513(5) Painting for parapet & Kerb	Sq. metre
513(6) Bridge Mesh Fence (Type-1) for Overpass Bridges	metre
513(7) Bridge Mesh Fence (Type-2) for Highway Bridges	metre
513(8) Bridge Rail for Overpass Bridges	metre
513(9) Bridge Mesh Fence (Type-3) before Highway Bridges	metre
513(10) Safety Net between Highway Bridges	Sq. metre
513(11) Name Plate	number
513(12) Bridge Pavement	tonne
512(12)-1 Filter Layer	Sq. metre
513(13) Precast Concrete Barrier	number
513(13)-1 Clay Pudding	Cubic metre
513(14) Joint Filler	Sq. m
513(15) Water Stop	metre
513(16) P.V.C Pipe 75 mm dia.	metre
513(17) Dry Stone Lining	Cubic metre
513(18) P.V.C Pipe 150 mm dia.	metre
513(19) Precast Concrete Barrier	metre
513(23) Stopper's Bar and Cap (Approach Slab)	number
513(25) Joint Filler for Approach Slab	Sq. metre

SECTION 600

DRAINAGE

SECTION 601

REINFORCED CONCRETE PIPE CULVERTS

601.1 Description

General

This work shall consist of reinforced concrete pipe excavated, furnished, installed and backfilled at such locations as are shown on the Drawings or required by the Engineer in accordance with the Specifications, the classes, lines and dimensions shown on the Drawings.

The work shall include the furnishing and construction of such joints and such connections to other pipes, catch-pits and other items as may be required to complete the structure as shown on the Drawings.

Standards

British Standards have been specified as standards for materials and workmanship.

However the contractor may employ materials manufactured to other internationally - accepted standards or Sri Lankan standards subject to Engineer's approval, which shall require submission of full documentation including test certificates for properties required by the relevant British Standard, carried out at an ISO 9001 - accredited laboratory by suitably qualified people.

Workmanship standards may be substituted with internationally-accepted workmanship standards not in conflict with the provisions of BS 5400 Parts 4, 7, 8 and 9.2 and BS 5911, subject to the Engineer's approval.

Site Survey

Before start of all drainage works, the Contractor shall conduct the site survey and check climate conditions, ground undulations, soil conditions, ground water, existing drainage structures and outlet to outside ROW. At the same time, he shall check the drainage and cross section drawings. If he founds any serious changes from the drawings, he shall consult with the Engineer and carryout ground surveys when necessary.

As a result of ground survey, if design changes are required, the Contractor shall propose the design as working drawings in consultation with the Engineer and obtain his approval. All the costs of the checking, survey, design changes and preparing working drawings shall be included in the unit rates of each construction, except otherwise agreed by the Engineer.

601.2 Materials

2.1 Pipe

(a) General - Reinforced concrete pipes shall conform to a strength class L, M or H as defined in BS 5911 and shall be constructed in accordance with the details shown on the Drawings.

(b) Concrete - Concrete shall be in accordance with Section 503 of the Specification, except where modified by the Drawings.

(c) Reinforcement - shall be in accordance with Section 504 of the Specification, except where modified by the Drawings.

The amount of water in the mix shall be such that the consistency of the mortar is suitable for the purpose intended and to the satisfaction of the Engineer.

All mortar shall be used within 30 minutes of adding the water.

2.2 Testing

(a) Test Specimens - The specified number of pipes required for the test shall be furnished without charge by the Contractor and shall be selected at random by the Engineer, and shall be pipe that would not otherwise be rejected under the Specification. The selection shall be made at the point or points designated by the Engineer, when placing the order.

(b) External Load Crushing strength test requirements - The proof load to produce a 0.25 mm crack or the ultimate load shall conform to the provisions contained in BS 5911 and supplemented in the Drawings. Pipes that have tested only to the formation of 0.25 mm cracks and that meet the 0.25 mm test load requirement shall be accepted for use.

The selection, acceptance or rejection of the pipe to comply with proof load test requirements shall be as described in BS 5911.

Pipes shall be considered as meeting the strength test requirements when all test specimens conform to the test requirements. Should any of the test specimens fail to meet the test requirement the contractor shall be allowed a retest on two additional specimens for each specimen that failed and the pipes shall be acceptable only when all of the retest specimens meet the strength requirements.

(c) Compression Tests - Compression Tests shall be carried out in accordance with the requirements of Section 503.

(d) Absorption Test Requirements of Concrete - The water absorption shall be conducted in accordance with BS 5911 and the increase in the dry mass of a single test piece by water absorption shall not exceed 3.6 % after 30 min. and 6.5 % after 24 hours.

(e) Test Equipment - Every Contractor furnishing pipes under the Specification shall furnish all facilities and personnel necessary to carry out the tests described in BS 5911.

2.3 Permissible Variations

(a) Permissible Variations

Permissible variations in dimensions shall be in accordance with Table 2 of BS 5911-100.

Pipes having localized variations in wall thickness exceeding those specified above shall be accepted if three edge bearing strength and minimum steel cover requirements are met.

(b) Permissible variations in the position of the reinforcement shall be plus or minus 10% of the wall thickness or plus or minus 10 mm whichever is greater. Pipes having variations in position of the reinforcement exceeding those specified above shall be accepted if the three bearing strength requirements obtained on a representative specimen are met. In no case, however, shall the cover over the reinforcement be less than 10 mm.

(c) Variations in laying lengths - Variation in lengths of a section of pipe shall not be more than 1% of the diameter with a maximum of 15 mm in any length of pipe, except where bevelled end pipe for laying on curves is specified by the Engineer.

(d) The variation in length of a section of pipe shall not be more than 1% of the diameter with a maximum of 15mm in any length of pipe.

2.4 Finish

Pipes shall be substantially free of fractures, large or deep cracks, and surface roughness. The ends of the pipes shall be at right angle to the centre line of the pipes.

2.5 Marking

The following information shall be clearly marked on each section of pipe.

(a) The pipe class

(b) The date of manufacture

(c) The name or trade mark of the manufacturer

2.6 Inspection and Rejection

Supplementing the requirements established in Clause 37.4 “Rejection” of the Conditions of Contract, the quality of materials, the process of manufacture and the finished pipe shall be subject to inspection and approval by an inspector employed by the Engineer.

Pipes shall be subject to rejection on account of failure to conform to any of the Specification requirements. Individual sections of pipe may be rejected because of any of the following:

(a) Fractures or cracks passing through the wall

(b) Defects that indicate imperfect proportioning mixture and moulding.

(c) Surface defects indicating honeycombed or open texture.

(d) Damaged ends where such damage would prevent the making of a satisfactory joint.

2.7 Repairs

Pipes may be repaired, if necessary, because of occasional imperfections in manufacture or accidental damage during handling and will be acceptable if, in the opinion of the Engineer, the repairs are sound and properly finished and cured and the repaired pipes conform to the requirements of the Specification.

601.3 Construction Methods

3.1 General

Pipes shall not be installed by the Contractor until the length called for at each station has been approved by the Engineer.

On laying the crossing culvert pipes under the high embankment, the difference of settlement between the embankment centre and the toe should be considered and the centre part should be raised beforehand, if required.

Unless otherwise directed by the Engineer, pipes to be laid on existing ground and/or under fill embankment shall have the fill constructed to a height or at least 0.60 m above the top of the pipe and then a trench excavated to receive the pipes. The method of excavation employed shall be as detailed in excavation, Clause 3.2 method (a). Where circumstances permit and only with the approval of the Engineer, the Contractor will be permitted to construct pipes on or in exiting ground without first forming embankment. When this approval is given, method (b) will be employed.

3.2 Excavation

Method (a):
The width of the pipe trench shall be sufficient to permit satisfactory jointing of the pipe and thorough tamping of the bedding material under and around the pipes.

Where rock, hard pan or other unyielding materiel is encountered it shall be removed below the foundation grade for a depth of at least 0.30m or 40mm for each metre of fill over the top of the pipe, whichever is greater, but not exceed three quarters of the inside diameter of the pipe.

Method (b):
Before laying, the ground shall be trimmed true to line and grade, as directed by the Engineer, over sufficient width to permit satisfactory construction of the bedding. Special care shall be taken to remove any hard or deleterious material from the foundation area.

When a firm foundation is not encountered and only soft, spongy or unstable soil is

found, they shall be removed for a width of at least one diameter on each side of the pipe and to the depth directed by the Engineer. After the removal, gravel or other suitable selected material shall be backfilled and compacted to provide adequate support for the pipe.

- Excavations for foundations and trenches shall be adequately supported at all times with Temporary works, shoring, sheetings and bracings.
- The sheeting and other excavation supports shall be removed as filling proceeds.

The prepared surface shall provide a firm foundation of uniform density throughout the length of the culvert.

Excavated materials shall not be deposited in the drainage channel but if suitable shall be utilized as backfill or embankment.

3.3 Bedding

Bedding for pipe shall be with the following materials and executed as specified below:

Unstable foundation ground shall be removed or reasonably treated until a stable foundation is formed.

The pipe bedding material shall be coarse aggregate of maximum size 10, 14, 20 or 40 mm conforming to BS 882

The selected backfill shall be backfill material conforming to the provisions of Section 203, Table 203-1.

Concrete shall be of grade 20.

The following classes of bedding shall be applied according to the Drawings (Structure, I. Culvert, Dwg. No. I-23):

- Class A Bedding: The pipe shall be laid on bedding concrete of Grade 20/20 with surrounding selected backfill as shown in the Drawings.
- Class B Bedding: The pipe shall be laid on a selected backfill up to a half of the diameter and the remainder in ordinary backfill as shown in the Drawings.
- Class C-1 Bedding: The pipe shall be encased in reinforced concrete as shown in the Drawings.
- Class C-2 Bedding: The pipe shall be encased in un-reinforced concrete.
- Class S: The pipe shall have a surround of selected backfill material as shown in the Drawings.

Cambering

Cambering of a culvert grade line shall always be considered before installation of the pipe is started. Subsidence varies widely depending on the fill height, the depth of foundation soil to a solid stratum and the compressible character of the foundation soil.

Camber shall not be used as a substitute for foundation stabilisation. Poor foundation shall be corrected before installing culverts and the amount of camber shall be based on the foundation soil profile after stabilisation

3.4 Installation

All reinforced concrete pipes shall be laid with cemented joints, unless flexible joints have been specified in the Drawings. The pipes shall be laid carefully, hubs up-grade, spigot ends fully entered into the adjacent hub, and true to lines and grades as shown on the Drawings or directed by the Engineer. Before succeeding sections of pipe are laid, the lower half of the hub of the preceding section shall be plastered on the inside with cement mortar (proportioned at 2 parts of sand per 1 part of cement) of sufficient thickness to bring the inner surface of the abutting pipes flush and even. At the same time the upper half of the spigot of the succeeding pipe shall be similarly plastered with mortar.

After the pipe is laid, the remainder of the joint shall be filled with similar mortar, and sufficient additional mortar shall be used to form a bead around the joint. The inside of the joint shall be wiped and finished smooth. The mortar on the outside shall be protected for two days or until the Engineer allows backfilling to proceed.

3.5 Backfilling

Backfilling shall be carried out with material approved by the Engineer placed in uniform layers not exceeding 0.15 m in uncompacted depth and thoroughly compacted. Each layer of backfill material, if dry, shall be wetted uniformly to a moisture content approved by the Engineer to obtain a density comparable with the density of the adjacent undisturbed material.

Special care shall be taken to compact thoroughly the material under the haunches of the pipe and to ensure that the backfill shall be brought up evenly on both sides of the pipe for the full required length. Heavy earth moving and compacting equipment shall not operate closer to the culvert by 1.5 m until covered to a depth equal to at least 25% of the diameter of the culvert, but in no case less than 0.60 m unless otherwise approved by the Engineer. Lightweight equipment may be operated within the above limitation after embankment has been placed and compacted to give a minimum cover of 0.30 m over the top of the culvert.

3.6 Placing of Embankment

Only when all backfilling has been completed in accordance with Clause 3.5 Backfilling, will the Contractor continue with forming embankment, which shall be done in conformity with the requirements of Section 203.

3.7 Headwalls and Wingwalls

Headwalls and Wingwalls shall be constructed in accordance with the requirements of Section 603.

601.4 Measurement

- Pipes shall be measured as the number of metres of pipe from end to end of each pipe structure, complete and accepted in place.
- Headwalls and Wingwalls for pipe culverts are included in Section 603.
- Structural excavation and backfilling for headwalls and wingwalls are included in Section 501.
- These items for Reinforced Concrete Pipes shall include:
  1) Excavation of acceptable and unacceptable materials
  2) Pipe bedding, laying, jointing and cutting
  3) Connection to headwalls and outfall works
  4) Formwork, backfilling and compaction
  5) Disposal of material
  6) Cleaning, surveying and recording
- Bedding, levelling concrete, cradles, joints, and other incidental works shall be made in accordance with the Drawings, but not measured for payment and it shall deemed be included in the prices introduced for the main item of pipe culverts.

601.5 Payment

Reinforced concrete pipes measured as provided above shall be paid for at the Contract unit price per metre for the particular size specified on the Drawings. The price shall be full compensation for furnishing, hauling and installing the pipe, jointing, excavation, backfilling, bedding, backfill and compaction for all labour, tools, equipment and incidentals necessary to complete the accepted structures.

No separate payment shall be made for the excavation of unsuitable material and its disposal.

Pay Item		Unit of Measurement
Type P-M(A)		
601(1)	Type P-M(A) – 450 mm dia.	metre
601(2)	Type P-M(A) – 600 mm dia.	metre
601(3)	Type P-M(A) – 900 mm dia.	metre
601(4)	Type P-M(A) – 1200 mm dia.	metre
601(5)	Type P-M(A) – 1500 mm dia.	metre
Type P-M(B)		

601(6)	Type P-M(B) – 450 mm dia.	metre
601(7)	Type P-M(B) – 600 mm dia.	metre
601(8)	Type P-M(B) – 900 mm dia.	metre
601(9)	Type P-M(B) – 1200 mm dia.	metre
601(10)	Type P-M(B) – 1500 mm dia.	metre
Type 2P-M(B)		
601(11)	Type 2P-M(B) – 450 mm dia.	metre
601(12)	Type 2P-M(B) – 600 mm dia.	metre
601(13)	Type 2P-M(B) – 900 mm dia.	metre
601(14)	Type 2P-M(B) – 1200 mm dia.	metre
601(15)	Type 2P-M(B) – 1500 mm dia.	metre
Type P-M(S)		
601(16)	Type P-M(S) – 450 mm dia.	metre
601(17)	Type P-M(S) – 600 mm dia.	metre
601(18)	Type P-M(S) – 900 mm dia.	metre
601(19)	Type P-M(S) – 1200 mm dia.	metre
601(20)	Type P-M(S) – 1500 mm dia.	metre
Type P-H(A)		
601(21)	Type P-H(A) – 450 mm dia.	metre
601(22)	Type P-H(A) – 600 mm dia.	metre
601(23)	Type P-H(A) – 900 mm dia.	metre
601(24)	Type P-H(A) – 1200 mm dia.	metre
601(25)	Type P-H(A) – 1500 mm dia.	metre
Type 2P-H(A)		
601(26)	Type 2P-H(A) – 450 mm dia.	metre
601(27)	Type 2P-H(A) – 600 mm dia.	metre
601(28)	Type 2P-H(A) – 900 mm dia.	metre
601(29)	Type 2P-H(A) – 1200 mm dia.	metre
601(30)	Type 2P-H(A) – 1500 mm dia.	metre
Type P-L(C-1)		
601(31)	Type P-L(C-1) – 450 mm dia.	metre
601(32)	Type P-L(C-1) – 600 mm dia.	metre
601(33)	Type P-L(C-1) – 900 mm dia.	metre
601(34)	Type P-L(C-1) – 1200 mm dia.	metre
601(35)	Type P-L(C-1) – 1500 mm dia.	metre
Type 2P-L(C-1)		
601(36)	Type 2P-L(C-1) – 450 mm dia.	metre
601(37)	Type 2P-L(C-l) – 600 mm dia.	metre
601(38)	Type 2P-L(C-l) – 900 mm dia.	metre
601(39)	Type 2P-L(C-l) – 1200 mm dia.	metre
601(40)	Type 2P-L(C-1) – 1500 mm dia.	metre
Type P-L(C-2)		
601(41)	Type P-L(C-2) – 450 mm dia.	metre
601(42)	Type P-L(C-2) – 600 mm dia.	metre
601(43)	Type P-L(C-2) – 900 mm dia.	metre
601(44)	Type P-L(C-2) – 1200 mm dia.	metre
601(45)	Type P-L(C-2) – 1500 mm dia.	metre
Type 2P-L(C-2)		
601(46)	Type 2P-L(C-2) – 450 mm dia.	metre
601(47)	Type 2P-L(C-2) – 600 mm dia.	metre
601(48)	Type 2P-L(C-2) – 900mm dia.	metre

601(49)	Type 2P-L(C-2) – 1200 mm dia.	metre
601(50)	Type 2P-L(C-2) – 1500 mm dia.	metre

SECTION 602

DRAINAGE DITCHES

602.1 Description

The Contractor shall construct drainage ditches with grouted stone riprap, concrete or reinforced concrete as shown on the Drawings.

602.2 Materials

2.1 Grouted Stone Riprap

Stone for riprap shall be derived from sound rock, approved by the Engineer. The stones shall, in general, be wide and flat with their larger faces roughly rectangular and parallel. The thickness of stone shall be 0.3 m (measured perpendicular to the faces of the stone). No face dimension shall be less than the thickness of the stone. Unless otherwise specified, each stone shall weigh approximately 30 kilograms.

2.2 Concrete

Concrete and reinforcement shall conform to the requirements of Section 500.

2.3 Mortar

Mortar shall be composed of one part of cement and two parts of sand by dry loose volume and sufficient water to make a mortar that can be easily handled and trowelled. Retampering of mortar that has not been used for periods of 45 minutes or longer will not be permitted. Cement for mortar shall conform to the requirement of Section 500.

602.3 Construction Methods

3.1 General

Unless otherwise specified, the drainage ditches shall always be constructed as an impervious layer upon designated surfaces. Stone riprap shall have mortared joints.

3.2 Side Ditch, Median Ditch and Vertical Ditch with Stone

(a) Excavation

Excavate to the required depth and compact base material. Replace soft, unacceptable material with approved material and compact.

(b) Installing

Set the front top face line to the required line and grade. Fill and tamp all spaces under the stone with the same material as the bed course.

(c) Joints

Lay stone with closed joints and fill with mortar, as specified.

(d) Backfilling

Fill remaining excavated areas with approved material in maximum 150 mm loose lifts. Compact to the density of the surrounding material.

3.3 Side Ditch with Cast-in-place Concrete

Excavate the ditch as Subsection 3.2. Use forms if necessary, mix and place concrete Grade 15 (Lean concrete) or Grade 30 (Side ditch) according to Section 500. Provide contraction and expansion joints, as required. Cure concrete and backfill and compact approved material to the specified elevations.

3.4 Pre-cast Side Ditch

Install under Subsection 3.2.

602.4 Measurement

Ditches will be measured for payment in metres for each type of ditch shown on the Drawings. The items for Drainage ditches shall include:

1) Excavation of acceptable and unacceptable materials

2) Disposal of material

3) Cutting, laying and bedding

602.5 Payment

This work measured as provided above shall be paid for at the Contract unit price for the items listed below. The price and payment shall be full compensation for all material, excavation, forms, screeding, curing precasting, handling, transportation, disposal of surplus material, backfill, mortar, joints, equipment, tools, labour and incidentals necessary to complete the work.

No measurement or allowance will be allowed for any excavation, backfilling or tamped fill in connection with ditches.

Pay Item		Unit of Measurement
602(1)	Type – DS(M) – A: **Ditches**	metre
602(2)	Type – DS(M) – B	metre
602(3)	Type – DS(M) – C	metre
602(4)	Type – DS(M) – D	metre
602(5)	Type – DS(M) – Ga	metre

602(6) Type – DS(M) – Gb	metre
602(7) Type – DS(M) – Gc	metre
602(8) Type – DS(M) – Gd	metre
602(9) Type – DS(M) – Ge	metre
602(10) Type – DS(M) – Gf	metre
602(11) Type – DS(M) – Gg	metre
602(12) Type – DS(M) – Gh	metre
602(13) Type – DS(M) – Gi	metre
602(14) Type – DS(M) – Gj	metre
602(15) Type – DS(M) – Gk	metre
602(16) Type – DS(M) – Gl	metre
602(17) Type – DS(M) – Gm	metre
602(18) Type – DS(M) – Gn	metre
602(19) Type – DS(M) – Go	metre
602(20) Type – DS(M) – Gp	metre
602(20)-1 Type – DS(M) – Gq	metre
602(20)-2 Type – DS(M) – Gr	metre
602(20)-3 Type – DS(M) – Gs	metre
602(20)-4 Type – DS(M) – Gt	metre
602(20)-5 Type – DS(M) – Gu	metre
602(21) Type – DV(M) – E: (Vertical ditch)	metre
602(22) Type – DS(E) – A	metre
602(23) Type – DS(E) – B	metre
602(24) Type – DS(E) – C	metre
602(25) Type – DS(E) – D	metre
602(26) Type - DS(M) – F	metre
602(27) Type – DS(C) – Aa	metre
602(28) Type – DS(C) – Ab	metre
602(29) Type – DS(C) – Ac	metre
602(30) Type – DS(C) – Ad	metre
602(32) Type – DS(C) – Ba	metre
602(33) Type – DS(C) – Bb	metre
602(34) Type – DS(C) – Bc	metre
602(35) Type – DS(C) – Bd	metre
602(36) Type – DS(C) – Ca	metre
602(37) Type – DS(C) – Cb	metre
602(38) Type – DS(C) – Cc	metre
602(39) Type – DS(C) – Cd	metre
602(40) Type – DS(C) – D	metre
602(41) Type – DS(C) – E	metre
602(42) Type – DS(C) – F	metre
602(43) Type – DS(C) – G	metre
602(44) Type – DS(C) – H	metre
602(45) Type – DS(C) – I	metre
602(45)-1 Type – DS(C) –J	metre
602(45)-2 Type – DS(C) – K	metre
602(45)-3 Type – DS(C) – La	metre
602(45)-4 Type – DS(C) – Lb	metre
602(45)-5 Type – DS(C) – M	metre
602(45)-6 Type – DS(C) – N	metre
602(45)-7 Type – DS(M)I	metre

602(45)-8 Type-CDS(C)L1a		number
602(45)-9 Type-CDS(C)L1b		number
602(45)-10 Type-CDS(C)H1b:	**Channel Drop Structure**	number
602(45)-11 Type-CDS(C)H2b		number
602(45)-12 Type-CDS(C)H3b		number
602(45)-13 Type-CDS(M)L1a		number
602(45)-14 Type-CDS(M)L1b		number
602(45)-15 Type-CDS(M)L1c		number
602(45)-16 Type-CDS(M)L1d		number
602(45)-17 Type-CDS(M)H1b		number
602(45)-18 Type-CDS(M)H2b		number
602(46) RCV – H:	**Catch Basin**	metre
602(47) RCVa		metre
602(48) RCVb		metre
602(49) RCVc		metre
602(50) RCVd		metre
602(53) AS – CB:	**Asphalt Kerb**	metre

SECTION 603

CATCH BASIN AND HEADWALL / WINGWALL

603.1 Description

The Contractor shall construct catch basins and Headwalls/Wingwalls for pipe culverts. (Headwalls/Wingwalls for box culverts are included in Section 500, Structures)

603.2 Materials

Concrete shall conform to the requirements of Section 503 of the Specification.

Reinforcement, where required, shall conform to the requirements of Section 504 of the Specification.

603.3 Construction Methods

Construction methods given under Sections 503 (Concrete) and 504 (Reinforcement) shall apply for this item, except as noted herein or in the Special Provisions.

- Use Grade 30 concrete.
- Make joints for precast catch basin to form flexible and watertight seal.
- Install pipe sections flush inside the structure wall. Place mortar neatly and tightly around the pipe.
- Build on stable foundations. Excavate and backfill under Section 200.
- Keep silt, debris and foreign matter away from each structure until work is accepted.
- Adjust catch basin covers to grade prior to placing asphalt wearing course material.

Underground drainage structures, including earthwork and backfilling incidental thereto, shall be completed before the adjacent roadway surfacing is placed, but pipe end-walls shall not be constructed until grading has been completed, as developments during construction may justify alterations in design or location of such end-walls. Inlets shall not be completed to final grade until after the grading has been finished and all necessary arrangements have been made to ensure suitable connections at proper grade and alignment with pavements, gutters, kerbs etc.

Gratings and frames for gratings and covers for inlets shall be set on full beds of mortar or be otherwise properly secured as indicated in the Drawings, so as to be held rigidly in place to proper grade and alignment.

Inlet and outlet of pipe culverts shall be set or cut flush with the inside faces of the walls of such structures and shall extend a sufficient distance beyond the outside faces of the walls to provide ample room for making proper connections. The joint around the pipe in

the structure wall shall be completely and neatly closed with mortar, or other materials as may be specified, so as to make it watertight.

603.4 Measurement

Catch basins and Headwalls/Wingwalls for pipe culverts shall be measured for payment by the number of each type.

603.5 Payment

Catch basins shall include for:

1) Excavation and backfilling
2) Locating existing drains,
3) Breaking into existing drains,
4) Connecting and re-connecting existing drains,
5) Covers and gratings,
6) Channels, fittings, benching inside,
7) Cleaning,
8) Steps, safety chains, ladders, handholds,
9) Lifting keys,
10) Concrete, formwork and reinforcement
11) Re-laying existing pipes disturbed.

Headwalls/Wingwalls for pipe culverts shall include for:

1) Excavation and backfilling
2) Concrete, formwork and reinforcement

This work measured as provided above will be paid for at the Contract unit price for each particular item, such price and payment constituting full compensation for all material, labour, tools, equipment, excavation and incidentals needed to complete the work. The complete work includes work associated with the structure and indicated in the Drawing or elsewhere in the Special Provisions, if not specifically mentioned in an item of the Bill of Quantities.

Pay Item		Unit of Measurement
603(1)	Catch Basin Type CB – A	number
603(2)	Catch Basin Type CB – Ba	number
603(3)	Catch Basin Type CB – Bb	number
603(4)	Catch Basin Type CB – Bc	number
603(5)	Catch Basin Type CB –Bd	number
603(6)	Catch Basin Type CB – E	number
603(7)	Catch Basin Type CB - Fa	number
603(8)	Catch Basin Type CB – Fb	number
603(9)	Catch Basin Type CB – Fc	number
603(10)	Catch Basin Type CB – Fd	number
603(11)	Catch Basin Type CB – Fe	number
603(12)	Catch Basin Type CB – G	number
603(13)	Catch Basin Type CB – H	number
603(14)	Catch Basin Type CB – I	number
603(15)	Catch Basin Type CB –J	number
603(15)-1	Catch Basin Type CB –M	number
603(15)-2	Catch Basin Type CB –La	number
603(15)-3	Catch Basin Type CB –Lb	number
603(15)-4	Catch Basin Type CB –Ka	number
603(15)-5	Catch Basin Type CB –Kb	number
Ditch Outfalls		
603(16)	Ditch Out Fall Type HW(C) – Aa	number
603(17)	Ditch Out Fall Type HW(C) – Ab	number
603(18)	Ditch Out Fall Type HW(C) – Ac	number
603(19)	Ditch Out Fall Type HW(C) – Ad	number
603(20)	Ditch Out Fall Type HW(C) – Ae	number
603(21)	Ditch Out Fall Type HW(C) – Af	number
603(22)	Ditch Out Fall Type HW(C) – Ag	number
603(23)	Ditch Out Fall Type HW(C) – Ah	number
603(24)	Ditch Out Fall Type HW(C) – Ai	number
603(25)	Ditch Out Fall Type HW(C) – Aj	number
603(26)	Ditch Out Fall Type HW(C) – Ak	number
603(27)	Ditch Out Fall Type HW(C) – Al	number
603(28)	Ditch Out Fall Type HW(C) – Am	number
603(29)	Ditch Out Fall Type HW(C) – An	number
603(30)	Ditch Out Fall Type HW(C) – Ao	number
603(31)	Ditch Out Fall Type HW(C) – Ap	number
603(32)	Ditch Out Fall Type HW(C) – Aq	number
603(33)	Ditch Out Fall Type HW(C) – Ba	number
603(34)	Ditch Out Fall Type HW(C) – Bb	number
603(35)	Ditch Out Fall Type HW(C) – Bc	number
603(36)	Ditch Out Fall Type HW(C) – Bd	number
Inlet/Outlet Type IO – S(P)		
603(37)	Head/Wing wall – Single Barrel 900mm dia pipe(S)	number
603(38)	Head/Wing wall – Single Barrel 900mm dia pipe(S2)	number
603(39)	Head/Wing wall – Double Barrel 900mm dia pipe(S)	number
603(40)	Head/Wing wall – Double Barrel 900mm dia pipe(S2)	number
603(41)	Head/Wing wall – Single Barrel 1200mm dia pipe(S)	number
603(42)	Head/Wing wall – Single Barrel 1200mm dia pipe(S2)	number

603(43) Head/Wing wall – Double Barrel 1200mm dia pipe(S)	number
603(44) Head/Wing wall – Double Barrel 1200mm dia pipe(S2)	number
603(45) Head/Wing wall – Single Barrel 1500mm dia pipe(S)	number
603(46) Head/Wing wall – Single Barrel 1500mm dia pipe(S2)	number
603(47) Head/Wing wall – Double Barrel 1500mm dia pipe(S)	number
603(48) Head/Wing wall – Double Barrel 1500mm dia pipe(S2)	number
Inlet/Outlet Type IO – C(P)	
603(49) Head/Wing wall at location 18+160(R)	number
603(50) Head/Wing wall at location 27+360(R)	number
Inlet/Outlet Type IO – D(P)	
603(51) Head/Wing wall at location 27+360(L)	number
Inlet/Outlet Type IO – E(P)	
603(52) Head/Wing Type IO-E(p)a	number
603(53) Head/Wing Type IO-E(p)b	number
603(54) Head/Wing Type IO-E(p)c	number
603(55) Head/Wing Type IO-E(p)d	number
603(56) Head/Wing Type IO-E(p)e	number
603(57) Head/Wing Type IO-E(p)f	number

SECTION 604

SUB-SURFACE DRAINS

604.1 Description

Sub-surface drains shall be provided underground to collect ground water and to prevent land slides. The locations are not shown on the Drawings but both the Contractor and the Engineer shall inspect the site (in particular seepage water from the cutting face) and the Engineer will decide the locations.

This work shall consist of perforated pipe underdrains constructed in accordance with the Specification and in accordance with the lines, levels, grades, sizes, dimensions and types shown on the Drawings (Dwg. No.L-03).

Horizontal drains in cutting sections will be designed by the Engineer during the construction and the payment will be made by Day works.

604.2 Materials

2.1 Pipes

Pipes for sub-surface drains shall be following materials or other approved material as shown on the Drawings and called for in the Bill of Quantities. Pipes supplied shall conform with the AASHTO Standard Specifications:

	AASHTO
Perforated concrete pipe	M 175
Porous concrete pipe	M 176
Polyvinyl Chloride (PVC) pipe	M 278 or M 304
Polyethylene (PE) corrugated drainage pipe	M 252 or M 294

2.2 Granular Material

The granular material (permeable backfill) for trench infill shall be hard and durable and either clean sand, gravel, or crushed stone. The gradation requirements shall be AASHTO M 80 with max. particle size of 37.5 mm.

2.3 Geotextile

The geotextile shall conform with AASHTO M 288, Class A or B and the requirements of Section 606 “Geotextile”.

604.3 Construction Methods

3.1 Trench and Bedding

Trenches shall be excavated to the width, line and grade as shown on the Drawings.

Unless shown otherwise, the depth shall vary from 1 m to 1.5 m below the finished surface at the top of the trench where the construction is under a gutter, ditch or road-bed and to depths required for proper drainage at other locations. Line the trench with a geotextile. A 100 mm bed of approved granular backfill material shall be spread in the bottom of the trench throughout its entire length and brought to a uniform grade.

3.2 Placing Pipes and Backfilling

Construction procedure will be as follows:

(a) Embed the perforated pipe at the bottom of the trench with perforations down. The last 3 m at the outlet end may be nonperforated pipe.

(b) Provide watertight joint using coupling fittings and bands. Terminate the pipe ends at nearest drainage to drain.

(c) After the pipes have been laid and have been inspected, and approved by the Engineer, porous backfill material shall be placed to the depth indicated on the Drawings. Care should be exercised not to displace the pipes or joint covering around and over the pipes. The upper portion of the trench shall then be filled with suitable porous material as shown on the Drawings. All filling material shall be thoroughly compacted.

All work shall be constructed to the dimensions and other requirements stated on the Drawings.

Sub-surface Drain Type DSS (G)-A: Without perforated pipe.
Sub-surface Drain Type DSS (G/P)-B: With perforated pipe (PVC), dia. 150 mm.

604.4 Measurement

The measurement of sub-surface drain shall be the summation of their individual lengths measured along their centre lines between the positions of terminations. Excavation, backfill and geotextile shall not be measured for payment.

604.5 Payment

The quantities of pipe underdrains, measured as provided above, shall be paid for at the Contract unit price per unit of measurement. The item shall include for:

- Geotextile,
- Excavation, disposal, backfilling and compaction,
- Perforated pipes
- Lapping and jointing,
- Termination of the pipe ends.

The price and payment shall be full compensation for furnishing and placing all materials

labour, equipment, tools and incidentals necessary to complete the work. Excavation and backfill shall not be measured for payment.

Pay Item	**Unit of Measurement**
604 (1) DSS(G) - A	metre
604 (2) DSS (G/P) - B	metre

SECTION 605

GABION

605.1 Description

The Contractor shall construct gabions for slope protection, flood plain protection (toe of embankment) and inlets/outlets of pipe and box culverts.

605.2 Materials

(a) Gabion mesh

Gabion mesh shall be manufactured from wire complying with BS 1052 having a minimum core diameter of 2.0 mm.

All wires shall be galvanized in compliance with BS 443.

(b) Gabion Filling

Gabions shall be sufficiently filled with selected granular material. The maximum size of fill material shall not exceed two-thirds of the minimum dimension of the gabion compartment or 200 mm whichever is smaller. The minimum size of the fill shall be 30-50 mm greater than the size of the mesh opening.

605.3 Construction

Gabion baskets shall be assembled in accordance with the manufacturer's instructions and shall be sufficiently filled with rock with an allowance for consolidation so as to minimise distortion during construction. Gabion baskets shall be maintained square and with vertical sides during filling. Internal tie wires shall be inserted and baskets shall be tensioned in accordance with the manufacturer's instructions. Gabion baskets shall be constructed so as to maintain tightness of mesh and shall be laced securely with wire complying with the requirements of Clause 605.2.

The baskets shall be filled with hard durable crushed stone. This fill shall comprise 100 mm to 150 mm well graded stone, it shall be not less than the mesh size (80mm) and not normally greater than 200mm. Filling shall be carried out by hand

Stagger vertical joints at 1/3 to 1/2 the length of the baskets.

605.4 Measurement

The measurement of gabion shall be the volume contained within the outline of the gabions:

- Gabion Box cu.m
- Gabion Cylinder cu.m

605.5 Payment

The items for gabion shall include for:

- Assembling, tying, fixing, staking and tensioning,
- Fill, compaction and finishes,
- Mesh including cutting and folding to form boxes and cylinders,

Gabion measured as provided above shall be paid for at the contract unit price and shall be full compensation for furnishing, installing and filling including all materials, labour, tools and incidentals necessary to complete the work.

Pay Item		Unit of Measurement
605(1)	Gabion (Box type - 2x1.2x0.5 m)	cu.m
605(2)	Gabion (Cylinder type ϕ 450 mm, L=4.0 m)	cu.m

SECTION 606

GEOTEXTILE

606.1 Description

This work shall consist of the placing of geotextile to separate or strengthen the earthworks materials.

606.2 Materials

Geotextile fabrics shall be manufactured from non-woven or woven and needle punched synthetic, polyethylene, or polypropylene materials. They shall be inert to all chemicals found in the soil and ground water and canal water and normally resistant to ultra violet light. They have a life expectancy when used in the conditions anticipated in the contract in excess of 50 years.

The following types of geotextile will be required in the works and the Contractor shall supply manufacturer's certified test certificates for the actual materials supplied to demonstrate compliance.

Item	Example-1, For drainage & earthworks separator	Example-2, High strength, woven, for high embankment
Tensile strength (ISO 10319)	9.5 KN/m	MD 800 KN/m CD 100 KN/m
Tensile elongation (ISO 10319, md/cd)	75 %/35 %	10%/10%
CBR puncture strength (ISO 12236)	1500 to 2500 N	-
Effective opening size (ISO 12956)	0.1 to 0.2 mm	-
Vertical water flow, 50 mm head (ISO 11058)	85-130 litter/sq.m./s	-
Thickness (ISO 9863)	1.2 to 2.0 mm	-
Long term design strength (120 years creep factor)	-	400 KN/m

Note: MD: Machine Direction,
CD: Cross Direction

606.3 Construction

Geotextile shall be stored on site away from direct sunlight in the manufacturer's wrapping in covered stores. They shall be carefully laid with minimum laps of 500 mm and any damage shall be patched to ensure at least a 300 mm overlap in all directions. They shall have sufficient allowance for subsequent settlement.

The layer of material on which the geotextile is to be placed shall not have protrusions or sharp projections which are likely to damage the geotextile during installation or service. The method of installation shall ensure that the geotextile is in continuous contact with the surface on which it is placed and the geotextile shall not be stretched or bridged over hollows or humps. Operation of construction plant directly on the geotextile will not be permitted and its covering with material shall take place immediately after its laying.

606.4 Measurement

The quantity of geotextile to be measured shall be the surface area covered in square metres of geotextile complete, accepted in place and allowance for subsequent settlement. Laps will not be measured.

606.5 Payment

The items for geotextile shall include for:

- Cleaning, trimming, regulating and preparing surfaces,
- Laps,
- Measures to protect material,
- Cutting, jointing, sealing and fixing,
- Securing material in place,
- Complying with the requirements of strengthened earthworks.

Laying of geotextile measured as provided above shall be paid for at the contract unit price for each type of geotextile which price and payment shall be full compensation for furnishing and all materials including labour, tools and incidentals necessary to complete the work.

Pay Item	Unit of Measurement
606 (1) Geotextile for Gabion (9.5 KN/m)	sq.m

(For other types of Geotextile, refer to Section 204: Soft Ground Treatment)

River Relocation Work

607 (1) Minor Flood Protection Scheme (Rakgahawatta)	ls.
607 (2) River Relocation	ls.

SECTION 700

INCIDENTALS

SECTION 701

STONE MASONRY

701.1 Description

This work shall consist of installation of slope protection (stone masonry) for embankment and cut slopes where the protection is necessary. The dimensions and locations as shown on the Drawings (Dwg.No.J-01) and instructed by the Engineer.

701.2 Materials

1) Rubble stone
Unweathered stone without worn, rounded, or weathered faces.

2) Other
Cement, water, sand aggregate and concrete specified in Section 503 and Dry stone lining in Section 513.

701.3 Construction Methods

1) Rubble stone
Furnish stone masonry free from depressions, with a minimum thickness 200 mm, a minimum width of 1.5 times the thickness, and a minimum length of 1.5 times the width, except headers.

2) Mortar
Proportion mortar by volume as follows:
1 part Portland cement and 3 parts sand approximately. Mix by hand or machine with enough water necessary to provide a workable mix. Use within 1.5 hours and before initial set. Ensure a 28-day compressive strength of 13 MPa.

3) Laying stone
Slopes to be protected by stone masonry shall be free of trees, plants, stumps and other objectionable material and be dressed to a smooth surface. Unsuitable soils shall be removed and backfilled with suitable soils which shall be compacted as required.

Unless otherwise specified or shown on the Drawings, the concrete foundation shall be at least 0.3 m below the bottom (toe) of the embankment. Where the embankment abuts streams, the foundations shall be placed at least 0.5 m below the stream bed.

Lay rubble masonry to line and in courses roughly levelled. Offset vertical joints a minimum 150 mm. Locate vertical joints not to occur directly above or below header.

Clean and saturate each stone with water before grouting. Provide weep holes through the wall.

701.4 Measurement

Stone Masonry shall be measured in sq. metres.

701.3 Payment

Payment for Stone Masonry shall include for all materials, cutting, shaping and face dressing, setting, jointing, grouting and pointing and all templates, centring, scaffolding and labour required to complete the works.

Pay Items	**Unit of Measurement**
701(1) Slope protection Type SM-A height not exceeding 1 m	sq. metre
701(2) Slope protection Type SM-A height exceeding 1 m not exceeding 3 m	sq. metre
701(3) Slope protection Type SM-A height exceeding 3 m	sq. metre
701(4) Slope protection Type SM-B height not exceeding 1 m	sq. metre
701(5) Slope protection Type SM-B height exceeding 1 m not exceeding 3 m	sq. meter
701(6) Slope protection Type SM-B height exceeding 3 m not exceeding 5 m	sq. meter
707(7) Slope protection Type SM-B height exceeding 5 m	sq. meter

SECTION 702

GREENERY WORK

702.1 Description

This work shall cover all operations, incidentals for the establishment of grass (turfing), planting of trees, palms, shrubs, foliage and ground covers including the soil improvement (mixing), watering, fertilizing, pegging in accordance with the specifications and at locations indicated on the drawings.

702.2 Materials

Materials shall confirm to the following:

2.1 Top Soil

Top soil shall consist of loose friable natural surface soil free of admixtures of sub soil, refuse, stumps, roots, rocks, weeds or other material which would be detrimental to proper development of vegetative growth.

2.2 Grass

Recommended grass type for the embankment turfing is Axonopus compresses (Buffalo Grass). Size of the grass for turfing is 200 mm x 150 mm, 25-50 mm thick, weed free, closely packed, healthy and uniform turfs. In case of grass planting for cut slope, the grass type is same as embankment turfing, Buffalo Grass, and the size is 225mm x 225mm, 40mm thick.

2.3 Coir Fibre Net

Coir fibre net will be installed on cut slope before planting grass blocks. Coir fibre net is 100 % coir fibre twins net, capable of 2.7 m/sec water velocity; tensile strength: 420 kg x 130 lbs/ft, Weight: 400 g/sq.m; Maximum thickness: 8 mm.

2.4 Shrubs, Ground Cover Plants, Foliage Plants and Trees

Recommended species for shrubs, ground cover plants, foliage plants and trees are indicated in Table 702-1.

Table 702-1 Recommended Tree Species

Local Name	Scientific Name
<Shrubs: evergreen, maximum 5m height>	
Bata Cheena	*Bambusa multiplex*
Kaha Una	*Bambusa vulgaris*
Wetakeyiya	*Pandanus kaida*
Baludan	*Ardisa willisii*
<Ground Cover Plants: evergreen>	
Maha dupiyaliya	*Desmodium*
Heen udupiyaliya	*Desmodium heterophyllum*
Hulantala	*Ageratum conyzoides*
Monara kukudumbiya	*Vernonia cinerea*

Local Name	Scientific Name
Habarala	*Alocasia macrsorhiza*
<Foliage Plants>	
Acalypha	*Acalypha marginata*
Pseudoeranthemum	*Pseudoeranthemum atropurpurieum*
Durantha	*Duranthas ripens*
<Trees-small size :evergreen, 5-10m height >	
Agladhara	*Justica adhatoda*
Ankenda	*Acronychia pedenculata*
Bowitiya	*Osbeckia aspera*
Etteriya	*Murraya paniculata*
Magul Karanda	*Pongamia pinnata*
Kopi	*Coffia Arabica*
Bombu	*Symplocos cochinchinensis*
Divi Kaduru	*Pagintha dichotoma*
Erabadu	*Erythrina fusca*
Gon Kaduru	*Cerbera odollum*
Kebella	*Aporusa lindlyana*
Goraka	*Garcinia quaesita*
Iriya	*Horsfieldia iriya*
Kumbuk	*Teminalia arjuna*
Dan	*Syzygium caryophyllatum*
<Trees-medium size :evergreen, 10-20m height >	
Godapara	*Dillenia retusa*
Diya Midella	*Barringtonoa asiatica*
Kaduru	*Cinnamomum verum*
Belipatta	*Hisbicus tiliaceus*
Muruta	*Lagrstroemia speciosa*
Diyapara	*Dillenia triquetra*
<Trees-large size :evergreen, height >20m >	
Bakmie	*Nauclea orientalis*
Dawata	*Carallia brachiata*
Diya Na	*Mesua ferra*
Wal Ehala	*Pterocarpus indicus*
Gas Kela	*Butea monosperma*
Havari Nuga	*Alstonia macrophylla*
Domba	*Calophyllum inophyllum*

2.5 Soil Improvement Materials

Excavated red soil, river sand, decayed coir dust, dried cow dung, compost (1:1:1 ratio), water and fertilizer.

2.6 Water

Water should be reasonably free from injurious chemicals

2.7 Fertilizer

Fertilizer shall be approved plant nutrients or mixture of plant nutrients and lime.

2.8 Tree Stakes

Rough sawed timber or other approved material used for guying or supporting newly planted

trees to ensure straight vertical trunk. The stakes shall be 50 mm square and of a length in proportion to the height of the tree. The following lengths for stakes shall be used as a guide:

Approximate Tree height /(m)	Stake length /(m)
1.0 to 2.0	1.5
2.0 to 3.0	2.0
3.0 to 5.0	2.5

Large sizes shall be guided or supported by stakes.

702.3 Planting Methods

All greenery work shall be carried out in accordance with Dwg. No. Q-01 through Q-06.

3.1 Embankment Turfing

Turfs to be cut from the ground and packed equal facing (grass to grass & soil to soil) and transport to the planting site within 24 hours. It is essential to cover the turfs from the sun to prevent drying up during the transport. Just after unloading, it is good to keep under shade and handle with care.

Turfing locations are every embankment slope in the construction areas except shrub planting areas. Turfs should be fixed to the ground manually on the improved and prepared soil surface using 20 cm long pegs. The turfs should be beaten down into position with a flat heavy piece of wood. The whole surface should be watered after beating. With effect from the second day it is necessary to water daily in the afternoon for the period of one month.

Turfing shall be done just before or during the rainy season or as instructed by the Engineer. The Contractor shall notify the Engineer not less than 7 days before cutting of turfs begin. Turfing shall be approved by the Engineer, in its original position before cutting and delivery to the site.

3.2 Grass Planting for Cut Slope

Identification for the areas of cut slope which is necessary for surface preparation should be conducted first. After smoothening of the surface of the cut slope, the coir fibre pit with fertilizers will be fixed on the slope using bamboo pegs. Grass blocks are planted on the coir fibre pit anchoring with bamboo pegs. Details for planting method are as shown on the Drawings.

3.3 Shrubs

Shrubs are seedling plants at planting stage and should be healthy, container grown, 0.3 m high, well-branched, well-rooted cuttings free from disease, insects or other causes. All plants shall be nursery grown, two years or older, and shall be subject to approval both at the nursery and on the planting site. Excavated soil mixed with sand, coir dust, and cow dung, compost in 1:1:1 ratio and filling of the pit. The pit size is 0.3 m x 0.3 m x 0.3m. With effect from the second day it is necessary to water daily in the afternoon for the period of one month.

3.3.1 Strip of Shrub Planting on Embankment

At the planting stage shrubs are 0.3 m high plants. The strip of shrub planting is introduced on the embankment of main trace facing the residential areas and the embankment of the interchange and approach roads. Planting along the road, 2 m outside from the road shoulders, 10 m long, 2 m wide, parallel to the road. Density of the planting of the areas is 5 seedlings /sq.m.

3.3.2 Informal Hedge Shrub

The planting of informal hedge shrubs should be done in the groups of 3 - 5 similar species together. Container grown 0.3 m height seedlings planted in a pre-prepared pit. The informal hedge shrubs are introduced along the boundary fence of the main trace facing the residential areas. Distance between two informal hedge shrubs is 0.3 m. 20 m length stretches is one unit for the informal hedge shrubs along the row as shown on the Drawings.

3.3.3 Interchange Foliage Plant

The foliage plants should be 0.15 m - 0.3 m in height, container grown with multi stem and healthy plants. Planting Location is in the areas in between road and interchanges as per the Drawings. Density of the planting of the areas is 5 seedlings /sq.m.

3.4 Cut Slope Ground Covers

Ground cover plants should be container grown, healthy, multi branched 0.15 m - 0.3 m high, rooted twigs. One species for both sides for each cut slope. Planting locations are along top level of the cut slope, 0.5 m away horizontal distance from the edge of the cut. Distance between two ground cover plants is 0.3 m. The ground cover plants are planted in a pre-prepared pit of 0.3 m x0.3 m x 0.15 m.

3.5 Informal Hedge Tree

Plants shall be healthy with well-developed root systems and top growth for the species, and shall be free of injury from disease, insects or other causes.

In the minimum root spread of bare-root collected plants shall be at least one third greater than that for nursery grown bare-root plants. In the case of collected plants, ball sizes shall be at least 10% greater in diameter than those specified for nursery grown stock and shall be of sufficient depth to include the greater portion of the root system. Container grown plants planted in a pre prepared pit of 0.5m x 0.5m x 0.5m almost equals to the size of the container on the filled pit.

3.5.1 Informal Hedge Trees Planting

Supply and planting of plants is container grown, healthy and erect 0.3 m - 1.0 m high plants. The informal hedge trees are introduced along the boundary fence of the main trace facing the residential areas. Distance between two informal hedge trees is 1.0 m. 50 m length stretches is one unit for the informal hedge trees along the row as shown on the Drawings.

3.5.2 Informal Hedge Tress on Approach Roads and Interchange

Planting locations are along the boundary fence of the approach roads and interchange. Distance between two trees is 1.0 m.

3.6 Interchange Palm Tree

Palm trees should be single stem, 1m in height, container grown or rootballed. Planting locations are in the areas in between road interchanges as per the drawing. Palm trees planted in a pre prepared pit of 0.5 m x 0.5 m x 0.5 m almost equals to the size of the container on the filled pit. Rootballed palms need not remove the gunny bag cover.

3.7 Watering

The Contractor shall water all planting undertaken under the greenery work at the frequency necessary to ensure establishment and survival, until completion of the Contract.

3.8 Fertilizing

A commercial fertilizer of the type specified shall be provided and applied uniformly around the pit area of individual trees and in bed areas of plants grown in prepared beds. The rate of application and the time of application of fertilizer shall be as specified or as established by the Engineer.

702.4 Maintenance

4.1 Care of plants

The Contractor shall maintain the trees, ground covers, palms, turfs and shrubs in healthy living condition during the life of the contract.

The Contractor and Engineer make a monthly inspection of all the plants, trees, turfs and shrubs to determine the need for maintenance and water. Any maintenance determined necessary should be taken care of during the one-week period immediately following the inspection.

i. The control of weeds
ii. Protect trees, ground covers, palms, turfs and shrubs from wilful destruction, damage by insects and diseases.
iii. Any other practices necessary to maintain the trees, ground covers, palms, turfs and shrubs in healthy living condition.

4.2 Replacement of plants

Following the initial fixing period the Contractor and the Engineer will make an inspection of all the planting areas to determine the replacement necessary.

If it is estimated that 85% or more of the estimated quantity of trees, ground covers, palms, turfs and shrubs in a specific area is living healthy and good growing condition, replacement will not be required to replace all the dead, missing or defective plants in the specific area. All replacements shall be completed and maintained until the completion of the contract.

702.5 Measurements

The greenery works shall be measured by the item of work completed, accepted and measured in place as per drawings and the instructions of the engineer.

Transporting plants to the site, digging of pits and soil mixing to improve existing soil, the miscellaneous items and the maintenance will not be measured separately, but their cost shall be included in the unit price bid for each item of greenery work.

702.6 Payment

The quantities determined as mentioned above will be paid for at the contract unit price bid for the items listed below. Prices and payments shall be considered full completion for furnishing all materials and performing all the work prescribed in a workmanlike and acceptable manner including all labour, tools equipment supplies and incidentals necessary to complete the work.

Pay Item		Unit of Measurement
702 (1)	Embankment Turfing	Sq. metre
702 (2)	Grass Planting for Cut Slope	Sq. metre
702 (3)	Embankment Shrubs	number
702 (4)	Cut Slope Ground Covers	number
702 (5)	Interchange Palm Trees	number
702 (6)	Interchange Foliage Plants	number
702 (7)	Informal Hedge Trees	number
702 (8)	Informal Hedge Shrubs	number

SECTION 703

GUARDRAIL

703.1 Description

This work shall consist of furnishing and installing the specified type or types of guardrail and emergency median openings (Chain link designed at approx. 2 km intervals) at locations indicated on the Drawings or as directed by the Engineer.

The work for guard rails shall include all required metal corrugated beam, guardrail posts, guardrail hardware, painting if required and all the processes necessary to complete the work.

The chain link consists of chain, posts and concrete foundations.

703.2 Materials

2.1 Guardrail

Materials shall follow either BS or AASHTO standards.

(a) General (BS)

If the material is based on BS, materials used shall be as given below:
Corrugated beams and posts: BS EN 10025, Grade S 275

Untensioned corrugated beam shall be assembled in accordance with BS 7669: Part 3, Section 2.2.

(b) General (AASHTO)

Guardrail shall follow AASHTO M 180, Corrugated Sheet Steel Beams for Highway Guardrail for the specified class and type of corrugated guardrail elements.
Galvanization: AASHTO M 232.
Guardrail posts: ARTBA Bulletin No.268, A Guide to Standardized Highway Barrier Rail Hardware.

Guardrail

The guardrail shall be zinc coated corrugated-sheet steel beam rail elements according to AASHTO M 180 or equivalent.

Type of guardrail: ..... Type I: Zinc coated 550 g /sq.m. minimum single-spot.
Class of guardrail: ..... Class A, Base metal nominal thickness, 2.67 mm.
Shape:..... W-beam as shown on the Drawing.

The guardrail shall be zinc coated steel of thickness not less than 10 or 12 gauge as shown on the Drawings. The steel shall elongate not less than 12 percent in a 50mm gauge length under tensile tests. Rail elements shall meet the strength requirements of Table 703.1 Other specification shall follow requirements in AASHTO M 180.

TABLE 703.1: Strength Requirements for Guard Rail Elements

Ultimate Tensile Strength N/sq.mm		Beam Strength			
		Traffic Face Up Load Max. Deflection		Traffic Face Down Load Max. Deflection	
Gauge	Minimum	kg	mm	kg	mm
12	560	680	50	540	50
12	560	910	75	720	75
10	700	910	50	720	50
10	700	1360	75	1080	75

The beam strength shall be determined with the guardrail element freely supported on a clear span (4 or 2 m) indicated by the Drawings as per the types and the load shall be applied through an 80 mm wide flat surface at the centre of the span. Rails and joints between rails shall both be tested. When the joint is tested, it shall be at the centre of the span.

"Traffic face up" means the load is applied to the traffic face. "Traffic face down" means the load is applied to the other face. Terminal Sections shall meet the requirements for rail except the beam strength test.

2.2 Chain Links

Chain-links for emergency median opening shall conform to the requirements of AASHTO M 181. The height, pole type and details shall be as specified on the Drawings.

2.3 Bolts and Nuts

Bolts and nuts shall be galvanised in accordance with AASHTO Standard Specification M111 and all connections shall be able to withstand a side pull in any direction of 2,200 kilograms. If the Contract documents indicate that galvanising is required, all steel except reinforcement for reinforced concrete shall be galvanised.

2.4 Protective Coating

Following fabrication, cutting, drilling or welding all guardrail components shall be galvanized to the requirements of BS EN ISO 1461 or AASHTO 232. Following fabrication, cutting, drilling or welding all components shall be galvanised.

2.5 Welding

Arc welding of carbon manganese steels shall comply with BS 5135. Welding shall not be used except where detailed on the Drawings. Processes other than arc welding shall be to the approval of the Engineer

703.3 Construction Methods

3.1 Storage and Preparation

All components shall be protected from damage and handled and stacked in such a way that permanent damage is not caused, particularly to threaded components. Means shall be provided to avoid damage to galvanized coatings and any damage that does occur shall be made good in accordance with BS EN ISO 1461.

3.2 Posts

Posts shall be set vertically in position and to the lines and levels shown on the Drawings. Postholes shall be back filled with approved material well tamped in layers of not more than 100 mm thickness. If driving of posts is permitted the type of posts shall have substantially the same dimensions as the body of the posts. Damage to posts in driving will be cause for rejection.

3.3 Guardrail

Rails shall be erected in a manner that will result in a smooth continuous taut rail closely conforming to the line and grade of the highway or as shown on the Drawings.

3.4 Chain Link

Chain links for the emergency median opening shall be erected conforming to the line and grade of the highway or as shown on the Drawings.

703.4 Measurement

The quantity to be measured for payment shall be the length in metres of rail and terminal sections measured from centre to centre of end posts for each continuous installation, including supply and installation of all posts and supports, painting, touch up painting and galvanizing.

703.5 Payment

This work measured as provided above will be paid for at the Contract unit prices for safety barriers. The price and payment will be full compensation for furnishing and installing all materials, including end anchorages, labour, equipment, tools and incidentals necessary to complete the work.

Pay Item		Unit of Measurement
703(1)	Guardrail (Road Side) Gr-4.0	metre
703(2)	Guardrail (Road Side) Gr-2.0	metre
703(3)	Emergency Median Opening (Chain Links)	metre

SECTION 704

FENCING

704.1 Description

Right of Way (ROW) fence shall be constructed at all along ROW. This work shall consist of fences and gates of the type indicated and constructed in accordance with the lines, grades, levels, designs and dimensions shown on the Drawings.

704.2 Materials

Materials shall confirm to the following:

2.1 Woven wire

Galvanized woven wire fence of the coating class specified shall confirm to AASHTO M 279 (ASTM A 116), BS 1722 or equivalent.

2.2 Fence posts

Steel posts for line fencing shall confirm to AASHTO M 281 (ASTM A 702), BS 1722 or equivalent. Steel posts shall be galvanized in accordance with AASHTO M 111. Fittings, hardware and other appurtenances not specifically covered by the plans and specifications, shall be galvanized in accordance with ASTM A 120 and shall be standard commercial grade, and in accord with current standard practice.

704.3 Construction Methods

Posts shall be set vertically to the depth shown on the Drawings and maintained in accurate alignment while fencing is erected and backfilling is done. Backfilling shall be done with suitable material, not necessarily the material excavated and shall be well tamped into compacted layers not exceeding 100mm thickness. On completion of erection the fence shall be firm with no loose or movable parts and true to lines, grades and levels to within 100mm. Gates shall be hung horizontally and placed at the locations instructed by the Engineer. Anchors shall be securely buried and backfilled as for posts, and shall show no signs of movement when wires are strained tight.

704.4 Measurement

The quantity measured for payment shall be the length in meters of fencing all as finally installed in the places required and accepted. Gates will not be measured for direct payment but will be considered as a subsidiary obligation of the contractor.

704.5 Payment

This work measured as provided above shall be paid for at the Contract unit price for

fencing which rate and payment shall be full compensation for furnishing all materials and for all labour, equipment, tools and incidentals to complete the work.

Pay Item	**Unit of Measurement**
704(1) Right of Way Fence	metre

SECTION 705

TRAFFIC SIGNS

705.1 Description

1.1 General

The Contractor shall furnish, install and maintain traffic signs, such as traffic regulatory signs, warning signs, delineators and guide signs in accordance with the details shown on the Drawings and as specified herein at the locations shown on the Drawings and as directed by the Engineer.

The work shall include all necessary foundations, excavation, backfill, anchorages, fixtures and fastenings, brackets, application of paints and finishes, testing and all the processes necessary to complete the work. Design of signs is included in the work.

1.2 Sizes, Colours and Types

Unless otherwise indicated on the Drawings or in the Special Provisions, or otherwise directed by the Engineer, signs and their supports shall be of the sizes, colours and types prescribed by and sited in accordance with the recommendations of the latest edition of the Ministry of Highways Manual on Traffic Control Devices, Part I and Part II and subsequent supplements and amendments.

1.3 Tests and Approval

Each complete traffic sign or part thereof shall be capable of passing the tests in BS 873, Road Traffic Signs and Internally Illuminated Bollards, Part 1, Methods of Test. Before the commencement of fabrication of any traffic sign, the Contractor shall submit, for the Engineer's approval, the following:

- Fabrication drawings for "directional informatory" and "informatory" signs.
- The information about "warning", "regulatory" and other traffic signs.

705.2 Materials

2.1 Posts for Traffic Signs

(a) Steel Posts shall be:

- Tubular or rectangular hollow sections complying with BS EN 10210,
- Joints, universal beams or columns with BS 4,
- Manufactured from steel with grade S275 J0 or S275 J2.

(b) Aluminium Posts shall be tubular or rectangular hollow section.

2.2 Sign Plates for Traffic Signs

All permanent sign plates shall comply with BS 873, Part 6, Specification for Retroreflective and non-retroreflective signs.

2.3 Frames and Stiffening

Except as otherwise provided on the Drawings or in the Special Provisions, sign plates requiring metal frames and stiffening bars shall have adequate ribs or flanges as an integral part of the sign plate or aluminium alloy complying with the appropriate specifications.

2.4 Fixtures and Fittings

Brackets and clips shall be manufactured from approved cast metal, steel, stainless steel or aluminium alloy.

Screws, bolts, nuts and washers shall be of steel, aluminium alloy or of a high tensile non-corroding metal. Washers in contact with surfaces, which may be damaged by over tightening of nuts or bolts, shall be of suitable soft and weather resisting material.

Steel fixings and fittings, which are in contact with aluminium, shall be coated with zinc or cadmium. All steel fittings shall be rust proofed. Rivets shall be made from copper, brass, aluminium alloy or pure aluminium. Brass, copper, lead or nickel shall not be used in contact with aluminium.

705.3 Design and Construction

3.1 General

When directed by the Engineer, signs shall be mounted on existing posts, lamp columns, walls and structures. The obstruction of footwalks shall be avoided. Design and construction of signs shall be such that all sign plates, posts, fittings, can be erected without site modification.

3.2 Construction

(a) Construction and Assembly

- Where framing and stiffening are not an integral part of the sign plate, their joints shall be welded or joined with suitable brackets utilising nuts, bolts and washers.
- Where purlins are adopted, they shall be attached to each vertical member of the sign frame. The sign stiffening and framing shall be continuous in the vertical direction.
- Where purlins are not adopted, the sign stiffening and framing shall be continuous in the horizontal direction.

- Sheet and plank signs shall be connected to posts by an appropriate method. Fixing material shall be of stainless steel.
- Traffic sign to be erected on road lighting columns shall have fixings compatible with the column cross section and finish.

(b) Location and Erection

- All traffic signs shall have their exact location determined and recorded.
- Traffic signs mounted on posts, except those on gantries, shall be erected to have their face plumb and be orientated in relation to the carriageway.

(c) Traffic Signs on Gantries

- Some traffic signs will be erected on gantries. Fabricated steel gantries shall be constructed to the requirements of relevant specifications.

3.3 Inspection and Testing

Before fabrication of signs the Contractor shall supply an example of each type of sign with information concerning equipment and procedures and state the location of the workshops manufacturing the signs. The Engineer will inspect the facilities and, if satisfactory, issue approval to fabricate the remaining signs.

When so requested by the Engineer, samples of preservatives, paints and finishes shall be supplied by the Contractor and shall be tested by him as directed by the Engineer for the appropriate conditions (exposure, compatibility of materials, bindings, reflectance etc). Testing shall be carried out for sufficient time to ascertain the quality and/or suitability of the materials.

705.4 Measurement

The quantity to be measured for payment shall be the actual number of completed road signs of each type and size furnished and accepted.

705.5 Payment

The work, measured as provided above, shall be paid for at the contract unit price for each type of sign and necessary post, fixings and fittings which price and payment shall be full compensation for furnishing and all materials including all labour, tools, testing and incidentals necessary to complete the work. It shall include location lettering and marking and preparation and supply of record drawings.

Pay Item		Unit of Measurement
705(1)	Traffic Sign Board (Regular Size, Round 600 mm)	number
705(1)-1	Traffic Sign Board (Regular Size, Square 600 mm)	number
705(2)	Traffic Sign Board (Regular Size, Round 900 mm)	number
705(2)-2	Traffic Sign Board (Regular Size, Square 900 mm)	number

705(3)	Traffic Sign Board (Rectangular Variable Dimension)	Square Meter
705(4)	Traffic Sign Board (Gantry Mounted)	number

SECTION 706

ROAD MARKINGS

706.1 Description

This work shall consist of application of continuous or intermittent lines, letters, figures, arrows or symbols and the supply and installation of reflecting road studs, including any necessary excavation, grouting and finishing of payment, to the dimensions and at the locations shown in the Contract Documents or as directed by the Engineer, including the supplying of all labour, tools and equipment, materials, warning and traffic guidance signs as necessary for the safe and efficient completion of the entire work.

Road markings shall be white or yellow complying with BS EN 1436, Road Marking Materials, Road Marking Performance for Road Users.

706.2 Materials

2.1 Hot applied Thermoplastic Materials (Superimposed Type)

The laid material shall be one of the two types (a) or (b) detailed below as required by the Contract Documents or as directed by the Engineer.

(a) Reflectorized Thermoplastic - the material shall be with ballotini (glass beads) shall be incorporated in the mixture during the manufacture of the thermoplastic material. The quantity of ballotini included shall be between 13% and 22% by weight of the total mix and shall be counted as part of the aggregate. The whole of the ballotini shall pass a 2mm sieve and not more than 10% shall pass a 425µm sieve. The ballotini shall be free of sharp angular particles and not less than 80% shall be of transparent glass, reasonably spherical and free from flaws.

(b) Reflectorized Thermoplastic with Ballotini Surface - the material shall be in accordance with (a) above except that a layer of ballotini shall be superimposed in the surface of the hot thermoplastic immediately after laying to give immediate reflectivity. The superimposed ballotini shall be of the same quantity as that incorporated in the reflectorized thermoplastic but may be smaller in size; no more than 20% shall pass a 212 µm sieve. Ballotini shall be applied at a rate of 250 - 450 grams per square metre such that the combined total of ballotini incorporated in and superimposed on the thermoplastic shall be between 20% and 26% by weight of the material.

2.2 Road Marking Paint (Hot applied and cold applied) for temporary marking

The paint shall be either hot or cold applied and the laid material shall be one of the three types (a), (b) or (c) detailed below as required by the Contract Documents or as detailed by the Engineer. Cold applied paints shall be suitable for applying by brush or mechanical means.

The following particulars of the paint shall be supplied:

- composition (analysis by weight)
- application (hot applied or cold applied)
- type and maximum amount of reducer (thinner)
- drying time (to touch)
- setting time (to re-coat)
- recommended coverage (litres per kilometre of 100mm stripe)
- heat resistance i.e., maximum road temperature
- details of any primer, undercoat or tack coat required. For hot applied paints the following additional information shall be supplied
- the temperature range of heating and application
- the open flash point

The paint shall be supplied fresh and ready for use in sealed containers which shall be stores in accordance with the manufacturer's instructions.

(a) Non-reflectorized Road Paint - the paint shall be a brand approved by the Engineer, specifically made for road marking, suitable for the type and location of application, factory mixed, and shall be suitable for applying to cement concrete or asphalt pavement to give a chemically stable, non-bleeding, film of uniform thickness with a flat (non-glossy) finish.

(b) Reflectorized Road Paint - the paint shall be in accordance with (a) above except that ballotini shall be incorporated in the paint during manufacture. The quantity of ballotini included shall be 330 to 500 grams per litre the whole of the ballotini shall pass a 1.18 mm sieve and not more that 5% shall pass the 150 µm sieve. The ballotini shall be free of sharp angular fragments and not less than 75% shall be of transparent glass, reasonably spherical and free from flaws.

(c) Reflectorized Road Paint with Ballotini Surface - the paint shall be in accordance with (b) above except that 50% to 70% of the ballotini shall be incorporated in the paint and 30% to 50% of the ballotini shall be superimposed on the surface of the freshly applied paint to give immediate reflectivity.

706.3 Construction Methods

3.1 Thermoplastic Materials

(a) Preparation of Road Surface - the material shall be applied only on a surface, which is clean and dry. It shall not be laid over loose detritus, mud or similar extraneous matter,

or over an old paint marking, or over an old thermoplastic marking which is faulty. In the case of smooth polished surfaces, etc. smooth concrete, old asphalt surfacing with smooth polished surface stones, and/or where the method of application requires or the Engineer directs, a tack coat shall be applied to the surface prior to the application of the material. The tack coat and the rate of application shall be, as the manufacturer of the thermoplastic material shall recommend with the approval of the Engineer.

(b) Preparation of Thermoplastic Material - the material shall be melted in accordance with the manufacturer's instructions in a heater fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic and such that local overheating shall be avoided. The temperature of the mass shall be within the range specified by the manufacturer and shall on no account be allowed to exceed the maximum temperature stated by the manufacturer. The molten material shall be used as expeditiously as possible and for thermoplastics, which have natural resin binders or are otherwise sensitive to prolonged heating the material shall not be maintained in a molten condition for more than 4 hours.

(c) Laying - centre lines, lane lines and edge lines shall be applied by approved mechanical means and shall be laid to a regular alignment. Other markings may be applied by hand screen hand-propelled machine as approved or directed by the Engineer. After transfer to the laying apparatus the material shall be maintained within the temperature range specified by the manufacturer and stirred to maintain the right consistency of laying.

In the case of screeded application the material shall be laid to a thickness of not less that 3 mm or more than 6 mm unless specifically authorized by the Engineer when laid over an existing marking. In the case of sprayed application the material shall be laid to a thickness of not less than 1.5mm unless specifically authorized by the Engineer. In all cases the surface produced shall be uniform and appreciably free from bubbles and streaks. Where the Contract Documents require, or the Engineer directs, that ballotini shall be applied to the surface of the markings, these shall be applied uniformly to the surface of the hot thermoplastic immediately after laying such that the quantity of ballotini firmly embedded and retained in the surface after completion complies with the requirements of Clause 2.1 (c).

Road markings of a repetitive nature, other than centre lines, lane lines etc. shall unless otherwise directed by the Engineer be set out with stencils which comply with the size and spacing requirements in the RDA’s manual.

(d) Refuse of Thermoplastic Material - at the end of the day's work as much as possible of the material remaining in the heater and/or laying apparatus shall be removed. This may be broken and used again provided that the maximum heating temperature has not been exceeded and that the total time during which it is in a molten condition does not exceed the requirements of Clause 3.1 (b).

3.2 Application of Road Marking Paint

(a) Preparation of Road Surface - the paint shall be applied only on a surface, which is clean and dry. It shall not be laid over loose detritus, mud or similar extraneous mater or over a

thermoplastic marking or over an old paint marking which is faulty or incompatible with the paint being applied. If a primer or undercoat is necessary to ensure proper adhesion of the marking paint to the road surface without bleeding or other discoloration the primer or undercoat shall be fully compatible with the marking paint and the road surface and shall be applied only if, and at the rate of application, approved by the Engineer.

(b) Preparation of Paint - all cold applied paint shall be thoroughly field mixed before applying in order to keep the pigments in uniform suspension. Hot applied paints shall be heated in a properly designed heater, preferably thermostatically controlled to the correct laying temperature at which it shall be maintained as required for the method of application. The paint shall on no account be allowed to exceed the maximum temperature specified by the paint manufacturer. The use of thinners or other additives shall not be used unless otherwise permitted by the Engineer.

(c) Laying - centre lines, lane lines and edge lines shall be applied by approved mechanical means and shall be laid to a regular alignment. Other markings shall be applied by brush, spray, screed, hand-propelled or self-propelled machine according to the marking configuration and the type of paint approved for use as directed by the Engineer. The rate of application of the paint for each coat shall be that recommended by the manufacturer unless otherwise directed by the Engineer. When more than one coat is used the succeeding coat shall not be applied until the previous coat has fully dried.

Road markings of a repetitive nature, other than centre lines, lane lines etc. shall be unless otherwise directed by the Engineer, be set out with stencils which comply with the size and spacing requirements of the Department.

(d) Protection of Markings - all markings shall be protected from traffic until they have dried sufficiently to show no pick up of tyre marks of traffic dirt.

3.3 Defective Materials or Workmanship

Materials, which are defective or have been applied in an unsatisfactory manner or to incorrect dimensions or in a wrong location shall be removed, the road pavement made good and the materials replaced, reconstructed and/or properly located, all at the contractor's expense and to the satisfaction of the Engineer.

3.5 Protection of Traffic

The Contractor shall protect pedestrian, vehicular and other traffic adjacent to the working area against damage or disfigurement by construction equipment, tools and materials or by splashes and smirches of paint or other construction materials and shall during the course of the work provide and maintain adequate signs and signals for the warning and guidance of traffic.

706.4 Measurement

Markings shall be measured by the area in square metres completed, accepted and

measured in place. Where the width or length of laid marking proves to be greater than that specified and is accepted by the Engineer the specified width or length shall be used when calculating areas for payment. Where the width or length of laid marking proves to be less than that specified and is accepted by the Engineer then actual width or length of laid marking shall be used when calculating areas for payment.

706.5 Payment

The work measured as provided above shall be paid for at the Contract unit price per unit of measurement for each of the items listed below that is shown in the Bill of Quantities.

The payment shall be full compensation for providing and placing or installing the materials including all labour, equipment, tools and incidentals necessary to complete the work.

Pay Item		**Unit of Measurement**
706(1)	Road Marking with Reflectorized Thermoplastic Paint	Square meter

SECTION 707

ROADSIDE MARKERS

707.1 Description

This work shall consist of kilometre posts and culvert markers furnished and installed in accordance with the Specification at the locations in accordance with the size, dimension and designs shown on the Drawings.

707.2 Materials

Kilometre posts shall be pre-cast in the shape and manner designated on the Drawings. The material and reinforcement shall conform to the details given in the Drawings

The culvert markers shall be made from plastics confirm to the detail given in the drawing.

707.3 Construction Methods

Construction, fabrication and installation of markers and posts shall be as shown on Drawing. Each marker and post shall be set accurately at required location and elevation and in such manner as to ensure that it is held firmly in place.

707.4 Measurement

The quantity measured for payment shall be the actual kilometre posts and culvert markers furnished, placed and accepted.

707.5 Payment

This work measured as provided above should be paid for at the Contract unit price for the several pay items shown in the Bills of Quantities. The price and payment shall be full compensating for furnishing and placing, including all material labour; equipment tools and incidentals necessary complete the work.

Pay Item		Unit of Measurement
707(1)	Kilometre Post	number
707(2)	Culvert Marker	number

SECTION 708

DELINEATORS

708.1 Description

Roadside delineators are light retro-reflecting devices mounted in series at the side of the roadway to indicate the roadway alignment. Delineators are effective aids for night driving and considered as guidance devices rather than warning devices. Delineators may be used on long continuous sections of highway or through short stretches where there are changes in horizontal alignment, particularly where the alignment might be confusing or at pavement width transitions.

708.2 Material

Delineators shall consist of reflector units capable of clearly reflecting light under normal atmospheric conditions from a distance of at least 200 m when illuminated by the upper beam of standard automobile lights.

The delineators may be designed to be mounted either on guardrails or on special delineator posts.

Delineator posts should be white and may have a black section at the upper part. The posts shall be of flexible in type.

The reflective elements shall be in colour described in the drawings and consist of either High Intensity Reflective sheeting or prismatic reflectors.

Reflective elements for delineators mounted on guard-rails and posts shall have the diameter of 100 mm.

708.3 Construction Method

Delineator posts, if used, shall have the top of the reflector unit about 1.20 m above the near roadway edge. Delineators shall be placed not less than 1.0 m or not more than 2.0 m outside the outer edge of the shoulder, or if appropriate, in the line of the guard-rail. Delineators mounted on guardrails may be placed at a height less than 1.2 m.

When mounted on posts, delineators should be erected on both sides of the roadway.

Delineators should be placed at a constant distance from the edge of the roadway. However, where a guardrail or other obstruction intrudes into the space between the pavement edge and the extension of the line of delineators, the delineators should be in line with, or inside the innermost edge of the obstruction.

Normally, delineators should be spaced 60 m to 100 m. When normal uniform spacing is interrupted by driveways, crossroads, or similar, interrupted delineators falling within

such areas may be moved in either direction, a distance not exceeding one-quarter of the normal spacing. Delineators still falling within such areas should be eliminated. On expressways and similar roads a normal delineator spacing is 100 m, or as shown in the drawings.

Spacing should be adjusted on approaches and throughout horizontal bends so that several delineators are always visible to the driver. The table given in the drawings shows suggested maximum spacing for delineators at horizontal bends.

708.4 Measurement

Measurement shall be numbers.

708.5 Payment

Payment shall be at the Contract unit rate, which shall be full compensation for providing all materials, transport, including labour, equipment, tools and other incidentals necessary to complete work to the specifications.

Pay Item	**Unit of Measurement**
708(1) Delineator - Type I-1	number
708(1)-1 Delineator - Type I-2	number
708(2) Delineator - Type II-1	number
708(2)-1 Delineator - Type II-2	number
708(3) Delineator - Type III	number
708(4) Delineator - Type IV	number
708(5) Delineator - Type V	number
708(6) Delineator - Type VI-1	number
708(6)-1 Delineator - Type VI-2	number
708(7) Delineator - Type VII	number

SECTION 709

CONCRETE KERB

709.1 Description

This work shall consist of kerb made of concrete and constructed in accordance with the Specification at the locations and with the lines, levels, grades, dimensions and types shown on the Drawings. The precast concrete Kerbs shall comply with BS 7263.

709.2 Materials

Bed course material, if any, as shown on the Drawings, shall consist of clean sand, gravel, crushed stone or other approved porous material of 10 mm maximum size and conforming to the requirements Section 302 of the Specification.

Concrete shall be of the class indicated on the Drawings and shall conform to the requirements for the concrete, Section 503 of the Specification

709.3 Construction Methods

Excavation for placement of precast kerb units shall be made to the required depths and the base upon which they are placed shall be compacted using hand tampers or by other approved means to an even surface. All soft and unsuitable material encountered during such excavation shall be removed and replaced with suitable material, which too shall be thoroughly compacted.

Bed course material, where required, shall be laid and compacted, on the prepared surface, as directed. The pre-cast kerbs shall be fitted in place on a bed of concrete and as indicated in drawings unless otherwise directed by the Engineer.

The kerb sections should be laid as required so that the face and top lines conform to lines and grades required. They shall be placed side by side and the faces shall be made to fit as closely as practicable and where approved the surfaces shall be chipped and or applied with a thin film of cement grout to achieve the desired fit and also a bond between the units.

Tapered and dropped kerbs shall follow relevant clauses of BS 7263.

709.4 Measurement

Pre-cast kerbing shall be measured by linear meters along the front face of the section of each type. Tapered and dropped kerbs shall be measured as standard type (125x255x900 mm).

No deductions shall be made for drainage structures installed in the kerbs.

709.5 Payment

The measured quantities for kerbs shall be paid of full compensation for providing and placing of all bedding and jointing materials of Standard kerbs and nailing of Nailed kerbs and shall include for all labour, equipment, tools and incidentals necessary to complete the work. Excavation, backfilling and compaction of soils and other materials in forming the bed etc., shall be considered as incidental to the construction procedure.

Pay Item	**Unit of Measurement**
709(1) Concrete Kerb (125x255x900 mm)	number
709(2) Concrete Seal (Grade 30, t=100 mm) for Median	Sq. m
709(3) Median strip (PC-PB)	metre
709(4) PC-CBa (Median Concrete Curve)	metre
709(5) PC CBb (Median Concrete Curve with inlet)	metre

SECTION 710

ASPHALT KERB

710.1 Description

This work shall consist of kerb made of asphalt and constructed in accordance with the locations, the lines, dimensions as shown on the Drawings (Layout Drawings, N-11 though 18). In addition, a tack coat shall be used and they shall be laid by a machine capable of producing a dense, smooth-surfaced kerb to true line and level.

710.2 Materials

2.1 Asphaltic Materials

The materials for, and making and placing of in situ asphalt kerbs shall comply with the recommendations of BS 5931.

The asphaltic tack coat for the asphalt kerb shall confirm to the requirements of Section 403 Aspartic Tack Coat.

2.2 Asphaltic Additive

The provisions of Section 404 Shall Apply.

2.3 Mineral Aggregate

The aggregate for the asphalt kerb shall confirm to the grading requirements given in the table below.

Sieve Size (mm)	5	2.5	0.6	0.3	0.15	0.074
Passing weight percentage (%)	71~100	55~100	30~70	20~55	7~35	4~20

710. 3 Construction

3.1 Mixture

Trial mixes shall be prepared and tested conforming to the Standard Mix Proportion given in table below and Section 404. Trial constructions shall be carried out. The mix proportions shall be changed until desired results are achieved as per the Standards or as requested by the Engineer. The Contractor shall carry out the trials for the mix proportion and construction without any additional cost to the Employer.

Item	**Coarse Aggregate**	**Screening Under 2.5 mm**	**Fine Aggregate**	**Mineral Filler**	**Asphaltic Material**
Mixing %	10	45	38	7	8

3.2 Asphalt kerbing

(a) Excavation

Excavate to the required depth and compact base material. Replace soft, unacceptable material with approved material and compact.

(b) Surface Preparation

- Clean fresh laid bituminous surfaces before placing kerbing.
- Clean all other existing surface with compressed air and dry the surface.
- Apply a tack coat at a rate of 0.2 to 0.7 litter/sq.m of surface under kerb, conforming to the Section 406 of the Specification.

(c) Placing

Construct asphalt kerbing with a self-propelled, automatic kerb machine or use a paver with kerbing attachments that meet the following:

- Machine weight compacts without having to ride above the paving machine.
- Machine forms kerbs of consistent texture, shape and density.
- Construct short sections of kerbing or kerbing with short radii by other approved methods that produce kerbing of equal quality to machine-produced kerbing.

(d) Painting and Sealing

Seal or paint only on clean dry kerbing that has cooled to the ambient air temperature. The sealing with the same Asphaltic material used for the mix at 1.0 litter/sq.m.

3.3 Weather

The surface on which the asphalt kerb to be constructed shall be dry and clean. The work shall not be carried out on rainy days.

710.4 Measurement

Asphalt Kerb shall be measured by linear meters along the front face of the kerb.

710.5 Payment

The measured quantities for Asphalt Kerbs shall be paid of full compensation for providing and placing of kerb and shall include for all labour, equipment, tools and incidentals necessary to complete the work.

Pay Item	Unit of Measurement
602 (53) Asphalt Kerb	metre

SECTION 711

NOSE TOP CONCRETE

711.1 Description

This work shall consist of the production of concrete of Grade 20/40, specified in Specifications and use the same for filling at the interchange nose tops as shown in the drawings or as directed by the Engineer.

711.2 Material

Concrete shall be of nominal mix proportions; Aggregate shall be of nominal maximum size 40 mm and conform to the Specification section 550.

711.3 Construction Method

In regard to quality control, materials, sampling and testing, compaction; equipment and tools, construction methods; the provisions of relevant sections of this specification shall apply.

The concrete shall be laid over the existing bituminous surface of the road, corrected where necessary. In the alternative the surface shall be primed with a suitable cutback or emulsion, prior to laying of concrete.

In the construction of nose tops, construction/through joints shall be positioned at spacing not exceeding 2.5m and as approved by the Engineer.

711.4 Measurement

Measurement shall be in cubic metre.

711.5 Payment

Payment shall be at the Contract unit rate, which shall be full compensation for providing all materials, transport, including labour, equipment, tools and other incidentals necessary to complete work to the specifications.

Pay Item		Unit of Measurement
711(1)	Nose-top Concrete	cubic metre
711(2)	Kerb Work for Nose	number

SECTION 800

FACILITIES

SECTION 801

ROAD LIGHTING AND TRAFFIC SIGNALS

801.1 General

This Section covers the supply of road electrical facilities included, such as all equipment and lanterns, complete with concrete foundations, brackets, columns and other supporting devices, bases, cables, switch-gear and all necessary ancillary equipment together with the transportation, storage, assembly, erection, connection and testing of the same in order to supply a complete street lighting system and traffic signal system (DWG. No.M-12) in accordance with the details shown on the Drawings and as specified herein.

1.1 Applicable Codes and Standards

1.2 British Standards Institution

BS 5489: ..... 1992 Road Lighting.
Part 1. Guide to general principles.
Part 2. Code of practice for lighting for traffic routes
BS 7671: ..... 2001 Regulation for Electrical Installations
(IEE Wiring Regulations Sixteenth Edition).
BSEN 60598-2-3: ..... 1994 Road Lighting Luminaires.
BS 5649: ..... Lighting Columns.
BS 5467: ..... 1997 Specifications for XLPE insulated Armoured Cables.
BSEN 60439-5: ..... 1996 Distribution Boards for outdoor locations.
BSEN 60529: ..... 1992 Degrees of protection provided by enclosures.
BSEN 60662: ..... High Pressure Sodium Vapour Lamps.
BS 5972: ..... Photo-electric Control Units.
BSEN 60920/12/2/3: ..... Ballasts.
BSEN 61048/9: ..... Capacitors.
BSEN 60898 and BSEN 60947:... Part 2:1992 Miniature Circuit Breakers.
BSEN 60947: ..... Part 2:1992 Moulded Case Circuit Breakers.
BSEN 50262: ..... 1999 Cable Glands.
BS 7430: ..... Code of practice for Earthing.

1.3 Commission Internationale De L' Eclairage (International Commission on Illumination)

CIE 23: ..... 1973 International Recommendations for Motorway Lighting.
CIE 30.2: ..... 1982 Calculation and Measurement of Luminance and Illuminance in Road Lighting.
CIE 31: ..... 1976 Glare and uniformity in road lighting installations.
CIE 47: ..... 1979 Road Lighting for Wet conditions.
CIE 66: ..... 1981 Road surfaces and lighting.

1.4 Standards Association of Australia.

AS/NZS 1158.1 ..... Vehicular Traffic Lighting.
1158.1.1:..... 1997 Performance and Installation Design Requirements.
1158.1.3:..... 1997 Guide to Design, Installation, Operation and Maintenance.

1.5 Australian Road Research Board.

AP 11.12/ 88 ..... Part 12 Roadway Lighting.

In case of any discrepancies, ambiguities or differences in the above Codes and Standards, the British Standards will take precedence over other Standards

801.2 Responsibility for Design and Materials

(a) All work shall be accomplished and all materials and equipment shall be made and tested strictly in accordance with

- The respective Standards and Codes specified above and stated specifically hereunder.
- The requirements of the Electrical Codes (SLS-703) of the Sri Lanka, where applicable. c) The requirements of the local Electricity Supply Authority- The Ceylon Electricity Board (CEB) or Lanka Electricity Company (LECO) as applicable.
- Materials, equipment and workmanship shall comply with BS 7671 Regulations for Electrical Installations (IEE Wiring Regulations) and the rules and regulations of the electricity supplier who provides the supply. Other reference regulations are NEMA, ASTM, AASHTO, CIE, JIS, IEC or equivalent, to the prior approval of the Engineer.
- Inspection and Testing of the completed installation shall be performed in accordance with BS 7671: 2001 or it's latest update.

(b) As design of the road facilities has been carried out and the structures have been designed to accommodate wiring, equipment, lanterns and columns in the positions shown on the layout drawings, no change to this layout shall be attempted without the prior written approval of the Engineer.

(c) Subject to the provisions of Sub Section 2.1 the Contractor shall be solely responsible for the adequate design and the coordinated functioning of all goods and constructions relating to road lighting.

(d) The equipment offered and the work done shall be suitable for continued trouble free operation under adverse climatic conditions of heavy rain, high humidity and intense sunlight. The equipment shall be able to withstand over long periods ambient air temperature varying from a normal of 30°C to a maximum of 50°C.

801.3 Compliance with Manufacturer's Specifications

(a) The Contractor shall ensure that the equipment used shall be entirely suitable for the work to be performed and that they shall be manufactured to proper clearances and fits. He shall further ensure that the loading of equipment shall under all normal circumstances not exceed the maximum laid down limits or as otherwise agreed upon in writing with the Manufacturer.

(b) The Contractor shall be responsible for the inspection of all equipment before their incorporation in the works to ensure that they comply with the conditions of the Contract and that they are not defective in any way as regards materials or workmanship. The Contractor shall, at his expenses and to the Engineer's satisfaction, correct any default to the requirements or defect found during the inspection.

801.4 Spare Parts

The Contractor shall supply the numbers of spare parts as shown on the Tender.

801.5 Working and Storage Areas

The working areas to be made available for purposes of storage, assembly and offices will comprise suitable areas adjacent to each Interchange. The Contractor shall be responsible for providing all storage, offices and other facilities he requires, both on and off Site. The Authority shall approve working and storage area on site required by the Contractor. However the Authority reserves the right to object. The Contractor shall provide two rooms of not less than 12 square metre each for the Engineer and Authority. Each room shall be fully furnished with electric lighting, air conditioning, and 2 desks with lockable drawer, one stool, two windows, and one lockable door. A telephone connected to Sri Lanka Telecomm line is to be provided. Sanitary facilities are to be provided in association with the National Water Supply and Drainage Board.

801.6 Electricity Supply

(a) The Engineer will assist the Contractor in the provision of an electricity supply at the positions shown on the Drawings by the Ceylon Electricity Board. The Contractor shall be responsible for arranging the date and time of the final connection at each position and maintaining an effective liaison with the Ceylon Electricity Board (CEB). The Authority shall make payment to CEB for the connections.

(b) The Contractor shall ensure that the equipment supplied shall correctly function at the supply voltage and must allow for normal supply Voltage variations and surges.

801.7 Payments

Payment for the requirements in this Section shall be deemed to be covered in other relevant Sections.

SECTION 802

EXCAVATION AND BACKFILL FOR FACILITIES' INSTALLATION

802.1 Description

This work shall consist of excavation for the foundations, cable laying in open ground, pumping, dewatering and bailing, backfilling, and the disposal of excavated material. Reinstatement shall be such that the surface is restored to its original standard.

802.2 Excavation and Backfill for Conduit Laying

(a) The approximate location of the trench is shown on the Drawing but the Contractor shall obtain the approval of the Engineer for each final location before excavation commences. The trenches shall be cleanly excavated, reasonably straight and free from loose soil or water before the conduit is laid. The trenches change depth to accommodate access to conduits, or for similar reasons, the change in level shall be gradual and wherever possible the slope should not be more than 1:5.

(b) No conduit shall be laid in a flooded trench and the Contractor is responsible for dealing with any surface water and any pumping or bailing of the trenches. Where trenches are flooded after the conduits are laid and before backfilling by the Engineer the conduits shall then be removed prior to pumping or bailing.

(c) Conduits shall not be laid in the trench until the Engineer has inspected and approved the excavation. Backfilling shall not commence until Engineer has inspected and approved the placement of conduits and accessories in the trench.

(d) Trenching for conduit's laying shall proceed as follows:

- The trench shall be excavated to the required width and depth and disposed of all unusable material. Trench bottom shall be compacted to true level.
- After the approval of the Engineer, a 7.5 cm thick layer of sand bedding and conduit spacers shall be laid. Conduits shall be laid at least 5 cm apart.
- After the approval of the Engineer, concrete shall be laid as specified in Section.
- The trench shall be backfilled with the selected material, ram and tamp in layers of not more than 15 cm compacted thickness. Allowance shall be made for subsequent settlement.
- Joint maker plate shall be installed at every joint position. At all places the conduits shall have a minimum cover of at least 60 cm.

802.3 Installation of Direct Buried Armored Cable

(a) Where excavation for armoured cable laying in open ground is carried out the buried cable shall have a minimum cover of 450 mm.

The location of the trench is approximately shown on the Drawings but the Contractor

shall obtain the approval of the Engineer for each final location before breaking the ground. The actual width of the trench shall be decided by the Contractor, with the approval of the Engineer, but the trenches shall be cleanly excavated, reasonably straight and free from loose soil or stones or water before the cable bed is laid. Trenches shall where necessary be adequately shored. Where trenches change depth to accommodate access to ducts or for similar reasons the change in level shall be gradual. A slope of not more than 1:5 shall be aimed for.

(b) No cable shall be laid in a flooded trench and the Contractor is responsible for dealing with any surface water and any pumping or bailing of the trenches. Trenches should be carefully bailed or pumped dry. If required by the Engineer the cables and accessories in the trench should be removed from the trench to facilitate effective bailing or pumping.

(c) Cables shall not be laid in the trench until the Engineer has inspected and approved the excavation. Backfilling shall not commence until the Engineer has inspected and approved the laying of cables and accessories in the trench.

(d) Trenching shall proceed as follows:

- Excavate the trench to the required width, 800 mm deep and dispose of all unsuitable material, level and ram trench bottom.
- After the approval of the Engineer, lay a 100 mm thick bed of sifted river sand and lay cables on the bed. Cables shall be at least 50 mm apart.
- After approval of the Engineer, lay and compact a further 200 mm layer of sifted river sand and lay pre-cast concrete protective slabs of minimum thickness 50 mm along the length of the cable to the approval of the Engineer.
- Partially backfill and compact the trench with material in two layers, ramming and tamping at each layer and laying a marker tape along the length of and above the line of the cable, 150 mm below the intended finished ground level. The remainder of the trench can then be backfilled with further selected material, well compacted, leaving an allowance for subsequent settlement. The marker tape shall be yellow in colour with black legend stating 'Electric Cable.'
- Lay cable markers (concrete slabs) with an engraving 'Electric Cable' along the cable trace at finished ground level at distances of 20m apart and at every turn position. At all places the cables shall have a minimum cover of at least 450 mm.

802.4 Measurement

The quantity of work done under this item shall not be measured but it shall be included in each item of facilities requiring excavation or backfilling.

802.5 Payment

No payment shall be made for the work, materials, labor and equipment. It shall be considered incidental to work performed under other items.

SECTION 803

ROAD LIGHTING

803.1 General

Description

This section covers the supply of all lanterns, Main Distribution Boards, Lighting Distribution Boards, Over Ground Junction Boxes, lighting columns complete with brackets, pole, fuse, miniature circuit breaker and enclosure, and other necessary ancillary equipment together with the transportation, storage, assembly, erection, connection and testing of the same in order to supply a complete road or street lighting system in accordance with the details shown on the Drawings and as specified herein.

803.2 Road Lighting

2.1 Quality of Road Lighting

Luminaries and lamps selected for the execution of the works shall ensure the achievement of the following photometric parameters.

- Minimum Maintained Average Luminance-L(cd/m2) 1.0
- Minimum Overall Uniformity Ratio-Uo 0.4
- Minimum Longitudinal Uniformity Ratio-UL 0.7
- Maximum Threshold Increment-TI (%) 15.0
- Minimum Surrounds Ratio-SR 0.5

2.2 Road Lighting Luminaire.

The luminaire shall comply with BSEN 60598-2-3, and shall employ High Pressure Sodium-vapour lamps of rating 250 W.

It shall belong to the low threshold increment (LTI) class.

The optical compartment of the luminaire shall have a minimum ingress protection rating of IP 66 to BSEN 605209/ IEC 60529.

The gear compartment shall have a minimum ingress protection rating of IP 54 to BSEN 605209/ IEC 60529.

The body and canopy shall be made of pressure die-cast aluminium, painted in steel grey. The reflector shall be of highly polished anodized high-grade aluminium. The enclosure shall be a shallow toughened glass curved bowl.

All lanterns shall be supplied complete with control gear and other accessories. fully

wired and ready for erection.

The control gear shall incorporate power factor correction and radio interference suppression capacitors complying with BSEN 610492:1993/ IEC 610492:1991 and BS 613 respectively. A minimum power factor of 0.90 lag shall be achieved by the capacitors.

The luminaire shall be insect and vermin poof.

The luminaire shall have a side entry socket for fitting the luminaire to the lighting column arm spigot. Cable entry to the luminaire shall be through cable glands complying with BSEN 50262:1999. A grounding earth-ring may be provided where necessary for completion of the earthing circuit. Fixing screws shall be made of stainless steel. All wiring within the luminaire shall have an insulation resistance not less than 0.5 Mega Ohm.

Power to the street lighting luminaire shall be supplied from a junction box enclosure that houses a Miniature Circuit Breaker dedicated to protect the luminaire and mounted inside the lighting column behind the compartment door.

Power cable from the junction box enclosure to the luminaire shall incorporate a plug and socket unit, custom made specifically for the purpose, for safe opening of the circuit in event of the slip-base pole dislodging from it's mounted position due to a vehicle striking the pole during a road accident. The plug and socket unit shall maintain the earth continuity from the junction box enclosure to the luminaire by the use of cable glands at the plug and socket entries. The plug and socket unit shall be to the prior approval of the Engineer.

Individual lamp feeders shall be XLPE insulated armoured cables with a minimum conductor cross sectional area of 2.5mm2.

Cables in and out of the junction box shall be through cable glands to BESN 50262:1999.

2.3 Road Lighting Lamps

High Pressure Sodium Lamps (HPS-T) shall be new and have a colour temperature of approximately 2,000oK. The rated average life of the lamp shall be 24,000 hours assuming 10 hours per start. The lamp shall have an initial luminous efficiency of not less than 100 lumens/watt after 100 burning hours (exclusive of circuit losses) at the rated voltage and frequency. At the rated voltage (230V) and frequency (50 Hertz), the run up time of the lamp shall not be longer than 5 minutes to reach 80% of its final luminous flux, and it shall be capable of re-ignition within 2 minutes after being switched off. The majority of the lamp output shall be concentrated and fall within the visible spectrum.

2.4 Sofit Lantern

Sofit lanterns of rating 70 W are required under pass of the main Highway. The locations

are shown on the Drawings. The lanterns shall be mounted in the position shown and interconnected by means of an exposed conduit system. No part of any soft lantern shall protrude below the soft of the bridge. The lanterns shall be installed so that the photometry axis of the lanterns is normal to the road. The power factor shall not be less than 90% lagging.

2.5 Wire and Cable

2.5.1 Underground Cabling

(a) Excavation

Underground cable installation shall, unless otherwise specified includes all necessary clearing, excavating, disposal of spoils temporary supports, baling, pumping and the provision of bedding material, conduit laying, cable laying, protection, backfilling, marking and reinstatement of the cable route. Prior to the commencement of excavation the Contractor shall mark the locations of all existing services along the proposed cable route. Any existing facilities, which become damaged during the course of the work, shall be repaired and reinstated to the original condition to the Engineers satisfaction.

(b) Cable Laying

Cables shall be enclosed in 50mm, or 100mm diameter PVC conduit as appropriate when laid direct in ground or in 50mm or 100mm steel conduit when between manholes under road crossings.

Conduits enclosing cables shall be laid at the depths shown in the Drawings and to the requirements of the Electricity Regulations. Conduits enclosing cables shall be bedded in clean river sand with minimum depth of bedding of 100 mm below the conduit and minimum cover of sand above the conduit of 200 mm. The minimum depth of cable shall mean the perpendicular depth from final finished surface level to the top of the buried cables, which shall be 450 mm. Conduit enclosing directly buried cables, shall be further protected by approved cover slabs placed directly on the sand bedding. Conduits or ducts shall be provided to the required depth. Long radius sweeps or bends shall be used for all changes of direction. Sharp bends will not be accepted. Cable markers shall be placed during backfilling along the full-buried length of cables as stated under Section 802.3 on straights and at all changes in direction. Cable markers shall be painted. Other appropriate colours shall be employed for signal, data and telecommunications cables. Underground cable joints shall not be permissible. Where unavoidable, underground cable joints shall be permitted only with the specific prior approval by the Engineer. All exposed ends of underground cables shall be capped and sealed until properly terminated, to prevent the ingress of moisture. A loop or slack section of cable shall be left at each side of a road or traffic way to allow for settlement of the road without stretching the cable. Plaques shall be provided to identify the points at which buried cables enter the ground. These shall be securely fixed to the structures or external walls of buildings from which the cables enter the ground.

(c) Backfilling

Backfilling material shall be free of stones, debris, rubbish, etc., and shall be placed, and thoroughly compacted in 200 mm (loose) layers. Make good the surface to match the original adjacent. The trench shall not be backfilled until the Electrical Supply Authority and the Engineer have reviewed installation. Where the trench is used for Electrical Supply Authority MV cables, liaise with that Authority for any installation of earthing within the trench prior to backfilling.

2.5.2

All wires and cables shall be copper, PVC/XLPE insulated, PVC sheathed and free of joint except at terminal blocks, and junction boxes. Direct burial cable enclosed in conduit shall be armoured. Wires conveying power supplies to lighting columns, over ground junction boxes, Lighting Distribution Boards etc. shall terminate in suitable sockets or terminal blocks enclosed in terminal boxes, cable entry being made through cable glands, which shall be covered and protected so that no live parts are exposed. Applicable Sri Lanka and International codes shall be used.

2.5.3

All wires and cables shall conform to the sizes and current ratings of BS 7671:2001.

2.5.4

All non-current carrying metallic parts shall form an electrically continuous system, which shall be grounded or separately grounded as specified in the latest IEE Regulations 16th Edition. All items below ground level shall be so designed and installed that they shall continue to operate without fault if immersed in ground water.

2.5.5

Where tees and joints are used, they shall be made in compound filled joint boxes and accessories specially manufactured for the cables. The compound shall be two-part resin-hardener, which will form a void-free quick-setting compound. Alternatively an equivalent insulating sealing compound to be applied and then wrapped with approved electrical insulating tape can be used.

2.5.6

The conductor connections within the joint shall be made using compression crimps or other means of positive mechanical clamping to ensure that the electrical continuity if the wire is maintained without significant increase in resistance as compared with that of straight cable runs.

2.5.7

The design of the joint box and the composition of the compound shall provide and effective seal to prevent moisture ingress to the circuit connections and clamps.

2.5.8

No joint shall be made in a cable without the specific approval of the Engineer in writing.

2.6 Road Lighting 12 m Column and Bracket

2.6.1

The lighting column shall be of the frangible slip-base octagonal flange-mounted type complying with BS 5649, constructed out of material complying with BS 4360 and shall be of longitudinally seam welded steel to BS 5135 and hot-dip galvanized to ISO 1461:1999 or BS 729.

The vertical column of the lighting pole and its detachable bracket (s) shall be made of ground single length (without joint) steel with yield point not less than 25 kg/mm2 and ultimate tensile strength of not less than 41 kg/mm2. The bracket is to be provided with spigot to suit the manufacturer's lantern. The outreach of the bracket shall be 2.50 m or as otherwise specified on the Drawings. Each column shall be provided with a base-plate for mounting the column onto a suitable foundation by means of anchor bolts or 'J' bolts. The column, arm (s), lanterns together with other accessories shall be designed to withstand a distributed wind load corresponding to the wind-speed 35 m/sec or wind pressure of 150 kg/m2. Each column shall be provided with weatherproof service door of minimum dimension 120mm x 400mm and drain holes at column toe.

2.6.2

The columns shall conform to the outlines on the Drawings and shall be manufactured to BS 1840 or approved equivalent such as ANSI. ASTM. JIS.

2.6.3

A non-hygroscope mounting board composed of electrically insulating material shall be fixed in an easily accessible position behind the service door inside the column and shall be of suitable size to accommodate an enclosure with all necessary electrical equipment such as terminal strip, connectors, miniature circuit breaker etc. Adjacent to this mounting board, there shall be provided on the inside of the column a grounding bus bar complete with two stainless steel bolts, lock nuts and washers, for use as grounding points.

2.6.4

All the columns shall be erected in a truly vertical position with the arms at right angle to

the traffic flow. In the case of parapet-mounted columns, the column doors shall all face in the same direction along the Highway. The doors of the column erected at the sides of the road shall be positioned away from the approaching traffic. In each run of columns of five or more, every fifth column shall be checked for verticality by means of a theodolite. The columns between each checked column must be in line along the road and parallel to the checked columns. Shim washers may be used to achieve vertically where necessary. The Engineer prior to installation of the lanterns and wiring shall inspect each group columns. Each column must be grounded.

2.6.5

Lighting pole shall be marked with a numbering system that can identify the source of power supply from pillars by means of white luminous paint. Size of numbering shall be as approved by the Engineer but in no case smaller than 50mm in height.

2.7 Contactor

The photo switches and time switches shall operate the road lighting in-groups via lighting control with mercury displacement relays. These relays shall be those best suited for installation where maintenance frees operation is required. All contacts shall be sealed and are to be impervious to corrosive atmosphere, gases, humid conditions dust and adverse climatic condition. The various capacities are specified on the Drawings.

2.8 Main Safety Switches

At the various positions shown on the Drawings, the electrical supplies are switched by heavy-duty safety switches, which shall be dual-purpose cover, interlock positive, with quick-make, quick-break mechanism, visible blades and line terminal shield. The handle shall be padlocked when closed. The enclosure shall conform to NEMA 1 unless otherwise specified.

2.9 Distribution Boards, Moulded Case Circuit Breakers and Miniature Circuit Breakers

2.9.1 Switchgear

Switchgear installed inside the panels/ Distribution Boards shall be suitable for operating on 400V, 3ph, 50 Hz power supply.

2.9.2 Switchgear

Assembly of switchgear and control gear shall conform to BSEN 60439.

2.9.3 Moulded Case Circuit Breakers and Miniature Circuit Breakers

(a) All Moulded Case Circuit Breakers shall conform to BSEN 60947-2:1992, a rated insulation voltage of 600V, a rated interrupting capacity of 50 kA or 25 kA as indicated in drawings. They shall have thermal over-load, electro-magnetic short circuit, under

voltage and earth fault relays incorporated with adjustable instantaneous trip settings. Further they shall have four poles with nominal rated currents as shown in the drawings.

(b) Miniature Circuit Breakers conforming to BSEN 60898 /IEC 60898 and a rated interrupting capacity of 20 kA or 10 kA as indicated in drawings shall be double pole with nominal rated current of 20A or 10A as indicated in drawings shall be of Type 3 or Type C.

2.9.4 Current Transformers

Current transformers of insulation rating 600V, accuracy class 1.0 with thermal limit current of 40 times the rated primary current, rated burden 5VA, transformation ratios as appropriate for use with polyphase kilowatt hour meter on a 230V, 50hz, 4 wire system shall conform to BS 7626: 1993 / IEC 60185: 1987.

2.9.5 Kilowatt-hour Meter

Polyphase kilowatt-hour meters, conforming to BSEN 60521 / IEC 60521 shall be suitable for 3 phase, 4 wire, 400/230V, 50Hz system with unbalanced load, a current rating of 5A, insulation resistance of 10m at 600 V-dc, for flush mounting and use in conjunction with current transformers of transformation ratios as appropriate.

2.9.6 Indicator Lamps

250 volt grade, 5 watt rated incandescent lamps, shall have round dome shaped lenses of diameter approx, 50mm and colors Red, Yellow and Blue to indicate live phases. The lenses shall be made of glass or synthetic material to approved standard, and be easily detachable for lamp replacement for front of panel.

2.9.7 Voltmeters

AC voltmeters conforming to BS 89/IEC 60051 shall be of the moving iron type ranged 0-300V, bezel size 96 mm x 96 mm, insulation voltage 600V accuracy class 2.5 suitable for direct connection and panel mounting on a 230 V, 50Hz, 4 wire supply.

2.9.8 Ammeters

AC Ammeters conforming to BS 89/ IEC 60051 shall be of the moving iron type ranged 0-5A. bezel size 96mm x 96mm, insulation voltage 600V, accuracy class 2.5 suitable for panel mounting on a 230V, 50Hz, 4 wire supply, and direct connection to current transformers rated 250/5A.

2.9.9 Busbars

Three phase and neutral busbars rated as indicated in the Single Line Drawings shall be air insulated, and of hard drawn high conductivity copper. They shall be rigidly supported so as to withstand any mechanical forces to which they may be subjected

under maximum fault conditions of 50 kA. Busbar supports shall be made of slotted back bakelite or other approved insulating materials with a minimum thickness of 5/8" (1.58 cm), and shall be securely bolted to the structural frame of the cubicle.

Busbars shall be painted to indicate phases, with one (1) coat of surface primer and two (2) coats of nitro cellulose lacquer.

All screws, bolt, washer and similar materials used for the construction of the switchboard shall be cadmium plated. The neutral bar shall be provided with an adequate number of terminals, including cable lugs bolts etc., to suit the installation. All bolted connections shall be adequately secured with lock nuts.

The colour coding for main, secondary, and connecting busbars shall be as follows:

Use	Colour
Phase	Red, Yellow, Blue
Neutral	Black
Earth	Green/Yellow

2.9.10 The Distribution Boards

(a) General

This Specification covers the manufacturing of outdoor lighting distribution panels, Main Distribution Boards (MDBs) and Lighting Distribution Boards (LDBs)

(b) Applicable Standard

The equipment and components supplied shall be in accordance with the latest editions of the standards specified below and amendments thereof. However this Specification shall supersede these standards in the event there is a discrepancy.

- MDBs and LDBs shall be in accordance with IEC 60439.
- Terminations for control cables shall be made in accordance with IEC 60439.
- MDBs and LDBs shall be in accordance with degrees of protection IP 54 classified in IEC.60529 of 1992 (BS.5490).
- All panel wiring shall comply with the requirements of BS.6231, Type A or B, as appropriate.
- Panel testing shall be in accordance with IEC 61592

(c) Design and Construction Features

Panel Board

MDBs and LDBs shall be free-standing and of weatherproof and vermin proof

construction. The construction shall employ folding techniques with the use of standard rolled sections or other reinforcement where necessary. The stiffness shall be such as to prevent mal-operation of contactors, timers or other apparatus by impact. The front of the panel shall have a smooth well-finished surface.

MDBs and LDBs shall have in front dust-tight and/or weatherproof door on robust hinges as shown in the drawings. All doors shall be fastened by integral handle with provision for locking each door. Doors shall be rigid, and fitted with weatherproof sealing-material suitable for the climatic conditions specified. All the supply pillars shall provide with the multiple locks and key. Six keys shall be marked with the numbering to identify the source of supply pillar and road number.

The panels shall be fitted with a steel channel base.

MDBs and LDBs shall be suitable for use in a tropical climate.

MDBs and LDBs shall be powder coated. All surfaces shall be prepared before coating in accordance with ISO 1456, ISO 1458 or others as applicable.

Where painting is carried out at the manufacturer's works and where erection at Site is the responsibility of the Contractor, any damage during delivery or erection at Site shall be made good to the requirements of the Engineer including, where deemed necessary, application of a complete finishing coat of an approved colour and quality paint.

Where painting is carried out entirely at Site after erection, the whole of the Plant, including bare pipe surfaces and hand railing, shall be well wire brushed down and cleaned after which all parts shall be given one coat of primer, one undercoat and at least one finishing coat of an approved colour and quality paint.

All paint shall have appropriate standard finish, requiring at least two finishing coats on prepared surfaces properly filled in to provide a smooth finish. The insides of outdoor control cubicles, cabinets, etc., where condensation is liable to occur, shall receive the same number of coats.

MDBs and LDBs should be suitably rated for a prospective short circuit breaking capacity of not less than 25kA at 415V and as indicated in the DFrawings. MDBs and LDBs shall be capable of carrying continuously rated currents without exceeding the maximum temperature given in the appropriate IEC Standards.

The metal cable gland plate shall be provided with knock-out or other approved cable entries for accommodation of the cables and cable glands. Regarding the number and size of such knock-outs, the breakers can be used in any combination of single-phase and three-phase circuits.

MDBs and LDBs shall be well ventilated through vermin-proof louvers comprising a brass gauze screen attached to a frame and secured to the inside of the cubicle.

Ventilation louvers must be properly screened to prevent ingression of dirt, insects and vermin.

Any divisions between compartments within the cubicles shall be perforated to assist air circulation. Also each division shall be equipped with separate door operated lamp.

In addition, a thermostatically controlled 230V AC anti-condensation heater (metal clad heater) of an approved type and having screened drainage holes shall be provided to prevent internal condensation. The equipment therein must be fungus and moisture proof.

Earth metal of MDBs and LDBs shall be bonded together and earthed to the transformer earthing system. Earthing connections within the panel shall be carried out in bare copper strip with cross sectional area of 150 sq.mm.

The Distribution Boards supplied for this Contract shall be totally enclosed, and be designed properly to accommodate MCCBs and MCBs. The enclosure shall be manufactured from metal or sheet metal. The doors shall be internally hinged and lockable. The Distribution Boards and Junction Boxes shall be mounted on plinths of plastered brickwork masonry. The Main Distribution Boards (MDBs) and Lighting Distribution Boards (LDBs) shall be manufactured to conform to the Tender Drawings. They shall have an ingress protection rating of IP 54 minimum to BSEN 605209/ IEC 60529.

The bus bars shall be fully shrouded.

2.10 Time Switches

At each supply pillar, a time switch is required to switch off part of the lighting circuit during the period of darkness when traffic volumes are low. The time switch shall be electrically wound motor driven from 230 volts; 50 hertz supply and have a spring driven clockwork reserve of not less than 12 hours. The contacts shall be inductively rated to accept an inrush current of the contractor coils and auxiliary relays.

2.11 Photo Electric Control

Photosensitive lighting controls shall be weatherproof enclosed, suitable for operation on 220-250 volts, 50Hz A.C. The controls shall function to energize artificial lighting when the natural lighting level fails to a preset, adjustable value, and to de-energize artificial lighting when natural lighting level rises to a present adjustable value. The operation shall be fail-safe, in that, in the event of failure of any components of the control unit the artificial lighting shall be continuously energized. Time delay devices shall be included to prevent switching of artificial lighting due to transient lighting changes. The control unit shall be completely unaffected by humidity. The switch mechanism shall be snap acting of sufficient capacity to adequately handle loads of inrush rating of contractor coils or auxiliary relays. Suitable mounting socket and bracket shall be provided.

2.12 Supply Pillars

(a) The Contractor shall supply and erect the outdoor mounting self-standing type pillars enclosing the Distribution Boards and Over Ground Junction Boxes in accordance with the Drawings. The pillars shall be mounted on the same plinths supporting the Distribution Boards and Over Ground Junction Boxes. The pillars shall be manufactured from steel or cast iron. The final appearance and finish of the surround shall be identical to that shown on the Drawings irrespective size to house the equipment shown on the Drawings and leave 10% spare usable space.

(b) The supply pillars shall be fitted with a steel channel base. The door shall be lockable with either wedge type locks approved by the Engineer. The pillars must be self ventilating and rainproof. The doors shall be hinged internally to prevent unauthorized access. All the supply pillars shall provide with the multiple lock and key. Six keys shall be marked with the numbering to identify the source of supply pillar and road number.

(c) The Contractor shall provide mount and wire the equipment as shown on the Drawings including a 12 mm thick backbite board and frame. The Contractor shall install the incoming cable from the CEB's meter to the supply pillar and the weather head if required. The equipment includes main safety switch, distribution fuse board, contactors, multi-terminal blocks, time switches etc. and some space must be left free for the possible future installation of addition equipment.

(d) In addition to the items shown on the Drawings, the following shall be provided and installed at each supply pillar:

- A multi ground terminal block shall be provided for the connection/bonding of all non-current carrying metallic parts, common grounding conductor and grounding electrode conductor. The size of the common grounding conductor shall be 25 mm2 insulated stranded copper.
- A circuit identification chart and circuit-wiring diagram sealed within a clear plastic envelope and fixed to the inside of the door.
- An approved sign fitted to the outside of the pillar to indicate that the pillar houses electrical equipment.
- Lighting and convenience outlet.
- All necessary internal wiring, which shall be of a size to match the rating of the protective fuse.
- Spare Mobs and McCabe, two of each size used.
- Supply pillar shall be provided with spare power plugs usable 20 watt tubular fluorescent lamp, voltmeter, ammeter. Circuiting procedure shall be as approved by the Engineer.

2.13 Grounding

Except where specifically indicated otherwise, all exposed non-current carrying metallic

parts of electrical equipment shall be grounded. Ground rods shall be driven so that the tops are approximately 0.30 m below the finished grade, the neutral conductor shall only be grounded at its origin or at the service entrance. Grounding electrodes shall be driven ground rods of the cone-pointed, copper-encased steel. Copper-encased steel ground-rods shall be tolled to a commercially round shape from a welded copper-encased billet and shall have a conductivity not less than 27 percent of that pure or pure copper with an equivalent cross-section. The rods shall have clean, smooth, continues copper surfaces and the proportion of copper shall be uniform throughout the length of the rod. Ground wires shall be secured to the upper ends of ground rods by exothermic process. Ground rods shall be of at least 10-ft (3.0 m) long unless otherwise specified, and shall have diameters sufficient to permit driving to the necessary depth without being damaged, but in no case shall they be less than 5/8 inch (16mm) diameter. If the maximum resistance cannot be obtained by one rod a sufficient number of additional rods shall be installed not closer than two (2) meters on center and bonded to the main system.

Grounding system for all lighting columns on structure shall be accomplished by use of cable armour bonded to grounding terminals and grounding rods at lighting columns and supply pillars.

2.14 Testing of the Lighting System

(a) A functional test shall be made on completion of the work in order to demonstrate that every part of the equipment and installation functions as intended and specified. The test shall consist of not less than five night's continuous and satisfactory operation. It any defects or unsatisfactory operation is revealed, this condition shall be corrected and the test repeated until the required five successive nights of satisfactory operation has been achieved.

(b) The Contractor shall make available to the Engineer a photometer, and other related accessories, suitable calibrated by an authorized authority, for measuring the illumination on the road surface if desired.

(c) Prior to the functional test, the Contractor shall provide the testing equipment and accessories and shall carry out the following tests to the entire satisfaction of the Engineer:

- Each circuit shall be tested for continuity and polarity.
- Each circuit shall be tested for ground continuity and ground resistance, as specified in the relevant British Standards.
- Voltage drop in each circuit shall be determined.
- Power factor for each circuit shall be determined.

(d) On the completion of testing, the Contractor shall supply to the Engineer three copies of "as built" drawings of wiring and circuit diagrams, which shall clearly indicate any modifications which have been made to the original design (See details in Section 113).

803.3 Concrete Work

3.1 Description

All lighting column foundations shall be constructed as per contract documents and drawings by the approved Civil Contractor unless otherwise specified on the Drawings. Foundations will be complete except that the top 12-mm shall be placed after the lighting column, has been positioned by the Contractor.

The foundation for the supply pillars and other incidental items shall be erected by the Contractor using concrete Class B (Grade 20).

3.2 Concrete Constituents

The constituents of Class B (Grade 20) concrete are as follows:

Class	Cement Content (kg/m3)		Range of Coarse Aggregate	Min. 28 day Cylinder Compressive strength (kg/cm2)	
	Min.	Max.		Preliminary	Site
B (20)	315	380	20 mm	320	240

Concrete placed under water shall be 1.5 times of cement content specified above. Still water shall be maintained at the point of deposit and the forms under water shall be watertight.

The grading of the coarse and fine aggregates shall be within the limits required by AASHTO Standard Specification M 80 and M 6 respectively.

All aggregates shall be stored in such a way that they shall be kept free of all deleterious matter, and aggregates of different sizes shall be stored separately. Aggregate stockpiles shall be shaded and shall be water sprayed in order to obtain a concrete laying temperature of less than 38oC.

The water/cement ratio for saturated surface dry aggregate shall not exceed 0.50 by weight.

3.3 Workability

The concrete shall be sufficiently workable for full compaction to be obtained.

3.4 Sampling of Concrete

The concrete mixes shall be sampled at the direction of the Engineer in order to check any of the foregoing stipulations.

Mixing: Unless otherwise agreed by the Engineer, the concrete shall be mixed in a power driven mixer, which has been approved by the Engineer.

Ready mixed concrete shall also be used with the approval of the Engineer.

3.5 Forms and Formwork

All concrete plinths, bases and foundations shall be constructed with the use of formwork. All formwork used shall be of such quality and strength as will ensure rigidity throughout the concreting operation. The Engineer shall inspect all formwork before concreting commences. An approved release agents shall be used on all formwork. No formwork shall be removed sooner than 24 hours after concreting.

All concrete shall be compacted to produce a dense homogeneous mass. Unless otherwise agreed with the Engineer, it shall be compacted by the use of vibrators.

The compacted concrete shall be cured for at least 7 days and shall be protected against the effects of rain, temperature changes and from drying out. The methods of protection shall be subject to the approval of the Engineer.

The foundation depths shown on the Drawings are approximate only and may be increased by the Engineer in order to obtain satisfactory foundations. Concrete for foundations underwater shall be placed in position by trim pipe, pipeline from the mixer or as approved by the Engineer.

803.4 Measurement

Measurement shall be made on the items detailed in the Bill of Quantities completed, accepted and measured in place. The units of measurement of each item shall be the unit of measurement shown in the Bill of Quantities.

The quantity of each item paid for under this clause will be system of individual system as detailed shown on the Drawings furnished and installed in accordance with this specification, the drawings and the instructions of the Engineer.

The system will be paid for as a “system” for the work as provided hereunder.

(a) Main Distribution Board (MDB)

Furnishing, transportation, erection, installation and connection as per contract drawings and specifications to incoming and outgoing feeder cables of Main Distribution Board (MDB) manufactured as per contract drawings and specifications and fixing on plinth and foundation with anchor bolts, nuts, washers, and providing and installing enclosure including foundation and all other incidental materials, field tests and data, relative civil and all other incidental work connected therewith the Main Distribution Board (MDB) to be installed shall be the Main Distribution Board (MDB) unit furnished, installed in place and accepted by the Engineer.

(b) Lighting Distribution Board (LDB)

Furnishing, transportation, erection, installation and connection as per contract drawings and specifications to incoming and outgoing distribution cables of Lighting Distribution Board (LDB) manufactured as per contract drawings and specifications and fixing on plinth and foundation with anchor bolts, nuts, washers, and providing and installing enclosure including foundation and all other incidental materials, field tests and data, relative civil and all other incidental work connected therewith the Lighting Distribution Board (LDB) to be installed shall be the Lighting Distribution Board (LDB) unit furnished, installed in place and accepted by the Engineer.

(c) Over Ground Junction Boxes (JB)

Furnishing, transportation, erection, installation and connection as per contract drawings and specifications to incoming and outgoing distribution cables of Over Ground Junction Boxes (JB) manufactured as per contract drawings and specifications and fixing on plinth and foundation with anchor bolts, nuts, washers, and providing and installing enclosure including foundation and all other incidental materials, field tests and data, relative civil and all other incidental work connected therewith the Over Ground Junction Boxes (JB) to be installed shall be the Over Ground Junction Boxes (JB) unit furnished, installed in place and accepted by the Engineer.

(d) Pole mounted type street lamps 250 W. Single Arm

Furnishing, transportation, erection, installation and connection as per contract drawings and specifications to incoming and outgoing distribution cables of Pole mounted type street lamps 250 W. Single Arm manufactured as per contract drawings and specifications complete with Luminaire, lamp and control-gear, lighting column terminal box with Miniature Circuit Breaker, and fixing on foundation with anchor or 'J' bolts, nuts, washers, ensuring verticality and all other incidental materials, field tests and data, relative civil and all other incidental work connected therewith the Pole mounted type street lamps 250 W . Single Arm to be installed shall be the Pole mounted type street lamps 250 W. Single Arm unit furnished, installed in place and accepted by the Engineer.

(e) Pole mounted type street lamps 250 W. Double Arm

Furnishing, transportation, erection, installation and connection as per contract drawings and specifications to incoming and outgoing distribution cables of Pole mounted type street lamps 250 W. Double Arm manufactured as per contract drawings and specifications complete with two Luminaires, lamps and control-gear, lighting column terminal box with Miniature Circuit Breakers, and fixing on foundation with anchor or 'J' bolts, nuts, washers, ensuring verticality and all other incidental materials, field tests and data, relative civil and all other incidental work connected therewith the Pole mounted type street lamps 250 W . Double Arm to be installed shall be the Pole mounted type street lamps 250 W. Double Arm unit furnished, installed in place and accepted by the Engineer.

(f) Pole mounted type street lamps 250 W (for Bridges)

Furnishing, transportation, erection, installation and connection as per Drawings and specifications to incoming and outgoing distribution cables of Pole mounted type street lamps 250 W. for Bridges manufactured as per contract drawings and specifications complete with Luminaire, lamp and control-gear, lighting column terminal box with Miniature Circuit Breakers, and fixing on foundation with anchor or 'J' bolts, nuts, washers, ensuring verticality and all other incidental materials, field tests and data, relative civil and all other incidental work connected therewith the Pole mounted type street lamps 250 W . for Bridges to be installed shall be the Pole mounted type street lamps 250 W. for Bridges unit furnished, installed in place and accepted by the Engineer.

(g) 70 W Luminaire for under pass lighting

Furnishing, transportation, erection, installation and connection as per contract drawings and specifications to incoming and outgoing distribution cables of 70 W Luminaire for under pass lighting manufactured as per contract drawings and specifications complete with Luminaire, lamp and control-gear, lighting unit terminal box with Miniature Circuit Breakers, and anchoring suitably with anchor bolts, nuts, washers, ensuring alignment and all other incidental materials, field tests and data, relative civil and all other incidental work connected therewith the 70 W Luminaire for under pass lighting to be installed shall be the70 W Luminaire for under pass lighting unit furnished, installed in place and accepted by the Engineer.

(h) 4core Cu/XLPE/SWA/PVC 120 sq. mm cables

Supply, lay and install 50 mm diameter Medium Pressure Type 600-400 uPVC conduit complete with sockets and other accessories a) laid directly under ground and / or b) laid from manhole to manhole for road crossing and elsewhere if applicable, and / or c) laid over Bridges and / or d) under Bridges inside box girder as per contract requirements encase 4core Cu/XLPE/SWA/PVC 120 sq. mm cables inside laid PVC conduits, ducts on Bridges, including laying on trays under Bridges and fastening with cable ties at one meter intervals, terminate cable ends in specified manner as per contract drawings and specifications on Lighting column/ unit terminal boxes or Main Distribution Board or Lighting Distribution Board terminals as per Drawings and specifications, ensuring proper cable grounding and termination with insulated compression lugs and ferrules shall be the 4core Cu/XLPE/SWA/PVC 120sq. mm cables unit furnished, installed in place and accepted by the Engineer.

(i) 4core Cu/XLPE/SWA/PVC 25 sq. mm cables

Supply, lay and install 50 mm diameter Medium Pressure Type 600-400 up conduit complete with sockets and other accessories a) laid directly under ground and / or b) laid from manhole to manhole for road crossing and elsewhere if applicable, and / or c) laid over Bridges and / or d) under Bridges inside box girder as per contract requirements encase 4core Cu/XLPE/SWA/PVC 25 sq. mm cables inside laid PVC conduits, ducts on Bridges, including laying on trays under Bridges and fastening with cable ties at one

meter intervals, as applicable terminate cable ends in specified manner as per contract drawings and specifications on Lighting column/ unit terminal boxes or Main Distribution Board or Lighting Distribution Board terminals as per contract drawings and specifications, ensuring proper cable grounding and termination with insulated compression lugs and ferrules shall be the 4core Cu/XLPE/SWA/PVC 25 sq. mm cables unit furnished, installed in place and accepted by the Engineer.

(j) 4core Cu/XLPE/SWA/PVC 240 sq. mm cables

Supply, lay and install 100 mm Medium Pressure Type 600-400 diameter uPVC conduit complete with sockets and other accessories a) laid directly under ground and / or b) laid from manhole to manhole for road crossing and elsewhere if applicable, and / or c) laid over Bridges and / or d) under Bridges inside box girder as per contract requirements encase 4core Cu/XLPE/SWA/PVC 240 sq. mm cables inside laid PVC conduits, ducts on Bridges, including laying on trays under Bridges and fastening with cable ties at one meter intervals, as applicable terminate cable ends in specified manner as per contract drawings and specifications on Lighting column/ unit terminal boxes or Main Distribution Board or Lighting Distribution Board terminals as per contract drawings and specifications, ensuring proper cable grounding and termination with insulated compression lugs and ferrules shall be the 4core Cu/XLPE/SWA/PVC 240 sq. mm cables unit furnished, installed in place and accepted by the Engineer.

(k) 2 x 4core Cu/XLPE/SWA/PVC 240 sq. mm cables

Supply, lay and install 50 mm diameter Medium Pressure Type 600-400 uPVC conduit complete with sockets and other accessories a) laid directly under ground and / or b) laid from manhole to manhole for road crossing and elsewhere if applicable, and / or c) laid over Bridges and / or d) under Bridges inside box girder as per contract requirements encase 2 x 4core Cu/XLPE/SWA/PVC 240 sq. mm cables inside laid PVC conduits, ducts on Bridges, including laying on trays under Bridges and fastening with cable ties at one meter intervals, as applicable terminate cable ends in specified manner as per contract drawings and specifications on Lighting column/ unit terminal boxes or Main Distribution Board or Lighting Distribution Board terminals as per contract drawings and specifications, ensuring proper cable grounding and termination with insulated compression lugs and ferrules shall be the 2 x 4core Cu/XLPE/SWA/PVC 240 sq. mm cables unit furnished, installed in place and accepted by the Engineer.

(l) 4core Cu/XLPE/SWA/PVC 35 sq. mm cables

Supply, lay and install 50 mm diameter Medium Pressure Type 600-400 uPVC conduit complete with sockets and other accessories a) laid directly under ground and / or b) laid from manhole to manhole for road crossing and elsewhere if applicable, and / or c) laid over Bridges and / or d) under Bridges inside box girder as per contract requirements encase 4core Cu/XLPE/SWA/PVC 35 sq. mm cables inside laid PVC conduits, ducts on Bridges, including laying on trays under Bridges and fastening with cable ties at one meter intervals, as applicable terminate cable ends in specified manner as per contract

drawings and specifications on Lighting column/ unit terminal boxes or Main Distribution Board or Lighting Distribution Board terminals as per contract drawings and specifications, ensuring proper cable grounding and termination with insulated compression lugs and ferrules shall be the 4core Cu/XLPE/SWA/PVC 35 sq. mm cables unit furnished, installed in place and accepted by the Engineer.

(m) 4core Cu/XLPE/SWA/PVC 16 sq. mm cables

Supply, lay and install 50 mm diameter Medium Pressure Type 600-400 uPVC conduit complete with sockets and other accessories a) laid directly under ground and / or b) laid from manhole to manhole for road crossing and elsewhere if applicable, and / or c) laid over Bridges and / or d) under Bridges inside box girder as per contract requirements encase 4core Cu/XLPE/SWA/PVC 16 sq. mm cables inside laid PVC conduits, ducts on Bridges, including laying on trays under Bridges and fastening with cable ties at one meter intervals, as applicable terminate cable ends in specified manner as per contract drawings and specifications on Lighting column/ unit terminal boxes or Main Distribution Board or Lighting Distribution Board terminals as per contract drawings and specifications, ensuring proper cable grounding and termination with insulated compression lugs and ferrules shall be the 4core Cu/XLPE/SWA/PVC 16 sq. mm cables unit furnished, installed in place and accepted by the Engineer.

(n) Manholes for Power cables

Furnishing, transportation, erection of pre-cast, or cast in-situ with all required materials included, manholes with incidental minor civil works at locations indicated in drawings or otherwise necessary for construction work to fulfill contract obligations shall be unit of each manhole furnished, installed in place and accepted by the Engineer.

(o) Steel Pullar Boxes

Furnishing, transportation, erection of pre-fabricated, in-situ with all required materials included, Steel Pullar Boxes with incidental minor welding and other mechanical including hot dip galvanization to BS 729 or ISO 1461:1999 and civil works at locations indicated in drawings or otherwise necessary for construction work to fulfill contract obligations shall be number of each Steel Pullar Boxes furnished, installed in place and accepted by the Engineer.

(p) Steel Cable Tray

Furnishing, transportation, erection of pre-fabricated, or fabricated in-situ with all required materials included, Steel Cable Tray with incidental minor welding and other mechanical including hot dip galvanization to BS 729 or ISO 1461:1999 and civil works at locations indicated in drawings shall be Steel Cable Tray unit furnished, installed in place and accepted by the Engineer.

(q) The Testing and Inspection of all the Distribution Boards.

Commissioning of the Main Distribution Boards, Lighting Distribution Boards, all

installed cables with all necessary connections and complying with all stipulated Standards, particularly BS 7671:2001, as an integrated system and a fully functional unit fit and proper for the purpose intended and as specified in tender documents shall be accepted by the Engineer as Testing and Inspection of all the Distribution Boards.

(r) Testing of all the operations, circuits, earthing system and commissioning.

Commissioning of the entire Electrical Installation, as per the Inspection and Certification requirements stipulated in BS 7671:2001, inclusive of the Earthing system to comply with the stipulated standards and achievement of the stipulated photometric parameters and criteria by the completed installation shall be accepted by the Engineer as Testing of all the operations, circuits, earthing system and commissioning

803.5 Payment

The work measured as provided in Sub-section 803.4 shall be paid at the Contract Unit Price for each item, such price and payment constituting full compensation for all materials, labor, equipment, tools and incidental needed to complete the work. All materials and work necessary for satisfactory completion of the installation which are not specifically mentioned in the Bill of Quantities shall be deemed to be included in the items shown.

Pay Items		Unit of Measurement
803(1)	Main Distributing Boards (MDB)	number
803(2)	Lighting Distribution Boards (LDBs)	number
803(3)	Over-Ground Junction Boxes (OGJBs)	number
803(4)	Pole Mounted Type Street Cut-off Lamps 250 W - Single Arm	number
803(4)-1	Pole Mounted Type Street Semi Cut-off Lamps 250 W - Single Arm	number
803(5)	Pole Mounted Type Street Semi Cut-off Lamps 250 W - Double Arm	number
803(6)	Pole Mounted Type Street Semi Cut-off Lamps 70 W for Bridge	number
803(7)	70 W Luminaire for Underpasses Lighting	number
803(8)	4 core Cu/XLPE/SWA/PVC 120 sq. mm cables	meter
803(9)	4 core Cu/XLPE/SWA/PVC 25 sq. mm cables	meter
803(10)	4 core Cu/XLPE/SWA/PVC 240 sq. mm cables	meter
803(11)	2x4 core Cu/XLPE/SWA/PVC 240 sq. mm cables	meter
803(12)	4 core Cu/XLPE/SWA/PVC 35 sq. mm cables	meter
803(13)	4 core Cu/XLPE/SWA/PVC 16 sq. mm cables	meter
803(13)-1	4 core Cu/XLPE/SWA/PVC 10 sq. mm cables	meter
803(13)-2	4 core Cu/SWA/PVC 2.5 sq.mm cables	meter
803(14)	Manholes for Power Cables	number
803(15)	Steel Puller Boxes	number
803(16)	Steel Cable Tray	meter
803(17)	Testing and Inspection of all the Distributing Boards	Lump Sum
803(18)	Testing of all the Operations, Circuits, Earthing system	

and Commissioning	Lump sum

SECTION 804

CONDUITS, FITTINGS AND BOXES

804.1 Description

(a) The type, size and locations of conduits, fittings and boxes shall be as indicated on the Drawings or otherwise approved by the Engineer.

(b) All conduits, fittings and boxes shall be hot dip galvanized steel and shall conform to American Federal Specifications WW-C-581d and ASA Specification C 80.1, BS 4568 or equivalent or shall be of unplasticised PVC to appropriate International Standard and specified size.

804.2 Supply

(a) Except as provided for in Sub Section 804.1 (b) conduit shall be formed of mild steel without laminations due to slag breaks, blisters or sockets, and without cinders or other foreign matters. Conduit shall have a circular cross section, with uniform wall thickness to permit the cutting clean, true threads.

(b) The conduit shall be dip galvanized rigid steel. All mill scale shall be removed before pickling and conduit shall be thoroughly cleaned and dried after pickling is completed. Galvanizing shall be done under controlled temperature. The zinc coating shall have an even, smooth appearance and do of uniform quality. Conduits shall be capable of standing five dips in the Preece Copper Sulphate test for galvanized coating in accordance with ASTM A239.

(c) The conduit seam and coating shall withstand being bent cold at minimum temperature of 16°C under slowly applied pressure through 90° to a radius six times the outside diameter of the conduit with the seam on the outside of the bend, without developing cracks or opening the weld and without cracking or flaking the coating.

(d) All conduit fittings without exception shall be made form the same material and shall have the same coating as specified for conduit. The test for the continuity of coating shall be the same as specified for conduit. One coupling shall be furnished with each length of conduit.

(e) Pull or junction boxes shall be made of sheet steel or cast iron in accordance with the Drawings. Sheet steel boxes shall have sharp, straight edges and continuous electric welded seams. A 10 mm flange, turned in, shall be used to take a rubber gasket and shall be drilled and tapped for an approved number of 5 mm stainless machine screws.

(f) Pull or junction boxes shall be made of sheet steel or cast iron in accordance with the Drawings. Sheet steel boxes shall have sharp, straight edges and continuous electric welded seams. A 10 mm flange, turned in, shall be used to take a rubber gasket and shall be drilled and tapped for an approved number of 5 mm stainless machine screws.

(g) If the box is to be encased in concrete, the cover shall extend 10 mm beyond the dimensions of the box and shall be drilled to match tapped holes in flange of same. When

boxes are completely exposed, the cover shall conform to the sheet steel boxes shall be drilled before galvanizing. Sheet steel boxes shall be galvanized in the same manner as for conduit.

(h) All conduits and fittings shall be qualified products by relevant agencies.

(i) Conduit runs shall be made with as few couplings as standard lengths will permit. Screw couplings shall be used. All cuts shall be made square and true with a hacksaw and reamed clear of fins or burrs with a reamer and all couplings shall be screwed up until the ends of the conduits are brought together in order to provide a good electrical contact throughout. The threads on all ferrous metal conduits shall be painted with a rust preventing paint before couplings are made up. Where the coating on ferrous metal conduit has been damaged in handling, such damaged places shall be painted with zinc enrich paint before installation.

(j) Conduit shall have threaded ends coated with red or white lead and of sufficient length so that they shall butt squarely and tightly in the coupling. Long running threads shall not be permitted. Conduits shall be installed so as to be continuous and watertight between boxes and/or equipment.

(k) Where conduits cross expansion joints in the structure or where otherwise specified, they shall be provided with suitable expansion fittings of an approved type. The electrical continuity of the conduit runs across the expansion fittings shall be assured by the approved fittings and bar cooper wire of size 10 mm2 bonded jumper.

(l) Pull boxes shall be used wherever necessary to facilitate the installation of the conductors. Conduits entering into cast iron pull boxes or enclosures shall be threaded into hubs on same. Conduits entering into sheet steel boxes or enclosures shall be secured with two lock nuts and the projecting end shall be equipped with an approved insulating bushing. No thread shall be exposed outside the box.

804.3 Storage

Conduits, fittings and boxes shall be stored under cover and above ground to ensure that the quality of the material is not adversely affected.

804.4 Installation of Conduits and Duct Banks

(a) The size of each conduit shall be such that the sum of the areas of the cross-section of all conductors, including insulation and protective coverings, shall be not greater than 40 percent of the inside area of conduit, except that no conduit smaller than 19 mm inside diameter shall be used except for fixture hangers.

(b) All conduit size and conduit layouts shall be approved by the Engineer before installation and the Contractor shall submit data on the layout for the exact make up, overall diameter, and cross-section areas of the actual conductors he intends to use and the sum of the areas of the conductors is each conduit.

(c) Bends shall be long sweep, free from kinks and of such easy curvature as to permit the drawing in of the conductors without injury. The radius of curvature of inner edge of bends shall not be less than that shown in Table 346-10 of National Electrical Code. Conduits shall not be flattened or distorted. The total angle of all bends between any two boxes or fittings shall not exceed 360 degrees.

(d) Exposed conduit runs shall be parallel to or at right angles to walls, slabs, girders and in locations giving the greatest accessibility for painting and the least accumulation of dirt. All exposed conduit runs shall be attached to steel, masonry, concrete or timber by galvanized steel bolts or lag screws. The runs shall be supported at not greater than 3m centres on horizontal runs, unless otherwise specified, and not less than 5 cm clear of the supporting members. Conduits mounted on structural steel members shall be securely clamped to prevent rattling and wearing.

(e) All ends of conduits installed during construction, or for future use, shall be closed against the introduction of foreign materials by the use of bush caps.

(f) All conduits installed underground shall be at least 60 cm below finished pave or ground level and have a concrete envelope, which shall afford a 7 cm cover beyond the maximum dimension of the conduit. Class B (20) concrete shall be used.

(g) Excavation for the concrete encased duct banks shall be carefully done, side-walls trimmed to line and bottom of trench graded, so that the envelope will be uniform, and there will be no pockets or low points in the conduit run. All backfill shall be carefully tamped to conform to the requirements of Sub-section 2.5.1 "Underground Cabling" (c) "Backfilling". unless otherwise specified, and care shall be taken not to injure the concrete envelope or conduit.

(h) Upon completion of the conduit installation, the system shall be cleaned in the presence of the Engineer before any conductors are installed. Immediately prior to the installation of conductors in any run, the conduits comprising that run shall be again be checked. Any and all obstructions shall be removed to the approval of the Engineer.

(i) The Contractor shall install and leave in place a No. 10 galvanized iron full wire in all conduit runs installed for future use.

804.5 Draw Pits

(a) Draw pits are required to pull the cables at not more than 60 m intervals on straight runs and at every change of direction of the conduit run. The Contractor may install additional draw pits without extra charge if he wishes to do so.

(b) Draw pits shall be of reinforced concrete filling, and shall be seated in cast iron frames. The seating faces of all components in metal to metal contact shall be machine finished to ensure that the installed covers are watertight. Covers shall be designed to carry a 12.3 metric tonne wheel load or as approved by the Engineer.

(c) Covers shall be inscribed "Road Lighting" and shall be provided with a recessed means of lifting.

(d) Tops of draw pits shall be effective level with the surrounding areas, whether paved or unpaved. The bottoms of draw pits shall be bedded with a sand and cement or crushed rock.

804.6 Shop Drawings and Working Drawings

The Contractor shall furnish shop drawings and working drawings, in accordance with the requirements and procedure stated in Specification Section 113, in duplicate for the Engineer's preliminary examination. After working drawings have been accepted by the Engineer and revisions made, the Contractor shall furnish additional copies as may be requested.

804.7 Painting and Coating

The requirements of Section 805 "Painting and Coating" shall apply to the painting and coating of all exposed metallic surfaces.

804.8 Measurement

Where the items in this Section form part of an installation for which a lump sum item is provided they shall not be measured.

Where they form part of work for which individual items are measured they shall be measured by the linear meter for all sizes and kinds complete.

804.9 Payment

Where this work is measured as provided above, it shall be paid for at the Contract Unit Price per unit of measurement. The Unit Price shall allow for all the work and equipment necessary to complete the conduit installation according to the Drawings and shall include all shop and working drawings, conduits, duct banks, fittings, pull and junction boxes, fixings, conduit expansion joints and incidentals, galvanizing, painting, tools, labor, and incidentals necessary to complete the work. These work items are included in other relevant Pay Items.

SECTION 805

PAINTING AND COATING

805.1 General

1.1 Description

(a) This Section covers the performance of all work in connection with the preparation of metal surfaces and application of paint and coating for miscellaneous steel items.

(b) No paint shall be applied to aluminium, stainless steel, copper, bronze, chromium or nickel unless specified or as directed by the Engineer.

805.2 Materials

2.1 Suppliers

(a) All paints, thinners, curing agents and cleaning solvents for any protective coating system in these Specifications shall be the products of the same approved manufacturer.

(b) They shall be furnished in proper, original containers of not more than 25 litres capacity bearing the manufacturers name and identifying code with a clear date of manufacture. Paint, which has not been used within the "shelf-life" specified on the container, shall be discarded and replaced.

2.2 Storage

All paints shall be stored in cool, dry conditions. Supplies of paints shall be used up in the same order in which they are delivered.

2.3 Samples

The Contractor shall supply to the Engineer one-litre samples of the selected paints, well in advance of their use. The Engineer may take samples for testing and analysis from containers of paint in use.

2.4 Thinning

All paints shall be used as supplied by the manufacturers without thinning or adulteration except where specifically allowed by the Engineer, when the thinner specified by the manufacturer shall be used.

2.5 Data Sheets

The Contractor shall submit to the Engineer copies of the data sheets for all paint materials he proposes to use, together with any identifying codes.

2.6 Paint System and Color

(a) The paint system to be applied shall be as follows:

Pre-treatment	Undercoat	Finish
Vinyl Wash	Vinyl Prime-Red Iron Oxide Applications 1, 3 Vinyl Prime-Titanium Dioxide Applications 2, 4 Total 0.1mm undercoat	Vinyl 2 applications Total 0.05mm finish

(b) The dry film thickness of the paint shall be measured in place with the instruments approved by the Engineer.

(c) Paints shall conforms to the materials requirements set forth in the appropriate AASHTO Materials Specifications.

(d) The color of the finish coat shall be as specified and as directed by the Engineer.

805.3 Construction Method

3.1 General

All protective coating operations shall be carried out within the recommendations for best practice as outlined in BS 5493 or international equivalent.

3.2 Surface Preparation

(a) For steelwork to be given protective treatment all welding slag, splatter, flux, residues, oxides, fumes, snags and strikes shall be removed and all sharp arises and burrs ground smooth. The surface shall be treated to remove deposits of oil or grease and other foreign substances.

(b) Unless cleaning is to be done by blast cleaning all welded areas, before cleaning is begun, shall be neutralized with a proper chemical, after which they shall be thoroughly rinsed water.

(c) The methods of cleaning are given in Sub Section 3.3, 3.4 and 3.5. Blast cleaning shall be used unless otherwise specified.

(d) Neither initial coating nor any subsequent applications shall be made unless the surface to be treated is clean, dry and dust free and had been approved for painting by the Engineer. If dust has settled on the surface it shall be removed by vacuum.

3.3 Blast Cleaning

(a) Blast-cleaning of steel surfaces shall be carried out generally in covered workshops with adequate lighting and in accordance with BS 4232 or international equivalent and the

equipment to be used shall be capable to producing the standards of cleaning specified herein. Visually, the blast-cleaned surfaces shall be equal to the Swedish Standard SIS 05,5,900 Preparation Grade or international equivalent specified and the Engineer may require evidence that there are no residual chemical contaminants. When compressed air is used, it shall be dry and free from oil.

(b) The abrasive used for blasting shall be free from contamination, and any recovered material shall be thoroughly cleaned before reuse. Non-metallic abrasives shall only used with the approval of the Engineer. The average and maximum amplitudes (peak to trough) of the blast cleaned surface shall be as specified when measured by a suitable roughness meter. Threaded fittings shall be protected by bolts or screwed rods in such way as to allow blast cleaning up to the edge of the hole and the temporary bolts retained for the coating process.

(c) Surface "shelling" and other imperfections raised by the cleaning process shall be repaired at this stage.

(d) The Contractor shall submit to the Engineer prior to the commencement of blasting information concerning the size and type of abrasive to be used. The abrasive shall meet the requirement of Table 2, BS 4232 or international equivalent.

(e) The blast-cleaned steelwork shall be freed from dust and adherent particles by vacuum or brush before any coating is applied and no member shall go forward for pretreatment or coating until the cleaned surfaces have been approved by the Engineer. Where a longer period than 3 hours has elapsed since cleaning or where blasted surfaces have, in the opinion of the Engineer, deteriorated they shall be reblasted immediately prior to painting.

(f) A sample blast-cleaned steel panel measuring not less than 150 mm x 150 mm x 6 mm adequately protected by sealed clean polyphone wrapping, shall be submitted to the Engineer for each blast-cleaned method.

3.4 Flame Cleaning

Flame cleaning shall be carried out in accordance with the following:

(a) Oil, grease and similar adherent matter shall be removed by washing with a suitable solvent. Excess solvent shall be wiped from the work before proceeding with subsequent operations.

(b) The surface to be painted shall be cleaned and dehydrated (free of occluded moisture) by the passage of oxyacetylene flames which have an oxygen to acetylene ratio of at least one. The inner cones of these flames shall have a ratio of length to port diameter of at least 8 and shall be not more than 3.7 mm center to center. The oxyacetylene flames shall be traversed over the surfaces of the steel in such a manner and at such speed that the surfaces are dehydrated and dirt, rust, loose scale in the form of blisters or scabs, and similar foreign matter are freed by the rapid, intense heating by the flames. The flames shall not be traversed so slowly that loose scale or other matter is fused to the surface of

the steel. The number, arrangement and manipulation of the flames shall be such that all parts of the surfaces to be painted are adequately cleaned and dehydrated.

(c) Promptly after the application of the flames, the surfaces of the steel shall be wire brushed, hand scraped wherever necessary, and then swept and dusted to remove all free materials and foreign particles. Compressed air shall not be used for this operation.

(d) Paint shall be applied promptly after the steel has been cleaned and while the temperature of the steel is still above that of the surrounding atmosphere, so that there will be no accumulation of moisture on the cleaned surface.

3.5 Hand Cleaning

The removal of rust, scale and dirt shall be done by the use of metal brushed scrapers, chisels, hammers or other effective means. Oil and grease shall be removed by the use of gasoline or benzene. Bristle or wood fiber brushes shall be used for removing loose dirt.

3.6 Number of Coats and Color

(a) All steel shall be painted in accordance with the paint system given in Sub Section 5.2.6. The color shall be as specified or determined by the Engineer.

(b) Each coat shall show a clear change of color from the one before.

3.7 Weather Conditions

(a) Paint shall not be applied when the air is misty or when, in the opinion of the Engineer, conditions are otherwise unsatisfactory for the work. It shall not be applied upon damp surfaces.

(b) Material painted under cover in damp weather shall remain under cover until dry or until weather conditions permit its exposure to the open. Painting shall not be done when the metal is hot enough to cause the paint to blister and produce a porous paint film.

3.8 Mixing of Paint

Paint shall be factory-mixed. All paint shall also be field mixed before applying in order to keep the pigments in uniform suspension.

3.9 Field Painting

(a) When the erection work is complete including all riveting and straitening of bent metal, all adhering rust, scale, dirt grease or other foreign materials shall be removed as specified under Sub Section 3.2.

(b) As soon as the Engineer has examined and approved all field rivets, the heads of such rivets and field bolts, all welds and any surfaces from which the shop or undercoat of paint has become worn off or had otherwise become defective, shall be thoroughly cleaned and spot painted with undercoats to the specified thickness.

(c) Surface to be riveted in contact and surfaces, which shall be in contact with concrete, shall not be painted. Surfaces, which shall be inaccessible after erection, shall be painted with the full number of application prior to erection. When the paint applied for retouching the shop coat has thoroughly dried and the field cleaning had been satisfactorily completed, such field coats as are required shall be applied. Each application of paint shall be thoroughly cured and any skips, holidays, thin areas or other deficiencies corrected before the succeeding application.

(d) The following provision shall apply to application of all field coats to secure a maximum coating on edges of plated or shapes, rivet heads, weld runs and other parts subjected to special wear and attack, the edges shall first be striped with a longitudinal motion and the rivet head with a rotary motion of the brush, followed.

(e) The application of the final field coat shall be deferred until adjoining concrete work has been placed and finished. If concreting operations have damaged the paint, the surface shall be recleaned and repainted.

(f) The Contractor shall protect pedestrian, vehicular and other traffic upon, alongside or underneath the structure and also all other portions of the structure, against damage or disfigurement by spatters, splashes and smirches or paint or paint materials.

3.10 Application of Paint

(a) General: Painting shall be done in a neat and workman . like manner. Paint may be applied with hand brushed or by spraying. By either method, the coating of paint applied shall be smoothly and uniformly spread so that no excess paint will collect at any point. If work done by spraying is not satisfactory to the Engineer, hand brushing shall be required.

(b) Brushing: When brushes are used, the paint shall be so manipulated under the brush as to produce a smooth uniform, even coating in close contact with the metal or with previously applied paint, and shall be worked into all corners and crevices.

(c) Spraying: Power-spraying equipment shall apply the paint in a fine, even spray without the addition of any thinner. If necessary, it shall be immediately followed by brushing to secure uniform coverage and to eliminate wrinkling, blistering and airholes.

3.11 Removal of Paint

If the painting is unsatisfactory to the Engineer, the paint shall be removed by an approved mean and the metal thoroughly cleaned and repainted.

3.12 Painting Galvanized Surface

(a) Washing with spirit solvent sufficient to remove any oil, grease or other materials foreign to the galvanized coating shall first clean all galvanized surfaces that are to be painted.

(b) After washing, all areas shall be roughened by abrasive blasting using as abrasive that is no longer than 30 mesh. Galvanizing shall not be removed by this operation.

(c) After preparation. All galvanized surfaces that are to be painted shall be covered with one application of zinc dust-zinc oxide primer, Federal Specification TT-P-641, Type II. The zinc dust-zinc oxide shall be applied by spraying to produce a complete covering of the galvanized surfaces.

(d) After the application of zinc dust-zinc oxide paint, one application of pre-treatment, vinyl wash primer shall applied by spraying to produce a uniform wet film on the surface.

(e) Such surfaces shall then be covered with two separate applications of white tint base vinyl finish coat, sufficient to completely cover the preceding color. Paint for the first application shall be tinted with a compatible coloring agent to slightly contrast with the color of the second application. The final application shall match the colour specified herein or as directed by the Engineer.

3.13 Shop Painting

(a) Unless otherwise specified, steelwork shall be given a vinyl wash and four applications of undercoat after is had been accepted by the Engineer and before it is shipped from the plant.

(b) Surfaces not in contact, but inaccessible after assembly or erection, shall be painted with the complete paint system. The shop contact surfaces shall not be painted. Field contact surfaces not painted with the shop coat shall be given a coat of approved lacquer or other protective coating if it is expected that there will be a prolonged period of exposure before erection.

(c) Surfaces, which will be in contact with concrete, shall not be painted unless otherwise specified.

(d) Structural steel, which is to be welded, shall not be painted before welding is complete. If it is to be welded only in the fabricating shop and subsequently erected by bolting, it shall be shop painted in accordance with Sub Section 3.13.1 after shop welding is finished. Steel, which is to be field welded, shall be given one coat of boiled linseed oil or other approved protective coating after shop welding and shop fabrication is completed.

(e) Surface of iron and steel casting, either milled or finished, shall be given one coat of paint.

(f) With the exception of abutting joints and base plate's machine-finished surfaces shall be coated as soon as practicable after being approved before removal from the shop.

(g) Erection marks for the field identification of members and weight marks shall be painted upon surface areas previously painted with the shop coat. Material shall not be loaded for shipment until it is thoroughly dry, and in any case not less than 24 hours after the paint has been applied.

3.14 Storage

Painted steelwork, which is to be stored prior to erection shall be kept clear of the ground and shall be laid out or stacked in and orderly manner that will ensure that no pools of water or dirt can accumulate on the surface. Suitable packing shall be placed to prevent

contact between members. Where a cover is provided it shall be well ventilated and not in direct contact with the coated surface.

3.15 Jointing

(a) The pre-treatment and any subsequent coats shall be mashed and stepped back as directed on the relevant drawings to leave sideweld areas and edges clear of paint.

(b) At bolted connections, clearance at holes must be maintained and runs through holes avoided; temporary bolts shall be fitted in any threaded fittings and removed before the coating has set.

(c) Bolted contact surfaces shall be thoroughly wire brushed and cleaned of all foreign matter immediately prior to being brought together.

(d) After tightening, the externally exposed surfaces of bolts, nuts and washers shall be cleaned, degreased and carefully painted by brush with the approved special primer for galvanized surfaces, following which they shall be receive the coats of paint of the adjacent area necessary to bring them forward and complete the protective scheme as specified. Special attention shall be paid to the filling of meeting edges of joints and connections with liberal applications of all coats.

(e) In the case of surface jointed by HSFG bolts the paintwork shall be stopped off at a distance of 8 cm from the joint. all interfaces shall be cleaned by hand wire-brushing before assembly. After jointing all exposed faces shall be made good to the same Specifications as for the adjoining material.

3.16 Sample Test Plates

The Engineer may require sample test plates of any system being applied for to be produced by the Contractor and tested to be check that the specified produced by the Contractor and tested to check that the specified protection is being provided by his operations.

3.17 Final Cleaning

The Engineer shall require all coated surfaces to be washed down and cleaned to his satisfaction before he make his final inspection of site treatments.

805.4 Particular Requirements

4.5 Vehicle Barriers

All metalwork not galvanized shall be painted using the system specified in Sub Section 2.6. The finish color shall be white.

4.2 Hand railing

All hand railing shall be galvanized, phosphate treated and painted in accordance with

Sub Section 3.12.

4.3 Road Traffic Signals

(a) Posts and brackets shall be provided with vinyl wash coats of finishing coats shall be provided after erection.

(b) The signal heads, terminal compartments, visors, louvers and sighting screens shall be painted with the complete paint system prior to delivery.

(c) Controllers and other cases shall be painted on the outside and inside using the specified paint system. A coating of sprayed molten zinc will be accepted as an alternative of painting of cabinets.

4.4 Road Signs and Gantries.

(a) All paints used foe steel parts, other than finished on a sign face shall be specified in Sub Section 2.6.

(b) All painting and finishing shall be carried out in clean, dry surroundings using heat lamps for drying and ovens for baking as may be needed. All paints shall be applied with a pressure spray to form a smooth even film and all surfaces and edges shall be coated unless stated otherwise. Paint shall be applied only when the surface or previous coat is dry.

(c) The following requirements shall, unless otherwise provided on the Drawings, apply to preparation and painting of sign components other than the finish on sign faces, but excluding plastic signs and components with finishes of reflective and plastics sheeting, film, sheathing and other proprietary finishes:

- Aluminium Alloys: Aluminium Alloys, other than sign faces, shall be treated or painted unless they are in contact with earth. Surfaces in contact with earth shall be prepared as described in the next paragraph and two coats of approved asphaltic paint shall be applied. Before painting, the surfaces of aluminium alloy sign plates shall be thoroughly degreased and pre-treated by anodizing or by an equivalent process or by using an etching primer. The prime coat shall them be applied. The back and edges of the plate shall receive a finish coat of light grey enamel.
- Steel: All steel components shall be galvanized and painted in accordance with Sub Section 3.12. The final finish coat shall be tinted light grey.
- Cast Iron: Cast Iron surface shall be cleaned and painted in accordance with Sub Section 2.6.

4.5 Miscellaneous Steel Items

All miscellaneous steel items not otherwise specified shall be painted in accordance with Sub Section 2.6.

805.5 Measurement

The quantity of work done under this item shall not be measured but is shall include all painting required on each structure or structure unit.

805.6 Payment

No payment shall be made for the work, materials, labor and equipment. It shall be considered incidental to work performed under other items.

SECTION 806

TRAFFIC SIGNALS

806.1 GENERAL

1.1 Description

The work shall consist of the supply of all signal heads, supports, controllers, detectors, cables, switch-gear with all necessary ancillary equipment together with the transportation, storage, erection, connection reinstatement, and testing of the same order to supply a complete traffic signal installation in accordance with the Drawings and as specified herein. The Contractor shall prepare the Detailed Design of the traffic signal system and get approval from the Engineer.

1.2 Responsibility for Design and Materials

Traffic signal equipment shall comply with BS 505: 1971 (AMD 1990, 1976) as amended by Specification TR 0102. Items of equipment and part shall have maker's specifications agreeing with those of the U.S.A. Standard Institute and practice, the American Society for Testing Materials, the American Association of State Highway and Transportation Officials, the National Bureau of Standards, the British Standards, Institution of Electrical Engineers Regulations for the Electrical Equipment of buildings or other similar internationally recognized body. All work shall be done and all goods shall be made in strict accordance with the requirement of the Electrical Code of the Sri Lanka.

The Contractor shall be solely responsible for the adequate design and the coordinated functioning of all goods and constructions furnished under this contract.

All the component parts shall be selected so as to ensure their proper coordinated functioning and operation. All equipment shall be of the maker's standard models and shall include all recent improvements in design and materials. All materials used in manufacture and construction shall be of high quality and fully in accordance with the best modern practice.

The equipment offered and the work done shall be suitable for continued trouble free operation under adverse climatic conditions of heavy rain, high humidity and intense sunlight. The equipment must be able to withstand over long periods ambient air temperatures varying from a normal of 40°C to maximum of 50°C.

The Contractor shall submit a complete design of the Traffic Signal System in accordance with this Specification in three copies including design calculations, drawings, wiring diagrams and equipment and materials lists to the Engineer within three months after the commencement date of the Contract.

In order to proceed with other aspects of the work, the Engineer has carried out a partial

design of the Traffic Signal System based on design assumptions as shown on the Drawings. The Contractor shall embody these assumptions in his design and accept responsibility for them, unless he finds difficulties, which he cannot resolve. If such difficulties arise, he shall inform the Engineer without delay.

1.3 Compliance with Manufacturer's Specifications

The Contractor shall ensure that the equipment and parts used shall be entirely suitable for the work to be performed and that they shall be manufactured to proper clearances and fit. He shall further ensure that the loading of equipment shall under all normal circumstances not exceed the maximum laid down or agreed in writing by the manufacturer.

The Contractor shall be responsible for the inspection of all equipment and parts before their incorporation in the works to ensure that they comply with the Conditions of the Contract and that they are not defective in any way as regards to materials or workmanship. Should any such non-compliance or defects be found during the inspection, the Contractor shall correct or cause to be corrected such non-compliance and defects, all at the Contractor's expense and to the satisfaction of the Engineer.

1.4 Maintenance Period

All repairs and replacements required during the Maintenance Period shall be carried out with dispatch and an adequate supply of spares shall be available for this purpose.

1.5 Electricity Supply

The Traffic Signal System will be provided with a source of three-phase power adjacent to the source of power for the Road Lighting System at the AB 010 Interchange the enclose housing the traffic signal control system shall be positioned there.

The Contractor must ensure that the equipment supplied will function correctly at a supply voltage of 230 volts, 1 phase 50 Hz and must allow for normal variations and surges.

1.6 Definitions

Unless specially defined herein, definitions shall be given in BS 892: "Glossary of Highway Engineer Terms", BS Code of Practice CP 1004 "Street Lighting " and BS 505: " Road Traffic Control (Electric) Light Signals", and all as amended at the time of Tender.

806.2 Materials and Equipment

2.1 Signal Heads

All signal lights shall be low power consuming Light-Emitting Diodes (LEDs) of the high intensity type possessing high resistance to shock and vibration. Equipment shall comply

with BS 505 (or equivalent international standard) and shall be vermin proof. All lanterns shall be of 300 mm in diameter.

All signal heads and the optical systems shall be a combination of the high intensity LED type with high rate of durability. Equipment shall be to the IP 55 to BSEN 60529 / IEC 60529.

Four types of the signals shall be used for the traffic control at the specified point:

Type ″A″ shall be with one red, one amber and one green controlling traffic through and the set of lights to be mounted on a 6 m post with arm as shown in Drawings M13.

Type ″B″ shall be with two red two amber and two green controlling traffic secondary to Traffic light No 1 & 3 on low level road. The above set of lights shall be mounted side ways of the overhead bridge with suitable brackets as given in Drawings M13.

Type ″C″ shall be with one red one amber and two green arrows controlling traffic through in each direction, one secondary to traffic light No. 1 and the other primary on opposite direction. The next is the right turn primary signal to enter the OCH. The above two sets of lights shall be mounted on a 6 m post as shown. Drawings M13.

Type ″D″ shall be with one red, one amber and one green (green with arrow to left/Right) controlling traffic descending to low-level road. Drawings M13.

There are three types of signal heads. The first type shall consist of three electrically operated and controlled optical units arranged as shown on the Drawings. The top unit shall show two reds, the centre two amber and the lowest two greens. The second type shall consist of two by tree electrically operated and controlled optical units arranged as shown on the Drawings. The top unit shall show two reds, the centre two amber and the lowest two greens. The third type shall consist of one electrically operated and controlled optical unit arranged as shown on the Drawings. The unit shall show amber. Additional optical units may be added as required for special facilities. Suitable visors shall be fitted to all optical units. Louvers and sighting screens shall be supplied if required to give the most efficient operation under all conditions. Each signal face shall conform to a sample submitted to and approved by the Engineer.

2.2 Posts

Posts if not specified on the drawings shall consist of solid drawn or longitudinally butt welded mild steel tube, 13.6 centimetres outside diameter and not less than 4.5 millimetres wall thickness. The length of the post shall be sufficient so that the centre of the lowest signal aspect shall be at least 2.15 meters above ground when the foot of the post is buried at least 60 centimetres below ground. A suitable base plate and final shall be provided for each post. Brackets shall be so designed that they shall allow full adjustment of the signal heads and shall support the signal heads rigidly under all normal conditions. Posts shall be provided with cable slots near the base and with the

required cable bush holes in correct positions. All cable slots provided to fasten base plated, brackets and signal heads firmly to the posts and to allow adjustment where required. All nuts, bolts, fastenings, hinges and adjusting brackets on posts, final, terminal compartment and signal heads shall be cadmium plated or of stainless steel or made corrosion resistant in positive manner.

2.3 Wiring

All lamp-holders shall be wired to a suitable terminal block mounted in the housing, and shall be ventilated to avoid condensation. Wires shall be P.V.C. insulated and free of all joints except in the terminal block and shall be permanently color-codes to facilitate maintenance and repair. At each signal location, unless shown otherwise on the Drawings, there shall be a terminal compartment provided on the mounting which shall be provided with a terminal block containing 12 holes, each with two screw type terminals of suitable size. A weather-tight cover shall be provided to the terminal compartment, which will give ready access to the terminal block, and the terminal compartment and cover shall be of sufficient strength to remain intact if the mounting pole is knocked down. Ventilation or other suitable means shall be provided in the terminal compartment to avoid excessive condensation. External connections from the signal face to the terminal compartment shall be protected by approved flexible conduit. Buried cables from the controller to signals and detectors shall be suitably armored, or laid in approved conduit, and free of all joints except at terminal blocks or junction pedestal unless it is to be connected to a signal that is mounted thereon. Sufficient conductors shall be provided to perform the functional operation of signal system throughout. In addition, between the controller and the signals, three spare conductors shall be provided of a size equal to the largest conductor in the run. Wires subject to bending due to opening and closing of doors shall be stranded. All metallic parts out carrying current shall form an electrically continuous system, which shall be earthed, or they shall be section area of 6 square millimeters. All items below ground level shall be designed and installed so that they shall continue to operate without fault of immersed in ground water.

All power cable shall be copper conductor PVC insulation; PVC Jacket (NYY Cable) minimum size of conductor shall be 2.5 square millimeters.

Each signal post shall be individually wire direct to controller. Tapping to other post shall not be permitted.

2.4 Painting

Paint and painting shall be accordance with BS 505 with the following additions and modifications. Posts and brackets shall be provided with a prime coat and follow by two coats of undercoat before delivery. A sufficient number of finishing coats shall be provided for final painting after erection. The signal head, terminal compartments, visors, louvers, and sighting screens shall be delivered primed and with two undercoats and a

finishing coat. Controller and other cases shall be finished with two coats of approved aluminium paint on the outside and shall have priming, two undercoats and one finishing coat of paint on the interior. A coating of sprayed molten zinc shall be accepted as an alternative to the painting of the cabinets. The Contractor shall submit the material, specifications and shop drawing of the traffic signal work to the Engineer for his approval 60 days prior to commencement of the work.

2.5 Detectors

Vehicle sensors shall be inductive loop sensors and shall consist of a loop or loops of insulated conductor, a sensor unit circuit and a power source. The loop detector shall operate on the principle that a vehicle standing or crossing over the loop shall cause a change in inductance, which shall be detected by the sensor unit, so operating the detector circuit in the signal controller. The loop shall be installed in slots cut in the highway surface or laid under the wearing course. The depth, orientation and dimensions of the loop shall be as recommended by the manufacturer. The sensor unit shall be a solid state electronic device capable of sensing changes in the inductance of one or more loops and mounted in a waterproof container which shall be located and suitably housed under the roadway or foot walk close to the loop or loops. Electronic switching is preferred, but if relays are used, they shall be hermetically sealed.

The detector shall be so designed, constructed and adjusted that:

- It shall respond only to a vehicle passing over or standing over any portion of the loop.
- It shall detect vehicles passing over it at speeds up to 100 km/h.
- The detector circuit shall be de-energized immediately after a vehicle passes over it.
- It shall re-balance to ignore vehicles parked over a portion of the lane and shall thereafter detect subsequent vehicles passing over it.
- Where operating as a speed detector, which shall influence the operation of the controller, the detector shall be fully capable of detecting differences of speed, which are consistent with the capabilities of the controller.

Inductive loop detectors shall operate over the entire width of the approach road leaving no gaps of more than 40 centimetres. Where required for separate detection, individual detectors shall be provided for each traffic lane, and these shall be so designed and installed that there shall be no mutual interference between them.

For each detector, a button shall be provided at the controller who can simulate a demand on that detector. An ON/OFF switch shall also be provided at the controller for each detector to allow that detector to be switched out of the circuit independently of any other detector. Both buttons and switches shall be clearly and permanently labelled to indicate which detector is controlled. Switches shall have the ON and OFF positions

labelled, the detector being in the circuit when the switch is in the ON position.

2.6 Controller

The controller shall be a Micro-processor based programmable controller, with back-up memory in the form of a server with facilities for 'Historical Trending' and 'Events Logging' and "self Diagnostics" for controlling the operations of the traffic control signals, including the timing mechanism and all necessary auxiliary equipment, securely mounted in a cabinet. Preference shall be given to solid-state circuitry and to design having replaceable units for ease of maintenance. Interval timing shall be by electronic and not by mechanical means. The color sequence of the signal indications shall be as given in Sub Section 3.1 and there shall be control to ensure that green shall not be shown at the same time on opposing phase under any circumstances. Operation shall be either by fixed time sequences, (variable by time switch) or shall be by vehicle actuation, or by combination of both, as herein described.

The software programme for controlling the traffic phase sequences shall preferably be 'Windows" based and shall provide at least eight options of phase sequences and in addition two extra options for new designs. The programme shall be designed so that each option is modifiable; adjustable the time delay is means of keyboard and monitor. The keyboard and monochrome monitor shall be provided in safety locked for every controller. The Road Development Authority (RDA) of the Ministry Highways or authorized agencies shall provide the programme and external terminals, linkable and controllable. All of the software shall be saved in erasable ROM. (Read Only Memory); floppy diskettes are provided in writings, trained to the Authority or his assignee.

At a temperature of 25°C, the controller shall be designed to operate satisfactorily with voltage variations up to + 17.5% or .20.0% from the normal 220 V operating voltage. The timing of the controller shall be within ±7.5% of the correct value at the rated voltage and shall not be affected by more than ± 10% for a ± 10% change in voltage or a ± 4% change in frequency of the supply. The Contractor shall submit evidence of this (traceable to National Bureau of Standard) to the Engineer.

The controller shall be so designed that temperature variations between 10°C and 70°C shall not change the timing by more than 5% or otherwise the cabinet shall be artificially ventilated to keep the internal temperature within satisfactory limits. In the event of power failure, the controller shall shut down and re-commence operations without the necessity for manual re-setting.

The controller shall be provided with a suitable mechanism for closing and opening the signal circuits, which shall be positive and without any dark intervals, flickering or conflicting signal indications. All contact points which carry make or break current shall be of fine silver, silver or an alternative better material and shall be capable of carrying, making or breaking a current of 150% of maximum demand load through one million operations without electrical or mechanical trouble. The use of hermetically sealed

contacts is preferred.

Every current interrupting device shall be equipped with a suitable radio interference suppressor and/or shielding installed at the input power point. Interference suppressors shall be of a design, which shall minimize interference on both broadcast, and aircraft frequencies. The attenuation shall be at least 50 dB at all frequencies from 50 kHz to 10 MHz.

The controller shall provide for the proper phase intervals and sequences as herein specified or as may be required by traffic conditions. The setting to time intervals shall be by means of a positive method against a scale calibrated in seconds. This timing scale shall be easily accessible and identifiable within the controller and it shall not be necessary to remove or change wires or contacts to adjust the time intervals.

(a) Manual Operation: Manual Operation shall be possible by means of an approved key or by external buttons on the controller housing. If push buttons are used, they shall be inoperative until the controller has been switched to manual operation, and automatic control shall resume without the need for any manual adjustment at the end of manual operation.

Provision shall be made for the following manual operations:

- Allocating right of way to approaches independently of the pre-set timing of the controller.
- Switching signals to "OFF" Provision shall be made so that under no circumstances shall an approach lose its right of way without having at least the appropriate minimum green time plus amber time

(b) Time Switch: Where a time switch is required this shall be capable of tow "ON-OFF" periods per day of a minimum length of sixty minutes each and with a minimum period of sixty minutes between successive "ON-OFF" positions. The setting dial shall clearly distinguish between day and night and the switching mechanism shall be fitted with a selective device enabling all switching to be eliminated on any one day in the week or clearly marked with the days. The time mechanism shall be fitted with a high quality mechanism movement, which shall be electrically wound and shall have a minimum spring reserve of twelve hours.

(c) Switches and Fuse: The controller shall be provided with a main manual switch and fuse, which shall isolate the complete installation. There shall all be provided on general-purpose outlet and fuse. All fuses and switches shall be adequately and permanently labeled. Two reserve fuses shall be mounted in the cabinet.

(d) Controller Housing: The controller shall be housed in a weatherproof cabinet, complying with an ingress protection rating of IP65 to BSEN 60529/IEC 60529,of aluminium, sheet metal, fiber glass or other approved material having sufficient strength and rigidity to protect the contents from the effects of water, dust, and accidental blows. Sheet metal

shall be at least 2 millimeters on thickness at all points and reinforced where necessary. Ferrous metal shall not be buried and it shall be aluminium or aluminium alloy is used, it shall be suitable protected against electrolytic or chemical corrosion. In the base of the housing it shall contain at least 8% of silicon.

The housing shall be securely fixed to a concrete base through which connections shall be made to detectors and signals. All doors shall be hinged with concealed hinges and provided with locks, the door hinges and pins being of non-corrodible metal which shall not require lubrication more often than once per year. Doors shall open and shut freely without binding on the frame or the base. Otherwise, doors may consist of a stiff removable panel having self-positioning interlock joints provided with suitable gaskets. Such panels shall be provided with at least two locks. All locks shall be captive, flush fitting and non-corrodible and shall operate by a standard key which shall fit all housings.

The controller shall be sited in such a way that it shall not cause an obstruction or hazard to traffic or pedestrians, and where it shall not be subject to accidental damage from traffic.

The cables running to signals and detectors shall be terminated in a convenient and readily accessible position on blocks having the required number of terminals and provided with non-hygroscope, non-inflammable insulating bases. Sufficient space shall be left between terminals and between blocks to enable external cables to enter and be formed in neat manner without obstructing individual terminal points. Electrical connection between controller and the terminals shall be approved-keyed plug and socket connections.

Each terminal point and connection shall be clearly marked by color-coding or by a numbering system. Ends of all spare conductors shall be shielded, covered, or insulated so that no live parts shall be exposed.

(e) Identification: All equipment and replaceable assemblies shall be marked with as a part number any other identification, which is required for re-ordering.

(f) Records: The following records shall be provided and kept within the housing, either fixed to the inside of the main door or placed within a metal pocket provided thereon:

- A wiring diagram of the system showing the color-coding number of the conductors.
- A layout plan of the intersection showing the detectors, the signals controlled by each phase and the cycle details, and
- A suitable ruled card shall be fixed within the controller upon which space is provided to record maintenance undertaken, the date visit and the name of the person doing the maintenance.

The signal serial number shall be stencilled in two conspicuous locations on the outside of

the housing in letters not less than two centimetres high.

(g) Fixed Time Signal Controller: In addition to the foregoing requirements, where fixed time signals are required, the controller shall be capable of carrying out the following operation, although it shall not necessary be limited to the followings:

- Allocation of right of way by suitable timed green aspects to the various approaches in accordance with the timings previously set on the controller.
- Changing from one phase to another by means of the correct sequence of aspects as herein given (Sub Section 3.1) and maintaining the correct pre-set amber periods throughout. It shall be possible to vary the length of the inter-green period without use of special tools.
- Allowing a late start or early cut off on one or more phases as may be required.
- Displaying left or right filter arrows as may be required.

By means of a time switching device, it shall be possible to alter the phase and cycle lengths to allow for varying traffic conditions. It shall be possible to operate at least four such programs during a period of 24 hours.

It shall be possible to integrate the controller into a linked system working under a master controller if required, and to add a facility for vehicle counting. The sequence of phase shall be possible automatically to dim the traffic signal lighting during the hours of darkness.

(h) Vehicle: Actuated Signal Controller. In addition to the fore-going requirements, where vehicle actuation is called for, the controller shall be capable of, but not necessarily limited to the following operations:

- In the absence of detector actuation, the right of way shall remain on the phase on which the last demand was made. However, a recall switch shall be incorporated into each phase which, when closed, shall result in the right of way automatically returning to that phase without further demand (Automatic Reversion).
- When the right of way is transferred to a phase in response to a demand, this right of way shall cause the initial minimum right of way period to be extended, the extension being proportional to the additional demands (Vehicle Extension Periods).
- In the absence of demands from other phases, continued demands on the phase having the right of way shall hold that right of way. When a demand is made form another phase, the phase holding the right of way shall lose it, even in the event of demands, after a pre-set adjustable maximum green period shall commence from the first receipt of a demand from another phase.
- Should there be outstanding demands on the phase losing the right of way, or should further demands made on phase during the clearance period, then right of

way shall revert automatically to the phase losing it, once demands of other phase have been satisfied.

- The transfer of right of way shall take place only after an adjustable clearance period, which may differ between phases (Inter-green Period).
- Provisional shall be made for green filter arrows and late-start or early cut-off facilities on any phase. If these are not required at the outset, there shall be provision for their inclusion at a later stage if required.
- It shall be possible to incorporate the controller into a linked system under a master controller if required, and there shall be facilities for resuming independent operation either on a time basis or as a result of altered traffic conditions.
- Traffic counting and queue detection, if not specified, may be required at a later stage, and facilities for these should be incorporated or it should be possible to add them easily when required. The details shall be submitted to the Engineer for his approval.
- It shall be possible to automatically dim the traffic signal lights during the hours of darkness.

(i) Vehicle actuated Controller with speed measuring equipment when the controller is to be used with speed measuring detector, the following additional facilities shall be required on the controller, as well as item above:

- The minimum green time referred to in Sub Section 2.6 (h)(i) above shall be reduced according to the number of demands that have been made below the predetermined number (Sub Section 2.6 (h) (iii), so that if there are less than the predetermined number of vehicles waiting for the right of way, sufficient time shall be given only for that number to clear the junction before right of way is given to another phase that has made a demand. (Variable minimum green time)
- If a demand is made on a phase not having the right of way and all demands have been met on the phase having the right of way, then the right of way shall be given to the phase making the demand after a minimum inter-green period. However, if at the expiration of the maximum green period on the phase having the right of way, there are still vehicle extension periods outstanding, the inter- green period is required to ensure that the right of way is not given to an opposing phase before last traffic has cleared the junction on the phase losing the right of way. (Variable Inter-Green Period).

806.3 Design Principles

This subsection is intended to give general guidance in the principles to be followed by the Contractor when designing the Traffic Signal System.

3.1 The Sequence off Aspects on any one Signal Face System with Light-Emitting Diode

(LED).

- Red
- Green
- Amber

During any aspect, there shall be no visual flicker of the signal illumination.

3.2 Siting of Signals

Siting of signals shall be carried out in detail at the junction generally in accordance with the Drawings and shall be agreed by the Engineer. Each approach road shall be served by minimum of two signal faces as follows:

The Primary Signal shall be located not less than one meter beyond the stop line on the near side of the road. Where there is a central median, a second primary signal may be provided similarly on the offside of the approach.

The Secondary Signal shall be on diagonally opposite side of the junction facing the approach, that is generally on the back of the primary signal serving the opposite approach in the case of a four arm junction. The secondary signal may be opposite the offside of the approach where there is a central median, but in any case should not be outside an angle of 30 degrees extended from the centerline of the approach at the stop line to the offside.

3.3 Stop Lines

Stop lines shall be located as shown on the Drawings.

3.4 Detectors

Detectors shall be neither more than 45 meters nor less than 30 meters from the stop lines on each approach, although on difficult approaches carrying only slow traffic, this minimum may be reduced to 20 meters. On high-speed roads, where secondary detectors are called for, these shall be placed at not more than 165 meters from the stop line.

3.5 Phases

The duration of each phase at the intersection shall be kept to the minimum required to avoid traffic long queues. Where additional phases are called for by unusual traffic conditions at certain times, these additional phases shall be suppressed when not required. In designing the number of phases and the details of the cycle, the principle shall be to arrive at the arrangement which shall at all times give minimum average delays to traffic with adequate capacity and maximum safety to both vehicles and to pedestrians.

3.6 Filter Signals

Filter signals mounted a side of the main signals may be used to allow a movement in one direction. A yellow and red aspect shall always follow a green filter arrow indication, and if this cannot be done on the main signal, separate yellow and red aspects must be provided for the filter signal. Particular care shall be taken to ensure that filtering traffic does not form an undue hazard to pedestrians crossing. Guardrails, slip roads, islands or some resisting to the stop line may be required to avoid this. Where an early out-off is used for offside turning traffic, an offside filter arrow shall be provided to indicate to turning traffic that is safe to proceed.

3.7 Clearance Period

Where required for safety or to allow turning traffic to clear, a longer clearance period may be introduced but this should be kept to the shortest period, which is consistent with the demands of traffic and safety at any time.

3.8 Linked Systems

The system shall be designed such that it can be incorporated within a linked system with the minimum modification. With fixed time signals, there shall be the facility to change automatically the programme of linking, so as to give preference to the heavier flows at different times of the day. With vehicle actuated signals, local controllers shall be free to revert to independent operation when there ceases to be continuous demand, providing that this shall not interfere with the overall progression through the system.

3.9 Signal Timing

Signal Timing shall be done on the basis of traffic demands as estimated from the traffic flows. Verification and adjustment shall be required on site after the system is in operation, but the Contractor must show by calculations that the system proposed is capable of handling the estimated maximum and normal flows in an efficient manner and with minimal delays. With fixed time signals, he shall submit details of phase and cycles for each approach throughout the day. In the case of vehicle-actuated signals, he shall give similar details of maximum cycle time, maximum and minimum green times, vehicle extension periods and inter-green periods.

806.4 Excavation

4.1 Excavation and Reinstatement

Excavation for duct or conduit lying or for foundations and reinstatement shall be carried out in accordance with the provisions of Section 802.2 of these Specifications. Reinstatement shall be such that the surface is restored to at least its original standard.

The Contractor shall carry out excavation for cable lying in open ground.

4.2 Concrete Work

Others shall carry out all the signal post foundations and footings or other concrete work in accordance with the Section 803.3 of these Specifications unless otherwise specified on the Drawings. Concrete shall be "Grade 20". Foundations shall be placed in one operation except that the top 5 centimetres may be placed after the superimposed structure is in position. The exposed portion of foundations shall be formed to present a neat and tidy appearance and sloped to shed water away from the structure supported.

Where existing structure obstruct the construction of foundations as shown on the plans, hen a positive alternative location shall be provided as approved by the Engineer.

4.3 Conduits, Fitting and Boxes.

Conduits, fittings and boxes shall be provided and installed in accordance with the provisions of Section 804 of these Specifications, except that chemically stable, tough plastic conduits, fittings and boxes according to samples previously approved by the Engineer, shall be permitted providing that they do not soften when exposed to high ambient temperature.

The Contractor may use a large size of conduit than that specified, at no extra charge, if he wishes, but in case the entire run shall be of the same size. No reducing couplings shall be permitted.

When metal conduits are used, cuts shall be made square and true and all couplings shall be screw-tightened until the ends of the conduits are brought together in order to provide good electrical contact throughout. The threads on all ferrous metal conduits shall be painted with a rust preventing paint before couplings are assembled. Where the coating on ferrous metal conduit has been damaged in handling, such damaged places shall be painted with rust preventing paint before installation.

All conduit ends shall be threaded and capped until wiring is started. When caps are removed, the threaded ends shall be provided with approved conduit bushings.

Conduit shall be laid to a depth of not less than 50 centimetres below paved foot walks and medians and not less than 75 centimetres below the roadway surface. The location of all conduits at curb lines shall be marked by means of a "Y" at least 10 centimetres high incision in the face of the curb directly above the conduit. Conduit terminating in standards, cabinets or pedestals shall extend at least 5 centimetres, vertically above the foundations and shall be sloped towards the hand-hole opening. Conduit entering pull boxes shall terminate at least 5 centimetres inside the box wall and at least 5 centimetres vertically above the bottom of the box. Such conduit shall be sloped towards the top of the box to facilitate pulling. Conduit entering the bottom of the box shall enter near the sides or end to leave the centre clear. All conduits shall enter in the direction of the run.

4.4 Pull Boxes

Pull boxes shall be installed at not more than 60 meters intervals. The Contractor may install addition pull boxes without extra charge if he wishes. Pull boxes shall be of reinforced concrete not less than 15 centimetres thick and may be of approved precast design. Reinforced concrete covers, secured by two recessed nickel-plated brass bolts shall be used on foot walks; the covers being inscribed "Traffic Signal" on the outside. Under the roadway, cover shall be of steel or cast iron inscribed as specified above, and laid in a suitable concrete footing to withstand traffic loads. Metal covers shall be effectively earthed to an earthing rod inside the box. Tops of pull boxes shall be effectively level with surrounding paved areas, whether foot walk or roadway, but in unpaved areas, the tops of pull boxes shall be buried 30 centimetres below ground level. The bottom of pull boxes shall be bedded in sand and cement. Permanent makers shall be provided and erected to show the position of all pull boxes.

806.5 Inspection and Testing to be Carried out by the Contractor

(a) Every lighting unit, traffic signal and network, on completion and before being energized, shall be inspected and tested to verify that the requirements of BS 7671 have been met. The method of testing shall be such that no danger to persons or property or damage to equipment can occur even if the circuit tested is defective.

(b) The following tests shall be carried out in the sequence indicated below and recorded on a Schedule, in an appropriate format, which shall be submitted to the Engineer immediately after completion of all the tests, including those on Lighting Units and Traffic signals, within each network:

Seq.	Description of Required tests	Lighting Units	Traffic Signals & Network
a	Cable sheath insulation test		*
b	Continuity of protective conductors incl. main and supplementary equipotential bonding	*	*
c	Earth electrode resistance		*
d	Insulation resistance at a test voltage of 500 V to be not less than 1.0 M ohm	*	
e	Insulation resistance at a test voltage of 500 V to be not less than 6 M ohm		*
f	Insulation of the site-built assemblies	*	*
g	Polarity, incl. the continuity of circuit conductors	*	*
h	Earth fault loop impedance at every cut-out		*
i	Operation of residual current devices		*
j	Voltage drop in each circuit	*	
k	Power factor for each circuit	*	

806.6 Measurement

Measurement shall be made on the items detailed in the Drawings completed, accepted

and measured in place. The systems of Equipment shown in the Drawings.

6.1 Type A signal post- Location 1 & 5

Furnishing, transportation, erection, and connection for Type A signal post, complete with Signal Heads and wired as per specifications and drawings, base plate, brackets, anchor bolts, nuts, washers, including all power and signal cables from controller to signal post terminal strips, conduits, foundation materials, field tests and data, relative civil works and all other incidental work including painting as per specifications, connected therewith shall be number of each Type A signal post unit furnished, installed in place and accepted by the Engineer.

6.2 Type B signal post- Location 2 & 4.

Furnishing, transportation, erection, and connection for Type B signal post, complete with Signal Heads and wired as per specifications and drawings, base plate, brackets, anchor bolts, nuts, washers including all power and signal cables from controller to signal post terminal strips, conduits, foundation materials, field tests and data, relative civil works and all other incidental work including painting as per specifications, connected therewith shall be number of each Type B signal post unit furnished, installed in place and accepted by the Engineer.

6.3 Type C signal post- Location 3.

Furnishing, transportation, erection, and connection for Type C signal post, complete with Signal Heads and wired as per specifications and drawings, base plate, brackets, anchor bolts, nuts, washers including all power and signal cables from controller to signal post terminal strips, conduits, foundation materials, field tests and data, relative civil works and all other incidental work including painting as per specifications, connected therewith shall be number of each Type C signal post unit furnished, installed in place and accepted by the Engineer.

6.4 Type D signal post- Location 6 & 7

Furnishing, transportation, erection, and connection for Type D signal post, complete with Signal Heads and wired as per specifications and drawings, base plate, brackets, anchor bolts, nuts, washers including all power and signal cables from controller to signal post terminal strips, conduits, foundation materials, field tests and data, relative civil works and all other incidental work including painting as per specifications, connected therewith shall be number of each Type D signal post unit furnished, installed in place and accepted by the Engineer.

6.5 Manholes for Traffic Signal Cables

Furnishing, transportation, erection of pre-cast, or cast in-situ with all required materials included, manholes with incidental minor civil works at locations indicated in Drawings

or otherwise necessary for construction work to fulfill contract obligations shall be number of each manhole furnished, installed in place and accepted by the Engineer.

6.6 Traffic Signal Control Unit.

Furnishing, transportation, erection, and of, Traffic Signal Control Unit compete with keyboard, monitor, vehicle detectors, sensors and loops appropriately located positioned and installed as per specifications and drawings, the controller complying with the specifications and mounted in cabinet with detector loops appropriately connected, anchor bolts, nuts, washers, and inter connecting cables, foundation materials, field tests and data, relative civil works and all other incidental work connected therewith the Traffic Signal Control Unit) to be installed shall be the Traffic Signal Control Unit furnished, installed in place and accepted by the Engineer.

6.7 Testing and Commissioning of Traffic Signalling System

Testing and Commissioning of the entire Traffic Signal Control System inclusive of Traffic Signal Control Unit, signal and detector loops in place, signal posts appropriately positioned and installed with all necessary connections as an integrated system and as a fully functional unit fit and proper for the purpose intended shall be accepted by the Engineer as the Testing and Commissioning

806.7 Payment

The work measured as provided above shall be paid at the Contract unit price for each system, such price and payment constituting full compensation for all materials, labor, equipment, tools and incidentals needed to complete the work. All materials and work necessary for satisfactory completion of the installation, which are not specified mentioned in the Drawings and Bill of Quantities, shall be deemed to be included in the items shown below.

Pay Items		Unit of Measurement
806(1)	Type A signal Post	number
806(2)	Type B signal Post	number
806(3)	Type B (OCH-S Type C) Signal Post	number
806(4)	Type C(OCH-S Type D) Signal Post	number
806(5)	Manholes for Traffic Signal Cables	number
806(6)	Traffic Signal Control Unit	number
806(7)	Testing & Commissioning of Traffic Signalling System	Lump Sum

SECTION 807

ROAD EMERGENCY TELEPHONE SYSTEM

807.1 General

(a) This work shall consist of furnishing and installing all materials and equipment necessary to complete in place Highway Road Emergency Telephone System and other supporting electrical work and the modification of such existing telephone cable network systems if required, when so specified, all in accordance with the Engineer. Unless otherwise noted, civil engineering works necessary for the work of this Sub section 807.17 shall be executed and paid for under Sub station 807.19 of this Specification.

(b) The location of outdoor type telephone unit, cable network plan, master control console unit in control room, and appurtenances shown on the Drawings are approximate and the exact location will be established by the Engineer in the field.

(c) The electrical and civil works for Highway emergency road telephone system shall be executed in accordance with these Specifications.

Payment under this Clause for telephone cables will terminate at the cabling branch boxes and connection to the main cable in the manhole of the each unit.

807.2 Scope of Work

The scope of work shall cover the supply, delivery to site, erection, test and commissioning of all material and equipment in connection with the Telephone Installation to the extent described and shown on the Drawings and includes but is not necessarily limited to:

(a) Preparation and submission of Shop Drawings

(b) Submission of detailed Material Supply Lists

(c) All work associated with the removal of section of the existing systems and the incorporation of the remaining section in the permanent works.

(d) All other electrical equipment and services needed to complete a usable and operable facility in accordance with the pertinent electric codes, Telecommunication system and local regulation for Telephone Installation.

807.3 Quality Assurance

For the actual fabrication, installation, and testing of the work described in this Clause, the Contractor shall use only thoroughly trained and experienced personnel who are completely familiar with the requirements for this work and with the installation recommendations of the manufacturers of the specified items. In acceptance or rejection of the installed electrical system, no allowance will be made for lack of skill on the part of installers.

- Installers shall hold the relevant valid certificates complying with the regulations of Sri Lanka Telecommunications Authority and Sri Lanka Telecom if any.
- All work shall comply with the Drawings and this Specification, in addition to complying with the requirements of local Telephone Company and local government authority.

807.4 Drawings and Documents

(a) The Contractor shall refer to all relevant drawings to ascertain for himself the location and routes of all other utility services so as to maintain adequate clearance between telephone and other services.

The drawings supplied are to indicate generally the arrangement of the work. The Contractor is therefore required to consider all under ground or under bridge telephone cables and conduiting or ductings, the exact run of all conduits and trunking, the location of manholes, draw-in and junction boxes, the number and size of wires in each conduit or trunking, the final connection arrangements at distribution boxes, the detail of ducts and the method of fixing Main and Sub-main Distribution Boxes, for the approval of the Engineer before commencing any portion of the work.

All such working drawings shall be submitted in duplicate and within the periods stipulated below:

Details of duct / conduit and method of fixing Main and Sub-main Distribution Boxes and cable entry into any places:

Main working drawings shall be submitted within two (2) months of handing over the site to the Contractor.

All other working drawings shall be submitted within a period of one (1) month from the date of approval of the Main and Sub- main Distribution Boxes by the Engineer.

Should however the Contractor be obliged to install electrical conduits prior to this period then he shall submit the relevant working drawings at least four (4) weeks prior to the proposed date for commencement of the work.

The Contractor shall submit a programme indicating the dates on which concreting in different sections will take place, together with the submission of the working drawings.

(b) On completion of testing, the Contractor shall make "as built" drawings of plans and circuit diagrams, which clearly indicate any modifications, which have been made to the original design. These shall be part of the requirements for as-built drawings refereed to in these Specifications.

(c) Upon completion of the work, and as a condition of its acceptance, the Contractor shall supply to the Engineer three copies of a Manual for the maintenance and operation of all telephone and electrical installations and a parts list sufficient for the ordering of parts.

807.5 Standards and Regulations

(a) The work covered by this Contract shall be carried out in accordance with the regulations issued by the Sri Lanka Telecommunication Regulatory Authority, Sri Lanka Telecom, if any, and with the other applicable standards and codes.

(b) Before submitting his Bid, the Contractor must carefully examine at his own expense all of the Regulations issued by the local Telecommunications Authority and selected materials and method of installation shall be in accordance with these Regulations.

The Tenderer shall include in his unit price for any changes or modification of contract documents to ensure conformance with local regulations.

807.6 General Requirements

The requirements for quality control of materials and workmanship that are obligatory for the satisfactory completion by a Contractor of the telephone unit and cabling works and other defined work items required for Highway shall be defined in accordance with the plans and specifications herein described.

All work hereunder shall comply with the latest Equipment codes, Telephone Cable codes, and other relative codes, in case of the absence of any code locally.

All work shall be done under the administrative supervision of the Engineer. Any changes made thereof shall be with the approval in writing of the Engineer.

The Requirements shall be as follows:

All Road Telephone installation shall be done in accordance with the applicable ordinances, rules and regulations of the Sri Lanka Telecommunications Authority and with requirements Provincial Authority, if any.

The Telephone work shall be under the supervision of a licensed Electrical and Telecommunication Engineer.

807.7 System Description

The Emergency Telephone System, consisting of a total of 24 Telephones, is required to provide an emergency roadside communications service for use in the event of an accident or vehicle breakdown on the Highway.

Emergency Telephones (ET) are to be placed at 1.0 km intervals on both sides (West and East side boundary) of the Highway. Emergency Telephones are intended to be connected to a fixed line telephone system, provided by a "fixed line system" provider such as Sri Lanka Telecom, via a Main Distribution Frame (MDF) located at the AB 010 Interchange at Kaduwela, and a Main Distribution Frame (MDF) located at the A 4 Interchange at Kottawa.

807.8 Emergency Road Telephone System.

8.1 Road side Emergency Telephone

The roadside telephone shall be installed basically at intervals of 1 km on both eastbound and westbound roadsides of the Highway. The telephone shall be of the type with a hook and handset and installed in a weather tight casing, mounted on the standard pillar, and easily distinctive for immediate visual identification by shocked or confused drivers. By lifting up the handset off the hook, the telephone shall be automatically connected.

All the speech circuits of the Emergency Telephone System should be designed to the public telephone transmission quality standard.

The inside of the roadside telephone kiosk shall be provided with lighting, which is operated by a light sensitive switch in order to facilitate identification and operation during dark hours.

8.2 Main Distribution Frame (MDF)

The Main Distribution Frame (MDF) will be housed inside an enclosure of metal, cast-iron, polycarbonate or reinforced fibre-glass material. This enclosure shall be weatherproof to IP 65 as per BSEN 60529 / IEC 60529, out-door located, vermin and dust protected, free standing, plinth mounted and shall be provided with lockable doors. The Main Distribution Frame (MDF) shall be constructed to comply with the latest International Standards. The Contractor shall design the Main Distribution Frame taking future expansion possibilities into consideration.

8.3 Test facility

The Emergency Telephone System shall be provided with circuit test facilities by which the circuits to roadside telephone sets are tested at the Main Distribution Frame (MDF). The Contractor shall describe the test function of the proposed system.

The description shall include the listing of detectable and undetectable troubles on the circuit and the telephone by the test.

8.4 Guide sign

At least two guide signs indicating the direction of the nearest Emergency Telephone shall be installed at roadside of each section between two telephones

807.9 Transmission loss

The transmission loss between the calling roadside telephone and the Main Distribution Frame (MDF) shall be within 20 dB.

807.10 Telecommunication Cables

Outdoor Telephone Cable

Outdoor armoured type telephone cable to be used in the installation. Alpeth is a fully color-coded, Polyethylene insulated, Polyethylene jacketed, telephone cable manufactured in accordance with ASTM standards and others. This cable is intended for aerial installation by attachment to support strand or by duct. The cable consists of individually insulated copper conductors twisted into pairs. The required number of twisted pairs is then stranded into a cable core. A corrugated 8 mils soft aluminium tape shield is applied longitudinally over the core. A heat barrier tape is provided between the core and the shield, and the cable is provided with an overall jacket of black polythlene.

(a) Conductor

Solid annealed bare copper, size 26, 24, 22, and 19 AWG (or 0.4 mm, 0.5 mm,

0.65 mm and 0.9 mm) conforming to ASTM B-3 except that the requirement for elongation and dimension may be waived with the approval of the local Telecommunication Authority and the Engineer.

(b) Installation

Colored high density polyethylene compound that meets the requirements of ASTM D-1248-70 type 3, class B, category 5, grade E-8. Color coded in accordance with standard telephone industry code.

(c) Twisted Pairs

Individual conductors are twisted into pairs with varying layers to minimize crosstalk and with specified color combination to provide pairs identification.

(d) Cable Assembly

Cable having 25 pairs or less are assembled in a single group. Those having more than 25 pairs are assembled in units, each unit identified by color-coded binders.

(e) Core Covering

The core assembly is covered with non-hygroscope dielectric tape that also serves as heat barrier to protect the conductors during the jacketing process.

(f) Shield

The shield shall be of electrically continuous 8 mils thick corrugated aluminium tape applied longitudinally with overlapped edges.

(g) Jacket

The jacket shall be black, high molecular weight low-density polyethylene with excellent

environmental, stress carrying resistance property, meeting the requirement of ASTM D-1248-70 for type class C, and grade 48.

807.11 Cables and Wiring

(a) Cable for telephone units

Main telecommunication cables to be installed in the ground under and along the Highway by the side shall be by pulling and shall be of the type and size shown on the Drawings or given in this Specification. Cables shall be pulled into the roadside telephone units through buried 100 mm diameter PVC conduits directly from under ground from manhole to manhole and inside steel conduit placed on cable trays, hot-dip galvanized to ISO 1461:1999 or BS 729, placed and anchored under the bridges , and shall be terminated at terminal boxes.

For this purpose all terminal blocks shall include approved molded type 10 pair terminals, installed in the base of each telephone units and accessible through the handhole.

Manholes shall be located at 50m intervals along the Telephone cable route and across road crossings. 100 mm diameter PVC Conduits shall connect the manholes buried at a depth of 700 mm from finished ground or pavement level and shall otherwise comply with the requirements stated at 804.6. For road crossings, the minimum depth of burial shall be 700mm from the finished road level. Conduits used for road crossings shall be made of steel, hot-dip galvanized to ISO 1461:1999 or BS 729 and shall otherwise comply with the requirements stated at 804.6.

(b) Cabling and Connections

All power and control cables shall be suitable for operation at the specified voltage in the direct burial and duct or conduit, under the connection of the maximum conductor operating temperature, which at rated current shall be less than 70°C.

Cable colors shall comply with color code standards in Sri Lanka.

Telephone and power cables shall be delivered to the Site on substantial non-returnable wooden drums, each bearing a securely fixed label stating gross weight, serial number, and length of cable and other description.

Covers shall be provided around the periphery of the drum in order to protect the cable in transit and the inner cable end shall be adequately protected by a metal guard or other approved means. Both ends of the cable shall be sealed by a suitable method to prevent the entrance of moisture.

All power supply cables inside of the lighting for signboard and telephone kiosk shall have two conductors per lantern. Cables shall be 600v / 1kV grade “Polyvinyl Chloride Insulated and Sheathed Cable” or shall be of the type approved by the Engineer.

All Telephone cables for the Road Emergency Telephone System to be installed underground shall be PVC insulated, with Galvanized Round Steel wire 1.6 mm armouring, and PVC sheeting type or equal approved by the Engineer.

All cables to be used shall be certified as tested, and approved by the Engineer before installation.

(c) Grounding

Conduit, steel poles and cabinets (Electrical panels) shall be made mechanically and electrically secure to form a continuous system, and shall be effectively grounded. Bonding and grounding jumpers shall be copper wire of the same cross-sectional area for all systems. Bonding jumpers shall be used in all non-metallic boxes. Metallic boxes shall employ hubs of double lock nuts and bushes. The bonding of all conduits, lighting poles and panels to form a continuous ground system shall be in accordance with applicable code standards.

Size of grounding wire shall be minimum 16 mm2 Bare or PVC insulated Copper Conductor (BBC) or as approved by the Engineer.

Ground rods shall be copper 10 mm dia x 1.5 meter length minimum, depth 1.5 meter below finished grade and welded or connected using connection hardware to the 16 mm2 grounding wire.

The Contractor shall investigate each site and measure the grounding resistance of the sites. After taking the data, the Contractor shall obtain the Engineer's approval of the site.

The grounding resistance shall be 5 ohms or less, or as approved by the Engineer. Details of all grounding points shall be submitted to the Engineer for approval.

(d) Electrical Splice Materials

Splices and taps shall be made with compression type solderless connectors to securely join the wires both mechanically and electrically.

An epoxy resin, cast type insulation shall be formed in clear plastic molds. The material used shall be compatible with the insulation specified in the Contract Drawings or these Specifications. Materials to be used for the work shall conform to the requirements of JIS C 2804, C 2805 and C 2806, or shall have the quality approved by the Engineer.

Insulating tape when specified for use in splice formation shall conform to JIS C 2336. Unfused quick-disconnect connectors such as In-line connectors or Tee connectors shall be of the quality approved by the Engineer.

(e) Conduit

Material for conduit to be installed below a bridge, above ground, under ground, in a concrete parapet or on the surface of structures shall be steel or PVC.

Conduit crossings under intersections and / or streets and roads shall be constructed at a minimum depth of 1.5 m beneath the finished surface from steel pipe that has been uniformly and adequately zinc- coated by a hot-dip galvanizing process, or concrete encased PVC conduit meeting the requirements of JIS C8430.

(f) Cable Trays

All details regarding material and installation of cable trays shall be as shown on the Drawings

(g) Pull Boxes.

Type - B of pull boxes of appropriate dimensions shall be installed in the medium center inner parapet of the main bridge section and also type. C of pull boxes shall be installed embed slab concrete in the medium center of the approach bridge sections as and where shown on the drawings. The body of the pull box shall be fabricated from 3.2 mm mild steel sheet and hot-dip-galvanized. The cover shall be made either from 3mm type SUS 304 stainless steel or from 3.2 mm mild steel sheet and hot-dip-galvanized. No sharp projections from screws or other objects shall be permitted within the pull box.

The covers shall be watertight by rubber gasket.

Details of dimensions and pullbox type will be shown on the drawings.

807.12 Modification of Existing Systems

(a) Removing

The Contractor shall remove existing materials such as lighting and lanterns, lighting panels, traffic signals, etc. which will obstruct the construction of the works, in accordance with the Drawings and these Specifications, and/or as established by the Engineer.

A detailed work method and timing schedule shall be submitted for the Engineer's approval prior to commencing any work of removal.

On completion of removal works, all holes shall be filled and the area left clean and tidy, all to the satisfaction of the Engineer.

It shall be the Contractor's responsibility to remove all useless materials such as lighting fittings and ballast's, poles, traffic signals, cables, conduits, etc. which shall be dumped or stored as specified or required by the Engineer.

(b) Relocation

Part of the existing materials removed shall be relocated in accordance with the Drawings and/or as established by the Engineer. All relocation shall be carried out by the same

means of construction as additional furnished materials in this works as required in these Specifications.

Prior to-fixing any lighting pole or control panel, accessible surfaces shall be rubbed or brushed clean of all rust, etc. and painted with 3 coats of a zinc based rust-preventing paint as specified by the Engineer. If there are any dents or other damage to materials during the relocation, the material shall be replaced with the same kind, or repaired to the satisfaction of the Engineer.

807.13 Construction

(a) General

All workmanship shall be complete and in accordance with the latest accepted standards of the industry, as determined by the Engineer. Installation of duct, construction of manholes, and excavation for cable or duct track, shall be in accordance with these Specifications

(b) Excavating and Backfilling required for the installation of foundations, poles and other appliances shall be performed in accordance with the requirement of these Specification but will not be measured for payment. The cost of such extra work will be deemed to be included in the unit price of the pay item being installed.

(c) Foundations

Foundation shall be constructed of Portland cement concrete 145kg/cm2 unless otherwise noted on the Drawings and all details shall meet the applicable requirements. The bottom of concrete foundations shall rest on firm ground.

Foundations shall be poured in one pour where practicable. The exposed portions shall be formed to present a neat appearance. The footing shown on the Drawings shall be extended if conditions require additional depth, and such additional work, if ordered by the Engineer, will be paid for under the applicable provision.

Forms shall be true to line and grade. Tops of footings for poles, except special foundations, shall be finished to ground line or sidewalk grade, unless otherwise noted on the Drawings or directed by the Engineer.

Forms shall be rigid and securely braced in place. Conduit ends and anchor bolts shall be placed in proper position and to proper height, and shall be held in place by means of a template until concrete sets.

Plumbing of poles shall be accomplished by adjusting leveling nuts. Shims or other similar devices for plumbing or raking will not be permitted.

Both forms and ground which will be in contact with the concrete shall be thoroughly moistened before placing concrete. Forms shall not be removed until the concrete has set

at least 3 days.

A "rubbed surface finish" shall be applied to exposed surface of concrete in accordance with the requirements.

Where obstructions prevent construction of planned foundations, the Contractor shall construct an effective foundation, satisfactory to the Engineer.

(d) Conduit

Installation of conduit shall be performed in accordance with these Specifications and in reasonably close conformity with the location as specified in the Drawings or as directed by the Engineer.

The size of conduit used shall be as shown on the Drawings. Conduit smaller than50mm dia meter electrical trade size shall not used, unless otherwise specified. It shall be the option of the Contractor, at his own expense, to use larger size conduit if desired, and where larger size conduit it used, it shall be for the entire length of the run from outlet to outlet. No reducing coupling will be permitted.

The ends of conduit shall be well reamed to remove burrs and rough edges. Field cuts shall be made square and true so that the ends will butt or come together for the full circumference thereof. Slip joints or running threads will not be permitted for coupling conduit. When a standard coupling cannot be used, an approved threaded union coupling shall be used. The threads of all steel conduits shall be well painted with a good quality of lead or rust-preventative paint before couplings are made up. All steel couplings shall be screwed up until the ends of the conduits are brought together, so that a good electrical connection will be made throughout the entire length of the conduit run. Where coating on steel conduit has been damaged in handling or installing, such places shall be thoroughly painted with rust- preventative paint.

All conduit ends shall be threaded and capped with standard conduit couplings capped with conduit push Penney's until wiring is started. When couplings and push Penney's are removed the threaded ends shall be provided with approved conduit bushing. The use of any plugs, even though temporary, in lieu of the aforementioned conduit couplings and push Penney's is expressly prohibited.

Conduit stubs from bases shall extend at least 15 cm from the face of foundations and at least 80 cm below the top of foundations.

Conduit bends, except factory bends, shall have a radius of not less than six times the inside diameter of the conduit. Where factory bends are not used, conduit shall be bent, using an approved conduit bending tools employing correctly sized dies, without crimping or flattening, using the longest radius practicable. All PVC conduit bends shall be pre-formed.

Conduit terminating in poles or pedestals shall extend approximately 15 cm above the foundation vertically and shall be sloped towards the handhole opening.

Conduit entering through the bottom of a pull box shall be located near the end walls to leave the major portion of the box clear. At all outlets, conduit shall enter from the direction of the run, terminate 15 to 20 cm below the pull box lid and within 9 cm of the box wall nearest its entry location.

Suitable markers shall be set at the ends of conduits, which are covered so that they may be easily located.

A galvanized pull wire shall be installed in all conduits, which are to receive future conductors. At least 60 cm of pull wire shall be doubled back into the conduit at each termination.

(e) Pull Boxes

Pull boxes shall be installed at the locations shown on the Drawings, and at such additional points as ordered by the Engineer. The Contractor may install, at his own expense, such additional boxes may be desired to facilitate the work.

(f) Wires

Wiring shall conform to appropriate code requirements. Wiring within cabinets,

manholes, etc. shall be neatly arranged and within cabinets shall be laced. Powdered soapstone, talc, or lubricant shall be used in placing conductors in conduit.

Splicing in conductors will be permitted only at manholes, transformer leads, in pole bases, or at control equipment.

Sufficient signal light conductors shall be provided to conform the functional operation of the signal system as shown, spare conductors shall be provided when noted on the Drawings.

(g) Field Test

Prior to completion of the work, the Contractor shall cause the following tests to be made on all traffic signal and lighting circuits, in the presence of the Engineer.

- Test for continuity of each circuit.
- Test for grounds in each circuit.

A megger test on each circuit between the conductor and ground with all switchboards, panel boards, fuse holders, switches, sockets and over current devices in place and all readings recorded. The Contractor shall furnish the Engineer with three copies of the test results identifying observed readings with their respective circuits. The Insulation

resistance between conductor and ground shall be not less than 4 meg ohms. Any change in the above stated minimum readings must be approved by the Engineer. Such approval must be in writing, following written application by the Contractor.

A functional test in which it is demonstrated that each and every part of the system function as specified or intended herein.

Any fault in any material or in any part of the installation revealed by these tests shall be replaced or repaired by the Contractor in a manner approved by the Engineer, and the same test shall be repeated until no fault appears.

(h) Painting

All painting required shall be in conformance with applicable portions of these Specifications.

If the enclosure of any electrical equipment (less signal heads) located above ground does not have an exterior surface of either aluminium or galvanizing, then it shall be finished with two coats of an approved zinc based paints, plus such finishing coat as the Engineer may direct.

Controller cabinets shall be finished in accordance with the above requirements for electrical equipment.

Galvanized steel lighting poles and lighting lanterns shall not be painted.

(i) Telephone Sign Head

All Telephone sign heads shall be planed layout as shown on the Drawings. Sign heads shall not be installed at any intersection.

(j) Guarantee

The Contractor shall furnish to the Employer any guarantee or warranty required as a normal trade practice in connection with the purchase of any materials or items used in the construction of the illumination or traffic signal system or system included in this Contract.

807.14 Method of Measurement

The quantity of each item paid for under this clause will be system of individual system as the typical is shown on the Drawing (DWG. No.M-14).

The system will be paid for as a "system" for the work as provided hereunder.

The system payment shall be full compensation for road telephones guide sign board, power supply and emergency back up battery system, central telephone exchanges, MDF, cable connection or termination boxes, cabling and connections, conduiting and fittings,

equipment grounding system, testing with data, materials, labor, tools, recording of data, and incidentals including all those necessary for requirements in full operational and functional conditions of the Road Emergency Telephone System.

(a) Emergency Telephone Unit

Furnishing, transportation, erection, and connection for Emergency Telephone units, stands, kiosks, anchor bolts, nuts, washers, and cables, conduits, foundation materials, field tests and data, relative civil works and all other incidental work connected therewith including pull boxes from Emergency Telephone to Main Distribution Frame (MDF) to be installed shall be number of each telephone unit furnished, installed in place and accepted by the Engineer.

(b) Telephone Cable laying

Supply, lay and install 100 mm diameter, Medium Pressure Type 600-400 uPVC conduit complete with sockets and other accessories including steel conduits and cable trays galvanized to BS 729 or ISO 1461:1999, a) laid directly under ground and / or, b) laid from manhole to manhole for road crossing including laying of 1 x 0.5 mm 5 pair Non armoured cable laid under Highway to emergency telephone units across the Highway in 100 mm conduit and elsewhere if applicable, and / or, c) laid over Bridges and / or, d) under Bridges inside box girder, or inside steel conduit supported by steel trays anchored under bridges, encase 10 x 0.5 mm5 pair unarmoured cable inside laid PVC conduit and steel conduit and terminate cable ends in specified manner on Emergency Telephone unit terminals and Main Distribution Frame (MDF) terminals, all incidental materials in addition to cables included, shall be the 10 x 0.5 mm 5 pair Unarmoured Telephone unit furnished, installed in place and accepted by the Engineer.

(c) Manholes for Telephone Cable

Furnishing, transportation, erection of pre-cast, or cast in-situ with all required materials included, manholes with incidental minor civil works at locations indicated in Drawings or otherwise necessary for construction work to fulfil contract obligations shall be number of each manhole furnished, installed in place and accepted by the Engineer.

(d) Main Distribution Frame (MDF)

Furnishing, transportation, erection, and connections for, Main Distribution Frame (MDF) anchor bolts, nuts, washers, and cables, plinth, enclosure, foundation materials, field tests and data, relative civil works and all other incidental work connected therewith the Main Distribution Frame (MDF) to be installed shall be the Main Distribution Frame (MDF) unit furnished, installed in place and accepted by the Engineer.

(e) Testing and Commissioning of Emergency Telephone System

Testing and Commissioning of the entire Emergency Telephone System inclusive of Emergency Telephones, Unarmoured Telephone cables and the Main Distribution Frame (MDF) with all necessary connections as an integrated system as a fully functional unit fit

and proper for the purpose intended shall be accepted by the Engineer as Testing and Commissioning

807.15 Basis of Payment

Method of measurements will be paid for under the prices for items:

Pay Items		Unit of Measurement
807(1)	Emergency Telephone Unit	number
807(2)	Telephone Cable Laying	meter
807(3)	Manholes for Telephone Cable	number
807(4)	Main Distribution Frame (MDF)	number
807(5)	Testing and Commissioning of Emergency Telephone System	Lump Sum

SECTION 900

DAYWORKS

SECTION 900

DAYWORK

900.1 General

Reference should be made to Sub-Clause 52.4 of Part 1 of the General Conditions. The Contractor shall execute the Works on a daywork basis if the Engineer gives the instruction in writing. Payments for daywork shall be subject to price adjustment in accordance with the provisions in the Conditions of Contract.

900.2 Composition

Daywork consists of:

- Daywork Labour
- Daywork Materials
- Daywork Construction Equipment

SECTION 1000

PROVISIONAL SUM

SECTION 1000

PROVISIONAL SUM

1000.1 General

Provisional Sum is defined in General Conditions of Contract, Clause 58.1 as "a sum included in the Contract and so designated in the Bill of Quantities for the execution of any part of the Works or for the supply of labour, materials and equipment, which sum may be used, in whole or in part, or not at all, on the instructions of the Engineer".

1001 (1)-(8), Provisional Sums

Provisional sums 1001 (1)-(8) are designated in the end of this Section 1000 according to the General Conditions of Contract, Clause 58.1.

Basis of Payment

Payment for Provisional Sum shall consist of net (direct cost) plus the Contractor's overhead and profit (fixed 10 % of the direct cost). The Contractor is entitled to claim the 10 % overhead and profit in addition to the direct cost.

In case the Contractor's overhead is proved to exceed the designated 10 %, the variation shall be considered between the Employer and the Contractor.

1002 (1)-(3), Specification for Diversion and Protection of Existing Facilities

1002.1 General

1) Utility Locations
   Utilities which will be affected by the Works are shown on the Utility location drawings (to the best of the knowledge of the design stage).
2) Duties of all the Parties
   - The Employer, the Engineer and the Contractor shall cooperate for the utility relocation to start and complete smoothly and quickly.
   - The final responsibility including payment rests on the Contractor.
3) Duties of the Employer and the Engineer
   - The Employer and the Engineer shall arrange initial meetings with utility agencies and request them to ensure that all utility relocations, within or adjacent to the ROW, are made as soon as possible.
   - The Engineer will decide whether to adjust or relocate utility facilities or appurtenances found but not recorded on the Drawings.
4) Duties of the Contractor
   - The Contractor shall make the sub-contracts with the utility agencies to carry out the design and the relocation.
   - The Contractor shall prepare the utility relocation plan and cooperate with the utility agencies to remove and rearrange underground or overhead utilities properly.
   - The Contractor shall divert and protect existing facilities and construct overhead and underground facilities as assistance to the utility agencies.
   - The Contractor shall correct and pay for any damages to the utilities that result

from his carelessness or omission.

5) Delays Caused by Utility Agencies
If following conditions apply, namely:
   (a) The Contractor has diligently followed the procedures laid down by the relevant legally constituted utility agencies in Sri Lanka,
   (b) These agencies delay or disrupt the Contractor's work and
   (c) The delay or disruption was Unforeseeable,

then this delay or disruption will be considered as a cause of delay under Sub-Clause 44.1 Extension of Time for Completion in Conditions of Contract.

1002.2 Location and Relocation of Utilities

(a) Where public utilities such as electricity, water, telephone, gas etc obstruct the permanent Works, the Contractor shall liaise with the utility authorities in relation to the relocation of such utilities. The Contractor shall liaise with the utility authorities to determine the locations of and regulations relevant to the utilities.

(b) Before commencing any construction work and as a first task during the mobilisation period, the Contractor shall undertake a survey to establish the detailed location of all utilities affected by the Works. To assist in this survey it is required that the Contractor equips himself with a suitable metal detector of a type suitable for locating underground utilities. The cost of this equipment shall be borne by the Contractor and he shall retain its ownership. Survey results and the information obtained by the Contractor from searches of utility records shall be recorded in plan for the satisfaction of the Engineer. The surface pegs shall be fixed on Site to indicate the location and depth of all underground utilities. These pegs shall remain until relocation work has been completed to the satisfaction of the utility authorities and the Engineer has given his approval that they may be removed. If required by the utility authorities permanent markers shall be supplied installed and maintained by the Contractor.

(c) The purpose of the survey and the preparation of the utilities plan is to record the location of all existing facilities so that the necessary arrangements may be made to relocate, remove or protect those utilities affected by the Works and also to enhance the Contractor's awareness of their presence.

(d) Upon completion of the utilities plan (or progressively for discrete sections of the work) the Contractor shall liaise with the utility authorities concerned in relation to the presence of the utilities on the plan.

(e) The Contractor shall, in co-ordination with the utility authorities, be responsible for determining the locations of any relocated utilities, however he shall seek the prior consent of the Engineer in all instances.

(f) When in the opinion of the Engineer and the authority concerned a relocation of an existing utility is required, the utility may, at the sole option of the authority, perform such relocation work and the Contractor shall provide assistance to the authority as

instructed by the Engineer.

(g) If it is judged by the Engineer and the authorities that it is more expedient for the Contractor to relocate the utility or to perform removal or other work in connection with such utility, then the Engineer may instruct the Contractor to perform such work. Any such work by the Contractor must be performed in accordance with any procedures advised by the authority and final approval obtained from the authority for that work.

(h) If any other hidden or unknown utility should be discovered during the course of the construction work and activities, such utility location and details shall be added to the utilities plan and its location discussed with the authority concerned as per sub-clause d) above.

(i) Within 28 days of the issue of any Taking Over Certificate, the Contractor shall submit to the Engineer fully detailed As-Built drawings relating to the works taken over indicating the position of all existing utilities and services, and utilities and services relocated by both the utility authorities and the Contractor. Such drawings shall be produced in AutoCAD and shall be submitted in 3 No sets of hard copy and in electronic format.

1002.3 Temporary and Permanent Protection of Utilities

Where works of either a temporary or permanent nature are to be undertaken by the Contractor in the vicinity of utilities, the Contractor shall adopt appropriate construction methods, provide adequate protective devices and take precautionary measures in order to avoid damage to the utilities. Any damage to the utilities caused directly or indirectly by the execution of the Works shall be the Contractor's responsibility.

The Contractor shall conduct its operations, make necessary arrangements and perform all required work and activities to avoid interference with and protect public utilities within its areas of operations during the course of the Contract including any unknown or hidden utilities discovered during the course of the work. The cost of providing temporary protection to utilities shall be deemed to be included in the Contractor's rates and prices. The cost of providing permanent protection to utilities as required by the utility authorities or the Engineer shall be reimbursed to the Contractor under the Provisional Sum in the Bill of Quantities.

The Contractor shall save harmless and indemnify the Employer against any claim, demand, cost, damages, charges or expense which may arise in relation to such construction operations, interference or other liability related to the aforementioned public utilities.

1002.4 Scope of Work

Public utilities and services that may be encountered are as follows:

(a) Overhead Power Transmission Lines

- High tension power line 35kV or more and sub-line systems including pylons
- Intermediate power line 3 KV to 35 KV
- Low voltage power distribution line 400 V/230 V after transformer substation
- Transformer stations . distribution capacity 500 KVA to 1,500 KVA
- Transformer stations . distribution capacity less than 500 KVA

(b) Telephone Lines

- Overhead line or underground metallic or fibre-optic cables.

(c) Underground Water Pipes

- Water distribution mains
  1) Less than 100 mm diameter
  2) 100 mm to 500 mm diameter
- Water Services
  Property water services 20 mm or larger.

1002.5 Drawings and Documents

The Contractor shall refer to all information obtained from utility authorities and other sources to ascertain for himself the locations and routes of all utility services so as to maintain adequate clearance between the services including the services of different authorities. The supplied drawings will usually only indicate the general arrangement for the works.

1002.6 Standards, Codes and Specifications

Should the Contractor be instructed to perform any work on behalf of utility authorities, applicable Standards, Codes and Specifications will be provided by the authority concerned.

1002.7 Method of Measurement

(a) The permanent diversion of existing utilities by the appropriate authority shall be measured for payment to the Contractor under a Provisional Sum.

(b) The permanent diversion of existing utilities instructed by the Engineer and carried out by the Contractor shall be valued under Clause 52 of the General Conditions with payment to the Contractor being under a Provisional Sum.

(c) The survey of existing utilities and services and the production of record drawings ("utility drawings") shall be measured as a Lump Sum. Such sum shall include all costs in liaising with utility authorities, gathering information, surveying, metal detector, production of drawings, providing and monitoring location pegs and the like.

(d) Temporary diversions of existing utilities (and services) and temporary protection of such

utilities (and services) shall not be measured but shall be deemed to be a general obligation on the Contractor included within the rates and prices in the Bill of Quantities.

(e) Permanent protection of public utilities (and services) instructed by the Engineer and carried out by the Contractor shall be valued under Clause 52 of the General Conditions with payment to the Contractor being under a Provisional Sum.

Such item sums shall be full compensation for all costs of liaising with utility authorities, landowners, the Employer, the Engineer, and any other party, including labour, Contractor's Plant, materials, temporary works, construction, removal and disposal of redundant equipment, sealing and making safe severed services, planning and scheduling and in complying with the Drawings, Specifications and all requirements of the appropriate parties.

In addition, the Contractor agrees that it has made full allowance for any delays and/or disruption which may arise in relation to the relocation, removal and protection of public utilities and services, in accordance with Sub-Clause 8.3 of the Conditions of Contract.

Notwithstanding the information given within this Specification or on the Drawings as to the existence of utilities, the Contractor shall comply fully with Clause 29 of the Conditions of Contract.

1002.8 Basis of Payment

Payment for Provisional Sum shall consist of net (direct cost) plus the Contractor's overhead and profit (fixed 10 % of the direct cost). The Contractor is entitled to claim the 10 % overhead and profit in addition to the direct cost.

The Provisional Sum for item 1002 shall be used for the payment for permanent diversions, relocations, removals and permanent protection by the utility authorities and the Contractor. The Contractor shall liaise with the Employer when discussing the amount to be paid to the utility authorities by the Contractor, and in each any every instance shall obtain the Employer's approval prior to agreeing any such amount or making any payment. No work will be included for payment to the Contractor under Item 1002 until the diversion has been successfully commissioned and accepted by the utility authority in writing.

If advance payment is requested by the utility authorities, the Contractor shall request and get approval from both the Engineer and the Employer.

Payment of the Provisional Sum under Item 1002 shall be made in two instalments:

- 80% will be paid upon the completion of the initial survey and submission of the utility drawings.
- 20% will be paid on acceptance by the Engineer of the As-Built drawings prepared by the Contractor pursuant to Sub-Clause 1002.2, i) above.

The Provisional Sums are deemed to fully compensate the Contractor for all overheads and profit associated with the work performed under Provisional Sums.

The pay item shall include:

- Cost of Right-of-Way or cost of land required for the relocation of the utility.
- Preliminary engineering, including location survey, preparation of plans and cost estimate prior to finalisation of the diversion agreement.
- Betterments, including any increase in the functional capacity or services improvement.

Pay Item	**Unit of Measurement**
1001(1) Stationery for Engineer	Provisional Sum
1001(2) Tests as requested by the Engineer	Provisional Sum
1001(3) Mobile Phone System for the Engineer	Provisional Sum
1001(4) Temporary Accommodations as requested by the Engineer	Provisional Sum
1001(5) Temporary Vehicles as requested by the Engineer	Provisional Sum
1001(6) Additional Soil Investigation as requested by the Engineer as per Section 1200	Provisional Sum
1001(7) Existing Road Repairing as requested by the Engineer	Provisional Sum
1001(8) Environmental Monitoring	Provisional Sum
1001(9) Environmental Control and Protection	Provisional Sum
<u>Permanent Diversion of Existing Utility or Service</u>	
1002(1) High Tension Powerlines by Ceylon Electricity Board	Provisional Sum
1002(2) Water Supply by National Water Supply & Drainage Board (NWS & DB)	Provisional Sum
1002(3) Telecom line by Sri Lanka Telecom	Provisional Sum

SECTION 1100

QUALITY MANAGEMENT

SECTION 1100

QUALITY MANAGEMENT

1100.1 Quality Assurance

The Quality Assurance Plan shall be submitted to the Engineer within two months from the commencement date.

1100.2 Quality Record

The Contractor shall keep Quality Record complying with ISO 9000 series, 2000 to demonstrate achievement of the required quality and the effectiveness of the quality system.

1100.3 Materials

The material supplied and work carried out shall conform to the relevant sections of the Specifications covering each type of work and as per Section 1300 of these Specifications. For ensuring quality of construction, the materials and the work shall be subjected to quality control tests prescribed in this Section. The testing frequencies given in this Section are desirable minimum values and the Engineer may direct the Contractor to carry out tests as frequently as he may deem necessary to satisfy himself, that the materials and the work comply with the appropriate specifications.

Section No./ Type of Construction	Material acceptance test	Work routine test	Frequency (the Contractor shall carry out)
Section. 200 Earthworks			
General fill - Embankment fill up to the subgrade level - Backfilling after excavation of unsuitable material	Grading		Twice a week or 1,000 m^3 , whichever is greater
	Atterberg limits		1 per 1,000 m^3
	CBR		1 per 1,000 m^3
	Max. dry density/ Optimum moisture content	Moisture content prior to compaction	1 per 500 m^3 or twice per section
		Degree of compaction of compacted layer	1 per 500 m^3 or twice per section
Selected material (Granular or cohesive) - Capping on embankments	Grading		1 per 300 m^3 or each source, whichever is greater
	Atterberg limits		1 per 300 m^3 or each source, which ever is greater
	CBR		1 per 300 m^3 or each source, which ever is greater
	Max. dry density/ Optimum moisture content	Moisture content prior to compaction	Regularly
		Degree of compaction of compacted layer	1 per 300 m^3
Top of subgrade	Max. dry density/ Optimum moisture content	Degree of compaction of compacted layer	1 per 300 m^3
Selected uniformly graded granular material - Rock fill - Porous backfill to structures - Permeable backing layer to structures - Drainage layer - *Fill to reinforced earth	Grading		1 per 200 m^3 or as required
	Max. dry density/ Optimum moisture content	Degree of compaction of compacted layer	1 per 300 m^3 or as required
	Plasticity Index *Chloride iron content *Total Sulphate content		1 per source 1 per source 1 per source
		Moisture content	Regularly
		Degree of compaction of compacted layer	1 per 300 m^3 or as required

Section No./ Type of Construction	Material acceptance test	Work routine test	Frequency (the Contractor shall carry out)
Gravel for gravel compaction piles/Gravel mat	Grading		1 per 200m^3 or as required
Geotextile	Ultimate tensile strength Permeability Pore size		As directed by the Engineer Manufacturer's test results/Every batch
Gabions	Fill Geomesh PVC coated wire	Grading Property	1 Per 400 tonnes 1 Per 400 m^2 Required (ASTM G23)
Section. 300 Sub-Base and Base Courses			
Section 301 Sub base -Type I -Type II -Type III **Section 302 Aggregate Base**	Grading		1 per 300 m^3
	Atterberg limits		1 per 300 m^3
	Percentage of wear LAAV		1 per 300 m^3
	Aggregate Impact Value		1 per 300 m3
	Flakiness Index		As required
	Soundness		1 per source
	CBR (4 days soaked)		1 per 300 m^3
	Max. dry density/ Optimum moisture content	Moisture content	Regularly
		Degree of compaction of compacted layer	1 per 300 m^3
Asphaltic material - Asphalt cement	Penetration		1 per 750 tonnes
	Softening point		1 per 750 tonnes
	Other acceptance tests as per the BS 3690-1:1997		Every batch
	Rate of application	2 per day	Rate of application
-Cutback Asphalt	Acceptance tests as per Section 1302.2		Every batch
		Rate of application	2 per day
		Temperature of application	Regularly

Section No./ Type of Construction	Material acceptance test	Work routine test	Frequency (the Contractor shall carry out)
-Emulsified Asphalt	Acceptance tests as per the Section 1302.3		Every batch
		Rate of application	2 per day
		Temperature of application	Regularly
Shoulders	Grading Atterberg limits		1 per each soil type thereafter 1 per 300 m^3
	CBR (4 days soaked)		1 per each soil type and thereafter 1 per 300 m^3
	Max. dry density/ Optimum moisture content		1 per each soil type
		Moisture content	Regularly
		Degree of compaction of compacted layer	1 per 300 m^2
Section 400 Pavement Asphalt Bound Base / Asphaltic Concrete	Acceptance tests for binder		1 per day or as required
	Aggregate grading		1 per each source or 400 m^3 whichever is greater
	Aggregate Impact Value		1 per each source or 400 m^3, whichever is greater
	Flakiness Index		
	Los Angeles Abrasion Value		
	Coating and stripping test		
	Acceptance tests of filler		As required
		Temperature of binder	At regular close intervals
		Temperature of aggregate	
		Temperature of mixing	
		Temperature of laying	
		Hot bin grading	1 test per day or 300 tonnes, whichever is greater
		Compliance to job mix	
		Bitumen extraction and compliance to the job mix	
		Marshall stability and flow	
		Density and void tests of Marshall specimens	
		Thickness of compacted layer	1 test per 250 m^2
		Degree of compaction of compacted layer	

Section No./ Type of Construction	Material acceptance test	Work routine test	Frequency (the Contractor shall carry out)
Asphaltic Prime coat & Tack coat	Acceptance tests for	binder	As required
		Depot tray test	At least once a month
		Rate of application	2 tests per day
		Temperature of application	Regularly
Seal Coat surface treatment	Acceptance tests for binder		As required
	Aggregate Impact Value		1 test per source or 200 m^3 whichever is greater
	Flakiness Index		
	Los Angeles Abrasion Value		
	Coating and stripping test		
	Soundness of aggregate, clay, salt, dust, fraction of aggregate & water absorption		
	Grading of aggregate		
		Depot tray test	At least once a month
		Rate of application of binder	1 per 500 m^2
		Temperature of application of binder	Regularly
		Rate of spread of aggregate	1 per 500 m^2
Section. 500 Structures	Acceptance tests for cement		Manufacturer's certificates
	Acceptance test for water		1 per source
	Acceptance tests for admixture		Manufacturer's certificates
	Acceptance tests for aggregate - Flakiness Index - 10 % fines value - Chloride content - Alkali-Silica reaction		1 per source and as required
	- Grading	Moisture content of mixing aggregate	Daily
		Temperature of fresh concrete	Regularly
		Casting of test cubes for compressive strength and flexural strengths	1 per 100 m^3
	Grouting	Cube strength	As directed by the Engineer
Reinforcement for Structures			1 set per day or 1 set per 100 m^3 for each grade, whichever is greater
	Acceptance tests for Reinforcements as per The BS 4482, BS 4483 & BS 4449		Manufacturer's Certificates and 1 per Each batch as required

SECTION 1200

SITE INVESTIGATIONS FOR EMBANKMENT CONSTRUCTION, BRIDGES & OTHER STRUCTURES AND CUTTINGS

1201 GENERAL

1201.1 Objectives

Section 1200 (from 1201 to 1210) will be used for Provisional sum of additional soil investigation.

The objectives of soil investigations are to ascertain the suitability or otherwise of the soil or rock in the vicinity of embankments, foundations and cuttings and soil parameters and rock characteristics for the design of the same by identifying the required strata and in-situ testing or testing of samples / cores taken out of explorations. The soil investigation shall be planned in such a way that different types of soils up to the desired depth and their profile for the proposed length of the embankment / bridges / structures / cuttings can be recorded and other information such as mechanical and physical properties like grain-size distribution, sensitivity, any existence of deleterious material in soil or ground water, etc. are determined along with soil parameters and rock characteristics. The site investigations shall also give an indication of the porosity of rock, ground water level, artesian condition, if any, likely cylinder sinking and pile driving effort, likely constructional difficulties, etc.

1201.2 General requirements

2.1 Standards used

All field work including in-situ tests, and the laboratory tests shall conform to those given in ICTAD Publication No. ICTAD/ID/11, unless otherwise stated in these specifications. Alternative British Standards (in particular BS 1377 and BS 5930), or equivalent ASTM Standards may also be allowed.

In Publication No. ICTAD/ID/11 wherever the words “Building/s” & “Foundation/s” appear they shall be taken as “Bridge/s / Structure/s, embankment/s and cutting/s” and “Foundation/s of bridge/s, structure/s and embankment/s” respectively.

2.2 Inspection of Site

Submitting a Tender means that the bidder has examined the site and is satisfied with the condition to be encountered in performing the work and with the tender requirements.

During the Contract, the Contractor shall inspect the site conditions and his works. When the Contractor encountered different site conditions on the Project, he shall notify the Engineer and the Employer of changes to the Contract resulting from differing site conditions, extra work,

altered work beyond the original Contract, or the Employer's actions that change the Contract terms and conditions.

If the Contractor failed to notify the changes and to provide required information, the increased costs or time extensions resulting from his failure won't be accepted.

2.3 Programme to be Furnished

According to Clause 14 of Conditions of Contract, the Contractor shall submit a programme to Engineer, showing the order of procedure and method in which he proposes to carry out the Works. The programme shall include the particulars of plant and temporary works which he intends to supply, use or construct as the case may be. The submission and approval by Engineer of such programme or particulars shall not relieve Contractor of any of his duties or responsibilities under the Contract.

2.4 Supply of Plant, Materials and Labour

Except where otherwise specified, Contractor shall at his own expense supply and provide all the plant, labour and materials both for temporary and for permanent Works, including the supervision there of, transport to or from the Site and in and about the work and other things of every kind required for the construction, completion and maintenance of the work.

2.5 Equipment for Investigations

Before boring or rotary drilling is commenced, Contractor shall obtain Engineer's approval of the equipment he proposes to use and method for supporting the sides of the holes. The equipment shall have adequate power to undertake all the work given in this specification within the times defined in the Contract. Engineer reserves the right to call for additional rigs and equipment at no extra cost if he considers the programme requirements is not being met.

All equipment which Contractor proposes to use for the work shall be in good working condition and suitable for the purpose. The drilling machine shall have the capacity suitable for drilling boreholes as specified, into all types of soil and rock to reach various required depths.

2.6 Watching and Lighting

The Contractor shall in connection with the work provide and maintain at his own cost all lights, guards, fencing and watching when and where necessary or required by Engineer or by any competent statutory body or other authority for the protection of the work or for the safety and convenience of the public or others.

2.7 Site and Temporary Accesses

The access to the site shall be in accordance with Clause 21 (Possession of the site) and Clause 22 (Access to the site) of Conditions of Contract of ICTAD Standard Bidding Document for Procurement of Works. (ICTAD/SBD/01)

The Contractor shall provide all temporary roads including timber planks on trestles etc. in marshy areas and gangways required for the execution of the work. He shall provide at all times during the progress of the work, proper means of access with ladders, gangways, pontoons, boats etc. and the necessary attendance for inspection of the work by Engineer.

2.8 Care in executing the work

a) The Contractor shall take full responsibility to ascertain the positions and take all reasonable precautions to avoid damage to services above and below ground, such as sewers, drains, water mains, electricity and other cables, and all structures above and below ground. He shall be responsible for the adequacy, stability and safety of all Site operations and of methods of construction.

Except to the extent specified in the Contract, the Contractor:

(i) shall be responsible for all Contractor's documents, Temporary works, permanent works (which were designed by the Contractor) and his design of each item of plant and materials as is required for the item to be in accordance with the Contract, and

(ii) shall not otherwise be responsible for the design or specification of the permanent works designed by the Engineer.

The Engineer shall be immediately informed if any of the original locations of the boreholes or other tests coincide with the positions of the mains or services. The Contractor shall propose the revised locations to the Engineer for approval.

The care of works shall be in accordance with Clause 12 (Contractor's Risks) of Section 3 - Conditions of Contract of ICTAD/SBD/01. In case of any damage, Clause 13 (Insurance) of Section 3 - Conditions of Contract of ICTAD/SBD/01 shall apply.

b) Upon completion of each borehole, the Contractor shall backfill each borehole as specified in sub section 1202.9 "Backfilling".

The position of the boreholes shall be marked by concrete monuments or by any other approved method.

c) All standpipe piezometers shall be adequately protected to allow readings to be continued subsequently.

d) All barriers breached or otherwise disturbed during the execution of the site operations shall be immediately repaired or replaced to the same standard.

e) Unless otherwise indicated in Schedule 1 (in "Appendix to Section 1200" after Section 1210), on completion of each borehole; all equipment, surplus material and rubbish of every kind shall be cleared away and removed from the site. Damage to land, property and underground and overhead services in the vicinity shall be made good, at the expense of the Contractor. The whole of the site shall be left in a clean and tidy condition.

2.9 Removal of Improper Plant and dismissal of Incompetent Personnel

The Engineer shall during the course of the work have the power to order in writing from time to time:-

a) The removal from the Site any plant not conforming to the requirements of the Specifications, and the replacement of such plant at Contractor's own cost.

b) The dismissal from the Site, any engineer, geologist, technician, supervisor, plant operator, or any workmen of Contractor found incapable or refusing to follow the proper procedure of work as specified, and replacement of such workmen at Contractor's own cost. Contractor's attention is drawn particularly to his personnel to identify and describe correctly soils and rock samples in the field, and to do survey work including taking reduced levels and setting out.

Geotechnical personnel

(i) The Contractor shall have on his site staff, a Geotechnical Engineer or Engineering Geologist or an Engineer as indicated in Schedule 2 (in "Appendix to Section 1200" after Section 1210) fully experienced in site investigation work, and he shall supervise the field work and prepare the daily report indicated in Section 1207. Contractor's assigned personnel shall have a minimum of two (2) years experience in soil investigation works who shall be approved by Engineer. Such approval may be withdrawn at any time by the Engineer depending on the performance of the personnel.

(ii) The Contractor shall engage the services of a Principal Geotechnical Engineer who shall be responsible for reviewing the results of all laboratory and field tests, and write a Final Report with Recommendations. However, this would not relieve the Contractor of any responsibility for the report and recommendations.

2.10 Methods of Investigation

The Engineer may require investigations to be carried out by all or any of the methods described in this document.

The equipment brought to site shall be capable of drilling through all subsoil conditions (including drilling through rock, boulders, logs, sandstone, etc.) which may be encountered at the site. Details of all such equipment which the Contractor intends to use shall be submitted to the Engineer before drilling commences; and the use of equipment shall be subject to the approval of the Engineer.

2.11 Extent of Exploration

The provisional number of exploratory holes and the provisional depth of each hole are as described in Schedule 3 (in "Appendix to Section 1200" after Section 1210) for bridges / structures, embankments and cuttings. The minimum extent of exploration / number of field tests shall be as stated under (A) to (C) and as summarized in Table 1201-1 or as directed by the Engineer.

Table 1201-1 Minimum Extent of Explorations / Field Tests

Type of Investigation / Test	Minimum Extent of Explorations / Numbers of Field Tests			
	Investigations for Embankments		Bridge and Other Structures 1201.2.13	Major Cuttings (>5m) and materials for fillings and crushed rock for concrete and pavement layers 1201.2.14
	Where Soft Soil are Encountered 1201.2.12	Where Soft Soil are not Encountered 1201.2.12		
Core Drilling	One per 1.0 km down to 3½m in bed rock	One per 1.0 km down to 3½ m in bed rock with a minimum of 1 location in every such section	2 minimum but could be reduced to 1 for minor structures per abutment/ piers and other structures down to 3½ m in bed rock	Major cuttings 3 per cutting down to 2 m below final grade or 3½ m into rock when rock is encountered For material survey for rock at quarry site in a grid of 50 m down to the required depths. (minimum of 4 core drillings per site)
Wash Boring (not used for OCH)	200 m intervals except at core drilling locations	—	—	—
Hand Auguring	50 m intervals at an offset of one half of the top width of embankment from centre line in between each boring / drilling	—	—	—
Standard Penetration Test (SPT)	1m depth intervals in each boring / drillings	Same as 2.12	Same as 2.12	Same as Clause 2.12
Undisturbed Samples	Such samples taken in between SPT when they can be taken	Same as 2.12	Same as 2.12	Major cuttings Same as 2.12 In addition, block samples shall betaken for direct shear and permeability tests as per TRL, UK Overseas Road Note 14
Disturbed Samples	Such samples taken at every SPT locations	Same as 2.12	Same as 2.12	Major cuttings Same as 2.12 Material survey for soil at borrow pits. Cutting test pits in a grid of 15 - 30 m down to the required depths - adequate samples for required testing. (minimum of 4 pits per site)
Rock Samples	Taken from core drilling locations	Same as 2.12	Same as 2.12	Same as 2.12
Vane Shear Test	Where required	—	Every drilling where clays are present	—
Static Cone Penetration Test	200 m intervals except at core drilling / wash boring locations	—	—	Major cuttings Adjacent to every drillings where clays are present
Other Tests	As per 1201.2(d) (i) A	Same as 2.12	As per 1201.2.13	As per 1201.2.14

2.12 Investigation for embankments including soft soils {such as organic and inorganic clays (soft) and peaty soils} sections

All investigations and laboratory tests shall be carried out as per ICTAD/ID/11, unless otherwise stated in these specifications.

a) Core Drilling as per Section 1202

Rotary core drilling technique shall be carried out at intervals stated in Table 1201-1 or as directed by the Engineer, to establish the bed rock profile. In this case, drilling through rock shall be carried out to 3½ m depth below the residual soil stratum.

b) Wash Boring as per Section 1202

This boring is suitable for water wells and disturbed samples. Core drilling is preferable to this.

c) Hand Augering

For shallow soft soils up to around 5 m deep, hand augering shall be carried out, as per ASTM D 1452, at intervals indicated in Table 1201-1 or as directed by the Engineer. In locations where hand augering cannot proceed due to sand layers being encountered, other methods shall be carried out.

d) Standard Penetration Test (SPT)

Standard Penetration Test shall be done at 1.5 m (this can be reduced to 1.0 m if undisturbed samples are not taken) depth intervals within the boreholes (core drilling and wash boring), in the overburden, in order to obtain a continuous strength profile throughout every borehole, as per ICTAD/ID/11.

e) Sampling

Disturbed and Undisturbed soil samples and rock samples shall be collected for visual classification and laboratory testing purposes. Water samples shall be collected for chemical testing.

(i) Undisturbed samples as per section 1204

Whenever soft soils (peaty soils or soft clays) are encountered within the boreholes, undisturbed samples shall be collected in between SPTs as per section 1204, in order to obtain the strength parameters of the soil for the design of side slopes of the embankments and settlement characteristics for the design of roads founded on soft soil.

(ii) Disturbed samples as per section 1204

Disturbed samples shall be collected at every SPT location as per section 1204, for visual classification and index property tests, in the laboratory.

(iii) Rock samples as per section 1205

Rock core samples shall be recovered from core drilling locations as per section 1205 for identification purpose and to establish the weathering conditions of rock.

(iv) Water samples

Water samples from boreholes shall be collected for determining sulphate, chloride and pH value.

f) Vane Shear Test

Field vane shear tests shall be carried out at some locations, at 1m depth intervals, where soft layers are encountered by the wash boring operations / core drillings, as per ICTAD/ID/11.

g) Static Cone Penetration Tests

Static cone penetration tests (SCPT) shall be done at locations indicated in Table 1201-1 or as directed by the Engineer.

h) Ground Water Monitoring

Ground water levels in boreholes shall be monitored before, during and after construction regularly.

i) Laboratory Tests

The disturbed and undisturbed soil samples collected from boreholes shall be used for visual soil classification and on them the following laboratory tests shall be performed.

(a) Soil Classification and index property tests

Sieve analysis of all SPT samples and undisturbed samples and Hydrometer analysis tests of all clayey soil SPT and undisturbed samples shall be carried out in order to find the grading of soil samples obtained from boreholes. This will give an indication of permeability of the soils encountered, as well.

Adequate Atterberg Limit tests shall be done on samples to classify the soils as well as to obtain compressibility, strength and compaction characteristics.

Adequate Natural Moisture Content and Specific Gravity tests shall be done to incorporate in classifications of soils and obtaining consolidation characteristics.

(b) Strength and Settlement Parameter Tests

Adequate consolidation tests shall be carried out on samples of soft soils in order to obtain settlement parameters.

Strength and stability parameters of soft soils encountered along the trace, shall be obtained by carrying out adequate number of Consolidated Undrained (CU) and Consolidated Drained [(CD), if required] triaxial tests and direct shear tests on block samples (taken as per Section 1203.6), as per BS or ASTM Specifications and Unconsolidated Undrained (UU) triaxial tests.

(c) Chemical Tests on Soil and Water

Adequate water samples collected shall be tested for contents of sulphate, chloride and pH value to check the aggressiveness effects of water on construction of structures. They shall be taken from suitable locations, where bridges and other structures are to be constructed.

Soil samples collected from different locations shall also be tested to obtain the content of organic matter as well as the above chemical properties.

(d) Shear Strength of Rock Cores

Uniaxial compressive tests on rock cores (taken as per 1205.1), if required, shall be carried out as per BS or ASTM Specifications.

2.13 Investigations for bridges and structures

(i) A minimum 2 (it can be taken as 1 for minor structures) core drilling for bridge abutments / structures / bridge pier shall be carried out in the area under investigations.

(ii) SPTs shall be carried out as per 2.12, d)

(iii) At locations where clay layers, are encountered in core drillings, SCPTs shall be carried out adjacent to such core drillings as per 2.12, g).

(iv) Ground water monitoring shall be carried out as per 2.12, h).

(v) Laboratory tests, if required, shall be carried out as per 2.12, i).

2.14 Investigations for Major Cuttings (>5 m) and materials for filling and crushed rock for concrete and pavement layers

(i) Core drillings at major cuttings shall be carried out at locations where there could be high water table after cutting to a depth of 2 m below final grade of road. Where rock is encountered, core drilling shall be taken down to the rock face and cores shall be drilled 3 m into intact rock. In all these boreholes, stand pipe piezometers at 3 depths shall be installed and recorded as per sections 1206.3 & 1206.4.

(ii) If any water seepage was observed at cutting face, horizontal borings shall be carried out to check the water and to prevent the land slides.

(iii) In the soil over burden, SPTs shall be carried out as per 2.12, d).

(iv) Same as 2.13, (iii).

(v) In each major cut a minimum of 3 test pits shall be carried out as per Section 1203, where the soils are of lowest strengths to obtain block samples of 0.3x0.3x0.3 m, in order to carry out direct shear and permeability tests, as per TRL UK Overseas Road Note 14 "Hydrological design manual for slope stability in the tropics".

(vi) In each major cut, a minimum of another three tests pits shall be excavated to obtain bulk samples of soils to determine the suitability of the material for use as compacted fill, Subgrade and Sub-base.

(vii) For material survey for rock at quarry sites core drilling shall be carried out in a grid of 50 m down to the required depths, to take adequate samples for the required testing for each variation of material. A minimum of 4 core drillings shall be carried out per site.

(viii) For material survey for soils after filling embankments, subgrade and subbases at borrow pits, cutting test pits in a grid of 15 - 30 m down to the required depths to take adequate samples for the required testing for each variation of material. A minimum of 4 test pits shall be dug per site.

(ix) In order to determine soil and hard rock excavation quantities, where rock is expected to be encountered seismic surveys shall be made on several cross-sections in each major cutting, in order to extrapolate the bed rock surface identified in the borings.

(x) Testing for suitability of materials for embankment filling, subgrade, subbase, base and surfacing shall be carried out as per relevant sections in Chapters 200, 300& 400 along with Section 1100, Section 1300 and Appendix 2 at the frequencies of 1 test for each type of required testing, for each sample taken.

2.15 The Engineer reserves the right to increase or decrease the number of exploratory holes and their depths based on the information obtained from the first few holes.

2.16 Ground elevation of exploratory holes

The Contractor shall establish the Reference Level at the top of each exploratory hole with reference to a benchmark agreed with the Engineer.

2.17 Miscellaneous

(i) The Contractor shall make his own arrangements for water required in connection with the work, including the supply and fixing of all fittings, maintenance of the supply, payment of all fees, removal of all fittings and making good all disturbances after completion of the work.

(ii) The Contractor shall make his own arrangement with the authority concerned for electricity supply and shall comply with all safety regulations and pay all fees in connection with installation and supply.

(iii) All samples of soil, rock and water collected during the site investigations shall be properly stored, protected and retained with the Contractor for a period of 1 year after submission of the Final Report, unless otherwise specified by the Engineer.

(iv) The Contractor shall provide third party liability insurance and shall indemnify the Employer against all claims whatsoever, during the course of his work. Clauses 23 and 24 ICTAD Publication No. SCA/1 shall apply.

(v) The requirements of the specifications shall not limit the Contractor's statutory obligations or liabilities under the laws of the country and under local regulations. Clause 26(2) of ICTAD Publication No. SCA/1 shall apply.

(vi) In general the rates quoted in the Bill of Quantities for an item shall include for all elements of work in connection with that item as required in accordance with this specification and the Standards referred to in sub section 1201.2.

(vii) This section shall be used for Provisional sum of additional soil investigation.

SECTION 1202

BOREHOLES AND HAND AUGER HOLES

1202.1 Method and diameter

(a) The method of advancement and the diameter of a borehole shall be such that the boring can be completed and logged to the scheduled depth, samples of the specified diameter can be obtained, in-situ testing can be carried out, and instrumentation installed as specified in the Contract.

(b) The following methods may be employed for advancement of a borehole unless otherwise stated in Schedule 1:

Rotary drilling; shell and auger boring; wash boring, and percussion drilling (in rock only) and hand augering.

1202.2 Supporting sides of boreholes

All boreholes except for hand auger holes shall be supported with casing, and/or drilling mud; unless the borehole is shallow and is in stiff soils. Casing shall not be driven below any level at which sampling or testing is to be carried out until the latter has been completed.

1202.3 Addition of water to the borehole

(a) In general, water shall not be used to advance a borehole above the water table. Addition of water in such cases may be permitted with the approval of the Engineer when boring in dry granular soils or hard laterites or hard stiff clays.

(b) When the borehole penetrates below the water table, and disturbance of the soils is likely due to artesian pressure, a positive hydraulic head shall be maintained in the borehole.

1202.4 Rotary drilling

Rotary drilling shall be permitted in all cases to advance the borehole.
The drilling fluid shall normally be clean water. However drilling mud could also be used.

1202.5 Shell and auger boring

Shell and auger boring shall be permitted if the Contractor can demonstrate that the validity of in-situ testing and extraction of undisturbed samples is not compromised. This method of boring can be used in sandy soils, lateritic soils, residual soils and completely weathered rock. However, special attention is required when boring in soft clays and peats.

1202.6 Wash boring

Wash boring usually disturbs the soil at bottom of the borehole especially before in-situ testing or sampling. It won't be used for OCH.

1202.7 Encountering of hard stratum or obstruction

(i) Any obstruction encountered during boring shall be brought to the attention of the Engineer.

(ii) If an obstruction in the form of bed rock, boulder, hard layer such as sandstone, concrete, brick, log, or either object is encountered which prevents further progress in boring, the Contractor shall first attempt to break through the obstruction either by chiseling, or by rotary coring methods to drill through and obtain cores of the obstruction.

(iii) If the drilling shows that the obstruction is bed rock, the rotary core drilling shall be continued to a depth of 3½ m or as required by the Engineer to prove the continuity and engineering characteristics of the formation.

(iv) If the obstruction is shown to be a boulder or other object underlain by soil, the Contractor shall consult and agree with the Engineer on the use of one of the following lines of action.

1202.8 Hand Augering

Hand augering shall be carried out as per Section 1201.2, at intervals as indicated in the Table 1201-1 or as directed by the Engineer.

1202.9 Backfilling

Upon completion of each borehole, the Contractor shall backfill the holes as the casing is withdrawn. The soil backfilled into the borehole shall be placed in layers, each successive layer being tamped by the boring tools. The surface shall be reinstated to the original condition.

1202.10 Measurement and Payment

(a) Measurement

i) The advancement of borehole shall be measured separately in linear metres in soil overburden and rock

ii) The hand augering shall be measured separately in linear metres in soft soil and soil overburden.

(b) Payment

The quantities of advancement of borehole and hand auger holes shall be paid at the Contract unit rates for each class of material encountered.

No extra payment shall be made to the Contractor for either exceeding the number of exploratory holes or the depth of boring and drilling of each hole, unless ordered by the Engineer.

No payment shall be made for holes rejected by the Engineer.

All prices shall include full compensation for all labour, materials, tools, equipments etc. necessary to complete the work to these specifications and in addition shall include

(i) Setting out

(ii) Planking and any other precautionary measures taken to ensure the stability of adjacent areas.

(iii) Removal of obstructions of boulders, road pavement logs etc.

(iv) Backfilling of the hole after completion of borehole or hand auger work.

Pay Item	**Description**	**Pay Unit**
1202(1)	Advancement of borehole	Linear m
1202(2)	Advancement of hand auger hole (state type of material to be augered)	Linear m

(These pay items will be used for provisional sum of additional soil investigation)

SECTION 1203

PITS AND TRENCHES

1203.1 Trial pits and trenches

Trial pits and trenches shall be excavated by hand to a maximum depth of 1.2 m or by machine to the required depth as directed by the Engineer to enable visual examination and sampling from outside the pit or trench as required. Trial pits or trenches deeper than 1.2 m shall not be entered by personnel, unless adequately supported.

Top soil shall be stripped from the pit or trench area at the commencement of the excavation works and the materials stockpiled separately until backfilling as per Subsection 1203.7.

1203.2 Observation pits and trenches

Observation pits and trenches shall be excavated by hand or machine as directed by the Engineer, sides shall be adequately supported to enable personnel to enter safely and to permit in site examination, soil sampling and testing as required .

1203.3 Pit and trench dimensions

Unless otherwise indicated in schedule 1.

(a) trial pits and observation pits shall have minimum base dimensions of 1.5 mx1.5 m.

(b) trial trenches and observation trenches shall be 1 m wide.

1203.4 Description

Trial pits and trenches, and observation pits and trenches shall be examined and described by a geotechnical person and if required, photographed.

1203.5 Groundwater

The Contractor shall keep pits and trenches free from surface water run-off . Groundwater shall be controlled by pumping from a sump to permit continuous work.

1203.6 Undisturbed block samples

Undisturbed block samples shall be taken from test pits as per BS and ASTM Specifications.

1203.7 Backfilling

Backfilling of the pits and trenches shall be carried out as soon as practicable. The backfilling shall be compacted in such a manner using excavation plant or as specified in Schedule 1 as to minimize subsequent depression of the ground surface. Any surplus excavated material shall be heaped proud over the site and covered with top soil unless otherwise instructed by the Engineer.

1203.8 Protection to pits and trenches left open

Where pits and trenches are required to be left open for a period, the Contractor shall provide fencing together with all necessary lighting and signing. Precautions shall be taken to protect the pits and trenches from the adverse effects of weather during this period. Support and strutting for the sides of the pit shall be provided to prevent the collapse of the sides.

1203.9 Measurement and Payment

(a) Measurement

Pits and trenches excavation for all required and completed work shall be measured in its original position and the volume determined in cubic metres. Trench excavation shall be measured separately in soil.

Pits and trenches reinstatement fill material shall be measured as compacted in position in cubic metres. Reinstatement using suitable material resulting from the excavation and using borrow excavation shall be measured separately.

(b) Payment

The quantities of pit and trench excavation will be paid for at the Contract unit rates for each class of material encountered.

The reinstatement of the excavation shall be paid at the Contract unit rates for the separate items as measured above.

All prices shall include full compensation for all labour materials, tools, equipment etc. necessary to complete the work to these specifications and shall include the following where applicable :-

(i) Setting out
(ii) Planking and any other precautionary measure taken to ensure the stability of adjacent areas.
(iii) Removal of excess or unsuitable material, logs, stumps etc.
(iv) Measures required for working under restricted conditions. Dewatering shall be considered as part of the work.

The Pay Items and Pay Units will be follows :-

Pay Item	Description	Pay Unit
1203(1)	Pits and Trenches in soil	Cubic metre
1203(2)	Pits and Trench reinstatement	Cubic metre

(These pay items will be used for provisional sum of additional soil investigation)

SECTION 1204

SOIL SAMPLING

1204.1 Undisturbed soil samples

Unless otherwise indicated in Schedule 1, the method of obtaining undisturbed sample from borehole shall be as follows;

(a) use of 75 mm diameter piston samplers for peat and soft clays.
(b) use of 75 mm diameter Thin Walled Samplers for clays which are not too soft and can be retained.
(c) use of 75 mm diameter Open tube sampler for medium stiff cohesive soils.
(d) use of 75 mm diameter Dension samplers for lateritic soils

The method of sampling from Trial Pits and Trenches shall be as specified by the Engineer.

1204.2 Disturbed soil samples

In a borehole investigation, when a Standard Penetration Test (SPT) is carried out, the sample from the split spoon sampler shall be retained. Where a sample cannot be recovered from the SPT tube, samples can be collected from either the cuttings brought to the surface in rotary drilling and wash boring, or the boring tools in the shell and auger boring or hand augering.

The method of collecting disturbed samples from Trial Pits and Trenches shall be as specified by the Engineer.

1204.3 Sampling frequency

(i) Undisturbed samples of soil shall be obtained from clayey soils as indicated in Schedule 1, or as otherwise instructed by the Engineer.

(ii) SPT carried out in boreholes shall be at depths of 1.5 m intervals; or as otherwise instructed by the Engineer. The SPT may be left out at any depth at which an undisturbed sample is being collected.

1204.4 Description of samples

All samples shall be examined and described by a geotechnical person meeting the requirements of Subsection 1201.2(b).

1204.5 Measurement and Payment

(a) Measurement

Collection of samples shall be measured separately in numbers for disturbed and undisturbed samples for stated weights or sizes respectively.

(b) Payment

The collected numbers of samples shall be paid for at Contract unit rates for each size or weight. All prices shall include full compensation for all labour, materials, tools, equipments etc. necessary to complete the work to these specification and in addition shall include the following where applicable :-

(i) Packaging and proper sealing

(ii) Labeling and storage

(iii) Transportation to the laboratory.

The pay items and pay units shall be as follows:-

Pay Item	Description	Pay Unit
1204(1)	Collection of undisturbed samples	No.
1204(2)	Disturbed samples	No.

(These pay items will be used for provisional sum of additional soil investigation)

SECTON 1205

ROCK SAMPLING

1205.1 Core Samples

(a) Unless otherwise stated in Section 1201.1, rock cores shall be obtained by rotary core drilling using a double tube coring system.
(b) Rotary core drilling shall produce cores of not less than 40 mm diameter.
(c) The first core run in each hole shall not exceed 1 m in length. Subsequent core runs shall not normally exceed 3m in length.
(d) In cases where rock cores are to be obtained, hammering of the core barrel or explosive extrusion under high air pressure or water pressure shall not be permitted.

1205.2 Disturbed Samples

The sludge from percussion borings, or from rotary drilling which has failed to yield a core, may be taken as a disturbed sample.

1205.3 Measurement and Payment

(a) Measurement

Collection of samples shall be measured separately in numbers for core and disturbed samples for stated weights or sizes respectively.

(b) Payment

The collected numbers of samples shall be paid for at Contract unit rates for each size or weight. All prices shall include full compensation for all labour, materials, tools, equipments etc. necessary to complete the work to these specification and in addition shall include the following where applicable :-

(i) Packaging and proper sealing
(ii) Labeling and storage in core boxes
(iii) Transportation to the laboratory.

The pay items and pay units shall be as follows:-

Pay Item	Description	Pay Unit
1205(1)	Collection of core samples	No.
1205(2)	Disturbed samples	No.

(These pay items will be used for provisional sum of additional soil investigation)

SECTION 1206

GROUNDWATER

1206.1 Groundwater measurement records

(a) When groundwater is encountered in a borehole, the Contractor shall immediately cease boring, and observe and record any movement in the level of the groundwater.

(b) If it is necessary to add water to the borehole to facilitate boring, this shall be used sparingly and not in such a manner as to prevent accurate observation of the groundwater conditions in the borehole.

The Contractor shall take all necessary precautions to prevent surface water entering the boreholes.

(c) The Contractor shall regularly take records of the following water levels in each Borehole where the Engineer has designated:

(i) The level at which groundwater was first encountered.

(ii) The levels at which ground water was standing at the commencement and termination of each working day.

(iii) Water seepage at cutting sections and water permeability of soil.

(d) The cost of above works shall be included in the rates quoted for advancing boreholes.

1206.2 Sampling of groundwater

Samples of groundwater shall be taken as directed by the Engineer, and as specified in Section 1201, Clause 2.12, h).

1206.3 Installation of Standpipes

The Contractor shall install standpipes in boreholes to the numbers and depths required by the Engineer. The Standpipes shall be as specified in Appendix 1206.1.

1206.4 Recording of reading of Standpipes

(i) While on the site, the Contractor shall take daily readings of water levels in all Standpipes. He shall also, where directed by the Engineer return to the site at intervals to make additional water level readings.

(ii) The measured water level, elevation of the tip of Standpipe together with dates and time of reading shall be reported to the Engineer and shall also be included in the Final Report.

1206.5 Measurement and Payment

(a) Measurement

Collection of ground water samples shall be measured separately in numbers.

(b) Payment

The collected numbers of ground water samples shall be paid for at Contract unit rates for each size or weight. All prices shall include full compensation for all labour, materials, tools, equipments etc. necessary to complete the work to these specification and in addition shall include the following where applicable :-

(i) Packaging and proper sealing
(ii) Labeling and storage
(iii) Transportation to the laboratory.

The pay items and pay units shall be as follows:-

Pay Item	Description	Pay Unit
1206(1)	Collection of ground water samples	No.

(These pay items will be used for provisional sum of additional soil investigation)

SECTION 1207

DAILY REPORTS

1207.1 General

The Contractor shall prepare in duplicate for each exploratory hole a daily report, one copy of which shall be submitted to the Engineer at the beginning of the next working day.

1207.2 Information for daily reports

(a) General Information

(i) Name of Project
(ii) Date
(iii) Weather Condition

(b) For boring in Overburden

(i) Borehole number
(ii) Type of plant used and method of boring
(iii) Times of boring
(iv) (a) Depth of hole at beginning of working day
(b) Depth of hole at end of working day
(c) Depth bored during working day
(v) Diameters of boring
(vi) Diameters and depths of casing
(vii) All water levels encountered
(viii) Levels at which ground water was standing as commencement and end of working day
(ix) Levels of water in standpipes
(x) Depths from ground level of each stratum, and a preliminary description of the samples.
(xi) Records of in-situ tests carried out

(xii) (a) Depths at which obstructions are encountered
(b) Extents in vertical direction of obstructions
(c) Time for chiseling through obstructions and weights of Chisel

(xii) Details and depths at which samples were taken and Reference Numbers of samples.

(c) For drilling in rock

(i) Borehole number
(ii) Types of core barrels and bits
(iii) Times of drilling

(iv) (a) Depth of hole at beginning of working day
(b) Depth of hole at end of working day
(c) Depth of hole drilled during working day
(v) Depths of 'start' and 'finish' of each core run
(vi) Core diameters
(vii) Time of drilling each core run
(viii) Total Core Recovery and Rock Quality Designation
(ix) Preliminary description of type of rock and degree of weathering of rock at each pull out
(x) Percentage of water return and colour of return of water
(xi) Levels at which ground water were standing at beginning and end of working day

1207.3 For Trial Pits and Trenches

(i) Reference Number of Pit or Trench
(ii) Type of equipment used
(iii) Times of excavations
(iv) (a) Depth of excavation at beginning of working day
(b) Depth of excavation at end of working day
(v) Details of groundwater inflow
(vi) Depths from ground level of each stratum, and a description of each stratum
(vii) Dip and strike details of each stratum
(viii) Records of in-situ tests carried out
(ix) Locations and details of buried services encountered
(x) Information on photographs taken

SECTION 1208

IN SITU TESTS

1208.1 All in situ tests shall be in accordance with standards indicated in Section 1201.

1208.2 Measurement and Payment

(a) Measurement

Tests shall be measured separately in numbers**.**

(b) Payment

The numbers of tests shall be paid for at Contract unit rates for each type of test. All prices shall include full compensation for all labour, materials, tools, equipments etc. necessary to complete the work to these Specifications.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
1208(1)	Carrying out insitu tests (Detail of the tests to be specified.)	No.

(These pay items will be used for provisional sum of additional soil investigation)

SECTON 1209

LABORATORY TESTS

1209.1 All laboratory tests shall be in accordance with the standards indicated in Section 1201.

1209.2 As soon as the first 2 boreholes have been completed. The Engineer shall in consultation with the Contractor decide on the actual number and types of tests to be carried out. During the construction, the Engineer shall review the requirements and revise as required.

1209.3 Measurement and Payment

(a) Measurement

Laboratory tests shall be measured in numbers**.**

(b) Payment

The laboratory tests shall be paid for at Contract unit rates for each type of tests. All prices shall include full compensation for all labour, materials, tools, equipments etc. necessary to complete the work to these Specifications.

The Pay Items and Pay Units shall be as follows:-

Pay Item	Description	Pay Unit
1208(1)	Carrying out laboratory tests	No.

(These pay items will be used for provisional sum of additional soil investigation)

SECTION 1210

REPORTING

1210.1 Preliminary Logs

The Contractor shall prepare a preliminary log of each borehole using an agreed format, and submit the same to the Engineer within 7 working days of the completion of each borehole. A sample format is given in Section 1207, Daily Reports.

1210.2 Final borehole logs

(a) After the completion of all soil classification tests and a visual examination of all the samples in the laboratory, final borehole logs shall be prepared.

This shall include

(i) Ground level at top of borehole related to a datum.
(ii) Description of each stratum in accordance with the Standards indicated in Section 1201.
(iii) Details of groundwater observations.
(iv) Symbolic legend of strata in accordance with the Standards indicated in Section 1201.
(v) Details of rock cores as given in (b) below.

(b) When rock of cores are obtained by rotary drilling methods, the final borehole logs shall also include

(i) Condition of each core run in terms of percentage of Core Recovery and percentage of Rock Quality Designation, i.e. the percentage of solid core received in pieces larger than 100 mm.
(ii) Description of rock type, its alteration state and relative strength; details of the natural discontinuities and rock structures.
(iii) Percentage of water return, and colour of water.

1210.3 Preliminary laboratory test results

Laboratory test results shall be submitted to the Engineer in batches at the completion of each week's testing. Legible photocopies of work sheets shall be acceptable.

1210.4 Form of Report

The report shall be submitted in two sections; the first being the factual report, and the second, if required by the Engineer, the interpretative report.

1210.5 Contents of factual report

The factual report shall contain the following information:

(i) a statement on the purpose and rationale of the investigation.
(ii) a description of the work carried out, including reference to specifications and standards adopted and any deviations from them
(iii) borehole logs
(iv) in situ test records
(v) laboratory test plan
(vi) plan with location of boreholes and other test locations
(vii) site location plan
(viii) any additional information that may be required and is included in Schedule 1.

1210.6 Contents of interpretative report

(a) The interpretative report shall contain the following information:

(i) the brief agreed with the procurer for the interpretative work
(ii) reference to the desk study information
(iii) a written appraisal of the ground and water conditions
(iv) analyses and recommendations as indicated in Schedule 1201.1.

(b) When required in the Contract the Contractor shall supply the calculations and analyses on which recommendations are based.

1210.7 Acceptance of report

A draft copy of the factual report and interpretative report shall be submitted to the Engineer for acceptance before submission of the Final Report.

1210.8 Alternative programme

The Contractor at the time of tendering may propose an alternative Investigation Programme which would still enable the Contractor to submit the Final Report and Recommendations as required by the Engineer.

The Contractor must however, price the investigation programme included in the Bill of Quantities and submit his alternative separately.

1210.9 Final Payment

No separate payments shall be made to this section or the payment is included in other sections.

Appendix to 1200

Standpipes for groundwater observations

A1.1 Specification of Standpipe

The standpipe shall consist of a rigid polyvinyl chloride (PVC) of 100-150 mm in diameter or as specified by the Engineer. The base of the standpipe shall be plugged and the lower 1.0 m of the standpipe shall be perforated by holes not greater than 5 mm in diameter at intervals of approximately 75 mm.

A1.2 Specification of filter

The filter materials in diameter and thickness shall be selected by the Contractor not to block the stand pipes and shall be approved by the Engineer.

A1.3 Installation

(i) The drilled hole shall be flushed until return water runs clear. The water from the hole shall be pumped out prior to installation.

(ii) Where the depth of the borehole is greater than the depth to which the filter and standpipe are to be installed, then the borehole shall be backfilled up to the base of the filter with natural materials approved by the Engineer.

(iii) The gravel filter shall be placed in the borehole up to the level of the proposed base of the standpipe. The elevation of the top of the filter shall be recorded.

(iv) The standpipe shall be lowered carefully down the borehole to the top of the filter, and the hole backfilled with filter gravel to within 1.0 m of ground level or as recommended.

(v) The top of the PVC tubing shall be covered by plastic caps or similar as approved by the Engineer.

(vi) A small hole shall be made in the side of the standpipe tube near the top to allow air to escape.

(vii) The pipe shall be sealed into the ground with a 0.5 m deep layer of cement grout or bentonite–cement grout , so that it does not rotate and the ingress of surface water is prevented

SCHEDULES (ATTACHMENT)

The attached schedule apply for "Chapter 1200 Site Investigation for embankment construction, bridges and other structures and cuttings" with information, amendments and additions as described in the Schedules.

Schedule 1 : Information

Schedule 2 : Specification Amendments

Schedule 3 : Exploratory holes (i.e. Boreholes, Hand auger holes, Pits and Trenches)

SCHEDULE 1
(SECTION 1201) INFORMATION

S 1201.1 Name of Contract

(Note. A concise and unique name shall be required for Contract and reporting purposes. The name shall include the nearest town)

S 1201.2 Description of Site

(Note. The description of the site shall include its location, geological setting (if known), previous use site (if known)

Detailed geological reports will be provided to the Contractor. Underground utility information collected during the design stage will be provided to the Contractor. Notwithstanding such information provided, the ultimate responsibility for the location of underground services shall be with the Contractor.)

S 1201.3 Type of development proposed at site

(Note. Type of development shall be indicated; e.g. road embankments, bridges or other structures and cuttings etc. Also, if possible, provide information on number of spans, loading details, etc. for bridges)

S 1201.4 Scope of Investigation

(Note. The text shall state whether the investigation is preliminary, main or supplementary. A brief outline is required of the work to be done under the Contract, stating the type of exploratory holes (boreholes, trial pits, etc). It shall also state whether sampling and testing (in situ and laboratory) are required, and also what types of report are required (factual or factual and interpretative.)

S 1201.5 Schedule of drawings and documents

Note. These shall include
(a) Site Plan
(b) Layout Plan, if available
(c) Contour Map, in sloping terrain

S 1201.6 The requirements/restrictions given below shall be included only if necessary

(a) Requirements for borehole in overburden

(i) The method of advancing the borehole
(ii) Special backfilling requirement

(b) Requirements for borehole in rock

(i) The method of advancing the borehole
(ii) Special backfilling requirement
(iii) Particular photographic requirements

(c) Requirements for Pits and Trenches

(i) any alternative dimensions
(ii) particular photographic requirements
(iii) special backfilling requirements

(d) Requirements for Sampling

(i) Frequency of sampling in overburden
(ii) The method of obtaining undisturbed samples from overburden
(iii) The minimum diameter of undisturbed samples from overburden
(iv) The method of obtaining rock cores
(v) The minimum diameter of rock cores
(vi) Special requirements for retention and delivery of samples.

(e) Requirements for in-situ testing

(i) Frequency of SPT
(ii) In-situ testing requirements other than SPT
e.g. Plate bearing tests, Static Cone Penetration Tests, Vane Shear Tests, Field permeability tests , Degree of compaction Tests, Pressure meter Tests.
(iii) Geophysical investigations.

(f) Requirements for particular instrumentation and monitoring

(i) Installation of piezometers and/or standpipes
(ii) Frequency of readings
(iii) If piezometers and/or standpipes are to be removed.

(g) Requirements for Final Report

(i) Requirements for interpretative report
(ii) Additional information required in factual report
(iii) Analysis and recommendations required in interpretative report
(iv) Calculations required.

SCHEDULE 2
(CLAUSE 1201.2.9) SPECIFICATION AMENDMENTS

The following clauses are amended:

Note: Clause 1201.2.9, Geotechnical personnel may be amended (for small jobs) to allow field works to be carried out under the supervision of a person with drilling experience; e.g. Drillers, Drilling Foremen , Soil Testers, etc.

Similarly, this schedule shall contain any other Specification Amendments.

SCHEDULE 3
(Sections 1202 and 1203) EXPLORATORY HOLES
(BOREHOLES, HAND AUGER HOLES, PITS AND TRENCHES)

(Note: The following information shall be provided for each exploratory hole.

Hole No:

Type :

Scheduled depth :

Method of locating hole:

SECTION 1300

TESTS FOR QUALITY CONTROL OF MATERIALS AND WORKS

Note: If any amendments were made to the standards and specifications quoted here, the latest versions will be applied.

1301 AGGREGATES AND SOIL – AGGREGATES MIXTURES

1301.1 Sieve Analysis

The sieve analysis test for aggregates shall be carried out in accordance with BS EN 932-1-1997 or ASTM test designation C 136-96a or AASHTO T27-99.

1301.2 Clay, silt and Dust fraction

The clay silt and dust fraction (fraction passing the 75 micron sieve) in aggregates shall be determined in accordance with BS 812: 103.2 (2000) or ASTM test designation C 117-95 or AASHTO T11-97.

1301.3 Aggregate Impact Value (AIV)

The test to determine aggregate impact value (AIV) shall be carried out in accordance with BS EN 1097-2-1998.

1301.4 Not used

1301.5 Los Angeles Abrasion Value (LAAV) (only ASTM)

The test to determine Los Angeles Abrasion Value (LAAV) shall be carried out in accordance with ASTM C 131-01or C 535-89 for small size and large size aggregates respectively or BS EN 1097-8 (2000) or AASHTO T96 – 02.

1301.6 Flakiness Index

The flakiness index test shall be carried out in accordance with: BS 812: part 105.1:1989. (2000), Elongation – BS 812: 105.2 1990 (2000)

1301.7 Specific Gravity of Coarse Aggregate

The specific gravity of coarse aggregate shall be determined in accordance with clause 5.3 of BS 812: Part 2:1975 or ASTM C 127 – 88(1993) or AASHTO T85 – 91 (2000).

1301.8 Specific Gravity of Fine Aggregate

The specific gravity of fine aggregate shall be determined in accordance with clause 5.5 of BS EN 1097.5 : 1999 or ASTM C 128 – 97,or BS 812 : 1990 (2000) or AASHTO T84 – 00.

1301.9 Soundness of Aggregate

The soundness of aggregate shall be determined by BS 812 – Part 121 – 1989 (2000) or ASTM C 88 – 83 or AASHTO T 104-99.

1301.10 Field Density

The field density of graded aggregate layers shall be determined by test 15 B of BS 1377: Part 9 Sec. 2.2 1990 or ASTM D 1556 - 82.

1301.11 Sand Equivalent Test

The sand equivalent of aggregate shall be determined by ASTM D 2419 – 1979 or AASHTO T 176-2000.

BITUMINOUS BINDERS AND BITUMEN – AGGREGATE MIXES

1302.1 Penetration Grade Bitumen

The penetration grade bitumen shall conform to ASHTO M20: 2000 and softening points to as per Section 1302.1, (b) of 48/56^{0}C and 47-55^{0}C for 60/70 and 80-100 penetration grade bitumen respectively.

(a) Penetration

Penetration test shall be carried out in accordance with ASTM test designation D 5-97, or BS EN 1426 – 2000 or AASHTO T49-97(2001)

(b) Softening Point

The softening point test shall be carried out in accordance with ASTM test designation D 36-95, or BS EN 1427 – 2000 or AASHTO 53-96(2000)

(c) Loss on Heating

The loss on heat test shall be carried out in accordance with BS 2000: Part 45:1993 or ASTM test designation D 6-95(2000) or AASHTO T47-98.

(d) Flash Point (ASTM or AASHTO)

The flash point test for penetration grade bitumen shall be carried out in accordance with ASTM test designation D 92-96 or AASHTO T48-99.

(e) Solubility

The solubility test shall be carried out in accordance with ASTM test designation D 2042 - 93 or BS EN 12592: 2000 or AASHTO T44-97(2001).

(f) Coating ability and water resistance

The test shall be carried out as per Section 1302.3(h)

1302.2 Cutback Bitumen

The cutback bitumen shall confirm to AASHTO 82-75(2000).

(a) Viscosity

The viscosity test for cutback bitumen shall be carried out in accordance with ASTM test designation D 2170 - 95.

(b) Distillation

The distillation test for cutback bitumen shall be carried out in accordance with ASTM test designation D 402 – 94 or AASHTO T78-96(2000)

(c) Ductility for Residue

The ductility test shall be carried out in accordance with ASTM test designation D 113 – 99 or AASHTO T51-00

(d) Water Percentage

The water percentage of cutbacks shall be determined in accordance with ASTM test designation D 95 – 99 or AASHTO T55-02.

(e) Flash Point

The flash point test for cutback bitumen using the tag open cup shall be carried out in accordance with ASTM test designation D 3143 - 98.

(f) Coating ability and water resistance

The test shall be carried out as per Section 1302.3(h)

1302.3 Bituminous Emulsions

The bitumen's Emulsion shall conform to ASSHTO M208-01 or ASTM D2397-98.

(a) Viscosity Test

The viscosity test for bitumen emulsions shall be carried out in accordance with Section 22 - 24 of ASTM test designation D 244 – 99 or AASHTO T59-01.

(b) Settlement

The settlement test for bitumen emulsions shall be carried out in accordance with Section 29 - 32 of

ASTM test designation D 244 – 99 or AASHTO T59-01.

(c) Storage Stability

The storage stability test for bitumen emulsions shall be carried out in accordance with Section 56 - 62 of ASTM test designation D 244-99 or AASHTO T59-01.

(d) Particle Charge

The particle charge test for bitumen emulsions shall be carried out in accordance with Section 19 - 21 of ASTM test designation D 244 – 99 or AASHTO T59-01.

(e) Sieve Test

The sieve test for bitumen emulsions shall be carried out in accordance with Section 38 - 41 of ASTM test designation D 244 – 99 or AASHTO T59-01.

(f) Distillation

The distillation test for bitumen emulsions shall be carried out in accordance with Section 8-10 of ASTM test designation D 244-99 or AASHTO T59-01.

(g) Characteristics of Residue

The characteristics of the residue by distillation shall be examined by carrying out tests in accordance with Section 63 - 68 of ASTM test designation D 244-99 or AASHTO T59-01.

(h) Coating Ability and Water Resistance

The coating ability and water resistance test for bitumen emulsion shall be carried out in accordance with Section 50 - 55 of ASTM test designation D 244-99, ASTM D1664-80 or AASHTO T59-01 & T182-84(1998).

(i) Cement Mixing

The cement mixing test for bitumen emulsion shall be carried out in accordance with Sections 33 -37 of ASTM test designation D 244 – 99 or AASHTO T59-01.

(j) Demulsibility

The demulsibility test for bitumen emulsions shall be carried out in accordance with Sections 25 -28 of ASTM test designation D 244 – 99 or AASHTO T59-01.

1302.4 Bitumen Aggregate Mixes

(a) Marshall Stability and Flow

The test determination of Marshall Stability and flow shall be carried out in accordance with

ASTM test designation D 1559 – 89 or for flow with AASHTO T245-97(2001).

The samples shall be compacted using 35, 50 or 75 blows for low, medium or high traffic depending on whether the cumulative number of standard axles for the design life of the surfacing is less than 104 or between 104 and 106 or greater than 106 respectively.

(b) Extraction of Bitumen

The test for extraction of bitumen shall be carried out in accordance with ASTM test designation D 2172 – 05 or AASHTO T164-01. The asphalt shall be recovered from the solution in accordance with AASHTO Test Method T 170 or ASTM D 1856-95a.

(c) Density of compacted bituminous mixtures

The test for determining the density (bulk specific gravity) of compacted bituminous mixtures shall be carried out in accordance with ASTM test designation D 2726 – 96a or AASHTO T230-68(2000) or T 209-99.

1302.5 Rate of Spread of Binders

Rate of spread of binder shall be determined by the Tray test as described below.

Three square metal trays, each of area between 0.06 - 0.12 m2 and of known weight are placed on the surface on which the binder is to be applied. After the binder is applied, the trays are weighed and the rate of application of binder calculated in l/m2. The specific gravity of the binder to be used in the calculation shall be as determined in the laboratory, which for most purposes may be, taken as 1.0. Care shall be taken to ensure that the binder does not drip off the tray prior to weighing.

CEMENT AND CONCRETE

1303.1 Cement

(a) Standard Consistency

The test for standard consistency (normal consistency) shall be carried out in accordance with Appendix E of SLS 107: 2002 or ASTM test designation C 187 - 04 or BS EN 196.3 – 1995 or AASHTO T129-01.

(b) Setting Times

The tests for the determination of initial and final setting times shall be carried out in accordance with Appendix F of SLS 107 : 2002 or ASTM test designation C 191 – 04b or BS EN 196-3:1995 or AASHTO T131-01.

(c) Fineness

The test for the determination of fineness shall be carried out in accordance with Appendix A of SLS 107: 2002 or ASTM test designation C 204 – 00 or BS EN 196-6 – 1992 or AASHTO T152-01

(d) Compressive Strength

The tests for the determination of compressive strength of cement shall be carried out in accordance with Appendix C or D of SLS 107:2002 or ASTM designation C109 / C–109M-05 or BS EN 196-1 – 1995 or AASHTO T106-02.

(e) Soundness Test

The test for the determination of soundness shall be carried out in accordance with Appendix BS 4550 Part 3 Sec. 3.7 or BS EN 196-3: 1995.

1303.2 Concrete

(a) Casting of Concrete Cubes

The casting of concrete cubes shall be carried out in accordance with BS 1881: Part 108: 83, BS EN 12390-1 - 2000 or ASTM C31/C31M-03a in the field or ASTM C192C/192M-05 in the laboratory.

(b) Testing of Concrete Cubes

The testing of concrete cubes shall be carried out in accordance with, BS EN 12390 – 3 - 2002.

(c) Casting of Concrete Beams

The casting or concrete beams shall be carried out in accordance with BS 1881 : Part 109 : 83 or ASTM test designation C 192 - C 192M-95 or C 31 - 00 as relevant. ISO 1920, ISO 2736-2 or AASHTO T126-01 or T23-02 as required.

(d) Testing of Concrete Beams

The testing of concrete beams shall be carried out in accordance with ASTM test designation C 78 – 94 or BS EN 12390 – 5 – 2000 or AASHTO 97-97(2001).

(e) Casting of Concrete Cylinders

The casting of concrete cylinders shall be carried out in accordance with ASTM test designation C 192 – C 192M-95 or AASHTO T126 - 01 or T23-02 as relevant or C 31 - 00 as relevant or BS EN 12390 – 2 - 2000.

(f) Testing of Concrete Cylinders

The testing of concrete cylinders shall be carried out in accordance with ASTM test designation C 39 – 86, BS EN 12504 – 1 – 2000 or AASHTO T22-97.

(f) Slump Test

The slump test shall be carried out in accordance with ASTM test designation C 143 / C 143M-05a or BS EN 12350 – 2 - 2000 or AASHTO T119-99.

SOILS AND SOIL AGGREGATES MIXTURES

1304.1 Sieve Analysis Test for soils

The sieve analysis test for soils shall be carried out in accordance with test 7A of BS 1377 – Part 2 – 1990 or ASTM D 422 – 63 (re-approved 1972) or AASHTO T88-00.

1304.2 Liquid Limit

The liquid limit test shall be carried out in accordance with test 2B of BS 1377 – Part 2 – 1990 or ASTM D 4318 – 05 or AASHTO T89-02.

1304.3 Plastic Limit

The plastic limit test shall be carried out in accordance with test 3 of BS 1377 Part 2 – 1990 or ASTM D 4318 – 05 or AASHTO T90-00.

1304.4 Standard / Modified Compaction

The standard / modified compaction tests shall be carried out in accordance with Test 12 or 13 of BS 1377 Part 4 – 1990 respectively or ASTM D 698–00a or D 1557-02 or AASHTO T99-01 or T180-01 respectively.

1304.5 California Bearing Ratio (CBR)

The California bearing ratio test shall be carried out in accordance with test 16 of BS 1377 Part 4-1990 or ASTM – D 1883 – 99 or AASHTO to T193-99.

1304.6 Field moisture

The field moisture content shall be carried out in accordance with ASTM D2218-98.

1304.7 Field Density

The field density test shall be carried out in accordance with test 15A of BS 1377 – Part 9 – 1990 or ASTM D 1556 – 90 or AASHTO T191-02.

APPENDIX I

(a) ASTM PUBLICATIONS

The following is a list of publications to which reference is made in this book.

Annual Book of ASTM Standards – 2006

Volume 04.01	-	for cement & lime -2006
Volume 04.02	-	for concrete and mineral aggregates - 2006
Volume 04.03	-	for road paving bituminous materials - 2006
Volume 04.08	-	for soils – 2006

(b) PUBLICATIONS OF BRITISH STANDARD INSTITUTION

BS EN 197-1-2000	Ordinary and Rapid Hardening Portland Cement
BS 882: 1992	Metal of Sampling and Testing of Mineral Aggregates Sands and Fillers

BS EN 12620–2002 (2000) Part 101	Guide to sampling and testing aggregate
BS EN 932–1–1997 Part 102	Method for sampling
BS EN 932–1–2000Part 103	Particle size distributor
BS EN 932–1–2000Part 105.1	Flakiness Index Test
BS EN 932–1–2000Part 105.2	Elongation Index Test
BS EN 1097–2–1998 Part 112	AIV Test

BS 1881: 1983 Methods of Testing Concrete

BS EN 12350-1-2000	Part 101	Method of sampling fresh Concrete on Site
BS EN 12350-2-2000	Part 102	Method for Determination of Slump
BS EN 12350-1-2000	Part 108	Method for Making Test Cubes from Fresh Concrete
ISO 1920, ISO 2736-2	Part 109	Method for Making Test Beams from Fresh Concrete
BS EN 12390-3-2002	Part 116	Method for Determination for Compressive Strength of Concrete Cubes
BS EN 12350-5-2000	Part 118	Method for Determination of Flexural Strength

BS 4449: 1997	Hot Rolled Steel Bars for Reinforcement of Concrete
URONORM 138, BS 4486: 1980	Cold worked High Tensile Alloy Steel Bars for Prestressed Concrete

BS 4027:1996	Part 3	Sulphate - Resisting Portland Cement
BS 4550: 1978		Method of Testing Cement Fineness test Strength test, determination of standard consistency, setting time

BS 3690	-	Bitumen testing
BS – 1707:1989	-	Depot tray test

(c) AASHTO PUBLICATIONS

Reference has been made to part 2A&2B "Tests" of the "Standard Specifications for Transportation Materials and Methods of Sampling and Testing – Twenty Second Edition – 2002."

APPENDIX TO SPECIFICATIONS

APPENDIX 1

FACILITIES FOR THE ENGINEER

1. General

The Contractor shall provide, maintain and service:

- Offices,

- Accommodation,

- Vehicles

including contents, access roads and hardstanding for the use of the Engineer. If offices, accommodation and land are rental, the rent should cover the whole period of the Project. If they are new construction, they shall be handed over to the Employer on completion of the Project.

The vehicles are on the purchase basis. They shall be handed over to the Employer on the completion of the Project.

2. Deadline and Payment of the Supply

(a) Offices (Rent or new construction)

-The Engineer's main office shall be available and ready for use within 6 months from the Commencement Date (4 months if the land is provided by the Employer).

-Pay items for the Engineer's offices shall include the land costs (rent or purchase). The Contractor shall find the suitable land by themselves.

-Payment for the Engineer's offices will be made when all the offices (incl. furniture and equipment) are completed and handed over to the Engineer.

In the event of the Contractor failing, within the specified time, to construct or rent the office satisfactory to the Engineer, the Engineer will provide suitable offices for his use and the cost involved shall be deducted by the Employer from payments due to the Contractor in accordance with Clause 49.4 of the Conditions of Contract.

(b) Accommodation (Rent or new construction)

-If the Engineer's accommodation is on rental basis, it shall be available and ready for use within 2 months of the Commencement Date. After the 2 months, the actual requirement shall follow the Engineer's assignment.

-If new construction, it shall be ready within 6 months (4 months if the land is provided by the Employer).

In the event of the Contractor failing, within the specified time, to construct or rent the accommodation satisfactory to the Engineer, the Engineer will provide suitable accommodation for his use and the cost involved shall be deducted by the Employer from payments due to the Contractor in accordance with Clause 49.4 of the Conditions of Contract.

(c) Vehicles (New purchase)

- Vehicles shall be provided within 2 months from the Commencement Date.

- Payment for the vehicles will be made after handover of all vehicles to the Engineer.

In the event of the Contractor failing, within the specified time, to supply the vehicles satisfactory to the Engineer, the Engineer will provide suitable vehicles for his use and the cost involved shall be deducted by the Employer from payments due to the Contractor in accordance with Clause 49.4 of the Conditions of Contract.

3. Offices for the Engineer

3.1 General

(a) The Contractor shall furnish and service offices made available by the Engineer. All offices shall be regularly cleaned for so long as it is in use and suitable arrangements be made for the disposal of any waste arising from use of such offices.

(b) All equipment supplied by the Contractor shall be of a quality and precision appropriate to its proposed use and shall be delivered in a serviceable condition. The Contractor shall maintain all such equipment in serviceable condition and replace, if necessary, any that becomes unserviceable.

(c) Generator The Contractor shall provide and operate generators to supply adequate power and shall provide pumps to supply water from wells or storage tanks. In the event of the mains electricity supply failing, electricity shall be supplied from a generator with adequate ground connection, installed and operated by the Contractor.

3.2 Maintenance of Offices

(a) The Contractor shall maintain in good decorative and working order the buildings and the contents thereof. The maintenance of these facilities shall include daily cleaning, the provision of cleaning consumables and toilet materials, garbage collection and disposal, and the maintenance of the gardens and surrounding ground all to the satisfaction of the Engineer.

(b) The Contractor shall supply and keep replenished at all times all consumable items such as tea, coffee, milk, sugar, insecticides, first aid supplies, laboratory supplies and so forth.

(c) The Contractor shall maintain in good condition and service regularly and repair or replace as required all items of furniture and equipment provided by him, and shall provide security to guard the facilities on a 24 hours per day basis.

(d) The Contractor shall be responsible for the cost of all domestic telephone calls but shall not be responsible for the cost of any overseas calls made from the telephone provided.

3.3 Office Stationery Supplies

The Contractor shall supply stationery as duly requisitioned by the Engineer. Stationery shall include paper, printing materials, including photocopy toner, laser printer toner, inkjet printer cartridges, plotter pens, computer consumables, pens, pencils, drawing instruments, drawing supplies and the like. It shall also include CD and diskettes as may be required by the Engineer.

4. Main Office for the Engineer

Facility shall have the following minimum provisions;

Room	Air Conditioner (BTU/hour)	Number of Rooms	Minimum Room size (m x m)
(- Asbestos materials shall not be used for roofs and ceilings.) (-Roof shall be closed type-underneath)			
Engineer's Staff	10,000	7	5x4
Conference Room	24,000	1	5x10
Administration/CAD/Copy Rooms	24,000 & 10,000	3	5x5
Toilets		2	5x4 (for men), 5x3 (for women)
Kitchen		1	4x2
Store Room		1	5x2
Drivers' Room		1	5x3
Minimum room floor total Area (excl. passageways and halls)			400 sq.m
Covered Parking for Vehicles		11	

4.1 Furniture and Office Equipment for the Engineer's Staff

The furniture and equipment to be supplied and installed in the offices shall be new, and of acceptable quality. The furniture may be steel, aluminium, wood or a combination of these. The Contractor should forward details of the items he intends to supply and obtain prior approval from the Engineer.

Upon completion of the Contract, all non-consumable items provided will become the property of the Employer.

The Contractor shall provide, install, maintain and provide consumables for the furniture and equipment detailed in the following list, until completion and to the satisfaction of the Engineer.

4.2 Main Office Details

Team Leader's Office (1 Room)1 Senior executive desk, 0.9 m x 1.8 m with 3 drawers each side.

1 Senior executive chair.

2 Chairs, cushion.

1 Filing cabinet, steel, 2-drawer.

1 Safe, Chubb, 0.5 m wide x 0.6 m high x 0.5 m deep.

1 Steel Bookcase, 4 shelves, 1.0 m wide x 1.5 m high.

1 White board, 1.0 m wide x 0.75 m high.

1 Layout table, 1.0 m x 2.0 m.
1 Cupboard, steel, lockable, 1.8 m high x 0.9 m wide x 0.45 m deep.
1 Telephone, international direct dial
1 Telephone, international direct dial for fax machine (A4 plain paper)
1 Telephone extension, general office number.
1 LAN and Internet connection (ADSL)
1 Note book type computer, Intel Pentium IV or equivalent, at least 2.0 GHz, 1 GB RAM 512 MB, 52x CD ROM with CD-R, mouse
1 LaserJet printer, A4 size, black and white (12 pages per minute minimum capacity)
1 Uninterrupted Power Supply (UPS), 600 VA, with at least 20 minutes backup time.
1 Air conditioner, 10,000 BTU

Deputy Team Leader's Office (1 Room)

1 Senior executive desk, 0.9 m x 1.8 m with 3 drawers each side.
1 Senior executive chair.
2 Chairs cushion.
1 Filing cabinet, steel, 2-drawer.
2 Steel Bookcase, 4 shelves, 1.0 m wide x 1.5 m high.
1 White board, 1.0 m wide x 0.75 m high.
1 Layout table, 1.0 m x 2.0 m.
1 Telephone extension, general office number
1 LAN and Internet connection (ADSL)
1 Desk top, Intel Pentium IV or equivalent of at least 2.0GHz, 1 GB RAM, 60GB Hard Drive, 3.5" Floppy disk drive, 52 x CD ROM, mouse, 101 keyboards, 17" colour monitor.
1 LaserJet printer, A4 size, black and white (12 pages per minutes minimum capacity)
1 Uninterrupted Power Supply (UPS), 600 VA, with at least 20 minutes backup time.
1 Air conditioner, 10,000 BTU

Engineers' Office (5 rooms each)

3 Junior executive desk, 0.75 m x 1.5 m with 2 drawers each side.
3 Junior executive chair.
3 Chairs, moulded plastic
3 Steel Bookcase, 4 shelves, 1.0 m wide x 1.5 m high.
1 Layout table, 1.0 m x 2.0 m.
1 Telephone extension, general office number.
1 LAN and Internet connection (ADSL)
3 Desk top, Intel Pentium IV or equivalent of at least 2.0GHz, 1 GB RAM, 60GB Hard Drive, 3.5" Floppy disk drive, 52 x CD ROM, mouse, 101 keyboards, 17" colour monitor.
1 LaserJet printer, A-3 size, black and white (12 pages per minutes minimum capacity)
7 Uninterrupted Power Supply, 600VA, with at least 20 minutes backup time, (total in 5 rooms)
1 Air-conditioner, 10,000 BTU, split type

CAD Operator's (1 room)

2 Junior executive desk, 0.75 m x 1.5 m with 2 drawers each side.
2 Junior executive chair.
2 Chairs, moulded plastic
1 Steel Bookcase, 4 shelves, 1.0 m wide x 1.5 m high.
1 Layout table, 2 mx3 m.
3 LAN and Internet connection (ADSL)
2 Computer IBM compatible Intel Pentium IV or equivalent of at least 2.0GHz, 4 GB RAM, 60GB Hard Drive, 3.5" Floppy disk drive, 52x CD ROM, mouse, 101 keyboards, 17" colour monitor.
1 LaserJet printer, A3 size, black and white (12 pages per minute minimum capacity)
1 Inkjet Color printer, A-3 size
1 Plotter (A-1 size)
2 Uninterrupted Power Supply, 600VA, with at least 20 minutes standby time)
1 Air-conditioner, 24,000 BTU, split type

Other Rooms

Administration Rooms (combined)/ Reception Area (1 room)

5 Clerk's desk, 0.75 m x 1.25 m with 2 drawers each side.
5 Junior executive chair.
7 Steel Bookcase, 4 shelves, 1.0 m wide x 1.5 m high.
4 Filing cabinet, steel, 4-drawer. 1 Telephone system, local exchange with general office number and recording number dialled and duration of outgoing calls.
1 Telephone line, international direct dial, for fax machine.
2 Telephone extension for blocking selected outgoing numbers.
1 White board, 2.0 m x 1.2 m, marked up to record staff movements.
1 Facsimile machine (A4, plain paper)
1 Coffee table.
2 Armchair.
1 Air-conditioner, 9000 BTU, split type
5 Computer with ADSL connection IBM compatible Intel Pentium IV or equivalent of at least 2.0GHz, 1 GB RAM, 60GB Hard Drive, 3.5" Floppy disk drive, 52 x CD ROM, mouse, 101 keyboards, 17" colour monitor complete. (56kb/sec internal fax/modem to be fitted to one computer) with Internet connection.
1 Computer server
1 Laser printer, A-4 size, black and white
1 Inkjet color printer, A-3 size
4 Uninterrupted Power Supply, 600VA, with at least 20 minutes standby time)

Copying Room (1 room)

1 Clerk's desk, 0.75 m x 1.25 m with 2 drawers each side.
1 Junior executive chair
1 Layout table, 1.0 m x 2.0 m.
2 Cupboard, steel, lockable, 1.8 m high x 0.9 m wide x 0.45 m deep.
1 Photocopy Machine (Toshiba 4570 or similar approved by the Engineer)

Conference Room (1 room)

1 Conference table.
15 Chairs, moulded plastic.
1 White board, 2.0 m x 1.2 m.
1 Air-conditioner, 24000 BTU, split type
1 Pedestal fan.

Kitchen

1 Refrigerator, 8 cubic feet capacity.
1 Cooker, gas, 4 rings.
2 Gas cylinders.
1 Sink, stainless steel, double basin, with cold water supply.
1 Crockery, complete set for 12 people.
1 Cutlery, complete set for 12 people.
1 Tea service, complete set for 24 people.
1 Electric kettle.
1 Draining rack.
1 Dustbin, plastic.

Drivers' Room

1 Table, 2 m x 1 m.
12 Chairs, moulded plastic.
1 Bookcase, 4 shelves, 1.0 m wide x 1.5 m high.
1 Ceiling fan, with regulator.

Computer Equipment/Facilities (summary of specification)

1 Computer Server IBM compatible Intel Pentium IV or equivalent of at least 2.0 GHz, 1 GB RAM, 60 GB Hard Drive, 3.5" Floppy disk drive, 52x CD ROM, 52x CD-RW, mouse, 101 keyboard, 17" colour monitor complete.
1 Uninterrupted Power Supply, 600VA, with at least 20 minutes standby time)
1 Computer network system (LAN network to all computers)
1 Laser printer, A3 size. (HP LaserJet 5000N or equivalent)
1 Inkjet colour printer A3 size. (HP DeskJet 1125C or equivalent)
1 Plotter (color), A1 size.
1 Scanner, flatbed, A4 size, multi-page document feeder, and latest Adobe Acrobat Writer software
1 Software (including Land desk top by Land desk Co. and virus soft) as directed by the Engineer.
1 Internet Service Provider for email and Internet access (ADSL).

Other Requirements

2 Digital camera, automatic, 35 mm, 28-90 mm zoom lens (3.3 Mega pixel min).
Mobile phone (to be provided in Consultant's contract)
1 Multi-media projector,
1 Shredder,
1 Thick glass on the table for paper cutting
2 Steel rule for paper cutting (L=1 m & 0.3 m),
30 Filing boxes.
12 Paper punches.
1 Paper punches, heavy duty.
12 Staplers.
1 Heavy duty stapler.
1 Spiral Binding machines.
16 Wastepaper baskets.
6 Fire extinguisher.
2 First aid kit, comprehensive.

5. Portable Offices for the Engineer

Facility shall be portable and have the following minimum provisions;

Room	Air Conditioner (BTU/hour)	Number of Rooms
Engineer's Staff	10,000	2
General	10,000	2
Toilet		1
Kitchen		1
Minimum Total Area		60 sq. m
Covered Parking for Vehicles		2

Site Office (Portable office)

Offices for the Engineer shall be portable, mobile or fixed and the floor area shall be subdivided with permanent walls and doors to suit the particular type of facilities and as directed by the Engineer. Minimum headroom or ceiling height shall be 2.5m.

Portable or mobile facilities shall be complete with insulated exterior walls and all interior walls shall be finished with 8mm thick wood panels or similar. This floor shall be covered with vinyl tiles or similar washable covering to the approval of the Engineer.

Fixed facilities shall be constructed in hollow concrete blocks or bricks. All internal surfaces to be plastered with a cement mortar to a smooth finish and painted white or any other colour approved by the Engineer. The floor shall be covered with vinyl tiles or similar washable covering to the approval of the Engineer.

All doors shall be lockable from both sides. Windows shall be horizontal sliding with anodized frames, glazed with tinted glass and lockable from inside only.

The office facilities shall be fully air-conditioned.

Each room shall be fitted with 2 No., 40-watt fluorescent light fittings, a ceiling fan with regulator and two 5A electric outlets with ground connection.

The office shall be equipped with a toilet room and kitchen as specified below:

Toilet Rooms

One toilet room shall be equipped with a water closet (pedestal type, ladies 1, and gentlemen 1). The other toilet shall be equipped with two water closets (floor type) and two urinal stalls. Both toilets shall be fitted with electric extractor fans, washbasins with taps, mirrors and wall hooks for clothing etc.

The Contractor shall supply and keep replenished at all times, all necessary supplies to toilet rooms.

Kitchen

This shall be fitted with a sink unit with cold water on tap and, at least two 5A and one 15A electric outlet.

The Contractor shall be responsible for any site grading required for the site office facilities including access to the project by means of roads and for covered parking areas adjacent to the facility.

The site shall be graded and properly drained so that there are no depressed areas where water will collect. The Contractor shall prepare for the Engineer's approval working drawings of the Engineer's site office facilities including but not by way of limitation the site layouts, front and

side elevations, floor plan with dimensions, details of construction with finishes and all other data as required for the completion of the office facilities in accordance with the Specification.

Where public sewerage disposal systems are not available, all wastewater shall be disposed of underground and as approved by the Engineer. The Contractor shall perform percolation tests at the location of the leach field, and the size of the leach field or pit will be subject to the result of these tests and the approval of the Engineer.

The septic tanks of size approved by the Engineer, shall be of reinforced concrete or glass fibre equipped with proper inlet and outlet baffles and sealed access hatch. The size shall be sufficient to operate at least one year without solids overflowing into the leach field. The leach field or pits shall penetrate through the catch layer, if there is one. The space below the distribution pipes shall be backfilled with a pervious material and compacted prior to installing the distribution pipes.

The design of the leach field or pits shall take into consideration only the area of the sidewalls of the trench or pit below the level of the inlet pipes. The area of the bottom of the trench or pit may not be used for percolation calculations, as it will be continuously saturated. The Contractor shall submit full details for the proposed system for the approval of the Engineer.

Engineer's Offices (Each room)

1 Desktop computer
1 Inkjet printer (A-4 size, black and white)
4 Junior executive desk, 0.75 m x 1.5 m with 2 drawers each side.
4 Junior executive chair.
4 Chairs, moulded plastic.
1 Filing cabinet, steel, 4-drawer.
2 Cupboard, steel, lockable, 1.8 m high x 0.9 m wide x 0.45 m deep.
2 Bookcases, 4 shelves, 1.0 m wide x 1.5 m high.
1 Layout table, 1.0 m x 2.0 m.
1 White board, 1.0 m wide x 0.75 m high.
1 Telephone extension

General Offices (Each room)

1 Desktop computer
1 Inkjet printer (A-4 size, black and white)
4 Junior executive desk, 0.75 m x 1.5 m with 2 drawers each side.
4 Junior executive chair.
4 Chairs, moulded plastic.
1 Filing cabinet, steel, 4-drawer.
2 Cupboard, steel, lockable, 1.8 m high x 0.9 m wide x 0.45 m deep.
2 Bookcases, 4 shelves, 1.0 m wide x 1.5 m high.
1 Layout table, 1.0 m x 2.0 m.
1 White board, 1.0 m wide x 0.75 m high.

2 Telephone line with a fax

Kitchen Area

1 Refrigerator, 8 cubic feet capacity.
1 Cooker, gas, 2 rings.
2 Gas cylinders.
1 Sink, stainless steel, double basin, with cold water supply.
1 Crockery, complete set for 8 people.
1 Cutlery, complete set for 8 people.
1 Tea service, complete set for 8 people.
1 Electric kettle.
1 Draining rack.
1 Dustbin, plastic.

Other Requirements

2 Fire extinguisher.
1 First aid kit, comprehensive.
8 Filing trays.
1 Paper punch.
2 Staplers.
6 Wastepaper baskets.

6. Accommodation for the Engineer

6.1 General

The Contractor shall provide either rented or newly constructed accommodation for the Engineer to the approval of the Engineer. The accommodation shall be equipped with air conditioners, security grilles and mosquito netting, and shall be fully furnished and equipped with new items by the Contractor to the satisfaction of the Engineer, including curtains, linen, blankets, glassware, cutlery, crockery and kitchen utensils.

Each house shall be wired to permit the use of standby generators as well as mains for the supply of electricity. The generators shall be fitted with automatic starting switchgear if so directed by the Engineer. Covered, hard standing areas for positioning generators and string fuel shall be provided.

Each house shall be provided with one telephone line. Telephone installation and rental shall be paid by the Contractor, but not for the calls.

Each house shall be provided with hot and cold water in the kitchen and the bathrooms.

The Contractor shall provide watchmen for security purposes to the approval of the Engineer.

The Contractor shall furnish and service accommodation made available by the Engineer. All accommodation shall be regularly cleaned for so long as it is in use and suitable arrangements be made for the disposal of any waste arising from use of such accommodation.

All equipment supplied by the Contractor shall be of a quality and precision appropriate to its proposed use and shall be delivered in a serviceable condition. The Contractor shall maintain all such equipment in serviceable condition and replace, if necessary, any that becomes unserviceable.

The following Table A1.1 indicates the minimum ground floor requirements of the Accommodation:

Table A1.1:

Description	Number of room required		Area of each (sq. m)
	Type A	Type B	
Living/ Dining Room (air conditioned)	1	1	40
Veranda	1	1	18
Office Room/ Study (air conditioned)	1	1	12
Bedroom (air conditioned)	2	3	16
Attached Toilets/ Bathroom	2	3	5
Kitchen	1	1	12
Pantry	1	1	12
Servants Accommodation	1	1	12
Servants Toilet	1	1	4.5

6.2 Furniture, Equipment and Fittings for the Accommodation of the Engineer's Site Staff

The Contractor shall provide, install and maintain and provide consumables to maintain the furniture, equipment and fittings as shown in Table A1.2, until Contract Completion and to the

satisfaction of the Engineer. All of the items shall be new and subject to the approval of the Engineer.

At Contract Completion, the furniture, equipment and fittings purchased shall be handed over to the Employer.

Table A1.2:

Item	Description	Number of room required	
		Type A	Type B
Roof and Ceiling material	Asbestos shall not be used.		
Roof	Roofs shall be closed underneath.		
All windows	With Iron grids and mosquito nets		
Telephone Connection			
Independent line		1	1
Veranda			
Veranda Table	Wooden 2.0m x 1.0m	1	1
Veranda Chair		4	6
Living/ Dining Room			
Lounge Suite	1No. 3 seater, 3 No. 1 seater, 1 No. coffee table and 2 No. side tables	1	1
Dining Table	Wooden 2.0mx 1.2m	1	1
Dining Room Chairs	Cushioned	4	4
Book case	1.0mx2.0mx0.35mx3 shelves	1	1
Occasional table		1	1
Air Conditioner	24,000 BTU/hour split type	1	1
Office Room			
Writing Desk	1.5mx0.75m	1	1
Chairs		2	2
Book case	1.0mx2.0mx0.35mx3 shelves	1	1
Air Conditioner	10,000 BTU/hour split type	1	1
Bedrooms			
Toilet & bathroom	Hot water heater, shower with curtains	As required	As required
Beds	Single with mattress and two pillows	4	4
	Queen size with mattress		1
Bedside Cabinet		2	3
Dressing Table with mirror and stool		1	1
Chest of Drawers	1.0m high with 6 drawers	2	3
Wardrobe with fittings	2m high, 1.0m wide, 0.35m deep, with Shelves and two doors	2	3
Bedside Lamp		2	3
Mattress covers		4	5
Mosquito Nets	Single	4	4
Waste paper basket		2	3
Air Conditioner	12,000 BTU/hour split type	2	3

Item	Description	Number of room required	
		Type A	Type B
Pantry			
Store shelves		Set	Set
Electrical Iron and ironing board		Set	Set
Pantry Cupboards		Set	Set
Glass Cabinet		1	1
Refrigerator	12 cu. ft capacity	1	1
Cold Water Dispenser (electric)	20 litre capacity including spring water	1	1
Kitchen sink Unit	with hot and cold water taps and waste water outlet	1	1
Kitchen			
Kitchen Cupboards		Set	Set
Kitchen Table		1	1
Chairs		2	2
Sink Unit with draining board	with cold water taps and waste water outlet	1	1
Electrical or Gas Cooker	with 4 - Heater Rings, Grill and Oven complete (with two gas cylinders if gas)	1	1
Electric Kettle	2 - litre capacity	1	1
Cooking utensils/ equipment	Complete set for 6 persons	Set	Set
Crockery	Complete set for 6 persons	Set	Set
Cutlery	Complete set for 6 persons	Set	Set
Tea Service	Complete set for 6 persons	Set	Set
Plate Rack		1	1
Servant Accommodation			
Beds	Single with mattress and pillows	1	1
Wardrobe with fittings	2m high, 1.0m wide, 0.35m deep with shelves and two doors	1	1
Armless Chairs		1	1
Occasional Table		1	1
Bedside Lamp		1	1
Mattress covers		2	2
Pillow Cases		4	4
Mosquito Nets	Single	1	1
General			
Rugs	Complete Set	1	1
Doormats	Complete Set	1	1
Curtains	Complete Set	1	1
Cleaning Equipment	Complete Set	1	1
Toilet Cleaning Equipment	Complete Set	1	1
Kitchen Cleaning Equipment	Complete Set	1	1

6.3 Hotel Accommodation

Where the Contractor fails to provide the required accommodation within the time specified or subsequently agreed by the Engineer, the Contractor shall provide, at no cost to the Employer, suitable hotel accommodation as approved by the Engineer's staff intended to occupy the accommodation until such time as the accommodation is ready for occupation.

The Contractor shall provide hotel accommodation, including meals but excluding alcoholic beverages, to the satisfaction of the Engineer during the Contractor's mobilisation period until the Engineer's accommodation specified in the Contract is approved for occupation by the Engineer. Such accommodation shall include provision for immediate dependants of the Engineer's staff.

Hotel accommodation provided after the time the Engineer's accommodation is due to be ready for occupation will not be reimbursable.

7. Vehicles for the Engineer/the Employer

(a) The Contractor shall provide vehicles as described later for the exclusive use of the Engineer and the Employer for any purpose in connection with the Works.
(b) The vehicles shall be delivered and maintained in good roadworthy condition.
(c) They shall be licensed and insured for use on the public highway and shall have comprehensive insurance cover for any qualified driver authorized by the Engineer and the Employer with any authorized passengers and the carriage of goods or samples.
(d) The Contractor shall provide fuel, oil and maintenance in conformity with the vehicle manufacturer's recommendations and shall keep clean the vehicles inside and out on regular basis.
(e) A suitable replacement shall be provided for any vehicle out of service for more than 8 working hours.

The type of vehicles the Contractor is required to provide in accordance with the Specification and Bill of Quantities is as shown below:

Vehicle Type 'A': New Toyota Prado or similar approved 5-6 doors (including one or two rear doors) Station wagon 4 wheel drive with a diesel engine of at least 2.8 litre capacity, air conditioner, cloth seats, removable seat covers, seat belts, floor mats, tinted windows, locking fuel cap, spare wheel, tool kit, jack, tow rope, jump leads, fire extinguisher and first aid kit.

Vehicle Type 'B': New "Double Cab" Pick-Up, 4-wheel drive, with a diesel engine of at least 2.5 litre capacity, air conditioner, cloth seats, removable seat covers, seat belts, floor mats, locking fuel cap, spare wheel, tool kit, jack, tow rope, jump leads, fire extinguisher and first aid kit.

Vehicle Type 'C': New mini bus (Toyota Hi-Ace or similar approved), capable of carrying at least 11 (eleven) passengers, with air conditioner, cloth seats, removable seat covers, seat belts, locking fuel cap, spare wheel, tool kit, jack, tow rope, jump leads, fire extinguisher and first aid kit.

Vehicle Type 'D': New Toyota Corolla or similar approved car with 4-door, front engine, front wheel drive petrol engine of at least 1.8 litter capacity, 16 Valve VVT i, 4-cylinder, 5-speed manual or 4-speed auto, air conditioner, seat belts, floor mats, locking fuel cap, spare wheel, tool kit, Jack Jump leads, Fire extinguisher, First aid kit, Power steering, Brakes: Power assisted ventilated front disc/rear drum with 4-wheel Anti-lock Brake System (ABS) & Electronic Brake force Distribution (EBD).
Motor cycle: New, any international brand, Engine (4-stroke & 125 cc), with two helmets each

(medium size, original).

On completion of the Contract, all vehicles shall be handed over to the Employer.

7.1 Fitments

All vehicles are to have as original equipment inertia reel seatbelts for all occupants and air conditioning. All vehicles are to be provided with a suitable tool kit, spare wheel, warning triangles, detachable magnetic flashing orange light, 2.5 kg fire extinguisher and first aid kit. In addition pickup trucks will be provided with twin lockable containers in the rear and a fitted rear tarpaulin.

7.2 Drivers and Costs

The Contractor shall provide skilled, fully qualified, properly licensed drivers for all the vehicles. The drivers will be subject to the approval of the Engineer, which may be withdrawn at any time at the sole discretion of the Engineer. Such approval may require the drivers to undergo medical and eyesight test as instructed by the Engineer. Drivers' overtime costs shall be born by the Contractor.

7.3 Operation

The Contractor shall provide all fuel, lubricants, spare parts and other consumables. Clean, service, repair and maintain the vehicles and ensure they are always in a safe, roadworthy and reliable condition.

7.4 Insurance, Tax and Licences

The Contractor shall tax and licence the vehicles to operate on public roads. Insure the vehicles fully comprehensively and as requested by the Engineer, provide certificates of insurance and proof of payment of insurance premiums.

7.5 Usage of Vehicles for the Engineer

The allocation and use of the vehicles provided for the Engineer shall be entirely at the discretion of the Engineer and in principle, as follows:

Vehicle type	Main users	Uses included
Type A: Station wagon	Team Leader, RE, Dy. RE	Commuting
Type B: Pick-up	Engineers, Inspectors, Technicians	Limited use of commuting
Type C: Mini bus	Engineers, Inspectors, Technicians + Admin. staff	Commuting
Motor cycle	Inspectors, Technicians (own driving)	Not for commuting

- Vehicles for expatriate engineers will be used also for private purposes. The drivers' costs including overtime shall be born by the Contractor.
- Type C: Mini bus for the Engineer will be also used as Admin. staff commuters on going to/back from the office.
- Names of the Engineer's users will be notified to the Contractor at the sole discretion of the Engineer.
- Private drivers other than the Contractor's are not allowed, except for motor cycles.

7.6 Replacement Vehicles

In the event that any vehicles are not available for use by reason of being under repair, broken down, being serviced, or for any other reason, the Contractor shall immediately supply an equivalent replacement vehicle until such time as the original vehicle is back in use. The cost of this provision is deemed to be included in the rates for the supply of vehicles.

APPENDIX 2

SURVEY AND LABORATORY EQUIPMENT

1. Survey equipment

The Contractor shall provide and maintain survey instruments for the sole use of the Engineer for the duration of the Contract. The instruments to be supplied are as detailed below, and on completion of the Contract they shall be handed over to the Employer.

Description of Equipment	No.
Total Station with built in facility for entry of field data into diskette, Sokkia Set 3C11 or similar approved	1
Rechargeable batteries for above	2
Charger for above	1
Single or Double prism - Tilt type with carrying case	2
Targets with carrying case	2
Interchangeable tribachs with optical plummet telescope	2
Tripods telescopic type	3
Pole Adopter for Targets and Prisms	2
Telescopic ranging rods	6
Theodolite 20” with Tripod and Accessories	1
Automatic level with accessories	1
Levelling staff – 4 m aluminium pole	2
Levelling staff – 5 m aluminium pole	2
Circular bubble (Clip-on type for pole)	2
Circular bubble (Angular type for staff)	2
100 m x 10 mm steel rustless measuring band divided throughout and numbered at 1 m intervals	1
50 m steel tapes (white faced same as above)	2
50 m fibre glass box tape	2
30 m fibre glass box tape	2
5 m steel pocket tape	4
Brass plum bobs	2
Hammer 7 kg	1
Hammer 2 kg	1
Surveyor’s Umbrella	2
3 m aluminium straight edges with handles and and 2 measuring wedges	2 set
Rolling straight edge	1 set
Axes, shovels, etc.	2 set
Pegs and stakes	As required

2. Laboratory

2.1 Contractor's Testing Laboratory

All costs in relation to sampling and testing required in connection with the Works shall be at the Contractor's own expense and all the costs are deemed to be included in the Contractor's unit rates. (If the Contractor considers the specified space or number of equipment are insufficient, he can propose in the Tender.)

The testing laboratory to be provided shall be used exclusively for design and control testing of materials to be incorporated in the Works. It shall be located adjacent to the Engineer's office block, or at another suitable location approved by the Engineer, and shall have a minimum internal floor area of 200 sq.m. The minimum ceiling height shall be 2.9m.

The laboratory shall be fully equipped to carry out all of the tests indicated in this Appendix. The Contractor shall provide sufficient quantities of testing equipment to meet the specified testing requirements, commensurate with his planned rates of production, including an adequate stock of breakable and consumable items as well as printed forms for recording all samples and tests carried out. The layout of the laboratory and the working areas, together with the furnishing schedule shall be proposed by the Contractor and approved by the Engineer.

The Contractor shall submit the proposed layout and a full list of the equipment and furniture he intends to order with his programme, for the comments and approval of the Engineer.

Such approval by the Engineer shall not relieve the Contractor of his responsibility to ensure that the laboratory is adequately equipped and the Contractor shall have no claim for delays resulting from the inadequacy of the testing facilities.

The laboratory shall contain a separate storeroom of not less than 24 sq.m. Access to the storeroom shall be provided from the outside as well as from the laboratory working area. Double entrance doors with a minimum clear opening of 2m. shall be provided in order to unload materials from site vehicles directly into the laboratory. The working areas of the laboratory shall have a section of floor constructed of reinforced concrete 2.5 m x 2.5 m x 400 mm thick to accommodate vibrating equipment. The remaining floor shall be of concrete with a smooth float finish. Concrete plinths for the mounting of equipment shall be provided as required. Two sinks with in trapped outlets shall be installed.

A minimum of 10 metres of workbenches 900mm high by 750mm wide shall be provided and arranged in an acceptable manner. The work benches shall have tops covered with approved plastic laminate or tin sheet, shall contain adjustable shelves and drawers and shall be constructed of 19 mm plywood. A minimum of 6 metres of cupboards shall be constructed approximately 600 mm above the workbenches. These cupboards shall have a minimum of two 450 mm high shelves approximately 300 mm deep. All cupboards shall be provided with doors.

The laboratory shall have a minimum of two exhaust fans, and window openings shall be provided with blinds. Air conditioning to maintain the temperature to no more than 21 degrees centigrade

throughout the year in the laboratory shall also be provided.

The building shall be supplied with potable running water, electricity, gas and kerosene and shall be adequately provided with fluorescent lighting. Adequate socket outlets shall be provided.

The Contractor shall be responsible for the staffing and operating of the laboratory. He shall provide a suitably qualified and experienced laboratory supervisor and sufficient technicians and assistants to meet the testing requirements. Details of the contractor's proposed staffing shall be submitted to the Engineer for approval and he shall be entitled to ask the Contractor to remove or replace any member of the laboratory staff who demonstrates incompetence, whether previously approved or not.

Notwithstanding the previous paragraph, all testing shall be carried out under the general direction of the Contractor and the Engineer will supervise the Contractor's testing. When the Contractor wants to confirm potential materials sources and mix design for their adoption of the Works, he shall be permitted to carry out the tests without the supervision of the Engineer.

The Contractor shall supply all samples of materials for testing. The Contractor shall also provide experienced technicians and labour, if needed, to work directly under the control of the Engineer, as required by the Engineer to carry out independent checks on laboratory procedures and test results.

All samples and records shall be preserved as long as the Engineer may direct and they shall be kept and labelled in orderly fashion to his satisfaction.

The facilities and equipment of the laboratory and all samples and records shall be available to the Engineer's Representative at all times.

The Contractor shall perform tests on materials as directed in various Clauses hereof and shall supply the Engineer with two copies of the results of each test, such results being entered on a printed form approved by the Engineer. A third copy of the results of each test shall be retained in the laboratory.

Ownership of the laboratory building, fittings and furniture shall be the Contractor's, who shall also bear all relevant costs in connection with sampling, testing, recording and disposing of the samples for the Works.

2.2 Laboratory Furniture

Item	No.
Water tank for concrete curing (indoor)	1
Desk with lockable drawers (1830mm x 915mm)	1
Tables (1830mm x 915mm)	3
Chairs	5
Filing Cabinet (3 drawers) lockable	1
Laboratory stools	3
Wall board	1
Laboratory benches with shelving under	1
Coat hooks	as required

Electric kettle	1
Refrigerator (small)	1
Glasses, cups, saucers, spoons, etc.	6 of each
Tray	1
Waste paper baskets	3
Consumables and stationery	as required

2.3 Laboratory Equipment.

(a) The Contractor shall provide new or "as new" testing equipment of approved manufacture to carry out testing as detailed in Section 1300, Tests for Quality Control of Materials and Works or any other tests as specified in these Technical Specifications for the project.

(b) The Contractor shall submit the name of the manufacturers and the list of laboratory equipment which he intends to provide for the approval of the Engineer, before he places any order.

(c) The Contractor shall provide all equipment, chemicals etc., necessary for the performance in the Laboratory.

APPENDIX 3

PROJECT SIGN BOARD

Provide and erect at the beginning and end of each section of road a project signboard 4 metres wide by 2.2 metres high with the wording in Sinhala, Tamil and English. Final details to be agreed with the Engineer.

The board to be galvanised steel, aluminium sheet or 25 mm thick marine plywood. Lettering and border to be in black on yellow background. Boards to be fixed with the bottom of the board at a minimum of 2.3 metres above adjacent ground level on suitable posts with struts in concrete foundations.

The Contractor will be responsible for the repair and maintenance of the signboards up to the completion of the construction work.

MINISTRY OF HIGHWAYS
ROAD DEVELOPMENT AUTHORITY

Colombo Outer Circular Highway Project
Southern Section: Kottawa – Kaduwela

COMPLETION	(DATE)
CONTRACTOR	(NAME) (ADDRESS)
CONSULTANTS	(NAME) (ADDRESS)

APPENDIX 4

ENVIRONMENTAL MANAGEMENT ACTION PLAN

1. Environmental Management Action Plan

The Contractor shall submit Environmental Management Action Plan (EMAP) to the Engineer within two (2) months from the commencement date for approval of the Engineer and Central Environmental Agency (CEA) in Sri Lanka. It shall be based on the attached:

- JBIC Guidelines for Confirmation of Environmental and Social Considerations, April 2002.
- CEA's approval letter dated February 2001.
- CEA's extension letter dated 19 May 2004
- CEA's approval for Supplemental EIA, dated 31 May 2005.
- CEA's approval letter dated 15 November 2007.

Reference EIA reports are:

- "Environmental & Social Impact Assessment", Volume I (Main Text) and Volume II (Figures, Tables, Maps), February 2000, JICA
- "Supplementary Environmental Impact Assessment Report on the Outer Circular Highway to the City of Colombo", September 2004, JICA

2. Monitoring

During the construction period, the Contractor shall conduct environmental monitoring based on the Environmental Management Action Plan which is a part of the EMP.

3. Reporting

The Contractor shall include monthly monitoring results in the Monthly Report and describe mitigation measures taken by them.

Environmental Management Plan

for

Northern Section-1 of OCH

2007

Road Development Authority (RDA)

Table of Contents

1. General

Subsequent to the findings of the 2000 EIA and the SEIA for Biyagama deviation, further studies have been conducted on the specific environmental impacts of the project and the required mitigation measures for the Northern Section 1: Kaduwela to A1 Interchange. The Environment Management Plan (EMP) including the Environmental Monitoring Plan for the Northern Section 1 of the OCH Project has been formulated based on these additional considerations and EIA findings. The EMP for the Northern Section 1 of the OCH presents the implementation details of the environmental protection measures recommended for the pre-construction, construction and operational phases of the Project.

RDA and the contractor should execute the environmental management plan with proper planning, coordination and management of all recommended environmental protection measures and monitoring activities.

It is recommended that the EMP is included in the tender documents with the condition that bidders for construction of the Northern Section 1 will submit an Environmental Management Action Plan (EMAP) based on this EMP, when tendering for the construction contract.

2. Environmental Management Plan

2.1 Pre-Construction Stage

In the pre-construction stage the Project related environmental issues are mainly the social impacts caused by land acquisition activities which need to be addressed from the early stages.

In addition, it is necessary to establish a base line for monitoring changes in ambient air quality, water quality and noise and vibration levels as a result of the OCH. Although the 2000 EIA has established the air and water quality and noise levels before the project, these need to be updated since the EIA was conducted in early 2000.

Further, the potential hydrological impacts will have to be mitigated by including the recommendations of the Hydrological Study to be conducted during the detailed design.

(1) Social Impacts

The objectives of the EMP with regard to social aspects are:

- To ensure that adverse impacts on community is avoided, mitigated or compensated
- To ensure better living conditions for project affected persons (PAPs)
- To ensure smooth and timely land acquisition and resettlement of PAPs

The mitigation measures recommended are:

- Prepare an inventory of PAPs and extent of damage to properties after the final ROW is identified
- Formulate a comprehensive Resettlement Action Plan (RAP), based on the national policy on involuntary resettlement and conduct validation of the RAP
- Conduct public consultations on the compensation package and relocation process

- Implementation of RAP to the satisfaction of the affected families

(2) Hydrological Impacts

The objective of the EMP in managing hydrological impact is:

- To ensure that hydrological and drainage impacts on flood levels, ground water table and surface run off are avoided.

The mitigation measures recommended are:

- Incorporating into the design the mitigation measures such as adequate cross drainage structures, recommended in the detailed Hydrological Study conducted as part of the detailed design.
- Implement the recommendations of the Sri Lanka Land Reclamation and Development Corporation (SLLRDC) with regard to detention areas and other hydrological issues.

2.2 Construction Stage

(1) Negligence of Contractor and Workers on the Environmental Requirements

The objective of the EMP with regard to conduct orientation for contractor and workers is:

- To ensure that the contractor and the workers understand the environmental requirements and implementation of mitigation measures.

The mitigation measure proposed in this regard is:

- Conducting special briefing and/or on-site training for the contractors and workers on the environmental requirement of the project

(2) Impact on Water Quality

The objective of the EMP with regard to water quality management is:

- To ensure adverse impacts on water quality caused by construction activities are minimized

The mitigation measures proposed in this regard are:

- Proper construction management including, training of operators and other workers to avoid pollution of water bodies by the operation of construction machinery and equipment
- Storage of lubricants, fuels and other hydrocarbons in self contained enclosures
- Proper disposal of solid waste from construction activities and labour camps
- Cover the construction material and spoil stockpiles with a suitable material to reduce material loss and sedimentation.
- Avoid stockpiling of material close to water bodies
- Stripped material shall not be stored where natural drainage will be disrupted.
- Servicing of vehicles and equipment at properly managed and equipped workshops, where waste oil is collected and disposed of at approved locations
- Sanitation arrangements at work sites and temporally accommodation facilities, such that no raw sewage could be released into drains or water bodies

(3) Impact on Air Quality/Dust

The objective of the EMP in relation to air quality management is:

- To minimize the air borne particulate matter released to the atmosphere

The mitigation measures recommended to achieve this objective are:

- All heavy equipment and machinery shall be fitted in full compliance with the national and local regulations.
- Stockpiled soil and sand shall be slightly wetted before loading, particularly in windy conditions
- Fuel efficient and well maintained haulage trucks shall be employed to minimize exhaust emissions
- Vehicles transporting soil, sand and other construction material shall be covered
- Exposed areas shall be dampened
- Procurement of high efficient plant, maintenance of them in good conditions, and operated by trained and qualified personnel.
- Selection of sites for materials extraction shall be away from residential areas in order to reduce the impacts from dust

(4) Noise/ Vibration

The objective of the EMP in relation to noise and ground vibration management is:

- To minimize noise level increases during construction operations.
- To minimize/avoid the ground vibration due to construction operations

The mitigation measures recommended in this regard are:

- All heavy equipment and machinery shall be fitted in full compliance with the national and local regulations.
- As a rule, the operation of heavy equipment shall be conducted in daylight hours.
- Hammer-type pile driving operations shall be avoided during night and close to residential areas.
- Construction equipment, which generates excessive noise shall be enclosed
- Well maintained haulage trucks will be used with speed controls
- Where blasting is required controlled blasting shall be employed under the supervision of Geological Surveys and Mines Bureau (GSMB) / Central Environmental Authority (CEA)
- Taking reasonable measures to minimize noise/vibration near noise sensitive areas such as schools and places of worship

(5) Sedimentation of Streams and Water Bodies

The objectives of the EMP in relation to sedimentation of streams and water bodies are:

- To minimize soil erosion
- Minimize carry over of eroded soil particles by surface run-off

The mitigation measures recommended include:

- Back-fill should be compacted properly in accordance with design standards.
- In the short-term, either temporary or permanent drainage works shall protect all areas susceptible to erosion.

- Measures shall be taken to prevent ponding of surface water and scouring of slopes.
- Newly eroded channels shall be backfilled and restored to natural contours.
- Use of silt traps where earthworks are carried out adjacent to water bodies, proper disposal of waste and excavated material, and re-use of suitable material where possible

(6) Handling and Storage of Construction Materials

The objective of the EMP in relation to handling and storage of construction material management is:

- To minimize contamination of the immediate surroundings

The mitigation measures recommended includes:

- Hazardous materials shall be stored on impervious ground under cover. The area shall be constructed as a spill tray to avoid spread of accidental spills.
- Safe ventilation for storage of volatile chemicals shall be provided.
- Access to areas containing hazardous substances shall be restricted and controlled.
- Blasting material used in construction activities shall be kept under lock and key and issues shall be closely monitored

(7) Spoil and Construction Waste Disposal

The objectives of the EMP in relation to spoil and construction waste disposal management are:

- To proceed the construction progress smoothly in the beginning of the Project.
- To minimize the generation of spoil and construction waste
- To optimize the reuse of spoil and construction waste
- To ensure safe and proper disposal of spoil and construction waste

The mitigation measures include:

- Estimating the amounts and types of spoil and construction waste to be generated by the project.
- Investigating whether the waste can be reused in the project or by other interested parties.
- Identify potential safe disposal sites close to the project and investigate the environmental conditions of the disposal sites and select the most suitable and safest sites.
- As soft ground treatment is envisaged it should be ensured that adequate disposal sites are identified and approval for agreed sites are obtained in advance
- If material to be disposed from soft ground treatment includes peat adverse impacts of the materials such as acidity shall be managed to avoid contamination of the environment of the disposal site.
- Unsuitable excavated materials should be systematically carried away from the areas prone to erosion.
- Incorporate reuse of waste materials and use of designated disposal sites
- Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national and local regulations.
- Oil wasted shall not be burned.

(8) Work Camp Operation and Location

The objective of the EMP in relation to office and work camp operation and location is

- To ensure that the operation of office and work camps does not adversely affect the surrounding environment and residents in the area

The mitigation measures recommended in this regard are:

- Identify location of work camps in consultation with Grama Niladaris (GNs). The location shall be subjected to approval by the RDA.
- Wherever possible, camps shall not be located near settlements or near drinking water supply intakes.
- Cutting of trees and removal of vegetation shall be minimized.
- Water and sanitary facilities shall be provided for employees.
- Solid waste and sewage shall be managed according to the national and local regulations. As a rule solid waste must not be dumped, buried or burned at or near the project site, but shall be disposed of to the nearest sanitary landfill or site having and complying with the necessary permits.
- The Contractor shall organize and maintain a waste separation, collection and transport system.
- The Contractor shall document that all liquid and solid hazardous and non-hazardous waste are separated, collected and disposed of according to the given requirement and regulations.
- Water logging and ponding in the office and work camp sites shall be avoided.
- At conclusion of the project, all debris and waste shall be removed. All temporary structures, including office buildings, shelters and toilets, shall be removed.
- Exposed areas shall be planted with suitable vegetation.
- The RDA supervising engineer shall inspect and report that the camp has been vacated and restored to pre-project conditions.

(9) Loss of Vegetative Cover of the Areas for Temporally Yard

The main objectives of the EMP in relation to loss of vegetative cover are:

- To minimize the loss of vegetation cover due to land clearing and construction related operations and undertakings
- To restore the loss of vegetation cover due to construction related operations and undertakings
- To avoid loss of top soil which may be used in reestablishing vegetative cover

The mitigation measures recommended in this regard are:

- Minimize cutting trees and other important vegetation during construction
- Stockpile and cover the top soil for future use
- Landscaping the road verges
- Planting of trees/shrubs/ornamental plants to contribute to the aesthetic value of the area and to compensate for the lost capability of the area to absorb carbon dioxide.
- At conclusion of the project, all debris and waste shall be removed. All temporary structures, including office buildings, shelters and toilets, shall be removed.

(10) Safety Precautions for the Workers

The objective of the EMP in relation to safety precautions of the workers is:

- To ensure safety of workers

The mitigation measures recommended include:
- Providing adequate warning signs
- Providing workers with skull guard or hard hat or other protective devices
- The Contractor shall instruct his workers in health and safety matters, and require the workers to use the provided safety equipment.
- Establish all relevant safety measures as required by law and good engineering practices
- Arranging for regular safety checks of vehicles and material, and allocation of responsibility for checking
- Ensuring that material extraction operations, especially blasting, are supervised and carried out by trained and experienced workers

(11) Traffic Condition

The objectives are:
- To minimize disturbances to vehicular traffic and pedestrians during haulage of construction materials, spoil and equipment & machinery
- To mitigate damage to the road network used during haulage of construction materials, spoil and equipment & machinery

The mitigation measures recommended are:
- Formulation and implementation of a construction related traffic management plan
- Installation of traffic warning signs, and enforcing traffic regulations during transportation of materials, equipment & machinery
- Conducting awareness programmes on safety and proper traffic behavior in densely populated areas near the construction sites
- Assign traffic control personnel

(12) Impact on Wetlands

The objective of the EMP in relation to wetlands is:
- To ensure that damage to wetlands and its ecosystem is minimized during construction

The mitigation measures recommended are:
- Avoid disposal of wash water, solid waste as discarded packing etc., on wetlands
- Avoid temporary structures or stockpiling on wetlands

(13) Social Impacts

The objectives of the EMP in relation to social impact management are:
- To ensure minimum impacts from construction labor force
- To ensure minimum impact on public health
- To ensure damage to property from construction activities and haulage of construction materials, spoil and equipment and machinery, is mitigated
- To adverse impacts of blasting and quarrying operations on the community are minimal

The mitigation measures proposed include:

- Conflicts with local community shall be avoided
- Potential for spread of vector borne and communicable diseases from labour camps shall be avoided
- Competition with locals for resources will be avoided
- A condition survey of properties along the haulage roads and located close to the construction works should be undertaken prior to construction and all damages to such properties will be repaired/compensated
- Quarrying operations should be subject to GSMB approval
- Other blasting activities should be carried out with CEA approval

(14) Hydrological Impacts

The objective of the EMP is to avoid hydrological impacts of temporary structures such as pilot road

The mitigation measures proposed are:
Provide adequate cross drainage structures when the pilot road is constructed to ensure that hydrological problems are avoided

(15) Impacts on Flora and Fauna

The mitigation measures proposed include:

- All hot mix plant, crushing plant, workshops, depots and temporary workers accommodation facilities shall be sited in approved locations
- Toxic and hazardous materials required for construction, including asphalt will be properly stored and secured and sited in approved locations
- Vehicles and equipment shall be maintained in good operable condition, ensuring no leakage of oil or fuel and the fitting of proper exhausted baffles

(16) Damage to Land, Visual Impact and Collection of Stagnant Water from Borrow Pit

The mitigation measures proposed include:

- Choice of borrow sites avoid cultivatable land, obtaining agreements with land owners and appropriate permits, siting borrowing pits away from residential areas, site restoration by landscaping

(17) Compaction of soil by construction plant and equipment

The mitigation measures proposed include:

- Limiting movement and stationing of plant and vehicles to the Right of Way, and specific sites where appropriate leases have been negotiated, and/or clearances obtained.

(18) Disruption to traffic damage to motor roads, increase dust and noise nuisance from haulage of materials

The mitigation measures proposed include:

- Choice of quarried and borrow sites that are served by roads of adequate capacity for heavy trucks.

- Repair damages to roads caused by haulage of construction materials, spoil and equipment and machinery
- If local road are used for transportation, approval shall be taken from local authorities.

(19) Severance of utilities during construction, where relocation is necessary and as a result of accidental damage

The mitigation measures proposed include:
- Inform the public on timing and duration of any disruption to electricity, water, telephone or other services
- Reduction of risk of accidental damage by ensuring that vehicles and equipment are operated by trained and licensed personnel, and that operations are adequately supervised

2.3 Operation Stage

In order to achieve sustainability of the development works, it is necessary to ensure the effectiveness of mitigation measures even after construction to avoid adverse environmental impacts that may result from the operation of the Project facilities.

(1) Air Quality

The objective of the EMP in relation to air quality management is
- To minimize air pollution from road usage.

The mitigation measures proposed are:
- Strict enforcement of the Vehicular Exhaust Emission Standards subsequent to an awareness program
- Implementing the Vehicle Emissions Testing (VET) Program
- Provision of a vegetative barrier to arrest the spread of air borne particles to residential areas

The first two mitigation measures should be considered in the national context.

(2) Noise / Vibration

The objective of the EMP in relation to noise /ground vibration emission management is:
- To minimize and/ or avoid the noise level enhancement resulting from road traffic.
- To avoid and/or minimize the ground vibration resulting from the vehicles.

The mitigation measures recommended for this purpose are:
- Expedite the establishment of standards and regulations for noise level / vibration emanating from vehicles/mobile sources
- Strict enforcement of the regulations, subsequent to an awareness programme
- In sensitive areas such as schools, places of worship, hospitals and libraries, sound barriers including tree linings shall be employed.

The first two mitigation measures should be considered in the national context.

The complete Environmental Management Plan for the Northern Section 1 of OCH is summarized as Table 1.

Table 1, Summary of EMP: Northern Section-1

Project Activity and Potential Environmental Impacts	Mitigation Measures	Approximate Location	Cost Estimate	Institutional Responsibility	
				Implementation	Supervision
<Pre-Construction Stage>					
Social Impacts	● Prepare the inventory of losses of PAPs and extent of damage to properties after the final ROW is identified ● Check whether impacts on PAP can be avoided/minimized through changes in the design or construction method. ● Formulate a comprehensive Resettlement Implementation Plan (RIP), based on the national policy on resettlement and conduct validation of the RIP ● Conduct public consultations in groups or individually on the special compensation package and relocation process ● Implementation of RIP plan to the satisfaction of the affected families	Throughout the project road		RDA(PMU)	RDA& Ministry of Land
Hydrological Impacts	● Incorporating into the design the mitigation measures recommended in detailed Hydrological Study conducted as part of the detailed design			Design Consultant	RDA(PMU)
<Construction Stage>					
Negligence of Contractor and Workers on the Environmental Requirements	● Conducting special briefing and/or on-site training for the contractors and workers on the environmental requirement of the project	Throughout the project site	Engineering cost	Contractor	RDA（PMU）
Impacts on Water Quality	● Proper construction management including as training of operators and other workers to avoid pollution of water bodies by the operation of construction machinery and equipment ● Storage of lubricants, fuels and other hydrocarbons in self contained enclosures ● Proper disposal of solid waste from construction activities and labour camps ● Cover the construction material and spoil stockpiles with a suitable material to reducing material loss and sedimentation. ● Avoiding stockpiling of materials close to water bodies ● Stripped material shall not be stored where natural drainage will be disrupted. ● Servicing of vehicles and equipment at properly managed and equipped workshops, where waste oil is collected and disposed of at approved locations ● Sanitation arrangements at work sites and temporally accommodation facilities, such that no raw sewage could be released into drains or water bodies	Throughout the project site (workcamps, storehouses etc.)	Engineering cost	Contractor	RDA（PMU）
Impacts on Air Quality/Dust	● All heavy equipment and machinery shall be fitted in full compliance with the national and local regulations. ● Stockpiled soil and sand shall be slightly wetted before loading, particularly in windy conditions ● Fuel efficient and well maintained haulage trucks shall be employed to minimize exhaust emissions ● Vehicles transporting soil, sand and other construction material shall be covered ● Spraying of bare areas with water ● Procurement of high efficient plant, maintenance of them in good conditions, and operated by trained and qualified personnel ● Selection of sites for materials extraction shall be away from residential areas in order to reduce the impacts from dust	Throughout the project site	Engineering cost	Contractor	RDA（PMU）
Noise / Vibration	● All heavy equipment and machinery shall be fitted in full compliance with the national and local regulations. ● As a rule, the operation of heavy equipment shall be conducted in daylight hours. ● Hammer-type pile driving operations shall be avoided during nighttime and build up areas ● Construction equipment, which generates excessive noise shall be enclosed	Throughout the project site and along the haulage road	Engineering cost	Contractor	RDA（PMU）

Table 1, Summary of EMP: Northern Section-1

	● Well maintained haulage trucks will be used with speed controls ● Controlled blasting should be employed under approval and supervision of GSMB/CEA ● Taking reasonable measures to minimize noise/vibration near noise sensitive areas such as schools and places of worship				
Sedimentation of Streams and Water Bodies	● Back-fill should be compacted properly in accordance with design standards. ● In the short-term, either temporary or permanent drainage works shall protect all areas susceptible to erosion. ● Measures shall be taken to prevent ponding of surface water and scouring of slopes. Newly eroded channels shall be backfilled and restored to natural contours. ● Use of silt traps where earthworks are carried out adjacent to water bodies, shall be properly disposal of waste and excavated material, and re-use of suitable material where possible	Throughout the project site	Engineering cost	Contractor	RDA（PMU）
Handling and Storage of Construction Materials	● Hydrocarbons and hazardous materials shall be stored on impervious ground under cover. The area shall be constructed as a spill tray to avoid spread of accidental spills. ● Safe ventilation for storage of volatile chemicals shall be provided. ● Access to areas containing hazardous substances shall be restricted and controlled. ● Blasting material used shall be stored safely and issues monitored closely	Storage areas	Engineering cost	Contractor	RDA（PMU）
Spoil and Construction Waste Disposal	● Estimating the amounts and types of spoil and construction waste to be generated by the project. ● Investigating whether the waste can be reused in the project or by other interested parties. ● Identify potential safe disposal sites close to the project and investigate the environmental conditions of the disposal sites and prepare recommendation of most suitable and safest sites. ● Provide adequate disposal sites and obtain approval ● Designated disposal sites to be used. ● Incorporate reuse of waste materials and use of designated disposal sites in the detailed design. ● Unsuitable excavated materials should be systematically carried away from the areas prone to erosion. ● Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national and local regulations. ● Oil wasted shall not be burned.	Throughout the project site and workers camps	Engineering cost	Contractor	RDA（PMU）
Work camp operation and Location	● Identify location of work camp and office sites in consultation with Grama Niladaris (GNs). The location shall be subject to approval by the RDA. If possible, camps shall not be located near settlements or near drinking water supply intakes. ● Cutting of trees shall be avoided and removal of vegetation shall be minimized. ● Water and sanitary facilities shall be provided for employees. ● Solid waste and sewage shall be managed according to the national and local regulations. As a rule solid waste must not be dumped, buried or burned at or near the project site, but shall be disposed of to the nearest sanitary landfill or site having and complying with the necessary permits. ● The Contractor shall organize and maintain a waste separation, collection and transport system. ● The Contractor shall document that all liquid and solid hazardous and non-hazardous waste are separated, collected and disposed of according to the given requirement and regulations. ● Water logging and ponding shall be avoided ● At conclusion of the project, all debris and waste shall be removed. All temporary structures, including office buildings, shelters and toilets, shall be removed.	Workers camps	Engineering cost	Contractor	RDA（PMU）

Table 1, Summary of EMP: Northern Section-1

	● Exposed areas shall be planted with suitable vegetation. ● The RDA supervising engineer shall inspect and report that the camp has been vacated and restored to pre-project conditions.				
Loss of Vegetation Cover of the Areas for Temporary Yard	● Minimize cutting trees and other important vegetation during construction. ● Stockpile and the top soil for future use ● Landscaping the road verges ● Planting of trees/shrubs/ornamental plants to contribute to the aesthetic value of the area and to compensate for the lost capability of the area to absorb carbon dioxide.	Temporary Yards	Engineering cost	Contractor	RDA（PMU/ESD）
Safety and Precaution for the Workers	● Providing adequate warning signs ● Providing workers with skull guard or hard hat and other safety devices. ● The Contractor shall instruct his workers in health and safety matters, and require the workers to use the provided safety equipment. ● Establish all relevant safety measures as required by law and good engineering practices ● Training and briefing of works on safety precautions, their responsibility for their safety and the safety of others, ensuring that vehicles and equipment operators are properly licensed and trained, arranging for provision of first aid facilities, rapid availability of trained paramedical personnel, and emergency transport to nearest hospital with accident and emergency facilities ● Allocation of responsibilities to ensure that these arrangements are kept in place ● Arranging for regular safety checks of vehicles and material, and allocation of responsibility for checking ● Ensuring that material extraction operations, especially blasting, are supervised and carried out by trained and experienced workers	Throughout the project site	Engineering cost	Contractor	RDA（PMU/ESD）
Traffic Condition	● Formulation and implementation of a construction related traffic management plan ● Installation of traffic warning signs, and enforcing traffic regulations during transportation of materials and equipment & machinery ● Conducting awareness programmes on safety and proper traffic behavior in densely populated areas near the construction sites ● Assign traffic control personnel	Throughout the project site and roads connecting the sites	Engineering cost	Contractor	RDA（PMU/ESD）
Impacts on Wetland	● Avoid disposal of wash water, solid waste as discarded packings etc., on wetlands ● Avoid temporary structures or stockpiling on or close to wetlands	Wet land areas	Engineering cost	Contractor	RDA（PMU/ESD）
Social Impacts	● Conflicts with local community should be avoided ● Potential for spread of vector borne and communicable diseases from labour camps shall be avoided ● Competition with locals for resources will be avoided ● Quarrying/blasting operations to be under GSMB/CEA supervision	Neighborhood of local communities	Engineering cost	Contractor	RDA（PMU/ESD）
Hydrological Impacts	● Provide adequate cross drainage structures	Along the project road	Engineering cost	Contractor	RDA（PMU/ESD）
Impacts on Flora and Fauna	● All hot mix plant, crushing plant, workshops, depots and temporary workers accommodation facilities shall be site in approved locations ● Toxic and hazardous materials required for construction, including asphalt will be properly stored and secured and sited in approved locations ● Vehicles and equipment shall be maintained in good operable condition, ensuring no leakage of oil or fuel and the fitting of proper exhausted baffles	Throughout the project site	Engineering cost	Contractor	RDA（PMU/ESD）
Damage to Land, Visual Impact and Collection of Stagnant Water from Borrow Pit	● Choice of borrow sites avoid cultivatable land, obtaining agreements with land owners and appropriate permits, siting borrowing pits away from residential areas, site restoration by landscaping	Borrow pit site	Engineering cost	Contractor	RDA（PMU/ESD）
Compaction of soil by construction	● Limiting movement and stationing of plant and vehicles to the Right of Way, and	Along the project	Engineering	Contractor	RDA（PMU/ESD）

Table 1, Summary of EMP: Northern Section-1

plant and equipment	specific sites where appropriate leases have been negotiated, and/or clearances obtained	road	cost		
Disruption to traffic damage to motor roads, increase dust and noise nuisance from haulage of materials	● Choice of quarried and borrow sites that are served by roads of adequate capacity for heavy trucks. Where minor roads are used, provision for repair and restoration ● Repair damages to roads caused by haulage of construction materials, spoil and equipment and machinery ● If local road are used for transportation, approval shall be taken from local authorities	Borrow and quarry site	Engineering cost	Contractor	RDA（PMU/ESD）
Severance of utilities during construction, where relocation is necessary and as a result of accidental damage	● Inform the public on timing and duration of any disruption to water, poser, telecommunications or other services ● Reduction of risk of accidental damage by ensuring that vehicles and equipment are operated by trained and licensed personnel, and that operations are adequately supervised	Throughout the project site	Engineering cost	Contractor	RDA（PMU/ESD）
< Operation Stage>					
Air quality/Dust	● Strict enforcement of the regulations subsequent to an awareness programme ● Provision of a vegetative barrier to arrest the spread of air borne particles to residential areas	Throughout project road section	To be detemined	RDA	CEA
Noise / Vibration	● Strict enforcement of the regulations subsequent to an awareness programme ● In sensitive areas such as schools, places of worship, hospitals and libraries, sound barriers including tree linings will have to be employed.	Throughout project road section	To be detemined	RDA	CEA

3. Environmental Monitoring Action Plan

The mitigation measures proposed in the environmental management plan will be carried out by the responsible agencies. Among the environmental parameters considered in the environmental management plan, the items mentioned below were prioritized for inclusion in the monitoring plan:

- Groundwater levels
- Water quality (surface water and ground water)
- Air quality
- Noise levels
- Social impacts

The sampling locations proposed for monitoring included in this EMP have been determined through consultation with CEA. Environmental monitoring results will be submitted to ESD/CEA periodically by the monitoring agencies/contractor.

As mentioned later, the baseline data of existing water quality, air quality and noise levels will be established before commencement of the construction. The monitoring locations shall be agreed by the four parties, that is, CEA, the Employer, the Contractor and the Engineer. All the four parties shall try to minimize the negative impact on the environment..

3.1. Ground Water Level

(1) Objective

- To assess the negative impact on ground water level caused by construction activities especially in the adjacent areas where cutting are planned. Cutting might induce decreasing ground water levels.

(2) Parameter

- Ground water level

(3) Monitoring Locations

No.	Locations
3	Well at Ms Premawathie/s house; 645/2, Ihalabiyanwila, Kadawatha
4	Well at Mr W Wimalasena`s house; 391/14, Galwala Handiya, Makola South, Makola

Sampling locations is referred to in **Fig.1**

(4) Frequency

- Two times during dry and wet seasons before construction (Pre-construction)
- Every 03 months and on complaints during construction
- Two times with an interval of six months during operation stage for 03 years

(5) Responsible agency

Independent laboratory under contract to RDA

3.2. Water Quality (Surface and Ground Water)

(1) Objective

- To avoid contamination of water by construction and related activities as accidental oil spills, disposal of solid waste, spoil, construction material and domestic wastewater

(2) Parameters

- pH
- Electrical Conductivity (EC)
- Dissolved Oxygen (DO)
- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Suspended Solids (SS)
- Nitrate
- Phosphate
- Chloride
- Oil/Grease
- Zinc
- Lead
- Total coliform
- E. coliform

(3) Monitoring Locations

<Surface Water>

No.	Locations
2	Stream opposite Ele Kade (proprietor – Mr Bertram), Pragathi Mawatha, Ihala Biyanwila

5	Water body at edge of marsh at Bandaranayake Mawatha, off Dewamitta Place; down stream of Kottunna Tank
6	Kelani River; north end of crossing

<Ground Water>

No.	Locations
3	Well at Ms Premawathie/s house; 645/2, Ihalabiyanwila, Kadawatha
4	Well at Mr W Wimalasena`s house; 391/14, Galwala Handiya, Makola South, Makola

Sampling locations are referred to in **Fig.1**

(4)Frequency

- Two times during dry and wet seasons before construction (Pre-construction)
- Every 03 months and on complaints during construction
- Two times with an interval of six months during operation stage and continued for one (1) year

(5) Responsible agency

Independent laboratory under contract to RDA

3.3. Air Quality

(1) Objective

- To minimize the air pollution in both construction and operation phases.

(2) Parameters

- Carbon monoxide
- Sulphur dioxide
- Nitrogen dioxide
- Ground level ozone
- pM10- particulate matter

(3) Monitoring Locations

No	Locations
1	At 500-600m along Bandaranayake Mawathao, off A1
4	At or near Galwala Handiya, Makola South, Makola

Samplings locations are referred to in **Fig.1**

(4)Frequency

- One time for 24 hour monitoring at dry weather condition before construction
- Suspended Particulate Matter (SPM) for 8 hours quarterly and on complains during construction
- Every six months during operation stage and continued for 03 years

(5) Responsible agency

Independent laboratory under contract to RDA

3.4. Noise / Ground Vibration

(1) Objectives

- To minimize the noise emission
- To minimize and /or avoid ground vibration

(2) Parameters

- For major interchanges- 24 hours measurements L_{Aeq} and L_{A} 90, 15 min (Day/Night)
- For other locations- Three (03) hours measurements L_{Aeq} and L_{A} 90, 15 min (Day/Night)

(3) Monitoring Locations

<Noise for 24hrs)

No.	Location
1	At 500-600 m along Bandaranayake Mawatha, off A1 road

<Noise for 3hrs)

No.	Location
4	At or near Galwala Handiya, Makola South, Makola

Sampling locations are referred to **Fig.1**

(4) Frequency

- Back ground noise levels and ground vibration (before construction) - One time with identification of noise barriers requirement locations. Every six months during construction
- During construction, noise levels (one (01) hour L_{Aeq} for day time and 5 minutes for

night time) and ground vibration should be carried out quarterly and on complains from residents.

- Every six months during operation stage and continued for 03 years

(5) Responsible agency

Independent laboratory under contract to RDA

3.5. Social Impacts

Monitoring of social impacts will be carried out based on the comprehensive Resettlement Implementation Plan (RIP) to be prepared by the RDA by the end of the Detailed Designs.

The objectives of monitoring social impacts are:

- To ensure that PAPs are settled in a similar or a better environment
- To ensure that PAPs are adequately compensated
- To avoid adverse direct and indirect impacts of resettlement of PAPs
- To identify residual adverse impacts of relocation

The items to be monitored are:

- Payment of compensation and resettlement
- Adverse social effects of relocation as disruption of cultural ties, access to social infrastructure etc.
- Impact on income levels and sustainability
- Impact on female headed families and disadvantaged PAPs
- Availability of employment opportunities for daily wage earners
- Potential conflict situations

Monitoring will commence as soon as relocation is started in the pre-construction phase and continue till the third year after resettlement.

Monitoring will be assigned to an organization with institutional capabilities to conduct social impact monitoring as detailed above. The responsible agency shall be RDA.

3.6. Baseline Data

The baseline conditions of existing water quality, air quality, noise levels and ground vibration should be established before commencement of the construction as requested by CEA, Environmental Monitoring and Assessment (EM&A) Div. Note that it is necessary to collect the baseline data for water quality (ground water and surface water) for dry and rainy season, respectively

The monitoring activities are summarized as below:

Items	Parameters	Responsible		Frequency
		Construction	Operation	
Ground water levels	Ground water level	PMU/ESD	RDA SLLRDC CEA	Two times during dry and wet period before construction; Quarterly and on complains during construction; Every six months during operation stage for 03 years
Water quality	pH, EC, DO, BOD, COD,SS, Nitrate, Phosphate, Chloride, Oil/Grease, Zinc, Lead, Total coliform, E. coliform	PMU/ESD	RDA/CEA	Two times during dry and wet period before construction; Quarterly and on complains during construction; Every six months during operation stage for one year
Air quality / Dust	Carbon monoxide Sulphur dioxide Nitrogen dioxide Ground level ozone pM10	PMU/ESD	RDA/CEA	One time 24 hour monitoring at dry weather before construction; Eight (8) hours SPM quarterly and on complains during construction; Every six months during operation stage for 03 years
Noise /ground vibration	Mean sound level (Leq(24)) Day-night sound level (Ldn)	PMU/ESD	RDA/CEA	Back ground noise levels and ground vibration (before construction) - One time with identification of noise barriers requirement locations; Every 03 months during construction, During construction, noise levels (one (01) hour LA eq for day time and 5 minutes for night time) and ground vibration should also be carried out on complains from residents; Every six months during operation stage for 03 years

Social Impacts	Payment of compensation Adverse social effects of resettlement Impact on income levels and sustainability Impact on vulnerable families and disadvantaged PAPs Availability of employment opportunities for daily wage earners, share croppers and Ande farmers. Potential conflict situations	PMU/ESD & Ministry of Land	RDA	Commencing Pre-construction phase continue till the third year after resettlement

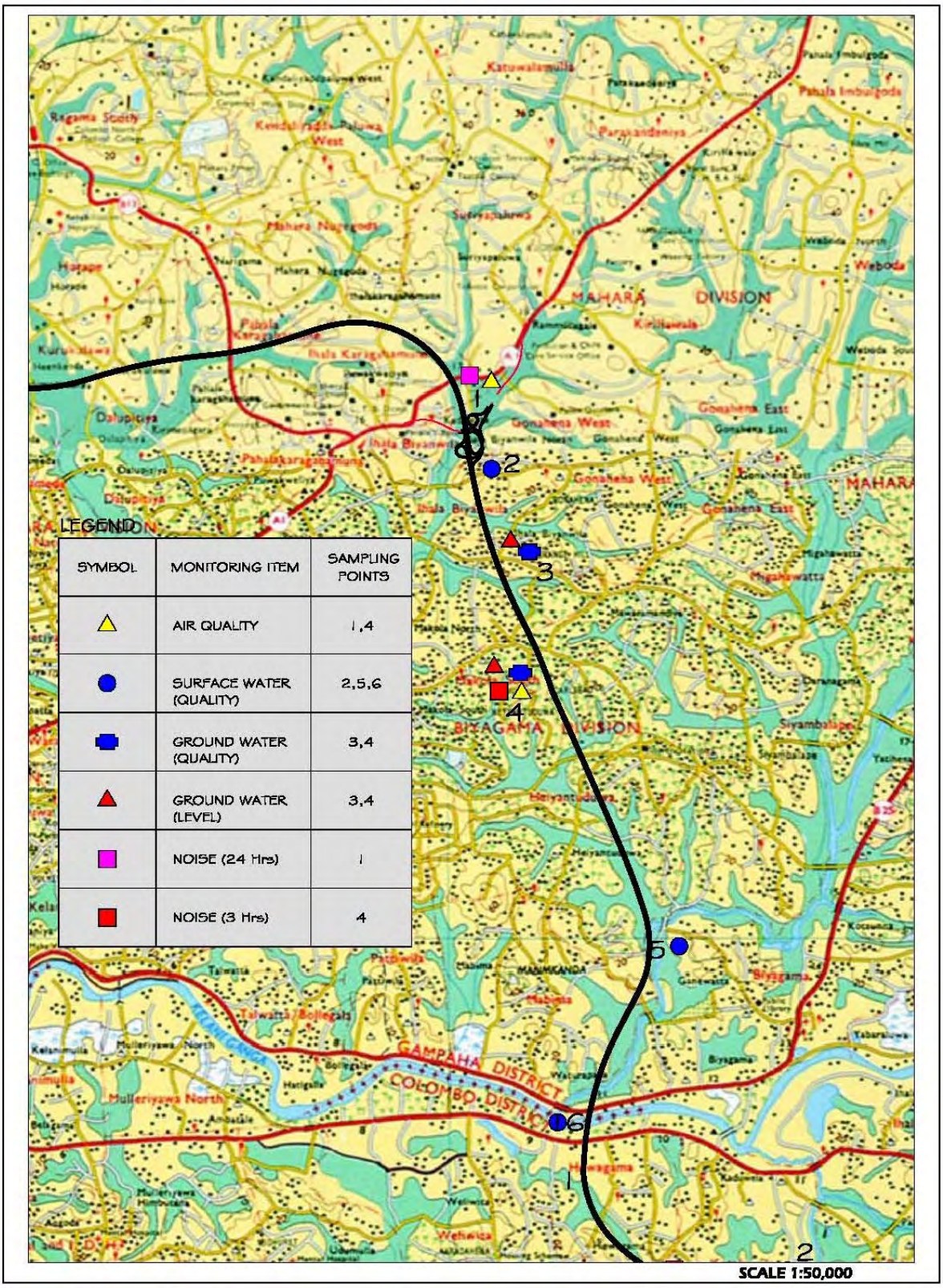


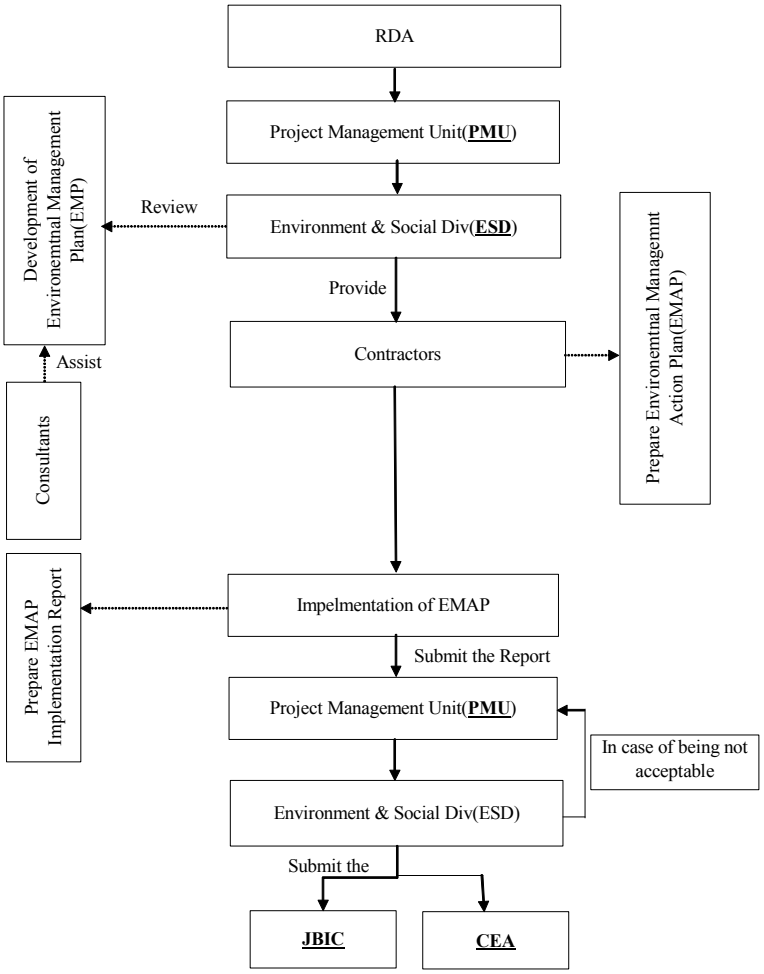
Fig.1 Sampling Locations

4. Responsibilities for Implementation of EMP

The Environmental and Social division (ESD) of RDA has a roll of supervising every road development project in terms of environmental and social management. The contractors will prepare Environmental Management Action Plan (EMAP) based on this EMP. Under supervising of the ESD, the PMU for the Project, with assistance of the Environmentalist of the Project Implementation Consultant (PIC), will

- Carry out Compliance Monitoring: the day-to-day inspection on compliance of mitigation measures of the **contractors**;
- Prepare Environmental Monitoring Reports.
- Address grievances from affected people

The general workflow for environmental management for the Project is as shown below.

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