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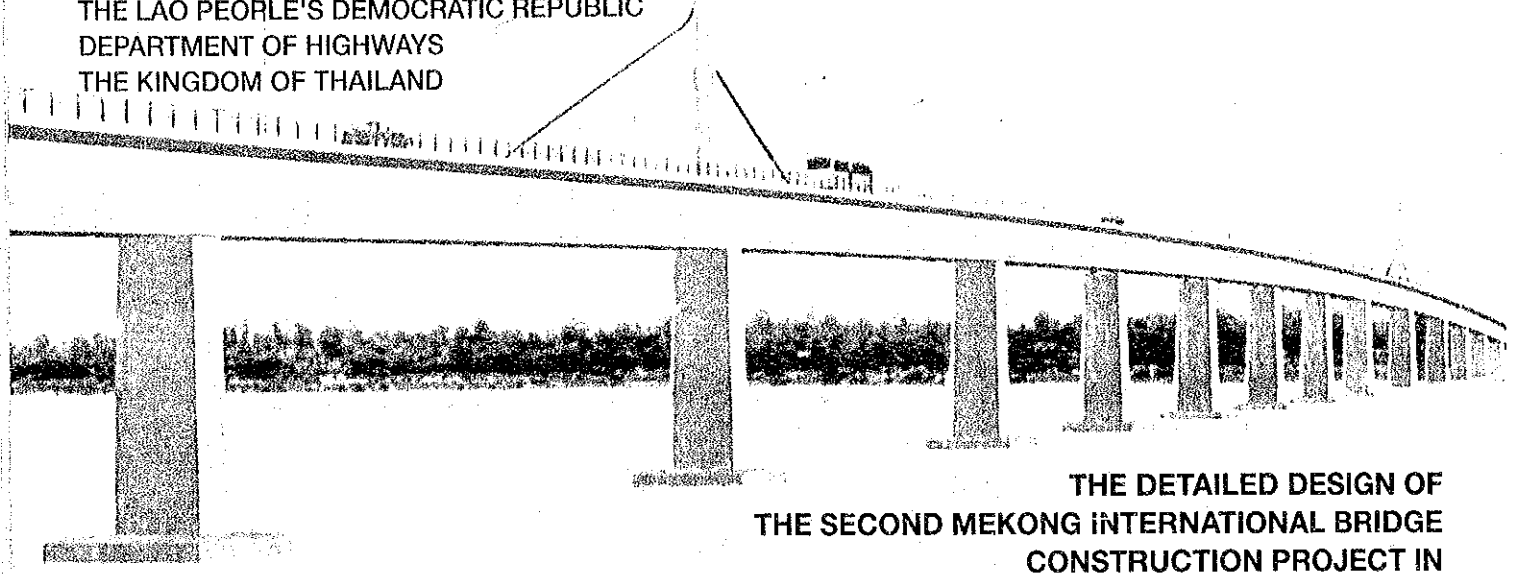
JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF COMMUNICATION, TRANSPORT, POST AND CONSTRUCTION
THE LAO PEOPLE'S DEMOCRATIC REPUBLIC
DEPARTMENT OF HIGHWAYS
THE KINGDOM OF THAILAND



THE DETAILED DESIGN OF THE SECOND MEKONG INTERNATIONAL BRIDGE CONSTRUCTION PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC AND THE KINGDOM OF THAILAND

FINAL REPORT

JUNE 2000

ORIENTAL CONSULTANTS COMPANY LIMITED
NIPPON KOEI CO., LTD.

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THE DETAILED DESIGN OF
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CONSTRUCTION PROJECT IN
THE LAO PEOPLE'S DEMOCRATIC REPUBLIC AND
THE KINGDOM OF THAILAND

FINAL REPORT
DRAFT BIDDING DOCUMENTS (PACKAGE 2)
VOLUME 2

JUNE 2000

ORIENTAL CONSULTANTS COMPANY LIMITED
NIPPON KOEI CO., LTD.


1158427 [3]

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PART 1 GENERAL

PART 1 GENERAL

SECTION 1 : GENERAL

1.1 SCOPE AND GENERAL INFORMATION

1.1.1 Location and Description of the Project

The Second Mekong International Bridge Construction Project is an integral part of the East-West Corridor System liking Vietnam in the east and Myanmar in the west with a road running through the Lao People's Democratic Republic and the Kingdom of Thailand. The bridge will service a defined target area in the northeast Thailand and the central Laos with access to Da Nang and Laem Chabang ports and will help to stimulate the local economies in the these areas. The Project consists of :

- A major two-lane bridge over the Mekong River, located 5km north of Savannakhet on the Lao PDR side and 7.5km north of Mukdahan on the Thailand side.
- Approach roads including embankment and culverts from/to the bridge on both sides
- Border Control Facility from/to the bridge on both sides
- A traffic changeover facility located between the Border Control Facility and the bridge on the Thailand side.

The project will be divided into three construction packages according to works detailed as follows:

(The project includes three (3) contract packages as described below.)

Package 1 : Main bridge, approach viaducts (Lao PDR and Thailand sides), approach roads (Lao PDR and Thailand sides) and traffic changeover (Thailand side).

Package 2 : Border control facility and connection road in the Lao PDR side.

Package 3 : Border control facility and connection road in the Thailand side.

Contractors for the above 3 Packages will be procured separately by the following manner.

- Package 1 will be divided into two sections. One is the section which belongs to the Lao PDR (Lao PDR Section) and the other section is that which belongs

to Thailand (Thailand Section). One (1) Contractor will be procured for the entire scope of works of Package 1 and the Contractor will make contracts with both the Lao PDR and Thailand according to the scope of works of Package 1.

- The Contractor of Package 2 will be procured by the International Competitive Bidding (ICB) and will make a contract with the Lao PDR Government.
- The Contractor of Package 3 may be procured by the International Competitive Bidding (ICB) and will make a contract with the Thailand Government.

1.1.2 Extent of the Works

The scope of the works covered under Package 2 shall include.

Package 2 (The Lao PDR side)

1) Connection road form the national highway road Route 9 to the Lao PDR Border Control Facility.

   Earth work
   Drainage
   Pavement
   Lighting facilities and other incidental works

2) Border Control Facility.

   Civil Works (land reclamation, surface water drainage , road works etc.)
   Building (office buildings and other buildings)
   Water supply and sewage systems (septic tank)
   Electric power supply system
   Communication system
   Lighting system

1.1.3 Drawings

The Drawings (Volume 4 of the Bidding Documents) contain details of the Works to be carried out under the Contract.

1.1.4 Informations Provided

The following informations are given for the guidance of the Contractor and are given in good faith. No warranty shall be given by the Employers nor the Engineer as to the accuracy or relevance of these informations.

1.1.4.1 Soil Investigation

The informations provided on soil investigations are given in the following reports.

- The detailed design of the Second Mekong International Bridge Construction Project in the Lao Peoples Democratic Republic and The Kingdom of Thailand. "BASIC DESIGN REPORT Volume-1 Main Report", August 1999. (3.3 GEO-TECHNOLOGY pages 3-8), Oriental Consultants Co., Ltd. in association with Nippon Koei Co., Ltd.

- Report Volume 1-2, 2-2 of the geological survey for the Second Mekong International Bridge Construction Project, July 1999, by SIAM TONE Co., Ltd.

1.1.4.2 Meteorological Data

The meteorology factors and conditions in the study area have been examined for the project. These data were obtained from the Provincial Meteorology Service at Savannakhet and for the Mukdahan side from the Meteorology Office in Bangkok. The Contractor could refer to the above offices and the data shall be given in the following reports.

- Basic Design Report Volume-1 Main Report, August 1999. Oriental Consultants Co., Ltd. in association with Nippon Koei Co., Ltd.

- Hydrological and Hydraulic Survey Part II Data Collecting June 1999. Asian Engineering Consultants Corp., Ltd.

1.1.4.3 Survey Datum

The fixed horizontal control station to be used as the survey reference was the existing RTSD (Royal Thai Survey Department) monument name GPS-3074 (OTVR 405)

The benchmark was the nearest RTSD bench mark and its elevation was + 141.1052 meters above MSL (Mean Sea Level measured at Ko Lak).The Bridge and Road centerline through point A (Lao PDR side) and point B (Thailand side) and the elevation and coordinates of these points by GPS are shown in the drawings.

1.2 SITE AREAS, ACCESS AND USE

1.2.1 Permanent right-of-way

The Contractor will be provided the right-of-way necessary for the use the execution of the Works in accordance with the provisions of Clause 42 of the Conditions of Contract. The Contractor himself shall, at his expense, make all arrangements to provide for such other land which he may need for housing of workmen, installation of offices, camps and workshops, extraction and hauling of materials and any other land needs outside of the designated right-of-way. The right-of-way shall be handed back to the Employer within 24 months of the Commencement date. All works shall have been completed by the Contractor to the Engineer's satisfaction by the date of hand over the area to the Employers.

1.2.2 Contractors' Working Areas

The permanent right-of-way shown in Drawings will be available to the Contractor for his temporary use to provide space for storage, offices, workshops, prefabrication facilities and the like. For the land, beyond that shown as the right-of-way on Drawing, required by the Contractor for working areas, disposal of surplus spoil or the like, the Contractor shall make his own arrangements, obtain any necessary permission and be solely responsible for paying any costs, charges or compensation in connection therewith.

The Contractor shall provide, erect, construct, equip and remove on completion of all offices, accommodation, workshops, stores, jetty facilities, weigh bridges, prefabrication and other areas for his staff, personnel and construction equipment required by him directly or indirectly for the execution and completion of the Works and the remedying of any defects therein. The Contractor shall submit for the prior approval of the Engineer his proposals for the layout of his working area and facilities. It is intended that such approvals will be given promptly provided there are no significant aspects which are not acceptable to the Engineer.

Upon completion of the Works, the Contractor shall clear away all surplus materials, construction equipment or any debris and temporary works of every kind from the Site and reinstate the areas to the satisfaction of the Engineer.

1.2.3 Adjoining Site

Drawing also shows the areas of adjoining land which have been allocated to the other contracts (Packages 1) to be carried out concurrently with this Contract. The Contractor shall permit the personnel, workmen, materials, vehicles, plant and equipment of the Contractors for adjoining contracts access and movement over and through the Site without charge for purposes in connection with the execution of their works.

1.2.4 Access

The Contractor shall be entirely responsible for providing all access to the Site for his personnel, materials, vehicles, plant and equipment and for all other requirements of the Works, whether such access be via the Mekong River or via the existing roads in the Lao PDR and Thailand.

The Contractor shall abide by all limitations, laws and regulations relating to the use of public transportation routes and waterways, and shall be responsible for any damage or disruption caused by his misuse of them. The Contractor may improve and / or widen existing roads, repair or strengthen existing bridges or culverts, and widen and / or deepen existing waterway routes to meet his haulage requirements, provided that such works will be so scheduled and conducted as to minimize disturbance to other users, and subject to the approval of the Engineer and any Statutory Authorities having jurisdiction.

Should the Contractor require any other form or route of access not provided in the site until the right-of-way is provided by the Employer the Contract, he shall make his own arrangements, obtain any necessary permission, and be solely responsible for payment of any costs, charges or compensation in connection therewith.

1.2.5 Security

The Contractor's responsibility for the security and safe working environment of the Site commences from the time any part of the right-of-way has been given by the Employer. As soon as possible after the right-of-way has been given, the

boundary of the Site shall be marked out, and the Contractor shall submit to the Engineer for approval, his proposals for maintaining the boundary and the security within.

The Contractor's proposals shall include a security control system which shall consist of sufficient equipment and personnel to prevent unauthorised access 24 hours per day, 7 days per week and which can meet the prevailing circumstances to ensure the safety and security of persons and property on the Site. The security control system shall include, interalia, outside lighting of all buildings and other facilities to be provided for the Engineer and the Employers as well as street-lighting and lighting of fencing and gates erected as part of the Contractor's security control system.

The Contractor shall erect and maintain at his own expense suitable and approved fencing and gate to enclose areas of the Works to be carried out and other areas of land as may be necessary to implement his obligations under the Contract to the satisfaction of the Engineer.

All authorized persons, as defined in Section 2.9 of this Specification, shall be registered by the Engineer, and the register shall be provided to and maintained by the Contractor.

1.2.6 Cleanliness and Reinstatement

The Contractor's attention is drawn to his obligations under the provisions of Clause 32 of the Conditions of Contract, and shall throughout the period of construction of the Works maintain the whole of the area of his operations in a clean, tidy and safe condition by arranging his materials and construction equipment in an orderly manner. All rubbish, waste materials, debris and the like shall be systematically cleared off the working areas and removed directly off the Site for disposal in authorized tips or other proper disposal facilities.

The Contractor shall immediately upon completion of any work and following the approval of the Engineer in accordance with the provisions of Clause 38.1 of the Conditions of Contract, fill up all holes and trenches which may have been made or dug, level any mounds made and clear away all rubbish which may have been occasioned or made in the course of the execution of the Works. These requirements are in addition to the Contractor's obligations under Clause 33 of the Conditions of Contract.

1.2.7 Disposal and Pollution

The Contractor shall not dispose of any waste, rubbish or offensive matter in any place not approved by the Engineer or Statutory Authorities having jurisdiction.

The Contractor shall not discharge into any watercourse oil, solids, noxious floating materials or untreated waterborne effluent, and take reasonable precautions to prevent their accidental spillage, contact with soil or discharge into watercourse.

The Contractor shall take all reasonable precautions to keep public or private roads clear of any spillage or droppings from his vehicles. Any spillage or droppings which occur shall be cleared without delay to the satisfaction of the Engineer.

1.2.8 Health and Safety

The Contractor shall be responsible for the provision of adequate sanitary facilities for all of his employees at all construction and camp sites, and shall provide details of sanitary arrangements for the Engineer's approval.

The Contractor shall observe and maintain standards of Health and Safety towards all of his employees not less than those laid down in his own national standards or statutory regulations. He should take all reasonable steps including training and safety drill to ensure the safety of all persons on the Site, whether in his employ or not. Safety is paramount.

The Contractor shall provide and maintain all appropriate protective clothing and equipment for the work to be done and ensure its proper use. Where required safety nets, belts, harnesses and lines shall be provided and, where work is in, over or near water, life preserving and rescue boats shall be provided. All men working over water shall be required to wear life preservers.

The Contractor shall provide and maintain in prominent and well marked positions all necessary first aid equipment, medical supplies and other facilities. A sufficient number of trained personnel will be required to be available at all times to render first aid.

A suitably equipped room shall be made available with beds and stretchers for emergency medical treatment, and a planned system for removal to hospital for

authorized persons requiring further treatment shall be provided by the Contractor to the satisfaction of the Engineer. Authorized persons are those approved by the Engineer as the registered personnel involved in the Works of this Contract.

The Contractor shall report to the Engineer promptly and in writing particulars of any accident or unusual or unforeseen occurrences on the Site, whether likely to affect progress of the work or not.

1.2.9 Temporary Works

The Contractor shall be responsible for the design, specification, execution and subsequent removal of all Temporary Works necessary for the completion of the Works. Temporary Works shall be designed by the Contractor in accordance with the standards described in Section 1.9 if this Specification or as agreed with the Engineer.

Before the Contractor starts construction on any part of the Temporary Works, he shall furnish to the Engineer complete drawings and, if so required, calculations relating to stability, strength and deflections of that part of the Temporary Works. Where the Temporary Works have direct contact with any part of the Permanent Works, the drawings and calculations shall clearly indicate the relationship, illustrate erection sequences and show any loading or stresses applied to or from the Permanent Works.

Calculations shall be submitted on size A 4 paper and shall be clearly and neatly set out in the English language. All calculations shall be in SI units. All pages shall be uniquely numbered, dated and titled. Pages may be in manuscript provided this is clear and legible. Script shall be such that clear photocopies can be reproduced.

The required submission of drawings and / or calculations shall be made to the Engineer at a reasonable period before the Contractor intends to commence any fabrication or installation of Temporary Works. The Contractor shall make due allowance in his programme for submission of Temporary Works proposals, review by the Engineer and amendment, resubmission and further review by the Engineer as may be necessary until the consent of the Engineer to the proposals is obtained.

The furnishing of any drawings and calculations of the Temporary Works to the Engineer shall not relieve the Contractor of any liability or obligation under the Contract in respect of such Temporary Works.

1.2.10 Works Off Site

The Contractor shall give an adequate written notice to the Engineer of the preparation or manufacture at a place not on the Site of the Permanent Works of any reconstructed units or parts of units to be used in the Works, all in accordance with the provisions of Section 1.6 of this Specification.

1.2.11 Contractor's Programme and Methods of Construction

The soils investigation required is to be programmed to enable the information to be available in sufficient time that the final decision on pile length can be made by the Engineer.

1.3 GENERAL AND SUNDRY OBLIGATIONS

1.3.1 Surveys and Setting Out

The Contractor shall, prior to the commencement of work in any portion of the project check all cross-sections and other drawings and check stakes for lines, slopes, grades, structures and the like. If the Contractor thereby finds any divergence, he shall so notify the Engineer and together with him perform a recheck of the divergence concerned and agree upon the corrections to be made.

The checked cross section sheets and other planes indicating existing terrain shall be mutually signed by the Contractor and the Engineer and the contractor agrees that his signing such cross section sheets and plans is construed as his acceptance of their correctness.

The Contractor agrees that by his commencing particular work in any portion of the road it is to be constructed as his agreement to acceptance as correct the cross section sheets and drawings for computation of quantities and cost.

The Contractor shall give the Engineer not less than 24 hours notice in writing of his intention to set out or give levels for any part of the Works so that arrangements can be made for checking the work. Work shall be suspended for such time as is necessary for checking lines and levels on any part of the Works.

The Contractor shall at his own expense provide all assistance which the Engineer may require for checking the setting out.

The Contractor shall also cooperate and co-ordinate with the other Contractors appointed by the Employer in the joint use of the survey reference points.

1.3.2 Sign Boards

The Contractor shall supply, erect, (within 45 days of the Commencement Date), maintain and remove on completion notice boards at/to the Site, giving brief details of the project in English, Lao PDR including but not limited to, the names of the Contractor, Employer and Engineer. The wording colours, style of the sign, size of lettering, and the like shall be given the approval of the Engineer.

1.3.3 Progress Photographs and Videotapes

The Contractor shall supply to the Engineer 35mm colour slides, approximately twenty in number for each occasion, taken by an approved photographer, before the start of the Works and monthly thereafter showing the progress of the Works and also such particular sections of the Works, Site, Plant or materials as the Engineer may direct. In addition, the Contractor shall supply 3 colour prints of each slide.

The prints shall be well executed, unmounted and approximately 18cm by 24cm in size. Each print shall be marked on the reverse side with the date of exposure, identification or reference number, and a brief description of the view, and delivered to the Engineer within 2 weeks of exposure.

The Contractor shall also supply 2 Nos. copies of videotape on an approved VHS system (Tape or VCD) of approximately 30 minutes 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 refer also to Section 1.5.4.

The copyright of such photographs and video tapes or discs and all rights of reproduction shall be reserved exclusively to the Employer. No other photographs and videotapes will be allowed to be taken without prior permission obtained from the Employer in writing.

1.3.4 Working Drawings

The Contractor shall submit working drawings for the prior approval of the Engineer. Such working drawings shall include the bar bending schedules and such detail drawings are required for all permanent and temporary works as deemed necessary by the Engineer. No part of the Works shall be constructed until the relevant working drawings are approved by the Engineer.

Drawings shall be prepared in metric units, with English text and to ISO A1 size unless otherwise approved by the Engineer, and shall be accurate to scale and fully dimensioned. The style and presentation shall be standardised.

Each working drawing shall have been assigned to a unique number and title. All issues of revisions of any working drawing shall be identified by a sequential revision letter or number, the date of revision and brief descriptions of the revisions. All copies of drawing issued shall be clearly marked with the status of the drawings, showing whether it has been issued for information, approval, construction or other purpose.

The Contractor shall maintain a comprehensive register of working drawings listing all relevant information including numbers, titles, date of issue, to whom issued, numbers of copies, status of issue, date of approval, rejection, receipt of comments, date when superseded, remarks etc. Copies of the register shall be issued to the Engineer as directed.

When errors and omissions are found on any approved working drawing, approval of that drawing shall be withdrawn. The drawing shall without delay be withdrawn from circulation, amended and resubmitted for the approval of the Engineer, Construction shall proceed only in accordance with the revised working drawings when approved by Engineer.

The Contractor shall on each submission of drawings to the Engineer provided four paper copies plus one polyester film copy of minimum thickness 75 microns, plus one CAD file copy (on computer diskette) where appropriate. Two paper copies are to be submitted directly to the Engineer with the balance (2 No. paper copies, 1No. polyester film copy, 1 No. CAD file copy on a diskette) to be submitted directly to the Engineer.

1.3.5 Environmental Obligations

1.3.5.1 General

The Contractor shall take all reasonable measures required by the Engineer to prevent harm to, and to minimize the impact of his operations on, the environment and socio-economic conditions around the project site, and shall ensure that his employees do likewise.

1.3.5.2 Water contamination

The Contractor shall take all reasonable measures required by the Engineer to prevent surface and under water contamination. Especially for the activities mentioned below, the adequate waste water treatment plants shall be installed.

- water contamination caused by excavation of the bridge piers
- drainage from concrete plant operations

In case the contamination occurs due to his negligence the Contractor shall be responsible to upgrade the water to its original quality especially where the surface water has potential use.

1.3.5.3 Air quality and noise/vibrations

All vehicles and construction equipment operated by the Contractor shall be maintained according to the original manufacture's specifications and manuals, with particular regard to the control of noise emissions.

The Contractor shall make every reasonable effort to reduce noise nuisance caused by construction activities, including the siting of concrete production plant in locations where the distance between them and residential areas is adequate.

The Contractor shall take all reasonable measures, including watering, if necessary in the opinions of the Engineer, to minimize dust nuisance resulting from his operations including the use by the public of temporary diversions. In addition control of dust on the existing road within the bounds of the Project Site, where the Contractor has not yet started construction of the Works, shall be undertaken.

1.3.5.4 Erosion control

The Contractor shall take all precautions to prevent the erosion of soil from any lands used or occupied by him, and from the bed or banks or any river, stream, irrigation or drainage system. The Contractor also shall take all precautions to prevent the deposition of excavated or eroded material that may result from execution of the Works in any river, stream, irrigation or drainage system.

1.3.5.5 Local transportation system

The Contractor shall be required to pay attention to the local transportation system both of land and in the river.

1.3.5.6 Public health

The Contractor shall be required to submit and obtain approval by the Engineer for a health and safety plan prior to the commencement of work. Workers will be required to undergo pre-employment medical screening and treatment if required, and periodic health checks thereafter,

Particular attention shall be given to the siting and infrastructure provided for Project Labor Camps. It is preferable to isolate labor camps from local communities. This reduces the risks of social conflict and transfer of diseases between local communities and construction workers. Construction camps shall have adequately designed water supply, sewage treatment facilities and solid waste disposal areas.

1.3.5.7 Environmental Monitoring Plan

The purpose of Environmental Monitoring Plan is to ensure that the mitigation measures proposed during the construction, and operation stages of the bridge and approach roads are carried out in an environmentally sensitive and responsible manner , and to ensure that institutional structures and responsibilities are in place so that the project is monitored adequately for environmental compliance.

The Contractor shall carried out the monitoring activities based on the technical specification described as below. The monitoring reports will be included in the progress report documentation. The cost of the monitoring activities shall be deemed to be included in the Bill of Quantities.

Based on the results of the monitoring activities, the Contractor shall ensure the effectiveness of the mitigation measures referring the environmental standard mentioned below.

(Water quality, Air Quality, Noise)

- Environmental Standard of Ministry of Science, Technology and Environment of Thailand

(Vibration)

- German Norm DIN 4150, Dieckman, Reichter & Meister

(1) Water Quality

- Period and Frequency

  3 times/year in dry season (February to May), winter season (November to January) and rainy season (June to October). Each sampling period must be carried out for 3 consecutive day.

- Sampling Station

  2 sampling stations in the Mekong river (see Figure 1.3.1) as : 1,000 m. upstream and 1,000 m. downstream of the Second Mekong International Bridge Construction Project.

- Parameter :

  The parameters for water sampling consisted of temperature, pH, turbidity, conductivity, DO, COD, BOD_5, SS, oil & grease, and faecal coliform bacteria.

(2) Aquatic life

- Period and Frequency

  3 times/year in dry season (February to May), winter season (November to January) and rainy season (June to October). Each sampling period must be carried out for 3 consecutive day.

- Sampling Station

  2 sampling stations in the Mekong river (see Figure 1.3.1) as : 1,000 m. upstream and 1,000 m. downstream of the second Mekong international bridge construction project.

- Parameter

  The parameters for aquatic ecology sampling consisted of plankton and benthic organisms.

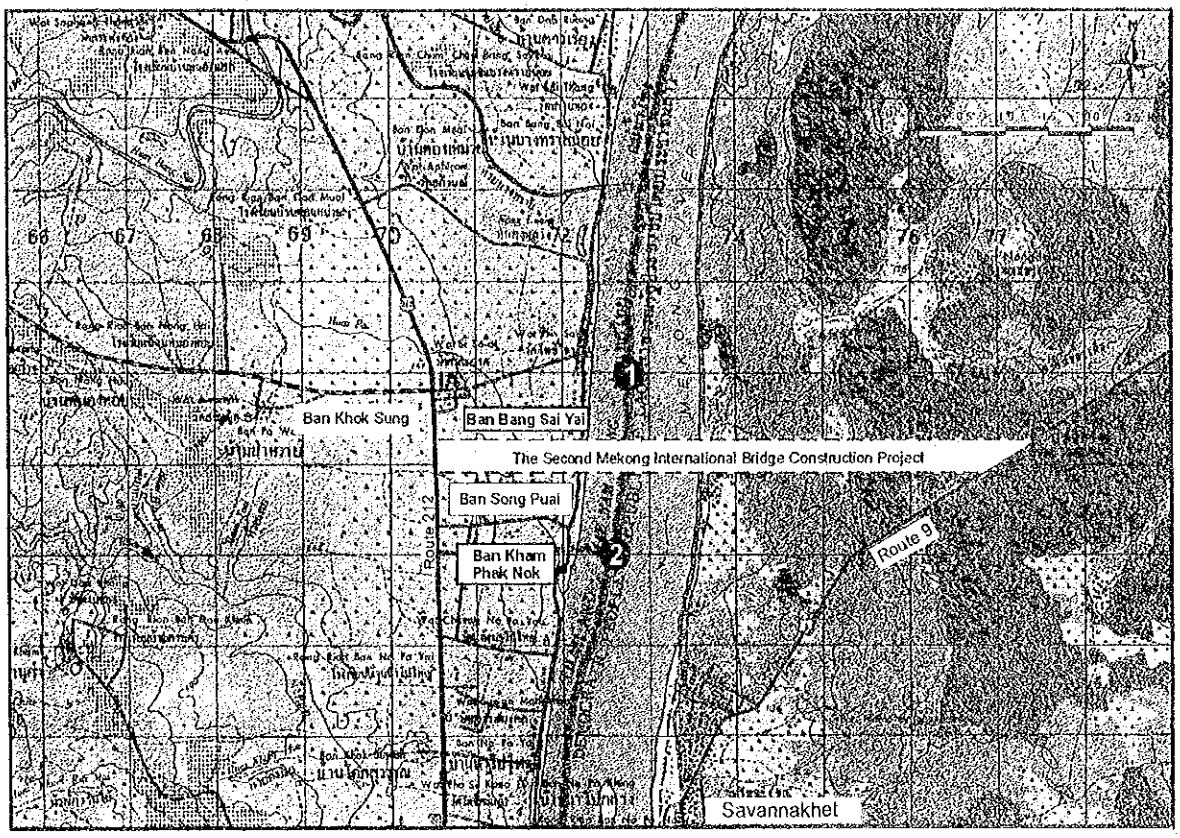


Figure 1.3.1 Sampling Station of Water Quality, and Aquatic Life

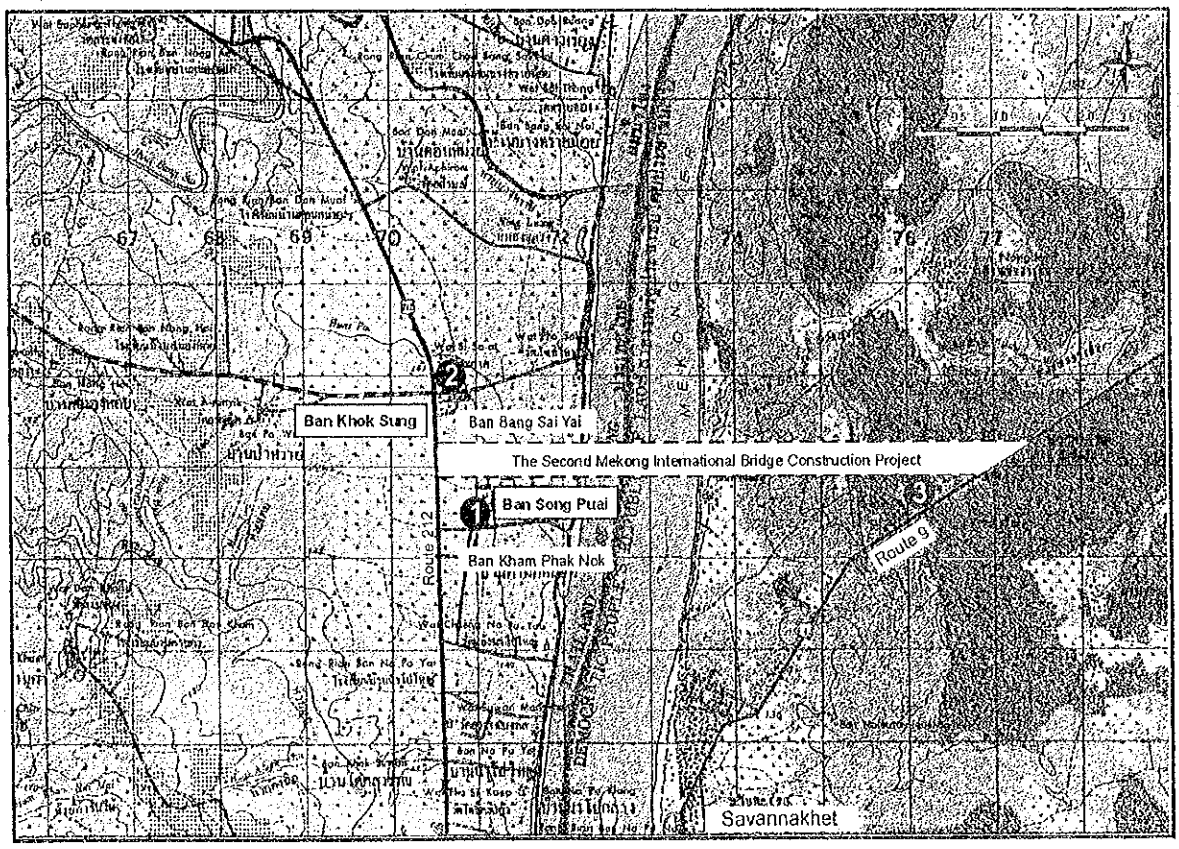


Figure 1.3.2 Sampling Station of Air Quality, Noise and Vibration Level

(3) Air Quality

- Period and Frequency
  2 times/year in dry season (February to May) and winter season (November to January). Each sampling period must be carried out for 3 consecutive day.
- Sampling Station
  2 sampling stations (see Figure 1.3.2) in Thai side (Ban Song Puai, Ban Khok Sung) and 1 sampling station in Lao side (Interchange of Route No. 9 & Kaysone Road).
- Parameter
  The parameters for air quality sampling consisted of total suspended particles (TSP-24 hr.), particulates matter (PM-10 (24 hr.)), nitrogen dioxide (NO_2-1 hr.), and carbon monoxide (CO-1 hr.).

(4) Noise

- Period and Frequency
  2 times/year in dry season (February to May) and winter season (November to January). Each sampling period must be carried out for 3 consecutive day.
- Sampling Station :
  2 sampling stations (see Figure 1.3.2) in Thai side (Ban Song Puai, Ban Khok Sung) and 1 sampling station in Lao side (Interchange of Route No. 9 & Kaysone Road).
- Parameter
  The parameters for noise level sampling consisted of Leq-24 hr., and Ldn.

(5) Vibration

- Period and Frequency
  2 times/year in dry season (February to May) and winter season (November to January). Each sampling period must be carried out for 3 consecutive day.
- Sampling Station
  2 sampling stations (see Figure 1.3.2) in Thai side (Ban Song Puai, Ban Khok Sung) and 1 sampling station in Lao side (Interchange of Route No. 9 & Kaysone Road)
- Parameter
  The parameters for vibration level sampling consisted of peak particle velocity(PPV), and frequency.

(6) Socio-economic

- Parameters
- The project information perception
- The impact during construction period

- Opinion and attitude toward the project
- Problems and needs and suggestion proposed for the project's consideration
- Method
  Socio-economic survey by interviewing
- Sampling population
  Households nearby the construction site
- Sample size
  About 100 samples
- Frequency
  Every 6 months

1.4 SPECIAL REQUIREMENTS

1.4.1 Training

The Contractor is required to assist and cooperate with the Engineer in the training of selected Employers' personnel to enable them to operate and maintain the Works during and after the Defects Liability Period. This training will be to a programme approved by the Employer and include instruction during the contract period in matters associated with the construction and imparting a thorough understanding of all elements of the Operation and Maintenance Manual.

1.4.2 Operation and Maintenance Manual

In addition to his obligations, before completion of the Works, the Contractor shall forward to the Engineer ten (10 Nos.) copies of an Operation and Maintenance Manual in English, plus 2 sets of electronic word processing files on computer diskettes.

Drafts of the manual shall be submitted to the Engineer for approval not less than 12 weeks before the date fixed for commissioning or handover of completed works. Any modifications to the form or extent of the contents required by the Engineer shall be incorporated in the final issue of the Manual.

The manual shall contain, but not be limited to the following:

- A folio of record drawings showing all details "as built" for the whole of the works ; (refer note).

- Operating instructions applicable to any items of mechanical or electrical equipment or appliance handed over to the Employer in accordance with the Contractor.

- A schedule for inspection and monitoring of all component parts susceptible to wear and tear, damage or weathering and deterioration with time.

- A schedule of routine and periodic maintenance activities appropriate for the climate, the anticipated level or use or exposure and availability of skilled labour.

- Instructions and procedure for the correction of faults or foreseeable accidental damage.

- Specifications for material and workmanship for all inspection, operation and maintenance or repair activities.

- Lists of tools, instruments and equipment's necessary for all inspections, operation maintenance activities.

Note :
For " as built" drawings, 10 paper copies and one polyester film copy of 75 micron thickens shall be submitted to the Engineer together with 2 sets of CAD files on computer diskettes where appropriate. Refer also to Clause 6.1 of the Conditions of Contract.

1.5 PROGRAM AND PROGRESS REPORTS AND RETURNS

1.5.1 General

The program required by Clause 14 of the Conditions of the Contract shall be in the form of both a bar chart and network diagram. They shall cover all the main items of work, showing their inter-relation with and independence on other items of work, and be laid out in a format which will permit progress of the various items to be marked up on them throughout the execution of Works. They shall be produced as a result of a critical path analysis in a form (based on a standard project management computer software package approved by the Engineer) capable of being updated, showing all requisite operations, earliest and latest start and completion dates, duration, float and critical activities and shall be submitted with the program.

The program shall include interalia :

- The dates by which the Contractor requires any information from the Engineer;
- The dates by which the Contractor requires instructions from the Engineer to carry out the work described in the Contract as Provisional Sums;
- The dates and periods during which the Contractor will require access to sites allocated to other contracts in the execution of his work;
- The dates and periods for the preparation of working drawings and review of these by the Engineer.

The method statements required in accordance with Clause 14.1 of the Conditions of Contract shall indicate a list of major items of construction equipment to be used, their deployment in relation to the programme, methods of movement of materials, Temporary Works and other like matters.

On the last day of each week the Contractor shall issue to the Engineer details of his intended programme of work for the week ahead.

1.5.2 Progress Meetings

Meetings will be held at intervals as required by the Engineer, but not exceeding one month, between the Engineer and the Contractor to discuss the progress of the Works and any problems which may have arisen. The Contractor shall give to the Engineer at these meetings details of his progress to date in relation to the programme.

1.5.3 Weekly Returns

At weekly intervals the Contractor shall in accordance with his obligations under Clause 35 of the Conditions of Contact, supply to the Engineer return of labour, materials and Contractor's Equipment and in addition, a schedule of the main work items in each section of the Works showing quantitative progress during the previous week and cumulative progress to date.

1.5.4 Monthly Return

At monthly intervals, and not later than the first week in every month, the Contractor shall submit to the Engineer the progress report documentation for the previous month which shall include, but not be limited to the following :

- A programme marked up with any agreed amendments and showing the actual percentage completion of each of the main items of work, in such a way that comparison can be made with the scheduled percentage completion of each item.
- Weather and other conditions, including daily temperature range, humidity, rainfall, wind speed and direction, river levels etc.;
- Summary of staff and labour employed on the Site;
- Schedule of Contractor's Equipment on Site with dates of arrival and departure as appropriate;
- Schedule of principal material items with dates of placing orders, progress of manufacture, dates of delivery to Site etc.;
- Profiles of the dredged slopes as slope protection works of partially completed and completed work;
- Record of Site safety;
- Photographs and videotapes and described in Section 1.3.3.

1.5.5 Submission of Returns

All reports, statements, returns, diagrams or drawings, etc. which the Contractor shall be required to submit to the Engineer during the progress of the Works shall be furnished in quadruplicate (3 Nos. copies) unless otherwise directed. Three copies shall be submitted to the Engineer.

1.6 QUALITY ASSURANCE, STANDARDS AND MATERIALS TESTING

1.6.1 Quality Assurance

The Contractor shall document and operate a Quality System generally complying with the AASHTO "Implementation Manual for Quality Assurance" 1996 or equivalent guideline approved by the Engineer.

The Contractor shall prepare a Quality Plan for the Works. The plan shall be submitted for the approval of the Engineer within 4 weeks of receipt of the Letter of Acceptance.

The Quality Plan shall be reviewed, updated and resubmitted for approval as necessary throughout the contract period.

The Quality Plan shall specially address the procedures for maintaining the project quality requirement with respect to the use of subcontractors, vendors and suppliers. The requirements for quality surveillance shall reflect the criticality of the item or material concerned. The criteria for assessment of criticality shall be approved by the Engineer.

The Contractor shall cooperate with the Engineer and shall provide all necessary access to works and records to enable the Engineer to assess the Contractor's Quality System and to audit the implementation of the Quality Plan and associated procedures.

1.6.2 Procedures

The Contractor shall not commence any item of Permanent Works until he has submitted to the Engineer a written statement of his proposed procedure for his own inspections of that item recording such inspection and obtaining the Engineer's written approval thereof. Each detailed procedure shall be formulated following detailed discussions with the Engineer as well. Every such statement shall identify the individuals on the Contractor's or Sub-Contractor's staff who are responsible for inspecting the workmanship and /or testing the materials for the item in question, the place of inspection, the stages at which inspections and tests are to be made, the detailed aspects to be verified or measured in each inspection. Each inspection shall be recorded.

1.6.3 Tests and Inspection Records

The record shall identify the Contractor involved, the place, the date and time when the inspection was completed, the section of the Works and the materials tested or inspected, and its state of completion. Reference shall be made to the relevant working drawings and the specific aspects or properties which were checked or measured shall be recorded.

One copy of each record of inspection shall be submitted to the Engineer. The records of inspections and tests shall be stored in an orderly fashion on the Site by the Contractor until the issue of the Liability Certificate for the whole of the Works, or such earlier time as the Engineer may instruct, and the Engineer shall have the right to access to them at all times.

After the issue of the Defects Liability Certificate for the whole of the Works, or such earlier time as the Engineer may instruct, the Contractor shall, as instructed by the Engineer, either dispose of the records or deliver them as directed.

1.6.4 Contractor's Testing and Inspection

The Contractor shall be responsible for ensuring that all specified testing (in the laboratory, in the field and off site) and inspections of materials and workmanship are carried out. No work shall be covered up without the written approval of the Engineer. All items of work concealed in the finished work shall be inspected by the Contractor and Engineer immediately before they are covered up. Inspection and testing shall be recorded according to the procedure specified in Section 1.6.3.

It is intended that the majority of the laboratory testing required will be undertaken in the Engineer's Laboratory described in Section 1.8. Some specialist testing is to be arranged by the Contractor and carried out in suitable laboratories off-site. Field sampling and testing will be carried out by suitably qualified and experienced Contractor's staff under the control of the Engineer.

It is expected that the Contractor's Materials Engineer will be responsible for leasing and coordinating with the Engineer's Laboratory, field sampling / testing staff and off-site laboratories to ensure all sampling, specified tests and inspections are carried out in a timely manner.

1.6.5 Engineer's Testing and Inspection

In addition to the Contractor's testing and inspection described in Section 1.6.4, the Contractor shall afford and facilitate access at all times for the Engineer's inspection and testing of materials and workmanship. The Contractor shall provide means of access and assistance as may reasonably be required by the Engineer. For all items of work the Contractor shall give adequate notice in writing to the Engineer that the item in question is complete and is ready for inspection, and shall not cover it by subsequent work until the Engineer has confirmed in writing that it has been inspected and is approved. No inspection or approval by the Engineer shall relieve the Contractor of any his duties and obligations under the Contract.

1.6.6 Notice of Works Off Site

The Contractor shall give adequate written notice to the Engineer of the preparation or manufacture at a place not on the Site of any preconstructed units or parts of units or materials to be used in the Works. Such notice shall state the place and time of the preparation or manufacture, quarrying or extraction, and be given sufficiently in advance as to enable the Engineer to make arrangements which he may deem necessary for inspection before the start and at any stage of the work, and not only when the units or parts are completed. Work off Site shall not commence without the prior approval of the Engineer.

Any units or parts which are prepared or manufactured without such prior notice having been given to the Engineer may be rejected if the Engineer considers that this inspection was necessary during the progress of the preparation or manufacture.

1.6.7 Standards

Except where otherwise specified or authorized by the Engineer all materials and workmanship shall conform to the latest edition of the relevant standard specification of the American State Highway and Transportation Officials, Inc. (AASHTO) or of the American Society for Testing Materials (ASTM), Japanese Industrial Standard (JIS) and Thai Industrial Standard current (TIS) at the date of invitation to Bidders.

Where reference is made to any of the above standard specifications in imperial units the nearest unit of imperial dimension to the metric dimension quoted in the Drawings or Specifications shall apply.

Materials meeting other internationally accepted equal to better standards may be accepted subject to review by the Engineer. Any such alternative standard proposed by the Contractor shall be submitted in the English language for approval by the Engineer.

The Contractor shall supply the Engineer three sets of each standards, codes and references to be used in the Contract within 45 days of the Commencement Date of the Works, and in addition he shall supply three sets of copies of any other standard or code subsequently specified or alternative proposed. One set of these documents is for the Engineer's laboratory. All standards shall be in English. On completion of the contract all standards, codes and references so provided shall become the property of the Employer.

1.6.8 Proprietary Products

Where the proprietary or brand name or the name of the supplier or the manufacture's is indicated on the Drawings or in the Specification this is in respect of items which are not otherwise adequately described by ASTM, AASHTO, JIS, TIS or equivalent recognised standards. Alternative items based on recognised national standards of country of origin may be accepted provided that document proof in the English language is submitted to the Engineer for his approval sufficiently in advance and showing that the alternative proposal is of equal or higher quality and performance than the specified item.

1.6.9 Materials to be New

All materials used in the permanent works shall be new unless otherwise specified or agreed by the Engineer in writing. No materials to be incorporated in the permanent work shall have previously been used in the temporary works unless otherwise specified or agreed by the Engineer in writing.

1.6.10 Orders for Materials

Before orders are placed for any materials of any description to be used in the permanent works, the Contractor shall submit to the Engineer the names and address of the manufacturers or suppliers proposed. Following approval by the Engineer, the Contractor shall submit to him copies of all orders placed for such materials.

1.6.11 Samples

In accordance with the provisions of Clause 36 of the Conditions of Contract, the Contractor shall as directed by the Engineer supply samples of materials to be incorporated in the Works. The samples required for approval shall be submitted by the Contractor in labeled boxes suitable for storage, and in sufficient time for testing, due allowance being made for the fact that if samples are rejected, further samples and testing will be required. Approved samples will be kept by the Engineer who will reject any materials not corresponding in character and quality with the approved samples.

1.6.12 Certificates

All manufacturer's certificates of test, proof sheets, mill sheets etc., showing that the material have been tested in accordance with the requirements of the relevant AASHTO, ASTM, JIS, TIS or other approved standard or this Specification, shall be supplied in the English language by the Contractor to the Engineer free of charge.

1.7 ENGINEER'S AND EMPLOYER'S REQUIREMENTS

1.7.1 General

All the requirements of the Engineer and Employer shall be provided by the Contractor in a timely manner to program agreed and approved by the Engineer. In this respect the Contractor shall submit detailed proposals for the provision of all requirements as an annex to the program to be submitted under Clause 14 of the Conditions of Contract.

The Contractor shall note that the Engineer's and the Employer's requirements set out in detail in this Section and those for this Contract (Package 2).

1.7.2 Attendance

The Contractor shall provide qualified laboratory technicians, drivers, labourers, watchmen and office cleaning labour and other attendance for the sole direction of the Engineer and the Employers and their respective staff as scheduled in this Section of the Specification. The Contractor shall supply capable personnel equal to the tasks required, maintain continuity of staff, and provide such overtime as may be required by the Engineer or on the site until the issuance of the Taking-

Over Certificate. Some of these staff must have an acceptable proficiency in the English language.

1.7.3 Removal of Buildings on Completion

The Contractor shall obtain permission from the Engineer before the removal or demolition of any buildings, installation, furnishings, fittings or anything provided, installed or constructed under the provisions this Section of the Specification.

Upon Completion of the Works, the Contractor shall remove and clear away from the site all buildings, installations, furnishings, fittings, everything provided, installed or constructed under the provisions of this Section of the Specification unless otherwise stated in the Contract or directed by the Engineer.

1.8 ENGINEER'S LABORATORY

1.8.1 General – Production Control Testing

The laboratory for Package 1 in Free Construction Zone will be used by the Engineer common use for the works in Package 1A, 2 (Lao PDR) side.

1.8.2 Personnel

The Contractor shall employ a suitably qualified experienced Materials Engineer proficiency in the English language throughout the Contract to take primary responsibility for formulation and implementation of the Contractor's Quality plan described in Section 1.6.1. He shall be responsible for liasoning and coordinating with the Engineer, Engineer's laboratory, field sampling/testing staff and off-site laboratories to ensure all sampling, specified tests and inspections are carried out in a timely manner.

The Contractor shall provide following number of drivers, suitably experienced and capable laboratory technicians and labourers to assist the Engineer with the taking of samples and testing. Some of these staff must have an acceptable proficiency in the English language.

- **1 Nos. Drivers**
- **1 Nos. Laboratory Technicians**
- **2 Nos. Labourers**

1.9 TEMPORARY WORKS

1.9.1 General

1.9.1.1 Description

This work shall consist of the construction and removal of temporary facilities which are generally designed by the Contractor and employed by the Contractor in the execution of the work and whose failure to perform properly could adversely affect the character of the contract work or endanger the safety of adjacent facilities, property, or the public. Such facilities include, but are not limited to, falsework, forms and form travelers, cofferdams, shoring, water control systems, and temporary bridges and deck.

The following publications are useful reference documents in the preparation of specifications for the design, review and inspection of temporary works :

Synthesis of Falsework, Formwork, and Scaffolding for Highway Bridge Structures, November 1991, (FHWA-RD-91-062).

Guide Standard Specifications for Bridge Temporary Works, November 1993, (FHWA-RD-93-031).

Guide Design Specification of Bridge Temporary Works, November 1993, (FHWA-RD-93-032).

Certification Program for Bridge Temporary Works, November 1993, (FHWA-RD-93-033).

Construction Handbook for Bridge Temporary Works, November 1993, (FHWA-RD-93-034).

1.9.1.2 Working Drawings / Calculations

Whenever specified or requested by the Engineer, the Contractor shall 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. When concrete is involved, such data shall include the sequence and rate of placement. Sufficient copies shall be furnished to meet the needs of the Engineer and other entities with review authority. The working drawings shall be submitted 30 days in advance of their proposed use to allow for their review, revision, if needed, and approval without delay to the work.

The Contractor shall not start the construction of any temporary work for which working drawings are required until the drawings have been approved by the Engineer. Such approval will not relieve the Contractor of responsibility for results obtained by use of these drawings or any of his other responsibilities under the Contract.

1.9.1.3 Design

The design of temporary works, including allowable stresses, shall conform to an established and generally accepted design code or specification for such work. When manufactured devices are to be employed, the design shall not result in loads on such devices in excess of the load ratings recommended by their manufacturer.

When required by statute or specified, the design shall be prepared and the drawings shall be signed by a Registered Engineer.

1.9.1.4 Construction

Temporary works shall be constructed in conformance with the approved working drawings. The Contractor shall verify that the quality of the materials and workmanship employed are consistent with that assumed in the design.

Necessary permission from the respective authorities for the temporary facilities construction shall be taken under the responsibility of the Contractor.

1.9.1.5 Removal

Unless otherwise permitted, all temporary works shall be removed and shall remain the property of the Contractor upon completion of their use. The area shall be restored to its original or planned condition and cleaned of all debris.

1.9.2 Falsework and Forms

1.9.2.1 General

Falsework is considered to be any temporary structure which supports structural elements of concrete, steel, masonry, or other materials during their construction or erection. Forms are considered to be the enclosures or panels which contain the fluid concrete and withstand the forces due to its placement and consolidation. Forms may in turn be supported on falsework. Form travelers, as used in segmental cantilever construction, are considered to be a combination of falsework and forms.

Whenever the height of falsework exceeds 4 meter or whenever traffic, other than workmen involved in constructing the bridge, will travel under the bridge, the working drawings for the falsework shall be prepared and sealed by a registered engineer.

Falsework and forms shall be of sufficient rigidity and strength to safety support all loads imposed, and produce in the finished structure the lines and grades indicated on the plans. Forms shall also impart the required surface texture and rustication, and shall not detract from the uniformity of color of formed surfaces.

1.9.2.2 Falsework Design and Construction

(a) Loads

The design load for falsework shall consist of the sum of dead and live vertical loads, and any horizontal loads.

As a minimum, dead loads shall include the weight of the falsework and all construction material to be supported. The combined weight of concrete, reinforcing and prestressing steel and forms shall be assumed to be not less than 2,500 kilogrammes per cubic meter of normal weight concrete.

Live loads shall consist of the actual weight of any equipment to be supported applied as concentrated loads at the points of contact and a uniform load of not less than 100 kilogrammes per square meter applied over the area supported, plus 110 kilogrammes per lineal meter applied at the outside edge of deck overhangs.

The horizontal load used for the design of the falsework bracing system shall be the sum of the horizontal loads due to equipment, construction sequence, including unbalanced hydrostatic forces from fluid concrete, stream flow when applicable, and an allowance for wind. However, in no case shall the horizontal load to be resisted in any direction be less than 2 percent of the total dead load.

For post-tensioned structures, the falsework shall also be designed to support any increased or redistribution of loads caused by prestressing of the structure.

Loads imposed by falsework onto existing, new or partially completed structures shall not exceed those permitted in Section 5.1.14, "Application of Loads".

(b) Foundations

Falsework shall be founded on a solid footing safe against undermining, protected from softening, and capable of supporting the loads imposed on it. When

requested by the Engineer, the Contractor shall demonstrate by suitable load tests that the soil bearing values assumed for the design of the falsework footings do not exceed the supporting capacity of the soil.

Falsework which cannot be founded on a satisfactory footing shall be supported on piling which shall be spaced, driven, and removed in an approved manner.

(c) Deflections

For cast-in-place concrete structures, the calculated deflection of falsework flexural members shall not exceed 1/240 of their span irrespective of the fact that the deflection may be compensated for by camber strips.

(d) Clearances

Unless otherwise provided, the minimum dimensions of clear openings to be provided through falsework for roadways which are to remain open to traffic during construction shall be at least 1.5 meter greater than the width of the approach traveled way, measured between barriers when used, and 4 meter high, except that the minimum vertical clearance over highways shall be 4.5 meter.

(e) Construction

Falsework shall be constructed and set to grades which allow for its anticipated settlement and deflection, and for the vertical alignment and camber indicated on the plans or ordered by the Engineer for the permanent structure. Variable depth camber strips shall be used between directed by the Engineer.

Suitable screw jacks, pairs of wedges or other devices shall be used at each post to adjust falsework to grade, to permit minor adjustments during the placement of concrete or structural steel should observed settlements deviate from those anticipated, and to allow for the gradual release of the falsework. Tell-tales attached to the forms and extending to the ground, or other means, shall be provided by the Contractor for accurate measurement of falsework settlement during the placing and curing of the concrete.

Falsework or formwork for deck slabs on girder bridges shall be supported directly on the girders so that there will be no appreciable differential settlement during placing of the concrete. Girders shall be braced and tied to resist any forces that would cause rotation or torsion in the girders caused by the placing of concrete for diaphragms or deck. Welding of falsework support brackets or braces

to structural steel members or reinforcing steel will not be allowed unless specifically permitted.

1.9.2.3 Formwork Design and Construction

(a) General

Forms shall be of wood, steel, or other approved material and shall be mortar tight and of sufficient rigidity to prevent objectional distortion of the formed concrete surface due to pressure of the concrete and other loads incidental to the construction operations.

Forms for concrete surfaces exposed to view shall produce a smooth surface of uniform texture and color substantially equal to that which would be obtained with the use of plywood conforming to the National Institute of Standards and Technology Product Standard PSI of Exterior B-B Class I Plywood. Panels lining such forms shall be arranged so that the joint lines form a symmetrical pattern conforming to the general lines of the structure. The same type of form lining material shall be used through out each element of a structure. Such forms shall be sufficiently rigid so that the undulation of the concrete surface shall not exceed 3mm when checked with a 1.5m long straightedge or template. All sharp corners shall be filleted with approximately 20mm chamfer strips.

Concrete shall not be deposited in the forms until all work connected with constructing the forms has been completed, all debris has been removed, all materials to be embedded in the concrete have been placed for the unit to be cast, and the Engineer has inspected the forms and materials.

(b) Design

The structural design of formwork shall conform to ACI Standard, "Recommended Practice for Concrete Formwork," (ACI 347) or some other generally accepted standard. In selecting the hydrostatic pressure to be used in the design of forms, consideration shall be given to the maximum rate of concrete placement to be used, the effects of vibration, the temperature of the concrete and any expected use of set-retarding admixtures in the concrete mix.

(c) Construction

Forms shall be set and held true to the dimensions, lines and grades of the structure prior to and during the placement of concrete. Forms may be given a bevel or draft at projections, such as copings, to ensure easy removal. Prior to

reuse, forms shall be cleaned, inspected for damage and, if necessary, repaired. When forms appear to be defective in any manner, either before or during the placement of concrete, the Engineer may order the work stopped until defects have been corrected.

Forms shall be treated with form oil or other approved release agent before the reinforcing steel is placed. Material which will adhere to or discolor the concrete shall not be used.

Except as provided herein, metal ties or anchorages within the forms shall be so constructed as to permit their removal to a depth of at least 25mm from the face without injury to the concrete. Ordinary wire ties may be used only when the concrete will not be exposed to view and where the concrete will not come in contact with salts or sulfates. Such wire ties, upon removal of the forms, shall be cut back at least 6mm from the face of the concrete with chisels or nippers; for green concrete, nippers shall be used. Fittings for metal ties shall be of such design that, upon their removal, the cavities that are left will be of the smallest possible size. The cavities shall be filled with cement mortar and surface left sound, smooth, even, and uniform in color.

For narrow walls and columns, where the bottom of the form is inaccessible, an access opening shall be provided in the forms for cleaning out extraneous material immediately before placing the concrete.

(d) Tube Forms

Tubes used as forms to produce voids in concrete slabs shall be properly designed and fabricated or otherwise treated to make the outside surface waterproof. Prior to concrete placement such tubes shall be protected from the weather and stored and installed by methods that prevent distortion or damage. The ends of tube forms shall be covered with caps that shall be made mortar tight and waterproof. If wood or other material that expands when moist is used for capping tubes, a premolded rubber joint filler 6mm in thickness shall be used around the perimeter of the caps to permit expansion. A PVC vent tube shall be provided near each end of each tube. These vents shall be constructed to provided positive venting of the voids. After exterior form removal, the vent tube shall be trimmed to within 10mm of the bottom surface of the finished concrete.

Anchors and ties for tube forms shall be adequate to prevent displacement of the tube during concrete placement.

(c) Stay-in-Place Forms

Stay-in-place deck soffit forms, such as corrugated metal or precast concrete panels, may be used if shown on the plans or approved by the Engineer. Prior to the use of such forms the Contractor shall provide a complete set of details to the Engineer for review and approval. The detailed plans for structures, unless otherwise noted, are dimensioned for the use of removable forms and any changes necessary to accommodate stay-in-place forms, if approved, shall be at the expense of the Contractor.

1.9.2.4 Removal of Falsework and Forms

(a) General

Falsework or forms shall not be removed without approval of the Engineer. In the determination of the time for the removal of falsework and forms, consideration shall be given to the location and character of the structure, the weather, the materials used in the mix, and other conditions influencing the early strength of the concrete.

Methods of removal likely to cause overstressing of the concrete or damage to its surface shall not be used. Supports shall be removed in such a manner as to permit the structure to uniformly and gradually take the stresses due to its own weight. For arch structures of two or more spans, the sequence of falsework release shall be as specified or approved.

(b) Time of Removal

If field operations are not controlled by beam or cylinder tests, the following minimum periods of time, exclusive of days when the temperature is below 5°C, shall have elapsed after placement of concrete before falsework is released or forms are removed in principle :

Falsework for :

Spans over 4 meters	14 days
Spans of 4 meters or less	10 days

Forms :

Not supporting the dead weight of the concrete	24 hours
For interior cells of box girders and for railings	12 hours

If high early strength is obtained with Type III cement or by the use of additional cement, these periods may be reduced as directed.

When field operations are controlled by cylinder tests, the removal of supporting forms or falsework shall not begin until the concrete is found to have the specified compressive strength, provided further that in no case shall supports be removed in less than 7 days after placing the concrete.

In addition to the above time requirements :

Forms shall not be removed until the concrete has sufficient strength to prevent damage to the surface.

Falsework for post-tensioned portions of a continuous or rigid frame bridge shall not be released until the aforementioned requirements have been satisfied for all of the structural concrete in that span and in the adjacent portions of each adjoining span for a length equal to at least one-half the length of the span where the falsework is to be released.

Unless otherwise specified or approved, falsework shall be released before the railings, copings or barriers are placed for all types of bridges.

(c) Extent of Removal

All falsework and forms shall be removed except :

- Portions of driven falsework piles more than 300mm below subgrade within roadbeds, or 600mm below the original ground or finished grade outside of roadbeds, or 600mm below the established limits of any navigation channel.
- Footing forms where their removal would endanger the safety of cofferdams or other works.
- Forms from enclosed cells where access is not provided.
- Deck forms in the cells of box girder bridges that do not interfere with the future installation of utilities shown on the plans.

1.9.3 Temporary Road

1.9.3.1 General

This work shall consist of all temporary roads for the construction both inside and outside of Free Construction Zone, maintenance of ongoing traffic and the

protection of travelling public approaching, crossing and passing the construction area.

The work shall include construction of temporary road, furnishing, installing and maintaining necessary fences, traffic signs, barricades, lights, signals, cones, warning devices, temporary bridges, bypasses and approaches and all equipment, materials and personnel required to maintain the travelled way in a passable condition and promote the safe conduct of public and private vehicles around and through the construction area.

1.9.3.2 Materials

All materials and traffic control devices shall be of strong and durable quality and shall be suitable to the requirements of the Specifications and of the Engineer. Temporary roadways, bridges and embankments shall be of suitable materials and construction so as to safely handle anticipated loads and to remain operational through all seasons of the year until such time that temporary traffic for the construction work does not require temporary roads, and that existing roads are restored to its original location and shape so that detours are closed and removed.

1.9.3.3 Construction Requirements

The Contractor shall maintain the free movement of all traffic on and around the temporary roads. If the Contractor so elects, he may, with the approval of the Engineer, construct and maintain detours to bypass public traffic in lieu of maintaining such traffic crossing the construction area.

Where detour is necessary, the Contractor shall submit to the Engineer a detailed program of the various stages of construction and details of the arrangement for directing the traffic at least two weeks prior to the need for the detour.

Where access or detour roads are situated outside the right-of-way, the Contractor shall, at his own expense, make all necessary arrangements with the land owners for permission to build and/or use and maintain such roads.

Where the Works interfere with existing roads and structures, the Contractor shall construct and maintain temporary travelled detour roads and ensure that any traffic passing the existing road can also pass such detour roads in complete safety and without difficulty.

Temporary detour roads shall be constructed as proposed by the Contractor and as approved by the Engineer.

Ongoing approach roads shall be recovered to its original location and shape by the Contractor to the approval of the Engineer when relating activities are completed.

Upon completion of the Work, all temporary roads and detour roads, access roads and structures, including piles above ground and riverbeds, shall be completely removed and approach ramps for temporary bridges shall be levelled. All materials shall be removed from the right-of-way or spread on the neighbouring ground if agreed by the Engineer, and due care shall be taken that no materials are spilled into streams or rivers.

The Contractor shall provide and maintain temporary barricades and warning signs in accordance with the provisions of local laws.

Where needed, the Contractor shall provide personnel for directing traffic and maintaining barricades and warning signs at all hours during the day or night in case so directed by the Engineer.

Construction operations shall be so scheduled that interference with the normal movement of traffic is minimized.

In cases of serious or willful disregard for safety of the public or his employees by the Contractor, the Engineer may proceed forthwith to place the traffic control measures in proper condition and deduct the cost thereof from monies due or becoming due the Contractor.

It shall be the Contractor's responsibility to clean up any spilled material and to repair any damage to existing roads caused by his construction equipment outside or within the right-of-way limits.

All flagmen, signs, barricades, cones and warning devices shall be in accordance with the local practice; laws and the approval of the Engineer.

For this project, maintenance of all traffic, temporary detours and access roads will not be paid for separately but will be considered incidental to the works.

PART 2 CIVIL WORKS

SECTION 2 : EARTHWORK

2.1 CLEARING & GRUBBING

2.1.1 Description

This work shall consist of all clearing and grubbing necessary for the performance of the work covered by the Contract in accordance with these Specifications.

The clearing and grubbing shall consist of clearing the designated areas of all trees, fallen timber, snags, vegetation, rubbish and objectionable material and shall include grubbing stumps and roots and disposing of all material resulting from the clearing or grubbing. It shall also include the demolition, removal and disposal of all structures that obtrude into or encroach upon or obstruct the work except where provided for otherwise.

Disposal of debris and foundations remaining after removal of houses or other structures is considered to be included in the unit rates for clearing and grubbing and no further payment will be made under this section.

Also included in this work shall be the removal of loose pavement material, road signs, right-of-way markers, kilometer stones, guide posts and all other incidentals within the limits of construction. These items shall be removed, if so instructed by the Engineer, outside of the construction limits but within the proposed right-of-way. The Contractor shall exercise care so as not to damage these incidental items during the removal operation. All signs, markers and incidentals removed from the limits of the construction works shall be stacked in neat piles so they may be collected by the Employer and will become the property of the Employer.

2.1.2 Preservation of Property

Attention is directed to the Contractor's obligations under law and under this Contract with regard to damage, particularly with regard to protection of property, forest, and landscape and to responsibility for damage claims.

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

In order to reduce the risk of erosion no topsoil shall be removed from the areas outside the limits of earthworks. Any topsoil outside these limits, which is inadvertently removed during clearing and grubbing operations or otherwise, shall immediately be replaced by the Contractor at his own expense.

Outside the limits of the construction works, certain trees or plants shall be left undisturbed, if so instructed by the Engineer, for ecological purposes. These trees or plants that are not to be removed shall be protected from injury or damage resulting from the Contractor's operations.

2.1.3 Construction Methods

2.1.3.1 General

Clearing and grubbing shall be performed on the areas designated by staking or on the Drawings or in the other contract documents. If no areas are designated on the Drawings or in the other contract documents, the areas to be cleared and grubbbed will be as directed by the Engineer.

2.1.3.2 Clearing

Clearing shall consist of the removal and disposal of everything above ground level including overhanging branches except those things the Engineer directs are to be left undisturbed. The material to be cleared shall include but not necessarily be limited to trees, stumps, logs, brush, undergrowth, grass crops, loose vegetable matter and structures. The contractor shall demolish and remove, if so instructed by the Engineer, houses and buildings left within the limits of earth work.

Outside the limits of the earth works, and under embankments more than 1.5 meters in height, trees and stumps shall be cut to a level not more than 30 centimeters above ground level and not less than 45 centimeters below the embankment slopes. Everything else shall be removed to ground level.

In cut areas clearing shall include the removal of stumps and roots exceeding 8 centimeters in diameter, to a depth of 45 centimeters below the finished surface except that in rounding areas at the tops of cut slopes they may be cut flush.

2.1.3.3 Grubbing

Grubbing shall be carried out on the area of embankment foundations where the embankment height is less than 1.5 meters. Grubbing shall consist of the removal and disposal of topsoil, stumps, roots, etc., to a 15cm below ground level.

Materials thus removed may be used as topsoil for slope protection if they, in the opinion of the Engineer, are suitable for this. If so, they will be measured and paid for in accordance with Section 6.8 "Top Soil" of these Specifications, but removal and replacement of such material shall be considered incidental to clearing and grubbing and will not be measured for payment. Materials not used as topsoil shall be disposed of at locations as directed by the Engineer.

Materials under original ground level within embankment areas which are removed during the operation of the clearing and grubbing, shall be replaced by acceptable fill materials which shall be compacted to the density as required in section 2.6 "Embankment" of these Specifications. Such removal and replacement of materials is considered incidental to the works of clearing and grubbing and will not be measured for payment, except in cases where the Engineer has issued a written instruction to the effect that materials deemed unsuitable by him shall be removed to depths greater than 15 cm from the original ground level, as shown on the checked cross-section sheets. All unsuitable materials shall be wasted and respread at locations specified and in a neat and orderly way as agreed by the Engineer.

Where existing embankment shall be raised or widened, all vegetation and topsoil shall similarly be completely removed from shoulders, slopes and ground under the widening before the operations of actual widening can be commenced.

Where roadway excavations are made, and where ditches, streams and rivers are diverted, all vegetation, roots, stumps and the like shall be completely removed and placed outside the excavation area concerned before the excavation works proper can be commenced.

At all remaining areas inside the right-of-way, the works of clearing and grubbing shall, unless otherwise instructed by the Engineer, include the levelling of obsolete dikes, terraces and ditches, the neat and complete removal of all remnants from structures and buildings, roots, stumps, untidy vegetation, rubbish, garbage and the like, to such an extent that these matters will not, in the opinion of the Engineer, obstruct future maintenance.

2.1.3.4 Ownership of Timber

The Contractor shall have the right to use unsaleable timber (or saleable timber when permission is granted in writing by the appropriate Government agency or authority) 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 authority.

2.1.3.5 Disposal of Cleared Material

Saleable timber shall be neatly stored in an approved accessible place within or near the right of way as directed and shall be trimmed and stacked in accordance with the requirements of the appropriate Government agency.

All other timber except timber to be used and all brush, stumps, roots, logs, and other refuse from the clearing and from the grubbing operations shall be burned, provided that, when permitted in writing by the authority having jurisdiction over the area through which the construction works are being carried out under this contract, large stumps may be disposed of without burning at locations out of sight of the road way and other facilities.

Likewise, large stumps may, with the Engineer's approval, be disposed of without burning on private land out of sight of the roadway. In such cases the Contractor will be solely responsible for making the necessary agreements and paying expenses and claims arising from the use of private land.

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 or other vegetation shall occur.

Should the burning precede the construction operations, the material piles may be placed in the centre of the right of way; otherwise the material piles shall be placed in the most convenient location at the side of the right of way and beyond the slope line where they may be burned without damage to the surrounding trees or adjacent property. All burning shall be done in conformance with regulations and at such times and in such manner as to prevent the fire from spreading to areas adjoining the right of way.

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 within the embankment limits and burn it.

All fences, buildings, structures, and encumbrances of any character, except those to be removed by others, upon or within the limits of the right of way, shall be removed by the Contractor and carefully placed on the abutting property or otherwise disposed of as indicated on the drawings or as directed by the Engineer. Materials so removed, including any existing drain or culvert pipes which the Engineer may order salvaged, shall by carefully removed and shall be the property of the Government.

The construction area shall be left with a neat and finished appearance. No accumulation of inflammable material shall remain on or adjacent to the right of way.

2.1.4 Measurement

Clearing and grubbing will be paid for together as one item on a per square meter basis. 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 and grubbing and the Contractor is permitted to exercise his own option as to whether he elects to use such disposal sites or borrow pit sites. All areas to be measured for payment shall have been approved by the Engineer prior to clearing and grubbing operations.

Ditches, streams, ponds and depressions in the embankment areas shall be properly cleared prior to being measured for payment of embankment quantities to be placed as fill. Material for such fill shall be placed and compacted to the requirements as specified in Section 2.6 "Embankment" of these Specifications and payment will be made as embankment fill

2.1.5 Payment

This work, measured as provided above, shall be paid for at the Contract unit price per square meter for clearing and grubbing, which price shall be full compensation for furnishing all labor, materials, tools, equipment and incidentals necessary to do the work as well as the removal, transport and satisfactory disposal of all resulting materials in accordance with these Specifications or at the direction of the Engineer.

Payment will be as follows:

Item No	Description	Unit
2.1(1)	Clearing and Grubbing	square meter

2.2 COMMON EXCAVATION

2.2.1 Description

The work shall consist of all the required excavation within the limits of the right of way except excavation specified in other sections of this Specification; the removal, hauling and proper utilization or disposal of all excavated materials and the shaping of excavation and preparation of exposed surfaces of excavation on the entire construction area, in accordance with these Specifications and the lines, levels, grades, dimensions and cross sections shown on the Drawings and as directed by the Engineer.

In addition to the requirements of Section 2.2.1, common excavation shall also include all ditch and temporary channel excavation.

2.2.2 Materials - Classification and Selection

2.2.2.1 General

Common excavation shall be classified according to the definitions given below for rock and earth. Rock excavation shall consist of igneous, metamorphic and sedimentary rock which cannot be excavated without blasting or the use of rippers or breaker, and all boulders or other detached stones each having a volume of 0.75 cubic meters or more as determined by the physical measurements or visually by the Engineer. Rock excavation shall be classified as two types; soft rock or hard rock.

2.2.2.2 Classified Excavation

Common excavation classified as "earth" shall include all excavation except that classified as hard rock or soft rock.

Common excavation classified as "soft rock" shall include all excavation, except that classified as hard rock or earth, which can be excavated by a track-type tractor with drawn rippers which will loosen the material sufficiently to permit

removal of the material. The tractor shall be of a type similar to a Caterpillar model D6D or D7G with a horse power rating between 140 and 200 at 2000 RPM, and with an operating weight between 14 and 24 metric tons. The ripping unit shall be a single shank hydraulic adjustable or a multi-shank ripper connected through a parallelogram linkage of the most efficient type as recommended by the tractor manufacturer. Soft rock shall be residual rock altered by physical and chemical processes to the extent that it is decomposed, disintegrated, fractured, loosely laminated or jointed, but retains sufficient strength to necessitate ripping. No alluvial or wind blown or transported soils, nor gravels, nor clays which soften when wet shall be classified as soft rock.

Common excavation classified as "hard rock" shall include only roadway excavation which cannot be ripped with the equipment as specified above and which can only be removed with the use of blasting, a hydraulic breaker or pneumatic tools.

The Engineer will make the final decision in the event a dispute occurs between the Contractor and the Engineer as to the classification of the excavation measured for payment.

2.2.2.3 Unsuitable Materials

Material encountered in cut areas and in the foundation of the road embankment that is unsuitable for the road embankment shall be excavated and used in embankment outside the road embankment or disposed of as directed by the Engineer. Backfill as necessary shall be with approved material.

Normally, highly organic clays and silts, peat, soils containing large amounts of roots, grass and other vegetable matter are considered to be unsuitable. Materials that are soft or unstable merely because they are too wet or dry are not to be classified as unsuitable unless otherwise directed by the Engineer.

The disposal of unsuitable material may include, but not necessarily be limited to, the following:

a) Used for filling-in ditches and channels not required in the Works outside of the earthwork limits.
b) Filling-in of holes, depressions, ponds, etc. outside of the earthwork limits.
c) Spread evenly in layers in stockyards or other locations where so directed by the Engineer.

d) Removal and haulage to disposal sites outside of the right-of-way.

The Contractor shall take all necessary precautions to prevent any interference with natural drainage or irrigation flow during the operation of disposing of unsuitable material.

All unsuitable material removed from below the ground surface after clearing and grubbing has been performed shall be measured and paid for. The Engineer shall specify the levels to which unsuitable materials are to be excavated.

2.2.2.4 Suitable Materials

All materials from excavation shall be used in road embankment if the materials can meet the requirements as specified in these Specifications.

2.2.3 Construction Methods

2.2.3.1 All excavation and embankment construction shall be performed as specified herein and in Section 2.6 "Embankment" conforming to the required alignment, levels, grades, and cross sections.

Unless otherwise indicated on the Drawings, excavation in solid rock shall extend 20 centimeters below the required subgrade elevation for the entire roadway width and yard pavement or 20cm below the required finished grade for other land grading area. The excavated area shall be backfilled with suitable materials as indicated on the Drawings or as directed by the Engineer.

Where provided for on the Drawings topsoil encountered in excavations shall be removed to such a depth as the Engineer may direct. The topsoil shall be removed and stored in piles at locations designated by the Engineer in accordance with the requirement of Section 6.8 "Topsoil".

2.2.3.2 All suitable excavated materials shall be used for the embankment of roadway and yard pavement.

Material thus used for the embankment shall be placed and compacted in the embankment area to meet the requirements specified in Section 2.6. "Embankment", of this specification.

2.2.3.3 Unsuitable material shall be excavated below subgrade level in cut and below embankment foundation level to the depth shown on the Drawings or directed by the Engineer. Where unsuitable material is excavated below the normal subgrade level or below embankment foundations or for benching under embankments the excavation shall be back filled with material and in a manner that conforms with Section 2.6 "Embankment".

2.2.3.4 All slopes shall be finished in a neat and workmanlike manner and to an accuracy appropriate to the material, and care shall be taken that no material is loosened below the required slopes. Breakages and slides shall be removed and disposed of as directed.

2.2.3.5 In cut areas, the top of the subgrade on which selected material or subbase or shoulder is to be placed shall be processed as necessary and compacted to a minimum depth of 15 centimeters to not less than 95% of the maximum dry density of the material as determined by AASHTO Test Method T-99-74. This work shall not be measured for payment but will be considered to be included in the unit price for common excavation.

2.2.4 Measurement

All required and accepted excavation shall be measured in its original position and the volume determined in cubic meters by the average end area method as computed from the checked cross sections specified in Section 1.3.1 in this specification and final cross sections of the required and completed work. Messurement of rock excavated below subgrade level as required in Section 2.2.3 "Construction Methods" shall be computed on the basis of excavation to the specified minimum depth below subgrade level only and no overbreak shall be included.

The contractor shall schedule his work so that the Engineer may make adequate field surveys to determine the classification of excavation being removed. The Contractor shall notify the Engineer at least 24 hours in advance of the need for survey measurement.

Excavation of temporary channel relocations at drainage structures, shall not be measured for payment. All temporary channel excavation shall be backfilled to the satisfaction of the Engineer upon completion of the drainage structure.

2.2.5 Payment

The quantities of roadway excavation measured as specified above will be paid for at the contract unit prices per cubic meter for the various types as detailed below. Such prices shall include excavation, removal, haulage and satisfactory disposal of all roadway excavation, for shaping, dressing and completion of all surfaces and for furnishing all labor, materials, tools, equipment and incidentals to complete the work.

In case excavation material is used for embankment, the prices for the excavation shall include all works required for the embankment construction and no separate payment for the embankment shall be made.

The above prices and payment shall be full compensation for all work involved in performing the roadway excavation completely as shown on the Drawings and specified in these Specifications and as directed by the Engineer.

Interim payment may be made on measured volumes of the required excavation actually executed, before final shaping, provided the Contractors intention to complete the work is clear. Measured Roadway Excavation shall include excavation for removal of slides, breakages and cave-ins except where caused by carelessness or improper methods by the Contractor.

Payment will be made under the following items:

Item No.	Description	Unit
2.2(1)	Excavation and Embankment, Earth	cubic meter
2.2(2)	Excavation, Unsuitable Material	cubic meter
2.2(3)	Excavation and Embankment, Soft Rock	cubic meter
2.2(4)	Excavation and Embankment, Hard Rock	cubic meter
2.5(5)	Excavation, Asphaltic Concrete Pavement	cubic meter

2.3 BORROW

2.3.1 Description

This work shall consist of the clearing and stripping of borrow pits, the excavating and hauling of materials obtained from approved sources using the material from

borrow pits for constructing embankment, back fill, subgrade, shoulders and other parts of the work as required by the Contract or by the Engineer.

This section applies to borrow pits outside the right of way. Borrow pits within the right of way are not allowed.

2.3.2 Acquisition and Use of Borrow Pits

The Contractor shall open borrow pits outside the right of way and shall be fully and solely responsible for the expenses incurred and any legal consequences.

The Contractor shall take all necessary precautions to prevent erosion or other damage that may affect or endanger the embankment and any ground neighbouring borrow pits or side borrow.

The Contractor shall undertake all the work of removing and stockpiling topsoil, overburden and unsuitable materials extracted from borrow pits. All such Works shall be considered incidental to other items of work for which the borrow material is used and will not be paid for separately.

2.3.3 Construction Methods

2.3.3.1 All suitable materials removed from borrow sources shall be used as indicated on the Drawings or as directed by the Engineer. During construction the borrow pits shall be kept drained as far as practicable and the work shall be executed in a neat and workmanlike manner.

2.3.3.2 Sites of the borrow operations shall be left in a suitable and neat condition such as to provide proper drainage where required.

2.3.3.3 On completion of the excavation of borrow pit material, the Contractor shall leave the borrow pit in a neat and tidy condition with side slopes not steeper than 3 horizontal to 2 vertical and the bottom to an even and smooth surface. Where borrow pits are required to be drained, the Contractor shall complete this work at his own expense in a manner approved by the Engineer.

2.3.4 Measurement and Payment

Borrow shall not be measured. No payment will be made to the Contractor for borrow. All expenses related to borrow pits shall be included in the items of other

work in which the borrow material is used and payment under the items which include all expenses of borrow pit shall be full compensation for the cost of searching for and finding borrow pits, for acquiring the right to occupy the sites and extract material, for the cost of any negotiation in connection with borrow pits, for the cost of obtaining right of access, for the cost of establishing and maintaining access, for any fees, licences, or royalties in connection with borrow pits, for clearing, grubbing, sloping, draining and cleaning up of pits, for furnishing hauling and excavation material from borrow pits and for all labour, materials, tools, equipment and incidentals necessary to complete the work.

2.4 CHANNEL EXCAVATION

2.4.1 Description

This work shall consist of excavation for channels both inside and outside the right of way where shown on the Drawings or directed by the Engineer. The work shall include the proper utilization and hauling or disposal of all excavated materials, constructing, shaping and finishing all earthwork involved in conformity with the required alignment, levels, grades and cross section.

2.4.2 Materials

Materials excavated shall be classified. If the Contract documents indicate classified material the classification shall be as laid down in Section 2.2 Excavation.

2.4.3 Construction Methods

All suitable materials removed from the excavation shall be used as far as practicable in the formation of embankments as specified under the items for embankment or shall be other wise properly utilized or disposed of as required on the Drawings or by the Engineer.

During construction the channel shall be kept drained as far as practicable and the work shall be constructed in a neat and workmanlike manner.

The channel shall be excavated to the alignment, levels, grades and cross sections required on the Drawings or by the Engineer. Excavation beyond the limits required shall not be paid for.

2.4.4 Measurement

When not specified in the Special Provisions or on the Drawings, channel excavation shall be classified and measured as specified in Section 2.2 "Common Excavation".

Quantities of channel excavation shall be measured in cubic meters determined by average end area methods computed based on the checked cross section sheets as measured in Section 1.3.1 and final cross sections of the authorized and completed excavation.

2.4.5 Payment

The work measured as provided above shall be paid for at the Contract unit prices per cubic meter as detailed below. The payment shall be full compensation for all excavation, hauling, backfilling old channels or otherwise properly using or disposing of material, for establishing and maintaining access to the channel and for all labour, materials, tools, equipment and incidentals necessary to complete the work.

In case excavation material is used for embankment, the prices for the excavation shall include all works required for the embankment construction and no separate payment for the embankment shall be made.

Interim payments may be made on measured volumes of required excavation actually executed, before final completion of shaping, provided the Contractor's intention to complete the work is clear.

Payment will be made under the following items :

Item No.	Description	Unit
2.4(1)	Channel Excavation and Embankment, Earth	cubic meter
2.4(2)	Channel Excavation and Embankment, Soft Rock	cubic meter
2.4(3)	Channel Excavation and Embankment, Hard Rock	cubic meter

2.5 EXCAVATION AND BACKFILL FOR STRUCTURES

2.5.1 Description

This work shall consist of the excavation of structures, including bridge abutments, piers, footings, wingwalls, concrete box culverts; constructing and removing cofferdams and sheeting; pumping, dewatering and bailing, blinding stone, backfilling of completed structures and disposal of excavated material. The work done shall meet the requirements as specified on the Drawings.

2.5.2 Materials

2.5.2.1 Foundation Fill Material

Material for foundation fill shall consist of suitably graded sand, gravel, or stone as shown on the Drawings or required by the Engineer, or concrete as described below.

2.5.2.2 Backfill Material

Backfill shall be approved compactible material. 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 borrow excavation unless otherwise directed by the Engineer.

2.5.2.3 Blinding Stone

Blinding stone for use as a foundation for structures shall be provided as shown on the Drawings or instructed by the Engineer.

The main component of the blinding stone shall be approved cobble-stone or crushed rock, of the maximum size compatible with the thickness of blinding stone as shown on the Drawings. The minimum height of any stone as placed shall be 7cm. Stone shall be closely packed by hand placing to the dimensions shown on the Drawings, and then thoroughly rammed by mechanical rammer. Smaller stone pieces of minimum size 3mm shall then be placed between the larger stones and the upper surface brought up to the finished level shown on the Drawings or instructed by the Engineer. The complete surface shall then be thoroughly compacted to the satisfaction of the Engineer using a mechanical rammer or vibrating roller.

The Contractor may propose an alternative to the above process, based on the used of graded, crushed stone of maximum size less than 5cm. The Engineer's acceptance of this alternative, and the maximum thickness to be laid in one layer will be dependent on the proposed compacting plant and its suitability for the restricted working area available.

2.5.3 Construction Methods

2.5.3.1 Clearing

Prior to starting excavation operations in any area, all necessary clearing and grubbing shall have been performed.

2.5.3.2 Excavation

The Contractor shall notify the Engineer sufficiently in advance of the beginning of any excavation so that cross section elevation and measurement may be taken after clearing and grubbing is completed according to section 1.3.1 in this specification.

Trenches and foundation pits for structures and structure footings and underdrains shall be excavated to the lines, grades and elevation shown on the Drawings or as staked by the Engineer. The elevations of the bottoms of 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 for his verification of the excavation work. No footing, bedding material or structure shall be placed until the Engineer has approved the 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 level or 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 or mucky or 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 that 15 centimeters thick or as directed by the Engineer. The degree of compaction shall be equivalent to that of the surrounding foundations.

All excavation surfaces and surface of backfill material against which concrete is to be placed shall be smooth and firm and true to line and level.

2.5.3.3 Disposal of Excavation Material

All excavated material so far as suitable, shall be utilized as backfill or embankment. The surplus material, shall be finally disposed of in such a manner as required in Section 2.2 "Common Excavation" and not to obstruct the stream nor otherwise impair the efficiency of the appearance of the works nor to endanger the partly finished structure

Excavated material suitable for use as backfill may be deposited by the Contractor in storage piles at points convenient for rehandling 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 facilities, 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 center line and the transverse or hub line of any part of the structure be kept free of obstruction.

2.5.3.4 Cofferdam

(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 dikes, 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 in the price for the temporary work as specified in this specification.

(b) When the drawings indicate cofferdams for the excavation of structures, 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.

(c) The Contractor shall submit upon request Drawings showing his proposed method of cofferdam 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.

(d) 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.

(e) If practicable cofferdams shall be so designed that no cross bracing shall be left in the permanent concrete structure. If this is not practicable bracing left in the permanent concrete structure shall be of new structural steel. The end of such structural members that would be exposed when the structure is completed shall be boxed back at least 15 centimeters behind the concrete face. The resulting holes shall be completely filled with concrete.

(f) In general, sheet piling cofferdams shall extend well below the bottom of the footing as much as practical and shall be well braced and as watertight as practicable.

(g) When foundation piles are to be driven inside a cofferdam and it is judged impracticable to dewater 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.

(h) Where it is possible to dewater the cofferdam the foundation material shall be removed to exact grade after the foundation piles are driven.

(i) Backfilling in a foundationn to compensate for excavation which has been extended below the required grade 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.

Unless otherwise permitted no excavation shall be made outside of cofferdams or sheet piling and any 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 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.

The contractor shall be fully responsible for the stability of the cofferdam during the construction period. Particular attention shall be given to the necessity of restriction of weight of construction equipment working outside of the cofferdam and suitable countermeasures of foundation for these equipment to maintain the stability of the cofferdam. Excavated material shall not be deposited in the vicinity of the cofferdam.

Material deposited within a stream area from foundations or other excavations or from the filling or cofferdams shall be removed and the stream area freed from obstruction.

(j) Cofferdams which tilt or move laterally during construction shall be corrected as necessary at the expense of the Contractor.

(k) Unless otherwise provided cofferdams shall be removed after the completion of the sub-structure. 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.

(l) When conditions are encountered which, in the opinion of the Engineer, render it impracticable to dewater 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 a seal shall be placed as shown in the Drawings or as required by the Engineer. The foundation shall then be dewatered and the footing placed. When weighted cribs are used and the weight is used to overcome partially 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.

Confferdams 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.

2.5.3.5 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 nor for a period of at least 24 hours thereafter unless it is done from a suitable sump separated from the concrete work by a water-tight wall.

Pumping or bailing to dewater a sealed cofferdam shall not be started until at least 36 hours after the final set of concrete.

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.

2.5.3.6 Backfilling

All spaces excavated under this Specification and not occupied by the permanent structure shall be backfilled as shown in the Drawings or as directed by the Engineer. Backfilled material shall be free from large lumps, wood and other extraneous material.

Backfill within the embankment area shall be placed in layers not more than 15 centimeters in depth (loose measurement) and shall be compacted to a dry density not less than 95% of the maximum dry density as specified by AASHTO T99.

Backfill not within the embankment areas shall be made with approved material placed in uniform layer not exceeding 25 centimeters in depth (loose measurement) and each layer shall be constructed in accordance with Section 2.6 "Embankment".

Compaction equipment or methods which may cause excessive displacement or may damage structures shall not be used. No backfill material shall be deposited against the back of concrete abutments, wingwalls or the outside walls of cast-in-place concrete structures until the concrete has developed a strength of not less than 300 kilograms per square centimeter in compression.

The work shall be performed without damage to the structure and embankment, and in such a manner that water will not be impounded. Ponding and jetting methods shall be supplemented by the use of vibratory or other compaction equipment when necessary to obtain the required compaction.

In placing backfill and embankment the material shall be placed insofar 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 for embankment shall not be placed behind the walls of bridges or box culverts until the top slab is placed for the required time and not less than three days. Backfill and embankment behind abutments held at the top by the superstructure shall be carried out simultaneously behind both abutments and 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.

Special care shall be taken to prevent any unduly high pressures against the structures.

The placing of embankment and the benching of slopes shall continue in such a manner that at all times there will be a horizontal berm of thoroughly compacted material for a distance at least equal to the height of the abutment or wall to be backfilled.

Adequate provision shall be made for drainage and to allow for porous backfill material to be placed in accordance with this specifications.

2.5.4 Measurement

Separate measurement for the payment for structure excavation and backfill shall be made only for the works of the abutments and piers, of the main bridge and approach viaducts which are located on land.

Cost of structure excavation and backfill for other structures such as pipe culverts, U-ditch and manholes shall be included in the unit price of the respective structures and no separate measurement for payment for excavation and backfill will be made.

The volume of excavation shall be measured in cubic meters of undisturbed material. The volume of the solid measurement shall be bounded on the bottom by the plane of the bottom of sand or gravel bedding and on the top by the surface after clearing and grubbing, and on the side by the line shown in the drawing as "payment line". When no payment line is shown in the Drawings the payment line shall be a line with 1.0 (vertical) : 1.0 (horizontal) slope, starting 50cm from the edge of the footing at the bottom boundary.

The volume of blinding stone shall be measured in accordance with these specifications.

Backfill material as described in Section 2.5.2.2 of this Specification shall be measured separately on a cubic meter completed in place basis. When specified or shown on the Drawings, Porous Backfill Material shall be placed, measured and paid for in accordance with this Specification. Backfill with concrete including concrete seals shall be measured separately as the volume accepted by the Engineer.

Material excavated as structure excavation shall be considered "Unclassified Excavation" which include all materials to be excavated.

Volume of the excess material replaced by permanent structures such as footings, pier wall, lean concrete and sand or gravel bedding shall be counted to be same volume as the volume of the permanent structures in the excavated area. If the excess material is used for the embankment, the same volume as the volume calculated above shall be deducted from the volume of embankment by borrow material.

2.5.5 Payment

Structure Excavation shall be paid for at the Contract unit price per cubic meter, which price shall include excavation, hauling, disposal or embankment construction work of surplus material, all equipment, tools, labor, sheeting, bracing, pumps, drills, explosives and incidentals necessary to complete the work. Structure Backfill will be paid for at the Contract unit price per cubic meter, complete in place, which price shall include all equipment, watering, compacting, labour and incidentals. Porous Backfill Material, as required, will be paid for as specified in of this Specification.

Should it be necessary, in the opinion of the Engineer, to lower the footings to an elevation below the grade shown on the Drawings, payment for the "Structure Excavation" and including an elevation 1.5 meters below plan grade for any individual footing will be made at a unit price equal to 115% of the contract unit bid price; and payment for the excavation from an elevation greater than 1.5 meters below plan grade will be made at a unit price equal to 125% of the Contract unit price bid for "Structure Excavation" and Structure Backfill. No increase in unit price will be allowed for any other bid items, and no additional compensation will be allowed for any required cofferdam adjustments made necessary by such lowering of footings.

In case the extra depth required for any footing or footings exceeds 3 meters, a supplementary agreement shall be made covering the quantities removed from depths in excess of 3 meters below plan grade.

Since this item provides for an adjustment in unit price for additional excavation quantities, a provision for renegotiating a price when overruns or underruns greater than 25% occur will not apply.

Blinding stone will be paid for at unit prices per cubic meter, complete, compacted and accepted in place, which prices shall include all equipment, excavation and hauling of materials, tools, labor, staking and all incidentals necessary for proper execution of the work.

Payment will be made under the following items :

Item No.	Description	Unit
2.5(1)	Structure Excavation, Type 1 Unclassified	cubic meter
2.5(2)	Structure Excavation, Type 2 Unclassified	cubic meter
2.5(3)	Blinding Stone	cubic meter

2.6 EMBANKMENT

2.6.1 Description

This work shall consist of the construction of embankment and fill for the areas of the roadway, yard pavement and land leveling by furnishing, placing, compacting and shaping embankment material of acceptable quality obtained from excavation within right of way or from the approved sources in accordance with these Specifications, and to the lines, levels, grades, dimensions, and cross sections shown on the Drawings and as required by the Engineer.

Construction of slope protection dike on the shoulder of embankment slope shall be included in this work.

2.6.2 Materials

Materials from the excavation described in Section 2.2 "Common Excavation", Section 2.4 "Channel Excavation" and Section 2.5 "Excavation and Backfill for Structures", shall be used for the fill as the first priority. Then if the excavated materials are in short supply for the embankment, materials from borrow pits outside of the right of way shall be used.

The Contractor shall prepare the balance sheet of earth works and then propose the most suitable borrow method to the Engineer for approval.

Unless otherwise directed by the Engineer, Embankment shall be constructed of materials with a CBR value not lower than the design values stated on the Drawings or this specification. The required CBR values shall be on soaked samples compacted to 95% of the AASHTO T99-74 maximum dry density at moulded moisture contents of optimum + 1% to optimum –2%. Any material with a CBR value of less than 3% shall not be considered suitable, and material

with a CBR value of less than 6% shall not be used for the top 100cm.of the embankment layer below subgrade and under the pavement structure.

Unsuitable material obtained from excavation works within the right of way shall be used for filling. The unsuitable material shall be placed and compacted, according to the requirements specified in this section, at locations far enough from the roadway structure and at the bottom layer of filling or as directed by the Engineer. The places where the unsuitable materials are used as a part of filling shall be scattered to avoid the concentration of the unsuitable materials in the filling.

Excavated rock material within right of way if any, shall also be used for the embankment. The excavated rock material shall be placed and compacted, according to the requirements specified in this section, at the bottom of embankment where embankment height is more than 3.0 meter or as directed by the Engineer.

2.6.3 Construction Methods

2.6.3.1 Preparation of Foundation for Embankment

Natural ground (including slopes of existing roadway) situated less than 1.5 meters below the surface of the road or side slopes shall, after proper clearing and grubbing or scarifying of the existing road surface, be compacted to a depth of 15 centimeters, measured from original ground as shown on the cross-section sheet, to not less than 95% of the maximum dry density of the material as determined by AASHTO test method T-99-74. Compression of existing soil which may result from this compaction will not be measured and backfilling of the corresponding volume of earth fill is considered incidental to other items of work and will not be separately paid for.

If unsuitable materials occur in some areas under the embankment or in existing embankments, such materials shall be removed to levels as directed in writing by the Engineer, the bottom of the excavation shall be compacted, as described above, and the areas backfilled and compacted layer by layer with suitable material. Excavation and removal of the unsuitable material, including all necessary work to construct embankment using the unsuitable material, shall be measured and paid for under the item of "Common Excavation unsuitable material" specified in Section 2.2. Fill material replacing unsuitable materials being excavated on the

written instruction of the Engineer will be measured and paid for according to Section 2.6 "Embankment".

All compaction shall comform to the requirements in sections 2.6.3.3 of these Specifications. Where an existing surface of a road is situated at subgrade level or lower, the surface shall be scarified, except where otherwise shown on the Drawings, to a depth of 15 cm, graded, spread and compacted, to the density prescribed for layers at the depth concerned below subgrade, in the full width of the new embankment. No materials shall be removed from these areas unless ordered in writing by the Engineer.

2.6.3.2 Placing Embankment

Embankment shall be placed in accordance with the following requirements:

(a) General: except as otherwise required all embankments shall be constructed in layers approximately parallel to the finished grade. During construction of embankment, a smooth grade having an adequate crown or superelevation shall be maintained to provide drainage. Embankments shall be constructed to the required grade, and completed embankment shall correspond to the shape of the typical sections shown on the Drawings.

(b) Earth Embankment: Earth embankments shall be defined as those principally of material other than rock, and shall be constructed of approved material from excavation or other approved sources.

Except as specified for embankment in swamps, earth embankments shall be constructed in successive layers, for the full width of the cross section and in such lengths as are suited to the compaction and watering methods used. Prior to compaction the layers shall not exceed 20 centimeters in depth unless permission is granted by the Engineer.

(c) Placing over swamp ground: Embankment in or over swamps or in water shall be placed as indicated on the Drawings and as required by the Engineer.

(d) Rock Embankment: Rock embankment shall be defined as those principally of rock, obtained by excavation within the right of way.

Except as otherwise specified, rock embankment shall be constructed in the bottom layer of embankment where the embankment height is higher than three

(3) meter. When in the opinion of the Engineer, the rock sizes necessitate a greater depth of layer than the height of fill will permit, the layer depth may be increased as necessary, but in no case shall the depth of the layer exceed one meter. Each layer shall be constructed by starting at one end of the section of embankment under construction and dumping the rock on top of the layer being constructed then pushing ahead with an approved bull dozer in such a manner that the larger rock will be placed on the ground and the interstices between the larger stones will be filled with small stones and spalls by this operation and by the placing of succeeding layers of embankment.

The maximum dimension of any rock shall be less then the depth of the embankment layer. All oversized rock which is otherwise suitable for construction shall be broken to the required dimension and used in embankment construction or placed at the points in the embankment where the layer is of greater depth. Compensation for additional haul involved in such alternate manipulation will not be allowed. Where excavated rock is wasted the Contractor shall, at his own expense, replace the rock wasted with other suitable materials.

Except as otherwise specified, all rock fills will be covered with one or more 20 centimeter layers of well graded material containing no stones larger than 10 centimeters and the material shall be sufficient to fill all the interstices in the top of the rock fill. These layers will be constructed to the requirements for earth embankment.

(e) Adjacent to culverts and bridges: Embankments adjacent to culverts and bridges which cannot be compacted by use of equipment used in compacting the adjoining section of embankment shall be compacted in the manner prescribed under the Section 2.5. Excavation and Backfill for Structures.
(f) Additional fill for settlement: All settlement occurring in embankment construction shall be corrected by the Contractor by providing additional layers of embankment at the contractor's own expense. No compensation shall be made for the additional fill to correct the settlement during construction period.

If a soil failure either occurs or becomes imminent during the construction of the embankment, the Engineer shall have the authority to suspend all embankment construction in the affected area until corrective measures can be determined and implemented. Any delay in the embankment construction schedule and any other effects caused by implementation of the above subclause shall not constitute grounds on the part of the Contractor for a claim for extension of the Contract

and/or financial compensation. The Contractor shall carry out necessary surveys and monitoring of the affected area according to the instructions and concurrence of the Engineer.

2.6.3.3 Compaction of Embankments other than Rock Embankments

(a) Before compaction, each layer shall be processed as required to bring the moisture content to within plus 1 and minus 2 percent of optimum moisture content as determined in AASHTO T-99-74 or as directed by the Engineer.

With respect to the type and size of the compactors being utilized, the material shall be so worked as to have a uniform moisture content throughout the layer. Full compensation for any additional work involved in wetting or drying embankment material to the required moisture content shall be considered as included in the contract price paid for embankment and no additional compensation will be allowed.

(b) Each layer of material shall be compacted uniformly by the use of adequate and appropriate compaction equipment. The compaction shall be done in a longitudinal direction along the embankment and shall generally begin at the outer edges and progress toward the centre in such a manner that each section receives equal compactive effort.

Hauling equipment shall be operated over the full width of each layer in so far as is practicable

(c) Embankment compaction shall be carried out as follows: Embankments shall be constructed in layers of uniform thickness not to exceed 20 centimeters in thickness after compaction and compacted to the requirements of this section. Each layer of embankment under roadways and other pavement areas shall be compacted to a dry density equal to at least 95% of the maximum dry density as determined by AASHTO test method T-99. Embankment in the other areas shall be compacted to a dry density equal to at least 90% of the maximum dry density as determined by AASHTO test method T-99 or as directed by the Engineer.

Embankments shall be maintained to the grade and cross section shown on the Drawings throughout the contract period.

The Contractor shall protect the prepared subgrade from both his own and public traffic. The Contractor shall maintain the subgrade by blading, watering and rolling as frequently as necessary to preserve the subgrade in a completely satisfactory condition as specified above.

The compaction of the subgrade shall, in cut areas, including areas of existing road where the surface layer has been removed, extend to a minimum depth of 15 centimeters and the compaction shall attain not less than 95% of the maximum dry density determined by AASHTO test method T-99.

Attention is drawn to the fact that the general compaction requirements shall at any level apply to the full width of the embankment. Slopes to be covered with topsoil and grassing shall have a firm surface before topsoil is placed.

2.6.3.4 Compaction of Rock Embankment

Rock embankment shall be compacted by the passage of approved heavy equipment until there is no visible movement of the rockfill under the equipment. Compaction shall be done in a longitudinal direction along the embankment and shall begin at the outer edge and progress towards the centre.

2.6.3.5 Preparation of Subgrade Surface

The subgrade shall be shaped to correct line and level and the Contractor shall at all times ensure that the subgrade is well drained and protected against damage from the public as well as construction traffic. The finished subgrade surface shall at no point deviate more than 1.5 cm from the cross-section shown on the Drawings. The surface shall be maintained in this state, with a regular light sprinkling of water to prevent a dusty condition until the pavement layers are spread.

2.6.4 Measurement

Measurement of Embankment

In case excavation materials inside right of way are used for embankment, no separate payment for the embankment shall be made but the cost for the embankment construction shall be incidental of the unit prices of the excavation or other works, which include the cost of the excavation. Only embankment constructed by borrow material shall be measured for payment in this section.

The total volume of embankment and fill shall be calculated based on the checked cross section sheets as measured in Section 1.3.1. The volume shall be measured as the volume between the surface of the final subgrade in the pavement area, finished grade in land levelling area and the side slopes and ground surface shown on the check cross section.

The volume of embankment by borrow material shall be calculated by deducting the volume of the excavation, of which material is used for embankment, from the total embankment volume.

The volume of topsoil on side slopes measured in accordance with these Specifications shall not be included in the volume of embankment fill.

The final volume of embankment fill shall not include the voids for bridges, box culverts, and pipe culverts. The measurement of the void for bridges shall be reckoned to extend between the vertical planes through the beginning and the end of the concrete deck slabs. The volume of the voids for box culverts and pipe culverts shall be reckoned as the product of the cross-sectional area of the void and the overall length of the box or circular pipes. No deductions shall be made for deviations from the regular shape of the embankment due to inlets or outlets for box or pipe culverts or rip-rap slope protection.

No measurement or payment will be made where materials are removed or backfilled for reasons not instructed in writing by the Engineer.

2.6.5 Payment

Embankment constructed by borrow material will be paid for at unit prices per cubic meter, complete, compacted and accepted in place, which prices shall include all equipment, excavation and hauling of materials, tools, labor, staking and all incidentals necessary for proper execution of the work.

Pay items will be made under the following items :

Item No.	Description	Unit
2.6(1)	Embankment by Borrow Material	cubic meter
26.(2)	Earth Fill in Median Island and Shoulder	cubic meter

In the monthly estimates, partial payments may be made for embankment fill which is placed, compacted and shaped in accordance with the Drawings and

these Specifications. The quantity shall be estimated provisionally on the basis of the cross-sections.

SECTION 3 : SUBBASE AND BASE COURSES

3.1 SUBBASE

3.1.1 Description

This work shall consist of the furnishing, placing and compacting of subbase material on a prepared and accepted subgrade in accordance with these Specifications, and the lines, levels, grades, dimensions and cross sections shown on the Drawings and as required by the Engineer.

This work shall also include, if specified in the Contract, construction of a sand layer cushion in conjunction with concrete pavement construction to the thickness and dimensions shown on the typical cross-section.

3.1.2 Materials

The subbase materials shall be selected from borrow areas at locations suggested on the Drawings or those selected by the Contractor. The materials shall consist of naturally occurring sand or gravels which comply with the requirements given below. All materials shall be free of topsoil and all other organic matter. The materials shall consist of sound durable particles, which do not breakdown under compaction or repeated wetting/drying cycles. All sizes greater than 50 percent of the specified lift thickness shall be handpicked and removed from the working surface.

The grading shall conform to grading envelopes A, B, C, D or E as determined by AASHTO test method T 27 and given in **Table 3.1.1** of these Specifications. The fraction of material passing the No.40 sieve shall have a liquid limit, as determined by AASHTO T 89-76, of not greater than 35 percent and a plasticity index, as determined by AASHTO T 90-70, of not greater than 11. The fraction passing the No.200 sieve shall be not greater than two-thirds of the fraction passing the No.40 sieve. Abrasion of the coarse part of the material shall be tested in accordance with AASHTO T 96-77 and shall shown a percentage of wear no greater than 50 percent. Shale material shall not be used for subbase. The minimum required CBR values indicated in the Drawings would be obtained within a moisture range of 3.0 percent.

The material used for a sand cushion underneath a concrete pavement shall be coarse sand having hard and durable particles without any clay lumps or deleterious material. The percentage by weight passing the (9.5 mm) sieve shall be 100% and that passing the 200 sieve shall not exceed 10%.

Table 3.1.1

Grading Requirement for Soil Aggregate Material

Percentage by weight passing square mesh sieves

Sieve Designation	Grading A	Grading B	Grading C	Grading D	Grading E	Grading F
2 inch	100	100	-	-	-	-
1 inch	-	75 – 95	100	100	100	100
3/8 inch	35 – 65	40 – 75	50 – 85	60 – 100	-	-
No.10	15 – 40	20 – 45	25 – 50	40 – 70	40 – 100	55 – 100
No.40	8 – 20	15 – 30	25 – 45	20 – 50	30 – 70	40 – 100
No.200	2 – 8	5 – 20	5 – 15	5 – 20	6 – 20	8 – 25

3.1.3 Method of Construction

3.1.3.1 Preparation of Subgrade

The subgrade shall be shaped and compacted in conformity with the provisions of Section 2.2 and Section 2.6 and completed at least 150 meters ahead of the placing of the subbase course material. Notwithstanding any earlier approval of subgrade, any damage to or deterioration of subgrade shall be made good before subbase is laid.

3.1.3.2 Spreading Subbase

Subbase shall be spread in even level lifts not exceeding 15 cm after compaction. Care shall be taken to prevent segregation and oversized particles shall be handpicked from the lift prior to compaction. Patches or pockets of fine material shall be removed and made good at the Contrator's own expense.

3.1.3.3 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 center, gradually in a longitudinal direction; except on superelevated curves, where rolling shall begin at the low side and progress toward the high side. Subbase of sandy material shall be compacted by use of vibrating equipment.

Each layer shall be compacted to at least 95 percent of the maximum dry density, as determined in AASHTO T 180-74. During compaction, the moisture content

shall be so controlled that the moisture content of the finished layer shall be within the limits of ±2 percent of the optimum dry density, also as determined in AASHTO T 180. Materials which do not contain sufficient moisture shall be watered prior to and during compaction to the satisfaction of the Engineer. Materials containing excess moisture shall be allowed to dry to the required moisture content prior to compaction. All costs involved in regulating the moisture content, both wetting and drying, shall be deemed to be covered by the unit prices for subbase.

One density determination shall be made for each 500 square meters, or less, on each layer of compacted subbase in accordance with AASHTO test procedures T 191-74, T 205-74, T238-76, as directed by the Engineer.

The finished subbase shall not vary more than 1.5 centimeters above or below the planned grade at any point. The thickness of the finished subbase shall be on average not less than required thickness and not thinner than 1.5 centimeters less than the required thickness at any point and the average of five thickness measurements in any 100 meters of road shall be not thinner than 1.0 centimeters less than the required thickness. Subbase, which does not conform to the above requirement, shall be reworked, watered and thoroughly re-compacted to conform.

3.1.3.4 Proof-Rolling

Where shown on the plans or indicated by the Engineer, the Contractor will proof-roll the compacted subbase surface. The proof-rolling will be done on a fully wetted subbase with a 24 ton axle having 4 tires. Each tire will be inflated to 120 psi. Proof-rolling will be considered complete after 30 repetitions of each point of the testing area. All the sections which develop shear failure of greater than 2.5 cm will be reconstructed at the Contractor's own expense.

3.1.3.5 Sampling

Suitable samples of the sources of subbase materials shall be submitted to the Engineer not less than 30 days before commencing the construction and additional samples shall be furnished during construction, as required, upon request. Method for obtaining material for tests shall conform to the requirements of the Engineer. The Engineer reserves the right to test the gradation of the material after compaction to ensure compliance. Materials rejected on this basis shall be removed and replaced at the expense of the Contractor.

3.1.3.6 Maintenance

After construction is completed the subbase shall be maintained throughout except where portions of the succeeding course are under construction thereon. Maintenance shall included drainage, rolling, shaping, and watering as necessary to maintain the course in proper condition. Deficiencies in thickness, composition, construction, smoothness or density, which develop during the maintenance, shall be corrected to conform to the requirements specified above. Sufficient moisture shall be maintained at the surface to prevent a dusty condition, by light sprinkling with water.

3.1.4 Measurement

Subbase as described in this section will be measured by the cubic meter of material compacted in place and accepted. Measurements shall be based on the cross section of the subbase on the Drawings and actual length measured horizontally along the centerline of the surface of the road. Subbase stabilized with lime or cement shall be measured in accordance with the Specifications for lime stabilized or cement stabilized base.

3.1.5 Payment

This work measured as provided in the Specifications shall be paid for at the Contract unit prices per cubic meter for subbase or sand cushion as detailed below. Payment shall be full compensation for furnishing all materials, equipment, hauling, placing, compacting, sprinkling, finishing and shaping and for all labor, tools, and other incidentals necessary to complete the work specified.

Subbase and sand layer cushion will not be paid for complete in place until the subsequent layer of payment is constructed thereon. However, the Engineer may authorize payment of 75% of the quantity of subbase or sand layer cushion on current estimate in advance of the succeeding operations, provided it has been completed in accordance with these Specifications and is satisfactorily maintained pending the placement of subsequent layers.

Payment will be made under the following item:

Item No.	Description	Unit
3.1(1)	Subbase	cubic meter
3.1(2)	Sand Layer Cushion	cubic meter

3.2 AGGREGATE BASE

3.2.1 Description

This work shall consist of a base composed of crushed aggregate material placed and compacted on a prepared and accepted subgrade, subbase 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.

3.2.2 Materials

Base course aggregate shall consist of a mixture of head durable crushed rock particles and mineral filler which satisfies the grading limits A, B or C in **Table 3.1.1** as determined by AASHTO test method T 27. The portion that passes the No.200 sieve shall not be more than 2/3 of that portion passing the No.40. The coarse aggregate, defined as that material retained on the 4.75 mm (No.4) sieve, shall have a percentage of wear not greater than 40 percent for 500 revolutions, when tested according to AASHTO T 96. Where the coarse aggregate is produced from crushing river source gravel, at least 90 percent of the particles shall have at least 2 crushed faces. When produced from a rock quarry, the source shall be first approved by the Engineer.

That portion passing the No.40 sieve of the total mixture shall have a liquid limit of not more than 25 and a plasticity index of not more than 6 percent, as determined in AASHTO T 90. The CBR strength of the whole mixture, as determined in AASHTO T 193, shall be no less than 80 percent after 24 hours soaking, on samples compacted to 95 percent of the maximum dry density in a moisture range of 4 percent as determined in AASHTO T 180. Shale material shall not be used as base course.

3.2.3 Construction Method

3.2.3.1 Preparation of Subgrade or Subbase

The subgrade or subbase shall be shaped and compacted in conformity with the provisions of Section 2.2, Section 2.6 and Section 3.1 and completed at least 150 meters ahead of the placing of the base course material.

3.2.3.2 Spreading Base

Base material shall be placed on the prepared roadbed and compacted to the thickness shown on the Drawings.

The contractor shall elect to produce haul and stockpile aggregate prior to placement on the roadbed.

When hauling is done over previously placed material, hauling equipment shall be dispersed uniformly over the entire surface of the previously constructed layer, to minimize rutting or uneven compaction.

Base layers up to 15 cm of compacted thickness may be placed in one layer. A specified compacted thickness greater than 15 cm shall be constructed in two (or more, as required) layers of approximately equal thickness.

When base course is spread continuous to curbs or gutters, extreme care shall be exercised not to damage the curbs or gutters. Any damage due to the construction methods or negligence of the Contractor shall be rectified to the satisfaction of the Engineer at the expense of the Contractor.

In order to control base course elevations, blue-top pegging or some other method as approved by the Engineer shall be employed at station intervals no greater than 12.5 meters.

3.2.3.3 Sprinkling, Rolling and Compaction

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 75 centimeters, 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 center, gradually in a longitudinal direction. On superelevated 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 95 percent of the maximum dry density as determined by AASHTO T 180-74. The density of the compacted base course shall be determined by AASHTO T 191-74, T 205-74 or T 238-76. One density determination shall be made for each 500 square meters, or less, on each compacted base course layer.

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, at the expense of the Contractor.

Any irregularities, which may develop in the surface during or after construction shall be corrected by removing or loosening the surface, and adding further material as required.

The final shaping and rolling of the shoulders to the full width shall be made after the base course is completed.

3.2.3.4 Surface Tolerance

In that area on which pavement is to be placed any deviation in excess of one centimeter from a straight edge 3 meters long applied to the surface parallel to the centerline of the road and 1.25 centimeters from a template laid transversely, shall be corrected by loosening, adding or removing material, reshaping and re-compacting.

The base completed in each day's work shall have an average thickness not less than the required thickness. The minimum thickness shall be not less than the required thickness less 1.5 centimeters. 80% of the base laid shall have a thickness not less than the required thickness less one centimeter.

The Engineer may order and the Contractor shall carry out at his own expense, the reconstruction of areas of base, which are too thin or too variable in thickness to meet this Specification.

3.2.3.5 Additional Base Course Material

If, after reconstructing an existing base course or excavating a soft spot or localized failure, additional base course material is required, it shall be constructed and paid for under the item of Aggregate Base Course in accordance with these Specifications, unless otherwise directed by the Engineer. Any associated works such as minor excavation of the existing pavement structure, squaring off of the adjoining pavement or other miscellaneous tasks shall be considered incidental to this and other items of the Contract.

3.2.3.6 Sampling

When the Contractor has set up his production of base course aggregate so as to obtain a uniform, consistent material, he shall submit suitable samples to the Engineer for approval not less than 30 days before commencing construction. Methods of sampling for testing shall conform to the Engineer's requirements.

3.2.3.7 Proof-Rolling

Where shown on the plans or indicated by the Engineer, the Contractor will proof-roll the compacted base surface. The proof-rolling will be done on a fully wetted base course with a 24 ton axle having 4 tires. Each tire will be inflated to 120 psi. Proof-rolling will be considered complete after 30 repetitions of each point of the testing area. All the sections which develop shear failure of greater than 2.5 cm will be reconstructed at the Contractor's own expense.

3.2.3.8 Maintenance

After construction is completed the base shall be maintained throughout expect where portions of the succeeding course are under construction thereon. Maintenance shall include drainage, rolling, shaping, and watering as necessary to maintain the course in proper condition. Deficiencies in thickness, composition, construction, smoothness, or density, which develop during the maintenance, shall be corrected to conform to the requirements specified hereinbefore. Sufficient moisture shall be maintained at the surface to prevent a dusty condition by light sprinkling with water.

Heavy equipment except for equipment required for construction of adjoining sections will not be permitted to drive over completed portions until curing is completed. Traffic control shall be as required by the Engineer.

3.2.4 Measurement

Base course will be measured as the number of cubic meters of material complete in place and accepted. Volume measurements shall be based on the cross sectional area shown on the typical roadway sections and the actual length measured horizontally along the centerline of the surface of the road.

3.2.5 Payment

This work as measured above will be paid for at the Contract unit price per cubic meter, complete in place, which price shall include furnishing all materials,

equipment, hauling, placing, compacting, sprinkling, finishing, shaping, labor, tools and other incidentals necessary to satisfactory completion of the work.

Payment will be under the following item:

Item No.	Description	Unit
3.2(1)	Aggregate Base Course	cubic meter

Base Course will not be paid for complete in place until the subsequent surfacing is constructed thereon. However, the Engineer may authorize payment of 75% of the base course on current estimates in advance of the succeeding operations, provide it has been completed in accordance with these Specifications and is satisfactorily maintained pending the placement of the surfacing.

3.3 SHOULDERS

3.3.1 Description

This work shall consist of constructing shoulders on both sides of the roadway in accordance with these Specifications to the lines, levels, grades, dimensions and cross-sections shown on the Drawings and as required by the Engineer.

3.3.2 Materials

The type of shoulder material to be used is shown on the typical roadway sections for this project.

The upper layer of material shall consist of natural soil aggregate conforming to one of the grading envelopes A, B, C or D of Table 3.1.1 of these Specifications. The portion of the material passing the No.40 sieve shall have a liquid limit of not greater than 35 and a plasticity index of 4 to 15. The material shall have a CBR value of 30% when compacted to 95% of maximum dry density as determined by AASHTO test T 180-74. The lower layer of a two-layer shoulder shall consist of aggregate base material in accordance with Section 3.2.

3.3.3 Construction Method

3.3.3.1 General

The shoulder shall be constructed on a previously prepared subbase or subgrade finished as required in the Specifications. The work shall be carried out in conformity with the requirements for simultaneous construction of subbase or

base if such requirements are applicable. The construction shall be done in such a way that courses of material of different types are not mixed together.

3.3.3.2 Compaction

Shoulders composed of base course material shall be compacted to at least 95 percent of the maximum dry density as determined by AASHTO T 180-74. Soil Aggregate shoulders shall also be compacted to at least 95 percent of maximum dry density as determined by AASHTO T 180-74.

All shoulders shall be processed and compacted in layers not exceeding 20 centimeters thickness before compaction.

3.3.3.3 Surface and Thickness Tolerance

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 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.

3.3.4 Measurement

The shoulder shall be measured as the number of cubic meters of each course separately (if courses of different kinds are required) of material complete in place, compacted and accepted. The volume shall be calculated from the required cross section as shown on the Drawings and the horizontal length of shoulder.

3.3.5 Payment

If required by the typical cross section, a surface treated shoulder on base course material shall be paid for in accordance with Section 3.2 Aggregate. Soil Aggregate Shoulder shall be paid for at the Contract unit price per cubic meter, complete in place, which price shall include all materials, hauling, equipment, tools, labor and incidentals necessary for satisfactory completion of the work.

Payment will be under the following item:

Item No.	Description	Unit
3.3(1)	Soil Aggregate Shoulder	cubic meter

SECTION 4 : SURFACE COURSES

4.1 GENERAL REQUIREMENTS FOR ASPHALTIC SURFACE

4.1.1 Description

4.1.1.1 General

This work shall cover the general requirements that are applicable to all types of asphaltic and surfacing irrespective of gradation of mineral aggregate, kind 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 for each type.

The work shall consist of one or more courses of plant-mixed asphaltic mixture constructed on a prepared and accepted, base course or other roadbed in accordance with these Specifications and specific requirements of the type under Contract, and in conformity with the required lines, levels, grades, dimensions and typical cross section.

4.1.1.2 General Composition of Mixtures

The asphaltic mix shall be composed basically of coarse mineral aggregate, fine mineral aggregate, filler, and asphaltic material. The several mineral constituents shall be sized, uniformly graded, and combined in such proportions that the resulting blend meets the grading requirements for the specific type under the Contract. To such composite blended aggregate shall be added asphalt within the percentage limits set in the Specifications for the specific type.

4.1.1.3 Formula for Job Mix

Before starting work, the Contractor shall submit to the Engineer a proposed job-mix formula, in writing, for the mixture to be supplied for the project. The formula so submitted shall stipulate for the mixture a single definitive temperature at which the mixture is to be emptied from the mixer, and for mixtures to be laid hot, a single definitive 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. The Engineer shall then set the job mix. In setting the job mix, the Engineer at his discretion may use the submitted formula, in whole or in part. In any event, the job mix formula for the mixture shall fix a single percentage of aggregate passing each required sieve size, a single percentage of asphalt to be added to the aggregate, a single temperature at which the mixture is to be emptied

from the mixer, and a single temperature at which the mixture is to be delivered on the road, unless the mixture is to be laid cold.

4.1.1.4 Applications of Job-Mix Formula and Allowable Tolerance

All mixture furnished shall conform to the Job-mix formula set by the Engineer, within the ranges of tolerance given below.

For Base Course:

Passing sieve 3/8 inch and larger	±7%
Passing sieves between 3/8 inch and No.200	±4%
Passing No.200 sieve	±1%
Asphalt	±0.30%
Temperature of mixture when emptied from mixer (11°C)	± 20 ° F
Temperature of mixture at delivery on road (11°C)	± 20 ° F

For Surface Course:

Aggregate Passing No.4 sieve and larger	±5%
Aggregate Passing No.8 and No.16 sieves	±4%
Aggregate Passing No.30 to No.100 sieves	±3%
Aggregate Passing No.200 sieve	±1%
Asphalt	±0.30%
Temperature of mixture when emptied from mixer (11°C)	± 20 ° F
Temperature of mixture at delivery on road (11°C)	± 20 ° F

Each day as many samples of the materials and mixture shall be taken and tested as the Engineer considers necessary for checking the required uniformity of the mixture. When unsatisfactory results or changed conditions make it necessary, the Engineer may establish a new job mix.

Should a change in a material be encountered or should a change in a source of material be made, a new job-mix formula shall be submitted and approved before the mixture containing the new material is delivered. Job materials will be rejected if they are found to have voids or other characteristics requiring for a balanced mix, an asphalt content greater or less than the specified range.

4.1.2 Materials

4.1.2.1 Coarse Mineral Aggregate

Coarse aggregate (retained on the No.4 sieve (4.75 mm)) shall be crushed stone, or crushed gravel, and unless otherwise stipulated, shall conform to the quality requirements of AASHTO M 80. Only one coarse aggregate shall be used except by written permission from the Engineer.

When crushed gravel is used, it shall also meet the pertinent requirements of Section 2.1 of AASHTO M 147-65 and not less than 75 percent by weight of the particles retained on the No.4 sieve (4.75 mm) shall have at least two fractured faces and 90 percent one or more fractured face.

The abrasion loss (AASHTO T 96) shall not exceed 40 percent. Any aggregate liable to polish shall not be used for the coarse aggregate fraction. The coarse aggregate shall be of such gradation that when combined with other required aggregate fractions in proper proportion the resultant mixture will meet the gradation required for the composition of the mixture.

4.1.2.2 Fine Mineral Aggregate

Fine aggregate (passing the No.4 sieve (4.75 mm)) shall consist of natural sand, stone, screenings, or a combination thereof, and unless otherwise stipulated shall conform to the quality requirements of AASHTO M 29 (ASTM D1073). Fine aggregate shall be of such gradation that when combined with other required aggregate fractions in proper proportion, the resultant mixture will meet the gradation required for the composition of the mixture. The sand equivalent, tested in accordance with AASHTO T 176-3, shall be greater than 50.

4.1.2.3 Mineral Filler

Filler material for asphaltic concrete shall conform to the requirements in AASHTO M 17.

Mineral filler shall consist of finely ground particles of limestone or cement in accordance with the requirements of AASHTO M17. It shall be dry loose and free from clay soil, foreign matter and lumped particles. At least 20% of the material shall pass the 0.075mm sieve.

The plasticity Index as determined by AASHTO T90 shall be non-plastic.

4.1.2.4 Asphaltic Materials

Asphalt cement shall conform to the requirements given in AASHTO M 20-70 for the particular grades stipulated in the drawings. Asphalt cement shall be designated by its penetration value (e.g. AC 60-70).

4.1.2.5 Sources of Supply

a) General

Asphaltic materials will be accepted at the source of shipment subject to the following conditions.

The supplier shall conduct laboratory tests of all materials intended for shipment to the Contractor and certify that the material meets the contract specifications.

Before loading, the Producer shall examine the shipping container, remove all remnants of previous cargoes, which might contaminate the material to be loaded and certify that it was clean and free of contaminating material when loaded.

The Contractor shall furnish with each shipment two copies of the delivery ticket. The delivery ticket shall contain the following:

Consignee _____ Designation _____
Project Number _____ Date _____
Grade _____ Loading Temp. _____
Net Weight _____ Specific Gravity at 15°C (60° F)
Identification No.
(Truck, Car, Tank, etc.) _____

The Contractor, or the Supplier as his agent, shall deliver to the Resident Engineer a certification signed by an authorized representative of the Supplier. The certification shall be essentially in the following form and may be stamped, written or printed on the delivery ticket.

"This is to certify that this shipment
of _____ Tons/liters of _____
asphalt meets all contract specification
requirements of the project, and the
shipping container was clean and free
from contaminating material when loaded:

Producer _____
Signed _____

Failure to sign the certification will be cause to withhold use of the material until it can be sampled, tested approved.

b) Acceptance procedures for asphaltic materials: The following acceptance procedure for asphaltic material will apply. The Contractor shall provide delivery tickets and certifications as set out in a) above. Acceptance samples of asphaltic materials shall be obtained in accordance with AASHTO T 40-78, at the applicable point of acceptance as defined herein:

Asphaltic materials used in direct application on the road: Acceptance samples shall be obtained under the supervision of the Engineer from the conveyances containing the asphaltic material at the point of delivery. Single samples shall be taken of each separate tank load of asphaltic material delivered, at the time of discharge, into distributors or other conveyances on the project.

Asphaltic materials initially discharged into storage tanks on the project: Acceptance samples shall be obtained from the line between the storage tank and the distributor on the asphaltic mixing plant after each delivery. A single acceptance sample shall be taken after a sufficient period of circulation of such asphaltic material has taken place to ensure sample representative of the total material then in the storage tank.

As soon after sampling as practicable, the acceptance sample shall be delivered by the Engineer to the nearest authorized laboratory for tests to determine compliance. Final acceptance of asphaltic materials shall be determined on the basis of the acceptance sample test results compliance with the applicable specification requirements.

Asphaltic material which deviates from the specification requirements shall be removed and replaced or otherwise corrected by and at the expense of the Contractor.

4.1.3 Construction

4.1.3.1 Weather Limitation

Asphaltic mixtures shall be placed only when the surface is dry, when the weather is not rainy and when the 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 plant, if laid at proper temperature and if the roadbed is free from pools of water. Such permission shall be in no way relax the requirements for quality and smoothness of surface.

4.1.3.2 Progress of Work

No work shall be performed when there is insufficient hauling, spreading or finishing equipment, or labor, to ensure progress at a rate not less then 60% of the capacity of the mixing plant.

4.1.3.3 Plant and Equipment-Requirements for All Mixing Plants

All plant used by the Contractor for the preparation of asphaltic mixtures shall conform to all of the requirements below, except that scale requirements shall apply only where weight proportioning is used, and in addition any batch mixing plants shall conform to the special requirements under 4.1.3.4 and any continuous mixing plants shall conform to the special requirements under 4.1.3.5.

The mixing plant, which can be a batching plant or a continuous mixing plant, shall have a capacity sufficient to supply the finisher on the road continuously when spreading the asphaltic mix at normal speed and required thickness. The plant must be capable of producing a minimum output of 60 tons per hour of asphaltic material, and shall be subject to inspection and approval by the Employer. All plant used by the Contractor for the preparation of asphaltic mixtures shall conform to all of the requirements below, except that scale requirements shall apply only where weight proportioning is used, and in addition any batch mixing plants shall conform to the special requirements under 4.1.3.4. When the Contractor has completed the installation of the mixing plant, he shall inform the Engineer who shall check the completeness and calibrate the plant before permitting the asphaltic concrete work to commence. The Contractor shall submit his work and equipment schedule to the Engineer for approval.

a) Uniformity

The plants shall be so designed, co-ordinated and operated as to produce a mixture within job-mix tolerance.

b) Plant scale and weigh house

Scales for any weighbox or hopper may be either of the beams or springless dial type and shall be of a standard make and design accurate to within one-half of 1% of the maximum load required. A weigh house shall be provided.

When scales are of the beam type, there shall be a separate beam for each size of aggregate. There shall be a "tell-tale" dial attached, which shall start to function when the load being applied is 50 kilograms of that desired. Sufficient vertical movements shall be provided for the beams to permit the "tell-tale" dial to function properly. Each beam shall have a looking device designed and so located that the beam can easily be suspended or thrown into action. The weighing mechanism shall be balanced on knife-edges and fulcrums and shall be so constructed that it can not easily be thrown out of alignment and adjustment.

When springless dial scales are used, the end of the pin pointer shall be set close to the face of the dial and be of a type that will free excessive parallax. The scale shall be provided with adjustable pointers for marking the weights of each material weighed into the batch. The scales shall be substantially constructed, and those that easily get out of adjustment shall be replaced. All dials shall be located so that they are in full view of the operator at all times.

Scales for the weighing of asphaltic material shall conform to the specifications for scales for aggregate except that each beam scale shall be equipped with a tare beam and a full capacity beam. The value of the minimum graduation in any case shall not be greater than kilogram. Dial scales for weighing the asphaltic material shall not have a capacity of more than twice the weight of the material to be weighed and shall read to half-kilogram. Beam scales shall be equipped with a "tell-tale" device, which will start to function in the case when the load being applied is within 5kilograms of that desired.

Scales shall have been approved by the Engineer and shall be checked as often as the Engineer may deem necessary to ensure their continued accuracy.

The Contractor shall provide and have at hand not less than ten 25 kilogram weights for frequent testing of all scales.

c) Equipment for preparation of asphaltic material

The tanks for storage of asphaltic material shall be capable of heating the material under effective and positive control at all times, to a temperature within the range specified. The heating shall be accomplished by steam coils, electricity or other

means such that no flame shall come in contact with the heating tank. The circulating system for the asphaltic material shall be of adequate size to ensure proper and continuous circulation during the entire operating period. Suitable means shall be provided, either by steam jackets or other insulation, for maintaining the specified temperature of the asphaltic material in the pipe lines, meters, weigh buckets, spray bars, and other containers or flow lines. The storage tank capacity shall be sufficient for at least one day's run. Asphaltic material may be partially heated in the tanks and brought to the specified temperature by means of booster heating equipment between the tanks and the mixer.

d) Feeder for drier

The plant shall be provided with an accurate mechanical means for uniformly feeding the mineral aggregate into the drier so that uniform production and uniform temperatures are obtainable.

e) Drier

A rotary drier of approved design for drying and heating the mineral aggregate shall be provided. The drier shall be capable of drying and heating the mineral aggregate to the specified temperature.

f) Screens

Plant screens, capable of screening all aggregate to the specified sizes and proportions and having normal capacities slightly in excess of the full capacity of the mixer, shall be provided. The screens shall be readily exposable for inspection by the Engineer.

g) Bins

The plant shall include storage bins adequately protected from the weather of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be divided into at least three compartments and shall be arranged to ensure separate and adequate storage of appropriate fractions of the aggregate. For a mineral filler admixture a separate feeder bin and/or weighing hopper arrangement may be required. Each compartment shall be provided with an overflow pipe that shall be of such size and at such location as to prevent any backing up of material into other bins. Bins shall be so constructed that representative samples can readily be obtained, and the aggregate level observed.

h) Asphaltic control unit

Satisfactory means either by weighing or metering shall be provided to obtain the proper amount of asphaltic material in the mix within the tolerance specified for the job-mix.

The metering device for asphaltic material shall be a rotating, positive displacement, asphalt metering pump, with a satisfactory spray nozzle arrangement at the mixer. For use with batching plants, it shall provide the designated quantity of asphaltic material for each batch. For continuous mixing plants, the operating speed of the pump shall be synchronized with the flow of aggregate in the mixer by an automatic locking control, and the device shall be easily and accurately adjustable. Means shall be provided for checking the quantity or rate of flow of asphaltic material into the mixer. Accuracy within +1% of the specified amount is required.

i) Thermometric equipment

An armored thermometer reading from 50°C to 200°C shall be fixed in the asphaltic feed line at a suitable location near the discharge valve at the mixer unit.

The plant shall be further equipped with an approved dial scale mercury-activated thermometer, an electric pyrometer, or other approved thermometric instrument so placed at the discharge chute of the drier as to register automatically or indicate the temperature of the heated aggregate.

For better regulation of the temperature of the aggregate, replacement of any thermometer by another approved temperature-recording apparatus may be required by the Engineer, and he will further require that daily temperature charts be maintained and submitted.

j) Dust collector

The plant shall 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 material to be returned from the dust collector shall be weighed over the filler scale.

k) Control of mixing time

The plant shall be equipped with accurate positive means to govern the time of mixing and to maintain it at a constant time unless changed under directions of the Engineer. The time of mixing shall be considered as the interval between the

time the asphaltic material is spread on the aggregate and the time the same aggregate leaves the mixing unit.

When asphalt is applied by a spray system, the mixing time shall begin with the start of the asphalt spray. When the asphalt is not applied by a spray system, a minimum dry mixing period of five seconds shall precede the addition of the asphalt to the mix.

l) Field laboratory

The Contractor shall provide a field laboratory. This laboratory shall be so located that details of the Contractor's plant are plainly visible from one window of the building. If conditions permit, this laboratory shall be adjacent to the weigh-house. As an alternative to a field laboratory the Contractor may use a recognized laboratory approved by the Engineer.

m) Safety requirements

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 all plant operations. All gears, pulleys, chains, sprockets, and other dangerous moving parts shall be thoroughly guarded and protected. Ample and unobstructed space shall be provided on the mixing platform. 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.

4.1.3.4 Plant and Equipment - Special requirements for Batching Plants

a) Weigh box or hopper

The equipment shall include a means for accurately weighing each bin size of aggregate in a weigh box or hopper, suspended on scales, ample in size to hold a full batch without hand-raking or running over. The weigh-box or hopper shall be supported on fulcrums and knife-edges so constructed that they will not easily be thrown out of alignment or adjustment. All edges, ends, and sides of weighing hoppers shall be free from contact with any supporting rods, columns or other equipment that will in any way affect the proper functioning of the hopper. There shall also be sufficient clearance between hoppers and supporting devices to prevent accumulations of foreign materials. The discharge gate of the weigh box shall be so hung that the aggregates will not be segregated when dumped into the mixer and shall close tightly when the hopper is empty so that no material is

allowed to leak into the batch in the mixer during the process of weighing the next batch.

b) Mixer

The batch mixer shall be an approved twin pugmill type, steam-jacketed, and capable of producing a continuous uniform mixture within the job-mix tolerances. It shall be of such design as to permit visual inspection of the mix. The mixer capacity shall not be less than 1,000-kilogram batch. The discharge gate of the mixer shall be controlled by an approved timelock that can be set and adjusted to measure individually the mixing time for the several materials entering the mix, and shall not release the gates until the total specified time has elapsed.

The mixer shall be equipped with a sufficient number of paddles or blades with proper arrangement to produce a properly and uniformly mixed batch. The clearance of blades from all fixed and moving parts shall not exceed 20 mm. unless the maximum diameter of the aggregate particle in the mix exceeds 25 mm.

4.1.3.5 Plant and Equipment Special Requirements for Continuous Mixing Plants

a) Gradation control unit

The plant shall include a means for proportioning accurately each bin size of aggregate either by weighing or by volumetric measurement.

When gradation control is by volume, the unit shall include a feeder mounted under the compartment bins. Each bin shall have an accurately controlled individual gate to form an orifice for volumetrically measuring the materials drawn from each respective bin compartment. The orifice shall be rectangular, of dimensions about 20 centimeters by 22.5 centimeters with one dimension adjustable by positive mechanical means provided with a lock. Indicators shall be provided for each gate to show the respective gate opening in centimeters.

b) Weight calibration of aggregate feed

The plant shall include provision for a calibration of the gate openings by means of weight test samples so that each of the materials fed out of the bins through individual orifices may be bypassed satisfactorily to suitable test boxes, each bin material being confined separately. The plant shall be equipped to handle conveniently such test samples weighing not less than 150 kilograms combined weight of samples from all bins, and not less than 50 kilograms for any one bin sample.

c) Synchronization of aggregate and bitumen feed

Satisfactory means shall be provided to afford a positive interlocking control between the flow of aggregate from the bins and the flow of bitumen from the meter or other proportioning source. This control shall be accomplished by an interlocking mechanical means or by a positive method satisfactory to the Engineer. The asphalt storage and the aggregate bins shall be provided with signal devices and controls, which will warn of low levels.

d) Mixer

The plant shall include a continuous mixer of an approved twin pugmill type, steam-jacketed, capable of producing a continuous uniform mixture within the job-mix tolerances. The paddles shall be of a type adjustable for angular position on the shafts and reversible to retard the flow of the mix. The clearance of the paddles and all fixed and moving parts shall not exceed 20 mm unless the maximum diameter of the aggregate particle in the mix exceeds 25 mm. The mixer shall carry a manufacturer's plate giving the net volumetric contents of the mixer at the different heights inscribed on a permanent gauge and charts shall be provided by the manufacturer giving the rate of feed of aggregate per minute, at plant operating speed.

Determination of the mixing time shall be by a weight method, using the following formula (the weights shall be determined for the job by tests made by the Engineer) : -

$$\text{Mixing time second} = \frac{\text{Pugmill dead capacity in kilograms}}{\text{Pugmill out put in kilograms per second}}$$

e) Hopper

The mixer shall be equipped with a hopper at the discharge end, of such size and design that no segregation of mix occurs. Any elevator used for loading mixture into vehicles shall have an equally satisfactory hopper.

4.1.3.6 Plant and Equipment

Equipment for Hauling and Placing

a) 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 mix 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 under direction of the Engineer be removed from the work until such conditions are corrected. When necessary, in order that the mixture be delivered on the road at the specified temperature, truck beds shall be insulated to maintain workable temperature of the mixture and all covers shall be securely fastened.

Trucks or any other equipment leaking petroleum products will not be allowed admittance to paved areas or areas where paving construction is being conducted.

b) Spreading and finishing equipment

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.

The pavers shall maintain precision of grade and confine the edges of the pavement to precise lines without the use of stationary side forms. The equipment shall include blending or joint leveling 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 meter of material required.

Pavers shall be equipped with activated screeds and devices for heating the screeds to the temperature required for the laying of the mixture without pulling or marring.

The term "screed" includes any cutting, crowding, or other practical action that is effective in producing a finished surface of the evenness and texture specified, without tearing, shoving, or gouging.

If, during construction, it is found that the spreading and finishing equipment in operation leaves surface tracks or indented areas or other objectionable irregularities in the pavement 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.

c) Small tools

The Contractor shall provide suitable means for keeping all small tools clean and free from accumulations of asphaltic material. He shall provide and have ready for use at all times a sufficient number of 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.

4.1.3.7 Preparation of Existing Surface

Where local irregularities in existing surfaces would otherwise result in a course more than 7.5 centimeters thick after compaction, the surface shall be brought to uniform contour by patching with an asphaltic mixture to be approved by the Engineer, thoroughly tamping or rolling it until it conforms to the surrounding surface. The mixture used shall be the same as that specified for the next course, unless the size of the largest aggregate in the mixture precludes this when the Engineer will decide the mixture to be used.

Where the existing roadbed is broken or 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 if the edge of the course has become eroded, disintegrated, or broken, the edges shall be trimmed back as directed by the Engineer, the debris removed and disposed of, and the space backfilled with an asphaltic mixture or with gravel or similar approved material, 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 4 centimeters or more and the sand asphalt shall be thoroughly compacted in joints and cracks to a level

not more than 5 millimeters below the surface. A tack coat shall then be applied to the surface.

4.1.3.8 Preparation of Asphaltic Material

The asphaltic material shall be heated to the specified temperature in kettles or tanks so designed as to avoid local overheating and provide a continuous supply of the asphaltic material to the mixer at a uniform temperature at all times.

4.1.3.9 Preparation of Mineral Aggregate

The mineral aggregates for the mixture shall be dried and heated before being placed in the mixer. Flames used for drying and heating shall be adjusted properly to avoid injury to the aggregate and to avoid forming a heavy coating of soot on the aggregate. The aggregates shall be heated to the temperature specified in the applicable section.

The aggregates, immediately after heating, shall be screened into three or more fractions and conveyed into separate bins ready for combining and mixing with asphaltic material. The fraction of aggregate deposited in any bin shall not contain more than 10% of material outside the specified size limits for that bin.

4.1.3.10 Preparation of Mixture

The dried mineral aggregates prepared as prescribed above, shall be combined in the plant in the amount of each fraction of aggregate required to meet the job - mix formula for the particular mixture. The asphaltic material shall be measured or gauged and introduced into the mixer in the amount determined by the Engineer. The proper amount of asphaltic material shall be distributed over the mineral aggregate and the whole thoroughly mixed for a period of at least 30 seconds, or longer if necessary to produce a homogeneous mixture in which all particles of the mineral aggregate are coated uniformly. The total mixing time shall be set by the Engineer and regulated by suitable locking means. For a continuous mixing plant, the mixing time shall be determined from the formula in Section 4.1.3.5(d) and may be regulated by fixing a minimum gauge in the mixer unit and/or by another mixing unit adjustment.

4.1.3.11 Transportation and Delivery of Mixture

The mixture shall be transported from the mixing plant to the point of use in vehicles conforming to the requirements of Section 4.1.3.6 a) Loading and transporting shall be such that spreading, compaction and finishing shall all be

carried out during daylight hours unless satisfactory illumination is provided by the Contractor.

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 of each load.

4.1.3.12 Spreading and Finishing

Upon arrival at the point of use, 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. Asphaltic mixture pavers conforming to the requirements of Section 4.1.3.6 b) shall be used for this purpose. 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 luted by hand to provide the correct weight or uniform thickness of material without segregation. Mixtures shall not be applied faster than they can be properly handled and spread.

4.1.3.13 Compaction of Mixture

a) 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.

b) Roller Requirements

Generally, with each paver, two steel wheeled tandem rollers and one pneumatic tired roller will be required, except that on projects involving a total of less than 500 metric 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 either the right or left side, water tank, sprinkler systems and co-mats to ensure even wetting of rolls or tiers. The Contractor shall supply to the Engineer for each type of roller a calibration chart showing the relation between depth of ballast and weight and giving the tare weight of the roller. Each roller shall be in good condition and driven by a competent and experienced operative.

Steel wheeled tandem rollers 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 rolling pressure of 35 kilograms per centimeter of roll width.

Pneumatic tired rollers shall be of an approved type having not less than seven wheels with smooth tread compactor tires of equal size and construction capable of operating at inflation pressures up to 8,500 grams per square centimeter. Wheels shall be equally spaced along both axle lines and arranged so that tires on one axle, line track midway between those on the other with an overlap. Each tire shall be kept inflated to the specified operating pressure such that the pressure difference between any two tires shall not exceed 350 grams per square centimeter. Means shall be provided for checking and adjusting the tire pressures on the job at all times. For each size and type of tire used the Contractor shall supply to the Engineer charts or tabulations showing the relationship between wheel load, inflation pressure and tire contact pressure, width and area. Each roller shall be so equipped that its total weight is adjustable by ballasting allowing the load per wheel to be varied from 1,500 to 2,500 kilograms. In operation the tire 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 pressures as high as the material will support.

c) Procedure

Rolling of the mix shall consist of six separate operations as follows:

(1) transverse joint
(2) longitudinal joint
(3) edges
(4) initial or breakdown rolling
(5) second or intermediate rolling
(6) finish 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 tired roller except on small operations as noted above.

Rolling shall start longitudinally at the sides and proceed toward the center of the pavement except that on superelevated 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 roll should be nearest the paver.

The speed of the rollers shall not exceed 4 kilometers per hour for steel wheeled rollers and 6 kilometers per hour for pneumatic tired rollers and shall at all times be slow enough to avoid displacement of the hot mixture. 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 the 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.

Along curbs, headers, manholes, and similar structures and at all places not accessible to the roller, thorough 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 kilograms and shall have a tamping face area of not more than 250 square centimeters.

The surface of the mixture 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 with the surrounding area. Any area of 1,000 square centimeters 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 as directed by the Engineer.

4.1.3.14 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 25 centimeters 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 mixture 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 curbs, 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.

When the wearing course is placed adjacent to curbs to form an asphalt gutter, it shall be sealed with asphalt for a distance of 30 centimeters from the curb. The seal shall be evenly applied to the surface by means of hot irons or squeegees so that the surface voids are completely filled and no excess asphalt remains on the surface. The desired drainage pattern shall be maintained.

4.1.3.15 Surface Test of the Pavement

The surface shall be tested by a crown template and 3 meter straight edge, furnished by the Contractor, applied respectively at right angles and parallel, to the centerline of the road. The Contractor shall designate some employee to use the template and straight edge under the direction of the Engineer in checking all

surfaces. The crown template shall conform to the typical cross section shown on the Drawings.

The variation of the surface from the testing edge of the crown template and the straight edge between any two contacts with the surface shall not exceed 12.5 millimeters for bases and 3.5 millimeters for surfacing.

Tests for conformity with the specified crown and grade 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, compression, or composition, shall be corrected as directed by the Engineer, including removal and replacement at the Contractor's expense if so directed by the Engineer.

The edges of the pavement shall be straight and true to the required lines. Any excess material shall be cut off square after final rolling, and disposed of by the Contractor off Government land and out of sight from the road.

4.1.4 Measurement and Payment

All work prescribed above shall be measured and paid for as provided in the respective sections for each type of pavement. The quantity measured and paid for shall always be the quantity ordered with any permitted excess or the actual quantity used whichever is the less.

4.2 ASPHALTIC PRIME COAT

4.2.1 Description

This work shall consist of the careful cleaning of the surface to be primed and furnishing and applying asphaltic material in accordance with these Specifications to the area shown on the Drawings and as directed by the Engineer.

4.2.2 Materials

4.2.2.1 Asphaltic Materials

The prime coat shall be a medium or slow curing cutback liquid asphalt conforming to the requirements of AASHTO M 82 or a slow setting cationic emulsified asphalt conforming to the requirements of AASHTO M 208. Application temperatures shall be as follows:

Type and Grade	Application Temperature
MC – 30	30 – 90°C
MC – 70	50 – 100°C
SC – 70	50 – 100°C
CSS – 1	25 – 55°C

4.2.2.2 Blotting Material

Blotting material to be used shall be approved clean dry sand or stone screenings free from any cohesive material. It shall contain no organic matter.

4.2.3 Construction Methods

The prime coat shall be either medium curing cutback grade MC 70 or MC 30 conforming to the requirements of AASHTO M 82. The medium curing cutback grade MC 30 will be recommended if it is found that medium curing cutback grade MC 70 can not penetrate the base. However, if medium curing cutback grade MC 30 is not available on the market, grade MC 70 may be blended with Kerosene in a proportion approved by the Engineer.

4.2.3.1 Weather Limitations

Prime coat shall be applied only when the surface to be treated is dry or slightly damp when the surface temperature in the shade is above 13°C (55° F) and rising or above 15°C (60° F) if falling and when the weather is not foggy or rainy.

4.2.3.2 Equipment

The Contractor shall provide equipment for heating and applying the asphaltic material. A power broom and/or power blower shall be provided for any required cleaning of the surface to be treated.

The distributor shall be so designed, equipped, maintained and operated that asphaltic material at even heat may be applied uniformly on variable widths of surface up to 4.5 meters at rates inclusive of the rates of application stipulated in Section 4.2.3.4 of this Specification, with an allowable variation from any specified rate not to exceed 0.1 liters per square meter. Distributor equipment shall include a tachometer, pressure gauges, and accurate volume measuring devices, calibrated tank and thermometer for measuring temperature of tank contents. Distributors shall be equipped with a power unit for the pump, and full circulation spray bars adjustable laterally and vertically.

4.2.3.3 Preparation of Surface

Immediately before applying the asphaltic material, all loose dirt and other objectionable material shall be removed from the surface with a power broom and/or blower as required. If the Engineer so orders, the surface shall be lightly bladed and rolled immediately prior to the application of asphaltic material, in which case brooming or blowing will not be required. When so ordered by the Engineer, a light application of water shall be made just before the application of asphaltic material.

4.2.3.4 Application of Asphaltic Material

The prime coat shall be applied to the prepared base course at a rate of 0.8 to 1.4 liters per square meter. The actual rate of application shall be decided by the Engineer based on the results of test areas. Sufficient prime coat should be applied so that the maximum penetration is achieved without excess asphalt remaining on the surface.

The initial application rate can be computed using the following formula:

Prime coate

$$\text{Application Rate} = \frac{P}{R}\frac{(1-r)}{G} \text{ Liters/square meter}$$

where :

P = depth that asphalt material penetrates base course; in mm

R = residual asphalt value;
0.62 for MC-30
0.73 for MC-70
0.80 for SC-70
0.75 for CSS-1

r =maximum dry density of base course (T 180); in gm/cm3

G =bulk specific gravity of base course material

The value of P will depend primarily on the porosity of the base course and the type and grade of asphaltic material. For the initial test section, use P = 4.5 mm and adjust for subsequent test sections in search of the most desirable application rate.

The bulk specific gravity (G) of the base course shall be determined as follows:

$$G = \frac{P1 \pm P2}{\frac{P1}{G1} + \frac{P2}{G2}} \quad \text{or} \quad \frac{100}{\frac{P1}{G1} + \frac{P2}{G2}}$$

where :

P1 = percent retained on the 4.75 mm (No.4) sieve
P2 = percent passing the 4.75 mm (No.4) sieve
G1 = bulk specific gravity of material retained on 4.75 (No.4) sieve
G2 = bulk specific gravity of material passing the 4.75 mm (No.4) sieve

Asphaltic material shall be applied to the width of the section to be covered by means of a pressure distributor in a uniform, continuous spread. When traffic is to be maintained, not more than 1/2 of the width of the section shall be treated in one application. Building paper or other approved material shall be used at the ends of the application, particularly at the junction of previous and subsequent applications, to ensure that a uniform thickness of the coating may be obtained over the entire area. Excess asphaltic material shall be removed from the surface. Omitted areas or deficiencies shall be corrected. Building paper used shall be removed and satisfactorily disposed of.

When traffic is maintained, one-way traffic shall be permitted on the untreated portion of the roadbed. As soon as the asphaltic material has been blotted and will not pick up, traffic shall be transferred to the treated portion and the remaining width of the section shall be covered.

The surfaces of structures and trees adjacent to the areas being treated shall be protected in such manner as to prevent their being splattered or marred. No asphaltic material shall be discharged into a borrow pit, gutter, or stream.

The Engineer will ensure that prime coat is not placed unless the Contractor has made preparations for applying the surface wearing course. These preparations shall include stockpiling of paving aggregates and supply of bitumen for surface treated roads and the construction of the asphalt plant, stockpiling of aggregate and supply of asphalt for asphaltic concrete pavements.

4.2.3.5 Application of Blotting Material

Blotting material shall be spread so that no wheels or tracks will travel in uncovered wet asphaltic material.

Blotting material should not be applied until 24 hours have elapsed after the asphaltic material has been applied. Sufficient material shall be applied so that all excess asphalt is soaked up by the blotting material.

4.2.3.6 General Precautions

Since cutback asphalt is flammable, extreme care must be exercised during the heating process. Care shall be taken in transporting emulsified asphalt to avoid separation of the mixture. Containers of emulsified asphalt shall be rolled five times to each side every week and pouring into the asphalt distributor. Emulsified asphalt shall not remain in the asphalt distributor holding tank overnight. Generally, it is desirable that an opened container of emulsified asphalt be completely used up; if not used completely, the container should by tightly sealed in order to prevent separation of the mixture.

4.2.4 Measurement

Asphaltic prime coat shall be applied to the full width of the top of base course, including where shoulders are constructed of base course material on all other areas requiring asphalt concrete as directed by the Engineer. Asphaltic prime coat shall be measured on the surface using the two-dimensional method on a square meter basis.

Blotting material shall not be measured for payment but will be considered to be included in the unit price for asphaltic prime coat. Blotting material shall always be used unless otherwise directed by the Engineer.

4.2.5 Payment

Asphaltic prime coat will be paid for at the Contract unit price per square meter, complete and approved in place, which price shall include all material, equipment, labor, preparation of the surface, construction paper, blotting material and all incidentals necessary for satisfactory completion of the work.

Payment shall be made under the following item

Item No.	Description	Unit
4.2(1)	Asphaltic Prime Coat	square meter

4.3 ASPHALTIC TACK COAT

4.3.1 Description

This work shall consist of furnishing and applying asphaltic material to a previously prepared roadbed, in accordance with this Specification and to the width and area required by the Engineer.

4.3.2 Materials

The tack coat shall be one of the following bituminous materials:

Designation	Type of Material	Application Temperature	Application Rate
RC – 70	Rapid Curing Liquid Asphalt	50 – 100°C	0.1 – 0.3 l/m2
RC – 250	Rapid Curing Liquid Asphalt	80 – 100°C	0.1 – 0.3 l/m2
CRS – 2	Rapid Setting Cationic Emulsified Asphalt	20 – 70°C	0.2 – 0.6 l/m2 (assuming 1:1 mixture)

The materials shown above shall be in compliance with AASHTO M 81-75 and M 208-81, as applicable, and shall be supplied in accordance with the requirements specified in Section 4.1.2.5 of these Specifications. The general precautions outlined in Section 4.2.3.6 of these Specifications shall be applicable.

4.3.3 Construction Methods

4.3.3.1 Equipment

The equipment shall be as specified in Section 4.2 Prime Coat.

4.3.3.2 Cleaning Surface

The full width of surface to be treated shall be cleaned with a power broom or blower to remove loose dirt and other objectionable material. The surface to be treated shall be dry.

4.3.3.3 Application of Asphaltic Material

Immediately after cleaning the surface, asphaltic material shall be applied by means of a distributor at the rates and temperature shown in Section 4.3.2 and

directed by the Engineer. The tack coat shall be applied only when the surface is dry unless otherwise directed by the Engineer.

The surface of structures and trees adjacent to the areas being treated shall be protected in such 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. This shall be done at the Contractor's expense.

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 as 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.

4.3.4 Measurement

Asphaltic tack coat shall be measured by the two-dimensional method on a square meter basis for an approved rate of application.

4.3.5 Payment

Asphaltic tack coat shall be paid for at the Contract unit price per square meter, complete and approved in place, which price shall be full compensation for all material, equipment, labor, surface preparation and all incidentals necessary for satisfactory completion of the work.

Payment will be made under the following item:

Item No.	Description	Unit
4.3(1)	Asphaltic Tack Coat	square meter

4.4 ASPHALTIC CONCRETE SURFACING

4.4.1 Description

4.4.1.1 General

This work shall consist of a surfacing of dense grade asphaltic concrete, constructed on a prepared base or roadbed in accordance with these Specifications, to the lines, levels, grades, dimensions and cross sections shown in the Drawings, and as required by the Engineer.

All the provisions of Section 4.1, "General Requirements for Asphaltic Surfacing" shall form a part of these Specifications unless otherwise stipulated herein.

The surfacing shall consist of one or two layers of the thickness shown in the Drawings. The top layer shall be denoted as the wearing course and the lower layer as the binder course.

4.4.1.2 General Composition of the Mixture

The design of asphalt concrete mixtures shall be undertaken by the Contractor in accordance with Section 4.1.1.3 of these Specifications. The design of mixtures shall be carried out in a materials testing laboratory approved by and under the supervision of the Engineer.

The mixture shall consist of mineral aggregate, filler (1–2% of lime or 2-4% of cement if necessary according to the Engineer) and the asphaltic cement. The total mineral aggregate shall have a job mix grading within the limits shown in **Table 4.4.1**. Gradations outside the limits specified must have the approval of the Engineer.

In addition to meeting the job mix formula in Section 4.1, laboratory samples shall be prepared according to the Marshall method (AASHTO T 245-78) using 75 blows to compact the sample. The sample shall be of approved material to the gradation and asphalt content stated and shall have the following characteristics. The strength Index shall be determined according to the Ontario Vacuum Immersion Marshall Test or the U.S. Army Corps of Engineer – Asphalt Institute Immersion Marshall Test.

1. Marshall Stability (lbs.) not less than 1,800 lbs. for Wearing and not less than 1,800 lbs. for Binder.
2. Marshall Flow (0.01 inch) not less than 8 nor more than 16.
3. Ratio of Marshall Stability (lbs.) to Marshall Flow (0.01 ins) shall not be less than 125.
4. Air voids in Mix: Wearing 3-5%; Binder 4-7%
5. Voids in mineral aggregate: 14-10%
6. Voids filled with asphalt: Wearing 65-80%; Binder 55-75%
7. Strength Index: minimum 75%

The selected job mix shall conform to the guidelines outlined in **Table 4.4.1** below. Asphaltic concrete for leveling courses shall follow the same mix requirements of the lowest layer of asphaltic concrete pavement (usually binder course) as shown on the Drawings or directed by the Engineer.

During the preparation of the job mix design, the Engineer may instruct the Contractor to adjust the cold bin openings or revise the proportions of the aggregates or add filler or additive or change the source of materials in order to obtain the most suitable formula, if the Engineer considers that such revision is necessary.

Table 4.4.1

Mix Classification		1	2	3	4
Course		Binder	Wearing	Wearing	Wearing
Thickness (centimeters)	Max.	7.5	6	4.5	6
	Min.	3.5	3	2.5	3
Total % by weight passing including filler	1"	100	-	-	-
Sieve Size	3/4"	90-100	100	100	100
	1/2"	-	-	-	-
	3/8"	55-82	60-83	75-95	70-90
	4 mesh	35-57	40-65	53-72	50-70
	8	23-40	30-50	35-53	35-50
	16	15-33	20-40	24-43	-
	30	10-26	15-35	19-35	18-29
	50	6-20	10-25	14-27	13-23
	100	3-13	7-17	9-18	8-16
	200	1-7	4-9	5-10	4-10
Asphalt cement content by total weight of mixture. Percentage by weight found by Analysis.		3.5-5.5	4.0-6.6	4.0-7.0	3.5-7.0

4.4.2 Materials

The materials shall conform to requirement of Section 4.1.2 of these Specifications with the additional requirements noted below.

4.4.2.1 Asphaltic Materials

Bituminous materials for asphalt concrete shall be asphalt cement with penetration grades of 60 - 70 only.

4.4.2.2 Asphalt Additive

Asphalt additives shall be used if and when directed by the Engineer. Prior approval must be obtained from the Engineer regarding the type of additive to be used.

4.4.2.3 Coarse Mineral Aggregate

The coarse aggregates shall be tested in accordance with British Standard 812 to determine the Flakiness Index and the Elongation Index. When so tested the Flakiness Index and the Elongation Index shall not exceed 35 percent.

When subjected to Coating and Stripping Tests, AASHTO Test Method T 182, the aggregates shall have a coated area of not less then 95 percent.

4.4.2.4 Combined Mineral Aggregates

The mineral aggregates when combined in the proportions required by the job-mix formula shall have a Sand Equivalent of not less than 50 as determined by AASHTO Test Method T 176.

4.4.2.5 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 milliliters 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% of 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 40 centimeters, when tested in accordance with AASHTO Test Methods T 49 and T 51, respectively.

4.4.3 Construction Methods

4.4.3.1 Tolerance

a) The temperature of the aggregate shall be so controlled that the temperature of the mixture on being discharged from the mixing plant is between 135 and 175°C. The Contractor shall select the minimum temperature which will

ensure the aggregates are properly dried, and which enables him to deliver the mixture to the paver at or slightly above the required temperature.

b) The temperature at which the asphalt mixture is fed into the mixer shall be between 0 and 15°C lower than the temperature of the heated aggregates.

c) The temperature at which the mixture is spread shall not be less than 130°C, or that temperature the Engineer directs so that a proper compaction is obtained.

d) The mixture shall be compacted as soon as it will bear the weight of a roller without causing under lateral displacement of the material. The density of the mixture after compaction shall be not less than 98 percent of the Marshall Density as determined from daily compacted samples. The density shall be checked by 10cm diameter cores made with an approved core drill.

e) The average thickness of the compacted pavement laid in any area one day shall not be less than the thickness shown on the Drawings. The minimum thickness at any one point shall not be more than 5 mm below the specified thickness.

f) Pavement Samples

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 25 centimeters square, except that, for measurement of the field density only, cores with a minimum diameter of 10 centimeters 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.

One sample for density measurement shall be taken for each day or part of a day that the plant operates or if the output exceeds 100 metric tons per day then at the rate of one per 100 metric tone 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 substantial change is made in the job mix formula.

Where samples have been taken from the surface course, fresh material shall be placed, throughly compacted and finished to the satisfaction of the Engineer.

g) The surface of the finished pavement shall be tested for evenness by the Engineer using a 3.5 meter straight edge. The surface will be considered acceptable transversely, if it does not exceed 3 millimeters between two contact points.

Pavement surface not conforming to this tolerance may be rejected by the Engineer. Rejected areas shall be removed and repaved at the Contractor's own expense.

h) The joints of an asphaltic concrete wearing course shall be sawn joints.

4.4.3.2 Control and Testing

The Contractor shall provide adequate laboratory accommodation and all the equipment required for sampling for each of the following tests.

1) Grading analysis of aggregate and filler.
2) Flakiness and Elongation Index of coarse aggregates.
3) Sand Equivalent of aggregates.
4) Bulk specific gravity of mixed aggregates.
5) Compacted density of mixed aggregates.
6) Compacted density of mixes (Marshall Density).
7) Marshall Stability and Flow.
8) Strength Index.
9) Density of compacted surface course.
10) Asphalt extraction.

The Engineer shall be responsible for all sampling and testing and will provide an adequate number of skilled technicians to do this work.

The following test 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 are required.

1) Temperature of mix when sampled at the plant and on the road.
2) Density of laboratory mix (Marshall Density).
3) Compacted density and percentage compaction of surface course.
4) Marshall Stability and Flow, and Strength Index.
5) Asphalt content and aggregate grading of mix.
6) Air voids in mix.

4.4.3.3 Protection of the Pavement

Sections of the newly finished work shall be protected from traffic of any kind until the mixture has cooled to approximately ambient air temperature. 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.

4.4.4 Measurement

Asphaltic concrete to be used as a binder course or wearing course, of thickness specified in the Drawings, shall be measured on a cubic meter basis, the dimensions of which shall comprise the thickness and width specified on the typical cross section and the length of completed and accepted construction. Side road intersections, curve widening, fillets and other smaller areas required to be paved shall also be measured on a cubic meter basis. Pavement thickness must be within the limit specified in Section 4.4.3.1 e). Additional payment will not be made for thickness greater than those specified.

Asphaltic concrete to be used in Leveling courses, patching, pothole repair or other remedial works not easily measured on a dimensional basis shall be measured by the number of metric tons used in the works as ordered by the Engineer. The material shall be weighed after mixing at the batch plant and the weight of mixture shall be controlled by triplicate load delivery tickets from the truck scales at the batch plant.

Asphalt additive, if required by the Engineer, shall be measured by the liter.

4.4.5 Payment

Asphaltic Concrete for Leveling, measured as provided for in Section 4.4.4, shall be paid for at the Contract unit price per ton, complete in place, which price shall include all material, labor, equipment, tools, cleaning and preparation of the area to be leveled or patched, removal of deleterious material or loose existing asphalt and all incidentals necessary to the satisfactory completion of the work.

Asphaltic Concrete for Wearing Course or Binder Course shall be paid for at the respective Contract unit prices per cubic meter, complete in place, which prices shall be complete compensation for all aggregates, mineral fillers, asphalt cement, crushing, heating and mixing plant, all equipment necessary for placement, tools, labor and incidental necessary to complete the work.

The use of Asphalt Additive, if directed by the Engineer, shall not be paid for, but will be considered as incidental to the Asphaltic concrete item.

Payment will be as follows:

Item No.	Description	Unit
4.4(1)	Asphaltic Concrete for Wearing Course	cubic meter
4.4(2)	Asphaltic Concrete for Binder Course	cubic meter

With the approval of the Engineer, payment will be made at the Contract unit price bid, regardless of the design mix cement content finally determined and agreed on the site, provided said cement content is within the range specified in Section 4.4.1.2.

4.5 PORTLAND CEMENT CONCRETE PAVEMENT

4.5.1 Description

4.5.1.1 General

This work shall consist of constructing a portland cement concrete pavement with or without reinforcement accepted subgrade or subbase in accordance with this 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 admixtures.

4.5.2 Material

4.5.2.1 Portland Cement Concrete

Concrete type shall be Class C and shall conform to the requirements of Section 5.1.

4.5.2.2 Reinforcement Steel

Pavements which are reinforced shall contain steel-wire fabric or bar-mat reinforcement, as called for on the Drawings and also such dowels, tie bars and other details as necessary.

Wire-fabric and bar-mat reinforcement shall extend to within 5 centimeters of each side of the slab. The sheets shall be furnished in such lengths that, with at least the minimum lap between sheets, the reinforcement extends to within 5 centimeters of transverse expansion or construction joints.

a) Steel-wire fabric

Steel-wire fabric reinforcement shall conform to the requirements of AASHTO M 55-81 or ASTM 185-79. It shall be furnished in flat sheets.

b) Bar-mats

Bar-mats shall conform to the requirement of AASHTO Standard Specification M 54. The bars used shall conform to the requirements of Thai Industrial Standard, grade TIS 20 class SR 24. Members shall be of the size and spacing shown on the Drawings.

Bars used shall be type SR 24, in accordance with the Thai Industrial Standard 20-2527.

c) Dowel and Tie Bars

Dowel and tie bars shall conform to the requirements of AASHTO Standard Specification M 31 and 42.

Dowels bars shall be types SR 24 and tie bars shall be type SD 30, all in accordance with the Thai Industrial Standard

Dowels bars shall be plain round bars. They shall be free from burring or other deformation restricting slippage in the concrete. Before delivery to the site of construction, one-half of the length of each dowel bar shall be painted with one coat of lead paint or asphaltic material.

Tie bars shall be deformed bars. Rail steel shall not be used for tie bars which are to be bent and restraightened during construction.

4.5.2.3 Sleeves

The sleeves for dowel bars shall be of metal or approved synthetic material. These shall be designed to cover not less than 5 centimeters nor more than 7.5 centimeters of the dowel, with closed ends, and with suitable stops to hold the end of the sleeve a distance equal to the thickness of joint filler or at least 2.5 centimeters from the end of the dowel bar.

Sleeves shall be of such design that they do not deflect or collapse during construction, and the arrangement of sleeves shall be in accordance with Clause 4.5.4.9.

4.5.2.4 Subbase Materials

Granular material conforming to AASHTO Standard Specification M 155 in every detail shall be used immediately beneath all concrete pavement, unless otherwise detailed on the Drawings.

Subgrade Paper

The Subgrade paper shall conform to the requirements of AASHTO Standard Specification M 74 or other approved by the Engineer.

Plastic Membrane

Plastic Sheeting used as a separation membrane under the pavement shall be dispensed from rolls immediately ahead of the paving machinery; joints in the sheeting should provide a lap of at least 20 cm. The width of roll shall be at least 1.20 m and the thickness of the plastic should be 0.07 mm with a tolerance not greater than seven percent.

4.5.2.5 Jointing Materials

a) Joint Filler

The expansion joint fillers shall conform to the requirements of AASHTO Standard Specifications M 153 or M 213. They shall be punched to admit the dowels where called for on the Drawings. The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint, unless otherwise authorized by the Engineer. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened closely together securely and accurately to shape by stapling or other positive fastening satisfactory to the Engineer.

b) Joint Primer

Joint priming compound shall be Expandite No.3 or other approved compound.

c) Joint Sealing Compound

Joint sealing material shall be Expandite Plastic hot poured rubber-bitumen sealing compound Grade 99 or other approved compound.

4.5.3 Equipment and Tools

4.5.3.1 General

Equipment and tools necessary for handling materials and performing the work, and satisfactory to the Engineer as to design, capacity, and mechanical condition, shall be at the site of the 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 discretion of the Engineer.

4.5.3.2 Finishing Equipment

a) Finishing Machine

The finishing machine shall be of the screening and troweling 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 disarrangement 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 impulses per minute and for the internal type not less than 500 impulses per minute.

4.5.3.3 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.

4.5.3.4 Forms

Straight side forms shall be metal forms having a thickness of at least half a centimeter 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 millimeters when tested as a simple beam with a span of three meters 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 meter straight edge by more than 3 millimeters at any point and the side by more than 6 millimeters at any point.

The forms shall contain provision for locking together tightly the ends of abutting form sections and for secure setting.

4.5.3.5 Curing Materials

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 any other substances which interfere with its absorting 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 meter when completely dry.

b) Sand

Sand shall be clean, sharp and free from any clay balls or any other deleterious matter.

c) Liquid membrane forming compounds

Liquid membrane forming compounds shall conform with the requirements of AASHTO. Standard Specification M 148 type 2.

4.5.4 Construction Methods

4.5.4.1 Preparation of Subgrade or Subbase

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 subbase. Laying this subbase shall be carried out as specified in Section 3.1.3 with materials as specified in Section 4.5.2.7.

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 subbase 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 60 centimeters 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.

4.5.4.2 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 one centimeter or less for 45 centimeters on each side of the base of the forms and thoroughly rerolled 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 150 meters 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 3 meter section, one pin being placed near each the 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 six millimeters 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 rechecked.

4.5.4.3 Condition of Roadbed

The roadbed shall be checked for conformity with the crown and elevation shown on the Plans by means of a toothed 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.

If the roadbed is disturbed after acceptance it shall be reshaped and compacted without additional compensation.

The finished roadbed shall be in a smooth, compacted condition when the concrete is placed, and shall be moist, but under no circumstances will concrete be placed on a muddy or unclean surface. If the roadbed is dry at the time the concrete is to be placed, it shall be sprinkled. The method of sprinkling shall be such that it does not form pools of water. If required by the Engineer the roadbed shall have been moistened at a time dependent on weather conditions prior to the placing of the concrete.

4.5.4.4 Limitations of Mixing

No concrete shall be mixed, placed, or finished when the natural light is insufficient, unless an adequate and approved artificial lighting system is operated.

Concrete shall be mixed only in the amount required for current use.

The Contractor shall be responsible for producing 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.

4.5.4.5 Placing Concrete

Concrete shall be placed only on a roadbed that has been prepared as specified in Section 4.5.4.3. 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 therefrom in such a way as to prevent segregation or precompaction of the materials.

Concrete to be reinforced shall be placed in two layers, the bottom layer being stuck off at the level for the reinforcement or as designated on the Drawings.

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, except in case of emergency.

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 5 centimeters 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.

4.5.4.6 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 some other approved device is provided therefore or unless the use of hand methods is specifically authorized 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 extent to within 5 centimeters 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 meter.

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 10 centimeters.

4.5.4.7 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) Transverse Expansion Joints

The material for a transverse 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 millimeter thick material having flanges not less than 3.75 centimeters 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 1 centimeter 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-250, graphite lubricant, or equivalent 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 dowels in correct alignment, both vertically and horizontally, subject to a tolerance of not more than 1 millimeter in 10 centimeters.

When assembled, the top of the installing bar shall be about 5 millimeters 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 center line of the road, subject to a tolerance of not more than 5 millimeters in the width of a traffic lane, and the dowels shall be parallel 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 1 centimeter 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 in such a way as to hold the assembly securely in 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-shape metal shall be of material of not less than 1.5 millimeters thick. They shall be 40 centimeters 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 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 centerline of the pavement and shall be true to line, subject to a tolerance of 5 millimeters in the width of the slab.

When the Drawings call for sawn contraction joints to be 18 meters 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 18 meters apart, it may be found impossible to saw all joints before uncontrolled cracking takes place. In this case part of the joints, generally 18 to 30 meters 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.

All sawn joints shall be 4 centimeters deep. When 18 meters or more apart they shall be not less than 12 millimeters in width and when less than 18 meters apart shall be the width of the conventional saw blade.

Any procedure for sawing joints that results 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-250, graphite lubricant, or equal 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 millimeter in 10 centimeters.

The assembly shall be placed into position so that the dowels are parallel to the centerline and shall be staked into position in such a way as to hold the assembly securely in position 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 Section 4.5.4.7 b) Planes of weakness.

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 contraction 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 3 meters of an expansion joint, contraction joint, or plane of weakness. If sufficient concrete has not been mixed at the time of interruption to form a slab at least 3 meters long the excess concrete back to the last preceding joint shall be removed and disposed of as directed by the Engineer.

4.5.4.8 Final Strike – off, Consolidation and Finishing

a) Machine finishing - As soon as the concrete of 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 places. The machine shall go over each area of pavement as many times and at such intervals 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 forms 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 maintained 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 acreed.

At transverse joints, the finishing machine shall be moved forward until the front screed is approximately 20 centimeters from the joint. Segregated coarse aggregate 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 mortar 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 lifting 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 fi .ishing – 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 60 centimeters 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, true 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 the floating operation at the proper time. In this operation, the

longitudinal front shall be worked with a sawing motion, while held in a floating position parallel to the road centerline, and passed gradually from one side of the pavement to the other. Movements ahead along the centerline 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 3 meter straight edge. The straight edge shall be held in contact with the surface in successive positions parallel to the road centerline 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 filled immediately with freshly mixed concrete, and any high areas shall be cut down. 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 straightedge testing and refloating shall continue until the entire surface is found to be free from observable departures from the straightedge 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 coarse 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 overlapping, in such a way as to corrugate the surface uniformly to a depth of not more than 2 millimeters. 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 millimeters. 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, any tool marks appearing on the slab adjacent to the joints shall be eliminated by brooming the surface. In doing this, the rounding of the corner of the slab shall not be disturbed. Along the edges of the slabs, the tool marks shall be left in place. All concrete on top of the joint shall be removed completely.

All joints shall be tested with a straight-edge before the concrete has set, and correction shall be made if one side of the joint is higher than the other or if they are higher or lower than the adjacent slabs.

4.5.4.9 Surface Requirements

After the concrete has hardened sufficiently, the surface shall be given a further test for trueness, using an approved 3 meter straight edge laid on the surface, in successive positions overlapping 1.5 meters, 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 millimeters but not exceeding 7.0 millimeters shall be marked and immediately ground down with an approved grinding tool until the variation does not exceed 3.5 millimeters.

Whenever the variation or departure from the testing edge is more than 7.0 millimeters the pavement shall be removed and replaced by the Contractor at his own expense. Such removal shall be of the full depth and width of the slab and at least 3 meters long.

4.5.4.10 Curing

As soon after brooming and edging as is feasible 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 to hand at the site.

Curing materials shall be weighted down in a manner satisfactory to the Engineer so that displacement is effectively prevented. Should any 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 hours or 12 hours 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 is called for in the Contract this shall be in accordance with AASHTO. Standard Specification M148 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 pressure 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 a coverage of not more than 4 square meters per liter for both coats. The application of curing compound by hand-operated pressure sprayers will be permitted only on add widths or shapes of slabs, and on concrete surface 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, pun 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 resprayed 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, fiber 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 alternate 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, the stand-by or alternate curing method shall be used only on the remaining portion of the paving already placed. Concrete surface 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 revved and sand shall be spread, without delay, to a thickness of at least 3cm. and wetted immediately. Other moisture-retaining materials may be used in place of sand subject to the approval of the Engineer. Whatever material is used 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 this clause carefully and expeditiously.

4.5.4.11 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 pointed 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 meters long.

4.5.4.12 Protection of Pavement

The Contractor shall erect and maintain suitable barricades and shall employ watchmen to exclude public traffic and that of his employees and agents from the newly constructed pavement until opened for use. These barriers shall be arranged 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 to 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 traffic lane or lanes.

Where the clearance between public traffic lanes and the Contractor's operating equipment is restricted, special delivering equipment may be necessary designed to deliver and depart within the width of the slab actually being placed without encroaching on any 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.

4.5.4.13 Sealing Joints

Before the pavement is opened to traffic, and as soon after the curing period as is feasible, 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 is 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 the pavement surface cleaned.

When required to prevent tackiness or pickup under traffic, the exposed surface of the seal material shall be dusted with an approved material. Other methods of preventing pickup 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 50°F, (10°C), except after approval by the Engineer.

4.5.4.14 Opening to Traffic

The new work shall not be opened to traffic until so authorized by the Engineer.

4.5.4.15 Finishing Shoulders

Shoulders shall be constructed in accordance with the details shown on the Drawings and as specified in the relevant section of these Specification.

The construction, shaping and other treatment of the shoulders shall follow the completion of the pavement as closely as possible.

4.5.5 Measurement

4.5.5.1 Tolerance in Pavement Thickness

It is the intent that the pavement be of the thickness called for on the Drawings. The Engineer will require two cores to be drilled from each 500 meters of slab, and measured in accordance with AASHTO. Test Method T148 to determine the average thickness of the pavement of each kilometer 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 drilled at intervals of not less that 100 meters. The additional information so obtained shall be used in determining whether and what adjustments to the Contract unit price are required.

The unit price for concrete pavement in the Bill of Quantities shall include for all the costs incurred in drilling and measuring cores and making good the holes with concrete of the specified quality.

All cores drilled in the pavement will be reinstated to the satisfaction of the Engineer as soon as possible after drilling is completed.

4.5.5.2 Area

The area of cement concrete pavement to be paid for shall be the number of square meters accepted and measured in place excluding all gaps for longitudinal, expansion and contraction joints. The width for measurement shall be from outside to outside of completed pavement as shown on the Drawings.

The length will be the actual length measured along the centerline of the riding surface. No account shall be taken of the surface areas of any arrises, slots, or bevels.

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 millimeters or less in thickness will be accepted and paid for at the unit rate shown in the Bill of Quantities. Areas of pavement deficient by between 3.5 and 15.0 millimeters in thickness will be reduced proportionately by the ratio of the deficient thickness to the specified

thickness. Areas 15 millimeters or more deficient in thickness will not be included for payment except where such areas have been removed and replaced by pavement meeting the Specifications.

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 for payment. When widths of constructed pavement prove to be less than those specified the areas to be included for pavement will be calculated using the widths as constructed and accepted by the Engineer.

4.5.5.3 Sand Layer Cushion

Fine aggregate for the sand layer cushion shown on the typical roadway section shall be measured in accordance with Section 3.1 of this Specifications.

4.5.5.4 Subgrade Paper

Subgrade paper under the pavement will not be measured separately but will considered to be included in the cost of cement concrete pavement as specified in Section 4.5.6 of this Specification.

4.5.5.5 Reinforcement

Steel reinforcement shall be placed in accordance with the detailed Drawings and shall conform to the requirements of Sections 4.5.2.2 and 5.2 of these Specifications. However, no separate measurement for payment will be made for steel reinforcement as it will be considered included in the cost of cement concrete pavement as specified in Section 4.5.6 of this Specification. In addition all associated work, load transfer devices, formwork and other materials shall be incidental to the Contract unit price per square meter for cement concrete pavement.

4.5.5.6 Plastic Membrane

Plastic sheeting used as a separation membrane under the pavement shall be measured on a square meter basis, complete and accepted in place. The width for measurement shall be from outside to outside of complete concrete pavement as shown on the Drawings. The length shall be the actual measured along the centerline of the pavement.

4.5.5.7 Joints

Longitudinal construction joints, expansion joints and constuction joints will be measured on a linear meter basis along the surface of the pavement. Transverse construction joints, as described in Section 4.5.4.7 b), shall not be measured and paid for separately but shall be considered incidental to the work.

4.5.6 Payment

Portland cement concrete pavement of a specified thickness shall be paid for at the Contract unit price per square meter, complete in place, which price shall include all aggregates, cement, reinforcement (if required), subgrade paper, other miscellaneous materials and hardware; mixing, placing, screeding, finishing, curing and protecting concrete; furnishing, placing and removing formwork, all transverse construction joints and all labour, equipment, tools and incidentals necessary to complete the work. Said contract unit price shall also include preparing, cutting, packing, and transporting to the Engineer's laboratory test cubes and drilled cores as required by the Engineer, as well as restoring and making good any cored or damaged pavement.

Longitudinal Joints, Expansion Joints and Contraction Joints shall be paid for at the respective Contract unit prices per liner meter, complete in place, which prices shall include the supplying and installing of dowels, tie-bars, other miscellaneous material and hardware, joint filler, joint sealant, lubricants, forms, joint assemblies and load transfer devices as well as supplying all labour, tools, equipment and incidentals necessary to complete the work.

Plastic membrane, where specified on the Drawings, shall be paid for at the Contract unit price per square meter, complete in place, which price shall include all laps, placing, cutting, joining, and all labour, materials, equipment, tools and incidentals necessary to complete the work.

Sand layer cushion, subbase material or other lower pavement items, where shown on the typical section or called for by the Engineer shall be paid for separately in accordance with the respective sections of these Specifications. With the approval of the Engineer, partial payment may be made for cement and reinforcement steel delivered and properly stored at the site in accordance with Section 1.9.7.

Payment will be made as follows :-

Item No.	Description	Unit
4.5(1)	Portland Cement Concrete Pavement, 25cms Thicknes	square meter

SECTION 5 : STRUCTURES

5.1 CONCRETE STRUCTURES

5.1.1 General

5.1.1.1 Description

This work shall consist of furnishing, placing, finishing, and curing concrete in bridges, culverts, and miscellaneous structures in accordance with these specifications and conforming to the lines, grades, and dimensions shown on the plans. The work includes elements of structures constructed by cast-in-place and precast methods using either plain (unreinforced), reinforced, or prestressed concrete or any combination thereof.

5.1.1.2 Related Work

Other work involved in the construction of concrete structures shall be as specified in the applicable sections of this specification. Especially applicable are Section 5.2 for reinforcing steel, and Section 5.3 for prestressing.

5.1.1.3 Construction Methods

Whenever the specifications permit the Contractor to select the method or equipment to be used for any operation, it shall be the Contractor's responsibility to employ methods and equipment which will produce satisfactory work under the conditions encountered and which will not damage any partially completed portions of the work.

Falsework and forms shall conform to the requirements of Section 1.13, "Temporary Works."

Generally, all concrete shall be fully supported until the required strength and age has been reached. However, the slip form method will be permitted for the construction of pier shafts and railings providing the Contractor's plan assures that: (1) the results will be equal in all respect to those obtained by the use of fixed forms, and (2) adequate arrangements will be provided for curing, finishing, and protecting the concrete.

5.1.2 Classes of Concrete

5.1.2.1 General

The class of concrete to be used in each part of the structure shall be as specified or shown on the Drawings. If not shown or specified, the Engineer will designate the class of concrete to be used.

5.1.2.2 Normal Weight Concrete

Six classes of normal weight concrete are provided for in these specifications as listed in Table 5.1.1. They are further subdivided into the structure designation as listed below.

Class of Concrete		Structure Designation
A – 1	-	Precast segment
A – 2	-	Cast-in-place PC sail, Tower
A – 3	-	Cast-in-place Pier Head of Rigid Pier
A – 4	-	Cast-in-place PC box girder of Approach Viaduct
A – 5	-	Cast-in-place Closure pour
B – 1	-	Cast-in-place pile Dia 2.0m. of Main Bridge
B – 2	-	Cast-in-place pile Dia 1.0m of Approach Viaduct
C – 1	-	RC rigid pier of Main Bridge
C – 2	-	Bridge Approach Slab
C – 3	-	Pipe Culvert
C – 4	-	Concrete Pavement.
D – 1	-	RC pier of Main Bridge
D – 2	-	RC pile cap of Main Bridge
D – 3	-	RC pier of Approach Viaduct
D – 4	-	RC pile cap of Approach Viaduct
D – 5	-	Abutment of Approach Viaduct
D – 6	-	Pre-cast RC skirt of Main Bridge pile cap
D – 7	-	Curb
D – 8	-	Bridge lighting poles bracket
D – 9	-	Bridge sidewalk precast RC plate
D – 10	-	RC Box culvert
D – 11	-	U – ditch
D – 12	-	Stairs
D – 13	-	Concrete barrier
E – 1	-	Lighting poles foundation in road

E – 2 - Steel pole foundation for traffic signs
E – 3 - RC drain outlet
F – 1 - Lean concrete

Table 5.1.1
Class and Constituents of Concrete for Use in Structures

Class of Concrete	Minimum 28 day Compressive Strength (N/mm^2)		Type of Cement	Minimum Cement Content (kg/m^3)	Maximum Water Cement Ratio (%)	Maximum Size of Coarse Aggregates (mm)
	Cylinder Test	15 cm cubes				
A	40	(47)	III	420	42	20
B	30	(35)	I	350	45	20
C	27	(32)	I	325	48	20
D	24	(28)	I	275	55	20
E	18	(21)	I	230	55	20
F	15	(18)	I	230	68	20

Comment : 1) 15 cm cubes strength is the reference data. Type of cement : I = normal, III = high early strength
2) Conversion coefficient; Cylinder strength = 0.85 x cube strength

The air content for concrete classes A, B, C and D will all not be more than 4±1 percent.

5.1.3 Materials

5.1.3.1 Cements

Portland Cements shall conform to the requirements of AASHTO M 85 (ASTM C 150) or JIS R5210 (Japan Industrial Standard) or TIS 15 (Thai Industrial Standard).

Unless otherwise specified, only Type I, II, or III Portland Cement, Types IA, IIA, or IIIA Air Entrained Portland Cement, shall be used. Types IA, IIA, and IIIA cements may be used only in concrete where air entrainment is required.

Low-alkali cements conforming to the requirements of AASHTO M 85 for low-alkali cement shall be used when specified or when ordered by the Engineer as a condition of use for aggregates of limited alkali-silica reactivity.

Unless otherwise permitted, the product of only one mill of any one brand and type of cement shall be used for like elements of a structure that is exposed to view, except when cements must be blended for reduction of any excessive air-entraining cement is used.

5.1.3.2 Water

Water used in mixing and curing of concrete shall be subject to approval and shall be reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable, or other injurious substances. Water will be tested in accordance with, and shall meet the suggested requirements of AASHTO T 26. Water known to be of potable quality may be used without test. Where the source of water is relatively shallow, the intake shall be so enclosed as to exclude silt, mud, grass, or other foreign materials.

Mixing water for concrete in which steel is embedded shall not contain a chloride ion concentration in excess of 1,000 ppm or sulphates such as SO_4 in excess of 1,300 ppm.

5.1.3.3 Fine Aggregate

Fine aggregate for concrete shall conform to the requirements of AASHTO M 6.

5.1.3.4 Coarse Aggregate

Coarse aggregate for concrete shall conform to the requirements of AASHTO M 80.

Coarse aggregates shall be clean with sufficient strength, durability and suitable particle size. They shall contain no garbage, mud, organic substances, salts or other harmful materials. In general, crushed stone shall be used in this Project. Durable rock of basalt, andesite, hard sandstone, hard limestone or others with equivalent quality shall be generally manufactured and applied.

5.1.3.5 Air-Entraining and Chemical Admixtures

Air-entraining admixtures shall conform to the requirements of AASHTO M 154 (ASTM C 260).

Chemical admixtures shall conform to the requirements of AASHTO M 194 (ASTM C 494). Unless otherwise specified, only Type A (Water-reducing), Type B (Retarding), Type D (Water-reducing and retarding), Type F (Water-reducing, high range) or Type G (Water-reducing, high range and retarding) shall be used.

Admixtures containing chloride ion (Cl) in excess of 1 percent by weight of the admixture shall not be used in reinforced concrete. Admixtures in excess of 0.1 percent shall not be used in prestressed concrete.

A Certificate of Compliance signed by the manufacturer of the admixture shall be furnished to the Engineer for each shipment of admixture used in the work. The Certificate shall be based upon laboratory test results from an approved testing facility and shall certify that the admixture meets the above specifications.

If more than one admixture is used, the admixtures shall be compatible with each other and shall be incorporated into the concrete mix in the correct sequence so that the desired effects of all admixtures are obtained.

Air-entraining and chemical admixtures shall be incorporated into the concrete mix in a water solution. The water so included shall be considered to be a portion of the allowed mixing water.

5.1.3.6 Steel

Materials and installation of reinforcing and prestressing steel shall conform to the requirements of Sections 5.2, "Reinforcing Steel," and 5.3, "Prestressing," respectively.

5.1.3.7 Control of Alkali Aggregate Reaction

The Contractor shall either use non-reactive aggregates or restrict the content of equivalent sodium oxide in the concrete mix.

5.1.4 Proportioning of Concrete

5.1.4.1 Mix Design

(a) Responsibility and Criteria

The Contractor shall design and be responsible for the performance of all concrete mixes used in structures. The mix proportions selected shall produce concrete that is sufficiently workable and finishable for all uses intended and shall conform to the requirements in Table 5.1.1 and all other requirements of this Section.

For normal weight concrete the absolute volume method, such as described in American Concrete Institute Publication 211.1, shall be used in selecting mix proportions.

The mix design shall be based upon obtaining an average concrete strength sufficiently above the specified strength so that, considering the expected variability of the concrete and test procedures, no more than 1 in 10 strength tests will be expected to fall below the specified strength. Mix designs shall be modified during the course of the work when necessary to ensure compliance with strength and consistency requirements.

(b) Trial Batch Tests

For classes A, B, C and D concrete, and for other classes of concrete when specified or ordered by the Engineer, satisfactory performance of the proposed mix design shall be verified by laboratory tests on trial batches. The results of such tests shall be furnished to the Engineer by the Contractor or the manufacturer of precast elements at the time the proposed mix design is submitted. For mix design approval, the strengths of a minimum of five test cylinders taken from a trial batch shall average at least 5 N/mm^2 greater than the specified strength.

If materials and a mix design identical to those proposed for use have been used on other work within the previous year, certified copies of concrete test results from this work which indicate full compliance with these specifications may be substituted for such laboratory tests. If the results of more than 10 such strength tests are available from historical records for the past year, average strength for these tests shall be at least 1.28 standard deviations above the specified strength.

(c) Approval

All mix designs, and any modifications thereto, shall be approved by the Engineer prior to use. Mix design data provided to the Engineer for each class of concrete required shall include the name, source, type, and brand of each of the materials proposed for use and the quantity to be used per cubic meter of concrete.

5.1.4.2 Water Content

For calculating the water/cement ratio of the mix, the weight of the water shall be that of the total free water in the mix which includes the mixing water, the water in any admixture solutions and any water in the aggregates in excess of that needed to reach a saturated-surface-dry condition.

The water/cement ratio shall be the lowest possible compatible with the required workability but never greater than the value in Table 5.1.1.

Workability shall be such as to enable the concrete to be fully compacted without segregation around the reinforcement, prestressing ducts and other inserts detailed on the approved Working Drawings and to completely fill the formwork and provide the specified surface finish under prevailing climatic conditions. The workability and test method in accordance with AASHTO test method T119 shall be agreed with the Engineer prior to or during the trial mixes for each class of concrete and for each application of that class in the Works.

Bleeding shall not exceed 0.5% after 1 hour from completion of mixing nor 1.5% maximum when tested in accordance with ASTM C232 Method B.

When the consistency of the concrete is found to exceed the nominal slump, the mixture of subsequent batches shall be adjusted to reduce the slump to a value within the nominal range. Batches of concrete with a slump exceeding the maximum specified shall not be used in the work.

If concrete of adequate workability cannot be obtained by the use of the minimum cement content allowed, the cement and water content shall be increased without exceeding the specified water/cement ratio, or an approved admixture shall be used.

5.1.4.3 Cement Content

The minimum cement content shall be as listed in Table 5.1.1 or otherwise specified. The maximum cement content shall not exceed 475 kg.per cubic meter of concrete. The actual cement content used shall be within these limits and shall be sufficient to produce concrete of the required strength and consistency.

5.1.4.4 Air-Entraining and Chemical Admixtures

Air-entraining and chemical admixtures shall be used as specified. Otherwise, such admixtures may be used, at the option and expense of the Contractor when permitted by the Engineer, to increase the workability or alter the time of set of the concrete.

5.1.5 Manufacture of Concrete

The production of ready-mixed concrete shall conform to the requirements of AASHTO M 157 (ASTM C 94) and the requirements of this Section 5.1.5. The production of concrete with stationary mixers shall conform to the applicable requirements of AASHTO M 157 (ASTM C 94) and the requirements of this Section.

5.1.5.1 Storage of Aggregates

The handling and storage of concrete aggregates shall be such as to prevent segregation or contamination with foreign materials. The methods used shall provide for adequate drainage so that the moisture content of the aggregates is uniform at the time of batching. Different sizes of aggregate shall be stored in separate stock piles sufficiently removed from each other to prevent the material at the edges of the piles from becoming intermixed.

When specified in Table 5.1.1 or in the special provisions, the coarse aggregate shall be separated into two or more sizes in order to secure greater uniformity of the concrete mixture.

5.1.5.2 Storage of Cement

The Contractor shall provide suitable means for storing and protecting cement against dampness. Cement which for any reason has become partially set or which contains lumps of caked cement will be rejected. Cement held in storage

for a period of over 3 months if bagged or 6 months if bulk, or cement which for any reason the Engineer may suspect of being damaged., shall be subject to a retest before being used in the work.

Copies of cement records shall be furnished to the Engineer, showing, in such detail as he may reasonably require, the quantity used during the day or run at each part of the work.

5.1.5.3 Measurement of Materials

Materials shall be measured by weighing, except as otherwise specified or where other methods are specifically authorized. The apparatus provided for weighing the aggregates and cement shall be suitably designed and constructed for this purpose. Each size of aggregate and the cement shall be weighed separately. The accuracy of all weighing devices shall be such that successive quantities can be measured to within 1 percent of the desired amount. Cement in standard packages (sack) need not be weighed, but bulk cement shall be weighed. The mixing water shall be measured by volume or by weight. The accuracy of measuring the water shall be within a range of error of not over 1 percent. All measuring devices shall be subject to approval and shall be tested, at the Contractor's expense, when deemed necessary by the Engineer.

When volumetric measurements are authorized for projects, the weight proportions shall be converted to equivalent volumetric proportions. In such cases, suitable allowance shall be made for variations in the moisture condition of the aggregates, including the bulking effect in the fine aggregate.

When sacked cement is used, the quantities of aggregates for each batch shall be exactly sufficient for one or more full sacks of cement and no batch requiring fractional sacks of cement will be permitted.

5.1.5.4 Batching and Mixing Concrete

(a) Batching

All concrete shall be mixed in a batch mixer. It shall be mixed at the site of construction at a control plant, or in transit.

The size of the batch shall not exceed the capacity of the mixer as guaranteed by the manufacturer or as determined by the Standard Requirements of the Associated General Contractors of America.

The measured materials shall be batched and charged into the mixer by means that will prevent loss of any materials due to effects of wind or other causes.

(b) Mixing

The concrete shall be mixed only in the quantity required for immediate use. Mixing shall be sufficient to thoroughly intermingle all mix ingredients into a uniform mixture. Concrete that has developed an initial set shall not be used. Retempering concrete by adding water will not be permitted.

For other than transit mixed concrete, the first batch of concrete materials placed in the mixer shall contain a sufficient excess of cement, sand and water to coat the inside of the drum without reducing the required mortar content of the mix.

When mixer performance tests, as described in AASHTO M 157, are not made, the required mixing time for stationary mixers shall be not less than 90 seconds nor more than 5 minutes. The minimum drum revolutions for transit mixers at the mixing speed recommended by the manufacturer shall not be less than 70 and not less than that recommended by the manufacturer.

The timing device on stationary mixers shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the Contractor will be permitted to operate while it is being repaired, provided he furnishes an approved timepiece equipped with minute and second hands. If the timing device is not placed in good working order within 24 hours, further use of the mixer will be prohibited until repairs are made.

For small quantities of concrete needed in emergencies or for small noncritical elements of the work, concrete may be hand-mixed using methods approved by the Engineer.

Between uses, any mortar coating inside of the mixing equipment which sets or dries shall be cleaned from the mixer before use is resumed.

5.1.5.5 Delivery

The organization supplying the concrete shall have sufficient plant capacity and transporting apparatus to ensure continuous delivery at the rate required. The rate

of delivery of concrete during concreting operations shall be such as to provide for the proper handling, placing, and finishing of the concrete. The rate shall be such that the interval between batches shall not exceed 20 minutes and shall be sufficient to prevent joints within a monolithic pour caused by placing fresh concrete against concrete in which initial set has occurred. The methods of delivering and handling the concrete shall be such as will facilitate placing with the minimum of rehandling and without damage to the structure or the concrete.

5.1.5.6 Sampling and Testing

Compliance with the requirements indicated in this Section shall be determined in accordance with the following standard methods of AASHTO or ASTM:

Sampling Fresh Concrete AASHTO T 141 (ASTM C 172)

Weight per Cubic Foot, Yield and Air Content (Gravimetric) of Concrete AASHTO T 121 (ASTM C 138)

Sieve Analysis of Fine and Coarse Aggregate AASHTO T 27

Slump of Portland Cement Concrete AASHTO T119 (ASTM C 143)

Air Content of Freshly Mixed Concrete by the Pressure Method AASHTO T 152 (ASTM C 231)

Specific Gravity and Absorption of Fine Aggregate AASHTO T 84 (ASTM C 128)

Specific Gravity and Absorption of Coarse Aggregate AASHTO T 85 (ASTM C 127)

Making and Curing Concrete Test Specimens in the Laboratory AASHTO T 126 (ASTM C 192)

Making and Curing Concrete Test Specimens in the Field. AASHTO T 23 (ASTM C 31).

Compressive Strength of Cylindrical Concrete Specimens AASHTO T 22 (ASTM C 39).

5.1.5.7 Evaluation of Concrete Strength

(a) Tests

A strength test shall consist of the average strength of two compressive strength test cylinders fabricated from material taken from a single randomly selected batch of concrete, except that, if any cylinder should show evidence of improper sampling, molding, or testing, the cylinder shall be discarded and the strength test shall consist of the strength of the remaining cylinder.

(b) For Controlling Construction Operations

For determining the adequacy of cure and protection, and for determining when loads or stresses can be applied to concrete structures, test cylinders shall be cured at the structure site under conditions that are not more favorable than the most unfavorable conditions for the portions of the structure which they represent as described in section 9.4 of AASHTO T 23. Sufficient test cylinders shall be made and tested at the appropriate ages to determine when operations such as release of falsework, application of prestressing forces or placing the structure in service can occur.

(c) For Acceptance of Concrete

For determining compliance of concrete with a specified 28-day strength, test cylinders shall be cured under controlled conditions as described in section 9.3 of AASHTO T 23 and tested at the age of 28 days. Samples of concrete for cylinder tests shall be taken from designed mixes at random, as directed by the Engineer, generally at the following rates :

(i) columns with less than 1.0 m dimensions in any direction, long cantilevers, and other critical structures	One sample per 10 m^3 of concrete for each mix produced
(ii) concrete to be post-tensioned at less than 28 days	Two samples per 50m^3 of concrete for each mix produced
(iii) other concrete	One sample per 50m^3 of concrete for each mix produced

At least one sample will be made per day for each mix produced on that day.

Any concrete represented by a test which indicates a strength which is less than the specified 28-day compressive strength by more than 3.5 N/mm^2 will be rejected and shall be removed and replaced with acceptable concrete. Such rejection shall prevail unless either:

(1) The Contractor, at his expense, obtains and submits evidence of a type acceptable to the Engineer that the strength and quality of the rejected concrete is acceptable. If such evidence consists of cores taken from the work, the cores shall be obtained and tested in accordance with the standard methods of AASHTO T 24 (ASTM C 42) or,

(2) The Engineer determines that the concrete is located where it will not create an intolerable detrimental effect on the structure and the Contractor agrees to a reduced payment to compensate the Employer for loss of durability and other lost benefits.

(d) For Control of Mix Design

Whenever the average of three consecutive tests, which were made to determine the acceptability of the concrete, falls to less than 1 N/mm^2 above the specified strength or any single test falls more than 1.5 N/mm^2 below the specified strength, the Contractor shall, at his or expense, make corrective changes in the materials, mix proportions or in the concrete manufacturing procedures before placing additional concrete of that class. Such changes must be approved by the Engineer prior to use.

(e) Steam and Radiant Heat-Cured Concrete

When a precast concrete member is steam or radiant heat-cured, the compressive strength test cylinders made for any of the above purposes shall be cured under conditions similar to the member. Such concrete will be considered to be acceptable whenever a test indicates that the concrete has reached the specified 28-day compressive strength provided such strength is reached not more than 28 days after the member is cast.

5.1.5.8 Comparative Testing of Superstructure Concrete Strength and Elastic Modulus

To demonstrate that the Contractor's proposed aggregates and curing regime will not lead to excessive deformations of the prestressed concrete superstructure, tests which compare the performance of the proposed mix with a control mix shall be carried out. Also the elastic modulus of the concrete placed in the structure shall

be compared with laboratory produced specimens. The Contractor shall propose detailed procedures for tests to be carried out in an approved independent laboratory, in conformance with the following outline procedure.

The control mix shall be designed within the Specification to achieve the same workability and strength as the Contractor's proposed mix. Aggregate for the control mix specimens shall be coarse and fine aggregate from uniform stone complying with sub clause 5.1.3.3 and 5.1.3.4. The source of the aggregate for the control specimens shall be proposed by the Contractor and be subject to approval by the Engineer. Cementitious materials, admixtures and water shall be from the same sources as the proposed mix. Strength tests shall be carried out on samples taken from the control mix as set out in sub clause 5.1.4.1 (b). Compliance of the control mix shall be assessed on the same basis as for the trial mix.

Three specimens from the mix considered most representative of the site superstructure concrete and three control specimens shall continue to be tested throughout the remaining period of the Contract, but in any case for at least a total of two years.

The criteria for acceptance of the relevant trial mix properties are given in Table 5.1.2.

Table 5.1.2
Comparative Test Criteria for Elastic Modulus of Superstructure Concrete

Property	Performance of Trial Mix versus Control Mix
Elastic Modulus:	
At time of first loading	95% minimum
At 28 days after first loading	95% minimum

To compare the elastic modulus of concrete cast in a structure with laboratory specimens, cores shall be cut from trial segments and tested. The cores shall be a minimum of 100 mm diameter and their length shall be in proportion to the 150 mm diameter specimens such that scale effects and differences in platten friction can be properly taken into account. Three cores shall be cut from the trial segments 28 days after casting and loaded to a compressive stress of $10N/mm^2$. The age of the concrete at loading and the rate of loading shall be the same as for the laboratory specimens above and the three cores shall be kept under identical environmental conditions as those specimens. The elastic modulus shall be calculated and compared with the values for the laboratory specimens.

5.1.5.9 Acceptance Criteria

Concrete shall be considered non-compliant with the Specification if the following criteria are not met:

(a) Water-cement ratio

Where assessment is by observation of the batching or by autographic records, the water-cement ratio shall be not more than 105% of the required value Where assessment is by analysis tests on fresh concrete, the water-cement ratio shall be not more than 110% of the required value. The quantity of concrete considered not to comply is as defined in respect of cylinder strength.

(b) Cement Content

Where assessment is by observation of the batching or by autographic records the cement content shall be not less than 95% nor more than 105% of the required amount, Where assessment is by analysis tests on fresh concrete, 90% and 110% respectively, The quantity of concrete considered not to comply shall be as defined in respect of cylinder strength;

(c) Workability

Workability of the fresh concrete shall be such that the concrete is suitable for the conditions of handling and placing as described in Section 5.1.7 so that after consolidation as described in sub clause 5.1.7.4 it surrounds all reinforcement, tendons and ducts and completely fills the formwork.

Workability shall be measured for each batch or at such times as directed by the Engineer using one of the following tests in accordance with BS1881 and shall be within the following limits of the required values:

(i) Slump test:	±25 mm or ± 1/3 of the required value whichever is greater
or	
(ii) Compacting Factor	±0.03, where the required value is 0.90 or greater ±0.04, where the required value is between 0.80 and 0.90 ±0.05, where the required value is 0.80 or less

(d) Temperature

Temperature of the fresh concrete at the time of placing (measured by a type A 110mm immersion thermometer complying with BS1704 graduated at each 1°c over a range from –5°c to +100°c inserted in a sample within 2 minutes of sampling and recorded 1 minute after reaching a stable temperature) shall be not more than 27°c.

5.1.6 Protection of Concrete from Environmental Conditions

5.1.6.1 General

Precautions shall be taken as needed to protect the concrete from damage due to weather or other environmental conditions during placing and curing operations. Concrete that has been damaged by weather conditions shall be either repaired to an acceptable condition or removed and replaced.

The temperature of the concrete mixture immediately before placement shall be between 10°c and 32°c, except as otherwise provided herein.

5.1.6.2 Rain Protection

Under conditions of rain, the placing of concrete shall not commence or shall be stopped unless adequate protection is provided to prevent damage to the surface mortar or damaging flow or wash of the concrete surface.

5.1.6.3 Hot Weather Protection

Concreting shall not be carried out when the shade air temperature rises above 43°c or if the temperature of the fresh concrete rises above 32°c during placing or within 5 minutes of placing.

During periods of hot weather when the shade air temperature rises above 32°c, special precautions shall be taken to prevent a similar rise in temperature of the concrete mix, i.e. by shading aggregate, painting mixer surfaces and pipes white or yellow, chilling the mixing water and liquid nitrogen injection. If ice is added to the mix it shall be well crushed or obtained from a flake ice machine. Care shall be taken to ensure that all the ice has completely melted by the time mixing has been completed. Reinforcement and shuttering shall be cooled by shading from direct rays of the sun and spraying the shuttering with clean fresh water, care being taken to remove surplus water before commencing concreting.

5.1.6.4 Special Requirements for Bridge Decks

During periods of low humidity, wind or high temperatures and prior to the application of curing materials, concrete being placed and finished for bridge decks shall be protected from damage due to rapid evaporation. Such protection shall be adequate to prevent premature crusting of the surface or an increase in drying cracking. Such protection shall be provided by raising the humidity of the surrounding air with fog sprayers operated upwind of the deck, the use of wind-breaks or sun-shades, additionally reducing of the temperature of the concrete, scheduling placement during the cooler times of days or nights, or any combination thereof.

5.1.6.5 Concrete Exposed to Sulfate Soils for Water

When the special provisions identify the area as containing sulfate soils or water, the concrete that will be in contact with such soil or water shall be mixed, placed, and protected from contact with soil or water as required for concrete exposed to salt water except that the protection period shall be not less than 72 hours.

5.1.7 Handling and Placing Concrete

5.1.7.1 General

Concrete shall be handled, placed and consolidated by methods that will not cause segregation of the mix and will result in a dense homogeneous concrete which is free of voids and rock pockets. The methods used shall not cause displacement of reinforcing steel or other materials to be embedded in the concrete. Concrete shall be placed and consolidated prior to initial set and in no case more than 1 ½ hours after the cement was added to the mix. Retempering the concrete by adding water to the mix shall not be done.

Concrete shall not be placed until the forms, all materials to be embedded and, for spread footings, the adequacy of the foundation material have been inspected and approved by the Engineer. All mortar from previous placements, debris, and foreign material shall be removed from the forms and steel prior to commencing placement. The forms and subgrade shall be thoroughly moistened with water immediately before concrete is placed against them. Temporary form spreader devices may be left in place until concrete placement precludes their need, after which they shall be removed.

Placement of concrete for each section of the structure shall be done continuously without interruption between planned construction or expansion joints. The delivery rate, placing sequence and methods shall be such that fresh concrete is always placed and consolidated against previously placed concrete before initial set has occurred in the previously placed concrete.

During and after placement of concrete, care shall be taken not to damage the concrete or break the bond with reinforcing steel. Workmen shall not walk in fresh concrete. Platforms for workmen and equipment shall not be supported directly on any reinforcing steel. Once the concrete is set, forces shall not be applied to the forms or to reinforcing bars, which project from the concrete, until the concrete is of sufficient strength to resist damage.

5.1.7.2 Sequence of Placement

Whenever a concrete placement plan or schedule is specified or approved, the sequence of placement shall conform to the plan. Unless otherwise specifically permitted by such a placement plan, the requirements of the following paragraphs shall apply.

(a) Vertical Members

Concrete for columns, substructure and culvert walls, and other similar vertical members shall be placed and allowed to set and settle for a period of time before concrete for integral horizontal members, such as caps, slabs, or footings is placed. Such period shall be adequate to allow completion of settlements due to loss of bleed water and shall be not less than 12 hours for vertical members over 4.5 meter in height and not less than 30 minutes for members over 1.5meter but not over 4.5 meter in height. When friction collars or falsework brackets are mounted on such vertical members and unless otherwise approved, the vertical member shall have been in place at least 7 days and shall have attained its specified strength before loads from horizontal members are applied.

(b) Superstructures

Unless otherwise permitted, no concrete shall be placed in the superstructure until substructure forms have been stripped sufficiently to determine the character of the supporting substructure concrete.

Concrete for box girders may be placed in two or three separated operations consisting of bottom slab, girder stems and top slab. In either case the bottom slab shall be placed first and, unless otherwise permitted by the Engineer, the top slab shall not be placed until the girder stems have been in place for at least 5 days.

(c) Box Culverts

In general, the base slab or footings of box culverts shall be placed and allowed to set before the remainder of the culvert is constructed. For culverts whose wall height is 1.5 meter or less, the sidewalks and top slab may be placed in one continuous operation. For higher culvert walls the requirements for vertical members shall apply.

(d) Precast Elements

The sequence of placement for concrete in precast elements shall be such that sound well-consolidated concrete which is free of settlement or shrinkage cracks is produced throughout the member.

5.1.7.3 Placing Methods

(a) General

Concrete shall be placed as nearly as possible in its final position and the use of vibrators for extensive shifting of the mass of fresh concrete will not be permitted.

Concrete shall be placed in horizontal layers of a thickness not exceeding the capacity of the vibrator to consolidate the concrete and merge it with the previous lift. In no case shall the depth of a lift exceed 600 mm. The rate of concrete placement shall not exceed that assumed for the design of the forms as corrected for the actual temperature of the concrete being placed.

When placing operations would involve dropping the concrete more than 1.5 meter, the concrete shall be dropped through a tube fitted with a hopper head, or through other approved devices, as necessary to prevent segregation of the mix and spattering of mortar on steel and forms above the elevation of the lift being placed. This requirement shall not apply to cast-in-place piling when concrete placement is completed before initial set occurs in the first placed concrete.

(b) Equipment

All equipment used to place concrete shall be of adequate capacity and designed and operated so as to prevent segregation of the mix or loss of mortar. Such equipment shall not cause vibrations that might damage the freshly placed concrete. No equipment shall have aluminum parts which come in contact with the concrete. Between uses, the mortar coating inside of placing equipment which sets or dries out shall be cleaned from the equipment before use is resumed.

Chutes shall be lined with smooth watertight material and, when steep slopes are involved, shall be equipped with baffles or reverses.

Concrete pumps shall be operated such that a continuous stream of concrete without air pockets is produced. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients.

Conveyor belt systems shall not exceed a total length of 170 lineal meter measured from end to end of the total assembly. The belt assembly shall be so arranged that each section discharges into a vertical hopper arrangement to the next section. To keep segregation to a minimum, scrapers shall be situated over the hopper of each section so as to remove mortar adhering to the belt and to deposit it into the hopper. The discharge end of the conveyor belt system shall be equipped with a hopper, and a chute or suitable deflectors to cause the concrete to drop vertically to the deposit area.

5.1.7.4 Consolidation

All concrete, except concrete placed under water and concrete otherwise exempt, shall be consolidated by mechanical vibration immediately after placement.

The vibration shall be internal except that external form vibrators may be used for thin sections when the forms have been designed for external vibration.

Vibrators shall be of approved type and design and of a size appropriate for the work. They shall be capable of transmitting vibration to the concrete at frequencies of not less than 4,500 impulses per minute.

The Contractor shall provide a sufficient number of vibrators to properly compact each batch immediately after it is placed in the forms. The Contractor shall also have at least one spare vibrator immediately available in case of breakdown.

Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and imbedded fixtures and into the corners and angles of the forms. Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be inserted and withdrawn out of the concrete slowly. The vibration shall be of sufficient duration and intensity to thoroughly consolidate the concrete, but shall not be continued so as to cause segregation. Vibration shall not be continued at any one point to the extent that localized areas of grout are formed. Application of vibrators shall be at points uniformly spaced and not farther apart than 1.5 times the radius over which the vibration is visibly effective.

Vibration shall not be applied directly to, or through the reinforcement to sections or layers of concrete which have hardened to the degree that concrete ceases to be plastic under vibration. Vibrators shall not be used to transport concrete in the forms.

Vibration shall be supplemented by such spading as is necessary to ensure smooth surfaces and dense concrete along form surfaces and in corners and locations impossible to reach with the vibrators.

When approved by the Engineer, concrete for small noncritical elements may be consolidated by the use of suitable rods and spades.

5.1.7.5 Underwater Placement

(a) General

Only concrete used in cofferdams to seal out water or cast-in-place bridge piles may be placed under water unless otherwise specified or specifically approved by the Engineer. If other than Class B concrete of Table 5.1.1 is to be placed under water, the minimum cement content of the mix shall be greater than 350 kg/m^3.

To prevent segregation, concrete placed under water shall be carefully placed in a compact mass, in its final position, by means of a tremie, concrete pump, or other approved method, and shall not be disturbed after being deposited. Still water shall be maintained at the point of deposit and the forms under water shall be

watertight. Cofferdams shall be vented during the placement and cure of concrete to equalize the hydrostatic pressure and thus prevent flow of water through the concrete.

Concrete placed under water shall be placed continuously from start to finish. The surface of the concrete shall be kept as nearly horizontal as practicable. To ensure thorough bonding, each succeeding layer of seal shall be placed before the preceding layer has taken initial set. For large pours, more than one tremie or pump shall be used to ensure compliance with this requirement.

(b) Equipment

A tremie shall consist of a water-tight tube having a diameter of not less than 250 mm and fitted with a hopper at the top. The tremie shall be supported so as to permit free movement of the discharge end over the entire top surface of the work and so as to permit rapid lowering when necessary to retard or stop the flow of concrete. The discharge end shall be sealed closed at the start of work so as to prevent water from entering the tube before the tube is filled with concrete. After placement has started the tremie tube shall kept full of concrete to the bottom of the hopper. If water enters the tube after placement is started, the tremie shall be withdrawn, the discharge end resealed, and the placement restarted. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, always keeping it in the deposited concrete. The flow shall be continuous until the work is completed. When cofferdam struts prevent lateral movement of tremies, one tremie shall be used in each bay.

Concrete pumps used to place concrete under water shall include a device at the end of the discharge tube to seal out water while the tube is first being filled with concrete. Once the flow of concrete is started, the end of the discharge tube shall be kept full of concrete and below the surface of the deposited concrete until placement is completed.

(c) Cleanup

Dewatering may proceed after test specimens cured under similar conditions indicate that the concrete has sufficient strength to resist the expected loads. All laitance or other unsatisfactory materials shall be removed from the exposed surface by scraping, chipping, or other means which will not damage the surface of the concrete before placing foundation concrete.

5.1.7.6 Concreting of Large Pours

For pier and abutment pile caps, pier head of rigid pier, and large pours in excess of 100 m^3, the following shall apply

(a) The maximum temperature of the concrete during curing shall not exceed 70°c

(b) The method of curing used shall minimise temperature gradients and differences within the concrete pour and the concrete adjacent to it and across construction joints. Unless approved, no temperature gradient shall be allowed to exceed 15°c in a distance of 1 metre and the maximum temperature difference between two parts of the same pour (except vertical temperature differences in slipformed concrete) shall not be allowed to exceed 20°c.

(c) The Contractor shall submit details of methods of protection, curing and temperature monitoring / control which shall be subject to the consent of the Engineer. The details shall be accompanied by supporting calculations of estimated maximum temperatures, temperature gradients and resulting stresses. These calculations shall be based upon temperatures measured during tests and/or elsewhere in the Works.

5.1.8 Construction Joints

5.1.8.1 General

Construction joints shall be made only where located on plans, or shown in the pouring schedule, unless otherwise approved. All planned reinforcing steel shall extend uninterrupted through joints. In the case of an emergency, construction joints shall be placed as directed by the Engineer and, if directed, additional reinforcing steel dowels shall be placed across the joint. Such additional steel shall be furnished and placed at the Contractor's expense.

5.1.8.2 Bonding

Unless otherwise shown on the plans, horizontal joints may be made without keys and vertical joints shall be constructed with shear keys. Surfaces of fresh concrete at horizontal construction joints shall be rough floated sufficiently to thoroughly consolidate the surface and intentionally left in a roughened condition. Shear keys shall consist of formed depressions in the surface covering approximately

one-third of the contact surface. The forms for keys shall be beveled so that removal will not damage the concrete.

All construction joints shall be cleaned of surface laitance, curing compound and other foreign materials before fresh concrete is placed against the surface of the joint. Abrasive blast or other approved methods shall be used to clean horizontal construction joints to the extent that clean aggregate is exposed. All construction joints shall be flushed with water and allowed to dry to a surface dry condition immediately prior to placing concrete.

5.1.8.3 Bonding and Doweling to Existing Structures

When new concrete is shown on the plans to be bonded to existing concrete structures, the existing concrete shall be cleaned and flushed as specified above. When the plans show reinforcing dowels grouted into holes drilled in the existing concrete at such construction joints, the holes shall be drilled by methods that will not shatter or damage the concrete adjacent to the holes. The diameters of the drilled holes shall be 6 mm larger than the nominal diameter of the dowels unless shown otherwise on the plans. The grout shall be a neat cement paste of Portland cement and water. The water content shall be not more than 20 litres per 50 kilogram of cement. Retempering of grout will not be permitted. Immediately prior to placing the dowels, the holes shall be cleaned of dust and other deleterious materials, shall be thoroughly saturated with water, have all free water removed and the holes shall be dried to a saturated surface dry condition. Sufficient grout shall be placed in the holes so that no voids remain after the dowels are inserted. Grout shall be cured for a period of at least 3 days or until dowels are encased in concrete.

When specified or approved by the Engineer, epoxy may be used in lieu of Portland cement grout for the bonding of dowels in existing concrete. When used, epoxy shall be mixed and placed in accordance with the manufacturer's recommendations.

5.1.8.4 Forms at Construction Joints

When forms at construction joints overlap previously placed concrete, they shall be retightened before depositing new concrete. The face edges of all joints that are exposed to view shall be neatly formed with straight bulkheads or grade strips, or otherwise carefully finished true-to-line and elevation.

5.1.8.5 Joints in Underwater Concrete

Under water concrete shall be placed in accordance with sub clause 5.1.7.5. If, for any reason, concreting is interrupted while placing under water concrete then the Contractor shall (as soon as possible after the concrete has set) remove all laitance and disturbed concrete from the surface of the set concrete and thoroughly clean the surface of all loose material and remove all the resulting debris before recommencing concreting. Concreting shall not be re-commenced until the Engineer has given his written approval. Vertical stop ends of approved design may be provided in underwater concrete. They shall be constructed of reinforced concrete planks incorporating horizontal shear keys and shall be left permanently in position. They shall be held securely in position by a steel or reinforced concrete framework which may also be cast into the concrete, subject to the Engineer's consent.

5.1.9 Finishing Plastic Concrete

5.1.9.1 General

Unless otherwise specified, after concrete has been consolidated and prior to the application of cure, all surfaces of concrete which are not placed against forms shall be struck-off to the planned elevation or slope and the surface finished by floating with a wooden float sufficiently to seal the surface. While the concrete is still in a workable state, all construction and expansion joints shall be carefully tooled with an edger. Joint filler shall be left exposed.

5.1.9.2 Road Surface Finish

All bridge decks, approach slabs, and other concrete surfaces for use by traffic shall be finished to a smooth skid-resistant surface in accordance with this sub clause. During finishing operations the contractor shall provide suitable and adequate work bridges for proper performance of the work, including the application of fog sprays and curing compound, and for inspecting the work.

5.1.9.3 Pedestrian Walkway Surface Finish

After the concrete for sidewalks and decks of pedestrian structures has been deposited in place, it shall be consolidated and the surface shall be struck off by means of a strike board and floated with wooden or cork float. If directed, the surface shall then be lightly broomed in a transverse direction. An edging tool

shall be used on edges and expansion joins. The surface shall not vary more than 3 mm under a 1.5 meter straightedge. The surface shall have a granular or matt texture that will be slippery when wet.

Sidewalk surfaces shall be laid out in blocks with an approved grooving tool as shown on the plans or as directed.

5.1.9.4 Troweled and Brushed Finish

Surfaces which are shown on the plans or specified to be troweled shall first be finished as specified under sub clause 5.1.9.1 then, after the concrete is partially set, the surface shall be finished to a smooth surface by troweling with a steel trowel until a slick surface free of bleed water is produced. The surface shall then be brushed with a fine brush using parallel strokes.

5.1.9.5 Surface Under Bearings

When metallic masonry plates are to be placed directly on the concrete or filler material less than 3 mm thick, the surface shall first be finished with a float finish. After the concrete has set, the area which will be in contact with the masonry plate shall be ground as necessary to provide full and even bearing. When such plates are to be set on filler material between 3 mm and 12 mm thick, the concrete surface shall be steel-trowel finished without brushing and the flatness of the finished surface shall not vary from a straightedge laid on the surface in any direction within the limits of the masonry plate by more than 2 mm. Surfaces which fail to conform to the required flatness shall be ground until acceptable.

Surfaces under elastomeric bearings and under metallic masonry plates which are supported on mortar or filler pads 10 mm or greater in thickness shall be finished by wood floating to a flat and even surface free of ridges.

5.1.10 Curing Concrete

5.1.10.1 General

All newly placed concrete shall be cured so as to prevent the loss of water by use of one or more of the methods specified herein. Curing shall commence immediately after the free water has left the surface and finishing operations are completed. If the surface of the concrete begins to dry before the selected cure

method can be applied, the surface of the concrete shall be kept moist by a fog spray applied so as not to damage the surface.

Curing by other than steam or radiant heat methods shall continue uninterrupted for 7 days. For other than top slabs of structures serving as finished pavements, the above curing periods may be reduced and curing terminated when test cylinders cured under the same conditions as the structure indicated that concrete Strengths of at least 70 percent of that specified have been reached.

When deemed necessary by the Engineer during periods of hot weather, water shall be applied to concrete surfaces being cured by the liquid membrane method or by the forms-in-place method, until the Engineer determines that a cooling effect is no longer required.

5.1.10.2 Materials

(a) Water

Water shall conform to the requirement sub clause 5.1.3.2.

(b) Liquid Membranes

Liquid membrane-forming compounds for curing concrete shall conform to the requirements of AASHTO M 148 (ASTM C 309).

5.1.10.3 Methods

(a) Forms-In-Place Method

Formed surfaces of concrete may be cured by retaining the forms in place without loosening for the required time.

(b) Water Method

The concrete surface shall be kept continuously wet by ponding, spraying or covering with materials that are kept continuously and thoroughly wet. Such materials may consist of cotton mats, multiple layers of burlap or other approved materials which do not discolor or otherwise damage the concrete.

(c) Liquid Membrance Curing Compound Method

The liquid membrane method shall not be used on surfaces where a rubbed finish is required or on surfaces of construction joints unless it is removed by sand blasting prior to placement of concrete against the joint. Type 2, white pigmented, liquid membranes may be used only on the surfaces of bridge decks, on surfaces that will not be exposed to view in the completed work or on surfaces where their use has been approved by the Engineer.

When membrane curing is used, the exposed concrete shall be thoroughly sealed immediately after the free water has left the surface. Formed surfaces shall be sealed immediately after the forms are removed and necessary finishing has been done. The solution shall be applied by power-operated atomizing spray equipment in one or two separate applications. Hand-operated sprayers may be used for coating small areas. Membrane solutions containing pigments shall be thoroughly mixed prior to use and agitated during application. If the solution is applied in two increments, the second application shall follow the first application within 30 minutes. Satisfactory equipment shall be provided, together with means to properly control and assure the direct application of the curing solution on the concrete surface so as to result in a uniform coverage at the rate of 1 litre for each 3.5 square meter of area.

If rain falls on the newly coated concrete before the film has dried sufficiently to resist damage, or if the film is damaged in any other manner during the curing period, a new coat of the solution shall be applied to the affected portions equal in curing value to that above specified.

(d) Steam or Radiant Heat Curing Method

This method may be used only for precast concrete members manufactured in established plants.

Steam curing or radiant heat curing shall be done under a suitable enclosure to contain the live steam or the heat. Steam shall be low pressure and saturated. Temperature recording devices shall be employed as necessary to verify that temperatures are uniform throughout the enclosure and within the limits specified.

The initial application of the steam or of the heat shall be from 2 to 4 hours after the final placement of concrete to allow the initial set of the concrete to take place if retarders are used, the waiting period before application of the steam or of the

radiant heat shall be increased to between 4 and 6 hours after placement. The time of initial set may be determined by the Standard Method of Test for "Time of Setting of Concrete Mixtures by Penetration Resistance," AASHTO T 197 (ASTM C 403), and the time limits described above may then be waived.

During the waiting period, the temperature within the curing chamber shall not be less than 10°C and live steam or radiant heat may be used to maintain the curing chamber at the proper minimum temperature. During this period the concrete shall be kept wet.

Application of live steam shall not be directed on the concrete or on the forms so as to cause localized high temperatures. During the initial application of live steam or of radiant heat, the ambient temperature within the curing enclosure shall increase at an average rate not exceeding 5°C per hour until the curing temperature is reached. The maximum curing temperature within the enclosure shall not exceed 70°C. The maximum temperature shall be held until the concrete has reached the desired strength. In discontinuing the steam application, the ambient air temperature shall not decrease at a rate to exceed 5°C per hour until a temperature 10°C above the temperature of the air to which the concrete will be exposed has been reached.

Radiant heat may be applied by means of pipes circulating steam, hot oil or hot water, or by electric heating elements. Radiant heat curing shall be done under a suitable enclosure to contain the heat, and moisture loss shall be minimized by covering all exposed concrete surfaces with a plastic sheeting or by applying an approved liquid membrane-curing compound to all exposed concrete surfaces. Top surfaces of concrete members to be used in composite construction shall be clear of residue of the membrane curing compound so as not to reduce bond below design limits. Surfaces of concrete members to which other materials will be bonded in the finished structure shall be clear of residue of the membrane curing compound so as not to reduce bond below design limits.

After attaining the desired strength, the temperature within the curing enclosure shall be decreased at an average rate not exceeding 22°C per hour until the inside temperature is within 11°C of the outside ambient temperature. The curing enclosure shall be of such size as to totally enclose both the segment against which casting is being carried out, the segment being cast and any rigid appendages thereto.

5.1.10.4 Bridge Decks

The top surfaces of bridge decks shall be cured by a combination of the liquid membrane curing compound method and the water method. The liquid membrane shall be Type2, white pigmented, and shall be applied from finishing bridges progressively and immediately after finishing operations are complete on each portion of the deck. The water cure shall be applied not later than 4 hours after completion of deck finishing or, for portions of the decks on which finishing is completed after normal working hours, the water cure shall be applied not later than the following morning.

5.1.11 Finishing Formed Concrete Surfaces

5.1.11.1 Classes of Concrete Finish – Formed Surfaces

The requirements over and above those given in Section 1.13 to provide the class of finish described in the Contract shall be:

Class F1: Nil Except that where a protective membrane or a waterproofing membrane is to be applied to the concrete, any sharp fins or other excrescences which might damage the membrane shall be removed.

Class F2: The irregularities in the finish shall be no greater than those obtained from the use of 2.4m x 1.2m unfaced plywood panels arranged in a uniform pattern to the satisfaction of the Engineer. Appropriate measures shall be taken to ensure continuity of line and surface at joints between panels and to avoid grout leakage. The finish is intended to be left as struck but imperfections such as fins and surface discolouration shall, if required, be made good by methods approved by the Engineer.

Class F3: The formwork shall be lined with a material approved by the Engineer to provide a smooth finish of uniform texture and appearance. The material shall leave no stain on the concrete and shall be so joined 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 as required by the Engineer. Internal ties and embedded metal parts shall not be allowed.

Class F4: The requirements for Class F4 are as for Class F3 except that internal ties and embedded metal parts shall be permitted. The ties shall be positioned in a

regular pattern in rebates or pockets in positions as described in the Contract or in other positions agreed by the Engineer.

Unless otherwise described in the Contract, all formwork joints for exposed surfaces of concrete to Class F3 and F4 finish shall form a regular pattern with horizontal and vertical lines continuous throughout each structure and all construction joints where permitted shall coincide with these horizontal or vertical lines.

The Contractor shall ensure that permanently exposed concrete surfaces to Class F4 and F3 finish are protected from rust marks, spillage and stains of all kinds.

The classes of formed concrete finish to be provided in the Works shall be as shown on the approved Shop Drawings or as directed by the Engineer. Where the Drawings do not show the Class of finish to be provided the following shall, subject to the Engineer's consent be used:

Buried and other hidden surfaces, Faces of expansion joints incorporating joint filler	F1
Surfaces which are not visible, faces of joints	F2
Exposed surfaces of parapets	F3
Visible surfaces of walls, exposed surfaces of piers and abutments, visible outside surface of bridge deck except parapets Outside of segmental units	F4

5.1.11.2 Classes of Finish – Unformed Surfaces

The requirements for the class of finish to unformed concrete surfaces shall be:

Class U1: The concrete shall be uniformly leveled and screeded in an approved manner by means of a steel-shod screed to produce a plain, textured or ridged surface as described in the Contract, and dense finish. Care shall be taken to ensure that the surface of the concrete is properly "closed" No further work shall

be applied to the surface unless it is used as the first stage for Class U2 or Class U3 finish.

Class U2: After the concrete has hardened sufficiently, the concrete Class U1 surface shall be floated by hand or machine sufficiently only to produce a uniform surface free from screed marks.

Class U3: When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, a Class U1 surface shall be lightly steel-troweled under firm pressure to produce a dense, smooth uniform surface free from trowel marks.

The classes of unformed concrete finish to be provided in the Works shall be as shown on the Drawings or directed by the Engineer. Where the Drawings do not show the Class of finish to be provided, the following shall be used, subject to the Engineer's consent.

Bridge deck and substructure footings	U1
Surfaces other than those classed as U3 or U1	U2
Upper concrete surfaces of parapet plinths, bearing shelves and tops of bearing plinths	U3

5.1.11.3 Trial Panels for Class F3 and Class F4 Surface Finishes

Trial panels shall be cast by the Contractor to set the standard for the classes of finish F3 and F4. The trial panels prepared under subclause 5.1.4.1 (b) to check the mix design may also be used for formwork finish trial panels. The minimum size of panels shall be 3m x 2m and shall contain both horizontal and vertical joints between facing sheets. The trial panels shall be constructed for approval before commencement of the parts of the Works incorporating those finishes. A trial panel shall be constructed using the approved mix for each of the classes of concrete for which the class of formwork is intended.

Where, in the opinion of the Engineer, the finished concrete of a trial panel fails to meet the requirements of the Specification, the panel shall be rebuilt and the trial

repeated as necessary until the Engineer's approval is given. Approved panels shall be retained as the standard for the class of finish exhibited by the panel.

The Contractor shall dispose of the trial panels off site when they are no longer required or when agreed with the Engineer

5.1.12 Precast Concrete Members

5.1.12.1 General

Precast concrete members shall be constructed and placed in the work in conformance with the details shown on the plans, specified or shown on the approved shop drawings.

If approved by the Engineer, the use of precasting methods may be used for elements of the work which are otherwise indicated to be constructed by the cast-in-place method. When such precasting is proposed, the Contractor shall submit working drawings showing construction joint details and any other information required by the Engineer.

5.1.12.2 Shop Drawings

Whenever specified or requested by the Engineer, the Contractor shall provide shop drawings for precast members. Such drawings shall be include all details not provided in the plans for the construction and the erection of the members and shall be approved before any members are cast. Such approval shall not relieve the Contractor of any responsibility under the contract for the successful completion of the work.

5.1.12.3 Materials and Manufacture

The materials and manufacturing processes used for precast concrete members shall conform to the requirements of the other articles in this Section except as those requirements are modified or supplemented by the provisions that follow.

When precast members are manufactured in established casting yards, the manufacturer shall be responsible for the continuous monitoring of the quality of all materials and concrete strengths. Tests shall be performed in accordance with appropriate AASHTO or ASTM methods. The Engineer shall be allowed to observe all sampling and testing and the results of all tests shall be made available to the Engineer.

Precast members shall be cast on unyielding beds or pallets. Special care shall be used in casting the bearing surfaces so that they will join properly with other elements of the structure.

For prestressed precast units, several units may be cast in one continuous line and stressed at one time. Sufficient space shall be left between the ends of units to permit access for cutting of tendons after the concrete has attained the required strength.

The side forms may be removed as soon as their removal will not cause distortion of the concrete surface, providing that curing is not interrupted. Members shall not be lifted from casting beds until their strength is sufficient to prevent damage. When cast-in-place concrete will later be cast against the top surfaces of precast beams or girders, these surfaces shall be finished to a coarse texture by brooming with a stiff coarse broom. Prior to shipment, such surfaces shall be cleaned of laitance or other foreign material by sand-blasting or other approved methods.

When precast members are designed to be butted together in the finished work, each member shall be match-cast with its adjacent segments to ensure proper fit during erection. As the segments are match-cast they must be precisely aligned to achieve the final structure geometry. During the alignment, adjustments to compensate for deflections shall be made.

5.1.12.4 Curing

Unless otherwise permitted, precast members shall be cured by either the water method or the steam or radiant heat method.

5.1.12.5 Storage and Handling

Extreme care shall be exercised in handling and moving precast prestressed concrete members. Precast girders shall be transported in an upright position and 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.

Prestressed concrete members shall not be shipped until tests on concrete cylinders, manufactured of the same concrete and cured under the same conditions as the girders, indicate that the concrete of the particular member has attained a

compressive strength equal to the specified design compressive strength of the concrete in the member.

Care shall be taken during storage, hoisting, and handling of the precast units to prevent cracking or damage. Units damaged by improper storage or handling shall be replaced at the Contractor's expense.

5.1.12.6 Erection

The Contractor shall be responsible for the safety of precast members during all stages of construction. Lifting devices shall be used in a manner that does not cause damaging bending or torsional forces. After a member has been erected and until it is secured to the structure, temporary braces shall be provided as necessary to resist wind or other loads.

Precast deck form panels shall be erected and placed so that the fit of mating surfaces shall be such that excessive grout leakage will not occur. If such fit is not provided, joints shall be dry-packed or sealed with an acceptable caulking compound prior to placing the cast-in-place concrete. End panels for skewed structures may be sawed to fit the skew.

5.1.13 Mortar and Grout

5.1.13.1 General

This work consists of the making and placing of mortar and grout for use in concrete structures other than in prestressing ducts. Such uses include mortar for filling under masonry plates and for filling keyways between precast members where shown on the plans, mortar used to fill voids and repair surface defects, grout used to fill sleeves for anchor bolts, and mortar and grout for other such uses where required or approved.

5.1.13.2 Materials and Mixing

Materials for mortar and grout shall conform to the requirements of section 5.1.3. The grading of sand for use in grout or for use in mortar when the width or depth of the void to be filled is less than 20 mm shall be modified so that all material passes the No. 8 sieve.

Type IA, air entraining, portland cement shall be used when air entrainment is required for the concrete against which the grout or mortar is to be placed.

Unless otherwise specified or ordered by the Engineer, the proportion of cement to sand for mortar shall be one to two and for grout shall be one to one. Proportioning shall be by loose volume.

When non-shrink mortar or grout is specified, either a non-shrink admixture or an expansive hydraulic cement conforming to ASTM C 845 of a type approved by the Engineer, shall be used.

Sufficient water shall be used only to permit placing and packing. For mortar, enough water shall be used so that the mortar will form a ball when squeezed gently in the hand.

Mixing shall be done by either hand methods or with rotating paddle-type mixing machines and shall be continued until all ingredients are thoroughly mixed. Once mixed, mortar or grout shall not be retempered by the addition of water and shall be placed within 1 hour.

5.1.13.3 Placing and Curing

Concrete areas to be in contact with the mortar or grout shall be cleaned of all loose or foreign material that would in any way prevent bond with the concrete surfaces and shall be flushed with water and allowed to dry to a surface dry condition immediately prior to placing the mortar or grout.

The mortar or grout shall completely fill and shall be tightly packed into recesses and holes, on surfaces, under structural members, and at other locations specified. After placing, all surfaces of mortar or grout shall be cured by the water method as provided in Section 5.1.10 for a period of not less than 3 days.

Keyways, spaces between structural members, holes, spaces under structural members, and other locations where mortar could escape shall be mortar-tight before placing mortar.

No load shall be allowed on mortar that has been in place less than 72 hours, unless otherwise permitted by the Engineer.

All improperly cured or otherwise defective mortar or grout shall be removed and replaced by the Contractor at his expense.

5.1.14 Application of Loads

5.1.14.1 General

Loads shall not be applied to concrete structures until the concrete has attained sufficient strength and, when applicable, sufficient prestressing has been completed, so that damage will not occur.

5.1.14.2 Earth Loads

Whenever possible the sequence of placing backfill around structures shall be such that overturning or sliding forces are minimized. When the placement of backfill will cause flexural stresses in the concrete, and unless otherwise permitted by the Engineer, the placement shall not begin until the concrete has reached not less than 80 percent of its specified strength.

5.1.14.3 Construction Loads

Light materials and equipment may be carried on bridge decks only after the concrete has been in place at least 24 hours, providing curing is not interfered with and the surface texture is not damaged. Vehicles needed for construction activities and weighing between 500 kg and 2,000 kg, and comparable materials and equipment loads, will be allowed on any span only after the last placed deck concrete has attained a compressive strength of at least 17 N/mm^2 . Loads in excess of the above shall not be carried on bridge decks until the deck concrete has reached its specified strength. In addition for post-tensioned structures, vehicles weighing over 2 Tonnes, and comparable materials and equipment loads, will not be allowed on any span until the prestressing steel for that span has been tensioned.

Precast concrete or steel girders shall not be placed on substructure elements until the substructure concrete has attained 70 precent of its specified strength.

Otherwise, loads imposed on existing, new or partially completed portions of structures due to construction operations shall not exceed the load-carrying capacity of the structure, or portion of structure, as determined by the Allowable Stress Design methods of JRA-SHB (Japan Road Association : Specification for

Highway Bridges) or the Load Factor Design methods of AASHTO using Load Group IB. The compressive strength of concrete (f_c') to be used in computing the load-carrying capacity shall be the smaller of the actual compressive strength at the time of loading or the specified compressive strength of the concrete.

5.1.14.4 Traffic Loads

Traffic will not be permitted on concrete decks until at least 14 days after the last placement of deck concrete and until such concrete has attained its specified strength.

5.2 REINFORCING STEEL

5.2.1 Description

This work shall consist of furnishing and placing reinforcing steel in accordance with these specifications and in conformity with the Drawings.

5.2.2 Material

All reinforcing bars shall be deformed except that plain bars may be used for spirals and ties.

Reinforcing steel shall conform to the requirements of the following specifications.

5.2.2.1 Uncoated Reinforcing

Bar reinforcement shall be deformed bar and plain round bar of the grades known in JIS as SD345, SD390 and SR235 having the properties as shown below:

Mechanical Characteristics (JIS G3112)

Grade	Yield Stress or 0.2% proof stress N/mm²	Tensile Stress N/mm²	Size of Tensile test piece	Elongation % min	Bending Nature		
					Bending Angle	Diameter of Bends	
SD345	345~440	≥ 490	No.2	≥ 18	180°	≤D16	1.5 times nominal diameter
			No.3	≥ 20		<D41	2 times nominal diameter
SD390	390~510	≥ 560	No.2	≥ 16	180°	2.5 times nominal diameter	
			No.3	≥ 18			
SR235	≥ 235	380~520	No.2	≥ 20	180°	1.5 times nominal diameter	
			No.3	≥ 24			

Comment : The elongation of D36 is reduced 2% from the value of D32.
The elongation of D40 is reduced 4% from the value of D32.

All reinforcement steel shall conform to the requirements of the Thai Industrial Standard 24-2527 (Deformed Bar; Grade SD40, SD35) and 20-2527 (Round Bars Grade SR24) or Japan Industrial Standard JIS G3112 (Grade SD390, SD345, SR235) or ASTM A615, unless otherwise approved by the Engineer.

5.2.2.2 Mill Test Reports

Whenever steel bars are to be spliced by welding or when otherwise requested, a certified copy of the mill test report showing physical and chemical analysis for each heat or lot of reinforcing bars delivered shall be provided to the Engineer.

5.2.2.3 Tests

Test results in addition to those to be submitted by the Contractor and specified above shall be required.

The Contractor shall cut out samples as directed by the Engineer.

The samples shall be tested according to the Engineer's instructions by an approved Testing Institution. Expenses incurred in connection with cutting out and transport and testing of the samples shall be born by the Contractor. Approximately one sample shall be tested from each 10 tons of reinforcement delivered to the site.

5.2.3 Bar Lists and Bending Diagrams

When the Drawings do not include detailed bar lists and bending diagrams, the Contractor shall provide such lists and diagrams to the Engineer for review and approval. Fabrication of material shall not begin until such lists have been approved. The approval of bar lists and bending diagrams shall in no way relieve the Contractor of responsibility for the correctness of such lists and diagrams. Any expense incident to the revision of material furnished in accordance with such lists and diagrams to make it comply with the design drawings shall be borne by the Contractor.

5.2.4 Fabrication

5.2.4.1 Bending

Bar reinforcement shall be cut and bent to the shapes shown on the approved working drawings including bending diagrams. Fabrication shall be in accordance with ACI 315. Bars partially embedded in concrete shall not field bent except as shown on the Drawings or as directed by the Engineer.

The weight of reinforcing bars will be computed using the following weights.

Bar Size	Weight Kg/m
9	0.499
10	0.616
12	0.888
15	1.387
16	1.578
19	2.226
20	2.466
25	3.853
28	4.834
32	6.313
36	7.991
40	9.865

5.2.4.2 Hooks and Bend Dimensions

The dimensions of hooks and the diameters of bends measured on the inside of the bar shall be as shown on the Drawings. When the dimensions of hooks or the

diameter of bends are not shown, they shall be in accordance with ACI 318, "Building Code Requirements for Reinforced Concrete."

5.2.4.3 Identification

Bar reinforcement shall be shipped in standard bundles, tagged and marked in accordance with the *Manual of Standard Practice of the Concrete Reinforcing Steel Institute.*

5.2.5 Handling, Storing, and Surface Condition of Reinforcement

Steel reinforcement shall be stored above the surface of the ground on platforms, skids, or other supports and shall be protected as far as practicable from mechanical injury and surface deterioration caused by exposure to conditions producing rust. When placed in the work, reinforcement shall be free from dirt, loose rust or scale, mortar, paint, grease, oil, or other materials that would reduce bond. Reinforcement shall be free from injurious defects such as cracks and laminations. Bonded rust, surface seams, surface irregularities, or mill scale will not be cause for rejection, provided the minimum dimensions, cross-section area, and tensile properties of a hand wire brushed specimen meet the physical requirements for the size and grade of steel specified.

All bundling bands shall be padded and all bundles shall be lifted with a strong back, multiple supports, or platform bridge so as to prevent bar-to-bar abrasion from sags in the bar bundle. Bars or bundles shall not be dropped or dragged.

5.2.6 Placing and Fastening

5.2.6.1 General

Steel reinforcement shall be accurately placed as shown on the Drawings and firmly held in position during the placing and setting of concrete. Bars shall be tied at all intersections around the perimeter of each mat and at not less than 600 mm centers or at every intersection, whichever is greater, elsewhere. Bundled bars shall be tied together at not more than 2 meter centers. If fabric reinforcement is shipped in rolls, it shall be straightened into flat sheets before being placed. Welding of cross bars (tack welding) will not be permitted for assembly of reinforcement unless authorized in writing by the Engineer.

5.2.6.2 Support Systems

Reinforcing steel shall be supported in its proper position by use of mortar blocks, wire bar supports, supplementary bars or other approved devices. Such devices shall be of such height and placed at sufficiently frequent intervals so as to maintain the distance between the reinforcing and the formed surface or the top surface of deck slabs within 6 mm of that indicated on the Drawings.

Platforms for the support of men and equipment during concrete placement shall be supported directly on the forms and not on the reinforcing steel.

5.2.6.3 Mortar Blocks

Mortar blocks shall have a compressive strength not less than that of the concrete in which they are to be embedded. The face of blocks in contact with forms for exposed surfaces shall not exceed 5 cm by 5 cm in size and shall have a color and texture that will match the concrete surface. When used on vertical or sloping surfaces, such blocks shall have an embedded wire for securing the block to the reinforcing. When used in slabs, either such a tie wire or, when the weight of the reinforcing is sufficient to firmly hold the blocks in place, a groove in the top of the block may be used.

5.2.6.4 Wire Supports

Wire bar supports, such as ferrous metal chairs and bolsters, shall conform to industry practice as described in the *Manual of Standard Practice of the Concrete Reinforcing steel Institute.* Such chairs or bolsters which bear against the forms for exposed surfaces shall be either Class 1—Maximum Protection (Plastic Protected) or Class 2, Type B-Moderate Protection (Stainless Steel Tipped) for which the stainless steel conforms to ASTM A 493, Type 430.

5.2.6.5 Adjustments

Reinforcement used in post-tensioned concrete shall be adjusted or relocated during the installation of pre-stressing ducts or tendons, as required to provide planned clearances to the pre-stressing tendons, anchorages and stressing equipment, as approved by the Engineer.

5.2.7 Splicing of Bars

5.2.7.1 General

All reinforcement shall be furnished in the full lengths indicated on the Drawings unless otherwise permitted. Except for splices shown on the Drawings and splices for 16 mm or smaller bars, splicing of bars will not be permitted without written approval. Splices shall be staggered as far as possible.

5.2.7.2 Lapped Splices

Lapped splices shall be of the lengths shown on the Drawings. If not shown on the Drawings, the length of lapped splices shall be as approved by the Engineer.

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 plans.

5.2.7.3 Welded Splices

Welded splices shall be used only if detailed on the Drawings or if authorization is made by the Engineer in writing. Welding shall conform to the Structural Welding Code, Reinforcing Steel, AWS D1.4 of the American Welding Society and applicable special provisions.

5.2.7.4 Mechanical Coupler Splices

Splices made with mechanical couplers shall be used only if pre-approved or detailed on the Drawings or authorized in writing by the Engineer. 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 to 125 percent of the specified yield strength by the Engineer.

5.2.8 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.

5.2.9 Substitutions

Substitution of different size bars will be permitted only when authorized by the Engineer. The substituted bars shall have an area equivalent to the design area, or larger.

5.3 STEEL

5.3.1 General

Mechanical characteristics of steel structures shall be constructed in accordance with the requirements of JIS (Japan Industrial Standard) or the AASHTO Standard Specification for Highway Bridges Sixteenth Edition 1996 Sections 10,11,12 and 14 all as amended by the Contract Drawings, Specifications.

5.3.2 Measurement and Payment

Unless otherwise provided, mechanical characteristics and steel structures will not be measured for payment.

SECTION 6 : INCIDENTALS

6.1 RIVERBANK PROTECTION

6.1.1 Description

This work shall consist of the provision and installation of riverbank protection for the Mekong River. Riverbank protection will be constructed of gabion mattress and riprap as shown on the Drawings.

6.1.2 Materials

6.1.2.1 Gabion Mattress

The general specification for gabion mattresses are as follows;

Gabion : 0.5m (thickness) x 2.0m (width) x 1.0m (length)

The width of gabion mattress will be 1-2m as directed by the Engineer. The length will be multiples of one metre subject to a maximum of 4.0m.

Mesh Wire	:	3.0mm diameter
Selvedge Wire	:	3.9mm diameter
Mesh Size	:	8cm x 10cm
Galvanizing Wire	:	All wire used shall be galvanized. The tensile strength of the wire shall be in the range of 400 to 500 N/mm^2, determined in accordance with ASTM A392. The minimum zinc coating of the wire shall be $240g/m^2$ of uncoated wire surface in accordance with ASTM A90.
Stone Size	:	100mm to 250mm

The contractor shall provide samples of the above materials to the Engineer for his approval.

6.1.2.2 Riprap and Boulders

Stone for riprap and boulders shall consist of field stone or rough, un-hewn quarry stone as nearly rectangular as practicable. The stone shall be dense, resistant to the action of air and water, and suitable in all other respects for the purpose

intended. The stones size shall not be less than 400 millimeter. In other respects, the stones shall conform to the requirements of the Engineer.

6.1.2.3 Geo-textile

Geo-textile type filter is "Polyfelt TS60" or approved equivalent.

6.1.2.4 Concrete

Concrete used in the works shall conform to the concrete class as shown in the Drawings and the requirements Specified in Section 5.1 in these Specification unless otherwise stated.

6.1.2.5 Reinforcement

Steel Reinforcement used in the works shall conform to the requirement of Section 5.2 in these Specifications, unless otherwise stated.

6.1.2.6 Incidentals

All incidentals required in the riverbank protection work shall conform to the requirements as specified in the Drawings, and these specifications or as directed and approved by the Engineer.

6.1.3 Construction Methods

1) The Contractor shall clear and grub the ground and slope surface above the water level.

2) Cofferdum shall be constructed for the placing of gabions below the water level.

3) The slope shall be excavated in a series of steps greater than 0.5m in height.

4) Compact the slope to the Engineers satisfaction but not less than 90% of the Standard Proctor density.

5) Cover the slope under the water by riprap.

6) For the geo-textile under the water hold down by weighted bamboo frames as shown in the Drawings.

7) The gabions shall be adequately filled with crushed stones in a manner to minimize the voids. After filling up to the top of each gabion, it shall be connected to each adjacent gabion.

8) Reinforced concrete structure shall be bedded on a firm foundation as shown on the Drawings.

6.1.4 Measurement

(1) Gabion Mattress for riverbank protection shall be measured on the exposed area basis in square meters. Measurement shall be made along the surface of exposed slopes. Excavation and Embankment to form slopes and shaping of riverbank and riprap shall not be measured separately but shall be considered incidentals to the works.

(2) Stairs and RC Chute Drain on riverbank shall be measured as units linear meter, completed in place in accordance with the Drawings or at the direction of the Engineer. The landings for stairs, inlet, outlet, wingwalls and aprons shall not be measured separately but shall be considered incidentals to the works.

6.1.5 Payment

The unit price paid for the items listed below which appear in the Contract shall be full compensation for the works as described herein and shown on the Drawings, including all materials, excavation, forms, screeding, curing, hauling of materials, backfill, equipment, tools, labour and all other incidentals necessary for the proper completion of the work.

Pay items shall be as follows:

Item No.	Description	Unit
6.1(1)	Gabion Mattress (t=50cm)	square meter
6.1(2)	Stairs on Riverbank Protection	linear meter
6.1(3)	RC Chute Drain on Riverbank Protection	linear meter

6.2 SUB-SURFACE DRAINS

6.2.1 Description

This work shall consist of providing drains for the removal of sub-surface water such as perforated pipe subdrains or layers of porous material placed below the

subgrade. The work shall be constructed to the lines, levels and dimensions as specified in the Drawings and these Specifications.

Subdrains may consist of perforated pipe placed in a trench and backfilled with sand and used to intercept and remove ground water encountered during excavation, usually in hilly or mountainous areas. The depth and location of subdrains shall be determined by the Engineer during construction when excavation reveals the location of ground water.

6.2.2 Materials

6.2.2.1 Pipe

Pipe for subdrains shall be perforated poly vinyl chloride as detailed in the Drawings or as directed by the Engineer.

Perforated poly vinyl chloride pipe (PVC) shall be a D-plast rigid type, class 6.5 with plain ends and shall conform to the requirements of the Thai Industrial Standard 17-2523.

Pipe of other materials shall be permitted if approved by the Engineer.

6.2.2.2 Pipe Backfill

Porous backfill material for bedding and backfilling pipe subdrains shall meet the gradation and quality requirements as specified in the Drawings or in Section 6.18 of these Specifications.

Impervious backfill material shall be a fine compactible material approved by the Engineer.

6.2.3 Construction Methods

6.2.3.1 Trench and Bedding for Pipe Subdrains

Trenches shall be excavated to the width, line and grade as shown on the Drawings. Unless shown otherwise, the depth shall vary from 1.0 to 1.5 meters below the finished surface at the top of the trench where the construction is under a gutter, ditch or the roadbed, and to depths required for the proper drainage at

other locations. A ten centimeter bed of granular backfill material shall be spread in the bottom of the trench throughout its entire length and brought to a uniform grade.

6.2.3.2 Placing Pipe and Backfilling

Pipe of the kind and size required shall be embedded firmly in the bedding material.

Bell and spigot pipe shall be laid with the bell ends up grade and the spigot ends fully entered in the adjacent bell and spot mortared to provide for centering of pipe, but not closed to the desired infiltration of water.

The joints of butt-jointed pipe shall be covered with two-ply tar paper strips not less than 150 millimeters in width and of sufficient length to permit the ends being turned outward and laid flat on the bedding material on either side of the pipe for a distance of 80 millimeters. In lieu of tar paper, the joints may be wrapped twice around with a strip of burlap or other approved material.

Perforated pipe shall be laid with the perforated side of the pipe down, and separate sections shall be firmly jointed with approved metal bands.

Polyvinyl chloride (PVC) pipe shall be perforated by drilling holes of one centimeter diameter at intervals of 150 millimeters extending along the length of the pipe. A crushed stone filter of maximum aggregate size 13mm shall be placed at end joints around the pipe as detailed in the Drawings.

After the pipe has been laid and has 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 pipe or joint covering around and over the pipe. The upper portion of the trench shall then be filled with suitable material of either porous or impervious type 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 or as directed by the Engineer.

6.2.4 Measurement

Subdrains with perforated PVC pipe shall be measured by the linear meter of pipe. Excavation and backfill shall not be measured separately but shall be considered incidentals to the work.

6.2.5 Payment

The quantities of subdrains, measured as provided above, shall be paid for at the contract unit price per unit of measurement. The payment shall be full compensation for trench excavation, furnishing and placing all materials, including outlets, backfilling, labor, equipment, tools and incidentals necessary to complete the work.

Payment shall be made under the following items:

Item No.	Description	Unit
6.2(1).1	Subdrain, Perforated PVC Pipe, 15cm Diameter	linear meter

6.3 DRAINAGE STRUCTURE

6.3.1 Description

6.3.1.1 Scope of Work

The works shall include the furnishing of all the equipment, materials, labor, testing and supervision required to complete the following works in compliance with the Drawings and these Specifications.

(1) The construction of permanent surface water drainage system consists of but is not limited to the provision, installation and furnishing of the types and sizes of reinforced concrete pipe, box culvert, U-ditch, headwall, retaining wall inlet, catchbasin, manhole, step, platform, spring box channel, cover, spacer, curb opening, concrete lining, stone masonry and other types of slope protection.

(2) The construction of an artificial canal and slope chute drain consists of the excavation, embankment, slope protection, and concreting as shown on the Drawings

6.3.1.2 General Requirements

The following general requirements are applicable:

(1) The Contractor shall be deemed to have satisfied himself as to the site conditions and other particulars whatsoever in connection with the drainage works.

(2) During the construction of the box culvert, the Contractor shall maintain the discharge of the existing canal and rivers. If any event of flooding arises inside the site area or outside the site area, the Contractor shall provide proper relief and protection measures, at his own expense.

(3) Prior to the commencement of the work, cleaning and grubbing of the site shall be carried out by the Contractor in accordance with the requirements of Section 2.1 "Clearing and Grubbing" of these Specifications.

6.3.2 Materials

6.3.2.1 Concrete

Concrete used in the works shall conform to the concrete class as shown in the Drawings and the requirements Specified in Section 5.1 in these Specifications unless otherwise stated.

6.3.2.2 Reinforcement

Steel Reinforcement used in the works shall conform to the requirement of Section 5.2 in these Specifications, unless otherwise stated.

6.3.2.3 Mortar

Mortar for joints shall contain one part of portland cement and two parts of sand by dry volume unless otherwise indicated in the Drawings or required by the Engineer. The sand shall conform to the requirements of AASHTO Standard Specification M45-70.

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 after adding the water to the dry mixture.

6.3.2.4 Riprap

Stone for riprap shall consist of field stone or rough, quarry stone as nearly rectangular as practicable. The stone shall be dense, resistant to the action of air and water, and suitable in all other respects for the purpose intended.

The stones shall, in general, be of the wide flat type with their larger faces roughly rectangular and parallel. The thickness of stone shall be as shown on the Drawings. Unless otherwise specified, the stones shall weigh not less than 5 kilograms each.

6.3.2.5 Reinforced Concrete Pipe

Tongue and groove type shall conform to the requirements as shown on the Drawings. Reinforced concrete pipe shall be constructed in accordance with the Drawings.

6.3.2.6 Steel Material

Steel for frames, covers and gratings for manholes and inlets shall conform to the requirements of Section 5.5 "Steel Structure" and as shown in the Drawings. Steel structure shall be galvanized by hotdip galvanizing process, the zinc coating weight shall be not less than 600g/sq.m. on the average value found per lot.

6.3.2.7 Acceptance of Materials at Site

(a) The variation in dimensions shall not vary more than the following.

Pipe – The internal diameter shall not vary more than ± 1% or ten millimeters, whichever is greater.

Box culvert, Channel and Manhole – The dimension of the inside faces and the thickness of the structure shall not be less than that shown on the Drawings.

(b) Finish – All precast pipes, manholes, channels and covers shall be free of fractures, large or deep cracks and surface roughness, all edges shall be precise for good locking during installation.

(c) Marking

Pipe – Each pipe shall be clearly marked on the outside surfaces as follow:

Trade name
Nominal inside diameter and class of pipe
Serial number for each lot of pipes

Fittings – Each fitting and accessory shall bear the mark as follow:

Manufacturer trade mark
Nominal diameter and size
Main characteristics of each fitting
Year of manufacture
Serial number of each lot of fittings

The marks shall be either cast on, stamped by die or painted.

(d) Manufacturers Certificate

The Contractor shall provide manufacturer's certificate for each lot of pipes, fittings and accessories supplied stating that all the material conforms to the specified standard. Any form of certificate certified by the manufacturer or recognized agency may be submitted.

6.3.2.8 Inspection and Rejection

The quality of materials, the process of manufacture and the finished pipe or other precast structures shall be subjected to inspection and approval by the Engineer.

Any material or product shall be subject to rejection on account of failure to conform to any of the Specifications requirements. Individual sections of pipe may be rejected because of any of the following.

i) Fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint.

ii) Defects that indicate imperfect proportioning, mixing and molding.

iii) Surface defects indicating honeycombed or open texture.

iv) Damaged ends where such damage would prevent making a satisfactory joint.

6.3.2.9 Repairs and Acceptance

Pipe or other precast members shall be repaired, if so directed by the Engineer, because of occasional imperfections in manufacture or accidental injury during handling and shall be acceptable if, in the opinion of the Engineer, the repairs are sound and properly finished and cured and the repaired pipe or precast member conforms to the requirements of these Specifications.

6.3.3 Construction Methods

6.3.3.1 General Consideration

Location, invert elevation and alignment of the drainage structure shall conform to the Drawings, or as directed by the Engineer. The Contractor shall obtain the permission and approval of the Engineer before the start of trench excavation in any location.

The Contractor shall verify the underground structures and utilities that might obstruct the works, before excavating the trench, then the Contractor shall establish the possible works method and locate all the underground and on ground structures and public utilities.

6.3.3.2 Embankment and Excavation

In general the embankment shall first be built to the elevations shown on the Drawings in accordance with Section 2.6 "Embankment" of these Specifications. After a sufficient consolidation period as determined by the Engineer, a trench shall be excavated to the bottom of the bedding. The bedding shall then be placed as specified on the Drawings.

Sheeting and bracing shall be used to retain the excavated soil from sliding and minimize the over excavation, damage prevention to the existing structures or road. Prior to excavation, the Contractor shall submit shop drawings and the construction method of sheeting and bracing for approval of the Engineer.

(1) The width of the pipe trench or other trenches shall be as specified on the Drawings to permit satisfactory joining of the pipe and thorough tamping of the bedding material under and around the pipe. The sides of trenches shall be adequately supported at all times and where permitted by the Engineer supports may be left in trenches.

(2) Where rock, hard pan or other unyielding material is encountered, it shall be removed below the foundation grade for a depth of at least 300mm.

(3) Before pipe 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.

(4) When a firm foundation is not encountered, due to soft, spongy or unstable soil, such unstable soil under the pipe and for a width of at least one diameter on each side of the pipe shall be removed to the depth directed by the Engineer and replaced with gravel or other suitable selected material properly compacted to provide adequate support for the pipe.

6.3.3.3 Pipe Installation

(1) Bedding

Bedding details for pipe culverts shall be as shown on the Drawings. The Engineer shall decide, in the field, which type of bedding shall be used depending upon the foundation soils. Granular material to be used as first class bedding shall conform to the requirements as specified in Section 8.18 of these Specifications – Porous Backfill Material Type A, or similar material approved by the Engineer, and shall be compacted as embankment fill for layers at the depths concerned below subgrade.

(2) Pipe Laying

The pipe shall be laid carefully, groove up-grade, tongue ends fully entered into the adjacent groove, and true to lines and grades as shown on the Drawings or directed by the Engineer.

Joints inside the pipe shall be grouted with cement mortar (proportioned 2 sand to 1 cement) of sufficient thickness to bring the inner surface of the abutting pipes flush and even. At the same time the mortar outside the pipe shall be protected for two (2) days or until the Engineer allows backfilling to proceed.

(3) Backfilling

Backfilling shall be carried out with material approved by the Engineer and placed in uniform layers not exceeding 150mm 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.

(4) Compaction

Special care shall be taken to compact thoroughly the material around 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 at least one fourth of the diameter of the culvert, but in no case less than 600mm, unless otherwise approved by the Engineer. Light weight equipment may be operated within the above limitation after embankment has been placed and compacted to give a minimum cover of 300mm over the top of the culvert.

6.3.3.4 Construction of Reinforced Concrete Structures

(1) Cast in-situ or precast reinforced concrete structures shall be bedded on a firm foundation as shown on the Drawings. In cases where the structure is placed next to others, the Contractor shall provide at his own cost, joint sealant or mortar to be grouted at all joints to prevent the water leakage.

(2) For the channel or ditch lining, expansion joints shall be formed at the intervals shown on the Drawings or as directed by the Engineer at the suitable location where not specified in the Drawings.

(3) Concrete shall be generally in accordance with the concrete class as shown in the drawings and the requirements specified in Section 5.1 "Portland Cement Concrete Structure". Forms shall be removed no earlier than 24 hours after concrete has been placed or until permission is given by the Engineer.

(4) Minor defects shall be repaired with mortar containing one part of Portland cement and two parts of fine aggregate. Repair shall not be permitted on the faces and rejected portions shall be removed and replaced at the Contractor's expense. The exposed surfaces shall be finished while the concrete is still green, by wetting a soft brick or a wood block and rubbing the surfaces until they are smooth. The surfaces shall be wet thoroughly either by dipping the brick or block in water, or by throwing water on the surfaces with a brush. After the concrete has been rubbed smooth, using water, it shall then be rubbed with a thin grout containing one part of Portland Cement and one part of fine aggregate. Rubbing with grout shall continue until a uniform color is produced.

(5) Grating, frames for grating, covers for inlets, channels and manholes shall be placed in full beds of mortar or otherwise properly secured as indicated on the Drawings, so as to be held rigidly in place to proper grade and alignment.

(6) Side inlet drains which connect inlets of curb and manholes or U-ditch 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 material as may be specified so as to make it watertight.

(7) When completed, the concrete shall be covered with suitable material and kept moist for a period of three (3) days. The concrete shall be suitably protected from the weather until thoroughly hardened.

The finished work shall be true to line, grade and level to within 10mm and shall present a smooth appearance.

(8) The Contractor shall install the underground conduit and PVC pipes for the Electrical and Mechanical works in advance of the construction of U-ditch and RC. Pipe culverts at the intercrossing sections shown in the drawings.

6.3.3.5 Construction of Open Drainage and Slope Protection

(1) Excavation or construction of embankments shall be processed to planned shape and dimensions. The Contractor shall be responsible for liasing with the Engineer, prior to the making of excavations or building of embankments in areas to be covered.

(2) The areas to be covered shall, at the proper time, be laid out to intended positions, and all necessary cut and fill stakes, batter boards and construction lines set up. Every effort shall be made to have the surfaces in such condition as to require some excavation immediately prior to the laying of the riprap or concrete lining. Where, however, low areas are encountered they shall be backfilled and thoroughly tamped at the earliest practical time in advance of the laying of masonry, to avoid settlement after placing riprap. It is not necessary that the entire area, to be protected, be excavated and fine graded in advance of the laying. Slope protection work should be always laid upon a freshly excavated and stable surface.

6.3.4 Measurement

(1) All pipes shall be measured as the number of linear meter of pipe (omitting all fractions less than one meter) from end to end of each pipe structure, complete and accepted in place.

Where manholes, catch basins, etc. exist, the length of pipe to be measured shall be from inside wall to inside wall of manhole, or as specified in the Drawings.

Headwalls, endwalls or riprap shall be considered as a separate item in the Bill of Quantities and shall be measured for each item. Excavation, bedding, backfill, and tamped fill shall not be measured as such and shall be considered incidental to the laying of the pipe structure. No separate or additional measurement shall be made for the excavation of bell hole, when required, or for reinforced concrete used in constructing pipe joints.

(2) Box culverts shall be measured in linear meter of the length along the centerline of culvert as indicated per station in the Bill of Quantities. The length shall be measured from end to end of the top headwall (not wingwall). The headwalls, wingwalls, excavation, bedding and backfilling shall not be

measured and shall also be considered incidental to the works. Cost for river diversion work required during the construction shall be considered incidental to the unit price of the box culvert and no separate payment shall be made.

(3) Reinforced concrete headwalls for pipes shall be measured in cubic meter of concrete of all type and size of structure. Reinforcing bars in headwall, excavation, bedding and backfill shall not be measured but shall be considered incidental to the works.

(4) Reinforced concrete manholes, catch basins and drop inlets shall be measured per number as indicated in the Bill of Quantities as completed and accepted in place. Concrete cover or steel grating shall be considered as part of the works. Excavation, bedding and backfill shall not be measured but shall be considered incidental to the works.

(5) Reinforced concrete U-ditch shall be measured in linear meters along the centerline of channels from end to end of the outer side of the adjoining structure. Mitered ends shall be neglected and considered as an incidental part of work. Concrete covers or steel grating shall be considered as a part of the works. Excavation, bedding and backfill shall not be measured but shall be considered incidental to the works.

(6) Precast concrete covers or steel gratings shall not be measured separately, however laid completely and accepted in place. The Contractor shall also take full responsibility for any damage and loss within the Contract period and shall replace any covers or gratings at once at his own expense as ordered by the Engineer.

(7) Stone Masonry for ditch lining shall be measured for payment on the exposed area basis in square meters. Measurement shall be made along the surface of the exposed slopes. Any part embedded in the ground shall not be measured. Excavation and embankment from the ditch shape shall be paid by Earth Excavation or Embankment items said specified in Sections 2.4 and 2.6.

(8) Curb inlet and side inlet drains shall be measured in linear meters along the centerline of the side inlet drain and the side walk of the road. Precast concrete side inlet, lean concrete, curb opening, steel grating at curb opening, and fixing motar shall be considered incidentals to the works, and no separate measurement shall be made. Similarly excavation, bedding, backfill and tamped fill shall not be measured but shall be considered incidental to the works.

(9) Reinforced concrete side ditch shall be measured in linear meters along the centerline of channels from and to end of connecting point with consisting side ditch. Filter material shall be considered incidental to the works, no separate measurement shall be made. Excavation to form the ditch shape shall be paid by Excavation and Embankment items as specified in Section 2.4.

(10) Slope chute drain shall be measured in linear meters along the centerline of channels from end to end of outer side of adjoining structure. Excavation, bedding and backfill shall not be measured but shall be considered incidentals to the works.

(11) Underground conduit and PVC pipes installed in advance of civil works shall not be measured separately for the payment but consider to be incidentals of respective electrical and water supply piping works.

6.3.5 Payment

This work measured as provided shall be paid for at the unit rates for each particular item entered into the Bill of Quantities, such rate and payment constituting full compensation for all material, labor, tools, equipment and incidentals needed to complete the work. The complete work includes work associated with the structure and indicated on the Drawings, specifically mentioned in items of the Bill of Quantities.

Pay items shall be as follows;

Item No.	Description	Unit
6.3(1).1	Reinforced Concrete Pipe, 40cm diameter L	linear meter
6.3(1).2	Reinforced Concrete Pipe, 40cm diameter T	linear meter
6.3(1).3	Reinforced Concrete Pipe, 60cm diameter L	linear meter
6.3(1).4	Reinforced Concrete Pipe, 60cm diameter T	linear meter
6.3(1).5	Reinforced Concrete Pipe, 80cm diameter L	linear meter
6.3(1).6	Reinforced Concrete Pipe, 80cm diameter T	linear meter
6.3(1).7	Reinforced Concrete Pipe, 100cm diameter L	linear meter
6.3(1).8	Reinforced Concrete Pipe, 100cm diameter T	linear meter
6.3(1).9	Reinforced Concrete Pipe, 120cm diameter L	linear meter
6.3(1).10	Reinforced Concrete Pipe, 120cm diameter T	linear meter
6.3(1).11	Reinforced Concrete Pipe, 150cm diameter L	linear meter
6.3(1).12	Reinforced Concrete Pipe, 150cm diameter T	linear meter
6.3(2)	RC. Pipe Headwall, Reinforced Concrete	cubic meter

6.3(3).1	Box Culvert, 2.40x2.40m. at STA.0+980.000 T	linear meter
6.3(3).2	Box Culvert, 3 x 3.60x3.60m. at STA.1+017.000 T	linear meter
6.3(3).3	Box Culvert, 2.50x2.50m. at STA.4+781.000	linear meter
6.3(3).4	RC. U-Wall for RC. Box Culvert T	linear meter
6.3(4).1	Reinforced Concrete U-ditch, 0.30m.x0.30m.	linear meter
6.3(4).2	Reinforced Concrete U-ditch, 0.30m.x0.50m. L	linear meter
6.3(4).3	Reinforced Concrete U-ditch, 0.30m.x0.50m. T	linear meter
6.3(4).4	Reinforced Concrete U-ditch, 0.30m.x0.80m. T	linear meter
6.3(4).5	Reinforced Concrete U-ditch, 0.45m.x0.45m. L	linear meter
6.3(4).6	Reinforced Concrete U-ditch, 0.50m.x0.50m. T	linear meter
6.3(4).7	Reinforced Concrete U-ditch, 0.50m.x0.50m. T with RC. Cover	linear meter
6.3(4).8	Reinforced Concrete U-ditch, 0.50m.x0.60m T	linear meter
6.3(4).9	Reinforced Concrete U-ditch, 0.50m.x0.80m. L/T with RC. Cover, Type B1	linear meter
6.3(4).10	Reinforced Concrete U-ditch, 0.50m.x0.80m. L/T with RC. Cover, Type B2	linear meter
6.3(4).11	Reinforced Concrete U-ditch, 0.60m.x0.60m T	linear meter
6.3(4).12	Reinforced Concrete U-ditch, 1.00m.x1.00m. L	linear meter
6.3(4).13	Reinforced Concrete U-ditch, 1.10m.x1.00m. L	linear meter
6.3(4).14	Reinforced Concrete U-ditch, 1.20m.x1.20m. T	linear meter
6.3(4).15	Reinforced Concrete U-ditch, 1.20m.x1.20m. T with RC. Cover	linear meter
6.3(4).16	Reinforced Concrete U-ditch, 1.30m.x1.00m. L	linear meter
6.3(5).1	Reinforced Concrete Chute Drain 0.4m.x0.4m. T	linear meter
6.3(5).2	Reinforced Concrete Chute Drain 1.0m.x1.0m. L	linear meter
6.3(5).3	Reinforced Concrete Chute Drain 1.0m.x1.0m. T	linear meter
6.3(6).1	Reinforced Concrete Side Ditch	linear meter
6.3(6).2	Stone Masonry T=20cm for Open Side Ditch	square meter
6.3(7).1	Manholes, 0.8m=< W < 1.0m with RC Cover	each
6.3(7).2	Manholes, 0.8m=< W < 1.0m with Steel Grating	each
6.3(7).3	Manholes, 1.0m=< W with RC Cover	each
6.3(7).4	Manholes, 1.0m=< W with Steel Grating	each
6.3(8).1	Catch Basin 0.6m.x0.6m. T	each
6.3(8).2	Catch Basin 0.7m.x0.7m. T	each
6.3(8).3	Catch Basin 1.0m.x1.0m. T	each
6.3(8).4	Catch Basin 1.5m.x1.6m. L	each
6.3(8).5	Catch Basin 1.5m.x1.7m. L	each
6.3(8).6	Catch Basin 1.5m.x1.9m. L	each

6.3(8).7	Catch Basin 1.2m.x1.2m. L	each
6.3(9)	Drop Inlet 1.0m.x1.6m. L	each
6.3(10).1	Curb Inlet and Side Inlet Drain L	linear meter
6.3(10).2	Curb Inlet and Side Inlet Drain T	linear meter
6.3(10).3	Inlet Drain RC Rectangular Pipe	linear meter

6.4 CONCRETE CURB

68.4.1 Description

Concrete curb, mountable curb shown on the Drawings or required at locations determined by the Engineer, shall be constructed as shown in the standard details and in conformance with the requirments of Section 6.4 of these Specifications. Concrete type shall be Class E(18N/mm^2) as Specified in Section 5.1 in these Specifications and shall be either precast or cast-in-place with the prior approval of the Engineer.

This work shall also include curb markings and concrete barrier marking of black and white paint or other color where shown on the Drawings or designated by the Engineer.

6.4.2 Materials

Bed course material, if any is shown on the Drawings, shall consist of clean sand, gravel, crushed stone or other approved porous material of 10 millimeter maximum size and conforming to the general requirements of Section 3.2.

Concrete for Curb shall be of the class indicated on the Drawings and shall conform to the requirements of the Section 5.1 on Portland Cement concrete structures.

Paint for curb and barrier shall be of approved industrial quality and shall conform to AASHTO M70-74.

6.4.3 Construction Methods

Excavation shall be made to the required depth, and the base upon which the curb, gutter, or combination curb and gutter is to be set shall be compacted to a firm even surface. All soft and unsuitable material shall be removed and replaced with

suitable material. If shown on the Drawings bed course material shall be placed and compacted to form a bed of the required thickness.

When a curb is placed next to a concrete pavement, expansion joints in the curb shall be located opposite expansion joints in the pavement. Expansion joints shall be formed at the intervals shown on the Drawings using preformed filler 1 centimeter in thickness in accordance with the requirements of Section 4.5.4.9. Dummy joint with the concrete pavement shall not be measured and paid for separately but shall be considered incidental to the pay item for the curb.

Concreting shall be generally in accordance with the requirements of Section 5.1. Forms shall be removed within 24 hours after concrete has been placed. Minor defects shall be repaired with mortar containing one part of portland cement and two parts of fine aggregate. Repair will not be permitted on the faces and rejected portions shall be removed and replaced at the Contractor's expense. The exposed surfaces shall be finished while the concrete is still green, by wetting a soft brick or a wood block and rubbing the surfaces until they are smooth. The surfaces shall be wet thoroughly either by dipping the brick or block in water, or by throwing water on the surfaces with a brush. After the concrete has been rubbed smooth, using water, it shall then be rubbed with a thin grout containing one part of portland cement and one part of fine aggregate. Rubbing with grout shall continue until a uniform colour is produced.

When completed, the concrete shall be covered with suitable materials and kept moist for a period of 3 days. The concrete shall be suitably protected from the weather until thoroughly hardened.

After the concrete has set sufficiently, the spaces in the front and back of the curb and gutter shall be refilled to the required elevation with the proper material, which shall be tamped in layers of not more than 150 millimeters, until properly compacted.

The finished work shall be true to line grade and level to within 3 millimeters and shall present a smooth appearance free from kinks and distortion visible to the eye.

6.4.4 Measurement

The quantity measured for payment shall be the number of linear meters of concrete of the several types of concrete curb completed in place and accepted.

Concrete curb shall be measured in place along the center of curb. No deduction shall be made for flattening of curbs for entrances or for curb drainage inlets.

Curb and Concrete Barrier Markings shall be measured on a two-dimensional basis by the square meter for the areas painted as directed by the Engineer.

6.4.5 Payment

Concrete Curb as measured in SubSection 6.4.4 of these Specifications shall be paid for at the respective Contract unit prices per linear meter, complete in place, which prices shall include all excavation, backfilling, tamping, materials, formwork, equipment, tools, labor and all incidentals necessary for the proper completion of the work.

Curb and Concrete Barrier Marking will be paid for at the Contract unit price per square meter, complete and accepted by the Engineer, which price shall include all paints of required colors and quality, labor, tools and incidentals necessary to the satisfactory completion of the work.

Pay items will be as follows:

Item No.	Description	Unit
6.4(1).1	Concrete Curb Type 1	linear meter
6.4(1).2	Concrete Curb Type 2	linear meter
6.4(1).3	Concrete Curb Type 3	linear meter
6.4(1).4	Concrete Curb Type 4	linear meter
6.4(2)	Curb and Concrete Barrier Markings	square meter

6.5 CONCRETE SIDEWALK

6.5.1 Description

This work shall consist of concrete sidewalks constructed of concrete paving blocks on prepared beds in accordance with this Specification and in accordance with the lines, levels, grades, dimensions and types shown on the Drawings. The work shall include the construction of bed courses.

6.5.2 Materials

Bed course material shown on the Drawings shall consist of sand.

Concrete paving block shall conform to TIS 827.

Joint shall be filled with drymix containing one part of portland cement and twenty parts of sand by dry volume.

6.5.3 Construction Methods

Excavation shall be made to required depth, and the foundation shall be shaped to conform to the section shown on the Drawings and compacted to a firm, even surface. All soft and unsuitable material shall be removed and replaced with suitable material.

Bed course material shall be placed and compacted to form a bed course of the required thickness.

All work shall be correct to line, grade and level to within 3 millimeters.

If shown on the Drawings, the Contractor shall construct the required sidewalk or island paving of individual concrete blocks of a size specified on the Drawings. If concrete blocks are not specified, the Contractors shall submit samples of concrete block to the Engineer and must have the prior written approval of the Engineer.

6.5.4 Measurement

This work shall be measured on a square meter basis, complete and accepted in place.

6.5.5 Payment

Concrete Paving Block for Sidewalk shall be paid for at the Contract unit price per square meter, complete in place, which price shall include all materials, sand bedding, equipment, tools, labor and all work incidental to satisfactory completion.

Pay item shall be as follows:

Item No.	Description	Unit
6.5(1)	Concrete Paving Block for Sidewalk	square meter

6.6 GRASSING

6.6.1 Description

This work shall consist of furnishing sods as required or permitted and planting them to give a healthy stable covering of grass which will maintain its growth in any weather and prevent erosion of the material in which it is planted.

This work includes the providing of block sodding or strip sodding on the topsoil covered slopes of embankment, subbase and shoulder and on other areas subject to erosion as shown on the Drawings and where required by the Engineer.

6.6.2 Materials

Grass shall be of species native to Thailand or the Lao PDR, harmless and inoffensive to people and animals and not of a kind recognized as a nuisance to agriculture. It shall be free of disease and noxious weeds, deep rooted and sufficiently rapid growing and spreading to give complete cover over the planted area within two years of planting.

The term "grass" embraces sods and, if the Engineer permits, may include plants of other types capable of giving effective protection.

Fertilizer shall be approved lime or mixtures of plant nutrients or both.

Sods shall be planted with their root system substantially undamaged and packed around with moist earth in which they have grown.

6.6.3 Construction Methods

Sodding shall be done by planting sods to give a continuous cover over the whole area.

Strip sodding shall be done by planting strips of sods not less than 80 millimeters wide, not more than 450 millimeters apart (centre to centre) or as required in the Contract Documents.

Strip sodding shall be planted with the strips lying along contours.

All sods shall be planted with roots well buried in firm material.

Grass shall be planted at such a time and the work shall be done in such a way that at the time of the final construction inspection all areas to be grassed are substantially covered with healthy, well established, firmly rooted grass and the planted area is free from erosion channels. In the case of strip sodding bare strips between the strips of sods will be permitted at the time of the construction inspection. In the case of sprigging bare patches between sprigs will be permitted provided clear paths for erosion channels do not exist.

Occasional small bare patches will not be cause for rejection. Any bare areas which, in the Engineer's opinion, may permit erosion shall be made good and replanted with Sodding.

Surfaces to be planted shall be trimmed in such a way that the ground surface after planting shall be as shown on the Drawings.

Fertilizer shall be added at the time of planting if required in the Contract Documents or if it is necessary to ensure good ground cover within the required time.

Whenever a slope is completed, dressed and ready for grassing, the Contractor shall proceed with block sodding or strip sodding as designated on the Drawings or instructed by the Engineer. The Contractor shall maintain the grass at his expense until the end of the Maintenance Period. Maintenance shall consist of preserving, protecting and replacing grass, and such other work as may be necessary to keep it in a satisfactory condition to prevent erosion and to present a dense and unifrom appearance. The Contractor shall be responsible for satisfactory growth and shall water, fertilize and mow the grass at such intervals as will ensure good ground cover of live grass through the Maintenance Period.

6.6.4 Measurement

The quantity measured for payment shall be Block Sodding or Strip Sodding measured as the number of square meters of planted surface (whether horizontal or sloping) measured on the slope, of required and accepted grassing well established in place. Fertilizer will not be measured. In the case of strip sodding planted surface shall mean the whole area including that initially uncovered between the strips.

6.6.5 Payment

Block Sodding and Strip Sodding, as shown in the Contract Drawings, will be paid for at the respective Contract unit prices per square meter, complete and accepted in place, which prices shall include all materials, handling, storage, site preparation, placing, maintenance, equipment, tools, labor, incidentals and satisfactory disposal of all unsuitable or surplus materials necessary for completion of the works.

Payment will be made under the following items :

Item No.	Description	Unit
6.6(1)	Block Sodding	square meter
6.6(2)	Strip Sodding	square meter

6.7 GUARD RAIL

6.7.1 Description

This work shall consist of furnishing, erecting, installing and completing steel beam-type guardrails as shown on the Drawings or as directed by the Engineer.

The work shall be constructed according to design and dimensions with the lines, levels and locations as shown on the Drawings and these Specifications or as directed by the Engineer.

6.7.2 MATERIALS

6.7.2.1 General

Posts, plates and all hardware shall be fabricated and ready for assembly before galvanizing.

6.7.2.2 Steel Posts

Steel posts shall be galvanized standard carbon steel pipe with round shape, outside diameter not less than 100mm. and thickness not less than 4mm., and shall conform to the requirements of TIS 248/2525.

6.7.2.3 Concrete and Reinforcement

Concrete shall conform to the requirements of Section 5.1. Reinforcement shall conform to the requirements of Section 5.2.

6.7.2.4 Rail Elements

Rail elements shall be made from steel of thicknesses not less than 3.2mm. Rail elements shall meet the strength requirements and have the mechanical properties shown in Table 6.7.1 below, and shall conform to the requirements of TIS 248/2525.

Table 6.7.1

Minimum Ultimate Tensile Strength (N/mm^2)	Elongation Not Less Than (%)	Maximum Deflection			
		Traffic Face Up		Traffic Face Down	
		Kg.	Deflection Not More Than (mm)	Kg.	Deflection Not More Than (mm)
400	21	910	50	720	50

The beam strength shall be determined with the rail element freely supported on a clear span of 365cm. and the load shall be applied through an 8cm. wide flat surface at the center of the span. Rails and joints between rails shall both be tested in the same manner. When the joint is tested, it shall be at the center of the span. Terminal sections shall meet the same requirements as for rail elements except for the beam strength test.

Guard rail elements not intended to be painted shall receive a zinc coat galvanizing of the least $550g/m^2$.

6.7.2.5 Bolts and Nuts

Bolts, nuts, rings and other hardware shall be galvanized in accordance with AASHTO standard M232-78 (ASTM A153-78) and all connections shall be able to withstand a side pull in any direction of 2,200 kilograms.

6.7.2.6 Paint

Paint shall be applied in the number of application and of the type indicated in the Contract Documents. Paint shall conform to the appropriate specification as follows :

Red Lead paint	AASHTO	M 72
White and tinted paint	AASHTO	M 70 Type 1 Class B
Aluminum paint	AASHTO	M 69
Zinc chromate paint	AASHTO	M 142

6.7.3 Construction Requirements

6.7.3.1 Erection of Guardrails

6.7.3.1.1 General

Guardrails shall be placed at the locations shown on the Drawings or designated by the Engineer, and shall be erected as shown on the Drawings.

6.7.3.1.2 Erection of Posts

Posts shall be set vertically in position to the lines and levels shown on the Drawings. Post holes shall be back filled with approved material well tamped in layers of not more than 10 centimeters thickness. If driving of posts is permitted the tops of posts shall have substantially the same dimensions as the body of the posts. Damage to posts in driving will be cause for rejection.

6.7.3.1.3 Installation of Beams

Beams, posts, and appurtenances for guardrails shall not be field punched, reamed, or drilled except as may be approved by the Engineer to provide for lapped beams, or for changes in location of splices necessitated by field clearances. The beams shall be spliced by lapping in the direction of traffic.

Rails shall be erected in a manner that will result in a smooth continuous taut rail closely conforming to the line grade of the highway or as shown in the Drawings.

Galvanized material shall be handled in a manner to avoid damage to the surface. Any galvanized material on which the spelter coating has been bruised or broken will be rejected or may, with approval of the Engineer be repaired by an accepted method.

6.7.4 Measurements

Steel guard rail shall be measured by the linear meter along the rail elements from center to center of posts for each continuous installation . Terminal section shall not be measured separately but will be considered incidental to the work.

6.7.5 Payments

Steel Guard Rail, shall be paid for at the respective Contract prices per unit of measurement, measured as specified above, which shall include furnishing and installing all steel rail elements, terminal sections, steel posts, brackets and splice plates, nuts, bolts, miscellaneous materials and backfill as well as all equipment, labor and incidentals necessary to the proper execution of the work.

Payment will be made under the following items :

Item No.	Description	Unit
6.7(1)	Steel Guard Rail, W-Beam	linear meter

6.8 TOPSOIL

6.8.1 Description

This work shall consist of furnishing, transporting and spreading topsoil removed from approved sources and fill the selected gravel on islands , in accordance with this Specification.

6.8.2 Materials

Topsoil furnished by the Contractor shall consist of a natural friable surface soil without admixture of undesirable soil, refuse or foreign materials. It shall be reasonably free from roots, hard clay, coarse gravel, stones larger than 50 millimeters in any dimension, noxious weeds, tall grass, brush, sticks, stubble or other litter, and shall have indicated by a healthy growth of crops, grasses, trees or other vegetation that it is free-draining and non-toxic.
Materials for Selecting gravel fill shall be in conformity with requirements shown on the Drawings.

Prior to selecting gravel for this work the Contractor shall submit a sample of gravel to the Engineer for approval.

6.8.3 Construction

The Contractor shall notify the Engineer at least 5 days before he intends to start topsoil stripping operations. After inspection and approval by the Engineer, and prior to stripping any topsoil, the Contractor shall remove noxious weeds and tall grass, brush, stones larger than 50 millimeters in any dimension, and roots.

The topsoil shall be evenly spread on the designated areas to a depth which, after settlement and compaction, shall be that shown on the Drawings. Spreading shall not be done when the ground or topsoil is excessively wet or, otherwise in a condition detrimental to the work. The roadway surface shall be kept clean during hauling and spreading operations. After spreading has been completed, large clods, stones larger than 5 centimeters in any dimension, roots, stumps and other litter shall be raked up and removed.

Where shown on the Drawings and where instructed in writing by the Engineer, topsoil shall be placed on the slopes of embankment, subbase, shoulders and cuts and in ditches and other areas in a thickness of 100 mm. measured perpendicularly to the slopes. To reduce erosion as much as possible, the placing of topsoil and the subsequent grassing shall be done simultaneously with or right after the placing and compacting of the individual layers of the embankment, subbase, shoulders or right after completing the cut.

Within the right-of-way no topsoil materials shall be obtained from areas outside the limits of earthworks, as stated in Section 2.1 of these Specifications but they may, if acceptable to the Engineer, be obtained from borrow pits, roadway excavation, channel excavation, excavation for structures and from areas under embankment. When obtained from areas outside the right-of-way, the Contractor must obtain permission or make contracts and pay any necessary fees.

Where layers of embankment fill are made from excavation of clay type silty materials conducive to the growth of grass, such layers may be extended in width to the outer surface of the prescribed layer of topsoil and no topsoil shall be placed thereon. The volume of fill corresponding to the prescribed layer of topsoil will not be measured as embankment, but will be measured and paid for as topsoil.

In the event sodding shall be placed and the root systems of the sods are as specified in Section 6.6.3 of these Specifications, topsoil may not be required. If, in the opinion of the Engineer, topsoil is not required under sods, it will not be measured for payment.

6.8.4 Measurement

The quantity measured for payment shall be the number of cubic meters of required topsoil and selected gravel of the designated thickness complete and accepted in place.

6.8.5 Payment

Topsoil and Selected Gravel Fill will be paid for at the Contract unit price per cubic meter, complete and accepted in place, which prices shall include furnishing and placing all material, labor, equipment, tools and incidental necessary to complete the works.

Payment for topsoil will be made as follows:

Item No.	Description	Unit
6.8(1)	Topsoil	cubic meter

6.9 FENCING

6.9.1 Description

This work shall consist of fences and gates of the type indicated constructed in accordance with this Specification at the locations and in accordance with the lines, grades, levels, designs and dimensions shown on the Drawings.

6.9.2 Materials

6.9.2.1 Concrete

Concrete used in the works shall conform to the concrete class as shown in the Drawings and the requirements specified in Section 5.1 in these Specification unless otherwise stated.

6.9.2.2 Reinforcement

Steel Reinforcement used in the works shall conform to the requirement of Section 5.2 in these Specifications, unless otherwise stated.

6.9.2.3 Concrete Block

Concrete block shall be conform to TIS 60.

6.9.2.4 Wire Netting, Steel Pipe, Barbed Wire

Wire netting, steel pipe and barbed wire shall be of the gauge, weight size and type indicated on the Drawings and shall be galvanized.

6.9.2.5 Steel Plate, Shapes Tube

Steel plate and shapes shall conform the requirements of TIS 1116. Steel tube shall conform to the requirements of TIS 107.

6.9.2.6 Timber Barricade

Posts and railing for the barricades shall be timber of Mai Teng, Rung or Takhien types. Timber posts shall be treated as specified in AASHTO M-122-73. Timber railing shall receive three coats of paint as specified on the Drawings.

6.9.3 Construction Methods

Posts shall be set vertically in positions to the lines and levels shown on the Drawings and maintained in accurate alignment while fencing is erected and backfilling is done. Post holes shall be filled with materials shown on the Drawings. Backfilling shall be done with suitable material, not necessarily the material excavated, and shall be well tamped into compacted layers not exceeding 100 millimeters 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 100 millimeters. Gates shall be kept horizontally. Anchors shall be securely buried

and backfilled as for posts and shall show no signs of movement when wires are strained tight.

6.9.4 Measurement

The quantity measured for payment shall be the number of linear meters of each type of fencing and the number of gates of each type, all as finally installed in the place required and accepted.

6.9.5 Payment

This work measured as provided above shall be paid for at the Contract unit price for fencing and gates which rate and payment shall be full compensation for furnishing all materials and for all labour, equipment, tools and incidentals necessary to complete the work.

Payment for topsoil will be made as follows:

Item No.	Description	Unit
6.9(1)	Security Fence L	linear meter
6.9(2)	Security Fence T	linear meter
6.9(3)	Barbed Wire Fence	linear meter
6.9(4)	Net Fence	linear meter
6.9(5)	Custom Checkpoint Gate	each
6.9(6)	Minor Gate	each
6.9(7)	Main Gate	each
6.9(8)	Permanent Timber Barricade	linear meter
6.9(9)	Handrail	linear meter

6.10 GUIDE POSTS

6.10.1 Description

This work shall consist of guide posts furnished and installed in accordance with details shown on the Drawings and these Specifications.

6.10.2 Construction methods

Details of construction materials, placing, painting, lettering, etc. are shown and fully described on the Drawings. Concrete and reinforcement steel shall conform to the requirements as specified in Section 5.1 and 5.2 of these Specifications. Any guide post shown on the Drawings or designated by the Engineer to be removed and relocated shall be carefully excavated, removed, cleaned, repainted and refurbished to a like-new condition and installed in the proper location as directed by the Engineer.

6.10.3 Measurement

This work shall be measured as the number of units each, properly constructed or relocated and accepted by the Engineer.

6.10.4 Payment

Payment for Guide Post shall be at the Contract unit prices each, complete in place, which prices shall include, furnishing and placing all materials, labor, equipment, tools and incidentals necessary to complete the work.

Item No.	Description	Unit
6.10(1)	Guide Post	each

6.11 ROAD SIGNS

6.11.1 Description of Work

6.11.1.1 General

This work shall consist of furnishing, assembling, erecting and installing road signs of post assemblies and sign frames, and non-illuminated signs of a permanent nature and as specified in these Specifications and as shown on the Drawings or as directed by the Engineer.

6.11.1.2 Scope

The work shall include all necessary foundations, excavation, backfill, anchorages, fixtures and fastenings, brackets, application of paint, finishes and testing and all materials, products and processes necessary to complete the work.

The work on the fabrication, construction, erection and finishing of cantilever signs supports and signs gantries is also included in this Section.

6.11.1.3 Size Colours Type

All sign faces and lettering shall be in accordance with road sign standards of the United Nations Conference on Traffic, Lao convention on Road Signs and Signals for signs constructed in the Lao PDR, with the recommendations of the latest edition of the Department's Traffic Control Device Manual and subsequent supplements and amendments for signs constructed in Thailand as shown in the Drawings, or as directed by the Engineer.

Prior to manufacture and fabrication of the signs the Contractor shall submit to the Engineer for approval, detailed drawings showing letter sizes, road sign symbols and signs layout. Unless otherwise shown in the Drawings or noted in the Specifications, all signs shall be lettered in both Lao and English.

6.11.2 Materials

6.11.2.1 General Requirements

Materials shall be of new stock as shown on the Drawings or directed by the Engineer and shall conform to requirements listed in the following.

6.11.2.2 Concrete

Concrete shall be of the Class shown on the Drawings or as otherwise approved by the Engineer. Materials, proportioning, mixing, slump, and transporting, placing, consolidating and curing of Portland cement concrete shall be in accordance with Section 5.1 these Specifications. Concrete shall be Class D ($24N/mm^2$) unless otherwise specified on the Drawings or in the Specifications.

6.11.2.3 Steel Reinforcement

Reinforcing steel bars shall conform to the requirements of Section 5.2 Reinforcement for structures.

6.11.2.4 Sign Posts

The sign posts and sign materials shall be in conformity with requirements shown on the Drawings.

(1) Reinforced Concrete Posts

Material shall conform to the requirements of Section 5.1 of these Specifications. Concrete shall be Class D.

(2) Prestressed Reinforced Concrete Posts

Materials shall conform to the requirements of the ASTM, JIS, TIS or other equivalently international standards.

(3) Steel Posts

Steel posts shall be in the form of round tubes or pipes of not less than 6 centimeters outside diameter or other approved sections of adequate torsional rigidity and strength complying with the appropriate specifications of the American Society for Testing Materials, the American Association of State Highway Officials or a similar internationally recognised body.

6.11.2.5 Structural Steel

Material sections, fixings and fittings of structural steel shall conform with the requirements of AASHTO M 183.

6.11.2.6 Galvanizing

If not otherwise shown on the Drawings steel posts shall be galvanized in accordance with AASHTO M 111.

6.11.2.7 Aluminium

Sections, fixings and fittings of aluminium shall conform to the requirements of Alloy 6.061-T6 or 6063-T6 complying with the applicable ASTM standards.

6.11.2.8 Post Caps

Caps for hollow posts or other hollow sections used in construction shall be approved metal or suitable weather resisting plastic material.

6.11.2.9 Painting

Painting of road sign posts shall be as shown on the Drawings or directed by the Engineer.

The paint material shall be in conformity with standard requirements of the metal to be painted.

The materials for road signs shall comply with appropriate standards and specifications of American Association of State Highway Officials (AASHTO). American Society for Testing Material (ASTM) or similar international recognized authority for road signs.

6.11.2.10 Sign Materials

1) General

Sign materials shall be as shown on the Drawings or as otherwise approved by the Engineer.

2) Aluminium Sheeting (Small Signs)

Aluminium alloy sheets for small signs shall conform with the requirements of ASTM B 209. The alloy shall be type 6061-T6 aluminium degreased and alodine-treated, three mm thick, unless otherwise shown on the Drawings.

3) Steel Sheet

Steel sheet for road signs shall conform with the requirements of ASTM A 245, Grade B, two mm thick, unless otherwise shown on the Drawings.

4) Stainless Steel Bolts, Washers and Self Locking Nuts

These items shall conform to ASTM A 276, Chromium-Nickel Grade.

Steel-Aluminium Contacts

Steel fixings and fittings which are in contact with aluminium shall be coated with zinc or cadmium.

5) Vulcanized Fiber Washers

Fiber washers shall conform to ASTM D 710 Gray, Commercial Grade, when shown on the Drawings.

6) Hard Rubber Washers

Hard rubber washers, when shown on the Drawings, shall be as approved by the Engineer.

7) Nylon and Neoprene Fittings

Nylon and / or neoprene washers, spacers, sleeves, etc. when shown on the Drawings, shall be as approved by the Engineer.

8) Reflective Sheeting

Reflective sheeting shall be as shown on the Drawings or as otherwise approved noncellulostic materials, transparent plastic of each of the colors specified, and glass spheres. The glass spheres shall adhere to the synthetic sheet resin, and be embedded beneath a flexible transparent plastic film forming a smooth flat surface. The reflective sheeting shall have a precoated pressure sensitive adhesive backing, or a precoated tack-free solvent or heat activated adhesive backing.

The sheeting shall adhere tightly to the prescribed surfaces when applied in accordance with the manufacturer's recommendations. The precoated adhesive shall not require additional adhesive coats on the reflective sheeting of application surface. The precoated adhesive shall form a durable bond to clean corrosion-proof metals, and shall adhere securely under normal service.

The precoated adhesive shall have no staining effect on the reflective sheeting and shall be mildew resistant. Protective liner for preventing contamination or premature adhesion shall be removable by peeling without the necessity of soaking in water or other solvents.

The Contractor shall submit samples of each certificate and results of tests conforming that the materials proposed to be used meet the applicable standards and specifications, color of the reflective sheeting, to the Engineer for approval, prior to ordering materials.

Reflective sheeting of all colors except black shall be Engineer Grade, Scotchlite 3M or as approved by the Engineer.

Black reflective sheeting shall be mate Scotchcal 3M or approved color by the Engineer.

Reflective sheeting shall meet the requirements and testing standards of U.S. Federal Specifications L-S-300C and AASHTO M 268, as applicable.

6.11.2.11 Preservatives, Paints and Finishes

All coatings, paints, varnishes and enamels used in the preparation and finish of the signs, posts and fittings shall be of the best quality, specially made for the purpose they shall serve, and of brands and types acceptable to the Engineer.

To ensure compatibility, primers, undercoats and finishing coats shall, wherever possible, be of the same manufacture.

Plastic sheetings, films, sheathings and sprayed plastic finishes shall be of approved types and thicknesses, of durable color and weather resistant, and shall be fully compatible with any materials with which they will come into contact. Such finishes shall be applied in accordance with the manufacturer's specifications or instructions.

6.11.3 Manufacture Requirements

6.11.3.1 Posts

Sign Post Support Assemblies shall be fabricated as detailed on the Drawings or shop drawings prepared by the Contractor and approved.

All the structures shall be such as to bear the stress caused by a wind blowing at 160 km/h measured at a height of ten meters above the ground on the support and the signs.

Breakaway Sign Post Support Assemblies shall be fabricated as shown in the Drawings or according to design prepared by the Contractor and approved by the Engineer. All welds shall be mechanically cleaned before galvanizing.

Galvanized materials on which the galvanizing has been damaged in transporting, handling, or erection will be rejected or may with the approval of the Engineer, be repaired in the field by the zinc alloy stick method. Required field welds and adjecent areas on which the galvanizing has been damaged shall be galvanized by this same method.

The Contractor shall furnish to the Engineer, manufacturer's certifications and test results certifying that the materials and products supplied and used conform to all of the requirements specified.

The use and location of breakaway sign posts for ground-mounted signs of all types shall be as directed by the Engineer.

6.11.3.2 Sign Panels

Each panel section shall be provided with a perimeter frame. The extruded horizontal top and bottom frame members shall have an integral retainer track for affixing mounting bolts to provide for blind fastening of sign panel to post support.

The vertical side frame members shall be of extruded channel. An additional slot shall be milled in the tip and bottom frame for later field insertion of self-tapping hexagonal head stainless steel screws. A sealant shall be used at the corner to prevent moisture penetration.

6.11.3.3 Sign Faces

All sign faces shall be of the type, color, design and size as shown in the Drawings or approved by the Engineer.

The laminating adhesive shall produce a permanent oil and water resistant bond. Adhesives shall be of the thermosetting type. Bonding of panels shall be done in a heated flat platen press of sufficient size to contain the entire panel at one time at a provision of 69 kPa over the entire platen area. Face and back panels shall be cleaned prior to laminating, in tanks of sufficient size to accommodate the complete panel.

All adhesively bonded panels shall have an exterior face of such flatness, that when measured at a temperature of 21 to 27 °C, the maximum wave slope of the surface at any point, measured from the nominal plane of the surface, shall not exceed one percent. Flatness will be considered satisfactory if the tolerance requirement is met with readings taken in sun or shade.

The manufacturer shall furnish certification as to prior testing of the adhesive laminates according to test methods ASTM E 72 and ASTM C 273, performed by an independent testing laboratory.

6.11.4 Construction Requirements

6.11.4.1 Placement and Orientation

The Engineer will establish and mark the longitudinal location of each sign.

The sign shall be laterally positioned from the shoulder edge or curb as shown on the Drawings or directed by the Engineer.

The Contractor shall stake the location of the sign supports.

The Contractor shall be responsible for the proper elevation, off-set, level and orientation of all signs he erects. He shall exercise due care in the preservation of stakes for his and the Engineer's use. If any stakes are lost, damaged, displaced, or removed, the Contractor shall have them reset.

Unless otherwise shown on the Drawings all signs shall be erected so that the edge and face of the sign are truly vertical and the face is at an angle of 92 degrees to the centerline; that is, facing slightly away from the centerline of the lane which the sign serves. Where lanes divide or are on sharp curves, the Contractor shall orient sign faces as indicated on the Drawings or by the Engineer so that they will be most effective both day and night and so as to avoid specular reflection and glare. All sign supports shall be plumbed.

6.11.4.2 Footings for Posts

Footings shall be excavated to the dimensions shown on the Drawings. Concrete of Class D (24 N/mm^2) shall be placed against the undisturbed excavated faces, except that the top 150 mm of each footing shall be formed.

Concrete shall be thoroughly rodded and spaded to eliminate all voids. Tops of footings shall be finished with a wood float and exposed edges shall be rounded with an edger.

Backfill shall be thoroughly compacted by mechanical tampers as required by these Specifications, brought up level with the finished ground line.

Post bases shall be firmly supported plumb and vertical and at the proper elevation.

Alternatively, prefabricated concrete footings may be approved based on drawings and Specifications submitted by the Contractor or of the proposed footings.

6.11.4.3 Sign Posts

Post lengths shown in the Drawings for signs are for basic information only. The Engineer will authorize the location of each sign, with the station and offset distance from the edge of pavement.

The Contractor shall be responsible for determination of post lengths to provide the vertical clearance shown on the Drawings. Field cutting of posts shall be performed by sawing.

6.11.4.4 Fastening Signs to Sign Posts

Signs shall be fastened to sign supports in accordance with the requirements of the Drawings, the recommendations of the sign manufacturer and to the acceptance of the Engineer.

After installation of signs on their supports all bolt heads, screw heads, and washers which are exposed on the face of the sign shall be painted. The color of the paint used shall be as nearly as practical the name or the color of the background or message area at the point when the bolt, screw or washer is exposed.

Where steel signs are mounted with alumimum hardware or where aluminum signs are mounted with steel hardware or on steel posts, approved asphalt, nylon, or neoprene insulation shall be installed at all points where dissimilar metals come in contract.

6.11.5 Measurements

(1) Concrete posts for road sign shall be measured in linear meter of the length of each size. Steel posts for road signs and overhanging signs and steel frame for overhead signs shall be measured per each indicated in the Bill of Quantities as completed and accepted inplace.

Excavation, Concrete, reinforcement and piles for foundation shall not be measured separately, however completed and accepted inplace, and shall be considered incidentals to the works.

(2) Road signs, overhanging signs and overhead signs shall be measured in square meter per each as completed and accepted inplace.

6.11.6 Payment

This work measured as provided shall be paid for at the unit rates for each particular item entered into the Bill of Quantities, such rate and payment constituting full compensation for all material, labor, tools, equipment and incidentals needed to complete the work. The complete work includes work associated with the structure and indicated in the Drawings, specifically mentioned in items of the Bill of Quantities.

Item No.	Description	Unit
6.11(1)	Concrete Post and Foundation for Road Sign, Size 0.12x0.12m.	linear meter
6.11(2)	Concrete Post and Foundation for Road Sign, Size 0.15x0.15m.	linear meter
6.11(3)	Steel Post and Foundation for Road Sign, Type L1	each
6.11(4)	Steel Post and Foundation for Road Sign, Type L2	each
6.11(5)	Steel Post and Foundation for Road Sign, Type L3	each
6.11(6)	Steel Post for Road Signs on Bridge	each
6.11(7)	Steel Post and Foundation for Overhanging Sign, Type L	each
6.11(8)	Steel Post and Foundation for Overhanging Sign, Type T1	each
6.11(9)	Steel Post and Foundation for Overhanging Sign, Type T2	each
6.11(10)	Steel Post and Foundation for Overhanging Sign, Type T3	each
6.11(11)	Steel Frame and Foundation for Overhead Sign	each
6.11(12)	Road Signs L	square meter
6.11(13)	Road Signs T	square meter
6.11(14)	Overhanging Signs L	square meter
6.11(15)	Overhanging Signs T	square meter
6.11(16)	Overhead Signs	square meter

6.12 STREET LIGHTING

6.12.1 General

6.12.1.1 Description

This work shall consist of the supply of all lanterns complete, brackets, columns and other supporting devices, bases, cables, switchgear 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 in accordance with the details shown on the plans and as specified herein and in the Specifications if any. Design of the system may be included.

The Contractor shall search for and take special precautions to protect any existing utility services such as power lines, telephone lines, gas and oil pipelines, sewers and water works affected by his operations at his own cost, and shall minimize and be responsible for any damage caused thereby. He shall at all times and at his own expense conduct his operations in accordance with the requirements of the Utility Authorities having jurisdiction in the area.

The following data shall be furnished by the Contractor to the Engineer and shall be included in the design documents:

a) catalogs of electrical components; lanterns, ballast, etc.

b) Plans and circuit diagrams, ground connection diagram.

c) Photometric data;
   i) Utilization Curve
   ii) Isocandela Diagram
   iii) Horizontal Iso Foot Candle Diagram
   iv) Polar Light Distribution Curve

d) Details of columns, brackets, base plates.

6.12.1.2 Maintenance Period

All repairs and replacements required during the Maintenance Period shall be carried out with despatch and an adequate supply of spares shall be available for this purpose.

6.12.1.3 Electricity Supply

The Contractor shall carry out negotiations with the Electricity Supply Authority concerned for an electricity supply to the installation, and any costs associated with obtaining this supply shall be included in the Contract rates. The Contractor must ensure that the equipment supplied will function correctly at the supply voltage, and must allow for normal variations and surges.

6.12.2 Materials and Equipment

6.12.2.1 Lanterns

Lanterns shall be of the cut-off or the semi-cut-off type as shown on the Drawings or as specified in the Specifications.

All lanterns shall be new, totally enclosed, side entry, dustproof, insect proof and water tight and tested for these requirements. All lanterns shall be supplied complete with all the necessary control gear fully wired and fixed and ready for erection. The gear shall be integral with the lanterns. The lantern wiring shall be of a size and insulated with materials that will effectively withstand the current, voltage and temperatures expected within the lantern during both the starting and operating modes in the ambient temperatures of the site. The lamp compartment of the lantern shall be accessible via a hinged bowl which shall, in the closed position, bed firmly upon a soft resilient gasket which shall be firmly secured to the lantern by means of stainless steel clips and large pins. In the lowered position the bowl shall be restrained from becoming detached or blown against the other parts of the lantern or column arm or bracket. Reflector, if used, shall be the mirror type and made of anodised aluminium sheet. The bowl, if made of transparent acrylic, shall not display any drop in output due to colour changes within the first five (5) years of service.

A sample lantern of the type proposed for use in this Contract is to be supplied to the Engineer for his approval, together with a certificate of approval by the Electricity Authority concerned before any installation is made. Transverse and longitudinal cross-section drawings of the lantern at 1:10 scale shall also be furnished to the Engineer.

The mininum average horizontal illumination on the road way shall be 21.5 Lux ($2.0Cd/m^3$)

6.12.2.2 High Mast Lighting

The High Mast Light shall be applied to the provisions of section 25.2.

6.12.2.3 Switching

The switching supplied for control of lanterns shall be of a type approved by and agreed with the Electricity Supply Authority. If approved by the Supply Authority

photoelectric relay switching will be permitted, each device controlling a group of lanterns. Switching shall be by photo-electric relay.

6.12.2.4 Columns and Brackets

a) Columns shall be of steel construction and shall consist of tapered round hollow shafts with anchor bases. Each column shall be provided with a suitable cable slot and a weatherproof service door fitted with a tamperproof lock. All locks shall be of the same pattern, and six keys shall be provided for them.

b) Columns and brackets shall be structural steel having the following mechanical properties:

- Thickness of sheet steel (min)	4 mm.
- Ultimate tensile Strength (min)	400 N/mm2
- Yield point (min)	250 N/mm2
- Elongation (min)	21%

c) A non-hygroscopic mounting board composed of electrically insulting material shall be fitted in an easily accessible position inside the column, and shall be of suitable size to take all necessary electrical equipment. Adjacent to this mounting board, there shall be provided on the inside of the column two stainless steel studs, not less than 4 centimeters long nor less than 8 millimeters diameter and complete with stainless steel lock nuts and washers, for use as earthing connections.

d) Brackets to provide the required outreach shall be of sufficiently strong construction to support the lantern under all normal conditions without significant movement, and shall be provided with suitable fittings to take the lanterns. When in position, brackets shall be inclined upwards at an angle of approximately 15 degree to the horizontal, and shall be fixed to their supports by suitable welding, fastenings or wall plates.

6.12.2.5 Supply Pillars

a) The Contractor shall supply and erect the pillars in accordance with the Drawings. The pillar 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 of the material used. The pillars shall be of

sufficient 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 protected by screw plugs or some other forms of secret lock approved by the Engineer. The pillars must be self ventilating and rainproof. The pillars shall have a fluorescent lamp switched on always open the door by limit switch or equivalent. The doors shall be hinged internally to prevent unauthorized access. All the supply pillars shall have the same lock and key. Six keys shall be provided.

c) The Contractor shall provide, mount and wire the equipment as shown on the Drawings including a 12mm. thick backelite backboard. The equipment includes main safety switch, distribution fuse board, contractors, multiterminal blocks, time switches etc. and some space must be left free for the possible future installation of addition equipments.

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 16mm^2 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 fuses, two of each size used.

6.12.2.6 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 220 volts, 50

hertz supply and have a spring driven clock-work 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.

6.12.2.7 Photo Electric Controls

Photo sensitive lighting controls shall be weather-proof enclosed, suitable for operation on 200-250 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 preset adjustable value. The operation shall be faill-safe, in that, in the event of failure of any components of the control the artificial lighting shall be continuously energized. Time delay devices shall be included to prevent switching of aritificial lighting due to transient lighting changes. The controls 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.

6.12.2.8 Protection Against Corrosion

Unless otherwise specified, columns, bracket arms, and brackets shall be protected against corrosion either by painting or galvanizing as follows:

a) Painting:

i) Columns and masts shall be treated internally with hot asphalt under high pressure so as to give a complete and unbroken asphaltic covering or other approved anticorrosion treatment shall be applied to give at least equally good protection. Bases shall be similarly treated up to a level of 250 millimeters above ground level.

ii) Before delivery to the site, columns, masts, steel brackets, and external fittings shall have all external welds ground down and all external surfaces cleaned by shot blasting or an other approved method to a white metal finish free of all signs of rust. Immediately following this treatment the items shall be painted with two coats of tropical red lead undercoat followed by two coats of aluminum paint or they shall be treated in a similar and not less effective manner acceptable to the Engineer to prevent subsequent corrosion. After erection, all imperfections and damages shall

be made good to the Engineer's satisfaction and the items shall be given a final coat of aluminum paint.

b) Galvanizing:

i) Before delivery to the site, columns, masts, steel brackets, and external fittings shall have all external welds ground down. Poles and other ferrous materials shall be galvanized both inside and outside by the hot dip process in accordance with ASTM A525. The weight of zinc coating shall not be less than 550 grams per square meter.

ii) Bases of columns, both inside and outside, shall be coated with bituminous paint up to a level of 250 millimeters above the base plate.

6.12.3 Construction Methods

6.12.3.1 Excavation and Reinstatement

Excavation for cable or conduit laying or for foundations and reinstatement shall be carried out in accordance with the provisions of Section 2.5 of these Specifications. Reinstatements shall be such that the surface is restored to at least its original standard.

6.12.3.2 Concrete Work

All necessary foundations and footings or other concrete work shall be carried out in accordance with Section 5.1 and 5.2 of these Specifications. Unless otherwise specified on the Drawings or in the Specifications, concrete shall be class D. Foundations shall be placed in one operation except that the top 50 millimeters may be placed after the superimposed structure is in position. The exposed portions of foundations shall be formed to present a neat and tidy appearance and sloped to shed water away from the structure supported. Where existing obstructions prevent the construction of foundations as shown on the plans, then an effective alternative may be provided subject to the prior approval of the Engineer.

6.12.3.3 Conduits, Fittings and Boxes

Conduits, fittings and boxes shall be provided and installed as shown on the Drawings. Plastic conduits, fittings and boxes, according to samples previously approved by the Engineer, will be permitted providing that they do not soften when exposed to high ambient temperature.
The Contractor may use a larger size of conduit than that specified, at no extra charge, if he wishes, but in this case the entire run shall be of the same size. No reducing couplings will be permitted.

Conduits shall be laid to a depth of not less than 500 millimeters below the paved footwalks and medians and not less than 600 millimeters below the roadway surface. The location of all conduits at curb lines shall be marked by means of a "Y" at least 100 millimeters high incised in the face of the curb directly above the conduit. Conduit terminating in standards, cabinets or pedestals shall extend at least 50 millimeters 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 in the direction of the run.

6.12.3.4 Drawpits

Drawpits shall be installed as shown on the Drawings and in any case at not more than 100 meters intervals on straight runs and at every change of direction of the conduit run. The Contractor may install additional drawpits without extra charge if he wishes. Drawpits shall be of reinforced concrete as detailed on the Drawing. Reinforced concrete covers, secured by two recessed brass bolts shall be used on footwalks, the covers being inscribed "Street Lighting" on the outside. Under the roadway, covers 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 drawpits shall be effectively level with the surrounding paved areas, whether footwalk or roadway, but in unpaved areas the tops of drawpits shall be buried 300 millimeters below ground level. The bottom of drawpits shall be bedded in sand and cement or crushed rock. Permanent markers shall be provided and erected to show the position of all drawpits.

6.12.3.5 Testing

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. This test shall consist of not less than five nights continuous and satisfactory operation. If any defects or unsatisfactory operation are revealed, this condition shall be corrected and the test continued until the required five nights of satisfactory operation have been performed.

Prior to the functional test, the Contractor shall carry out the following tests to the entire satisfaction of the Engineer.

i) Each circuit shall be tested for continuity
ii) Each circuit shall be tested for earthing
iii) A 'megger' test shall be made between each circuit and earth. The insulation resistance shall be shown to be at least that specified within the relevant Codes.

The distribution horizontal illumination value of specified spacing in each code item, in rate of lux measured between two luminaries every two meters along longitudinal and transverse roadway lines, are essentially measured to show maximum, mean and minimum illumination and also uniformity ratios.

$$\text{Uniformity ratio} = \frac{\text{minimum illumination}}{\text{average illumination}} = \text{not less than } 0.40$$

$$\text{and} = \frac{\text{maximum illumination}}{\text{minimum illumination}} = \text{not more than } 6.0$$

iv) Rainproof Test

The lantern under test shall be mounted in its normal orientation on an adjustable support as shown in BS 1788, 1964 so that the fitting is near the center of the area described by the oscillating tube.

After being switched on for one hour, the lantern shall be subjected to a spray of water at temperature not exceeding 20°C and at a pressure of approximately 0.04 N/mm2, the tube being oscillated so as to describe an angle of 60 degrees from the vertical and in both directions from it. This treatment shall be continued for 20 minutes, the fitting being switched off after 10 minutes.

At the end of this test, there shall be no damage to the lamp or enclosure and no visible evidence of water having accumulated in the fitting.

On the completion of testing, the Contractor shall supply to the Engineer three copies of `as built' plans and circuit diagrams, which shall clearly indicate any modifications which have been made to the original design.

6.12.4 Measurement

Tapered steel lighting poles and column high mast mountings, with height and single bracket requirements specified on the drawings and fitted with high pressure sodium lamps, will be measured as sets complete including all connecting cable from each supply pillar to lamp and ancillary items required for the operation of the street lighting system. Supply pillar shall be measured per each as indicated in the Bill of Quantities as complete including all connecting cable from each lighting panel to each supply pillar and ancillary items.

6.12.5 Payment

6.12.5.1 The work measured as provided in 6.12.4 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 incidentals 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.

Tapered steel poles, single brackets, and column high mast mounting, with high pressure sodium lamps, will be paid for at the Contract unit prices per set, complete and accepted in place, which prices shall be all inclusive of drawpits poles, bracket arms, luminaries, painting, rectro-reflective sheets, ballast, pole foundations, transformers (where necessary or as specified), transformer bases, cable, conduit, trenching, pull wires, cable and conduit markers, labor, equipment and all incidentals necessary for the complete operation of the lighting system.

Payment will be made under the following items:

Item No.	Description	Unit
6.12(1)	10.00 m. Tapered Steel Pole with One High Pressure Sodium Lamp Type L	each
6.12(2)	High Mast with Lanterns for Lao PDR Side Connecting Road	each
6.12(3)	Electric Facilities for Street Lighting, SP1	ls.
6.12(4)	Electric Facilities for Street Lighting, SP2	ls.
6.12(5)	Electric Facilities for Street Lighting, SP5	ls
6.12(6)	Electric Facilities for Street Lighting, SP6	ls
6.12(7)	Electric Facilities for Street Lighting, SP7	ls

6.12(8)	Electric Facilities for Street Lighting, SP8	ls
6.12(9)	Electric Facilities for Street Lighting, SP78	ls

6.13 ROAD TRAFFIC SIGNALS

6.13.1 General

6.13.1.1 Description

This item shall consist of the supply of all signal heads, supports, controllers, detectors, cables, switchgear with all necessary ancillary equipment together with the transportation, storage, erection, connection and testing of the same in order to supply a complete traffic signal installation in accordance with the Drawings and as specified herein.

6.13.1.2 Maintenance Period

The provisions of section 6.12.1.2 shall apply.

6.13.1.3 Electricity Supply

The provisions of section 6.12.1.3 shall apply.

6.13.2 Materials and Equipment

6.13.2.1 Signal Face

Each signal face shall consist of three electrically operated and controlled optical units arranged vertically. The top unit shall show red, the centre amber and the lowest green. Additional optical units may be added if required for special facilities. Suitable visors will be fitted to all optical units. Louvres and sighting screens shall be supplied if required to give the most efficient operation under all conditions.

6.13.2.2 Optical Units

Optical Units shall consist of a lens, a reflector, a lampholder and a clear traffic signal lamp visible to the traffic to be controlled. They shall be housed in a non-ferrous corrosion resistant casing which shall be weather tight and capable of being securely fixed in direction and elevation. Access shall be provided by hinged doors which when shut shall be forced against a neoprene gasket on the body and fastened by a simple, corrosion resistant, non-detachable fastening device which does not required special tools for operation.

6.13.2.3 Lenses

Lenses shall be made from polycarbonate free from imperfections, and shall conform to the latest requirements of the relevant ASA or British Standards for colour and transmittance. All lenses will be unlettered and shall be mounted so as to display a circular area 300 millimeters in diameter towards the traffic to be controlled. The lens shall be so designed and finished that when it is installed in an optical unit as herein described, that unit shall, when the lamp is illuminated, display a uniformly bright area to traffic without any shadows or dark areas. The polar curve shall be reasonably smooth and free from sudden changes or secondary maxima. The mounting of the lens shall ensure that there will be no escape of light from the lamp, apart from that passing through the lens itself.

6.13.2.4 Reflectors

Reflectors may be of silvered glass or metal. Silvered glass reflectors shall conform to sub clause 6.2 of the Institute of Traffic Engineers Technical Report No.1 "Adjustable Face Vehicle Traffic Control Signal Head Standard" as approved by the American Standards Institute. Metal reflectors shall be of non-ferrous metal not less than 0.55 millimeter thick plated with nickel and then chromium plated, or other suitable construction which is not less effective. Metal reflectors shall be stiffened and supported to prevent distortion.

6.13.2.5 Lampholders

Each lampholder shall be suitable for an Edison screw lamp or other type approved by the Engineer and the dielectric shall be of a tough incombustible insulating material which will not be affected by prolonged heating to 200°C nor by prolonged immersion in water. The lampholder shall be permanently positioned

in such a way that the lamp filament shall be at the focal centre of the reflector. A means shall be provided to rotate either the lampholder or the reflector so that the lamp lead-in wires will be at the top, and there shall be a suitable clamp to ensure that the lamp will not unscrew due to vibrations. The lampholder shall be provided with two insulated wires of sufficient length to reach the specified terminal block at all times. The metal parts of the lampholder shall be electrochemically compatible with other contiguous metals.

6.13.2.6 Lamps

The lamps shall be halogen, 50w and the Edison screw type, or such other type as approved by the Engineer.

6.13.2.7 Wiring

All lampholders 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 terminal blocks and shall be permanently colour coded 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 poles each with two screw type terminals of suitable size. A weathertight 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. Connections from the signal face to the terminal compartment, where external, shall be protected by approved metallic tubing. Buried cables from the controller to signals and detectors shall be suitably armoured or laid in approved conduit and free of all joints except at terminal blocks of junction boxes. Wiring to signal will not be run to a terminal block on a signal 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 the signal system throughout and in addition between the controller and the signals three spare conductors shall be provided of size equal to the largest conductor in the run except neutral. Wires subject to bending due to opening and closing of doors shall be stranded. All metallic parts not carrying current shall form an electrically continuous system which shall be grounded or they shall be separately grounded using bare copper conductors with a minimum cross-sectional area of 4 square millimeters. All items

below ground level shall be so designed and installed that they will continue to operate without fault if immersed in ground water.

6.13.2.8 Poles

Poles shall consist of solid drawn or longitudinally mild steel tube, the dimension of this as shown on the Drawings. Brackets shall be so designed that they will allow full adjustment of the signal heads and will support the signal heads rigidly under all normal conditions. Poles shall be provided with cable slots near the base and with the required cable bush holes in correct position. All cable slots and holes shall be free from burrs and rough edges. Suitable means shall be provided to fasten base plates, brackets and signal heads firmly to poles and to allow adjustment where required. All nuts, bolts, fastenings, hinges and adjusting brackets on poles, finial, terminal compartment and signal heads shall be cadmium plated or of stainless steel or made corrosion resistant in a not less effective manner.

6.13.2.9 Painting

Paint and painting shall be in accordance with this Section of these Specifications with the following additions and modifications. Pedestals and brackets shall be provided with a prime coat and two coats of undercoat before delivery and sufficient finishing coaks shall be provided for final painting after erection. The signal heads, terminal compartments, visors, louvres, and sighting screens shall be delivered primed and with two undercoat and a finishing coat. The controller and other cases shall be finished with two coats of an 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 will be accepted as an alternative to painting of the cabinets.

6.13.2.10 Controller

The controller shall be a complete microprocessor for controlling the operations of the traffic control signals, including the timing mechanism and all necessary auxiliary equipment, securely mounted in a cabinet. Preference will be given to solid state circuitry and to designs having replaceable units for ease of maintenance. Interval timing shall be by electronic and not by mechanical means. The colour sequence of signal indications shall be as given in section 6.13.3.1 and there shall be control to ensure that green will not be shown at the same time

on opposing phases under any cirumstances. Operation shall be either by fixed time sequences, (variable by time switch) or shall be by vehicle actuation or by combination of both, as specified in the Specifications, and as herein described.

The operating voltage shall be as given in the Specifications and the controller shall be designed to operate satisfactorily with voltage variations up to +17.5% or-20.0% from that specified. The timing of the controller shall be within ±7.5% of correct 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 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 opreations without the necessity for manual re-setting.

The controller shall be provided with a suitable mechanism for closing and opening signal circuits, which shall be positive and without any dark intervals, flickering or conflicting signal indication. All contact points which carry, make or break current shall be of fine silver, silver alloy or an alternative better material and shall be capable of carrying, making or breaking a current of 150% of the maximum demand load through one million operations without electrical or mechanical trouble.

Every current interrupting device shall be equipped with a suitable radio interference suppressor installed at the input power point. Interference suppressors shall be of a design which will minimise interference on both broadcast and aircraft frequencies.

The controller shall provide for the proper phase intervals and sequences as herein specified or as may be required by traffic conditions. The setting of time intervals shall be by means of a positive method against a scale calibrated in seconds. This timing scale shall be easily accessible and indentifiable 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 swiched to manual operation by means of a switch mounted under a lockable cover. The automatic operation of the controller shall not be upset by 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:

i) substitution of flashing signals in place of the normal cycle (where flashing signals have been specified)
ii) allocating right of way to approaches independently of the pre-set timing of the controller
iii) switching signals to "OFF"

Provision shall be made that under no circumstances will 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 two '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 early or late switching on two selected days. The week dial shall be clearly marked with the days. The time mechanism shall be fitted with a first quality mechanical movement which shall be electrically wound and shall have a minimum spring reserve of twelve hours.

c) Flashing signals

Where flashing operation is called for, this shall permit either amber or red flashing on any or all approaches. The flashing unit shall generate signal indications at the rate of not more than 60 nor less than 50 per minute, and the rapidity of flashes shall remain constant. The illuminated period of each flash shall be approximately equal to the non-illuminated period. A switch or fuse shall be provided which will allow the controller to be isolated and shut down when the flashing signals are in operation.

d) Switches and Fuses

The controller shall be provided with main switch and fuse which will isolate the complete installation. There shall also be provided one general purpose outlet and fuse. All fuses and switches shall be adequately and permanently labelled.

e) Controller Housing

The controller shall be housed in a weatherproof cabinet of aluminium, sheet metal, glass fiber 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 in thickness at all points and reinforced where necessary. Ferrous metal shall not be buried and it shall be rust-proofed by galvanising or some other equally effective means. If aluminium or aluminium alloy is used, it shall be suitably protected against electrolytic for chemical corrosion and 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 require lubrication not 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 will fit all housings.

The controller shall be sited in such a way that it will not cause an obstruction or hazard to traffic or pedestrians, and where it will 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-hygroscopic non-inflammable insulating bases. Sufficient space shall be left between terminals and between blocks to enable external cables to enter and be formed in a neat manner without obstructing individual terminal points. Electrical connection between the controller and the terminals shall be by approved plug and socket connections.

Each terminal point and connection shall be clearly marked by colour coding or by a numbering system. The ends of all spare conductors shall be shielded, covered or insulated so that no live parts will be exposed.

f) Identification

All equipment and replaceable assemblies shall be marked with a part number and any other identification which is required for re-ordering.

g) 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.

i) A wiring diagram of the system showing the colour coding or number of the conductors,
ii) a layout plan of the intersection showing the detectors, the signals controlled by each phase and the cycle details, and
iii) a suitable ruled card shall be fixed within the controller upon which space is provided to record maintenance undertaken, the date of 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 25 millimeters high.

h) 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 operations, although it shall not necessarily be limited to these:

i) allocation of right of way by suitable timed green aspects to the various approaches in accordance with the timings previously set on the controller.
ii) changing from one phase to another by means of the correct sequence of aspects and maintaining the correct pre-set amber periods throughout. It shall be possible to vary the length of intergreen period without use of special tools.
iii) allowing a late start or early cut off on one or more phases as may be specified.
iv) displaying left or right filter arrows as may be specified.

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 three such programmes during a period of 24 hours.

6.13.3 Construction Methods

6.13.3.1 Excavation and Reinstatement

The provisions of section 6.12.3.1 shall apply.

6.13.3.2 Concrete Work

The provisions of section 6.12.3.2 shall apply.

6.13.3.3 Conduits, Fittings and Boxes

Conduits, fittings and boxes shall be provided and installed as shown on the Drawings. Plastic conduits, fittings and boxes, according to samples previously approved by the Engineer, will be permitted providing that they do not soften when exposed to high ambient temperature.

The Contractor may use a larger size of conduit than that specified, at no extra charge, if he wishes, but in this case the entire run shall be of same size. No reducing couplings will be permitted.

Conduit shall be laid to a depth of not less than 500 millimeters below paved footwalks and medians and not less than 750 centimeters below the roadway surface. The location of all conduits at curb lines shall be marked by means of a 'Y' at least 100 millimeters high incised in the face of the curb directly above the conduit. Conduit terminating in standards, cabinets or pedestals shall extend at least 50 millimeters vertically above the foundations and shall be sloped towards the handhold opening. Conduit entering pull boxes shall terminate at least 50 millimeters inside the box wall and at least 50 millimeters vertically above the bottom of the box. Such conduit shall be sloped towards the top of the box so as to facilitate pulling. Conduit entering the bottom of the box shall enter near the sides or end to leave the centre clear. All conduit shall enter in the direction of the run.

6.13.3.4 Pull Boxes

Pull boxes shall be installed as shown on the Drawings and in any case at not more than 60 meter intervals. The Contractor may install additional pull boxes without extra charge if he wishes. Pull boxes shall be of reinforced concrete not less than 100 millimeters thick and may be of approved precast design. Reinforced concrete covers, secured by two recessed brass bolts shall be used on footwalks, the covers being inscribed 'Traffic Signals' on the outside. Under the roadway,

covers 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 the surrounding paved areas, whether footwalk or roadway, but in unpaved areas, the tops of pull boxes shall be buried 300 millimeters below ground level. The bottom of pull boxes shall be bedded in sand and cement or crushed rock. Permanent markers shall be provided and erected to show the position of all pull boxes.

6.13.4 Testing

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. This test shall consist of not less than five days continuous and satisfactory operation. If any defects or unsatisfactory operation are revealed, this condition shall be corrected and the test continued until the required five days of satisfactory operation have been performed.

Prior to the functional test, the contractor shall carry out the following tests to the entire satisfaction of the Engineer.

i) Each circuit shall be tested for continuity
ii) Each circuit shall be tested for earthing
iii) A 'megger' test shall be made between each circuit and earth. The insulation resistance shall be shown to be at least that specified within the relevant Codes. On the completion of testing, the Contractor shall supply to the Engineer three copies of "as built" plans and circuit diagrams, which shall clearly indicate any modifications which have been made to the original design.

6.13.5 Measurement

This item will not be measured, payment being made on a lump sum basis.

The details of the work to be included in the lump sum measurement shall be as shown on the Contract Drawings and as specified in these Specifications.

6.13.6 Payment

The lump sum payment for the traffic signal system shall be full compensation for furnishing all labor, materials, tools, equipment, supervision and incidentals and

for doing all work involved in furnishing and installing the system shown on the Drawings and as specified herein and in the Specifications, and as directed by the Engineer, including any necessary backfill, concrete foundations, and in making all tests. It shall also cover the costs of design if this is called for.

The lump sum payment shall be deemed to include full compensation for all additional materials and work not shown on the Drawings or specified which are necessary to complete the installation.

Payment will be made under the following item:

Item No.	Description	Unit
6.13(1)	Traffic Signals at Sta.1+120.000	lump sum

6.14 PAVEMENT MARKINGS

6.14.1 Description Of Work

6.14.1.1 General

This work shall consist of the providing and applying continuous or intermittent marking of lines, letters or figures on completed and approved surface course pavements to the dimensions and at the locations shown on the Drawings or as directed by the Engineer and in conformity with these Specifications and Drawings, including the supply of all labour, materials, tools and equipment, warning and traffic guidance signs as necessary for the safe and efficient completion of the entire work.

The pavement markings may be the following types:

Hot Applied Thermoplastic Pavement Marking Paint

- Applied without Reflectorized Glass Beads
- Applied with Reflectorized Glass Beads in the Mixture

6.14.2 Materials

6.14.2.1 General

Materials used for pavement markings include :

1. Normal Themperature Pavement Marking Paints
2. Hot Applied Termoplastic Pavement Marking Paints
3. Glass Beads (Ballotini)

Paint for pavement markings shall be with or without reflectorized glass beads, homogenous and well-dispersed to a uniform and smooth consistency, abrasion proof manufactured by an approved manufacturer, subjected to demonstration testing under traffic in the Lao PDR and Thailand or satisfactorily used elsewhere under traffic and field trials as required by the Engineer.

All testing trials and documention of use under traffic shall be governed by the appropriate AASHTO, ASTM and other institutional standards, testing procedures, test results and reports.

All such tests, trials and documentation shall be at the Contractor's own costs.

6.14.2.2 Normal Temperature Pavement Marking Paint

(a) Description

The paint shall be a cold-applied, ready-mixed, durable pavement marking paint suitable for application to cement concrete or asphaltic pavements. The paint may be made reflectorized by incorporating in the mixture and superimposing glass beads (Ballotini) on the surface of the paint. The paint shall be suitable for applying by brush or mechanical means.

The following particulars of the paint shall be supplied by the Contractor:

i) composition (analysis by weight)
ii) application
iii) type and maximum amount of reducer (thinner)
iv) drying time (to touch)
v) setting time (to recoat)
vi) recommended coverage (liters per square meter)
vii) heat resistance (max. road temperature)
viii) details of any primer, undercoat of tack coat required.

The paint shall be supplied fresh and ready for use in sealed containers which shall be stored in accordance with the manufacturer's instructions.

(b) Color

Following types of color may be used :

i) White

The white paint shall have a directional reflectance of not less than 80 percent when compared with a magnesium oxide sample when tested in accordance with the Federal Test Method Standard No. 141, Method 6121.

ii) Yellow

The yellow paint shall have a directional reflectance of not less than 40 percent when compared with a magnesium oxide sample when tested in accordance with the Federal Test Method Standard No. 141, Method 6121.

(c) Properties

The paint shall conform to the requirements of AASHTO M 248, unless otherwise specified in sub clause 6.14.2.2 (b) above and in the table below :

Item No	Description	Requirements		Test Method No.
		Min	Max	
1.	**Quantative Requirements**			
1.1	Nonvolatile Vehicle (% by weight)	38	44	4051 Federal Std.141
1.2	Total Dry Solids (% by weight)	67	77	4041 Federal Std.141
1.3	Consistency, Krebs Units (K.U.)	65	85	1281 Federal Std.141
1.4	Unit Weight (kg/liter)			
	White	1.35		4184 Federal Std.141
	Yellow	1.38		
2.	**Drying Time**			
2.1	No Pick-up (minutes)		40	ASTM D-771

The paint shall have the property to adhere to the pavement surface firmly for a long period of time. The paint shall have the same properties, as samples tested and accepted as described in sub clause 6.14.2.1.

(d) Sampling

Samples of pavement marking materials proposed to be used by the Contractor shall be submitted by the Contractor, at least 28 days before starting the pavement marking paint application.

During construction random samples of paint shall be taken as noted below for testing as required by the Engineer.

The samples shall be a homogeneous, representative sample of the paint proposed to be used or being used.

(e) Testing

Testing of all paint samples shall conform to the requirements as detailed in this Section of these Specifications and as listed below.

Item	Standard	Description
1.	Federal Specification TT-P-85D	
2.	Federal Test Method Standard No.141	Paint, Vani Lacquer and Related Materials, Method of Inspection, Sampling and Testing
3.	ASTM Specification D 771	

6.14.2.3 Hot Applied Thermoplastic Pavement Marking Paint

(a) General

The thermoplastic pavement marking material shall conform to the requirements of AASHTO M 249.

The material may be one or several of three types detailed below as required by the Drawings or as directed by the Engineer.

(b) Non-reflectorized Thermoplastic Material

The thermoplastic material shall be factory mixed, from an approved manufacturer and shall be suitable for the type and location of application. The material shall possess adequate thermoplastic properties over the range of climatic conditions of the location viz. resistance to spreading under traffic at the highest road temperatures and retention of plasticity at the lowest road temperatures and shall give an effective marking.

The composition of the material with minimum and maximum proportions and grading of the constituents, the acid value of the binder, the temperature range of mixing and application, the setting time, the softening point and the open flash point shall be stated by the manufacturer.

The material shall be supplied in containers which do not contaminate the contents and which protect the contents from contamination and shall be stored in accordance with the manufacturer's instructions.

(c) Reflectorized Thermoplastic Material

The material shall be in accordance with section 6.14.2.3 above, except that 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 percent and 22 percent by weight of the total mix and shall be counted as part of the material.

The whole of the ballotini shall pass a 1.70 mm (No. 12) sieve and not more than 10 percent shall pass a 0.425 mm (No.40) sieve. The ballotini shall be free of sharp angular particles and not less than 80 percent shall be of transparent glass, reasonably spherical and free from flaws.

(d) Reflectorized Thermoplastic Material with Ballotini Surface

The material shall be in accordance with section 6.14.2.3 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 quality as that incorporated in the reflectorized thermoplastic but may be smaller in size; not more than 20 percent shall pass a 0.212 mm (No.70) sieve. Ballotini shall be applied at a rate of 250-450 grams per square meter such that the combined total of Ballotini incorporated in and superimposed on the thermoplastic shall be between 20 percent and 26 percent by weight of the material.

6.14.2.4 Glass Beads

(a) Description

Glass beads (ballotini) in these Specifications means the glass beads used for mixing into and superimposing on the surface of road marking paint as specified in these Specifications.

The glass beads shall be transparent, clean, free of color and shall conform to the requirements described in the following.

Glass beads shall have a spherical shape and be free of flaws and sharp angular particles.

(b) Properties

The glass beads shall meet the requirements of AASHTO M 247.

Glass beads shall be resistant to chemicals and shall retain their brightness after soaking in the following solutions :

i) Buffered acid solution

ii) 1 N calcium chloride

iii) Distilled water which is free from carbon dioxide gas. This water when titrated with 0.1 N hydrochloric acid at the amount of not more than 2.5 milliliters will reach a neutral point.

iv) The glass beads when soaked in sodium sulfide shall not turn black.

All testing regarding the brightness of glass beads shall be in accordance to the requirements of Federal Specification TT-P-85 b.

1 Index of Refraction

The index of refraction of the glass beads shall be not more than 1.50 when tested by the immersion method in accordance with test method acceptable to the Engineer.

2. Sizes

Glass beads shall meet the gradation requirements as specified below in accordance with Standard Test Method :

AASHTO Sieve		Percentage Passing by Weight
Mm	Designation	
	No. 22	100
0.600	No. 30	95 - 100
0.425	No. 40	30 - 80
0.250	No. 60	10 - 30
0.150	No. 100	0 - 50
0.075	No 200	0 - 1

(c) Sampling

Random samples of glass beads shall be taken from each sack for testing. The number of samples shall be one percent of the total sacks of the glass beads supplied. Each sample shall contain a minimum of two kilograms of beads which shall be collected by use of a sample splitter or by quartering.

(d) Testing

All testing required for glass beads shall be as specified herein in section 6.14.2.4(b).

6.14.2.5 Equipment

(a) Equipment Spraying

Spraying equipment shall consist of a motor powered self-propelled machine coupled with a compressor of sufficient capacity to fulfill the requirements of the work to the satisfaction of the Engineer. At least one spray gun and one bead gun shall be available, so that a minimum line width of 100 mm can be sprayed in one pass.

The spray gun should be heated so that even working is attained and the material flows out at the correct temperature, producing a clean, straight line without furry edges or blemishes. The bead gun shall be synchronized to spray glass spheres immediately onto the hot sprayed plastic at the rates specified hereunder.

An automatic skip mechanism shall be fitted in order to produce, without pre-measurement, the correct pattern of dashed or dotted lines as shown on the Drawings. Such a mechanism must be capable of operating at the application speed.

(b) Hand Spraying

The Contractor shall provide pressurized apparatus and adequate equipment, stencils, specialized labor and everything else necessary to perform hand spray in a proper manner for arrows, pedestrian crossings, chevron striping, lettering, etc.

Particular care shall be taken during hand spraying to ensure that the results obtained match in quality and finish, the mechanically sprayed work, to the acceptance of the Engineer.

6.14.3 Construction Requirements

6.14.3.1 General

The road surface shall be cleaned of all dirt, loose detritus and other objectionable material immediately prior to the application of the paint. The paint or material shall be applied only on a surface which is clean and dry. It shall not be laid over loose detritus and or similar extraneous matter or over an old paint marking, or over an old thermoplastic marking which is faulty or incompatible with the paint or material being applied.

Paint and material shall not be applied until the shoulders are completed. The pavement surface shall be inspected and accepted by the Engineer before the application work is started.

6.14.3.2 Application Trials

Prior to the commencement of application operations, the Contractor shall apply normal temperature pavement marking paint or thermoplastic marking material on trial areas as directed by, and in the precauce of, the Engineer. The materials, equipment and method used shall be that which the Contractor intends to use for the work proper. The purpose of the trials is to determine the adequacy of the Contractor's, equipment and methods.

The Contractor may proceed with the application operation only after the equipment and methods in the trial have been accepted by the Engineer.

6.14.3.3 Premarking Lines

Premarking shall be done manually in an approved manner. Straight lines shall be premarked by means of 100m rope and curves shall be similarly premarked. On straights, premarking shall consist of one dot every 3m and on curves every 1m. The premarking dot shall be a circle of 40 mm diameter cut into equal parts by a gap of 10 mm.

6.14.3.4 Pavement Marking Paint

(a) Preparation of Pavement Surface

When a primer or undercoat is necessary to ensure proper adhesion of the marking paint to the pavement surface without bleeding or other discoloration the primer or undercoat shall be fully compatible with the marking paint and the pavement

surface and shall be applied only when, 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. The use of thinners or other additives shall not be permitted, unless otherwise agreed by the Engineer.

(c) Application

1) General

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 or as directed by the Engineer.

The rate of application of the paint for each coat shall be such as to produce a uniform coverage of unthinned paint of not less than 0.5 mm, or 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 set.

Road markings of a repetitive nature, other than centre lines, lane lines, edge lines and similar. shall, unless otherwise directed by the Engineer, be set out with stencils which comply with the size and spacing requirements of the Drawings.

2) Glass Bead Surface Application

Glass beads shall be superimposed on the surface of the freshly applied paint immediately after laying to give immediate reflectivity.

Glass beads shall be applied at a total rate of 250-450 grams per square meter, unless otherwise directed by the Engineer.

(d) Thermoplastic Materials

1) Preparation of Road Surface

In the case of smooth polished surfaces e.g. smooth concrete, old asphalt surfacings 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 thermoplastic material recommends, with the approval of the Engineer.

2) Preparation of Thermoplastic Material

The material shall be heated and melted in accordance with the manufacturer's instructions in a heater thermostatically controlled, fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic material and such that local overheating shall be avoided. The temperature of the material shall be within the range of laying temperature specified by the manufacturer required for the method of application used. On no account will it be allowed to exceed the maximum temperature stated by the paint 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.

3) Laying

Centerlines, 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-screed, hand-propelled machine or by self-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 for laying.

In the case of a screeded application the material shall be laid to a thickness of not less than 3 mm or more than 6 mm, unless specifically authorized by the Engineer when laid over an existing marking.

In the case of a sprayed application the material shall be laid to a thickness of not less than 1.5 mm, unless specifically authorised by the Engineer.

In all cases the surface produced shall be uniform and appreciably free from bubbles and streaks.

Where required by the Drawings or the Engineer directs, that glass beads 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 glass beads are firmly embedded and retained in the surface after completion.

Pavement 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 of the relevant Department.

4) Use 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 it is in a molten condition does not exceed the requirements of sub clause 6.14.3.4(d).

(e) Protection of Paints and Materials

All markings shall be protected from traffic until they have dried sufficiently to show no pick-up of tire marks. The Engineer in the field shall determine a time period in which traffic will not be allowed to pass over the particular pavement markings being used.

(f) 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 pavement made good and the materials replaced, reconstructed and/or properly located, all at the Contractor's costs and to the acceptance of the Engineer.

(g) 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 spatter, splashes and smirches of paint or other construction materials.

During the course of the work the Contractor shall provide and maintain adequate signs and signals for the warning and guidance of traffic.

6.14.4 Measurements

Marking shall be measured by the area in square meters 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 the actual width or length of laid marking shall be used when calculating areas for payment.

6.14.5 Payment

Normal temperature pavement markings and thermoplastic pavement markings will be paid for at the respective unit prices per square meter, complete and accepted in place, which prices shall include preparation of surfaces, all labour, materials, equipment, tools, and incidentals necessary for the proper completion of the work.

Payment will be made under the following items when entered in the Bill of Quantities:

Item No	Description	Pay Unit
6.14(1)	Road Marking without Reflectorized Beads	square meter
6.14(2)	Road Marking with Reflectorized Beads	square meter

6.15 LANDSCAPING WORK

6.15.1 Description

This work shall consist of planting for landscaping areas in accordance with these Specifications to lines, levels, grades, dimensions and types as indicated on the Drawings.

6.15.2 Materials

6.15.2.1 Top Soil For Landscaping Area

Top soil shall be natural loam from the local area, free from large stones, roots, sticks, clay, weeds and shall be obtained from rice fields, gardens, foothills or other approved sources. It shall be soil having a pH between 6.5 to 7.5 and having more than 3% of organic matter without any toxic materials harmful to plant growth.

6.15.2.2 Fertilizer

Fertilizer shall be urea, containing not less than 46% of nitrogen (N) or other fertilizers in 15-15-15 (N-P-K) grade or organic fertilizer as directed by the Engineer. The fertilizer shall be delivered to the site in the original unopened containers, showing the manufacturer's guarantee and analysis. It shall be stored in a dry and ventilated area before use.

6.15.2.3 Plants and Sods

Plants shall be of the type, size and dimensions as shown on the Drawings. All plants shall be of complete form and free from any disease and shall, as much as possible, be delivered from a single plant nursery as approved by the Engineer. The plants shall, at time of delivery, be clearly marked with a name plate tied to the trunk. Shrubs and ground covers shall be of complete form and fine grown in standard flower pots.

Sod sheets shall be 50x100 cm., obtained from the local area, free from noxious weeds and burned spots and shall have a complete mat with healthy root systems. Sod stored more than 3 days before use shall be rejected.

6.15.3 Planting

Tree and shrub pits shall be as shown on the Drawings and sufficiently deep to allow for a 300mm thick layer of loam (topsoil) beneath the ball or roots.

The depth of planting beds and pits shall be adjusted as necessary to permit a minimum of 100mm of topsoil over the balls or roots of all plants.

Plant pits shall not be backfilled with topsoil until they have been approved by the Engineer. If pits are prepared and backfilled with topsoil on grade prior to planting, their location shall be marked and recorded on the Drawings so that when planting proceeds they can easily be found. Plants shall be planted at the densities noted in the schedule.

After the plants are set in the center of pits plumb and straight, topsoil shall be compacted around bases of balls to fill all voids. All burlap, ropes or wires shall be removed from the balls. After planting, tress and shrubs shall be secured by stakes or wires as long as necssary to ensure a satisfactory growth.

Topsoil around roots or balls shall be thoroughly compacted and watered. Immediately after the plant pit is backfilled, a shallow basin slightly larger than the pit shall be formed with a ridge of soil to facilitate watering and to preserve water.

After planting, ground cover shall be covered with approved covering materials to protect against the sun for as long as necessary to promote growth.

Fertilizer shall be added at the time of planting if necessary to acquire a healthy growth. The type of fertilizer shall be appropriate for each type of plant (conforming to the principles of Botany) as recommended by the nursery and as approved by the Engineer.

6.15.4 Sodding

The subgrade of areas to be sodded shall be raked and all rubbish, sticks and lumps of soil shall be removed. Topsoil, conforming to section 6.15.2.4 of this Section, shall be spread and lightly compacted to a depth of 100 mm. over areas to be planted, with fertilizer applied as recommended. Sods shall be placed in a solid strip laid edge to edge with staggered joints. The combined thickness of the sod and topsoil shall be at least 130mm. Careful handling of the sods and maintenance of the sodded area as mentioned in Section 6.6.3 of these Specifications shall be followed.

6.15.5 Maintenance Period

The Contractor shall maintain the plants at his expense until one year from the completion date. Maintenance shall consist of preserving, trimming, and

protecting plants, as well as replacing dead plants. The Contractor shall water and fertilize the plants at such intervals as may deemed necessary for the healthy growth of the plants during the Maintenance Period. Dead Plants shall be replaced by the Contractor as soon as possible.

6.15.6 Measurement and Payment

Plants shall be measured for payment by the number of each type complete in place and accepted. Excavation and carrying to waste of excavated material as well as fertilizer will not be measured but considered incidental to the work of planting. Sod shall be measured for payment by the area of each type including topsoil and fertilizer, completed in place and accepted. The maintenance of plant and sod shall also be incidental to the work and shall be undertaken by the Contractor up until the end of the "Maintenance Period"

Sodding of the road embankment shall be measured and paid for separately in Section 6.6

The pay items included in the Bills of Quantities for landscaping works shall constitute full compensation for all the specified requirements of these Specifications and all requirements not shown on the Drawings or specified which are necessary to complete the work, covering the furnishing and placing of all materials shown on the Drawings including all labour, equipment, tools and incidentals necessary to complete the work.

Pay items shall be:

6.15(1)	Planting Palm Tree	each
6.15(2)	Planting Champar	each
6.15(3)	Planting Paper Tree	each
6.15(4)	Planting Shrub	each
6.15(5)	Planting Chaiyaphruk (Koon)(Cassia Fistula L.)	each
6.15(6)	Planting Parad Ooban	each
6.15(7)	Planting Rajcha Phruk	each
6.15(8)	Planting Kalapa Phruk	each
6.15(9)	Planting Songbadarn	each

6.16 KILOMETER POSTS AND RIGHT-OF-WAY MONUMENTS

6.16.1 Description of Work

6.16.1.1 Scope

This work shall consist of furnishing, erecting, installing and completing reinforced concrete Kilometer Posts and Right-of-Way monuments.

The work shall be constructed according to the design and dimensions, lines, levels and locations as shown on the Drawings or as directed by the Engineer.

6.16.2 Materials

Concrete shall be Class D in accordance with Section 5.1.
Reinforcing steel bars shall be in accordance with Section 5.2 Steel Reinforcement.
Sand - cement mortar shall consist of one part Portland cement and three parts of sand.

6.16.3 Construction Methods

6.16.3.1 Excavation and Backfill

Foundation trenches and pits shall be excavated to the required depth. Before placing the kilometer posts or Right-of-Way Monuments the bottom shall be trimmed and compacted to form a level and solid surface. Unsuitable material shall be removed to a minimum depth of 0.15 m below the foundation elevation.

Excavation, backfill and compaction shall conform to the relevant requirements of Section 2.1, 2.2 Structural Excavation and Section 2.5 Structural Backfill.

6.16.3.2 Locations

The Kilometer Posts and Right-of-way Monuments as shown on Drawings or as directed shall be placed at the locations ordered by the Engineer.

Kilometer Posts shall be placed at every kilometer on each alternate side of the road.

Kilometer Posts and Right-of-Way Monuments shall consist of precast concrete elements with a reinforced cast insitu concrete base. The shape and dimensions shall be as shown on the Drawings or as directed by the Engineer.

6.16.3.3 Placing

Kilometer Post and Right-of-way Monuments shall be inserted in a hole excavated in the earth, which shall be backfilled as shown the Drawings.

6.16.3.4 Painting

The precast concrete posts shall be painted white with an approved oil-based paint recommended for use on concrete by the manufacturer.

Numerical figures, mark and wording shall be painted all as shown on the Drawings or directed by the Engineer.

6.16.4 Measurement

Kilometer Posts and Right-of-Way-Monuments shall be measured as the number of respective unit each, properly constructed and accepted by the Engineer.

6.16.5 Payment

Payment for this work shall be at the respective Contract unit prices each, complete in place, which prices shall include furnishing and placing all materials labor, equipment, tools and incidentals necessary to complete the work.

Following items shall be included in the Bill of Quantities:

Item No	Description	Pay Unit
6.16(1)	Kilometer Post L	each
6.16(2)	Kilometer Post T	each
6.16(3)	Right-of-Way Monuments L	each
6.16(4)	Right-of-Way Monuments T	each

6.17 ROAD STUD

6.17.1 Description of Work

6.17.1.1 General

This work shall consist of furnishing, erecting, installing and completing road stud.

The work shall be constructed according to design and dimensions, and levels and locations as shown on the Drawings and these Specification, or as directed by the Engineer.

6.17.2 Materials

6.17.2.1 Sheet Metal for Signs

6.17.2.1.1 General

Sheet metal as required for delineators shall conform to the types, dimensions and thicknesses shown on the Drawings.

The sheet metal shall conform to the following requirements, if not shown otherwise on the Drawings:

Item No	Description	Requirement
1.	Aluminum Alloy Sheet	ASTM B 209, Specification and Aluminum Alloy Sheet and Plate, Alloy 6061-T6

6.17.2.2 Reflectorized Sheeting

6.17.2.2.1 Description

This material shall be a reflective sheeting capable of being used to reflectorize any smooth surface. It shall consist of glass spheres embedded in a waterproof plastic film adhered to a waterproof flexible backing of synthetic sheet resins.

Prior to ordering any reflectorized materials, the Contractor shall submit, for approval, the manufacturer's name and identifying information on the material he proposes to furnish.

There shall be no substitution subsequent to such approval without the prior written permission of the Engineer.

6.17.2.2.2 Type

The sheeting to be furnished shall be the enclosed lens type and shall have the beads or lenses even with or below the surface of the sheeting so that it will have a smooth flat surface that will be easy to clean.

6.17.2.2.3 Adhesive

The sheeting shall be precoated with adhesive or, when approved by the Engineer furnished with a sufficient quantity of a suitable adhesive primer which shall be supplied with the sheeting.

The type to be furnished will be shown on the Drawings. Sheeting shall be one of the following types:

Item No	Description	Method of Application
1.	Solvent Activation	Application by hand rolling or power driven combining rolls.
2.	Heat Activation	Application by vacuum applicator or other acceptable source of heat and pressure.
3.	Pressure Sensitive	Pressure only by hand rolling or power driven combining roll.

6.17.2.2.4 Colors

The colors of the sheeting to be furnished shall be as shown or designated on the Drawings.

The colors shall conform to the colors shown and specified in the AASHTO "Manual for Signing and Pavement Marking of the National System of Interstate and Defense Highways".

6.17.2.5 Certification

Road stud shall consist of materials conforming to the requirements in Paragraph (1) and (2) above.

When commercial manufacture is specified, or substituted equal as acceptable to the Engineer, the Contractor shall submit to the Engineer for approval adequate guarantees and certified test certificates, which verify that all materials used in the road stud and components conform with the relevant cited Specifications.

6.17.3 Construction Requirements

6.17.3.1 Erection of Delineators

Road stud shall be erected at locations shown on the Drawings unless otherwise directed by the Engineer and to the depth and size shown on the Drawings.

6.17.4 Measurement

Road stud shall be measured by inspection in the field of delineators manufactured, placed and installed in conformity with Drawings and these Specifications and accepted by the Engineer.
There will be no separate measurement for subsidiary work.

6.17.5 Payment

Road stud will be paid for at the Contract until price each complete, installed and accepted in place, which price shall include all material, labour, equipment, tools and incidentals necessary to the completion of the work.

Following items may be included in the Bill of Quantities :

Item No	Description	Pay Unit
6.17(1)	Road Stud	each

6.18 POROUS BACKFILL MATERIAL

6.18.1 Description

This work shall consist of placing porous backfill material and other accessories in order to facilitate the drainage function as shown on the Drawings against the rear faces of abutments, wingwalls, against box culverts, retaining walls, including drains, and all structures requiring porous backfill material in accordance with these Specifications, as shown on the Drawings or as directed by the Engineer.

6.18.2 Materials

Porous backfill material shall be hard durable and clean. It shall be gravel or crushed rock or sand and shall be free from organic material, clay balls and other deleterious substances. Laterite or concretionary materials shall not be used.

Sand used for porous backfill material shall conform to the following grading requirements.

Sieve Designation	Percentage by weight passing Square mesh sieves (AASHTO T 27) Type A
3/8 inch	100
No. 4	95 - 100
No. 16	45 - 80
No. 50	10 - 30
No. 100	2 - 10

Gravel and crushed rock shall conform to one of the following grading requirements:

Sieve Designation		Percentage by weight passing square mesh sieves (AASHTO T 27) Type B	Type C	Type D	Type E
2	inch	100	-	-	-
1 1/2	inch	70-100	100	-	-
1	inch	55-85	75-100	100	-
3/4	inch	50-80	60-90	70-100	100
3/8		40-70	45-75	58-75	-
No. 4		30-60	30-60	35-65	45-80
No. 10		20-50	20-50	25-50	30-60
No. 40		10-30	10-30	15-30	20-35
No.200		0-2	0-2	0-2	0-2

Where one or more of the gradings shown above are indicated on the Drawings or other Contract Documents, material conforming to the gradings indicated shall be used, otherwise the Contractor may select any one of the above gradings.

6.18.3 Construction Methods

6.18.3.1 Underdrains to Structures

Trenches for underdrains shall be excavated, the pipe installed and the trench backfilled with porous backfill material according to the dimensions and details shown on the Drawings and in accordance with Section 6.2 of these Specifications.

6.18.3.2 Behind Structures

Porous backfill material shall be placed in layers in conjunction with the adjacent fill and compacted as specified in Section 2.5 "Backfilling" of these Specifications. Any fill material removed for placing the porous backfill material will be at the expense of the Contractor.

6.18.4 Measurement

Only Porous Backfill for Abutment shall be measured by the cubic meter for this work.

Porous Backfill for other structure will not be measured separately.

This work shall be considered incidental to the construction of the particular structures or culverts in which the material is required and shall be included in the unit prices paid for such structures or culverts.

6.18.5 Payment

Porous Backfill shall be paid for at the Contract unit price per cubic meter for "Porous Backfill Material" which price shall be full compensation for all labour, material , equipment, tools and incidentals necessary to furnish and place the materials.

Item No.	Description	Unit
6.18(1)	Porous Backfill for Abutment	cubic meter

6.19 FLAGPOLE

6.19.1 Description of Work

The work covered by this Section consists of furnishing, erecting, installing and completing flagpole.

The work shall be constructed according to the design and dimensions, levels and locations as shown on the Drawings or as directed by the Engineer.

6.19.2 Materials

The flagpoles to be provided under the Contract shall be subject to the approval of the Engineer. The pole shall be manufactured from fiber glass reinforced

polyester or the approved equivalent materials. Overall length of the pole shall be 12.0 meter minimum with fixtures under the manufacturer's recommendations. Details of fixing shall be submitted to the Engineer for approval.

Concrete for foundation shall be Class D in accordance with Section 5.1.

Steel plate and anchor rod for base shall conform to the requirement as shown on the Drawings.

6.19.3 Construction Method

Foundation trenches shall be excavated to the required depth. Anchor rod and base plate shall be set to keep the post vertically in position and levels shown on the Drawings.

6.19.4 Measurement

Flagpole shall be measured per each as sets completed. Excavation, concrete, base plate and anchor rod shall not be measured separately and shall be considered to be incidentals.

6.19.5 Payment

The work measured as provided above will be paid for at the contract unit price, respectively. Payment shall consist of full compensation for furnishing, fabricating, transporting, painting and placing of all materials including all labor, tools, equipment, and incidentals necessary to complete the work prescribed, details of necessary accessories are shown on the Drawings, anchor bars and reinforcement, etc. should these items be applicable.

Pay Item No.	Name	Unit of Measurement
6.19(1)	Flagpole	each

6.20 PAINTING METAL STRUCTURE

6.20.1 Description

This work shall consist of unless otherwise provided in the Contract, the preparation of metal surfaces, the application, protection and drying of the paint coatings and the supplying of all tools, tackle, scaffolding, labour and materials necessary for the entire work.

6.20.2 Materials

6.20.2.1 Shop coat (Prime Coat)

The shop or prime coat of paint for metal shall be a red lead paint and shall conform to the AASHTO. Standard Specification M 71 for Red Lead (Dry and paste-in-Oil) and paint made therefrom.

The paint, preferably, shall be factory mixed. As an alternative the pigment shall be furnished in red lead paste.

The above specified paint shall not be used on aluminium or aluminum alloy surfaces which will unless otherwise specified remain unpainted.

6.20.2.2 First Field Coat

When the finished coat of paint is specified to be aluminium, black or graphite paint, or colored green, brown or dark gray, the first field coat shall be a red lead paint as specified for the shop coat, tinted light brown as required, with lamp black in an amount not to exceed 1/32 kilogram per liter of linseed oil.

When the finished coat is to be white or gray, a first field coat conforming to AASHTO. Standard Specification M 70 for White and Tinted Ready-Mixed paint (Lead and Zinc Base) may be used in lieu of red lead paint. The paint shall be tinted as directed by the Engineer.

6.20.2.3 Second Field Coat (Finish Coat)

The paint to be used for the second field coat shall be as required by the Specifications or as noted on the Drawings. It shall conform to one of the following AASHTO.Standard Specifications:

(1) Foliage Green Bridge Paint M 67
(2) Black Bridge Paint, M 68
(3) Aluminum Paint (Paste-Mixing Vehicle) M 69
(4) White and Tinted Ready-Mixed Paint (Lead and Zinc Base) M 70
(5) Red Lead (Dry and Paste-in-Oil) and Paint made therefrom, M 71
(6) Red Lead Ready-Mixed Paint, M 72

If red lead is used for the second field coat, it shall be tinted with lamp black as directed by the Engineer.

6.20.3 Construction Methods

6.20.3.1 Cleaning of Surfaces

Surfaces of metal to be painted shall be thoroughly cleaned, removing rust, loose mill scale, dirt, oil or grease and other foreign substances. Unless cleaning is to be done by sand blasting, all weld areas, before cleaning is begun, shall be neutralized with a proper chemical, after which it shall be thoroughly rinsed with water.

Three methods of cleaning are provided herein. The particular method to be used shall be specified by the Engineer.

6.20.3.2 Hand Cleaning

The removal of rust, scale and dirt shall be done by the use of metal brushes, 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.

6.20.3.3 Sandblasting

All steel shall be cleaned by sandblasting. The sandblasting shall remove all loose mill scale and other substances down to the bare metal. Special attention shall be given to cleaning of corners and re-entrant angles. Before painting, sand adhering to the steel in corners and elsewhere shall be removed. The cleaning shall be approved by the Engineer prior to any painting, which shall be done as soon as possible before rust forms.

6.20.3.4 Flame Cleaning

Unless otherwise provided in the Specifications all metal except the exposure of the inside of boxed members and other surfaces which will be inaccessible to the flame cleaning operation after the member is assembled, shall be flame cleaned in accordance with the following operations:

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 0.37 centimeters center to center. The oxyacetylene flames shall be traversed over the surfaces of the steel in such manner and at such speed that the surfaces are dehydrated; and dirt, rust, loose scale in the form of blisters or scabs, are 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 foreign 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 recondensation of moisture on the cleaned surfaces.

6.20.3.5 Number of Coats and Colour

All steel shall be painted one shop or prime coat, and with not less than two field coats. The colour shall be as specified or determined by the Engineer. The coats shall be sufficiently different in colour to permit detection of incomplete application.

6.20.3.6 Weather Conditions

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.

Material painted under cover in damp weather shall remain under cover until dry or until weather conditions permit its exposure in 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.

6.20.3.7 Application

a) Mixing of Paint - Paint shall be factory-mixed except as provided in this section. All paint shall also be field mixed before applying in order to keep the pigments in uniform suspension.

b) Field Painting - When the erection work is complete including all riveting and straightening of bent metal, all adhering rust, scale, dirt, grease or other foreign material shall be removed.

As soon as the Engineer has examined and approved all field rivets driven, the heads of such rivets and field bolts, all welds and any surfaces from which the shop or first coat of paint has become worn off or has otherwise become defective, shall be cleaned and thoroughly covered with one coat of shop-coat paint.

Surfaces to be riveted in contact and surfaces which will be in contact with concrete shall not be painted. Surfaces which will be inaccessible after erection shall be painted with such field coats as are required. When the paint applied for retouching the shop coat has thoroughly dried and the field cleaning has been satisfactorily completed, such field coats as are required shall be applied. In no case shall a succeeding coat be applied until the previous coat has dried throughout the full thickness of the paint film. All small cracks and cavities which are not sealed in a watertight manner by the first field coat shall be filled with a pasty mixture of red lead and linseed oil before the second coat is applied.

The following provisions shall apply to application of both field coats: To secure a maximum coating on edges of plates or shapes, rivet heads and other parts subjected to special wear and attack, the edges shall first be stripped with a longitudinal motion and the rivet heads with a motion rotary of the brush, followed immediately by the general painting of the whole surface, including the edges and rivet heads.

The application of the second 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.

The Contractor shall protect pedestrian vehicular and other traffic upon or underneath the structure and also all other portions of the structure, against damage or disfigurement by spatters, splashes and smirches of paint or paint materials.

c) General - Painting shall be done in a neat and workmanlike manner. Paint may be applied with hand brushes or by spraying except that aluminum paint preferably shall be applied 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 will be required.

d) 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.

e) Spraying-Power spraying equipment shall apply the paint in a fine, even spray without the addition of any thinner.

Paint, when applied with spray equipment, shall be immediately followed by brushing when necessary to secure uniform coverage and to eliminate wrinkling, blistering and airholes.

f) Removal of Paint - If the painting is unsatisfactory to the Engineer, the paint shall be removed and the metal thoroughly cleaned and repainted.

g) Thinning paint - Paint as delivered in containers when thoroughly mixed is ready for use. If it is necessary to thin the paint in order that it shall spread more freely, this shall be done only by heating in hot water or on steam radiators, and liquid shall not be added nor removed unless permitted by the Engineer.

h) Painting Galvanized Surfaces - Painting of galvanized surfaces shall be as directed in writing by the Engineer.

i) Shop Painting - Unless otherwise specified, steelwork shall be given one coat of approved paint after it has been accepted by the Engineer and before it is shipped from the plant.

Surfaces not in contact, but inaccessible after assembly or erection, shall be painted three coats. 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.

Surfaces which will be in contact with concrete shall not be painted.

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 receive one coat of paint 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.

Surfaces of iron and steel castings, either milled or finished, shall be given one coat of paint.

With the exception of abutting joints and base plates, machine-finished surfaces shall be coated as soon as practicable after being approved before removal from the shop.

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.

6.20.4 Measurement

The quantity of work done under this item will not be measured unless otherwise specified but it shall include all painting required on each structure or structure unit.

6.20.5 Payment

No Payment will be made for the work, materials, labour and equipment unless otherwise specified. It shall be considered incidental to work performed under other items.

PART 3 BUILDING WORKS

PART 3 BUILDING WORKS

SECTION 7 : GENERAL REQUIREMENT

7.1 SCOPE OF WORK

These Specifications shall cover supply of all labour, material and equipment and the performance of all works necessary for construction of the building works for the Border Control Facilities in accordance with the Drawings, Specifications, and as may be further directed by the Engineer.

7.2 GENERAL

(1) Materials and works

The Contractor shall supply all materials required for completion of the works in accordance with these Specifications.

If the Drawings do not contain particular materials and works which are obviously necessary for the proper completion of the works, all such materials and works shall be included in the unit price stated in the Bill of Quantities for the appropriate items of the building construction works.

Unless otherwise specified, all materials and equipment which will become a part of the permanent works shall be new and of good quality, and shall be subject to inspection, examination and/or test according to the proper industrial standards as specified.

(2) Standards

Unless otherwise specifically provided, the quality of materials, equipment and workmanship shall comply with TIS or other equivalent international standards as specified hereinafter and as approved by the Engineer.

(3) Working drawings and samples

Working drawings, shop drawings or full size drawings shall be prepared and submitted by the Contractor to the Engineer for his approval as specified herein at no extra cost. The Contractor shall also submit samples or catalogues of construction materials for approval as specified without extra cost. The Engineer will check such samples or catalogues for the assurance of compliance with the design concept and the Specifications.

(4) Scaffolds, runways, etc.

The Contractor shall furnish, erect and maintain during the work as required all scaffoldings, runways, guard rails, and all other temporary constructions as may be necessary for the construction of the works.

(5) Cleaning

The Contractor shall from time to time remove all dirt and rubbish caused by the work from the construction site. At completion of the work, the Contractor shall thoroughly clean the interior and exterior of the buildings.

7.3 GEOLOGICAL SURVEY

Contractor shall perform geological survey at both the Lao PDR and Thailand – Border Control Facility sites in accordance with these Specifications and as directed by the Engineer.

The survey shall be made by normal boring in the following location. The exact location shall be directed by the Engineer.

Item	Investigation Site	Required Nos.
Normal	Lao PDR-BCF:	
Boring(over ϕ	1. At the cross section of BCF Main Office	2
66mm)	2. At the center of accommodation site	1
	Thailand -BCF:	
	1. At the cross section of the BCF center	2

The work shall comprise the following items;

1) The Depth of the Boring:

Lao PDR-BCF	6 m
Thailand-BCF	20 m

In case silty strata is found to exist more than two (2) meter deep, a sample of the strata shall be taken as directed by the Engineer. The Standard Penetration Test (S.P.T) shall be done every one (1) meter at each boring hole. A Cone Penetration Test shall also be done at each hole and observation records shall be taken and reported. The depth of boring shall be counted from the EL.151.5 at Lao PDR-BCF and EL.144 at Thailand-BCF.

2) The Laboratory Test:

The laboratory test shall be done in conformity with AASHTO standard method and the following items.

Items	Normal Soil Strata	Sandy Gravel Strata	Rock Strata
Grain-size analysis	O	O	
Unit weight test	O	O	O
Specific gravity test	O	O	O
Moisture test	O	O	
Permeability test	O	O	
Plastic Limited test	O	O	
Unconfined compression test	O	O	
Triaxial compression test	O	O	
Compression test			O
CBR test (all sample of normal boring)		O	

The Contractor shall exercise great care during the work and shall be responsible for any faults, accidents, and acquiring permission from the appropriate agencies and no claim shall be accepted by the Engineer.

The Contractor shall submit working program showing procedures and method of the work for the approval of the Engineer.

The S.P.T shall be carried out in conformity with AASHTO Designation: T. 206-74.

Disturbed and undisturbed samples and core samples shall be obtained and kept in a manner as defined in AASHTO standard.

7.4 MEASUREMENT AND PAYMENT

Measurement for payment for geological survey shall be measured on the basis of the actual linear meters drilled in accordance with the Drawings and the Specifications and as directed by the Engineer.

Measurement for payment for Standard Penetration Test (S.P.T) and laboratory test shall be made on the Lump Sum basis of the required number of S.P.T and laboratory test performed in accordance with the Specifications and as directed by the Engineer.

The unit price for the boring shall include all tools, equipment, labor, materials and other all incidental items necessary to complete the works.

The lump sump price for S.P.T and laboratory test shall include the cost for the required number of S.P.T and laboratory lest performed in accordance with the Specifications and as directed by the Engineer.

Pay items shall be as follows:

Item No.	Description	Unit
7.3 (1)	Geological Survey, normal boring	Linear Meter
7.3 (2)	Standard Penetration Test and Laboratory Test	Lump Sum

SECTION 8 : EARTH WORKS

8.1 SITE PREPARATION

The Contractor shall, before commencing any of his works, perform survey work to take the level of the graded ground, prepare survey drawings and submit these to the Engineer. The levels shall be taken at maximum 10 meters spacing and contours at every 20 centimeters. The cost for the above shall be included in the Contract Price. If, in the opinion of the Engineer, further grading work is necessary, the Engineer may order the Contractor to perform grading works at a suitable time taking into account of the smooth progress of the works.

8.2 EXCAVATION

The excavation to form a foundation for buildings, equipment or the like shall be made to the dimensions and elevations indicated on the Drawings and the Specifications or required for the buildings.

The excavation shall extend a sufficient distance from walls and footing to allow for installation of forms, services and for inspection.

Bottoms of excavation shall be level, free from loose materials, and brought to the indicated or required levels in undisturbed earth or compacted fill.

Excavation for pipes of water, gas, steam, sewage, waste water and electric cable services shall be carried out to a depth lower than the bottom of pipe orifice by 10cm for constructing the sand base as specified hereafter.

If there is an increase or decrease in the excavation volume due to the change in excavation depth, in the opinion of the Engineer, the cost for the related works shall be adjusted in accordance with the provision of Section 2.5.5 payment.

The Contractor shall provide necessary slopes or shoring to the ground faces to prevent ground faces from caving in at no extra cost to the Employer.

The excavated trench or pit shall be kept well drained of storm water or subsoil water as specified in the General Specifications until and during backfilling operation.

8.3 BACKFILL AND EMBANKMENT

Prior to commencement of backfilling and embanking, the places shall be cleaned of all temporary facilities, concrete forms, refuse, debris or any other deleterious matters and all embedded structures, pipes, cables and the like shall be inspected and approved by the Engineer.

Soil to be used for backfill and embankment may, in principle, be excavated soil so far as it does not contain any vegetation, organic matter, large fragments of rock, metallic or other harmful refuse.

The soil shall be placed in not more than 20cm layers evenly spread and each layer shall be well compacted to attain a dry density of at least 90% of the maximum dry density. The soil shall be dried or watered as required to have optimum moisture content to attain the required consolidation.

The surface of backfilling after compaction shall have a slightly cambered surface where required to facilitate drainage.

Care shall be exercised on the places adjacent to the structure not to cause damages to them. Compaction on such places shall be carried out by approved hand tools. Unless otherwise specified by the Engineer, backfilling or embanking material shall not be placed and compaction shall not be permitted adjacent to concrete for seven (7) days after the placing thereof.

8.4 BACKFILL FOR PIPING

Prior to installation of pipes, a base layer of approved sand shall be constructed to a thickness of 10cm. The base layer shall be properly compacted by means of hand tamper or soil compactor and provided with a suitable depression for pipe rest.

After the pipe is tested and accepted by the Engineer, backfilling with the sand shall be carried out to cover the pipe by not less than 15cm. The remaining space up to the grade may be backfilled with the ordinary soil as specified hereinbefore.

The sand shall not contain stones larger than 9mm diameter.

Care shall be execised in compacting the backfilled material so as not to damage the pipe by excessive or concentrated compaction work.

8.5 BORROW PITS

If there is an insufficiency of soil suitable for use of backfilling and embanking, the Contractor shall obtain good soil for this purpose from borrow pits.

On completion of the Work, the Contractor shall carry out the reinstatement of the borrow pits to the satisfaction of the Engineer by leaving them in a tidy, regular and self-draining state: all loose rock on upstanding faces shall be barred down and no face shall be left overhanging.

The Contractor shall be responsible for selecting suitable borrow pits and for devising and effecting the methods of working them to the approval of the Engineer.

The cost for this work shall be included in the Contract Price.

8.6 RUBBLE FOUNDATION

For concrete structures of building, equipment foundations, tanks or the like, a rubble foundation course shall be constructed on the excavated or embanked ground as shown on the Drawings or where directed by the Engineer.

The rubble foundation shall be made of approved rubble or crushed stone having a nominal size of larger than 65mm to a total thickness of 10cm or 15cm. The rubble or crushed stone shall be well compacted with jumping rammer, vibrating soil compactor or roller depending on the place to the satisfaction of the Engineer. Top faces of the foundation shall be filled up with gravel or crusher-run of suitable size and made smooth while compaction work proceeds.

8.7 DISPOSAL OF SURPLUS SOIL AND REFUSE

The Contractor shall remove surplus soil from excavations from the Site and deposit these at dumping points approved by the Engineer. The dumping point shall be selected in or out of the Site not further than 10 km away from the boundary lines of the Site.

The Contractor shall keep at all times the dumped soil in a tidy and self-draining state.

The Contractor shall not deposit any refuse inside the Site and shall select dumping points for these at his sole responsibility and expense.

8.8 MEASUREMENT AND PAYMENT

Measurement for payment for site preparation shall be made on the area in square meters of the preparation performed in accordance with the Drawings and the Specifications and as directed by the Engineer.

Measurement for payment for excavation, backfilling, embankment and rubble foundation shall be made on the volumes in cubic meters in accordance with the Drawings and the Specifications or as directed by the Engineer. When no payment line is shown in the Drawings the payment shall be made with the provision of Section 2.5.4 Measurement and Payment.

The unit price for the above items shall include all tools, equipment, labor, materials and other all incidental items necessary to complete the works.

Pay items shall be as follows:

Item No.	Description	Unit
8.1 (1)	Site Preparation	Square Meter
8.2 (1)	Excavation	Cubic Meter
8.3 (1)	Backfilling	Cubic Meter
8.3 (2)	Embankment	Cubic Meter
8.6 (1)	Rubble Foundation	Cubic Meter

SECTION 9 : PILE WORK

9.1 GENERAL

The work under this Section shall comprise the supply of all labour, materials and plant and the performance of all work required for the pile work for the buildings and facilities as shown on the Drawings or as directed by the Engineer and as specified herein.

9.2 MATERIALS

The pile to be used for building works shall be classified into the following types:

	Type of Pile	Structure
1	Prestressed Spun Concrete Pile:	
	300mm ϕ	Common Buildings
	400mm ϕ	Large Scale Steel Structures
2	Precast Reinforced Concrete Pile:	
	I - shape, 180mm x 180mm	Small Scale Facilities

9.2.1 Precast Reinforced Concrete Piles

a) General - Piles shall be constructed, in accordance with the details shown on the Drawings, of concrete classes specified, proportioned, mixed and placed in accordance with the provisions of Section 5.1, "Concrete Structures". Reinforcement shall comply with the provisions of Section 5.2, 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.

The pile shall be straight such that a line stretched from tip to butt on any face will not be more than 1/1000 of length of the pile from the face of the pile at any point.

b) Formwork - Forms for precast concrete piles shall conform to the general requirements for concrete formwork as described in Section 5.1. 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.

c) Reinforcement - Reinforcement shall be in accordance with the provisions set out in Section 5.2 and positioned as shown on the Drawings.

d) Pile shoes - Shoe bases where used shall consist of "chilled hardened" high duty cast iron , 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.

e) 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, honeycombs or other defects.

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 surface finished to a uniform, even texture similar to that product by the forms.

f) 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.

g) Curing - Concrete piles shall be covered with wet burlap immediately after concrete placing is completed and shall be kept continuously wet for at least 7 days.

h) 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 concrete casting or such reduced time as the Engineer may decide as a result of tests.

9.2.2 Precast Prestressed Concrete Piles

a) General - Piles shall be constructed in accordance with the details shown on the Drawings, of prestressed concrete as specified, proportioned, mixed and placed in accordance with the provisions of Section 5.3 Prestressed Concrete.

The pile shall be straight that such a line stretched from tip to butt on any face will not be more than 1/1000 of the length of the pile from the face of the pile at any point.

b) Formwork - The formwork shall be sufficiently rigid not to deform during the placing and compaction of the concrete and shall be sufficiently tight to prevent loss of water from the concrete.

The casting bed shall be adequately supported to prevent any settlement which might cause cracking of the concrete. If the pile is to be stressed on the casting bed, provision shall be made for the elastic shortening of the concrete under prestress and for the transfer of dead weight after stressing.

All rubbish shall be removed from the interior of the forms before concrete is placed. The faces of the formwork in contact with the concrete shall be cleaned and treated with form oil approved by the Engineer.

Side forms shall be removed as soon as possible after the concrete has set to avoid shrinkage cracks. The pile will not be moved until after the pile has been stressed. All formwork will be removed in such a way as to ensure no damage is done to the concrete.

c) Prestressing Steel - All prestressing steel shall comply with the provisions of Section 5.4. All prestressing steel shall be free from loose mill scale, loose rust, oil, grease, or other harmful matter at the time of fixing and of placing concrete. Steel shall not be pitted.

All prestressing steel shall be stored in a suitable weather proof shed and protected from dampness.

Coils of prestressing wire of strand shall be obtained from the manufacturer in sufficiently large diameters to ensure the wire or stand running off the coils is straight.

Wires, strands, or bars shall be accurately positioned and maintained in position, both vertically and horizontally as shown on the Drawings.

All cutting to length and trimming of ends shall be done by suitable mechanical cutting means. Care shall be taken if flame cutters are used with the Engineer's permission, to ensure that the flame does not come into contact with other stressed wires or strands and that overheating of the wire or strand to be cut does not occur where the wire or strand is to be stressed.

d) Reinforcement - Ordinary reinforcement steel shall be in accordance with the provisions set out in Section 5.2 "Reinforcement for Structures", and positioned as shown on the Drawings.

e) 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, honeycomb 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 the top surfaces finished to a uniform, even texture similar to that produced by the forms.

f) Tensioning Procedure - Tensioning shall be carried out only in the presence of the Engineer unless prior permission has been granted the Contractor by the Engineer to proceed without the supervision of the Engineer.

As used here the work "tendon" shall be defined as any single prestressing element used to apply prestressed forces to the concrete. For pretensioning this shall be each strand or straight wire.

All tendons to be stressed in a group shall be brought to a uniform tension of approximately 500 kilograms per tendon prior to being given their full tension. After this initial stressing the group shall be stressed to a total tension as required on the Drawings by means of hydraulic jacks or other approved appliances equipped with gauges graduated to read directly to one percent of the total load applied, and calibrated to measure accurately the stress induced in the steel. The induced stress shall be measured by elongation of the tendons and checked by gauge pressure. The results obtained shall be within five percent of each other.

Means shall be provided for measuring the elongation to an accuracy to one millimeter in twenty meters of length between the jacking heads. In the event of apparent discrepancies of more than five per cent between stresses indicated by gauge pressure and elongation, the entire operation shall be checked carefully and the source or error determined and corrected before proceeding further.

Independent references shall be established adjacent to each anchorage to indicate any yielding or slippage that may occur between the time of initial stressing and final release of the tendons.

g) Curing - Curing of the concrete shall be commenced prior to the formation of surface shrinkage cracks and as soon as the concrete has hardened sufficiently to prevent injury.

The pile shall be covered with wet burlap or membrane curing compound as an interim measure to elevated temperature curing.

Precast, pretensioned members shall be cured continuously, until the concrete strength, as indicated by compressive tests on 15 centimeter cylinders has reached the "Release Strength". Curing then may be interrupted for a time interval of not more than two hours for removal of the piles from the casting bed to a curing area. Curing operations shall then be resumed for an additional 48 hours.

h) Release - for precast pretensioned members the tendon stress shall be maintained between anchorage's until the concrete has reached a compressive strength equal to the "Release Strength" specified on the Drawings as determined by compressive tests on 15 centimeter cylinders.

After strength requirements are attained, the tension in the tendons shall be gradually and simultaneously released and the tendons cut off as required in such a way as to prevent shock. It shall be the Contractor's responsibility to transfer the prestress safely and to the Engineer's satisfaction in all respects.

When elevated temperature curing is used, the release of stress shall be prior to the beginning of temperature reduction. Piles shall remain protected until there is a differential of temperature inside the curing jacket and air temperature of not more than 8°c.

i) Finishing - At the ends of piles a recess shall be cut around each tendon to allow cutting off the tendon and filling the recess with grout so that the cover to the end of the tendon is not less than 20 millimeters.

Piles shall present true, smooth, even surface free from any surface blemishes and true to the dimensions shown on the Drawings.

9.2.3 Prestressed Spun Concrete Pile

Prestressed spun concrete piles shall comply fully with the requirements of Japanese Standard JIS 5337-1995, and the other applicable sections of this Specification.

9.2.4 Auger Press Piles

Unless otherwise shown on the Drawings, auger press piles shall be precast prestressed concrete piles of hollow square or circular sections. All piles specified on the Drawings or directed by the Engineer as predrilled shall be installed by the semi auger press technique. They shall be auger pressed to a depth approximately 4 to 5 m above the specified pile tip elevation. They, then, shall be driven to the required pile tip elevation.

Excavated material shall be removed from the site at the Contractor's expense.

9.3 CONSTRUCTION METHODS

9.3.1 Preparation for Driving

(a) Pile Caps

The heads of all concrete piles shall be protected by caps of approved design, preferably having a rope or other suitable cushion next to the pile head and fitting into a casting which in turn supports a timber shock block.

(b) Splicing Piles

Full length piles shall be used where practicable. In exceptional circumstances splicing of piles may be permitted. The method of splicing shall be as shown on the Drawings or as approved by the Engineer.

9.3.2 Methods of Driving

(a) General

Reinforced concrete piles may be driven using a drop hammer, single or double acting steam hammer, or a diesel hammer. The Contractor shall provide a suitable hammer of sufficient weight and/or energy capable or installing each pile to the required penetration and to control the hammer and/or energy to ensure that no pile is damaged during driving.

In case the required penetration cannot be obtained by the use of a hammer complying with the above minimum requirements, the Contractor shall provide a heavier hammer, or resort to jetting at his own expense.

(b) Leads

Pile driver leads shall be of approved design and constructed in such a manner as to afford freedom of movement of the hammer, and they shall be held in position by guys or stiff braces to ensure support to the pile during driving. Except where piles are driven through water, the leads , shall be of sufficient length so that the use of a follower will not be necessary. Inclined leads shall be used in driving batter piles, and shall provide sufficient lateral support for the pile so that no undue stresses are induced in the pile during driving.

(c) Followers

The driving of piling with followers shall be avoided if practicable and shall be done only under written permission of the Engineer. When followers are used, they shall be fabricated from steel of approved type and size, and one pile from each group of 10 shall be a long pile driven without the follower and shall be used as a test pile to determine the average load carrying capacity of the group. Expenses incurred in connection with the testing of the pile shall be born by the Contractor.

(d) Water Jets

When water jets are used, the number of jets and the volume and pressure of water at the jet nozzles shall be sufficient to freely erode the material adjacent to the pile. The plant shall have sufficient capacity to deliver at all times at least 0.7 N/mm2 pressure from 20mm jet nozzles. Before the desired penetration is reached, the jets

shall be withdrawn and the piles shall be driven by hammer to secure the final penetration.

(e) Accuracy of Driving

Piles shall be driven with a deviation of not more than 1° from the vertical or from the batter shown on the plans. After driving, the positions of the pile heads shall not deviate by more than 80 mm from the positions shown on the Drawings. The center of gravity of any row of piles shall be within 50 mm from its theoretical position in any direction.

(f) Defective Piles

The procedure incidental to the driving of piles shall not subject them to excessive and undue abuse producing crushing and spalling of the concrete. Manipulation of piles to force them into the proper position, considered by the Engineer to be excessive, will not be permitted. Any pile damaged by reason of internal defects, or by 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 :

- A second pile or piles shall be driven adjacent to the defective pile.

- The pile shall be built up or extended or sufficient portion of the footing extended to properly embed the pile as approved by the Engineer.

All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down again to their previous elevations.

(g) Cutting off piles

Piles shall be cut off at such an elevation that they will extend into the cap or footing as indicated on the Drawings. Precast Concrete piles may be cast the full length of the reinforcing bars, provided that the concrete is cut off to expose the reinforcement steel as shown on the Drawings after the piles have been driven.

All cut-off lengths of piling shall become the property of the Contractor. Cut-off lengths of piling may be incorporated in the work if approved in writing by the Engineer, otherwise pile cut-off lengths shall be disposed of to the satisfaction of the Engineer.

9.3.3 Determination of Bearing Capacity

(a) General

All piles shall be driven to such depths or sets as may be required to obtain the necessary allowable bearing value. The Engineer will decide on the criteria for when this value has been achieved, based on load tests or the driving records. He will choose a factor of safety dependent on the uniformity of the foundation conditions, but the required ultimate load will generally be two and a half times the working load for loading tests, or three times or more the working loads when determining the final set of the pile according to the specified driving formula.

(b) Test Piles

The lengths of piles shown on the Drawings are based on information which it has been possible to obtain from a site investigation prior to the driving of test piles.

Before the driving criteria are finally settled, the Contractor shall construct to the lengths specified by the Engineer such pilot piles as may be found necessary and these piles shall be driven in the positions and to the set specified by the Engineer, who shall be notified in advance of the driving. The Contractor shall furnish the Engineer daily report with a detailed record of the driving of pilot piles throughout the full depth of driving, as specified in 'e' below.

Based on the results of the pilot piles, the Engineer will choose one or more locations for pile loading tests which shall be carried out prior to driving production piles.

(c) Static Load Tests

The Engineer may require one or more static loading tests at each Border Control Facility location. At the start or the Project, the Contractor shall therefore submit to the Engineer detailed drawings of the equipment and arrangement he intends to use for loading tests. The equipment shall be designed to apply loads in smooth increments up to at least 3 times the working load specified in the drawing. If the Contractor proposes to use tension piles for the load reaction, such tension piles shall be of the same type and size as the permanent piles and shall be driven in the location of permanent piles. Loads for the load test shall not be applied until 10 days or such time as directed by the Engineer have elapsed since the driving of the piles.

Tension piles will require strengthening with extra steel to carry the tension loading. The Contractor shall submit drawings to the Engineer showing the extra reinforcement and method of transferring the load between the piles and loading frame. A minimum of 3 pile diameters clear distance shall be allowed between the test pile and tension piles.

No particular payment will be made for any additional length supplied, cast or driven, or for any additional reinforcement of such piles that may be required for use as tension piles, nor for any resumed driving that may be ordered by the Engineer, during or after the test, due to the piles having moved, or for repair of any damage caused during the test, such costs being considered incidental to load tests and paid for the structure itself.

Piles selected by the Engineer for static load tests shall be tested as follows :

- The test load shall be applied by a method approved by the Engineer and shall be measured within an accuracy of 2 percent. Settlements shall be measured within an accuracy of 0.2 mm.

- The test load shall be applied in the increments of 25 percent of the working load of the piles.

- The load after each increment shall be kept constant until the rate of settlement does not exceed 0.2 mm per hour.

- The amount of settlement shall be recorded before the next increment of load.

- The full test load shall be maintained on the test pile not less than 48 hours.

- The load shall be reduced in stages equal to those in which it was applied.

- The amount of recovery shall be recorded before the next decrement of load.

- The Contractor shall, within 24 hours of the completion of the test, submit to the Engineer for each pile tested graphs showing load and settlement plotted above and below a common base line of time; settlement and recovery plotted vertically against a base line of load.

- The ultimate bearing capacity of the pile shall be defined as that load where the gross settlement begins to exceed 1 mm per Tonne of additional load, or which causes a gross settlement of 25 mm, whichever occurs first.

(d) Dynamic Load Tests

In addition to the static load test mentioned above, the Engineer may require one or more piles to be tested by the dynamic load test conforming to ASTM D4945.

This item of work requires a dynamic load to be applied by a pile hammer to a driven pile (restrike) or to a pile being driven, while transducers obtain measurements for predicting the static capacity of the pile. The dynamic load shall be applied to the pile by a pile hammer which is operating at its normal operating level. Waiting periods may be necessary so that soil set-up and relaxation characteristic can be determined.

The Contractor shall notify the Engineer of his intent to drive piles at least three days prior to the installation of the first pile and shall supply a Contractor's pile driving schedule. The Engineer shall determine if a test is to be performed or if some pile driving experience at the proposed site is to be obtained before a decision can be made. The Engineer will establish data for the tests and will also determine the location of all piles to be dynamically load tested.

The hammer selected for driving the test loaded pile shall be used for driving all test piles. If the Contractor subsequently finds it necessary to use a diffrent hammer, the Engineer will determine if an additional dynamic load test is necessary. Any such test shall be completed at no additional cost to the Employer.

After the dynamic testing measurements have been obtained and analyzed and the report in terms of ultimate capacity of piles has been submitted to the Engineer, the Engineer will provide instructions and guidelines for driving the piles.

(e) Driving Records

A record of all piles installed shall be kept by the Contractor and a copy of the record of each day's work shall be given to the Engineer within 24 hours. The record shall contain the following information:

- Date of Driving
- Date of Casting and Identification Number
- Location of Pile
- Length of Pile and Cross Section
- Ground Level before Driving
- Estimated Tip Elevation (as shown on the Drawings)
- Actual Tip Elevation after Driving
- Number of Blows for each 30 cm Penetration from Start of Driving
- Number of Blows for each 10 cm penetration from last 1.0m of driving
- Hammer Type, Weight and Rated Energy
- For Drop Hammer, the Actual Drop Height
- Details of Interruptions to Driving
- Details of Re-driving
- Details of condition of Pile Head

On completion of piling, the Contractor shall deliver to the Engineer a drawing recording the final depths of all piles relative to project elevations.

(f) Driving Formula

To interpolate bearing capacities of piles between load test locations, or at locations where load tests have not been carried out, the ultimate capacity of piles may be calculated from the formula as shown on the Drawings.

In the event no formula is given in the Drawings, an acceptable pile driving formula can be used, subject to the Engineer's approval.

The working load of the pile shall be calculated by applying a safety factor of 3.

9.3.4 Measurement

The unit of measurement for all types of piling including pilot and or test piles will be the linear meter of pile furnished, driven and accepted in the structure. The pay lengths of the satisfactorily driven piles will be measured from the pile tip to the cut-off.

Cut off lengths will not be measured for payment. Load tests will be measured by the number completed and accepted.

When concrete piles are extended, the length of the extension from the cut-off to the top of the extension shall be considered as concrete piling and will be added to the original length for measurement.

The cut-off elevation will be considered to be the level 100mm above the bottom of the pile cap whether the pile head is extended or not. If after driving of test piles or completing the pile tests for a particular structure the Contractor desires for his own convenience of pile rig utilization to drive the other piles of the particular structure, before their tip elevations have been calculated and agreed upon, he may apply in writing to the Engineer to do so. The Engineer may approve this application provided that the Contractor agrees to redrive the piles so driven at a later date if the calculated pile tip elevations fall lower than the elevations to which the piles were driven or, if the piles were over driven to a lower elevation than those calculated from the pile load test, to accept payment to the pile tip elevation established by the pile load tests.

The quantities of steel reinforcement or prestressing wire or strand required in concrete piling, including the length extending into pile caps , footings or braced beams, will not be paid for separately but will be considered as included in the Contract unit price per linear meter for concrete piles, unless otherwise specified by the Engineer.

9.3.5 Payment

Reinforced concrete piles (R.C.) and prestressed concrete piles (P.C), of specified cross sectional dimensions, shall be paid for at the respective Contract unit prices per linear meter, complete in place, which prices shall include all materials, including reinforcement, prestressing strand, hardware, furnishings, formwork, driving, jetting, in-place casing and infilled material or pre-auger, cutting off, splicing, welding, coupling, and all related equipment including rigs, cranes, boilers, hammers, jets, leads stressing jacks and tools as well as labor and all other incidentals necessary for the satisfactory completion of the work.

Static and/or dynamic load tests on piles, completed and accepted, shall be paid for at the Contract unit price for each, which price shall include all equipment, jacks, kentledge, frames, supports, precise measuring apparatus, survey instruments, miscellaneous tools, labor and all other incidentals necessary for the proper execution of the test.

No payment will be made for unauthorized, defective, unsound or unsatisfactorily driven piles or for any costs incurred by the Contractor for such piles.

The length of each pile described in the pay items shall be tentative. The final length shall be determined by the Engineer based on the result of the geological survey and load tests or the driving records.

Pay items shall be as follows:

Item No.	Description	Unit
9.3 (1)	Precast Reinforced Concrete Pile I-shape, 180mm x 180mm, L=6.0m	Linear Meter
9.3 (2)	Prestressed Spun Concrete Pile 300mm ϕ, L= 18.0 m	Linear Meter
9.3 (3)	Prestressed Spun Concrete Pile 400mm ϕ, L=18.0 m	Linear Meter
9.3 (4)	Pile Head Cut	Each
9.3 (5)	Static Load Test on Prestressed Spun Concrete Piles	Each

SECTION 10 : CONCRETE AND FORMWORK

10.1 GENERAL

Except otherwise provided herein or directed by the Engineer the works under this Section shall be performed in accordance with the provision of Section 5, Structures, hereinbefore.

10.2 MATERIALS AND PARTICULAR SPECIFICATIONS

(1) Type of Concrete

The type of concrete to be used for building structures, equipment foundations shall be as follows:

Description	Type of Concrete
• Reinforced concrete for building structures, equipment foundations and the like	Type – D
• Plain concrete for various purposes	Type – F

(2) Size of Aggregate

Maximum size of aggregate to be used for concrete shall be 25mm in size in all respect.

(3) Water/Cement Ratio

The water/cement ratio to be applied to the concrete shall be 65% or as directed by the Engineer.

(4) Standard Slumps

The slumps of concrete to be used for buildings and equipment foundations shall be approximately as follows and subject to the Engineer's instructions.

Description	Standard Slump
• Reinforced concrete building framing	10~15 cm
• Building foundation and equipment foundation	7.5~12.5 cm

(5) Admixture

No admixture shall be permitted in the concrete without approval of the Engineer. When the admixture is employed, tests shall be carried out by the Contractor to show that the density has not been reduced by more than 5% by the use of admixture.

(6) Formworks

Before manufacturing the forms, the Contractor shall submit working drawings of the forms to the Engineer for his approval.

The type of forms shall be classified for exposed concrete finish and ordinary form for finishing with cement plaster in accordance with the Drawings and the Specifications and as directed by the Engineer.

Removal of forms shall be subject to the Engineer's approval. A minimum period for forms to be left in places shall be as follows:

Description	Minimum Period
• Foundation, column, wall, side of beam	Two(2) days or not less than 50 kg/cm^2
• Bottom of slab and beam	Slab: Fourteen (14) days Beam: Twenty one (21) days

(7) Reinforcing Bars

The Contractor shall submit shop drawings showing fabrication of reinforcing bars to the Engineer for his approval in accordance with the Drawings and the Specifications.

Minimum concrete covering to the reinforcing bars shall be as follows:

Portions	Minimum Concrete Covering
• Slab, wall	2 cm
• Column, beam	3 cm
• Wall, column and beam contact with soil	4 cm
• Foundation	6 cm

Clearance of each reinforcing bars shall be not less than one and half (1.5) times the bar diameter and more than 2.5cm unless otherwise specified.

10.3 MEASUREMENT AND PAYMENT

Measurement for payment for concrete, formwork and reinforcing bars shall be made in accordance with the provision of Section 5, Structures, hereinbefore.

The unit price for each item shall include supplying, erecting and placing each item including tools, plants and any other relevant works required.

Pay items shall be as follows:

Item No.	Description	Unit
10.2 (1)	Concrete (Type-D)	Cubic Meter
10.2 (2)	Concrete (Type-F)	Cubic Meter
10.2 (3)	Exposed Form	Square Meter
10.2 (4)	Ordinary Form	Square Meter
10.2 (5)	Reinforcing Bar	Kilogram

SECTION 11 : STRUCTURAL STEEL WORK

11.1 GENERAL

The work under this Section shall comprise supply and performance of all work necessary for completion of structural steel work, in every respect as shown on the Drawings or as directed by the Engineer.

11.2 MATERIALS

All steel members, inclusive of bolts and nuts shall conform to the latest revision of TIS Designation or ASTM listed below or equivalent approved by the Engineer.

Shaped, Steel Plates	ASTM A 36 (3000 ksc)
High Tensile Bolts	ASTM A 490
Bolts and Nuts	ASTM A 307
Design, Fabrication and Erection	AISC AND BS 5950
Welding	AWS

The structural steel section and plates shall conform to the following minimum requirements:

Strength at yield point	30 kg/mm^2
Tensile strength	50 kg/mm^2
Elongation	20% minimum

11.3 FABRICATION

All structural steel work shall be fabricated strictly compliance with the Drawings and these Specifications. The size of assembled pieces of structure steel shall be limited by the permissible weight and dimensions for transportation.

The Contractor shall provide reinforcements and holes for convenience for other contractors where shown on the Drawings or directed by the Engineer.

The materials shall be carefully handled so that no part will be bent, broken or otherwise damaged. Hammering that may damage or distort the members shall not be permitted. Bearing surfaces to be in permanent contact shall be carefully cleaned prior to their assembly.

High tensile bolts shall be used for all primary connections as shown on the Drawings and where directed by the Engineer.

11.4 ERECTION

The Contractor shall erect the steel structure to the dimensions and elevations shown on the Drawings. The steel shall be carried up true and plumb and temporary bracing shall be introduced wherever necessary to take care of all loads to which the structure may be subject. Such bracing shall be left in place as long as may be required for safety.

As erection progresses, the work shall be securely bolted to take care of all dead load and erection stresses. No permanent bolting shall be done until as much of the structure as will be stiffened thereby has been properly aligned, levelled, and inspected by the Engineer. Connections of members shall be carefully carried out so that no part will be bent, broken or otherwise damaged. Hammering that may damage or distort the members shall not be permitted.

The installation of high tensile bolts shall be in accordance with appropriate standards.

11.5 CORRECTION OF ERRORS AND DEFORMATIONS

Any deformation resulting from improper handling by the Contractor that prevents the proper assembling and fitting-up of parts shall be corrected in the field as approved by the Engineer. Field corrections that are required because of incorrect fabrication shall be made as directed by the Engineer.

11.6 MEASUREMENT AND PAYMENT

Measurement for payment for erection of structural steel shall be made on the basis of the actual weight in kilograms of structural members installed in accordance with the Drawings and the Specifications and as directed by the Engineer.

No deduction shall be made for bolt and rivet holes in structure steel but the weight of bolts and rivets shall be counted.

The unit price shall cover supply and erection of the structural steel works including fabrication and any other relevant works required. Painting shall be paid for under a separate item.

Pay item shall be as follows:

Item No.	Description	Unit
11.2 (1)	Structural steel	Kilogram

SECTION 12 : MASONRY WORK

12.1 GENERAL

The work under this Section shall comprise the supply of all labour, materials and plant and the performance of all work required for the masonry works for the buildings as shown on the Drawings or as directed by the Engineer and as specified herein.

12.2 BRICK MASONRY

(1) Materials

All bricks shall be of size 35x70x160mm unless otherwise approved by the Engineer. The bricks shall be uniform in size and shape and shall be deep red in colour and must be sufficiently well burnt. The bricks shall be wholly clean and free from flaws, cracks and underburnt lumps of any kind. They shall have sharp edges and angles and even surfaces. The Contractor shall submit to the Engineer sample bricks for his approval.

(2) Brick Laying

The bricks shall be thoroughly soaked with water before their use and they shall be laid end and side in one operation in close compact mortar joints. The cement mortar to be used shall have a cement to sand ratio of 1:3 mixed and applied as specified in Section 16 hereinafter.

12.3 CONCRETE BLOCK MASONRY

(1) Materials

Concrete blocks to be used shall be hollow core blocks of approved design having exterior dimensions of 390 x 190 x 100mm. The concrete blocks shall have a compressive strength of not less than 40 kg/cm^2 and an apparent specific gravity, air dried of not less than 1.7.

(2) Concrete Block Laying

The concrete block shall be laid in straight and struck joints of about 1cm thick with 1:3 cement mortar as shown on the Drawings.

The concrete block walls shall be reinforced with steel reinforcement deformed bars of a diameter of 10mm in a manner as shown on the Drawings. Anchor steel bars shall be preinstalled to the surrounding floor, columns, walls and ceiling at intervals and locations to enable connection to the reinforcement bars. All splices shall be taken 40 times the bar diameter.

The vertical and horizontal joints through which the reinforcement bars run shall be thoroughly filled with 1:3 cement mortar.

Where required to install doors, windows and any other opening in the concrete block wall, reinforced concrete lintels shall be provided.

Laying of the concrete blocks shall not exceed 1.2m in height per day.

The Contractor shall design the lintel and shall obtain the approval of the Engineer.

12.4 MEASUREMENT AND PAYMENT

Measurement for payment for brick masonry and concrete block wall shall be made on the basis of the respective areas in square meters of brick masonry and block walls constructed in accordance with the Drawings and the Specifications and as directed by the Engineer.

The unit price for brick masonry works shall include supplying and placing bricks and concrete blocks including bonding and filling cement mortar, reinforced concrete lintels and any other relevant works required. Reinforcement bars shall be paid for under a separate item.

Pay items shall be as follows:

Item No.	Description	Unit
12.2 (1)	Half Brick, t=70mm	Square Meter
12.2 (2)	Concrete Hollow Block, t=100mm	Square Meter

SECTION 13 : WATERPROOFING AND DAMPPROOFING WORKS

13.1 GENERAL

The work under this Section shall comprise the supply of all labour, materials and plant and the performance of all work required for waterproofing and dampproofing for the buildings as shown on the Drawings or as directed by the Engineer and as specified herein.

13.2 MATERIALS

All materials shall be best quality and shall comply with the applicable standards. The Contractor shall submit samples or catalogues of the waterproofing and dampproofing materials to the Engineer for his approval.

(1) Membrane Waterproofing

The membrane waterproofing shall be of polyvinyl chloride membrane roofing for the roof and the interior floor with the thickness of approximately 2.0mm.

(2) Dampproofing

The dampproofing shall be of moisture protection consisting of polyethylene film 0.08mm thick and providing for the underside of the ground slabs in contact with soil where the vinyl floor tiles are to be laid on the slabs as shown on the Drawings.

13.3 APPLICATION

(1) Membrane Waterproofing

The membrane waterproofing shall be laid onto smooth, primed 15mm thick base mortar placed on the concrete slabs by applying epoxy resin or urethane resin adhesive.

The membrane shall be well rolled with minimum 65mm overlaps and laid strictly in accordance with manufacturers instructions.

The extruded aluminum flashing shall be provided on the parapet walls to cover the end of membrane waterproofing by using plastic screws and sealed all around the flashing and the end of waterproofing as shown on the Drawings. Aluminum surfaces in contract with masonry, concrete, dissimilar metals shall be coated with bituminous paint, vinyl primer or zinc chromate paint.

The work shall be guaranteed for period of not less than ten (10) years.

(2) Dampproofing

The polyethylene film shall be laid onto 30mm thick lean concrete placed on the well compacted backfill with not less than 150mm side and end laps.

13.4 PROTECTION CONCRETE ON MEMBRANE WATERPROOFING

Materials such as cement, aggregate and sand, mixing, casting and curing of concrete shall comply with applicable provisions in Section 10 hereinbefore.

The protection concrete shall cover the entire faces of the roofing in a minimum thickness of 5 cm by steel trowel.

The concrete shall be reinforced with 6 ϕ, 100 by 100mm steel welded mesh and provided with expansion joints to the full depth in a grid pattern of not larger than 3m. Top of the joint shall be filled up with asphalt compound to a thickness of 25mm on top of bituminous or foamed plastic board.

13.5 MEASUREMENT AND PAYMENT

Measurement for payment for the membrane waterproofing and dampproofing works shall be made on the basis of area in square meters of waterproofing performed in accordance with the Drawings and the Specifications and as directed by the Engineer.

The overlap joints shall not be considered in the measurement of the area.

The unit price shall include supplying and applying the membrane waterproofing and dampproofing inclusive of asphalt compound joints 25mm wide in protection concrete over roofing, aluminum flashing, approved caulking to required portion and any other relevant works required.

The base mortar, protection concrete on the membrane waterproofing shall be paid for under separate items.

The lean concrete for dampproofing shall be paid for under separate items.

Item No.	Description	Unit
13.2 (1)	Membrane Waterproofing, t=2mm, including joint seal, flashing, caulking	Square Meter
13.2 (2)	Dampproofing	Square Meter

SECTION 14 : TERRAZZO WORK

14.1 GENERAL

The work under this Section shall cover the supply of all labour, materials and plant and the performance of all work required for terrazzo finish work in the buildings.

The work shall be performed as shown on the Drawings or as directed by the Engineer and as specified herein.

14.2 MATERIALS

The marble chips to be used for terrazzo work shall be of hard and durable marble and of colours approved by the Engineer. The grading of the chips shall be as follows:

- Percentage (by weight) passing through 12mm mesh screen 100%
- Percentage (by weight) passing through 2.5mm mesh screen 0%

Colour pigments shall be added to produce the required colour pattern. Samples of terrazzo shall be submitted for the approval of the Engineer.

14.3 APPLICATION

(1) Terrazzo in-situ

The marble chips shall be mixed with white cement paste to a ratio of 1:2.5 in volume. The total thickness of terrazzo in-situ including base mortar shall be 50mm thick.

The base for the terrazzo finish shall be of cement mortar rendering 18mm thick performed as specified in Section 16 hereinafter.

After sufficient hardening of the finish coat, the surface shall be ground with emery powder ranging from coarse to fine and polished with wax to a luminous and satisfactory finish using appropriate grinding machine or by hand.

Brass dividing strips, 6x15mm in size shall be installed prior to the application of the base mortar, anchored and set in place to the dimensions and alignment as shown on the Drawings.

(2) Terrazzo tiles and blocks

Terrazzo tiles and blocks shall be precast to the dimensions as selected by the Engineer. The method of precasting terrazzo tiles shall be made in accordance with the Specifications for terrazzo in-situ described above.

The precast terrazzo tiles and blocks shall be laid over a base cement mortar and laid level and plumb with butt joints. Expansion joints 6mm width with polyethylene foam back-up shall be provided at approximately 6m interval and along the walls filled with polysulfide type sealing materials after completion of all works.

After sufficient lapse of time for cement mortar and paste to harden, the terrazzo tiles or blocks surface shall be washed down with water and polished with wax.

14.4 MEASUREMENT AND PAYMENT

Measurement for payment for terrazzo in-situ and terrazzo tile floor finishes shall be made on the basis of the area in square meters of floor and the length in linear meters of terrazzo tile skirting, terrazzo block door sill, shelf and counter supplied and laid respectively in accordance with the Drawings and the Specifications and as directed by the Engineer.

The unit price shall include the base mortar, dividing brass strips, expansions, anchors and any other relevant works required.

Pay items shall be as follows:

Item No.	Description	Unit
14.3 (1)	Terrazzo in-situ	Square Meter
14.3 (2)	Terrazzo Tile Floor, 300x300	Square Meter
14.3 (3)	Terrazzo Skirting, H=100	Linear Meter
14.3 (4)	Terrazzo Door Sill, 50x100	Linear Meter
14.3 (5)	Terrazzo Shelf, W=100	Linear Meter
14.3 (6)	Terrazzo Counter, W=600	Linear Meter

SECTION 15 : TILE WORK

15.1 GENERAL

The work under this Section shall comprise the supply of all labour, materials and plant and the performance of all work required for the various tile works in the buildings. The work shall be performed as shown on the Drawings and as specified herein.

15.2 MATERIALS

Only first-class quality tiles shall be used in the works. The Contractor shall submit to the Engineer samples of the tiles for the approval of the Engineer.

(1) Mosaic Tile

Mosaic tile shall be porcelain tile of 25x25x5mm approximately in size and shall have unglazed surfaces. Colours and patterns shall be selected by the Engineer.

(2) Ceramic Tiles for Interior Walls

Ceramic tile for interior use shall be 200x200x6mm approximately in size. The ceramic tiles shall have unglazed surface and round arris. Colours shall be selected by the Engineer.

(3) Porcelain Floor Tile

Porcelain floor tile shall be 300x300x8mm approximately in size and shall have unglazed surfaces. Colours shall be selected by the Engineer.

(4) Porcelain Wall Tile

Percelain wall tile shall be 227x60x12mm approximately in size and shall have glazed surface. Colors shall be selected by the Engineer.

15.3 MOSAIC TILE, CERAMIC TILE, PORCELAIN TILE SETTING

Concrete and/or brick surfaces to receive the tiles shall be cleaned free from dirt, oil, grease and other deleterious substances and soaked with clean water prior to application of the rendering cement mortar base.

The rendering cement mortar base for the tile works shall be prepared as specified in Section 16 hereinafter.

Procelain tile for the floors shall be set with 1:3 cement mortar to the level and slope specified. Ceramic tile, porcelain tile and mosaic tile for the walls shall be set with 1:3 cement mortar.

Joints for ceramic tile to interior wall shall be 3mm wide, uniform and true to line grouted flush with white cement paste. Joints for porcelain floor tiles shall be 4mm wide and grouted with cement paste. Joints for mosaic tiles to exterior wall shall be 2mm wide and grouted with cement paste. Joints for parcelain tile to exterior wall shall be 10mm wide and grouted with cement paste.

After completion of setting, the tile surfaces shall be washed down to clean with plain water or muriatic acid according to the manufacturer's instructions.

Plumbing fixtures and any others to be built in the tile surface shall be installed to suit tiling work progress.

15.4 MEASUREMENT AND PAYMENT

Measurement for payment for tile works shall be made on the basis of the actual surface areas in square meters covered with each type of tiles supplied and laid in accordance with the Drawings and the Specifications and as directed by the Engineer.

The unit price shall include all special mouldings, bedding cement mortar, joint filling cement paste, bonding adhesives and any other relevant works required.

Pay item shall be as follows:

Item No.	Description	Unit
15.2 (1)	Mosaic Tile Wall, 25x25x5	Square Meter
15.2 (2)	Ceramic Tile to Interior Wall, 200x200x6	Square Meter
15.2 (3)	Ceramic Tile to Floor, 200x200x6	Square Meter
15.2 (4)	Porcelain Floor Tile, 300x300x8	Square Meter
15.2 (5)	Porcelain Tile to Exterior Wall, 227x60x12	Square Meter

SECTION 16 : PLASTERING WORK

16.1 GENERAL

The work under this Section shall comprise the supply of all labour, materials and plant and performance of all work for the plastering works to floors, walls, ceilings in the buildings. The work shall be performed as shown on the Drawings or as directed by the Engineer and as specified herein.

16.2 CEMENT MORTAR PLASTER

(1) Materials

The sand to be used in the cement mortar shall be clean, hard, solid and durable and shall not contain harmful amounts of dust, mud, organic materials or other objectionable matter. The grading of the sand shall be within the following limits :

Classification	Screen Designation	Percentage by Weight Passing Screen
Rendering coat	5 mm	100%
	0.15 mm	10% or under
Finishing coat	2.5 mm	100%
	0.15 mm	10% or under

The mix proportions of the cement mortar shall be as follows :

Applying Bed	Place of Application	Rendering Coat Cement : Sand	Finish Coat Cement : Sand or Cement : Sand : Lime
Concrete	Floor	-	1 : 2
	Interior wall	1 : 2	1 : 3 : 0.3
	Ceiling	1 : 2	1 : 3 : 0.3
	Exterior wall	1 : 2	1 : 3
Brick & Interior wall		1 : 3	1 : 3 : 0.3
Concrete Block masonry	Exterior wall	1 : 3	1 : 3

(2) Application

The surfaces which are to receive a rendering coat shall be roughened, brushed or washed clean, free from all laitance, scum, loose carbonate scale, loose aggregate, dirt and other foreign matter. In the case of brick surfaces, they shall be sufficiently and uniformly dampened immediately before the application of mortar.

Concrete surfaces shall be kept thoroughly wet for 24 hours prior to application of cement mortar.

Cement mortar shall be used within 30 minutes from the time of mixing. Retampering will not be permitted.

The rendering for tile work shall be made 18 mm thick and its surface shall be cross scratched. The rendering for an interior wall tile in the toilets and shower rooms as well as an exterior wall tile shall be mixed with water proofing admixtures approved by the Engineer. In the case of cement mortar finish, the total thickness of rendering and finishing coat shall be 30 mm for the floors, and 20 mm for walls and other places. When the finishing coat is applied, the entire surface of wall or ceiling shall be finished in one operation in order to minimize joint marks. Where expansion and control joints exist in the base structure, provision shall be made to prevent cracking of the cement mortar by inserting galvanized steel expansion beads within the coating thickness in a manner approved by the Engineer. The finished surface shall be perfectly plumb or level as the case may be without any bulging, runs, bruises or stains.

After application of the finishing coat, the surfaces shall be kept continuously damp for not less than 48 hours and then allowed to become thoroughly dry. Moistening shall be started as soon as the surface has hardened sufficiently to prevent displacement or damage.

Where shown on the Drawings or directed by the Engineer, metal wire lath shall be fixed to brick wall surfaces and into waterproof cement mortar on roofs before applying cement mortar plaster. The metal wire lath shall be galvanized expanded metal sheet with reinforcing ribs and shall be fixed with staples.

16.3 WATERPROOF CEMENT MORTAR

Waterproof cement mortar shall be applied to roofs, canopies, parapets, eaves and other places required as shown on the Drawing or as directed by the Engineer.

Cement mortar shall conform to the Specifications as provided for in this Section. Waterproof admixture shall be used in the cement mortar in accordance with the manufacturer's recommendations to effect waterproofing. Catalogues of waterproofing admixture shall be submitted to the Engineer for his approval.

16.4 EXPANDING GROUT

An expanding grout shall be used around any pipe passing through a concrete or masonry wall where water may stand on one or both sides of the wall and where the pipe is not embedded in the initially constructed structure. Such grout shall expand upon setting to effect bonding to the concrete and the pipe. An approved expanding agent shall be used and the grout composition shall conform to the manufacturer's instructions.

16.5 COLORED CEMENT MORTAR

The sand to be used shall have the same quality and grading as specified in this Section. The mix proportion of the colored cement mortar shall be 1 : 2 : 6 : 9 in ratios by volume of white cement, ordinary Portland cement, slaked lime and sand. Pigment and pattern shall be approved by the Engineer. Colored cement mortar shall be applied in two coats. The first coat shall be applied thinly and the second coat in sufficient thickness to produce a uniform appearance in color and texture. The second coat shall be applied 24 hours after the first coat.

16.6 WASHED GRAVEL

The sand to be used for gravel surfacing shall be course aggregate of well-graded, sound granular materials passing through a 9 mm mesh screen and retained on 6 mm mesh screen, unless otherwise instructed by the Engineer.

The mix proportion of the washed gravel shall be 0.05 : 1 : 2 by the volume of mineral pigment for coloring, ordinary portland cement and coarse aggregate.

The subsurface on which cement paste to be applied shall be swept clean and thoroughly moistened.

The mix shall be laid on the subsurface not less than 15 mm thickness to a level, dense and even surface by metal rollers in each panel formed by a clear wood strip.

Before the topping surface hardens, wash the surface thoroughly with brush and clean water until coarse aggregate is exposed about 1/3 of its thickness.

The completed gravel surfacing shall be kept moist and free of traffic during a 5-day curing period covered with building paper.

The surfaces shall be washed with cleaning compound mixed with warm water, and shall be cleaned with a fine abrasive where necessary to dry thoroughly.

Where gravel finished surfaces meet other surfaces, 1 cm width groove line shall be provided.

16.7 MEASUREMENT AND PAYMENT

Measurement for payment for cement mortar plaster, waterproofing cement mortar plaster, colored cement mortar and washed gravel shall be made on the basis of actual areas in square meters plastered and specifically for skirtings on the basis of length in linear meters plastered in accordance with the Drawings and the Specifications and as directed by the Engineer.

The unit prices shall include all necessary materials including admixtures, wire lath and any other relevant works required.

Pay items shall be as follows:

Item No.	Description	Unit
16.2 (1)	Cement Mortar Plaster, Wall	Square Meter
16.2 (2)	Cement Mortar Plaster, Floor	Square Meter
16.2 (3)	Cement Mortar Skirting, H=100	Linear Meter
16.3 (1)	Waterproof Cement Mortar	Square Meter
16.5 (1)	Colored Cement Mortar	Square Meter
16.6 (1)	Washed Gravel	Square Meter

SECTION 17 : DOOR AND WINDOW WORKS

17.1 GENERAL

The work under this Section shall comprise the supply of all labour, materials and plant and the performance of all work necessary for providing doors and windows in the buildings. Before manufacturing doors and windows, the Contractor shall submit shop drawings showing complete details of the doors and windows to the Engineer for his approval.

17.2 WOODEN DOOR LEAVES

17.2.1 General

Wooden door leaves shall be flush and assorted panel types 40mm in total thickness, installing panes, wood louvers and panels as shown on the Drawings.

All wood surfaces shall be sanded and putty applied to smooth surfaces to receive painting.

The plywood shall be covered with teak laminate, and varnished. Panes or louvers, if provided, shall be fixed with adequate beads.

17.2.2 Hardware

The Contractor shall supply and install the hardware for the wooden doors as listed in the Drawings.

The Contractor shall submit catalogues or samples of the hardware to the Engineer for his approval.

The hardware shall comply with the following requirements:

Hinges	:	Bronze or stainless steel, 13cm in approximate size, 3 hinges for each door leaf
Knobs	:	Stainless steel
Lock Sets	:	Bronze, cylindrical lock, 3 sets of key to be furnished
Door Closer	:	Die-cast aluminum body, oil and spring activated with 90 degree stop device
Push and pull	:	For toilets door, plastic made 15cm x 25cm in handle size.

17.2.3 Measurement and Payment

Measurement for payment for wooden doors shall be made on the basis of the actual total area in square meters of door leaves supplied, fabricated and fixed in accordance with the Drawings and the Specifications and as directed by the Engineer.

The unit price shall include supplying and installing wooden door leaves including hardware and any other relevant works required.

Painting finish for door leaves and wooden door frames shall be paid for under a separate item.

17.3 STEEL DOORS AND FRAMES

17.3.1 General

The work under this Section shall comprise the supply of all labour, materials and plant and the performance of all work necessary to supply and install steel doors and frames, in the buildings. The work shall be performed as shown on the Drawings or as directed by the Engineer and as specified herein.

All steel doors, frames and hardware shall be of first-class quality.

The Contractor shall submit shop drawings showing details of various parts, method of anchoring and any other pertinent details to the Engineer for his approval.

Before placing orders, the Contractor shall submit catalogues or samples of hardware to the Engineer for his approval.

All surfaces exposed to view shall be oil paint finished.

17.3.2 Hollow Steel Door Leaves

Hollow steel door leaves shall be fabricated of cold rolled steel sheet. The sheet thicknesses shall be as follows:

Panel	:	1.6mm
Stiffener plate and anchor plates	:	2.3mm

The door leaves shall be full flushed seamless panel type, 40mm thick unless otherwise specified. All four edges shall be sealed and ground smooth.

Door leaves shall be formed of cold rolled steel sheet. The sheet thickness shall be as follows unless otherwise specified:

Frame	:	1.6mm
Architrave	:	1.2mm
Threshold	:	2.3mm

Door frames shall be profiled accurately to details and dimensions shown on the shop drawings approved by the Engineer.

Door frames shall be reinforced, drilled and tapped to receive hardware and shall be provided with rubber bumpers.

Door frames shall be provided with adjustable anchors as required. Perimeters of door frames facing outdoor shall be securely caulked with approved caulking material.

17.3.3 Hardware

Hardware for the steel door shall comply with the requirements specified in the list of fittings shown on the Drawings. The Contractor shall submit catalogues or samples to the Engineer for his approval.

Each door shall be provided with the following hardware:

Hinge	:	Pivot hinge, 2 pieces for each door leaf
Knob	:	Stainless steel hair line finish
Lock Sets	:	Bronze, cylindrical lock, 3 sets of key to be furnished
Door Bolt	:	Bronze, surface or flush type
Door Closer	:	Die-cast aluminum body, oil and spring activated with 90 degree stop device.

The Contractor shall supply a key box as directed by the Engineer.

17.3.5 Measurement and Payment

Measurement for payment for steel doors shall be made on the basis of the total area in square meters of door leaves fabricated and fixed in accordance with the Drawings and the Specifications and as directed by the Engineer.

The unit prices for steel doors shall include supplying and installing each item including frames, louvers, hardware, caulking materials and any other relevant works. Painting finish will be paid for under a separate item.

17.4 ALUMINUM DOORS, WINDOWS, LOUVERS AND FRAMES

17.4.1 General

The work under this Section shall comprise supply of labour, materials and plant and the performance of all work necessary to supply and install aluminum doors, windows, louvers and frames in the buildings. The work shall be performed as shown on the Drawings or as directed by the Engineer and as specified herein.

All aluminum doors, windows, louvers and frames shall be of first-class quality.

The Contractor shall submit shop drawings showing details of various parts, method of anchoring and any other pertinent details for the approval of the Engineer.

Before placing orders, the Contractor shall submit catalogues of hardware to the Engineer for his approval.

17.4.2 Materials and Workmanship

All aluminum sections shall be of extruded aluminum satin anodized colour finish and before delivery shall be protected with strippable plastic. The plastic shall be removed after the major construction work has been completed.

Doors, windows, and louvers shall be furnished and installed complete with door and window frames, fixing lugs and glazing beads. Fixing lugs shall be firmly secured in the openings and the frames attached to the lugs so that glazing surfaces are vertical.

Prior to installation of doors, windows and louvers, the Contractor shall ensure that the surface of the concrete or steel to receive the frames are free from all loose and foreign material. All surfaces of the aluminum in contact with cement mortar, concrete or dissimilar metals shall be coated with bituminous paint or provide polyethylene film. The frames shall be installed in vertical planes without warping and shall be adjusted before glazing is commenced. Spaces between the frames and the surrounding concrete shall be grouted with cement mortar and outdoor perimeters sealed with approved caulking materials.

Insect screen shall be fabricated of extruded aluminum frames with wire secured in frames to the inner side of windows and louvers by means of spline or galvanized screws. Screen unit shall be removable and rewirable. Screen wire shall be aluminum mesh, stainless mesh or other approved wire.

The Contractor shall submit catalogues or samples of the hardwares to the Engineer for his approval.

The hardware shall comply with the following requirement:

Floor Hinge	:	Cast iron body with stainless steel cover, oil and spring activated with 90 degree stop device
Push and Pull Handle	:	For entrance door, stainless steel, 20cm x 20cm in size
Hinge	:	Bronze or stainless steel, 13cm in approximate size, 3 hinges to each door leaf (less than 2.1 meters high)
Knob	:	Stainless steel
Lock Set	:	Bronze, cylindrical lock, 3 sets of key to be furnished
Door Closer	:	Die-cast aluminum body, oil and spring activated with 90 degree stop device
Door bolt	:	Bronze, surface or flush type
Sash fastener	:	Die-cast aluminum

17.4.3 Measurement and Payment

Measurement for payment for the aluminum doors, windows, and louvers shall be made on the basis of areas in square meters of interior opening of the frames supplied, fabricated and installed in accordance with the Drawings and the Specifications and as directed by the Engineer.

The unit price shall include insect screen, hardware, caulking materials and any other relevant work required.

17.5 GLAZING WORK

17.5.1 General

The work under this Section shall comprise the supply of all labour, materials and plant and the performance of all work necessary for the glazing work in the buildings. The works shall be performed as shown on the Drawings or as directed by the Engineer and as specified herein.

17.5.2 Glass

Door and window panes shall consist of the following types of glass:

a. Plate glass – 8mm thick
b. Plate glass – 5mm thick
c. Plate glass – 3mm thick
d. Figured glass – 4mm thick

The brand and quality of glass shall be subject to the approval of the Engineer.

17.5.3 Glazing

All panes shall be accurately cut to fit in the frames with 3mm clearance all around. Panes in windows or door leaves shall be set in glazing mastic applied on all four sides for the full length by using spacer shims and vinyl splined glazing bead as recommended by the manufacturer.

Panes for wooden frames shall be fixed with wood stops.

All door and window panes shall be cleaned and polished when the building work is completed.

17.5.4 Measurement and Payment

Measurement for payment for glazing shall be made on the basis of the actual areas in square meters of openings glazed under each category in accordance with the Drawings and the Specifications and as directed by the Engineer.

The unit price shall include supplying and installing each type of glass including glazing mastic, beads, shims and any other relevant works required.

Pay items shall be as follows:

Item No.	Description	Unit
17.2 (1)	Wooden Glazed Flush Door	Square Meter
17.2 (2)	Wooden Flush Door	Square Meter
17.2 (3)	Wooden Panel Door	Square Meter
17.2 (4)	Wooden Glazed Window	Square Meter
17.3 (1)	Steel Flush Door	Square Meter
17.4 (1)	Aluminum Sliding Window	Square Meter
17.4 (2)	Aluminum Top Hinge Window	Square Meter
17.4 (3)	Aluminum Fixed Window	Square Meter
17.4 (4)	Aluminum Louver	Square Meter
17.4 (5)	Aluminum Doors	Square Meter
17.5 (1)	Clear Glass, 8mm	Square Meter
17.5 (2)	Clear Glass, 5mm	Square Meter
17.5 (3)	Clear Glass, 3mm	Square Meter
17.5 (4)	Figured Glass, 4mm	Square Meter

SECTION 18 : PAINTING WORK

18.1 GENERAL

The work under this Section shall comprise the supply of labour, materials and plant and performance of all work necessary for applying painting finishes to the interior and exterior surfaces of the buildings and facilities. The work shall be performed as shown on the Drawings or as directed by the Engineer and as specified herein.

18.2 MATERIALS

Paints shall be of the best quality of its kind. The Contractor shall submit catalogues and specifications of all paints to be used to the Engineer for his approval.

18.3 APPLICATION

(1) General

All metal components other than galvanized steel shall be prepared and primed in the shop and finish painted after erection. Metal cabinets and machinery shall be prepared, primed and given two coats of paint in the shop and all damaged places shall be cleaned and touched-up after installation is completed.

Metal surfaces shall be cleaned with mechanical methods by metal scrapers and wire brush to remove all mill scale, weld spatter, rust and any other deleterious materials. Oil and grease shall be removed by an approved solvent. The surfaces shall be wiped clean of any dust prior to priming. Priming shall be done immediately after cleaning to prevent new rust. Any primed surfaces that shown rusting, flaking, powdering or peeling shall be recleaned and repainted.

All wood surface to receive paint shall be cleaned of all dirt, grease, dust or any other deleterious matters. All surfaces shall be thoroughly sanded and all nail holes, cracks and any other defects shall be puttied, re-sanded to a smooth and flush finish. The painted surface shall show a smooth, level and uniform finish, free from any stains and shall be uniform in colour and shade.

Concrete surfaces to be painted shall be treated with a thin cement plaster to smooth the surfaces. Any flaws, holes shall be filled up with cement plaster and

left for about 3 weeks. After hardening, the surfaces shall be rubbed with a hardwood block and dusted.

All painting work shall conform to the manufacturer's specifications and instructions.

Painting shall not be done in rain, fog or mist, or at any other time considered unsuitable by the Engineer.

All the surrounding works shall be protected in a suitable manner from paint drops and overspray. All smeared and damaged surfaces shall be cleaned or repaired to the Engineer's satisfaction.

Colours shall be later designated by the Engineer.

(2) Oil Paint to Metal Surfaces

The roof truss and deck plates shall be primed prior to delivery to the site, then paint shall be applied after erection of the structure steel at the site.

Steel doors, steel louvers and all other miscellaneous steel surfaces shall be painted with one coat of anti-corrosive paint and 2 coats of oil paint. Sufficient time shall be allowed for drying between each new coat.

Galvanized metalwork to be painted shall be first etched with 5% acetic acid and washed clean before priming.

(3) Oil Paint to Wooden Surfaces

Wooden doors and all other wooden surfaces to receive paint shall be thoroughly dry and free from foreign substances.

Paints shall be applied in 3 coats including one coat of primer paint. Sufficient time shall be allowed for drying between each new coat.

(4) Acrylic Emulsion Paint to Cement Mortar and Concrete

The cement mortar shall be left to dry for a minimum period of 3 weeks after application. The acrylic emulsion paint shall be applied in 3 coats for interior and

exterior walls and ceilings including a primer coat. Minimum 12 hours shall be allowed before application of each successive coat.

(5) Acrylic Emulsion Paint to Gypsum Board

The surfaces of gypsum board shall be puttied to remove any flaws and gaps and rubbed down with fine sand paper to smooth surface.

Paint shall be applied in 3 coats including a primer coat. Minimum 12 hours shall be allowed before application of each successive coat.

(6) Clear Lacquer and Varnish Finish

Wood surfaces shall be carefully sandpaper smoothed. Clear lacquer finish shall be applied in 3 coats to a clear and uniform finish in shade and to reveal the grain of the wood.

Varnish finish shall applied to wooden base in the same manner as clear lacquer.

18.4 MEASUREMENT AND PAYMENT

Measurement for payment for painting work shall be made on the basis of the actual area in square meters of painted surface supplied and applied in accordance with the Drawings and the Specifications and as directed by the Engineer.

The unit price shall include all surface preparation and making good painting after damage by other trades and any other relevant works required.

Pay items shall be as follows:

Item No.	Description	Unit
18.3 (1)	Oil Paint to Steel	Square Meter
18.3 (2)	Oil Paint to Wood	Square Meter
18.3 (3)	Acrylic Emulsion Paint, Exterior	Square Meter
18.3 (4)	Acrylic Emulsion Paint, Interior	Square Meter
18.3 (5)	Clear Lacquer Paint to Wood	Square Meter
18.3 (6)	Varnish Paint to Wood	Square Meter

SECTION 19 : CARPENTRY AND JOINERY WORK

19.1 GENERAL

The work under this Section shall comprise the supply of all labour, materials and plant, and the performance of all work necessary for the fabrication and fixing of carpentry and joinery works in the building. The work shall be performed as shown on the Drawings or as directed by the Engineer and as specified herein. The Contractor shall submit working drawings for respective work items in this Section to the Engineer for his approval.

19.2 MATERIALS AND WORKMANSHIP

Timber shall be of suitable kinds for the purposes and the best grade of each kind which are available locally. Selection of timber shall be subject to the approval of the Engineer.

All timber shall be well-seasoned and shall be free from large knots, flaws, shakes or blemishes of any kind. Timber with loose, rotten or dead knots will not be accepted. Sawn timber shall have the shape and size shown on the Drawings and twisted or warped materials shall not be used.

All wooden members shall be brought and fixed exactly as shown on the Drawings and planed wherever exposed to view. Wood members not to be painted and having direct contact with concrete shall receive a coat of creosote prior to fixing. Wood members to be painted or exposed shall be painted with an approved clear type preservative. All wood members not to be exposed shall receive approved termite resistive chemicals.

(1) Wooden Handrails

Wooden handrails shall be moulded and polished as shown on the Drawings and fixed to the metal base using screws at 30cm intervals. The surfaces of handrails shall be coated with clear lacquer.

(2) Partition Screens

Partition screens shall be installed in toilets as shown on the Drawings. Panel cores shall be of hollow core panel covered with waterproof plywood 6mm thick. Total thickness of the partition screen shall be 40mm thick, and panel surfaces

shall be overlaid with plastic laminate on the plywood. The panel covers shall be fixed to the cores with synthetic adhesive and all sides of the panels shall be trimmed with hard wood. Metal foot stands shall be securely anchored to the concrete floor slab prior to the floor finish. Wall angle brackets shall be fixed by ornamental screws secured into the rendered cement mortar on the walls.

The following metal hardware shall be used for partition screens:

Hinges	:	Stainless steel, spring type
Latches and strikers	:	Chrome plated brass
Door stops	:	Chrome plated brass with rubber top
Foot supports	:	Chrome plated brass
Angle metal and coping metal	:	Stainless steel or chrome plated brass with ornamental screws and bolts

(3) Wooden Door Frames

All wooden door frames shall be made of hard wood and mortise jointed. The door frames shall be moulded as shown on the Drawings or as directed by the Engineer, and sanded and putty applied to a smooth surface to receive vanish paint. The frames shall be securely fixed to the walls by using galvanized steel lugs.

(4) Wooden Skirting

Wooden skirting shall be made of hard wood with mortise joints, moulded at top as shown on the Drawings or as directed by the Engineer. The surface of the skirting shall be sanded and putty applied to a smooth surface to receive varnish paint.

The skirting shall be securely fixed to the wall by using galvanized steel lugs at approximately 1.0 meter at intervals before applying the wall plastering.

19.3 MEASUREMENT AND PAYMENT

Measurement for payment for wooden handrails, wooden door frames and wooden skirting shall be made on the basis of the actual lengths in linear meters of each item installed in accordance with the Drawings and the Specifications and as directed by the Engineer.

Measurement for payment for partition screen shall be made on the basis of the actual area in square meters of partition screens installed in accordance with the Drawings and the Specifications and as directed by the Engineer.

The unit price for handrails shall include supplying and installing the wooden handrails including steel balusters, steel plates, cover plates and any other relevant works required.

The unit price for wooden door frames and wooden base shall include supplying and fixing of each item including wooden blocks and any other relevant works required.

The unit price for partition screen shall include supplying and installing the partition screens including all necessary fixing devices and hardware.

Painting finish to the wooden surfaces shall be paid for under a separate item.

Pay items shall be as follows:

Item No.	Description	Unit
19.2 (1)	Wood Handrail	Linear Meter
19.2 (2)	Wood Door Frame	Linear Meter
19.2 (3)	Wood Skirting, H=100	Linear Meter

SECTION 20 : INTERIOR FINISHING WORK

20.1 GENERAL

The work under this Section shall comprise the supply of all labour, materials and plant, and the performance of all work necessary for the interior finishing works in the buildings. The work shall be performed as shown on the Drawings or as directed by the Engineer and as specified herein.

20.2 MATERIALS

All materials shall be of the best quality and shall comply with the applicable standards. The Contractor shall submit samples and/or catalogues of the finishing materials to the Engineer for his approval.

(1) Acoustical Tile Suspension System

Acoustic tiles shall be of a product of plaster and rockwool having a fissured surface simulating travertine stone with a white finish, and shall be approximately 600 x 1200 x 15mm in size.

(2) Metal Spandrel and Panel Ceilings

Metal spandrel ceiling shall be of siding board type aluminum ceiling tile approximately 0.8mm thick, 100mm wide anodized aluminum sheathing flanged on both sides.

Metal panel ceiling shall be of formed aluminum panel ceiling approximately 1000mm by 1000mm in size and 2.0mm thick with recessed joints. The panel shall be anodized and colored approved.

(3) Vinyl Floor Tile

Vinyl floor tiles shall be of high quality, resilient tiles 300mm x 300mm x 2mm thick.

(4) Vinyl Soft Base

Vinyl soft base to skirting shall be of 100mm high.

(5) Gypsum Board Suspension System

Gypsum board shall be of a plastered board laminated with craft paper on both sides with a dimension approximately 600x600x9mm in size. . The tiles to be used for toilets, pantry and exterior or similar portions as shown on the Drawings shall be of moisture resistent type.

(6) Welded Mesh Ceiling

Welded mesh ceiling shall consist of galvanized welded mesh 6ϕ, 150mm grid and galvanized steel ceiling suspension systems.

20.3 INSTALLATION

(1) Acoustical Tile Suspension System

Ceiling suspension system shall be constructed of hot-dip galvanized steel, exposed grid type suspension system complete with anchors, hangers, clips, main runners, furring strips, and such other accessories as ceiling moulding.

Main runners shall be provided at intervals of approximately 120cm, installed with allowance for adequate camber. They shall be designed for ceiling loads of 70 kg/m^2.

Furring strips shall be provided at intervals of approximately 60cm according to the ceiling material. Adjustable suspending rod shall be provided at approximately 90cm on main runners. Adequate reinforcing and metal framing shall be provided for mounting the lighting fixtures and ceiling access holes.

Acoustic tile shall be installed on the main runner and furring strips true to level and line.

Ceiling trims shall be of the same steel with the system and fixed to the wall as shown on the Drawings.

The entire suspended ceiling shall be to the level shown on the Drawings with adequate camber and shall not have a deviation in levels and lines of more than 3mm in 4m bay.

(2) Metal Spandrel and Panel Ceiling

Aluminum spandrel shall be fixed on the metal ceiling suspension system.

Metal ceiling suspending system shall consist of anchors, hangers, clips, main runners, furring strips and other accessories and all other related works required. The method of installation shall strictly comply with the manufacturer's specifications.

Main runners shall be provided at approximately 90cm intervals and installed with allowance for adequate camber. They shall be designed for ceiling loads of $70kg/m^2$.

Furring strips shall be provided at intervals of 30cm or according to the ceiling material of manufacturer's requirements. Adequate reinforcing and metal framing shall be provided for mounting the lighting fixtures and other openings.

Aluminum spandrel shall be securely fixed to the metal suspended ceiling systems with galvanized screws true to level and line. Completed surface shall not have a deviation in level and lines of more than 3mm in 4m bay.

Ceiling trims shall be of aluminum moulding with uniform colour to a spandrel ceiling and fixed around walls and lighting fixture as shown on the Drawings.

Expansion joints and reinforced openings for lighting fixtures shall be provided where shown on the Drawings.

The aluminum panel ceiling shall be fixed on the metal ceiling suspension system as specified herein. The joint shall be of aluminum trims with uniform colour to a panel ceiling.

(3) Vinyl Floor Tile

Floor surfaces upon which tiles are to be placed shall be covered with a cement plaster bed 30mm thick bonded to the structural concrete as specified in Section 16 plastering work in this Specifications. The plastered surfaces shall be clean and free from dust, oil and moisture. The back surfaces of the tiles shall be clean.

Vinyl floor tile shall be applied with adhesives upon the plastered surface in such a manner as to produce a tiled surface tightly bonded to the floor. Adjacent tiles shall be butted tightly together to form straight continuous joints and uniform regular patterns as shown in the Drawings or as prescribed by the Engineer.

Adhesive for applying tiles shall be of epoxy resin type and furnished in sealed containers bearing the manufacturer's label and instructions for application.

The moisture protection film shall be provided underside of the ground floor slabs where the vinyl floor tiles are to be laid on the floor as specified in Section 13.

(4) Vinyl base for skirting

Vinyl base shall be applied on a smooth surface, dry and clean. Adhesive shall be applied and vinyl base firmly placed with its toe in contact with the finished floor. The base shall then be rolled with a roller. External and internal corners shall be installed with preformed pieces.

(5) Gypsum Board Suspension System

Gypsum ceiling suspension system shall be installed in the same manner as in the acoustical tile suspension systems stated hereinbefore and in accordance with manufacturer's instructions.

(6) Welded Mesh Ceiling

Welded mesh shall be securely fixed on the ceiling bed with galvanized steel clumps and shall be baked enamelled. The Contractor shall submit working drawing to the Engineer for his approval.

20.4 MEASUREMENT AND PAYMENT

Measurement for payment for acoustical tile suspension system, metal spandrel ceilings, metal panel ceiling, gypsum board suspension system and welded mesh ceiling shall be made on the basis of the actual areas in square meters of ceiling installed in accordance with the Drawings and the Specifications and as directed by the Engineer.

The unit price for acoustical tile, metal spandrel, metal panel, welded mesh and gypsum board ceilings shall cover supplying and installing the ceiling materials

including complete suspending system, the provision of access holes and covers and any other relevant works required.

Measurement for payment for vinyl floor tile and vinyl base to skirting shall be made on the basis of the actual areas in square meters of vinyl floor tile and the length in linear meters of vinyl base applied respectively in accordance with the Drawings and the Specifications and as directed by the Engineer.

The unit price shall cover supplying and installing the vinyl floor tile or vinyl base including adhesive and other relevant works required.

Pay items shall be as follows:

Item No.	Description	Unit
20.2 (1)	Acoustical Tile Ceiling, t=15	Square Meter
20.2 (2)	Aluminum Spandrel Ceiling, t=0.8	Square Meter
20.2 (3)	Aluminum Panel Ceiling, t=2.0	Square Meter
20.2 (4)	Gypsum Board Ceiling, t=9	Square Meter
20.2 (5)	Vinyl Floor Tile, 300x300x2	Square Meter
20.2 (6)	Vinyl Soft Base, H=100	Square Meter
20.2 (7)	Welded Mesh Ceiling, 6ϕ, 150x150	Square Meter

SECTION 21 : MISCELLANEOUS METAL WORK

21.1 GENERAL

The work under this Section shall comprise the supply of all labour, materials and plant and the performance of all work necessary to install miscellaneous metal work in the buildings. The work shall be performed as shown on the Drawings or as directed by the Engineer and specified herein.

21.2 MATERIALS

All materials to be incorporated in the works shall be of the best of their kind.

Catalogues of non-slip stair nosing, roof drains, floor drains and steel roofing shall be submitted to the Engineer for his approval.

The Contractor shall prepare and submit shop drawings showing complete details of all miscellaneous steel parts, assemblies, components, supports and connections to the Engineer for his approval.

The work shall be shop fitted and shop assembled where possible.

Wherever necessary, metals shall be insulated to prevent electrolysis due to contact with dissimilar metals. Insulation shall be made by means of bituminous paint or other approved means.

21.3 MATERIALS AND INSTALLATION

(1) Roof and Floor Drains

Roof and floor drains of the buildings shall be of cast iron body, heat coated with asphalt. Care shall be exercised in fitting the surrounding waterproofing works to prevent any damage to the water proofing membrane. Caulking shall be applied as required.

Floor drains shall be fitted with flat removable cast iron grate. Roof drain grates shall be convex in profile at least as high as the pipe diameter and the total area of the openings of the grate shall be larger than 1.5 times the cross-sectional area of the drain pipe. Grates shall be fixed with noncorrosive screws.

Roof drains shall have two flanges. The bottom flange shall be integral with the drain body and shall be set with anchor lugs to coincide with the waterproof membrane or with top surface of the surrounding concrete. The top flange shall be screwed to the bottom flange and shall be set lower than the surrounding roof finish. The two flanges shall be used to clamp the roof waterproof membrane.

(2) Non-Slip Nosing

Non-slip stair nosing shall be of stainless steel with serrated or plastic tire for non-slip. The nosing shall be approximately 40mm wide and installed on the full width of each stair tread as detailed on the Drawings. Anchorage shall be provided to the underside of the nosing.

(3) Stainless Steel Handrails and Screen

Stainless steel handrails shall be provided for the stairs and other places as shown on the Drawings. The handrails shall be fabricated with stainless steel pipes. Embedded feet of balusters shall be weld-connected to the reinforcement bars in the structure. All surfaces of stainless steel shall be hair-line finished.

Stainless steel screen shall be fabricated with stainless pipes and shall be securely fixed to studs and floor in accordance with the Drawings and as directed by the Engineer.

(4) Steel Handrails

Steel handrails shall be provided for the processing open area and other places as shown on the Drawings. Steel handrails shall be fabricated of mild structural steel pipes. Embedded feet of balusters shall be weld-connected to the reinforcement bars in the structure. Oil paint finish shall be applied to all exposed steel surfaces.

(5) Steel Ladders and Steel Caged Ladders

Steel ladders and steel caged ladders shall be fabricated and installed to concrete structure as shown on the Drawings. Anchor plates shall be embedded in concrete at the proper locations while the concrete is placed, or recesses shall be left in the concrete for anchors and thoroughly grouted with cement mortar after setting anchors. Oil paint finish shall be applied to all exposed steel surface.

(6) Door Mats

Stainless steel door mats shall be provided in front of the entrance door as shown on the Drawing. The door mat shall be of grating fabricated of stainless steel flat bars into a depth of not less than 30mm, set in a recess provided in the floor. Polyvinyl chloride drain pipe shall be provided under the door mat recess.

(7) Cable Trench Covers

Cable trench covers for floor cable duct shall be of checkered steel plate 4.5mm thick unless otherwise specified. Bearings shall be fabricated of steel angles with floor trimmings and anchorages. The checkered steel plates shall be properly reinforced with steel angles depending on the sizes of the floor duct provided with lifting devices and set flush with the floor finish. Conccaled surfaces shall be anti-corrosive painted and surfaces exposed to view shall be oil paint finished.

(8) Roof Gutters

Roof Gutters shall be provided for in the required places as shown on the Drawings. The gutters shall be approximately 300mm x 400mm, 120mm x 150mm in size as shown on the Drawings and fabricated of galvanized steel sheet 0.5mm in thickness with steel reinforcing frames and supporting arms at approximately 2.0m intervals. The arms shall be securely fixed to the eaves frames with bolts. Galvanized steel surfaces shall be oil painted.

(9) Steel Roofing

Steel Roofing for the structural steel roofs shall be of a formed steel roofing systems consisting of fixing clips, ridge capping, barge capping, fascia capping, flashing and other accessories including all related works required.

The roofing shall be a pre-painted and organic film laminated galvanized steel sheet with approximately 0.5mm total coated thickness. The roofing shall be rollformed steel roofing with formed side hems to conform to ASTM A792 M or equivalent standards.

The roofing shall be placed on the supporting steel purlines provided at approximately 180cm intervals and adjusted for proper alignment. The method of installation shall strictly comply with the manufacturer's specifications.

(10) Fittings for the Handicapped

Public toilet booths for the handicapped shall be provided with stainless steel pipe fixed or movable handrails, bars, inclinable mirror, emergency call button and other complete accessories in accordance with the appropriate regulation and the Drawings and as directed by the Engineer.

(11) Security Cages

The security cages shall be installed to cover the outdoor units of the air-cond. unit to be provided behind the inspection booths as shown on the Drawings. The security cages shall comprise steel angle frames, wire meshes and entrance door with padlock. All steel exposed to view shall be primed and painted. Concrete foundation shall be constructed to a dimension as shown on the Drawings.

(12) Manhole Covers

The manhole covers provided at the fire water tank and other portion shall be made of cast iron and water-proof type with a locking device. The location and size of manholes shall be as shown on the Drawings and as directed by the Engineer.

The manhole shall be coated with the approved paint.

21.4 MEASUREMENT AND PAYMENT

Measurement for payment for roof drains, floor drains, door mats and manhole covers shall be made on the basis of number of each item in pieces or numbers installed under each category in accordance with the Drawings and the Specifications and as directed by the Engineer.

Measurement for payment for non-slip nosing, steel and stainless handrails, stainless screen, steel ladders, steel caged ladders and roof gutters shall be made on the basis of nominal lengths in linear meters of each item installed under each category in accordance with the Drawings and the Specifications and as directed by the Engineer. Balusters and intermediate rails shall not be counted in the measurement of steel handrails. Reinforcing frames and supporting arms for gutters shall also not be counted.

Measurement for payment for cable trench covers shall be made on the basis of area in square meters of checkered steel plates installed in accordance with the Drawings and the Specifications and as directed by the Engineer.

Measurement for payment for steel roofing shall be made on the basis of area in square meters of steel roofing installed in accordance with the Drawings and the Specifications and as directed by the Engineer.

Measurement for payment for fittings for the handicapped, and security cages shall be made on the lump sum basis installed in accordance with the Drawings and the Specifications and as directed by the Engineer.

The unit price for each item shall include supplying and installing each item including any other relevant works required. Paint finishes will be paid for under a separate item.

Pay items shall be as follows:

Item No.	Description	Unit
21.3 (1)	Roof Drain, C.I. 100ϕ	Each
21.3 (2)	Roof Drain, C.I. 125ϕ	Each
21.3 (3)	Roof Drain, C.I. 200ϕ	Each
21.3 (4)	Floor Drain, C.I 100ϕ	Each
21.3 (5)	Non-Slip Nosing, W=40	Linear Meter
21.3 (6)	Stainless Handrail	Linear Meter
21.3 (7)	Stainless Screen, H=2,500	Linear Meter
21.3 (8)	Steel Handrail, H=1100	Linear Meter
21.3 (9)	Steel Ladder, 22ϕ, W=400	Each
21.3 (10)	Steel Caged Ladder, W=400	Linear Meter
21.3 (11)	Door Mat, Stainless, 600x1500	Each
21.3 (12)	Cable Trench Cover	Square Meter
21.3 (13)	Roof Gutter, 300x400	Linear Meter
21.3 (14)	Roof Gutter, 150x120	Linear Meter
21.3 (15)	Formed Steel Roofing	Square Meter
21.3 (16)	Fittings for Handicapped	Lump Sum
21.3 (17)	Security Cage	Lump Sum
21.3 (18)	Manhole Cover, C.I. 600x600	Each

SECTION 22 : MISCELLANEOUS WORK

22.1 GENERAL

The work under this Section shall comprise the supply of all labour, materials and plant, and the performance of all work necessary for the fabrication and installation of miscellaneous work in the buildings. The work shall be performed as shown on the Drawings or as directed by the Engineer and as specified herein.

22.2 MATERIALS

Each item shall be of the best of its kind in design, quality and appearance and free from any defect that would impair strength, durability or appearance. Catalogues and/or working drawings shall be submitted to the Engineer for his approval.

22.3 MATERIALS AND INSTALLATION

The work shall be fitted and assembled in the shop as much as possible. The work shall be erected true and straight, accurately fitted with tight joints and intersections. All works shall be reinforced where required. The rims shall be neatly and accurately mitred. Where screws are used, the heads shall be concealed.

(1) Kitchen Sink Units

Kitchen sink units shall consist of a sink unit and a range table unit having dimensions as shown on the Drawings. The counter tops and rim of the units shall be made of stainless steel plate not less than 0.6mm thick or ceramic tile finish on reinforced concrete slab supporting by brick wall. The remaining parts shall be of wooden fabrication finished with melamine or polyester resin. Metal flashing shall be provided in the back of kitchen sink unit as shown on the Drawings. The metal flashing shall be of stainless steel sheet 0.6mm thick and securely fixed to the wall. Caulking shall be applied to the joint of flashing metal and wall finish.

(2) Cupboard Units

Cupboards shall be fabricated and installed as detailed on the Drawings. Cupboards shall be of wooden fabrication finished with melamine or polyester resin, with chromium-plate finish hardware.

(3) Downspouts

Downspouts shall be of polyvinyl chloride pipe with adaptable fittings. The downspouts shall be securely fixed to the walls or columns with galvanized steel rung supports at approximately 150cm intervals. All surfaces exposed to view shall be oil painted.

(4) Expansion Joint Filler

Joint filler for expansion joints shall be of foamed plastic board 50mm thick or other approved equivalent materials. The Contractor shall submit samples or catalogues of the joint filler to the Engineer for his approval.

(5) Room Name Plates

Room name plates shall be provided on the entry door of each room. The plates shall be made of acrylic resin plate and fixed with stainless screws or other approved fixing devices. Size of the plates shall be approximately 8cm x 35cm. On the plate shall be engraved the name of the room as directed by the Engineer.

(6) Venetian Blinds

Venetian blind shall be of a horizontal type made of colored aluminum blade 25mm in width. The blind shall consist of a complete set of head roller and aluminum rail, bottom chains, box and operating devices. The blind shall have adequate dimensions to cover the whole area of the required window and securely fixed to the wall with screws. The Contractor shall submit samples or catalogues of the blind to the Engineer for his approval.

(7) Shower Curtain and Rail

Shower Curtain and rails shall be installed where shown on the Drawings. The curtain rail shall be chromium-plated steel pipe and shall be securely fixed to the wall with chromium-plated ferrule and screw. Vinyl shower curtain shall be provided.

(8) Roof Insulation

The roof insulation shall be of approximately 50mm thick glass fiber sheets with density approximately 48kg/m3 packed with the glass fiber cloth and laid on the

underside of the roof concrete slabs by using galvanized wire mesh with fixing screws. The glass fiber shall conform to TIS or equivalent standard approved.

The Contractor shall submit working drawings showing fixing methods to the Engineer for his approval.

(9) Roof Tiling

Roof tiling work shall be of a first grade colored roof tile laying system consisting of roof tiles, steel bed furrings, fixing clips and other parts with insulation papers necessary for completion of the works.

The Contractor shall submit the catalogue, samples and working drawings to the Engineer for his approval.

The roof tile shall be of colored concrete made with ridge tile, ridge end, gable tile, hip end and other complete parts conform to TIS 535-2530 or equivalent approved.

The roof tile shall be securely fixed onto the hot-dipped steel furring provided approximately 1.0m centres by using fixing nails and holding clips.

The reflective insulation paper, which consist of aluminum and moisture films, asphalt primer and craft paper, shall be laid onto the furring strips.

(10) Window Flashing Frames

Window flashing shall be provided all around marginal window sashes to details and dimensions as shown on the Drawings or as directed by the Engineer.

The flashing shall be constructed with reinforced concrete and finished on the upper surfaces with steel trowel. The flashing shall be secured to the adjacent walls by using steel lugs on all four sides.

(11) Fibre Cement Roof Tiling

Fibre cement roof tiling shall be of a formed fibre cement tile approximately 50cm wide by 120cm or 150cm long and 0.4cm or 0.5cm thick products with complete accessories in conformity with TIS or appropriate standards.

The fixing shall be made strictly in accordance with manufacturer's instruction.

Color and pattern shall be selected by the Engineer.

(12) Gable Decoration

Gable decoration shall be constructed with reinforced concrete to dimensions as shown on the Drawings. The gable decoration shall be anchored to the reinforced beam at the bottom and roof trusses at the top by using fixing steel members.

The gable decoration shall be finished with acrylic emulsion paint after fixing.

(13) Connection Corridor

The arrival and departure buildings in the main office of Lao PDR-BCF shall be connected to each other by two sets of connection corridors.

The corridor shall comprise a set of supporting steel beam with a steel deck plate and concrete slab reinforced with welded mesh. Main framing on the floor shall be constructed with steel square tube framing provided at 1.5m spacing and fixed on the beams. Each framing shall be connected by steel tube at top.

All finishing and accessories shall be constructed in accordance with the Drawings and the Specifications and as directed by the Engineer.

(14) Inspection Booth

Inspection booth shall be of prefabricated aluminum cells classified into two types: one shall have two cells with 2.4m by 4.0m floor area and the other shall have one cell with 2.4m by 2.05m and 2.0m by 2.25 floor area.

The booth shall be composed of galvanized steel framings, aluminum claddings and complete sealing to all external joints and constructed on the reinforced concrete foundation.

The booth shall be provided with built-in working desk in each cell and equipped with complete electrical and mechanical equipment.

The Contractor shall construct the booths in accordance with the Drawings and the Specifications and as directed by the Engineer. Prior to fabrication the

Contractor shall submit shop drawings and samples to the Engineer for his approval.

(15) Aluminum Cladding

Aluminum cladding shall be of formed aluminum panels 2.0mm thick and cladded the top and the face of the steel columns as shown on the Drawings.

The claddings shall be securely fixed with stainless screws to galvanized steel furring strips which shall be provided approximately 400mm at vertical intervals to the portion not less than 2,000 mm in height from the finished floor level to withstand any external impact.

The surfaces of the panels exposed to view shall be anodised and colored approved. All external joints shall be sealed with polysulfide type caulking.

The Contractor shall submit shop drawings showing all details and samples to the Engineer for his approval.

(16) Inspection Table

Custom inspection table shall be composed of concrete counter table and supporting brick walls. The counter top shall be covered with hair-lined stainless steel plate 1.2mm thick on the plywood base panel 15mm thick in accordance with the Drawings. The Contractor shall submit shop drawing showing all portions to the Engineer for his approval.

(17) Mirrors

Mirrors shall be 6mm thick polished plate second silvered glass and shall be 550mm high and with the length as shown on the Drawings. The mirror shall be set in chromium-plated metal arms which shall be securely attached to the walls with bolts or approved means. All parts shall be smooth and true.

22.4 MEASUREMENT AND PAYMENT

Measurement for payment for the sink unit, room name plates, and cupboards, inspection booth shall be made on the basis of number of each item in set installed in accordance with the Drawings and the Specifications and as directed by the Engineer.

Measurement for payment for the downspouts, window flashing frames and mirrors shall be made on the basis of the nominal lengths of downspout, flashing frames and mirrors in linear meters installed in accordance with the Drawings and the Specifications and as directed by the Engineer.

Measurement for payment for the expansion joint fillers, venetian binds and shower curtains shall be made on the basis of area of each item in square meters installed in accordance with the Drawings and the Specifications and as directed by the Engineer.

Measurement for payment for roof insulation, roof tiling, fibre cement roof tiling and aluminum cladding shall be made on the basis of area of the roof insulation, roof tiling, fibre cement roof tiling and aluminum cladding laid in accordance with the Drawings and the Specifications and as directed by the Engineer.

Measurement for payment for gable decoration, connection corridor and inspection counter shall be made on the lump sum basis erected in accordance with the Drawings and the Specifications and as directed by the Engineer.

The unit prices for the above item shall cover supplying and installing each item including all necessary fixing devices, components, caulking where required and any other relevant works required.

The lum sum price for the gable decoration, connection corridor and inspection counter shall include supplying and erection and all other relevant works required.

Pay items shall be as follows:

Item No.	Description	Unit
22.3 (1)	Kitchen Sink Unit, l=1800	Each
22.3 (2)	Kitchen Table Unit, l=900	Each
22.3 (3)	Cupboard, l=1800	Each
22.3 (4)	Downspout, PVC, 100ϕ	Linear Meter
22.3 (5)	Downspout, PVC, 125ϕ	Linear Meter
22.3 (6)	Downspout, PVC, 200ϕ	Linear Meter
22.3 (7)	Expansion Joint Filler, t=20	Square Meter
22.3 (8)	Room Name Plate, 80x350	Each
22.3 (9)	Venetian Blinds	Square Meter
22.3 (10)	Shower Curtain and Rail	Square Meter
22.3 (11)	Roof Insulation, t=50	Square Meter

22.3 (12)	Concrete Roof Tiling w/Complete Parts	Square Meter
22.3 (13)	Window Flashing Frames	Linear Meter
22.3 (14)	Fiber Cement Roof Tiling	Square Meter
22.3 (15)	Gable Decoration	Lump Sum
22.3 (16)	Connection Corridor	Lump Sum
22.3 (17)	Inspection Booth, 2400x4000	Each
22.3 (18)	Inspection Booth, 2400x2050	Each
22.3 (19)	Inspection Booth, 2000x2250	Each
22.3 (20)	Aluminum cladding	Square Meter
22.3 (21)	Inspection Counter	Lump Sum
22.3 (22)	Mirrors	Linear Meter

SECTION 23 : OUTDOOR WORK

23.1 GENERAL

The work under this Section shall comprise the supply of all labour, materials and plant, and the performance of all work necessary for construction of the plant boxes and planting to the boxes and other area as shown on the Drawings. The work shall be performed as shown on the Drawings or as directed by the Engineer and as specified herein.

23.2 PLANT BOXES

The plant box shall be constructed with brick walls and plastered internal and external to the dimension as shown on the Drawings. The walls exposed to view shall be sand wash finished in accordance with the Specification of concrete work and plastering finish.

23.3 PLANTING AND TURFING

Grass area shall be furnished and constructed where shown on the Drawings. The work shall be composed of constructing concrete, masonry or rock borders, placing top soil, fertilizing, planting trees and flowers and turfing. The top soil shall be of fertilized black soil and shall be placed minimum 300mm in depth. The trees and flowers shall be best quality and good appearance available within the area and approved by the Engineer.

The Contractor shall be responsible for the care of planting and turfing areas for a period of 30 days, and shall water the areas whenever necessary, and when directed by the Engineer during this period, any trees, shrubs or sodding which die or fail to take root shall be replaced by the Contractor.

23.4 DRAIN DITCH AND CATCH BASIN

Drain ditch and catch basin shall be constructed with reinforced concrete to a dimension and location as shown on the Drawings and as directed by the Engineer.

Concrete covers shall be provided onto the drain ditches located in front of the entrance, passageways and catch basins. The covers shall be provided with appropriate slits for lifting.

23.5 MEASUREMENT AND PAYMENT

Measurement for payment for the plant boxes and drain ditches shall be made on the basis of the length in linear meters of the wall lines constructed in accordance with the Drawings and the Specifications and as directed by the Engineer.

The unit price shall include supplying and installing concrete and brick walls, foundation concrete, cement plastering, PVC 50mm ϕ drain pipes, and sand wash finishing and any other relevant works required.

Measurement for payment for the planting and turfing shall be made on the basis of lump sum in accordance with the Drawings and Specifications and as directed by the Engineer.

The unit price shall include constructing concrete, masonry or rock borders, supplying and furnishing top-soil, fertilizing, planting trees and flower, turfing and any other relevant works required.

Measurement for payment for catch basin shall be made on the basis of numbers constructed in accordance with the Drawings and Specifications and as directed by the Engineer.

The unit price shall include constructing concrete walls, foundation, covers and any other relevant works required.

Pay items shall be as follows:

Item No.	Description	Unit
23.2 (1)	Plant Box	Linear Meter
23.3 (1)	Planting	Lump Sum
23.3 (2)	Turfing	Lump Sum
23.4 (1)	Drain Ditch, W=300	Linear Meter
23.4 (2)	Catch Basin, 600x600	Each

PART 4 UTILITY WORKS

PART 4 : UTILITY WORK

SECTION 24 : GENERAL REQUIREMENT

24.1 SCOPE OF WORK

These specifications shall cover the supplying of all labour, material, equipment and the performance of all works which are necessary for construction of the Border Control Facility's utility works. The utility works shall comprise internal & external electricity, water supply system, drainage system, waste water treatment system, air conditioning & ventilation system and fire fighting system in accordance with the Drawings, Specifications, and as may be further directed by the Engineer.

24.2 GENERAL

The work under this Section shall comprise electrical and mechanical work for the Border Control Facility (BCF).

Because of the small scale of the Drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the structural and finish conditions affecting all his work and shall arrange such work accordingly, at no additional cost to the Employer.

The general arrangement of the utility shall be as indicated on the Drawings. Detailed drawings of proposed departures due to actual field conditions or other causes shall be submitted for approval. Materials and equipment installed in the utility system shall be suitable for the pressures and temperatures encountered. Installation shall be as required by applicable national utility code of the country and local regulations around the site and as specified herein.

Installation shall be accomplished by workmen skilled in this type of work.

(1) Shop drawings and working drawings

At least 60 days prior to starting installation of any materials or equipment, the Contractor shall submit to the Engineer for his approval the following shop or working drawings :

a. Layout drawings of equipment including list of equipment and materials to be incorporated

b. Details layout of electric wiring and conduit
c. Details of piping and valves
d. Details of sleeves for conduit, wiring and piping
e. Complete electrical connection diagrams
f. Details of supports, hangers, attachments and anchoring
g. Details of foundation for equipment
h. Other drawings as required by the Engineer

(2) Data and samples

The Contractor shall submit for approval of the Engineer a complete list of materials and equipment to be incorporated in the works under this Section including sufficient descriptive materials such as catalogues, diagrams, performance curves, charts, layout drawings and other data published by the manufacturer to demonstrate compliance with the Specifications and the Drawings.

(3) Operation and maintenance manuals

a. Bound instructions :

Six (or as directed by the Engineer) complete sets of operation and maintenance manuals for all utility system shall be furnished as specified hereafter. The manuals shall be furnished at the time of performance tests of the system.

The manuals shall include but not limited to the following :

b. Explanation of system :

- General description of system including function, design conditions, system design and equipment incorporated
- Schematic diagrams of each utility
- Schematic diagram of electric power supply and controls
- Layout plan of equipment

c. Operation and maintenance instructions :

- Method of operation including procedures for safe starting and stopping of equipment, preventative procedures, and checking methods
- Manufacturer's instructions on each piece of equipment including lubrication instructions

- Daily, weekly, monthly and yearly inspection items on each piece of equipment and system
- Method of finding causes of breakdown of each piece of equipment and system and countermeasures to be taken

d. Manufacturer's data :

- Manufacturer's specifications, shop drawings and catalogues of each piece of equipment.

e. Manufacturer's certifications :

- Any guarantee, test data and engineering data furnished by the manufacturers.

f. Spare parts list :

- List of spare parts and consumables furnished with the equipment as standard appurtenances as required by the Specifications.

g. Service and maintenance organizations :

- Name and address of nearest recommended service and maintenance agent who can practically be contacted by the Employer at the time of breakdown of an equipment.

(4) Attachments and spare parts

The Contractor shall furnish with each piece of equipment standard attachments and spare parts which the manufacturer supplies under normal commercial transactions. In addition to these the Contractor shall furnish spare parts, consumables or stand-by equipment as recommended by manufacturer. The Contractor shall also furnish a complete list of spare parts as recommended for operation of each piece of equipment for a period of one year with current prices and source of supply.

(5) Tools

The Contractor shall provide sufficient special tools as recommended by manufacturers for field maintenance of the system. One complete set shall be provided at no extra cost to the Employer.

(6) Field instructions

Upon completion of the work, the services of one or more instructor shall be provided by the Contractor for a total period of not less than 10 days to instruct the representative of the Employer in operation and maintenance of the equipment and the systems. These field instructions shall cover all the items contained in the bound instructions as specified for operation and maintenance manuals, and all costs for services shall be borne by the Contractor.

(7) Tests

The Contractor shall submit his proposed testing programs and procedures at least 2 weeks prior to the scheduled tests and obtain the Engineer's approval. All tests shall be conducted in the presence of the Engineer. Any materials, equipment, instruments, personnel, water and electricity required for the tests shall be provided by the Contractor.

Accurate data of each test shall be recorded and reports of test data shall be submitted.

(8) Floor, wall and ceiling escutcheons

Escutcheons shall where directed by the Engineer be proved at finished surfaces where exposed piping and conduit bare or insulated, passes through floor, walls or ceilings. Escutcheons shall be fastened securely to pipe or pipe covering and shall be of chromium plated iron or chromium plated brass, either one piece or split pattern, held in place by internal spring tension or setscrew.

(9) Foundation for equipment

All foundations for equipment shall be designed at the responsibility of the Contractor. Loading data of the equipment shall be submitted to the Engineer as required for him to check the structural strength of the buildings. All costs for foundations including grouting and plastering on all exposed faces of concrete with cement mortar shall be included in pertinent work items.

24.3 MATERIALS AND WORKS

The Contractor shall supply all materials required for completion of the works in accordance with these specifications.

If the drawings do not contain particular materials and works which are obviously

necessary for the proper completion of the works, all such materials and works shall be included in the unit price stated in the Bill of Quantities for the appropriate items of the facilities construction works.

Unless otherwise specified, all materials and equipment which will become a part of the permanent works shall be new and good quality, and shall be subject to inspection, examination and/or test according to the proper industrial standards as specified.

24.4 STANDARDS

Unless otherwise specifically provided, the quality of materials, equipment and workmanship comply with IEC, TIS or applicable international standards approved by the Engineer.

24.5 SCAFFOLDS, RUNWAYS, ETC.

The Contractor shall furnish, erect and maintain during the work as required all scaffoldings, runways, guard rails, and all other temporary constructions as may be necessary for the construction of the works.

24.6 CLEANING

The Contractor shall from time to time remove all dirt and rubbish caused by the work from the construction site. At completion of the work, the Contractor shall thoroughly clean the interior and exterior of the buildings and other equipment.

24.7 WARRANTY

(1) This warranty shall remain valid for twelve (12) months after certificate for the date of the Taking-Over Certificate.

(2) The Employer shall promptly notify the Contractor in writing of any claim arising under this warranty. Upon receipt of such notice, the Contractor shall promptly repair or replace the defective facilities or parts thereof, without to the Client including import duties, taxes and any other similar duties and taxes.

(3) Without prejudice to above (1) and (2), the Contractor shall promptly correct, at no cost to the Employer, any defect in any work of correction performed pursuant to above (1) and (2), upon receipt of written notice of defect within twelve (12) months from acceptance of the corrected defect. The warranty for replaced or renewed parts shall start from the date of replacement or renewal.

(4) The Contractor shall not be liable for any defects resulting from the Employer's negligence or failure on the operation of the facilities.

SECTION 25 : ELECTRICAL WORK

25.1 POWER RECEIVING FACILITY

25.1.1 General

The BCF receives the electric supply from EDL's (Electricity du Laos) transmission line (T/L) located in the provincial road (Route 9) running along side the Mekong River.

(Power Source)

- Rated Voltage : 22kV
- Phase : 3 (three)
- Frequency : 50 Hz

The incoming power source shall be transformed from 22kV to 400/230V by the transformer mounted on the pole at the 2 (two) point. The one point is the power house area and otherwise is the accommodation area. The power transformed at the power house area shall be distributed to each facility in the BCF (excluding the accommodation) and half of the Lao PDR side bridge. On the other hand, the power transformed at the accommodation area shall be distributed to the facility in the accommodation and the road from BCF to Route 9.

25.1.2 Scope

The scope of this work is 2 sets of complete construction of the power receiving facility composed by following materials and works.

Disconnecting switch : 3phase 22kV with power fuse
Lightning arrester
Transformer : 3phase 4wire 22kV/400-230V 500kVA
Pole : H=12m, Double structure
Grounding works
Foundation
Earth works
Complete with all accessories and installation

The power line from the power receiving facility (power house area) to Route 9 shall be constructed by EDL, the payment of them shall be included in this scope.

25.1.3 Material

25.1.3.1 Transformer

The transformers shall comply with the standard, type construction and include the necessary accessories as presented herein.

(1) Standards

The transformers shall be manufactured and tested in accordance with the lastest applicable standard specifications and codes of IEC 76-1 1993 or approved equivalent.

(2) Type, rating and characteristics

The transformers shall have the following ratings and features when operating at the site with an elevation up to 1000m above SL:

a)	Type	:	Oil-immersed type, outdoor
b)	Type of cooling	:	Natural air cooled type (ONAN)
c)	Number of phases	:	Three (3) – phase
d)	Rated power	:	As specified on the drawings
e)	Rated frequency	:	50 Hz
f)	Rated voltage and insulation class of windings and connected parts		
	High voltage	:	22 kV delta (22 kV class) basic impulse insulation level (BIL), not less than 150 kV
	Low voltage	:	400/230 V
g)	Vector group	:	Dyn 11
h)	No load tap changer	:	±2x2.5% of rated primary voltage
	(Manual operation)		
i)	Rated no load loss		
	- 500 kVA	:	1,000 w

j) Rated copper loss

- 500 kVA : 5,500 w

k) Impedance voltage : Not more than 5%

l) The maximum temperature rise of the transformer shall not exceed the following values under the continuous rated power on the condition that the maximum ambient air temperature at the site should not exceed 40 degree.

Top oil : 60 degree by thermometer

Winding : 65 degree by resistance method

m) Type of coil : Copper

(3) Accessories

Each transformer shall be equipped with the following accessories:

- Arcing horns, corrosion proved
- No load tap changer
- Nameplate with connection diagram
- Drain valve, sampling
- Grounding terminal
- Oil level gauge
- Lifting eyes (3-ϕ transformer only)
- Oil check valve

(4) Factory assembly and tests

The transformer shall be completely assembled at the factory. The transformer shall be subjected to the following tests by and at the expense of the Contractor.

All tests described below shall be performed by the provincial electricity authority (pea):

a) Routine tests

- Resistance measurements on all windings

- Measurement of insulation resistance
- Applied potential test
- Inducted potential test
- Ratio tests on the rated voltage connections and on all tap connections
- Polarity and phase-relation tests
- No-load loss test at rated voltage
- Full-load loss test at rated voltage
- Measurement of exiting or no-load current at rated voltage
- Impedance voltage measurement at rated current on the rated voltage connection

b) Special tests

All the special tests described below shall be performed in the presence of the Engineer.

- Visual and dimensional check
- Check of vector-group symbol
- Check of insulation oil
- Operation test for tap changer
- Measurement of insulation resistance
- Measurement of voltage ratio

The instruments for the above tests shall be prepared by the Contractor. The cost of the tests shall be borne by the Contractor.

25.1.3.2 Pole

(1) Requirements

The Contractor shall design pre-stressed concrete poles conforming to the requirements specified below :

1) For 12.0 m Pole

Dimension of Tip End	15 x 18 cm
Dimension of Bottom End	24 x 27 cm
Minimum Bending Moment at Point	
2 m from the Lower Pole Tip End :	
- Design	2,550 kg-m
- Ultimate	5,100 kg-m

Weight (Approximate) 1,265 kg

2) Safety Factor = 2

(2) Concrete for pre-stressed concrete poles

1) Cement

The cement used shall conform to the requirements specified in ASTM C 150 or TIS 15 – Portland Cement or Equivalent.

2) Aggregate

The fine and coarse aggregates used shall be clean, hard and durable conforming to the requirements of ASTM C33 and shall not include dust, mud and organic substances to a harmful extent. For coarse aggregate, crushed rock shall be used.

The maximum size of aggregate shall be 20 mm.

3) Water

Water used in mixing concrete shall be clean and free from injurious amounts of oil, acid, alkali, salt organic minerals or other substances that may be deleterious to concrete or steel and shall meet the requirements of ASTM C94.

4) Pre-stressing Steel and Reinforcement Bar

Pre-stressing steel and reinforcement wire used shall conform to the requirements specified in the following standards :

(a) Stirrup bar shall be round steel diameter 2.80 mm in accordance with TIS 194-2519 and able to withstand ultimate tensile strength of not less than 5,500 kg/cm^2.

(b) High Tensile Strength Steel Wire

High tensile steel wire shall comply with requirements of TIS Standard 95 or AASHTO M 204 type WA, with the following metric substitutions.

Tensile Strength Requirements for High Tensile Steel Wire

Nominal Diameter Millimeters	Minimum Tensile Strength kg/cm^2
5	17,000
7	16,500

Yield Strength Requirements for High Tensile Steel Wire

Nominal Diameter Millimeters	Initial Stress Kg/cm^2	Minimum Stress at 1% Extension kg/cm^2
5	2,050	14,000
7	2,050	13,200

In addition to satisfying the requirements of AASHTO M 204, the steel wire must satisfy the following relaxation requirements :

Relaxation Characteristics of High Tensile Wire

Maximum Relaxation after 1,000 hours from	
70% Minimum Tensile Strength	80% Minimum Tensile Strength
5%	8.5%

5) Testing of Pre-stressing Reinforcement

(a) Test certificates – The Contractor shall supply in the form required by the Engineer, certification of tests on samples taken from each parcel of steel to be used, carried out by an independent recognized or authorized testing authority at the expense of the Contractor.

(b) Relaxation Tests – The Contractor shall submit results of relaxation test for the approval to the Engineer.

The relaxation tests shall be performed under the following conditions :

(i) The temperature of the test piece shall be 20°c ± 2°c and the temperature shall be maintained within this range for the duration of test.

(ii) The test piece shall not have been subjected to any loading or temperature treatment subsequent to manufacture.

(iii) The initial load equivalent to 70% or 80% of the minimum tensile strength shall be applied uniformly over a period of not more than 5 minutes. Thereafter the gauge length shall be maintained constant and load relaxation readings shall commence one minute after application of the initial load.

(iv) Overstressing of the test piece during the loading operation shall not be permitted.

(v) The duration of the test shall be 1,000 hours.

25.2 EMERGENCY DIESEL GENERATOR

25.2.1 General

The emergency diesel generator system shall be installed in the DG room at the power house to provide the power when the commercial power is interrupted.

25.2.2 Scope

The scope of this work is 1 set of complete construction of the emergency diesel generator system.

25.2.3 Material

- Function :

  Auto start for commercial power interruption and auto stop for commercial power restoration

- Composition :

Diesel engine generator	1 set
Control panel	1 set
Battery for starting	1 set
Fuel tank (500 l) w/structure	1 set
Muffler	1 set
Exhaust fan with canvas duct	1 lot
Flexible exhaust pipe	1 set
Piping work	1 lot
Accessories	1 lot

- Operating condition :

Temperature	Tropics spec.
Humidity	up to 95% RH
Altitude	Up to 200m

- Diesel engine :

Type	Water cooled
Overload endurance	110% for 30 minutes
Rotation	1500rpm
Over speed endurance	110% for one minute
Fuel to be used	Heavy diesel oil

	Cooling system	Radiator
	Direction of rotation	Clockwise looking from exciter end
	Starting system	DC motor
- Generator :		
	Output capacity	More than 120kVA
	Voltage	AC 400-230V 3-phase 4-wire
	Frequency	50Hz
	Winding	Star
	Insulation	F class
	Exciting system	Brushless self-exciting system
	Power factor	80% lag

25.3 POWER DISTRIBUTION PANEL

25.3.1 General

Power distribution panels shall be installed in each location shown in the drawings to provide the power to each area when required. The panels shall be made based on the following descriptions.

(1) The panels shall include molded case circuit breaker distribution board (MCCB) and miniature circuit breaker distribution board (MCB) and shall be factory built assembly.

(2) The panels shall be totally enclosed by galvanized sheet steel of 2.0 mm for length less than 2 m or 2.3 mm thick for length greater than 2 m. The metal enclosure shall be adequately sized to allow for free circulation of air and be complete with one (1) coat of anti-corrosion primer and baked enamel painted in factory. The door shall be hinged 180 deg. C swing gasketed door fitted with ball catch and chrome-plated handle. For boards allocated in areas accessible by the public, cylindrical lock shall be provided complete with three (3) keys.

(3) Knock out and slot openings shall be neatly provided suitable for conduit/trunking connection and proper protection by bushes, gromet, etc. to protect cable entry from damages shall be included.

(4) Bus bar shall be hard drawn high conductivity copper properly tinned. The bus

bar shall be rated not less than the rating of main switch or main circuit breaker.

Neutral connector can be brass block having finished screw terminals equal in number and in same order as the individual outgoing circuits. Earth terminal shall be provided.

(5) Proper indication of phases by color discs or approved equivalent insulating means shall be provided.

(6) Removable insulating phase barriers and front shields covering live bus bar and terminal, shall be provided by 2.5mm thick acryl sheet.

(7) Replacement of fuses, MCCB and bus bar from the front shall be possible.

(8) Except for solder less termination type MCCB or fuse holder, all cable termination shall be by compression cable lug or proper soldered lug.

(9) Permanent circuit chart shall be affixed to identify individual circuits.

(10) The panels shall be provided with 20% spare circuit breaker, unless otherwise specified in the drawings.

25.3.2 Scope

The scope of this work is providing all of the panels and accessories and complete installation shown in the drawings. The suitable foundation and earth works for the outdoor standing type panel shall be included in this scope, and The mortar filling work for the wall recessed type panel shall be included in this scope.

25.3.3 Material

(1) L/V panel-1

Indoor floor standing type

Input power :	3phase 4wire 380-220V(commercial)
	3phase 4wire 380-220V(DG)
Output power :	3phase 4wire 380-220V(commercial)
	3phase 4wire 380-220V(DG)
Function :	Power distribution
	Breaking short circuit and overload currency
	Electric power shall be provided to fixed various equipment after switching emergency generator power and commercial

power

(2) LP-IC-1,2

Indoor wall recessed type

Input power :	1phase 2wire 220V(commercial)
	1phase 2wire 220V(DG)
	1phase 2wire 220V(UPS)
Output power :	1phase 2wire 220V(commercial)
	1phase 2wire 220V(DG)
	1phase 2wire 220V(UPS)
Function :	Power distribution
	Breaking short circuit and overload currency

(3) LP-IC-3

Indoor wall mounted type

Input power :	1phase 2wire 220V(commercial)
	1phase 2wire 220V(DG)
	1phase 2wire 220V(UPS)
Output power :	1phase 2wire 220V(commercial)
	1phase 2wire 220V(DG)
	1phase 2wire 220V(UPS)
Function :	Power distribution
	Breaking short circuit and overload currency

(4) L-MT, P-AC-MT

Indoor wall mounted type

Input power :	1phase 2wire 220V(commercial)
Output power :	1phase 2wire 220V(commercial)
Function :	Power distribution
	Breaking short circuit and overload currency

(5) L-P

Indoor wall mounted type

Input power :	1phase 2wire 220V(commercial)
	1phase 2wire 220V (DG)
Output power :	1phase 2wire 220V(commercial)
	1phase 2wire 220V (DG)

Function : Power distribution
Breaking short circuit and overload currency

(6) L-B-1,2

Indoor wall recessed type
Input power : 3phase 4wire 380-220V (commercial)
1phase 2wire 220V (UPS)
Output power : 1phase 2wire 220V(commercial)
1phase 2wire 220V (UPS)
Function : Power distribution
Breaking short circuit and overload currency

(7) L-B-1-A-1:11,L-B-2-D-1:11

Indoor wall mounted type
Input power : 1phase 2wire 220V (commercial)
1phase 2wire 220V (UPS)
Output power : 1phase 2wire 220V(commercial)
1phase 2wire 220V (UPS)
Function : Power distribution
Breaking short circuit and overload currency

(8) L-B-1-EN1,2 L-B-2-EX1,2

Indoor wall mounted type
Input power : 1phase 2wire 220V (commercial)
1phase 2wire 220V (UPS)
Output power : 1phase 2wire 220V(commercial)
1phase 2wire 220V (UPS)
Function : Power distribution
Breaking short circuit and overload currency

(9) L-T1,2

Indoor wall mounted water proof type
Input power : 1phase 2wire 220V (commercial)
Output power : 1phase 2wire 220V(commercial)
Function : Power distribution
Breaking short circuit and overload currency

(10) P-AC-1,2

Indoor wall recessed type

Input power :	3phase 4wire 380-220V (commercial)
Output power :	1phase 2wire 220V(commercial)
Function :	Power distribution
	Breaking short circuit and overload currency

(11) P-AC-3

Indoor wall mounted type

Input power :	3phase 4wire 380-220V (commercial)
Output power :	1phase 2wire 220V(commercial)
Function :	Power distribution
	Breaking short circuit and overload currency

(12) L-OL

Indoor wall mounted type

Input power :	3phase 4wire 380-220V (commercial)
Output power :	1phase 2wire 220V(commercial)
Function :	Power distribution
	Breaking short circuit and overload currency
	Lighting (on-off) control by switch located on panel surface

(13) L-RL, L-BRL

Outdoor standing type

Input power :	3phase 4wire 380-220V (commercial)
Output power :	3phase 4wire 380-220V (commercial)
Function :	Power distribution
	Breaking short circuit and overload currency

(14) L-OLH

Outdoor standing type

Input power :	3phase 4wire 380-220V (commercial)
Output power :	3phase 4wire 380-220V (commercial)
Function :	Power distribution
	Breaking short circuit and overload currency
	High mast lighting control (on-off):

Auto control by timer switch
Manual control

(15) L-CHT, L-CH

Indoor wall mounted type

Input power :	1phase 2wire 220V (commercial)
Output power :	1phase 2wire 220V(commercial)
Function :	Power distribution
	Breaking short circuit and overload currency

(16) L/V PANEL-2

Outdoor standing type

Input power :	3phase 4wire 380-220V(commercial)
Output power :	3phase 4wire 380-220V(commercial)
Function :	Power distribution
	Breaking short circuit and overload currency

(17) LP-ACOM

Outdoor standing type

Input power :	3phase 4wire 380-220V(commercial)
Output power :	1phase 2wire 220V(commercial)
Function :	Power distribution
	Breaking short circuit and overload currency

(18) LP-ACOM-S1 : 10, LP-ACOM-K, LP-ACOM-T, LP-ACOM-F1 : 3

Indoor wall mounted type

Input power :	1phase 2wire 220V (commercial)
Output power :	1phase 2wire 220V(commercial)
Function :	Power distribution
	Breaking short circuit and overload currency

25.4 UNINTERRUPTED POWER SUPPLY SYSTEM (UPS)

25.4.1 General

The uninterrupted power supply system (UPS) shall be installed in the power house and shall supply power to the computer system.

25.4.2 Scope

The scope of this work is providing 1 set of the UPS including all accessories and complete installation.

25.4.3 Material

Type	Indoor standing cubicle type
Function	AC power shall be provided without interruption by the included battery.
AC input voltage	3-phase 4-wire 400-230V 50Hz
AC output capacity	30kVA
AC output voltage	3-phase 4-wire 400-230V 50Hz
Back-up time	10 minutes

25.5 EXTERNAL LIGHTING (HIGH MAST LIGHTING)

25.5.1 General

The high mast lighting shall be installed in the BCF outside area shown in the drawings. The average illuminance shall be 22 (lx).

25.5.2 Scope

The scope of this work is 20 set of complete construction of high mast lighting composed by following materials and works.

HID lighting with sodium lamp 400W x 10sets (each pole)
Pole : 30m
Arms
Winch
Lightning protection and grounding work
Foundation
Earth works
Complete with all accessories and installation

25.5.3 Material

(1) Columns carrying high mast lighting shall be designed to permit the whole of the lamp carriage to be easily, safely and quickly lowered to ground level for maintenance works. The columns shall be designed in accordance with British Standard 449 or other internationally accepted standard for design of structural

steelwork in buildings, except that the temporary horizontal deflection of the top of the column may be up to 7½% of the height above ground. In calculating the bending moment at ground level due to wind load, it shall be assumed that the wind speed at a point ten meters above ground level is 60 kilometers per hour, and the design of the column shall be such that wind excited oscillations are damped as much as possible. Adequate allowance shall be made for the stresses produced by such oscillations. Details shall be given of the vertical and horizontal load and the bending moment at the foundations.

(2) The base plate shall be free from laminations and all dimensions of the base plate shall be provided, including details of the holding down bolts. A cable entry hole of not less than 30 centimeters diameter shall be provided centrally in each base plate, and the bottom of the mast shall pass through the base plate and be welded on both sides. An alternative construction of equal strength may be accepted by the Engineer, but a butt weld on to the base plate will not be accepted.

(3) Each holding down bolt shall be tensioned to the design value, and within the maintenance period, the bolts shall be checked and re-tightened as necessary, after which the nuts shall be repainted.

(4) The columns shall be delivered to the site in the minimum practicable number of lengths. Any joints necessary shall be positioned as near the top of the columns as possible.

(5) The lamp carriage shall support the designed number of lamps without significant sway or movement, and shall be capable of supporting these lamps plus a cradle with two men for maintenance work. The lamp carriage shall be protected to prevent damage to the painted surface of the columns, rotation of the carriage during raising and lowering shall be prevented and correct location when raised shall be ensured by some positive means. It shall be possible to remove the lump carriage without lowering the column.

(6) The lamp carriage shall be raised and lowered by a self sustaining winch capable of being operated either by hand or by a portable electrically operated tool. It shall be possible to lock the winch in any position by a simple, robust and easily operated mechanism. The worm gear shall have a ratio of at least 20:1.

(7) The winch shall have removable handles, and it shall be mounted within the

base compartment at a convenient working height. The opening in the column shall be of sufficient size to allow proper operation and maintenance of the winch mechanism. A weather proof label shall be fixed in an obvious position within the column base, giving a full list of all lubricating points on the winch and other mechanism, and details of recommended lubricants. Winch fixed inside the column shall be provided with a substantial cover to fully protect them from falling dirt and dust.

(8) A sufficient number of turns of the hoisting cable shall be left on the winch drum when the carriage is fully lowered to ensure that the cable anchorage on the drum does not take the full load of the carriage at any time.

(9) The last 30 centimeters of travel to the fully raised position of the carriage shall be by hand operation, and for this purpose either a limit switch shall be provided to cut off the power supply to the portable electric tool at the appropriate time, or else some form of indication shall be provided to indicate when the carriage is 30 centimeters from the fully raised position.

(10) The winch cable shall be of stranded stainless steel wires and shall have sufficient capacity to carry safely the lamp carriage complete with lamps plus a cradle with two men attached thereto. Great care shall be taken during installation to ensure that the hoisting cables do not twist or kink, and any twist or kink shall be sufficient reason for the rejection of that cable.

(11) All parts of the raising and lowering mechanism which are inaccessible after erection of the columns shall be adequately protected against moisture, dirt and corrosion. Where necessary, pulleys shall be fitted with shields to prevent the winch cable becoming displaced. Pulleys for electrical cables shall be of sufficient diameter that the cable will not be bent to a smaller radius than that permitted by local regulations or equivalent international standard.

(12) When power tool operation is used, a suitable power outlet shall be provided and the operator shall be adequately safeguarded against any electrical shocks. The power tool shall preferably be designed to work on a reduced voltage and in this case, a suitable approved type of transformer shall be provided. The power tool shall be designed so that continuous operation will cause no harmful effects on either the winch or the tool, and in the event of power failure the winch shall be self locking. Conversion from power to hand operation and vice versa shall be quick and easy and shall not require special tools. Full information on the type of power tool proposed shall be given with the tender.

(13) One set of lightning protection rod shall be provided on top of the column and one set of grounding electrode to protect the high mast lighting from lightning. The lightning rod shall be connected to respective grounding electrode through the lead wire.

25.6 CABLE AND WIRING

25.6.1 General

(1) All cable shall comply with the relevant TIS or equivalent standard requirements, be used for appropriate application as defined in the NE code.

(2) PVC insulation and sheath shall have flame retardant characteristic in accordance with B.S. 4066 or approved equivalent.

(3) Cables shall be terminated in the approved form i.e. compression cable lug, tinned copper cable socket, cable gland, etc.

(4) Each core of the cable shall be identified by means of colored insulation and code in accordance with IEE regulation. Overall sheath shall be colored black.

(5) The size of power cables shall be selected by Contractor considering the allowable voltage drop, ampacity and mechanical tension, and shall be approved by the Engineer.

(6) The permissible bent radius of the cable and wiring are follows;

(Cable with shield)
Single core : more than 12 times of the outside diameter
Multi core : more than 8 times of the outside diameter
(No shield cable and wiring)
Single core : more than 12 times of the outside diameter
Multi core : more than 6 times of the outside diameter

25.6.2 Scope

The scope of this work is complete provision and installation of Cables and wiring in the BCF, and all facilities and equipment shall be fit for their purpose.

The kinds of cables and wiring shall be as follows;

High voltage cable (XLPE/PVC)

Low voltage cable (XLPE/PVC)
Low voltage cable (PVC/PVC)
Telephone cable
Coaxial cable for TV
Alarm cable for public announcing
PVC wire
Other required

25.6.3 Material

25.6.3.1 PVC wire

(1) PVC insulated cable shall comply with TIS 11-2531 to 75°C, 750V grade or approved equivalent.

(2) The cable shall be single or stranded annealed copper insulated by PVC.

(3) Minimum cable size allowable is 1.5 sq-mm Copper.

25.6.3.2 Cable-PVC Insulated/PVC Sheathed

(1) PVC/PVC cable shall comply with TIS 11-2531 70°C, 750V grade or approved equivalent.

(2) Cable shall be single or stranded annealed copper conductor PVC insulated and sheathed by PVC.

25.6.3.3 Cable-XLPE Insulated/PVC Sheathed

XLPE/PVC cable shall be of 600V or 22kV, single or multi-core copper, cross link polyethylene insulated polyvinyl chloride sheathed type with suitable cable ends and 600V, PVC insulated, copper conductor as shown on the drawings or approved equivalents.

Chemicals for anti-termite protection shall be added to the sheath.

25.6.3.4 Communication cable

Indoor cable shall be PVC insulated 2-core copper cable of 0.65mm diameter or equivalent.

Outdoor cable shall be polyethylene insulated, PVC sheathed and anticorrosion protected over sheathed copper cable of 0.65mm diameter or equivalent of the numbers and pair as shown on the Drawings.

All telephone cable shall be separated from low and high voltage power cable by the grounded conduit or distance (low voltage 0.3m, high voltage 1.5m).

25.7 UNDER GROUND CONDUIT, MANHOLE AND HANDHOLE

25.7.1 General

The under ground conduits, manholes and handholes shall be installed in the BCF outdoor area to install and protect the under ground cables and wiring. The under ground conduit shall be installed not less than 600mm depth from finishing ground level. The size of conduit diameter shall be selected by the Contractor. The percentage of total number of cables and wiring cross section area which is installed in the conduit shall be less than 32%.

The suitable size of manhole and handhole compared with the number of conduit shall be installed in the under ground, and conduits shall be connected to them securely. The installation interval of the manholes and handholes shall be less than 40m (Approx.).

The empty conduit as spare shall be installed in the required under ground route to provide for the future plan of computer system LAN cable or others. The Contractor shall refer to the drawings which show the spare conduits, and provide the necessary number.

25.7.2 Scope

The scope of this work is complete provision and installation of under ground conduit, manholes and handholes (incl. all accessories) in the BCF area which required to install the cables and wiring.

25.7.3 Material

25.7.3.1 Under ground conduit

The under ground conduit shall be flexible plastic conduit (EFREX type or equivalent). The under ground conduit shall be installed more than 0.6m under the ground, and the intensity under this situation shall be less than 3.5% of transformation factor when a load of 25 ton is exerted on the ground above the

under ground conduit.

A pilot wire shall be installed in the conduit in advance for ease of cable installation.

25.7.3.2 Manhole and Hand-hole

(1) Manhole

The manholes shall be utilized as junctions for high-tension cable pulling. The manholes shall be made of reinforced concrete and shall have steel covers. The manhole shall be utilized as three direction installation of cable.

The size of manhole shall be 2000 * 2000 * 1500H approximately.

(2) Handhole

The hand-holes shall be utilized as junctions for high-tension cable pulling. The hand-holes shall be made of reinforced concrete and shall have covers made of hot-dip galvanized steel.

The lineup size of handhole shall be 600 * 600 * 900H and 1200 * 1200 * 1200H approximately.

25.8 CONDUITS, FITTINGS AND BOXES

25.8.1 General

The rigid metal conduits shall be installed in the required area shown in the drawings. The flexible tube shall be installed in the wall to install the cables and wiring which connected to the wall mounted equipment.

25.8.2 Scope

This work shall consist of the furnishing and installation of all the conduits, fittings, pull and junction boxes, conduit expansion joints, required supports and incidental. The type, size and location of conduits, fittings and boxes will be as indicated on the Drawings. The Contractor shall refer to the drawings and provide the necessary materials.

25.8.3 Material

25.8.3.1 Rigid metal conduit

Conduit shall be formed of mild steel without laminations due to slag breaks, blisters or pockets, and without cinders or other foreign matter.

The conduit shall be galvanized on the outside by one of the three methods of hot dip galvanizing or electric-galvanizing, and the inner surfaces shall be protected in a like manner by a thick coating of enamel.

All conduit fittings without exception shall be made from the same material and shall have the same coating as specified for conduit.

25.8.3.2 Flexible tube

The flexible tube installed in the wall or floor (recessed) shall be made of plastics. (PFLEX-CD or equivalent)

25.8.3.3 Pull box

Pull boxes shall be installed at all necessary points, whether indicated on the drawing or not, to prevent damage to the installation or other damage that might result from pulling friction of for the other reasons related to improper installation. Pull box locations shall be approved by the Engineer prior to installation. All pull boxes shall be constructed of galvanized sheet steel, of not less than 2 mm. thick.

Where so indicated, certain pull boxes shall be provided with barriers. These pull boxes shall have a single cover plate, and the barriers shall be of the same gauge as the pull boxes. Each circuit in pull boxes shall be marked with a tag guide denoting panels to which they connect.

25.8.4 Construction Methods

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 32 per cent of the inside area of conduit.

All conduit sizes and conduit layout shall be approved by the Engineer before installation, and the Contractor shall submit data on the layout for the exact makeup, overall diameter, and cross-sectional areas of the actual conductors he intends to use and the sum of the areas of the conductors in each conduit.

Bends shall be of long sweep, free from kinks and of such easy curvature as to permit the drawing in of conductors without damage. The radius of curvature of inner edge of bends shall not be less than ten times the inside diameter of the conduit except as may be otherwise noted on the Drawing or in the Special Provisions. Conduits shall not be flattened or distorted. The total angle of all bends between any two boxes or fittings shall not exceed 90 degrees.

All conduit used shall be the product of one manufacturer.

Exposed conduit runs shall be parallel to or at right angles to walls, slabs, girders and in locations giving greatest accessibility for painting and least accumulation of dirt. All exposed conduit runs shall be attached to steel, masonry, concrete or timber by galvanized malleable iron or galvanized steel straps, clamps or hangers of an approved type, held at not less than two points by galvanized steel bolts or lag screws. The runs shall be supported at not greater than 3 meter centers on horizontal runs, unless otherwise specified and not less than 5 centimeters clear of the supported members. Conduits mounted on structural steel members shall be securely clamped to prevent rattling and wear.

All ends of conduits installed during construction, or for future use, shall be closed against the introduction of foreign material by the use of standard pipe or bush caps. All conduits shall be installed so that they will drain and necessary holes for this purpose shall be made as directed.

Upon completion of the conduit installation, the system shall be cleared 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 again be checked. Any and all obstructions shall be removed to the approval of the Engineer.

The Contractor shall install and leave in place a No.10 iron wire in all conduit runs installed for future use.

The conduit runs shall be with as few couplings as standard lengths will permit. Screw couplings shall be used. All cuts shall be made with a hacksaw and reamed clear of fins or burrs with a reamer.

Where conduits cross expansion joints in the structure, or where otherwise specified, they shall be provided with expansion fittings of an approved type. The electrical continuity of the conduit runs across the expansion fittings shall be

assured by approved fittings and bare No.8 copper wire.

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 ends shall be equipped with an approved insulating bushing.

All surfaces of conduit, boxes, fittings, etc., in contact with concrete encasement shall be painted one coat of approved paint.

25.9 LIGHTING AND POWER OUTLET SYSTEM

25.9.1 General

The lighting and power outlet and switches shall be installed in the required area shown in the drawings and other required area.

25.9.2 Scope

The Contractor shall finish and install all lighting, power outlets and switches shown in the drawing and other required.

25.9.3 Lighting fixture

The lighting shall be wired to a single point with the approved fixture wire for proper connection. The Contractor shall ensure that the lighting furnished is compatible with the ceiling suspension system being installed. The lighting schedule shall be as shown on the drawings for types, and types of mounting. The Contractor shall submit complete shape data, manufacturer's name, catalogue number and type of lamp(s) to be installed together with the shop drawing for approval before giving the fixture manufacturer a purchase order.

Lamps shall be the number and types shown as specified. All lamps installed shall be new, and all shall operate on the completion of the work.

Fluorescent lighting fixtures shall be rapid start type equipped with complete fittings for AC 200V, 50Hz source for lamps.

Emergency lighting fixtures shall have a built-in battery rated for 30 min operation of the lamp.

High-bay lighting fixtures shall be equipped with a screwed base lamp holder suitable for high-pressure mercury and sodium lamp, and appropriate ballast of high-power factor for stable operation. The fixture shall be built-in ballast type.

The lighting fixtures for outdoor use shall be of weatherproof type. Special care shall be exercised on selection of fixtures so that illumination of the lamps is not obstructed by accumulation of insects and dust. The garden lighting fixture installed in accommodation shall be provide the complete foundation (Incl. earth works) in this scope.

25.9.4 Power outlet

The power outlets shall comprise the following kinds of outlets to be arranged as shown in the drawings.

a) 2P-16A-2 w/ET wall recessed

Single phase, duplex and grounded type rated for 16A-250V (Incl. outlet box)

b) 2P-16A-2 w/ET WP wall recessed

Single phase, duplex , grounded and water proof type rated for 16A-250V (Incl. outlet box)

c) 2P-16A-2 w/ET surface mounted

Single phase, duplex and grounded type rated for 16A-250V (Incl. outlet box)

The cover plates shall be of stainless steel.

25.9.5 Tumbler switch

Wall switches shall comprise the following kinds off switches to be arranged as shown on the drawings.

a) Tumbler switch rated 15A 300V 1way

b) Tumbler switch rated 15A 300V 2way

c) Tumbler switch rated 15A 300V 3way

25.10 PRIVATE TELEPHONE SYSTEM

25.10.1 General

Telephone system shall be provided for the external and internal communication for the whole facility.

25.10.2 Scope

The telephone system works shall comprise supply and installation of all equipment and materials necessary to complete the system.

The system shall comprise the by following major equipment :

(Main office area)

a) Private Branch Exchange (PBX)
b) Main Distribution Frame (MDF)
c) Terminal boxes
d) Telephone outlets
e) Conduit and wiring

(Accommodation area)

1) Main Distribution Frame (MDF)
2) Telephone outlets
3) Conduit and wiring

The PBX and MDF unit shall be installed in the electricity room located in power house and the telephone lines shall be distributed to each telephone outlets through the terminal boxes shown in the drawings.

The power supply for the PBX shall be emergency diesel generator source through UPS.

The telephone line receiving work before each MDF shall be done by Lao Telecom., but share of expenses of them shall be included in this scope.

25.10.3 Codes and Standards

The Contractor shall consult the local telephone company as to the standards, codes and regulations on the equipment and materials and installation thereof effective at the Site and shall comply with them in every respect.

25.10.4 Equipment and Materials

a) Private Branch Exchange (PBX)

i) Capacity and Circuit Arrangement

External line : 20 circuits
Facsimile line : 10 circuits
Internal line : 120 circuits

ii) Function

Emergency telephone receiving (from Bridge 1 line)
Long distance internal line (to Thai side BCF)
Other normal function recommended by manufacturer

iii) Enclosure

Self supporting, dust-proof and sound screening steel cabinet.

b) Main Distribution Frame (MDF)

For 30 external circuits with arresters in self-supporting steel cabinet.

c) Telephone Outlets

Telephone outlets shall be of special design to distinguish them from power outlets. They shall be mounted on the wall as shown on the Drawings and covered with stainless steel cover having outlets point.

25.10.5 Inspection And Tests

The equipment and materials shall be inspected and tested at factory in accordance with applicable standards and procedures.

After installation of the telephone system, the following tests shall be carried out by the Contractor in the presence of the Engineer.

a) PBX

Construction check
Dial impulse speed
Make impulse ratio

Cross talk attenuation
Connection and function tests
General inspection of MDF
Overall test

b) Communication Line

Inspection of communication line
Cross talk and characteristic impedance
Insulation and conductor resistance and unbalance
Pair numbering check

25.10.6 Spares And Tools

The Contractor shall furnish spare parts and accessories and tools for inspection, tests and maintenance as recommended by the equipment manufacturer.

25.11 PUBLIC ANNOUNCING SYSTEM

25.11.1 General

Public announcing system shall be provided as an external communication system for the outside area of the BCF.

The system shall comprise the following major equipment and accessories.

(Public announcing unit)

a) Microphone
b) AMP
c) Tape recorder
d) Zone select switch unit
e) Sound mixer
f) Store rack or desk

(Speaker)

a) Horn type speaker 3 W
b) Support

The public announcing unit shall be installed in the immigration office located in the arrival side main office.

25.11.2 Scope

The announcement system works shall comprise supply and installation of all materials and equipment necessary to complete the system.

25.11.3 Equipment and Materials

a) Amplifier

Type	:	Desk top type
Rated output	:	60 W
Power source	:	A.C 220 V, 50 Hz
Frequency characteristics	:	50 Hz– 20 Hz
Distortion factor	:	Less than 3% at 1 kHz
Tone control	:	±10 dB at 10 kHz
Input and output circuits	:	Microphone, tape recorder, sound mixer, amplifier, speaker and speaker selectors
Speaker selector	:	5 sections
Built-in radio receiver	:	2 bands (AM and FM)

b) Microphones

Type	:	Dynamic, directive type
Frequency characteristics	:	100-8,000 Hz (Dev. 15 dB)
Microphone stand	:	Table top, height adjustable

c) Speakers

Horn speaker	:	30 cm ϕ, wall hung type, outdoor type, Max. rated input : 3 W Frequency range : 280-7,000 Hz

d) Tape Recorder

Open reel, monorail sound, 2-tracks, 1-channel, portable type

Features	:	Recording and regenerating Escalate drive mechanism

Automatic stop mechanism at tape end

Power source : A.C. 220 V, 50 Hz

25.11.4 Tests

After the installation of the system, the following tests shall be carried out by the Contractor in the presence of the Engineer :

a) Performance tests
b) Temperature measurement on amplifier
c) Insulation resistance tests
d) Withstand voltage tests

25.12 TV SYSTEM

25.12.1 General

The TV system shall be installed in main office shown in the drawings and other required.

25.12.2 Scope

The scope of works are complete provision, installation and tests of the following equipment.

UHF anntena
VHF anntena
U-V mixer
Distributer
TV outlets
Booster

25.13 COMPUTER SYSTEM

The scope of the work for computer system is outlet and wiring for power supply only to be installed in each computer room and booths shown in the drawing. The wiring is connected to the DG circuit through the UPS. The scope of work covers only power outlet, power cable and empty conduit (for future communication cable) which are installed in each computer room and booths which require a computer.

25.14 GROUNDING

25.14.1 General

(1) All grounding systems and all protective conductors shall be selected and erected so as to satisfy the requirements of IEE publication No.80, B.S. code of practice CP 1013 for the safety and proper functioning of the associated equipment of the installation.

(2) All exposed conductive parts or metal work associated with an electrical installation but not forming part of current carrying circuit shall be connected to the main grounding terminal by means of protective conductor.

(3) The main grounding terminal shall be connected via grounding conductor to the grounding electrode and plate.

(4) Grounding conductor for electrical equipment :

Grounding conductor for electrical equipment table

Rating or setting of automatic over current device in circuit ahead of equipment not exceed (A)	Copper conductor (mm^2)
15	2.5
20	4
30	6
40	6
60	6
100	10
200	16
400	25
600	35
800	50
1,000	70
1,200	95
1,600	95
2,000	120
2,500	185

(4) The overall grounding resistance shall be less than 5 ohm for electrical system.

25.14.2 Scope

The scope of this work is complete provision and installation to keep the ground resistance less than 5 ohm. The grounding equipment is as follows;

Grounding electrode
Grounding plate
Earth terminal box
Earth works
Complete with all accessories and installation

25.14.3 Material

(1) Grounding electrode : Copper 1.5m w/lead wire

(2) Grounding plate : Copper 900sq t=1.5mm

(3) Earth terminal box : Wall mounted type, 10 terminal

25.15 LIGHTNING PROTECTION SYSTEM

25.15.1 General

(1) The lightning protection system shall comprise horizontal conductors connected to reinforcement structural steel bar as earth electrode for the entire lightning protection system in accordance with the recommendations of the B.S 6651:1985, protection of structural against lightning.

(2) All metallic projections, chimneys, ducts, vent pipes, railings, gutters, etc. on the roof shall be bonded to the conductor network to form part of the protection system and bonding conductor shall have a cross-sectional area not less than that employed for the main conductors.

(3) The resistance of the whole system shall not exceed 5 ohms and shall be tested after complete installation to the Engineer's approval.

(4) Joints and bonds shall be mechanically and electrically effective, e.g. clamped, screwed, bolted, crimped, riveted or welded. Contact surfaces shall first be cleaned then inhibited from oxidation and galvanic action with a suitable non-corrosive compound.

25.15.2 Scope

The scope of this work is complete installation of the lightning protection system to protect the main office building from lightning damage.

25.15.3 Material and installation

This system shall be used for main office buildings.

(1) Down conductor

a) Down conductors shall be of 70 mm^2 bare copper conductor in ¾ inch PVC conduit.

b) Down conductors shall be connected to the horizontal conductor and air terminal system at the roof and the grounding electrodes via test clamp.

c) The down conductors shall run in the most direct route possible between the air termination and grounding termination.

(2) Horizontal conductor

a) Horizontal conductor shall be 25 mm x 3 mm bare tin plated annealed copper tape installed flat on the roof and fixed by means of copper saddles at intervals of 1.5 m.

b) The horizontal conductor shall be installed in such a way that every point on the roof will not be more than 1.5 m from any conductor.

(3) Grounding electrode

a) The grounding electrode shall comprise grounding rods and plate (if required) driven into ground and interconnecting grounding conductor.

b) The portion of the tape connecting the pressure clamp to the test clamp buried underground shall be 500 mm below ground level.

c) Sufficient numbers of electrodes shall be driven into the ground at a distance not less than 3 m and connected together by bare copper conductor of 70mm2 cross-section buried 500 mm underground so that the overall resistance shall be less than 5 ohms for lightning protection system.

d) The grounding conductor shall be clamped to the earth electrode and shall

enable the connection to be removed for testing as often as may be necessary.

e) Exact locations of the earth electrodes shall be submitted for approval by the Engineer prior to installation.

25.16 CIVIL WORKS FOR UNDER GROUND CONDUIT

The Contractor shall refer to Building work specification (PART 3) about excavation, back fill, sand work, crasher stone and excess soil disposal for under ground conduit.

This civil work has 6 (six) pattern methods shown in the drawings.

25.17 MEASUREMENT AND PAYMENT

Measurement and payment for each work shall be made on the basis of the unit price specified in the contract Bill of Quantity. The unit price shall include the cost for all incidental works as specified below, not limited.

25.1(1) Power receiving facility (nos)

The power receiving facility shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Disconnecting switch	1 set
Lightning arrester	3 set
Transformer	1 set
Pole	1 set
Grounding works	1 lot
Foundation	1 lot
Earth works	1 lot
Complete with all accessories and installation	1 lot

25.1(2) Power receiving payment to EDL (Ls)

The power receiving payment shall be measured by amount paid to EDL actually.

Power receiving payment to EDL	1 lot

25.2(1) Emergency Diesel Generator (nos)

The Emergency diesel generator shall be measured by number of set installed

actually at site. The unit price shall include the following incidental works.

Generator/Engine with Control panel and Battery	1 set
Fuel tank	1 set
Fuel pipe	1 lot
Muffler and flexible exhaust pipe	1 lot
Exhaust fan with canvas duct	1 lot
Complete with all accessories and installation	1 lot

25.3(1) : (29) Power distribution panel (nos)

The power distribution panels shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Power distribution panel	1 set
Complete with all accessories and installation	1 lot
Mortar filling (wall recessed type only)	1 lot
Foundation (outdoor standing type only)	1 lot
Earth works (outdoor standing type only)	1 lot

25.4(1) UPS (nos)

The UPS shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

UPS	1 set
Complete with all accessories and installation	1 lot

25.5(1) High mast lighting (nos)

The high mast lighting shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

HID lighting with sodium lamp 400W	10 set
Pole : 30m	1 set
Arms	1 set
Winch	1 set
Foundation	1 lot
Lightning protection and grounding work	1 lot
Earth works	1 lot
Complete with all accessories and installation	1 lot

25.6(1) : (38) Cable and Wiring (lm)

The cable or wiring shall be measured by length of linear meters from output terminal to input terminal installed actually at site. The unit price shall include the following incidental works.

Cable or wiring	1 lm
Sleeve and Fire proof work	1 lot
Coring (if required)	1 lot
Complete with all accessories and installation	1 lot

25.7(1) : (4) Under ground conduit (lm)

The under ground conduit shall be measured by length of linear meters from center to center of connected manhole or handhole installed actually at site. The unit price shall include the following incidental works.

EFLEX or equivalent	1 lm
Complete with all accessories and installation	1 lot

25.7(5) Manhole (nos)

The manhole shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Manhole	1 set
Steel cover	1 set
Grounding work	1 set
Earth works	1 lot
Complete with all accessories and installation	1 lot

25.7(6) Handhole-1 (nos)

The handhole-1 shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Handhole	1 set
Steel cover	1 set
Grounding work	1 set
Earth works	1 lot
Complete with all accessories and installation	1 lot

25.7(7) Handhole-2 (nos)

The handhole-2 shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Handhole	1 set
Steel cover	1 set
Grounding work	1 set
Earth works	1 lot
Complete with all accessories and installation	1 lot

25.8(1) : (6) Rigid metal conduit (lm)

The rigid metal conduit shall be measured by length of linear meters from center to center of connected pull box installed actually at site. The unit price shall include the following incidental works.

EMT or equivalent	1 lm
Support	1 lot
Complete with all accessories and installation	1 lot

25.8(7) : (9) Flexible tube (lm)

The flexible tube shall be measured by length of linear meters from roof/floor slab to connected outlet box installed actually at site. The unit price shall include the following incidental works.

PFLEX-CD or equivalent	1 lm
Complete with all accessories and installation	1 lot

25.8(10) : (11) Pull box (nos)

The pull box shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Pull box	1 set
Complete with all accessories and installation	1 lot

25.9(1) : (16) Internal lighting (nos)

The internal lighting shall be measured by number of set installed actually at site.

The unit price shall include the following incidental works.

Lighting fixture	1 set
Support	1 lot
Foundation and earth works (Garden lighting only)	1 lot
Complete with all accessories and installation	1 lot

25.9(17) : (19) Power outlet (nos)

The power outlet shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Power outlet	1 set
Outlet box w/cover	1 set
Complete with all accessories and installation	1 lot

25.9(20) : (23) Tumbler switch (nos)

The tumbler switch shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Tumbler switch	1 set
Outlet box w/cover	1 set
Complete with all accessories and installation	1 lot

25.10(1) PBX (nos)

The PBX shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

PBX	1 set
MDF box for main office	1 set
MDF box for accommodation	1 set
Complete with all accessories and installation	1 lot
Telephone line receiving work	1 lot

25.10(2) : (4) Terminal box (nos)

The terminal boxes shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Terminal box	1 set

Complete with all accessories and installation	1 lot

25.10(5) Telephone outlet (1 nos)

The telephone outlet shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Telephone outlet	1 set
Outlet box w/cover	1 set
Complete with all accessories and installation	1 lot

25.11(1) Public announcing unit (nos)

The public announcing unit shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Microphone	1 set
AMP	1 set
Tape recorder	1 set
Zone select switch unit	1 set
Sound mixer	1 set
Store rack or desk	1 set
Complete with all accessories and installation	1 set

25.11(2) Speaker (nos)

The speaker shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Horn type speaker 3W	1 set
Support	1 set
Complete with all accessories and installation	1 lot

25.12(1) UHF antenna (nos)

The UHF antenna shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

UHF antenna	1 set
Support	1 set
Complete with all accessories and installation	1 lot

25.12(2) VHF antenna (nos)

The VHF antenna shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

VHF antenna	1 set
Support	1 set
Complete with all accessories and installation	1 lot

25.12(3) TV outlet (nos)

The TV outlet shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

TV outlet	1 set
Outlet box	1 set
Complete with all accessories and installation	1 lot

25.12(4) U-V mixer (nos)

The U-V mixer shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

U-V mixer	1 set
Complete with all accessories and installation	1 lot

25.12(5) U-V Distributor (nos)

The distributor shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Distributor	1 set
Complete with all accessories and installation	1 lot

25.12(6) Booster (nos)

The booster shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Booster	1 set
Complete with all accessories and installation	1 lot

25.13(1) Out box for CPU (nos)

The outlet box for CPU shall be measured by number of set installed actually at site.

The unit price shall include the following works.

Outlet box for CPU	1 set
Complete with all accessories and installation	1 set

25.14(1) Grounding (Ls)

The grounding work shall be measured by lump sum to keep the ground resistance less than 5 ohm. The unit price shall include the following incidental works.

Grounding electrode	1 lot
Grounding plate	1 lot
Earth terminal box	1 set
Wiring and conduit	1 lot
Earth works	1 lot
Complete with all accessories and installation	1 lot

25.15(1) : (2) Lightning rod (nos)

The lightning rod shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Lightning rod	1 set
Support	1 set
Complete with all accessories and installation	1 lot

25.15(3) Down conductor (lm)

The down conductor shall be measured by length of linear meters from the end of horizontal conductor to connecting electrode or plate installed actually at site. The unit price shall include the following incidental works.

Down conductor	1 lm
PVC pipe	1 lm
Support	1 lot
Complete with all accessories and installation	1 lot

25.15(4) Horizontal conductor (lm)

The horizontal conductor shall be measured by length of linear meters from the lightning rod to the starting point of the horizontal conductor installed actually at site. The unit price shall include the following incidental works.

Horizontal conductor	1 lm
Support	1 lot
Complete with all accessories and installation	1 lot

25.16(5) Grounding work for lightning protection (e.a.)

The grounding work shall be measured by each of grounding point keeping the ground resistance less than 5 ohm. The unit price shall include the following incidental works.

Grounding electrode	1 lot
Grounding plate	1 lot
Wiring and conduit	1 lot
Earth works	1 lot
Complete with all accessories and installation	1 lot

25.15(6) Test terminal box (nos)

The test terminal box shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Test terminal box	1 set
Complete with all accessories and installation	1 lot

25.16(1) : (6) Civil works for under ground conduit (lm)

The civil works for under ground conduit shall be measured by length of linear meters from one manhole/handhole to the other based on the cross sections (type-1-1,1-2,2-1,2-2,3-1,3-2) shown in the drawings. The unit price shall include the following incidental works.

Excavation	1 lot
Sand work	1 lot
Back fill	1 lot
Excess soil dispose	1 lot
Complete with installation	1 lot

SECTION 26 : MECHANICAL WORK

26.1 PLUMBING WORK

26.1.1 Water supply system

26.1.1.1 General

The water supply system to be covered under this Section shall include receiving of raw water, pressurizing and distribution works to each of the respective points of requirement.

The city water from the water purification plant in Savannakhet shall be received at the water tower-1. Then, the water shall be distributed to the water tower-2, roof top tank, buildings, public toilets, outdoor faucets for sprinkle and other required place by gravity.

The water stored in the water tower-2 shall be distributed to the accommodation and near area which require the water.

The PVC pipes shall be installed for the water supply system to distribute the water. The rated pressure of the PVC pipe for water supply system shall be class 13.5 (1.35Mpa).

The under ground pipes shall be installed not less than 600mm depth from finishing ground level, on the other hand, it shall be installed not less than 1200mm depth from finishing ground level in the road crossing section.

The under ground pipes shall be installed lower than electrical under ground conduit where their crossing point.

26.1.1.2 Scope

The works shall include the installation of water tanks (water tower, rooftop tank), piping, pumps, valves and required electrical works (panel, wiring, level switch, etc.) for the supply and distribution of domestic water to the sanitary equipment and all other required points as shown on the drawings. The system shall be made complete including piping, inserts, hangers, valves, plumbing fixtures, installations, painting and any other works required as shown on the drawings or as specified herein.

The water pipe line from the BCF to the Route 9 shall be constructed by Nampapa Lao, but share of expenses of them shall be included in this scope.

26.1.2 Waste water drainage system

26.1.2.1 General

The waste and sanitary water from the main office, public toilets and accommodation and 'check and toll office' shall be drained into the nearest point of the outdoor drainage system composed of septic tank and filter tank. The treated water shall be discharged to the surface water drainage manhole or open ditch through the connecting PVC pipe.

The PVC pipes shall be installed for the waste water drainage system to discharge the waste water. The rated pressure of the PVC pipe for this system shall be class 8.5 (0.85Mpa).

The under ground pipe shall be installed not less than 600mm depth from finishing ground level, on the other hand, it shall be installed not less than 1200mm depth from finishing ground level in the road crossing section.

The gradient of the horizontal pipe shall be as follows;

Under 2 inch : 1/50
Upper 3 inch : 1/100

26.1.2.2 Scope

The drainage system to be covered under this Section shall include the drainage of the building waste and sanitary water as shown on the drawings.

The works shall include the installation of the piping, inserts, hangers, fixtures, insulation, invert, painting, and any other works required for the complete functioning of the system.

26.1.3 Rain water drainage system

26.1.3.1 General

The rain water from main office roof will down flow to the ground level through the gutter and downspout. The down flowed rain water shall be discharged to surface water drainage manhole through the under ground pipes and catch basins.

The under ground pipe shall be installed not less than 600mm depth from finishing ground level, on the other hand, it shall be installed not less than 1200mm depth from finishing ground level in the road crossing section.

26.1.3.2 Scope

The scope of this work is complete provision and installation of under ground pipe and catch basin located between the downspout (Architecture work) and surface water drainage manhole (Civil work) which are shown in the drawings.

26.1.4 Materials and workmanship

26.1.4.1 Water tower

(1) Water tower-1

Composed as follows;

Tank capacity : 12m3
Total head : 15m/H2O
Pump 1.5kW (0.15m3/min) * 2sets
Control panel : Outdoor standing type
Level switch
Electrical works
Piping and valve works
Lightning protection work (incl. Grounding)
Foundation
Earth works
Complete with all accessories and installation

(2) Water tower-2

Composed as follows;

Tank capacity : 10m3
Total head : 15m/H2O
Pump 0.75kW (0.1m3/min) * 2sets
Control panel : Outdoor standing type
Level switch
Electrical works
Piping and valve works

Lightning protection work (incl. Grounding)
Foundation
Earth works
Complete with all accessories and installation

26.1.4.2 Roof top tank

The roof top tank shall be made of FRP and shall have capacity as shown in the drawing. The tank shall be provided with a cover, base structure w/ladder, pipe connections, a level switch, a ball cock tap and vent pipe. The tank shall be installed on the high structure (shown in the drawing) to distribute the water to each equipment by enough gravity and pressure.

Composed as follows;

Tank (FRP): capacity 2m3
Pump 0.75kW (0.1m3/min)
Control panel : Indoor wall mounted type
Level switch
Electrical works
Piping and valve works
Structure (height : 8m Approx.)
Complete with all accessories and installation

26.1.4.3 Septic tank

(1) Septic tank-1

Composed as follows;

Septic/filter tank
Inlet : 50person, For office (soil only)
Outlet : BOD under 60mg/l, SS under 50mg/l
Pipe works
Foundation
Earth works
Complete with all accessories and installation

(2) Septic tank-2

Composed as follows;

Septic/filter tank
Inlet : 70person, For toilet (soil only)
Outlet : BOD under 60mg/l, SS under 50mg/l
Pipe works

Foundation
Earth works
Complete with all accessories and installation

(3) Septic tank-3

Composed as follows;

Septic/filter tank
Inlet : 2.5person, For office (soil only)
Outlet : BOD under 60mg/l, SS under 50mg/l
Pipe works
Foundation
Earth works
Complete with all accessories and installation

(4) Septic tank-4

Composed as follows;

Septic/filter tank
Inlet : 15person, For resident
Outlet : BOD under 60mg/l, SS under 50mg/l
Pipe works
Foundation
Earth works
Complete with all accessories and installation

(5) Septic tank-5

Composed as follows;

Septic/filter tank
Inlet : 6person, For resident
Outlet : BOD under 60mg/l, SS under 50mg/l
Pipe works
Foundation
Earth works
Complete with all accessories and installation

26.1.4.4 PVC pipes and valves

(1) PVC pipe

PVC pipe and fittings shall conform to TIS or equivalent international standard. The fittings manufactured by the same manufacturer as pipe shall be used wherever possible.

Unions shall be provided in all piping to allow disassembly of the piping into reasonable lengths for handling during maintenance. Unions shall be provided at all equipment.

All cut pipe shall be carefully reamed to remove the burr formed on the inside.

(2) Valves

All valves shall be standard pattern and shall be of a reputable manufacture to facilitate obtaining replacement parts. Gate valves and check valves in 2inch or smaller pipe lines shall be brass or bronze construction throughout. Valve of brass or bronze shall conform to TIS or equivalent international standard.

All valves throughout the project shall be of the same manufacture.

(3) Hangers and supports

Hangers, brackets and supports shall be installed for all pipe hangers required for the support of the piping.

Unless shown otherwise on the drawing, PVC pipe shall be supported at the spacing recommended by the pipe manufacturer. Hanger rods shall be vertical without bends and workmanship shall be such that finished piping is true with respect to both line and grade.

Where pipe is embedded in concrete, it shall be carefully set to the required lines and grades and securely braced and held so that no movement shall occur while the concrete is being placed. Pipe supports to be embedded in concrete shall be made of material which will not deteriorate, weaken or cause damage to the pipe.

(4) Piping insulation

All exposed water conducting pipe shall be insulated with closed cell, foamed plastic tubular or sheet insulation with vapor barrier. Tubular insulation 20mm thick

shall be used on pipe 3inch and smaller and shall be installed on the pipe to avoid slitting the insulation. The insulation shall continue over fittings, joints and valves and shall be fitted tightly around hangers and supports and adhered to these. All joints in the insulation shall be made tight and waterproof with an adhesive compatible with piping material and insulation. The adhesive shall have a tensile strength of not less than 4kg/cm2, be designed for use with the insulation and shall be approved by the Engineer. Pipe larger than 3inch shall be insulated with 20mm thick sheet insulation. The sheet shall be formed around the pipe and the butted edges adhered with the approved adhesive. The ends of the cylindrical forms shall be butted and adhered in the same way. A high quality caulking shall be used at supports, hangers and fittings where the insulation cannot be made to fit up tightly. The caulking shall have good bonding strength, remain flexible and not bleed. All surfaces shall be clean and dry before installing the insulation.

(5) Invert

The invert which is connected under ground PVC pipes shall be composed by follows;

Invert (size : 900 * 900 * 1200 H)
Water proof cover
Accessories

26.1.4.5 Concrete pipe and catch basin

(1) Concrete pipe

The diameter lineup of concrete pipes which installed for the rain water drainage system shall be as follows;

Diameter lineup : 150mm, 200mm, 250mm, 300mm

(2) Catch basin

The catch basin which is connected concrete pipes shall be composed by follows;

Catch basin (size : 600 * 1000 * 1600 H)
Concrete cover
Accessories

26.1.4.6 Sanitary and water supply equipment

All sanitary equipment to be used shall comply with the following specifications.

(1) Water closet

Low tank type complete with accessories.

(2) Urinal

Wall hung type complete with accessories.

(3) Lavatory

Complete with faucet, brackets and other accessories.

(4) Slop sink

Complete with faucet and other accessories.

(5) Faucet for kitchen sink

Standard style suitable for a variety of settings. Single hole mount, swivel spout, chrome.

(6) Faucet for outdoor sprinkle

Cased in a box and installed in the ground, with swivel spout, chrome.

(7) Shower unit w/shower nozzle, hose, etc.

Electronic control system (ELB)

Heater coil : safety standard DIN 0700

Cut off temperature > 60 degree

(8) Toilet paper holder

Chromed double holder, wall mounted type (RELY TP-3116-2 or equivalent)

(9) Soap holder

Liquid soap holder (RELY 1108 or equivalent)

(10) Floor drain

Chromed, Size as shown in the drawings.

(11) Clean out

Chromed, Size as shown in the drawings.

26.1.5 Installation and workmanship

Piping shall be installed in the locations, elevations and to lines shown on the Drawings. All drainage lines shall be sloped to allow drainage to lower point. Waste water and soil drain lines shall be installed to a uniform slope of 1 in 50 for sizes smaller than 3 inch and of 1 in 100 for 3 inch size or larger, unless otherwise shown on the Drawings or directed by the Engineer.

All piping shall be fitted and assembled to introduce a minimum stress to the pipe and fittings, and the assembly shall conform to the best piping practice. PVC pipe shall be supported at the spacing recommended by the pipe manufacturer.

All threads shall be accurately and clearly cut and all burrs shall be removed. The same standard of thread system shall be used throughout the work.

All piping to be embedded shall be tested and approved by the Engineer prior to being embedded.

Sleeves or check-outs shall be provided where pipe passes through a wall, floor or beam. The space shall be filled with incombustible, rodent proof, inorganic material, approved by the Engineer. Where pipe passes through a wall or floor where a waterproof joint is required, the space shall be filled with an expanding grout.

Clean-outs shall be provided and installed at changes in direction or in horizontal drains at intervals of 16m, at the end of branch drains, at base of vertical soil, waste or rainwater pipes or as otherwise required by the Engineer.

All surfaces of the pipe which come in contact with concrete shall be cleaned prior to placing the concrete in order to secure a satisfactory bond. In placing concrete, care shall be exercised that pipe joints are not disturbed and that concrete is brought up evenly on both sides and is compacted around and under the pipe to ensure a continuous, full and even bearing throughout its length.

Stop valves and pipe unions shall be provided at water service connections to fixtures and equipment, accessibly located to facilitate removal of such equipment.

Pipe unions shall be fitted where necessary to facilitate installation or maintenance of equipment.

26.1.6 Performance tests

Functional check-out of all controls shall be made prior to the operational testing of the system. After the check-out, the entire domestic water supply system shall be performance tested to demonstrate the capacity specified and general operating characteristics of the equipment shall be tested.

Testing of individual pumps will not be needed if the supplier presents to the Engineer evidence to certify that the pump are manufactured by a reputable manufacturer in accordance with an applicable standard.

26.1.7 Testing

All pipe lines shall be water or air tested as directed by the Engineer and all labor, material, pumps, plugs, gauges, etc., required to make the complete test shall be provided. Lines shall be tested in convenient sections. In the case of failure due to faulty workmanship, material failure or leaks, repair all damage and leaks, replace the faulty material, and retest the piping until the tested section is acceptable to the Engineer.

All tests shall be carried out in the presence of the Engineer. All piping systems shall be flushed clean prior to testing.

(1) Testing of water piping

All pipes to convey water under pressure shall be subjected to a hydraulic test pressure of 5 kg/cm^2.

Before testing, all anchor blocks, thrust supports, and hangers shall be in place. If piping is tested in sections, temporary end caps shall be fitted to the approval of the Engineer. Each section shall be slowly filled with water, care being taken to expel all air from the piping. For acceptance, the test pressure shall remain constant for a period of one hour without pumping additional water into the section under test. If a drop in pressure occurs, leaks shall be repaired and the pipe line re-tested until acceptable.

(2) Testing of drainage piping

No pipes shall be covered or concealed before they are tested. Each drainage system within the buildings and outdoors shall be tested after all drains have been placed in position and all branches installed, but before the fixtures have been set

and connected. The test shall be carried out in the following manner. All openings and pipe ends shall be securely closed throughout the work by means of approved plugs and the entire system including vent stacks, branches to the fixtures and all horizontal mains and drains shall be filled with water up to the top of the highest opening. This water shall stand at the same level for not less than two hours. Another test shall be made of the entire plumbing system after the fixtures have been set. This test shall consist of allowing entry of water into all pipes, fixtures and traps in order that any imperfect material or workmanship may be detected.

Soil and waste water drains outside the buildings in which manholes are incorporated shall be water pressure tested by plugging the ends of sections of the system and filling the lines with water to a level of one meter above the highest point of the system being tested. This pressure shall be maintained for a period of two hours without a decrease in the level of water.

All drain systems shall also be inspected visually to ensure that there are no projections into the pipe and to ensure that the pipe line is straight and void of abrupt kinks. At least three-quarters of the area of the open pipe of any section between manholes shall be visible when viewed from the opposite end of the pipe section. Drain pipe that cannot be visually inspected by the above method shall have a heavy ball rolled through the pipe. The diameter of the ball shall be not less than 2/3 of the diameter of the pipe for size up to 4 inch. For pipe larger than 4 inch, the ball shall be 3 inch diameter.

If the drain does not pass the visual or the ball test, the pipe shall be removed and correctly placed.

26.2 AIR CONDITIONING AND VENTILATION SYSTEM

26.2.1 Air conditioning system

26.2.1.1 General

The air conditioner shall be provided to each room shown in the drawings located in the following buildings. The Contractor shall refer to the Mechanical and Electrical drawings about the location of air conditioner.

Main office
Booths
Check point office
Accommodation
Power house

The cooling capacity shall be calculated by Contractor, and the air-conditioner unit approved by the Engineer shall be installed.

26.2.1.2 Scope

The scope of this work is complete provision and installation included condensing unit, refrigerant pipe, drain pipe and control cables and all accessories required.

26.2.1.3 Material

(1) Split type air conditioner

The air conditioning units shall be of the split system type. Each unit shall consist of an air-cooled condensing unit with a matching fan coil unit. The air conditioner shall consist of one or more compressors, fans, motors, evaporators and all necessary valves, tubing, piping, safety devices, and accessories for a complete operating unit. Each unit shall be completely charged of refrigerant and room remote control unit in the field. Refrigerant shall be ASHRAE standard no.15,34. Units shall conform to the requirements of ARI standard no.210, TIS standard no.315, 385 and approved by the Federation of Thai Industries.

(2) Air-cooled condensing unit

The condensing unit shall be an air-cooled condenser type, completely factory assembled complying with the following :-

a) The compressor shall be rotary type, suitable for refrigerant. The power supply for 36,000 Btu/Hr and smaller condensing unit shall be 220/1/50.

b) Each compressor shall be mounted on vibration isolator.

c) The condenser coil shall be made of hard drawn copper tube with plate fins.

d) The condensing unit control board and pre-wired control shall be completely factory assembled.

e) The refrigerant pipes shall covered by the insulation.

f) The condensing unit shall have the following ;

- A complete set of safety devices.
- A magnetic contactor starter with a 3-coil overload relay for the compressor and fan motors.

- A time delay relay.
- Thermal overload protection for the compressor and fan motors.
- A high-low pressure controller.
- Liquid line and suction line shut off valves.
- Refrigerant charging ports.

26.2.2 Ventilation system

26.2.2.1 General

The ventilation system shall be installed in the required rooms shown in the drawings.

26.2.2.2 Scope

Provide all labor, materials, equipment and incidentals necessary to furnish and install the ventilating systems complete as shown on the drawings and specified herein. The work includes all supply air fans, all exhaust & intake fans, all ductwork connected with the supply and exhaust & intake fans, aluminum louvers, filters, hangers and support.

26.2.2.3 Material

Materials shall comply with the TIS standards or other approved international standards.

All fans shall be statically and dynamically balanced by the manufacturers.

The fan heads given in the schedules are given for guidance only, and the Contractor shall be responsible for checking the total final resistance of each system, based on the actual duct runs and equipment offered, prior to ordering. The Contractor shall be responsible for any modifications to the system or any component, i.e. fans, ductwork, motors, cables, switch-gear, and the like, which may be required to meet the scheduled duties and space limitations.

Not withstanding the above no modifications to any system shall be carried out where such modification may result in a reduction in system performance or efficiency, without the prior approval of the Engineer.

All fans shall be so located to allow for easy maintenance.

Each supply and exhaust air system shall be balanced to produce the indicated air

quantities at the conditions shown. Bearings shall be lubricated, and the speed and direction or rotation of each fan shall be checked. The running current of each motor shall be checked.

Upon completion, and prior to acceptance of the installation, the Contractor shall subject the ventilating systems to such operating tests as may be required by the Engineer to demonstrate satisfactory functional and operating efficiency. Operating tests shall cover a period of not less than 6 hours for each system, and all tests shall be conducted at such times as the Engineer may direct. If tests do not demonstrate satisfactory operation of the ventilating systems, deficiencies shall be corrected and tested. All instruments, facilities, and labor required to properly conduct the tests shall be provided by the Contractor.

26.3 FIRE FIGHTING SYSTEM

26.3.1 Fire hydrant system

26.3.1.1 General

The outdoor fire hydrant system shall be installed in the main office building area.

The water for the hydrants shall be taken by the fire hydrant pump from the under ground water tank located in the central building. The fire hydrant pump shall be remote operated through a push button fitted in the hydrant box.

The water source and pipes for this system shall be used for only this system.

The capacities are as follows;

Nozzle discharging volume	:	More than 350 little/min
Discharging pressure	:	More than 2.5kgf/cm2
		Less than 6kgf/cm2
Hydrant pump discharging volume	:	More than 800 little/min

26.3.1.2 Scope

The scope of this work is complete provision and installation of the fire hydrant system. The under ground water tank for the hydrant system shall be excluded (included in Architecture work).

26.3.1.3 Material

(1) Fire Water Pipe

The pipe shall be of galvanized steel pipe. Exposed surfaces of the pipe shall be painted with two coats of oil paint.

(2) Fire-hydrant pump unit

The fire-hydrant unit shall be composed of pump, valves, control box and other requirements made by the manufacturer.

(3) Hydrant box

The hydrant box shall consist be of hydrant valve, hose rack, hose and nozzle as shown on the Drawings.

The box shall be constructed of steel plate 1.6mm thickness, shop coated with melamine.

The door shall be a steel flush door.

The box shall be outdoor self-standing type depending on the places as shown on the Drawings.

(4) Hydrant Valve, Hose Rack, Hose and Nozzle

The hydrant valve shall be ϕ - 40mm, 90° angle globe valve having hose connection rated for 10kg/cm^2 working pressure.

The hose rack shall be of cast bronze construction chromium plated, swing out type.

The hose shall be of cotton or linen rubber lined hose treated to prevent mildew, rated for 7 kg/cm^2 water pressure. The hose shall have 40mm dia. and 30 meters (15m x 2) length and shall be provided with suitable couplings for connection to the hydrant valve and the nozzle.

The nozzle shall be of bronze construction, steam water discharge type.

26.3.2 Fire extinguisher

26.3.2.1 General

Suitable number of fire extinguishers shall be provided in the main office and other required buildings.

26.3.2.2 Scope

The scope of this work is provision of fire extinguishers and complete installation of the storage boxes.

26.3.2.3 Material

The fire extinguisher shall be of the dry chemical, heavy-duty, portable, 6kg (12pound) capacity, air pressure operated type.

Each fire extinguisher shall be supplied with a free flowing, moisture repellant fire extinguishing chemical powder. The chemical powder shall extinguish fires in paper, wood, rags, petroleum products and electrical fires.

Wall recessed storage box for extinguisher shall be supplied and installed where directed by the Engineer (Approx. 20m in the main office, Accommodation and Booths, etc.).

26.4 CIVIL WORKS FOR UNDER GROUND PIPING

The Contractor shall refer to the Building work specification (PART 3) about excavation, back fill, sand work, and excess soil disposal for under ground conduit shown in the drawing.

26.5 TRUCK SCALE

26.5.1 General

One set of truck scale shall be installed arrival side truck lane.

26.5.2 Scope

The scope of this work is complete provision and installation of one set of truck scale including the foundation and earth works.

26.5.3 Material

Maximum capacity : 60 ton 2 (two) times measuring type

Composed by follows;

Load cell
Weight indicator

UPS
Steel plat form
Wiring and conduit
All required accessories
Drain pipe works (PVC pipe)

26.6 GAS SUPPLY SYSTEM

The gas supply system shall be installed in the accommodation. The scope of work are complete provide and installation of gas pipe and accessories (valves and cocks).

26.7 MEASUREMENT AND PAYMENT

Measurement and payment for each work shall be made on the basis of the unit price specified in the contract Bill of Quantity. The unit price shall include the cost for all incidental works as specified below, not limited.

26.1(1) : (2) Water tower (nos)

The water tower shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Water tower	1 set
Pump	2 set
Control panel	1 set
Level switch	1 set
Electrical works	1 lot
Piping and valve works	1 lot
Lightning protection work (incl. Grounding)	1 lot
Foundation	1 lot
Earth works	1 lot
Complete with all accessories and installation	1 lot

26.1(3) City water receiving payment to Nampapa (Water authority) (Ls)

The city water receiving payment shall be measured by amount paid to Nampapa actually.

Power receiving payment to Nampapa	1 lot

26.1(4) Roof top tank (nos)

The roof top tank shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Tank	1 set
Pump	2 set
Control panel	1 set
Level switch	1 set
Electrical works	1 lot
Piping and valve works	1 lot
Structure	1 set
Complete with all accessories and installation	

26.1(5) : (9) Septic tank (nos)

The Septic tank shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Septic/filter tank	1 set
Pipe works	1 lot
Foundation	1 lot
Earth works	1 lot
Complete with all accessories and installation	1 lot

26.1(10) : (12) Valve (nos)

The valve shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Valve	1 set
Complete with all accessories and installation	1 lot

26.1(13) Valve box (nos)

The valve box shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Valve box	1 set
Foundation	1 lot
Earth works	1 lot
Complete with all accessories and installation	1 lot

26.1(14) : (23) PVC pipe (lm)

The PVC pipe shall be measured by length of linear meters actually at site. The unit price shall include the following incidental works.

PVC pipe	1 lm
Complete with all accessories and installation	1 lot

26.1(24) Invert (nos)

The invert shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Invert	1 set
Water proof cover	1 set
Earth works	1 lot
Complete with all accessories and installation	1 lot

26.1(25) : (28) Concrete pipe (lm)

The concrete pipe shall be measured by length of linear meters actually at site. The unit price shall include the following incidental works.

Concrete pipe	1 lm
Complete with all accessories and installation	1 lot

26.1(29) Catch basin (nos)

The catch basin shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Catch basin	1 set
Concrete cover	1 set
Earth works	1 lot
Complete with all accessories and installation	1 lot

26.1(30) Water closet (nos)

The water closet shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Water closet	1 set
Toilet paper holder	1 set

Pipe works	1 lot
Complete with all accessories and installation	1 lot

26.1(31) Urinal (nos)

The urinal shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Urinal	1 set
Pipe works	1 lot
Complete with all accessories and installation	1 lot

26.1(32) Lavatory (nos)

The lavatory shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Lavatory	1 set
Soap holder	1 set
Pipe works	1 lot
Complete with all accessories and installation	1 lot

26.1(33) Slop sink (nos)

The slop sink shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Slop sink	1 set
Pipe works	1 lot
Complete with all accessories and installation	1 lot

26.1(34) Faucet for kitchen sink (nos)

The faucet for kitchen sink shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Faucet for kitchen	1 set
Pipe works	1 lot
Complete with all accessories and installation	1 lot

26.1(35) Faucet for outdoor sprinkle (nos)

The faucet for outdoor sprinkle sink shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Faucet for outdoor sprinkle	1 set
Valve 1 inch	1 set
Steal box	1 set
Pipe works	1 lot
Foundation	1 set
Earth works	1 lot
Complete with all accessories and installation	1 lot

26.1(36) Hot shower unit (nos)

The hot shower unit shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Heater unit w/faucet	1 set
Shower nozzle and hose	1 set
Electrical works	1 lot
Pipe works	1 lot
Complete with all accessories and installation	1 lot

26.1(37) Clean out (nos)

The clean out shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Clean out	1 set
Complete with all accessories and installation	1 lot

26.1(38) Floor drain (nos)

The floor drain shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Floor drain	1 set
Complete with all accessories and installation	1 lot

26.2(1) : (6) Air conditioner (nos)

The air conditioner shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Air conditioner	1 set
Condensing unit	1 set
Refrigerant pipe	1 lot
Drain pipe	1 lot
Control cable	1 lot
Complete with all accessories and installation	1 lot

26.2(6) : (22) Ventilation (nos)

The ventilation shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Ventilation	1 set
Duct	1 lot
Complete with all accessories and installation	1 lot

26.3(1) Fire hydrant system

The fire hydrant system shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Pump unit w/control panel	1 set
Outdoor hydrant box	2 set
Galvanized steel pipe 4inch	50 m
Foundation	1 lot
Earth works	1 lot
Complete with all accessories and installation	1 lot

26.3(2) Fire extinguisher (nos)

The fire extinguisher shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Fire extinguisher	1 set
Storage box	1 set
Complete with all accessories and installation	1 lot

26.4(1) : (5) Civil works for under ground pipe (lm)

The civil works for under ground pipe shall be measured by length of linear meters from one invert/catch basin to the other based on the cross sections (type-S1, S2, W1, C1, C2) shown in the drawings. The unit price shall include the following incidental works.

Excavation	1 lot
Sand work	1 lot
Back fill	1 lot
Excess soil dispose	1 lot
Complete with installation	1 lot

26.5(1) Truck scale (nos)

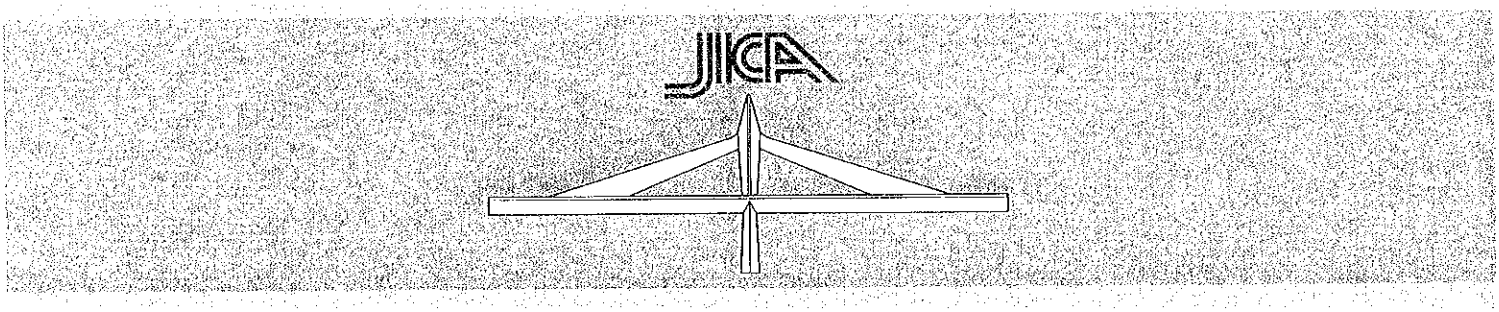
The truck scale shall be measured by number of set installed actually at site. The unit price shall include the following incidental works.

Load cell	1 lot
Weight indicator	1 set
UPS	1 set
Steel plat form	1 set
Wiring and conduit	1 lot
Drain pipe works	1 lot
Foundation	1 lot
Earth works	1 lot
Complete with all accessories and installation	1 lot

26.6(1) SGP pipe (Gas pipe) (lm)

The SGP pipe shall be measured by length of linear meters actually at site. The unit price shall include the following incidental works.

SGP pipe (Gas pipe)	1 lm
Valve	1 lot
Cock	1 lot
Complete with all accessories and installation	1 lot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