JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

PEOPLE'S COMMITTEE OF HO CHI MINH CITY (PCHCMC)
MINISTRY OF PLANNING AND INVESTMENT (MPI)
THE SOCIALIST REPUBLIC OF VIET NAM

THE DETAILED DESIGN STUDY
ON
HO CHI MINH CITY
WATER ENVIRONMENT IMPROVEMENT PROJECT
IN
THE SOCIALIST REPUBLIC OF VIET NAM

FINAL REPORT

DRAFT BIDDING DOCUMENTS

PACKAGE E :
WASTEWATER TREATMENT PLANT CONSTRUCTION

VOLUME 2

JUNE 2001

PACIFIC CONSULTANTS INTERNATIONAL

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SECTION 1. GENERAL SPECIFICATION

1.1 DESCRIPTION OF THE PROJECT

1.1.1 Overview of the Project

Ho Chi Minh City has been rapidly urbanized and expanded over the last 20 years without development of city infrastructure, particularly urban drainage and sewerage systems. Water pollution in canals and rivers, caused by direct discharge of domestic and industrial sewage, has resulted in an unsanitary, unhealthy environment. Solid waste dumping, housing development along canals and sludge accumulation have led to obstruction of waterway transportation. Low ground level combined with inadequate drainage systems result in periodic flooding of certain areas.

The Ho Chi Minh City Water Environment Improvement Project, in addressing the above problems, aims to contribute to the improvement of urban drainage and sewerage system of Ho Chi Minh City.

The project area covers an area of 3,065 ha which includes the central part of the city as well as the outlying areas of Thanh Da and Ben Me Coc. Certain elements of the overall project have been deferred to a future phase which, in the case of sewerage development, will integrate with works to be completed under the present project.

The main elements of the project are:

- Tau Hu – Ben Nghe canal improvement of 7.3 km
- Pump drainage improvement at Thanh Da (15.4 ha) , Ben Me Coc (1) (70.9 ha) and Ben Me Coc (2) (46.0 ha)
- Existing combined sewer improvement of 9.5 km
- Interceptor sewer of 12.2 km
- Conveyance sewer of 3.5 km
- Intermediate wastewater pumping station with a total pumping capacity of 133 m^3/min
- Wastewater treatment plant with a capacity of 141,000 m^3/day

1.1.2 Contract Packages

The project has been divided into packages for the purposes of implementation as follows:

Package A:	Tau Hu – Ben Nghe Canal Improvement
Package B:	Pump Drainage Improvement
Package C:	Interceptor Sewer Construction, Intermediate Wastewater Pumping Station Construction and Procurement of Sewer Cleaning Equipment
Package D:	Conveyance Sewer Construction and Existing Combined Sewer Improvement
Package E:	Construction of Wastewater Treatment Plant

1.1.3 Interfaces with Other Packages

The Works for Package E has interfaces with those of Package D as follows:

(a) At the defined interface shown on the Drawings near the northern abutment of the bridge with embankment and roadworks constructed under Package D;

(b) At the defined interface shown on the Drawings with that portion of the conveyance sewer constructed under Package D.

1.1.4 Scope of Work for Package E

The Works to be completed by the Contractor consists of, but not limited to, the construction manufacture, delivery, installation, testing and commissioning of the wastewater treatment plant and associated facilities and technical guidance and training for its operation and maintenance.

The Works to be completed under the Contract represent the first phase of a scheme which will increase the capacity of the plant from 141,000 cubic metres per day (Phase 1) under this contract to a capacity of 469,000 cubic metres per day (Phase 2) in order to meet future demands.

A breakdown of the Works, by discipline, is as follows:

A. Civil Works

Civil works comprise the following:

(a) Site preparation works which include:
- Clearing and grubbing
- Demolition
- Excavation and filling
- Construction of access road
- Soil improvement
- Construction of earth dikes
- Protection of existing electric towers

(b) Construction of a reinforced concrete jetty with piled foundations

(c) Earthworks and piling for buildings and facilities consisting of excavation for the various facilities, reinforced concrete and timber piling works for foundations, and backfilling.

(d) Reinforced concrete construction works for the following facilities:
- Lift pump station
- Primary sedimentation tank, aeration tank and final sedimentation tank
- Disinfection tank
- Water supply facility
- Effluent pipe
- Pipe gallery
- Main building substructure
- Blower building substructure
- Dewatering building substructure
- Gravity thickener
- Compost plant facilities including fermentation tank, deodorizing soil filter tank and weigh bridge

(e) Construction of a bridge across the Tac Ben Ro River comprising piled foundations, reinforced concrete substructure and prestressed concrete girder, approach ramps and asphalt paving.

(f) Roadworks throughout the wastewater treatment plant, approach road and bridge

(g) Stormwater drainage works throughout the wastewater treatment plant
(h) Landscaping works
(i) Sanitary sewer construction within the wastewater treatment plant
(j) Miscellaneous other work
(k) Conveyance Sewer construction comprising
- Earthworks
- Construction of a portion of the sewer beneath the Tac Ben Ro canal by pipe jacking methods
- Construction of a portion of the reinforced concrete sewer by open cut methods
- Construction of manholes and inspection chambers

B. Building Works

Building works comprise the completion of architectural, structural, mechanical, plumbing and electrical works for the following buildings:

(a) Lift pumping station
(b) Chlorine storage building
(c) Blower building
(d) Main office building
(e) Dewatering and centrifugal thickener building
(f) Compost plant facility buildings comprising:
- First fermentation tank building
- Second fermentation tank building
- Storage vessel building
- Sub-storage vessel building
- Compost control building

(g) Guard House
(h) Stair Houses for stairs A, B, C
(i) Ventilation works for underground civil structures (M & E works only)

C. Mechanical Works

Mechanical Works comprise the design, supply, installation, testing and commissioning of the various items of mechanical equipment summarized as follows:

(a) Grit chamber equipment
(b) Lift pump equipment
(c) Distribution tank equipment
(d) Blower equipment
(e) Primary sedimentation tank equipment
(f) Aeration tank equipment
(g) Final sedimentation tank equipment
(h) Disinfection equipment
(i) Treated water supply equipment
(j) Filtered water supply equipment
(k) Gravity thickening equipment
(l) Centrifugal thickening equipment
(m) Sludge dewatering equipment
(n) Recycle flow equipment
(o) Fermenting equipment
(p) Curing equipment
(q) Deodorization equipment
(r) Piping

D. Electrical Works

Electrical works comprise the design, supply, installation, testing and commissioning of the various items of electrical equipment for the facilities as summarized below:

(a) 22kV Substation

(b) Main Building
- Main electric room
- Main control room
- Emergency generator

(c) Lift Pumping Station
- Lift pumping station electric room
- Local control panel
- Instrumentation equipment

(d) Waste Water Treatment Facility
- Wastewater treatment electric room
- Local control panel
- Instrumentation equipment

(e) Chlorine Storage Building Facility
- Chlorination electric room
- Local control panel
- Instrumentation equipment

(f) Dewatering and Centrifugal Thickener Facility
- Dewatering electric room
- Local control panel
- Instrumentation equipment

(g) Blower Building Facility
- Electrical equipment
- Local control panel
- Instrumentation equipment

(h) Compost Plant Facility
- Compost electric room equipment
- Local control panel
- Instrumentation equipment

(i) Pipe Gallery Equipment

(j) Outdoor and Road Lighting Equipment

(k) Transmission Line

Complete descriptions of the requirement are included in the Drawings, the Specification, the Bill of Quantities and other documents comprising the Contract.

1.2 GENERAL INFORMATION

1.2.1 Site Conditions

The site of the waste water treatment plant is located on a low lying island formed by the Tac Ben Ro River and other waterways. The average elevation the ground is about 0.500. The area is sparsely populated and is characterised by fish farms and swamp vegetation.

Soil at the site is alluvial and details are shown in the Drawings. Reference should be made to Section 2: Site Preparation

1.2.2 Climate

Ho Chi Minh City is located in the tropical monsoon zone and its climatic characteristics are almost uniform temperature, high humidity, and heavy precipitation. Meteorological observation has been carried out at Tan Son Nhat station since 1915.

Meteorological characteristics as recorded at the Tan Son Nhat station from 1976 to 1977 station are s follows:

- The annual average temperature and relative humidity are 27.4 °C and 77.2 % respectively;
- Annual sunshine hours are 2,508 hours,

Annual average rainfall is 1,929 mm, of which about 93 % (1,788 mm) occurs during the rainy season starting from May to November with maximum monthly rainfall of 308 mm occurring in the month of August. Only about 7% (141 mm) of annual rainfall occurs during the dry season from December to April.

1.2.3 Access to the Site

1.2.3.1 Location of Site

The Site of the Works is located approximately 3 km south of Ho Chi Minh City in the Binh Chanh district in the Socialist Republic of Vietnam.

There are no existing roads or bridges linking the Site with Ho Chi Minh City. However, access is available by means of the extensive network of rivers and canals which enable water transport from Ho Chi Minh City, the Port of Saigon and other areas.

The Works include construction of bridge across the Tac Ben Ro canal. Furthermore, a temporary road connecting a proposed public road and the bridge is included in the Works be constructed by the Contractor. Subsequently, access to the Site will be available by road.

The Contractor shall fully inform himself of the conditions of roads, traffic conditions, traffic regulations, waterway conditions and regulations governing navigation with respect to gaining access to the Site for the purposes of performing the Works and shall take all necessary actions to ensure availability of access to the Site as required.

1.2.3.2 Load Limits

(a) The public roads and bridges have various load limits and the Contractor shall be responsible for determining the load limits existing at the time and ensuring that his Equipment does not exceed such limits. Before moving any heavy construction equipment into public roads and bridges, the Contractor shall make suitable arrangements with the appropriate Government authorities and obtain their approval for the passage of such traffic.

(b) The Contractor shall use every possible means to prevent any public roads or bridges connecting with or on the road to the Site from being damaged by any traffic of the Contractor or his subcontractors.

1.2.3.3 Tracked Vehicles

The Contractor shall not travel tracked vehicles on any bituminous sealed road surface or bridge. Rubber tired vehicles conforming to applicable load restrictions will be permitted to use bituminous sealed roads and bridges.

1.2.3.4 Safety

The Contractor shall take necessary care at all times to ensure the convenience and safety or residents along or nearby the roads and streets used to access the Site.

1.2.3.5 Construction of Additional Access Roads

All additional roads required by the Contractor as temporary road on the Site shall be provided by the Contractor at his expense.

1.2.3.6 Maintenance

All damage caused to the public roads or bridges used by the Contractor for access to the Site shall be promptly repaired by the Contractor at his expense.

1.2.4 Sources of Materials

The following sources of materials are listed for information only. The Contractor shall satisfy himself as to the suitability of such sources.

Material	Source	Approx. Distance from Site
Sand and Gravel	Long Thanh District, Dong Nai Province	60 km
Sand Fill	Dong Nai River	40 km
Concrete Aggregate	Bien Hoa City, Dong Nai Province	30 km
Cement	Thu Duc District, HCMC	15 km
Concrete Reinforcement	Long Thanh District, Dong Nai Province	60 km
Precast Concrete Piles	Thuan An District, Binh Duong Province	25 km
Precast Concrete Pipes	Thu Duc District, HCMC	15 km

1.2.5 Spoil Disposal Area

Excavated material unsuitable for reuse as fill or surplus to requirements shall be disposed of in the area designated as a spoil disposal area within the Site as shown on the Drawings subject to constraints specified in Section 2.

1.2.6 Water Supply, Power and Telephone Facilities

There are no water supply, electric power or fixed-line telephone facilities available at the Site. However, it is anticipated that electric power and telephone cable will be available at the site boundary (near the abutment of the proposed bridge across the Tac Ben Ro River) during the course of the works.

1.3 CONTRACT DOCUMENTS AND DRAWINGS

1.3.1 Contract Documents

The Contractor will be provided with a maximum of five (5) sets of Contract Documents for his own use. Bid Documents in the Contractor's possession shall be marked superseded or returned to the Employer after issue of the Contract Documents and will not be recognised in the administration of the Contract. Further instructions issued by the Engineer shall be kept at all times on the Site by the Contractor and shall be available to the Engineer and his staff.

1.3.2 Bid Drawings

The Drawings included in the Bidding Documents are to be used for bidding purposes only. The Drawings show the work to be carried out in accordance with the Contract as definitely and in as much detail as is possible at the time of bidding. The Contractor may use the Bid Drawings for placing preliminary orders for materials or for preparing Drawings of Temporary Works. However, the Bid Drawings shall not be used as a basis for fabrication of equipment or for construction of the Works.

1.3.3 Construction Drawings

Bid Drawings will be supplemented or superseded by such Construction Drawings as necessary for the purpose of the proper and adequate execution of the Works. Two (2) full size prints of such Construction Drawings will be issued by the Engineer to the Contractor in accordance with the construction programme required under the provisions of Clause 1.4. On receipt of the Construction Drawings, the Contractor shall check them carefully and advise the Engineer in writing of any discrepancies, errors or omissions and full instructions will be furnished to the Contractor should any discrepancies, errors or omissions be found. The Contractor shall be required to perform the Work in accordance with such Construction Drawings at the applicable rates bid in the Bill of Quantities for such work or work of a similar nature. Although the Drawings are prepared to scale, work shall be based upon dimensions shown on the Drawings and not on dimensions scaled from the Drawings.

The Engineer may, from time to time during the construction, issue further Drawings to supplement or amend the Construction Drawings, if deemed necessary. Such further Drawings shall become part of the Construction Drawings.

The Contractor shall be governed by figure dimensions as given on the Drawings. Where the required dimensions are not shown in figures, the Contractor shall obtain such dimensions from the Engineer before proceeding with the construction of the portion of the Works to which they refer. In every case, detailed Drawings shall take precedence over general Drawings.

When additional information regarding foundation or other conditions becomes available as a result of excavation work, further testing or otherwise, and if it is found desirable to make changes in the alignment, cross section, dimensions or design of the Works to conform to such conditions, the Employer reserves the right to make such changes as in the opinion of the Engineer are necessary or desirable, and the Contractor shall forthwith comply with any such direction of the Engineer.

Bid drawing may be used as construction Drawings, as defined above, when authorised, in writing, by the Engineer.

1.3.4 Drawings to be furnished by the Contractor

1.3.4.1 General

All of the various types of Drawings as stated hereinafter shall be prepared in a form approved by the Engineer and submitted in advance to give the Engineer sufficient time to review and approve them without causing any delay to the field works. The Contractor shall provide qualified staff and a sufficient number of draftsmen/CAD operators and assistants capable of producing all Drawings required.

All Drawings and supporting computations to be submitted by the Contractor for the Engineer's approval shall be in English. All dimensions shall be given in the metric system. The Drawings shall be in JIS A1 size (594 mm by 841 mm) unless otherwise specified or approved by the Engineer.

The Contractor shall be held responsible for all Drawings and documents not submitted within the time limits stipulated in Clause 1.3.5. and for all costs involved for delays and damages consequent thereto. Contractor's Drawings approved by the Engineer are to be used for construction.

1.3.4.2 Working Drawings

The Contractor shall prepare the working Drawings for all items of the Permanent Works on the basis of the Construction Drawings issued by the Engineer. The working Drawings shall show sufficient details of the structure of the works or the construction methods or procedures such as, but not limited to, and as applicable, excavation and embankment fillings, concrete reinforcement bar arrangement including bending/cutting schedule and bar list, expansion joints, contraction joints, construction joints, concrete placement details, waterstop layout, equipment installation, etc., by which the Contractor will proceed with the field construction and operation. Further, Drawings presenting full details of items not to be incorporated into the Permanent Works but which affect the quality of work such as concrete forms, supports, etc., shall also be included in the working Drawings. All the working Drawings related to any section on the Works shall be approved by the Engineer prior to the time the Contractor plans to perform such section of work.

1.3.4.3 Shop Drawings

Shop Drawings, shall be prepared by the Contractor, or the Contractor's materials/equipment supplier on behalf of the Contractor, to show the outline, dimensions, type of material, etc., of particular items indicated in the Drawings and/or Specifications and as directed by the Engineer. Such shop Drawings shall be submitted by the Contractor to the Engineer for approval.

1.3.4.4 Drawings of the Temporary Works

Thirty (30) days before starting any section of the temporary facilities specified in Clause 1.8 hereof, the Contractor shall submit to the Engineer for approval Drawings showing details of such facilities.

The Drawings for temporary facilities shall show the locations and other pertinent details of the principal components of the Contractor's Equipment, offices, quarters, warehouses, storage areas, workshops, labour camps and other temporary buildings and facilities which the Contractor proposes to construct in the Works area.

If any change is made in the items mentioned above during erection or after the items become operational, the Contractor shall submit revised Drawings showing such changes to the Engineer for approval.

1.3.4.5 As-Built Drawings

Throughout the period of construction, the Contractor shall maintain an up-to-date set of as-built Drawings for the various items of work completed. Such Drawings shall show all authorised changes to the Construction Drawings and Shop Drawings to the extent that they correctly portray the true "as-built" condition of each item of the Permanent Works. The format of the as-built Drawings shall be as approve by the Engineer.

The up-to-date set of as-built Drawings shall be subject to periodical inspection at the Site by the Engineer and if the Drawings are found unsatisfactory or not up-to-date the Contractor shall bring them up-to-date within fourteen (14) days after inspection. If any part of the permanent Works delineated on the Drawings is complete, the pertinent as-built Drawings, after approval by the Engineer, shall be signed by both the Engineer and the Contractor, or their representatives, and three (3) copies shall be kept by the Engineer.

The as-built Drawings shall be made on high quality reproducible paper so that clearly readable copies can be made. The finished set of as-built Drawings shall be submitted by the Contractor to the Engineer for his approval and transmittal to the Employer in the manner specified in Clause 1.3.5.

1.3.4.6 Other Drawings

Drawings other than those mentioned above, which are of a general nature, such as the proposed construction methods, temporary works for construction purposes, schematic diagrams and outlines of how various types of work are to be performed shall, as directed by the Engineer or as stipulated in the Contract Conditions and Specification, be submitted to the Engineer for approval.

1.3.4.7 Form and Presentation of Drawings

(a) General

All shop Drawings and Working Drawings produced by the Contractor or his subcontractors for this Contract shall use a common system of sizes, title blocks and numbers in accordance with this Clause, regardless of who produces the Drawings.

(b) Drawing Sizes and Standards

All Drawings shall be drawn in the accordance with Clause 1.3.4.7.

(c) Title Blocks

(i) The Contractor shall submit a sample of the title block he proposes to use for approval by the Engineer. The general format of the title blocks shall follow those of this Specification.

(ii) The Contractor or his subcontractor's title blocks shall show the Contractor's and subcontractor's name, the date, the title, and number of the drawing and each new issue of the drawing shall be identified by a revision letter as a part of the number. In addition each drawing shall show the following details in the lower right hand corner:

HO CHI MINH CITY
WATER ENVIRONMENT IMPROVEMENT PROJECT

PACKAGE E: CONSTRUCTION OF
WASTE WATER TREATMENT PLANT

DRAWING NO. ……..

(d) Numbering System

(i) Primary reference to drawing numbers on all Drawings, correspondence, operation, and maintenance instructions and elsewhere, shall be the number from the Engineer's numbering system, which system will be notified to the Contractor.

(ii) The Contractor may, if he desires, insert his own reference number in the appropriate place on the title block.

(iii) Drawing number shall be as allocated by the Engineer.

(e) Quality

The quality of working Drawings, shop Drawings, "as-built' Drawings and Drawings for temporary works shall be in accordance with Clause 1.3.5.

(f) Drawing Index

The Contractor shall compile a drawing index for all Drawings produced by himself and his subcontractors. The Contractor shall submit an up-to-date copy of each sheet of the index to the Engineer at three monthly intervals or on request.

(g) Drawings on Site

Copies of the latest revisions of all Drawings shall be sent to the Contractor's site office as soon as possible after they are approved. The Drawings shall be available at all reasonable time for inspection by the Engineer.

1.3.5 Submittal and Approval of Contractor's Drawings

1.3.5.1 General

(a) It is to the Contractor's advantage to prepare his Drawings and submit them to the Engineer at the earliest possible time to avoid delay in the fieldwork due to lack of approved Drawings on hand for the construction crew.

(b) Any work done prior to the Engineer's approval of the Drawings shall be at the Contractor's risk. Approval by the Engineer of the Contractor's Drawings shall not relieve the Contractor from any of his obligations in the complying with the provisions of the Contract.

1.3.5.2 Procedure for Submittal and Approval

(a) Unless otherwise specified the Contractor shall submit his working drawing, shop Drawings and other required Drawings to the Engineer for approval at least twenty eight (28) days prior to the commencement of construction of any particular item of work. Shop Drawings for any particular item which has to be fabricated outside of the Site shall be submitted early enough to allow adequate time for review, approval, fabrication, transportation and receipt at the Site.

(b) Four (4) clearly readable print copies of each drawing shall be submitted to the Engineer by means of a standard transmittal sheet. The format of the transmittal sheet shall be as approved by the Engineer.

(c) The Engineer shall have the right to direct the Contractor to provide additional details and change in the Drawings if they are necessary to ensure compliance with the provisions and intent of the Specifications. Within thirty (30) days after the receipt of the Drawings submitted by the Contractor, the Engineer shall return one (1) copy thereof to the Contractor marked "Approved for Construction", "Approved for Construction-Except as Noted", or "Not Approved Resubmit".

(d) The return and receipt of any approved drawing shall be deemed to authorise the Contractor to proceed with the work covered by such drawing, but before proceeding with the work the Contractor shall first submit to the Engineer by logged transmittal sheet two (2) prints of each drawing. When requested by the Engineer, one (1) transparency of working Drawings and shop Drawings shall also be submitted together with two (2) prints. Copies of all approved Drawings shall be maintained at the Contractor's site office in proper order.

(e) When correction or revision is directed on the Contractor's submitted Drawings, the Contractor shall make the necessary corrections and/or revisions in a timely manner and shall resubmit them in two (2) copies to the Engineer in the same manner as for new drawing. This procedure shall continue until the Drawings have been finally approved.

1.3.5.3 Other Information

All applicable requirements of this Clause shall apply equally to other submittals described in Clause 1.4.

1.3.5.4 As-Built Drawings

Within one (1) month following the issue of the Certificate of Completion of the Works, the Contractor shall furnish to the Engineer, for his approval; and transmittal to the Employer, the final version of as-built Drawings. These as-built Drawings shall consist of:

(a) Two (2) sets of transparent polyethylene sheets ;

(b) Three (3) sets of full-sized (A1 size) bound copy ; and

(c) Ten (10) sets of reduced size (A3 size) bound copy.

(d) Two (2) sets of CD ROM of all Drawings prepared by CAD

1.3.6 Language and Units

The English language shall be used for all Drawings, specifications and other submissions by the Contractor except that Operation and Maintenance Manuals shall be prepared in both English and Vietnamese.

SI Units shall be used on in all Drawings, specifications and other submissions by the Contractor. Where printed information uses other units the equivalent SI units shall be shown.

1.3.7 Payment

1.3.7.1 Working Drawings and Shop Drawings

Payment for shall be made at the Lump Sum price entered in the Bill of Quantities.

For the purposes of monthly progress payments the amount completed, expressed as a percentage of the total number of Working and Shop Drawings required to be completed by the Contractor, shall be determined. Payment shall be calculated by multiplying the percentage completed by the lump sum entered in Bill of Quantities. Payment for Drawings shall never exceed the lump sum entered in the Bill of Quantities.

1.3.7.2 As-Built Drawings

Payment for shall be made at the Lump Sum price entered in the Bill of Quantities.

For the purposes of monthly progress payments the amount completed, expressed as a percentage of the total number of As-Built Drawings required to be completed by the Contractor, shall be determined. Payment shall be calculated by multiplying the percentage completed by the lump sum entered in Bill of Quantities. Payment for Drawings shall never exceed the lump sum entered in the Bill of Quantities.

1.3.7.3 Other Drawings

No separate payment shall be made for other categories of Drawings describe in this Clause 1.3 and the cost of preparing such Drawings shall be deemed to be included in the rates and lump sum prices of other items in the Bill of Quantities.

1.4 CONSTRUCTION PROGRAMME, CONSTRUCTION PLAN, PROGRESS REPORTS AND OTHER SUBMITTALS

1.4.1 General

The Contractor shall prepare and submit a construction programme, a construction plan, progress reports and other required documents in the manner specified herein.

1.4.2 Construction Programme

1.4.2.1 General

The Contractor shall prepare a construction programme in accordance with Conditions of Contract, Part II, Sub-Clause 14.1.

1.4.2.2 Revision of Programme

If in the course of execution the rate of progress of the Works or any section thereof falls behind the Contractual Construction Programme the Contractor shall prepare a revised programme in accordance with Conditions of Contract, Part II, Sub-Clause 14.2.

1.4.3 Construction Plan

1.4.3.1 General

Within twenty eight days of receiving the notice to proceed in accordance with Sub-Clause 41.1 of the Conditions of Contract, the Contractor shall submit a revised general construction plan including a detailed list of equipment to be mobilised, particulars of Temporary Works and method statements for major items of work to the Engineer for approval. The plan shall be prepared on the basis of the Construction Schedule and Method Statement submitted by the Contractor with his Bid. Any instructions given by the Employer and/or the Engineer on and after award of the Contract shall be incorporated.

1.4.4 Weekly Schedule

The Contractor shall, at the end of each week, submit to the Engineer for his review and comments two (2) copies of a weekly schedule for the succeeding week in a form approved by the Engineer. The schedule shall contain appropriate comments with regard to the work to be performed on each major item as well as other construction work related to the execution of the Works including procurement of materials, transportation of materials and equipment, preparation of Drawings and other items required by the Engineer.

1.4.5 Monthly Progress Report

1.4.5.1 Written Report

The Contractor shall submit, before the tenth (10^{th}) day of each month or at any time designated by the Engineer, five (5) copies of a monthly progress report in a form acceptable to the Engineer detailing the progress of the Works during the preceding month. The report shall contain, but not be limited to, the following items:

(a) A brief but detailed description of all works executed during the reporting month together with a cumulative summary of progress to date for each main activity.

(b) Total overall percentage of work completed up to the end of reporting month as well as the total overall schedule percentage completed and the forecast completion date computed by the critical path method (or other method previously approved by the Engineer) as of the end of the reporting month with appropriate comments on progress.

(c) Actual percentage of each main work item completed, as well as their schedule percentage, with appropriate comments on their progress. The percentages shall be provided for each month and cumulatively.

(d) Schedule of activities to be started within the succeeding two (2) months with the forecast starting and completion dates. If the dates are different from those shown on the approved Construction Programme an explanation shall be given.

(e) List of manpower by trade, and supervisory personnel by position, employed during the reporting month.

(f) List of Construction Equipment and materials on Site used in the execution of the Works including those that arrived at or were removed from the Site. The records shall include duration for which Equipment was not in working order.

(g) General description of the weather conditions during the reporting month including records of each rainfall duration.

(h) List of each accident involving, lost time, and/or death of any person, damage suffered by Works, properties and equipment.

(i) Occurrence of any event or condition that might delay or prevent completion of the Works in accordance with the current, approved Construction Programme and the steps taken by the Contractor to correct the situation.

(j) Schedule of the amount of payments received to date and the amount of any monthly invoice submitted but not yet paid.

(k) Estimated amount of payment from the Employer to the Contractor for the succeeding month.

(l) Colour photographs (not smaller than 8 cm x 12 cm) of the work progress of all major components of the Works from start to completion taken at locations directed by the Engineer. A brief description and date of each photograph shall be stated. The date shall be imprinted in each negative and photograph. A minimum of two photographs shall be taken of each major component under construction in the month including temporary works.

(m) Any other matters which may be required under the Contract or statement concerning any matter arising from or relating to the execution of the Works during the reporting month.

1.4.5.2 Video Report

The Contractor shall make a video tape recording of the progress of the Works on a monthly basis and shall engage a professional recording company approved by the Engineer to carry out the work.

The monthly recording shall be of 10 minutes duration and shall be carried out throughout the duration of the Contract or as directed. Additional recordings may be necessary to record significant milestone events.

A copy of each monthly recording shall be submitted to the Engineer. The recording shall be accompanied with dialogue, in English, describing the events recorded.

At the completion of the Works the monthly recordings shall be compiled and edited into a single recording of one hours duration, or as directed, complete with approved dialogue and soundtrack and submitted to the Engineer.

1.4.6 Daily Report

The Contractor shall prepare daily and periodical reports in a form approved by the Engineer. The following items:

(a) Weather conditions;

(b) Staff and labour force employed on the work;

(c) Materials and Equipment on Site;

(d) Work in progress including locations and estimates of daily production;

(e) Work in preparation;

(f) Accident or any other reason causing a suspension of the work;

(g) Occurrence of any event or condition that might delay the progress of work; and

(h) All other information relevant to the progress of the Works.

1.4.7 Other Submittals

During the course of the Works the Contractor shall submit to the Engineer for approval construction programmes, design computations, financial schedules, construction plans, various plans of work, survey, tests and operation, reports on the results of survey, test and inspection, written description of equipment to be used, pamphlets, brochures and samples of materials and equipment, and other required documents and goods as prescribed in this Specification and as directed by the Engineer. Such submittal of documents and goods shall be made in advance to avoid causing any delay to the field works. The procedure for submittal and approval shall be in the same manner as specified in Clause 1.3.5.

1.4.8 Payment

Except as otherwise specified, separate payment will not be made for complying with the requirements of Clause 1.4 and all costs shall be deemed to be included in the rates and lump sum prices entered in the Bill of Quantities.

1.5 PROGRESS MEETINGS

1.5.1 General

A regular meeting between key personnel of the Engineer and the Contractor's authorised representative shall be held once a week at a time agreed upon by both parties to discuss the progress being made, the work proposed for the forthcoming week and any problem having a direct bearing on the immediate or near term work activities.

1.5.2 Payment

Except as otherwise specified, separate payment will not be made for complying with the requirements of Clause 1.5 and all costs shall be deemed to be included in the rates and lump sum prices entered in the Bill of Quantities.

1.6 STANDARDS AND TESTS

1.6.1 Standards and Specifications

All materials and equipment to be furnished and installed for the Works and all construction works to be executed under the Contract shall conform to the respective standards and specifications stated in the Specification. Where applicable standards and specifications for any material, equipment and construction are not stated in the Specification, they shall conform to the latest edition of the relevant standards of the following organizations:

JIS	:	Japanese Industrial Standard
ISO	:	International Standards Organization
AASHTO	:	American Association of State Highways and Transportation Officials
ANSI	:	American National Standards Institute
ASTM	:	American Society for Testing and Materials
BS	:	British Standards
TCVN	:	Vietnamese Codes
JEC	:	Japanese Electro-Technical Committee Standard
JEM	:	Japanese Electric Machine Industry Association Standard
JCS	:	Japanese Cable-Makers Association Standard
IEC	:	International Electrical Committee

If the Contractor proposes equivalent standards or specifications for materials and equipment, he shall state the exact nature of the proposed change and shall submit complete standards and specifications in English, including information and data on such materials and equipment, for approval of the Engineer. Such submittal shall be made in sufficient time for approval by the Engineer and failure to do so the purchase of any proposed equivalent materials and equipment prior to the approval of the Engineer shall be at the Contractor's risk.

The Contractor shall have available in his site office at all times at least one (1) copy of every standard referred to in this Specification or necessary for the execution of the Works.

In the event of a Vietnamese standard being more stringent than the specified standard, the Vietnamese standard shall govern.

1.6.2 Inspection, Examination and Testing of Materials and Equipment

Materials and equipment furnished by the Contractor, which will be incorporated in the Permanent Works, shall be subject to inspection, examination and test as provided in the Contract. To allow sufficient time to provide for inspection, examination and testing, the Contractor shall submit to the Engineer at the time of issue, copies in duplicate of all orders, including Drawings and other pertinent information covering the materials and equipment to be furnished by the Contractor, or shall submit other evidence in the event of such orders being issued verbally or by letter. The inspection, examination and testing of materials and equipment or the waiving of inspection, examination and testing thereof shall in no way relieve the Contractor of the responsibility for furnishing materials and equipment meeting the requirements of this Specification.

All examinations and tests shall be carried out by the Contractor in the presence of the Engineer in accordance with the normal practice for such examination and tests. The Contractor may carry out the examinations and tests with his staff and equipment available at the Site. Examinations and tests carried out off the site shall be made at a laboratory approved by the Engineer.

The Engineer shall be at liberty to reject any material or item of Plant that does not comply with the requirements of the Contract notwithstanding any previous approval thereof. The Contractor shall not be entitled to any extra payment or extension of time for completion of the Works on account of the rejection of materials due to their non-compliance with the requirements of the Contract, or of the waiting time required for carrying out the examinations and tests.

The Contractor shall furnish test samples as requested and shall provide reasonable assistance and co-operation as necessary to permit tests to be performed on materials or work in place, including reasonable stoppage of work during testing.

1.6.3 Tests and Testing Laboratory

The Contractor shall provide a site laboratory equipped with sufficient apparatus and staffed by qualified personnel for the control of concrete placement and compaction of fill materials. Other testing, such as concrete cylinder testing, shall be carried out at a laboratory approved by the Engineer at the Contractor's expense.

The Contractor shall carry out all field tests such as compaction tests, concrete workability tests and so on in accordance with the manner and frequency prescribed in the Specification and shall provide the testing equipment and apparatus, testing staff, labour and consumables necessary for carrying out his field testing. The Contractor shall prepare schedules of his field and laboratory testings taking into account the work progress schedule and shall submit them to the Engineer for approval.

The Engineer will supervise the Contractor's testing for the purpose of adequate and sufficient quality control of the Works during its execution. The cost of all testing shall be borne by the Contractor.

All test reports shall be submitted to the Engineer as soon as possible and within 24 hours of their completion.

1.6.4 Payment

Separate payment will not be made for complying with the requirements of this Clause 1.6 and all costs shall be deemed to be included in the rates and lump sum prices entered in the Bill of Quantities for the items to which the standards and tests apply.

1.7 MOBILISATION AND DEMOBILISATION

1.7.1 General

Mobilisation shall refer to the transportation of Contractor's Equipment, based on the construction programme submitted by the Contractor in accordance with Clause 14 of the Conditions of Contract, from the place of origin to the Site where they are to be used. When the mobilisation has been

substantially completed to the extent the Works can be effectively performed and obtain the scheduled progress, the Contractor shall submit the required documentation for the Engineer's approval and certification. Subject to the authorisation of the Engineer the Contractor may at any time during the execution of the Works, make alteration, reduction and/or improvement to the Equipment.

Demobilisation shall be made after the written approval of the Engineer and shall include the removal of the Contractor's Equipment from the Site.

1.7.2 Equipment

The Contractor shall furnish the necessary Contractor's Equipment, as defined in Clause 1 of the Conditions of Contract, required for the execution of the Works. The Engineer may, if he consider it necessary for the execution of the Works in accordance with the Contract, instruct the Contractor to furnish additional Equipment. All equipment to be furnished by the Contractor shall be complete with all spare parts and the Contractor shall maintain a sufficient stock of such spare parts to ensure the efficient execution of the Works.

1.7.3 Programme and Notice of Transportation

Concurrently with the submittal of the programme in accordance with Clause 14 of the Conditions of Contract, the Contractor shall furnish the Engineer with a complete transportation programme for Equipment, showing, in detail, the sequence of transportation and delivery on the Site to comply with his proposed construction programme.

The Contractor shall keep the Engineer informed of the arrival of Contractor's Equipment and materials at the Site.

1.7.4 Payment

Payment for mobilisation and demobilisation will be made at the lump sum price tendered therefore in the Bill of Quantities. Progress payment will be made in the following manner :

(a) Seventy percent (70 %) of each approved Sub-item of the lump sum price tendered in the Bill of Quantities will be paid upon certification by the Engineer that mobilisation has been substantially completed for each item of equipment shown in the Contractor's breakdown submitted with his bid.

(b) The remaining thirty percent (30 %) of each approved Sub-item of the lump sum price tendered in the Bill of Quantities will be paid upon certification by the Engineer that the demobilisation of concerned equipment has been completed for each of the items of plant or equipment mentioned above.

Monthly estimates of progress for payments of mobilisation and demobilisation shall be supported with appropriate records and documents showing that mobilisation or demobilisation for each item of equipment as mentioned above has been completed during the month for which the estimate is prepared.

1.8 TEMPORARY FACILITIES

1.8.1 General

1.8.1.1 Extent of Temporary Facilities

For the purposes of this Clause temporary facilities shall mean those parts of the Temporary Works required for the purposes of the establishment, gaining and maintaining access to the site and continuing obligations for managing the site as described hereunder. Other Temporary Works which are associated with the executions of the Works such as shoring, formwork, etc. are addressed elsewhere.

All Temporary Facilities shall be provided, installed, operated, maintained and subsequently removed by the Contractor, except as otherwise provided in the Contract.

1.8.1.2 Approval of Temporary Facilities

The Contractor's proposal for the erection of all Temporary Facilities shall be in accordance with the proposals submitted with his Bid or with such modifications as approved by the Engineer from time to time.

The Contractor shall submit to the Engineer for approval, twenty eight (28) days from the receipt of the notice to proceed, the revised general plan of Temporary Works, based on the proposals in the Bid, layout, dimension, installation programme and schedule. The Engineer may direct the Contractor to modify or change the proposals, if in the opinion of the Engineer it is deemed necessary. Such direction of the Engineer shall not relieve the Contractor from any of his obligations and responsibilities under the Contract.

Before starting any part of Temporary Facilities the Contractor shall, at least twenty eight (28) days before starting construction, submit to the Engineer for the approval the detailed proposal for such part of the Temporary Works including plans, Drawings, schedules, and other information as specified in Clauses 1.3 and 1.4 of the General Specification which will supplement or modify the general plan of the Temporary Works already submitted by him.

1.8.1.3 Removal of Temporary Facilities

Unless otherwise directed or approved by the Engineer, all Temporary Works constructed by the Contractor shall be removed and the area made safe, vegetation and natural drainage reinstated all to the satisfaction of the Engineer prior to the end of the Defects Liability Period.

1.8.1.4 Payment

Separate payment will not be made for Temporary Facilities and all the costs thereof shall be deemed to be included in the lump sum prices entered in the Bill of Quantities for Establishment.

1.8.2 Use of Construction Facilities and Work Areas

1.8.2.1 Location of Temporary Facilities

The Contractor shall, as far as practicable, lay out the Temporary Works within the Site.

1.8.2.2 Restoration of Temporary Facilities Areas

Before acceptance of the Works by the Employer the Contractor shall restore the land occupied by the Temporary Works as nearly as practicable to its original condition or to a condition to the satisfaction of the Engineer.

1.8.2.3 Rights of Others to Use Construction Facilities

The contractor for Package D of this project, who will be carrying out work on or near the Site of the Works, shall have the right to use, without charge, the access facilities, including bridges, jetties and roads, of which the Employer has given possession to the Contractor or which have been constructed or acquired by the Contractor for use in constructing the Works or which form part of the Permanent Works. The contractor requiring to use such facilities shall be required to make application to and receive the approval of the Engineer before use.

1.8.3 Establishment

1.8.3.1 General

An item has been included in the Bill of Quantities for Establishment which item shall be deemed to include the cost of provision, erection and removal if required, of all Temporary Works at the Site including the Engineer's site office, the Contractor's site office, buildings, temporary fences, sanitary facilities, medical facilities, fixed construction facilities including but not limited to workshops, electric power supply, water supply, telecommunications, temporary roads, bridges and jetties, traffic control (including waterway traffic) and other temporary facilities required for the execution of the works and cleaning-up and restoration of the Site on completion.

1.8.3.2 Payment

The Contractor shall provide a breakdown of the lump sum for Establishment in accordance with Sub-Clause 57.2 of the General Conditions of Contract. The breakdown shall be arranged such that it includes not more than ten (10) sub-items which can be readily recognised and measured for payment purposes.

Payment for Establishment will be made at the lump sum price entered in the Bill of Quantities. Progress payments for work under each sub-item will be made as follows:

(a) Sixty percent upon certification by the Engineer that work under each sub-item is substantially complete.

(b) Ten percent upon certification by the Engineer that the facility under each sub-item has been removed.

(c) Thirty percent to be distributed uniformly over the duration of the Contract.

1.8.4 Utilities

1.8.4.1 Water Supply System

The Contractor shall ensure that there is an adequate supply of water to the Engineer's Site Office as specified in Sub-Clause 1.8.7, his offices, laboratory, labour quarters, workshops, batching plant and other places on the Site where water is required in accordance with the Contractor's proposal in his Bid and approved in the Letter of Acceptance or as otherwise approved by the Engineer. Water for the human use shall be of a standard equal to the domestic town water supply in Ho Chi Minh City.

The Contractor shall supply to the Engineer's Site Office and Facilities, and to all work areas, an adequate supply of purified, bottled water

1.8.4.2 Electric Power Supply

The Contractor shall be responsible for providing at the Site, all electric power required for his construction activities, his site office, his labour camps, the Engineer's site office and any other areas where electric power is required.

The method of supplying such electrical power to the various parts of the Site shall be as proposed by the Contractor in his Bid and approved in the Letter of Acceptance or as otherwise approved by the Engineer.

The Contractor shall design and install the electrical power supply system in accordance with the requirements of the relevant Vietnamese codes of practice and the requirements of the power supply authority.

1.8.4.3 Telecommunication System

(a) General

The contractor shall supply, install and maintain telephone (fixed line and mobile) and facsimile facilities for the purposes of communication between the Engineer and the Contractor and in the various parts of the site.

(b) Telephone Requirements for Engineer's Office

Three external lines shall be provided to the Engineer's site office for the exclusive use of the Engineer. All external lines shall be capable of international direct dialling.

Separate metering shall be provided for the external lines and the Contractor may charge the Employer for international calls but not for calls made within Vietnam.

(c) Telephone Requirements for the Contractor's Site Office

The Contractor shall provide the quantity and type of communications facilities he deems necessary for the execution of the Works which shall not be less than two external telephone lines.

(d) Payment

Separate payment will not be made for complying with the requirements of this Sub-Clause and all costs shall be deemed to be included in the lump sum price for Establishment in the Bill of Quantities.

1.8.5 Temporary Roads and Bridges

1.8.5.1 General

The Contractor shall construct and maintain temporary access facilities, including haul and access roads, bridges, jetties and the associated drainage and watercourse crossing facilities necessary for the execution of the Works.

The Contractor shall make the necessary arrangements with the appropriate Local Government Authorities and private landowners where new temporary access and haul roads are required through private land.

Not less than thirty (30) days before the Contractor intends to commence construction of any part of the temporary construction roads, the Contractor shall submit to the Engineer for approval a detailed construction plan including:

(a) The location and design of the temporary construction roads, including the associated drainage; and

(b) The construction method and construction time schedule of such temporary construction roads,

The location of these roads shall be in accordance with the Contractor's proposals submitted with his Bid and approved in the Letter of Acceptance or as otherwise approved by the Engineer.

1.8.5.2 Design Requirements for Temporary Roads and Bridges

The temporary construction roads shall be designed so as to generally have a driveway width of not less than 6.0 m

The Contractor shall provide a gravel pavement or other measures in stretches where trafficability is in the opinion of the Engineer, not sufficient for the efficient transportation of Contractor's Equipment and materials.

Where the temporary construction roads cross existing watercourses, the Constructor shall provide an appropriate section of concrete or steel pipe or other means to allow water discharge. The Contractor shall be responsible for the repair at his own expense of any damage to the temporary construction roads caused by the passage of heavy equipment and trucks used by the Contractor or his subcontractors for the execution of the Works. On the completion of the Works, such temporary construction roads shall be removed and the land restored to its original condition to the satisfaction of the Engineer.

1.8.5.3 Use of Roads by Others

During the period of the Contract, the Employer and the contractor for Package D, will be engaged on other works in the vicinity of the Works, and the Contractor shall allow the Employer and the other contractor free and unrestricted use of all temporary roads subject to application and approval of the Engineer as provided in Sub-Clause 1.8.2.3.

1.8.6 Contractor's Site Office and Facilities

1.8.6.1 General

The Contractor shall provide, maintain and operate the Contractor's Site office and construction facilities which include, among other things, staff quarters, warehouse, workshop, laboratory, labour camp and other temporary buildings and facilities necessary for the execution of the Works,

and shall remove them upon the completion of the Works except as otherwise specified in the Contract or directed by the Engineer. The Contractor shall be solely responsible for providing the land for his site office and facilities.

The Contractor shall submit revised Drawings showing the site, layout plans and general particulars of such temporary buildings and facilities to the Engineer for his approval. The construction of any buildings or facility shall not be started until the Contractor's proposals have been finally approved by the Engineer.

1.8.6.2 Construction Camp

The Contractors shall construct his construction camp as proposed in his Bid and approved in the Letter of Acceptance. It shall include housing camps and other facilities and amenities for his employees and for the employees of his subcontractors.

The Contractor's staff quarters and labour camp shall be provided with all the necessary services for drainage, electricity, lighting, roads, paths, parking spaces, fencing, sanitation including sewage treatment, water supply, kitchen, fire prevention and fire fighting equipment.

1.8.6.3 Contractor's Site Office

The Contractor shall provide the Site office as soon as the preparatory work at the Site takes place. The Site office shall be constructed with all the necessary facilities for drainage, lighting, sanitation, parking spaces, etc.

1.8.6.4 Completion of Contractor's Site Office and Construction Facilities

The Contractor shall notify the Engineer in writing as soon as the temporary buildings and facilities have been constructed and are ready for operation. The Engineer shall certify that such buildings and facilities have been constructed in accordance with the approved plans.

1.8.7 Engineer's Site Office

1.8.7.1 General

The Contractor shall design, construct, operate, maintain and demolish after completion of the Works, the Engineer's site office.

The office shall have a gross floor area of not less than 230 m^2

The Engineer's site office shall be constructed at a location in close proximity to the Contractor's office and shall comply with the general design requirements included or referred to in the Appendix to the General Specification.

The buildings shall be fully air conditioned and provided with the utility services as specified in Sub-Clause 1.8.4. and with the furniture and office equipment listed in the Appendix to the General Specification

1.8.7.2 Technical Requirements and Standards

The Engineers Office shall be constructed to a good quality standard and shall be fit for its intended purpose. All work shall comply with Vietnamese Codes, Standard and local Authority requirements.

1.8.7.3 Submissions

The Contractor shall make detailed proposals for the provision of the facilities included in Sub-Clause 1.8.7 in the form of detailed design Drawings, schedules of finishes, materials lists, construction programme and specifications, all of which shall be subject to the Engineers approval. Procedures shall be in accordance with Sub-Clause 1.3.

1.8.7.4 Time for Completion

The Engineer's Site Office shall be completed within 3 months of the Commencement Date

1.8.7.5 Maintenance and Operation

The Contractor shall ensure that the Engineer's Site Office and Facilities are at all times maintained in good order and provided with the utility services specified in Sub-Clause 1.9.4.

1.8.7.6 Removal and Hand-over

At the conclusion of the Contract the Contractor shall remove all of the buildings and facilities provided under this Clause and reinstate the area to the satisfaction of the Engineer and all items of furniture and equipment shall be handed over to the Employer.

1.8.7.7 Payment

Separate payment will not be made for complying with the requirements of Sub-Clause 1.8.7 and all costs shall be deemed to be included in the lump sum price for Establishment in the Bill of Quantities.

1.8.8 Transport Facilities for the Engineer

1.8.8.1 General

The Contractor shall provide transport facilities as specified hereunder for the exclusive use by the Engineer and his staff for the purpose of construction supervision throughout the duration of the Contract commencing within 56 days of the issue of the Letter of Acceptance.

The transport facilities shall include the following:

(a) One (1) New, four-door four- wheel drive, Toyota Land Cruiser or equivalent including driver;

(b) One (1) New two-wheel drive Toyota Previa van or equivalent

(c) Two (2) New Honda Dream motor cycles or equivalent.

The Contractor shall arrange for payment of all vehicle registration and comprehensive insurance fees for each vehicle.

All vehicles shall be registered and ownership shall be vested with the Employer.

In the event that the above facilities cannot be provided within the said 56 days, the Contractor shall arrange temporary vehicles for the Engineer's use for interim period until the specified facilities have been provided.

Following completion of the Contract the vehicles shall be handed over to the Employer in good condition.

1.8.8.2 Maintenance of the Engineer's Transport Facilities

The Contractor shall arrange to service and repair vehicles at regular intervals in accordance with the manufacturers' recommendations and provide all necessary spare parts to maintain the vehicles in a proper and safe running condition.

All consumables, including fuel, oil, filters, etc., required for the vehicles shall be provided by the Contractor.

If any vehicle requires maintenance for a period exceeding 2 days, the Contractor shall provide an alternative vehicle to the vehicle being repaired for the use of the Engineer.

1.8.8.3 Measurement and Payment

Payment for the provision of transport of the Engineer shall be made at the Lump Sum Price entered in the Bill of Quantities and shall include full compensation for the cost of providing the vehicles, drivers, maintenance, insurance, consumables and any other incidental costs.

Payment shall be made as follows:

60 % of the lump sum shall be paid upon delivery of all of the specified vehicles

The remaining 30 %, representing operation cost, shall be made in uniform monthly payments over the duration of the Contract.

1.8.9 Engineer's Accommodation

1.8.9.1 General

The Contractor shall provide accommodation for the Engineer commencing 28 days after the date of the Letter of Acceptance and extending to the date of Completion plus 1 month in accordance with the following requirements.

Type of Accommodation:	One (1) two-bedroom, fully-furnished, air conditioned, serviced apartment
Location:	Located in a modern apartment building situated in District 1,2, or 3 of Ho Chi Minh City

1.8.9.2 Payment

Payment shall be made at the monthly rate entered in the Bill of Quantities which shall be full compensation for all cost of providing the said accommodation.

1.8.10 Garbage Disposal

1.8.10.1 Scope

The Contractor shall undertake the collection of and disposal of all garbage from within the Contractor's Site office, the Contractor's Temporary Facilities, the Engineer's Site office and other areas used in connection with the Works. Garbage collections shall be made at least twice each week and shall continue until completion of the Works.

Garbage shall be disposed of in a manner acceptable to the relevant local authority.

1.8.10.2 Payment

Separate payment will not be made for the provision for garbage disposal and the cost of this work shall be deemed to be included in the lump sum price entered in the Bill of Quantities for Establishment.

1.8.11 Maintenance of Existing Public Roads

1.8.11.1 General

The Contractor shall maintain all roads within the vicinity which he uses for purposes of carrying out the Works required by this Contract

1.8.11.2 Contractor's Operations

If the Contractor's operations obstruct or hinder the passage of traffic on the roads described in Sub-Clause 1.8.11, the Contractor shall provide and maintain for the duration of such disruption an alternative route, approved by the Engineer, of a standard not less than that of the road so affected.

Existing roads and bridges have load limits which the Contractor shall be responsible for determining. Before moving any heavy construction traffic into highways, roads, and bridges, the Contractor shall make suitable arrangements with the relevant authorities and obtain their approval for the passage of such traffic.

The Contractor shall not travel tracked vehicles or equipment on any bituminous sealed road surface. Rubber-tired vehicles conforming to applicable load restrictions will be permitted to use bituminous sealed road surfaces.

All the work of improvements or modifications on the existing public roads made by the Contractor for his own convenience shall be at the Contractor's own risk and expense.

1.8.11.3 Maintenance of Roads

The Contractor shall nominate public roads to be used by him during the execution of the Works in his construction plan. Prior to the commencement of the use of such roads, a joint inspection shall be carried out by the Engineer and the Contractor to document their conditions.

All damage caused by the Contractor's operations to the nominated roads shall be promptly repaired by the Contractor. At the end of the use by the Contractor of any particular section of public road, or completion of the Contract, whichever is the earlier, the Contractor shall ensure that the nominated roads used by him are reinstated to a condition equal to or better than the condition documented in the pre-commencement joint inspection referred to above. All expenses relating to the maintenance of public roads shall be borne by the Contractor.

In fulfilling his obligation for maintaining roads the Contractor shall:

(a) reinforce to pass his traffic, if necessary, and keep in good working condition at all times all road structures, bridges, culverts, drains and other waterways;

(a) patch potholes with approved materials, keep the road surfaces in good repair, and perform all grading and necessary resurfacing;

(b) maintain all fenders, posts, guideposts, guard posts, rails, fencing, signs, signposts and other roadside structures;

(c) keep road surfaces and shoulders free from all earth, mud, stones, timber, rubbish, and other debris and materials removed from the Works;

(d) adequately maintain cut-slopes and fill-slopes of the roads and appurtenant drainage ditches; and

(e) keep the road surface watered where dust is likely to be a safety or health problem.

1.8.11.4 Payment

Separate payment will not be made for complying with the requirements of Sub-Clause 1.8.12, and the cost of this work shall be deemed to be included in the various rates and lump sum prices entered in the Bill of Quantities.

1.9 SOIL INVESTIGATION

1.9.1 General

Prior to commencing construction works the Contractor shall conduct soil investigation under the Engineer's direction to determine the subsurface conditions. Such soil investigation shall consist of test drilling with core recovery and in situ testing at 20 locations with depths of 40m. The holes shall be located on a square grid and the locations shall be subject to the Engineer's approval prior to commencing drilling.

1.9.2 Soil Tests Required

In situ and laboratory testing and the relevant standards to which tests shall be performed shall be in accordance with the following:

TEST	TESTING FREQUENCY
Standard Penetration (ASTM D 1586) 2m	every 1 m
Vane Shear Test (ASTM D 2573)	every 5 m
Natural Water Content (ASTM D 2216)	every 5 m
Grain Size Analysis (ASTM D 422)	every 5 m
Liquid Limit Test (ASTM D 423)	every 5 m
Plastic Limit Test (ASTM D 424)	every 5 m
Wet Density Test (Calliper method)	every 5 m
Unconfined Compression (ASTM D 2166)	every 5 m
Consolidation Test (ASTM D 2435)	every 5 m

1.9.3 Reporting

Upon completion of testing, the Contractor of shall prepare and submit to the Engineer five (5) copies of a Soil Testing Report in a format to the Engineer's approval.

1.9.4 Measurement and Payment

Payment for soil investigation will be made at the Lump Sum Price entered in the Bill of Quantities, which shall constitute full compensation for the cost of all labour, tools, equipment and materials for the test drilling, performing standard penetration tests, vane tests, recovering cores, laboratory testing, analysis, preparation of report, and other items necessary to complete the work.

1.10 SAFETY, HEALTH CONTROL AND SECURITY

1.10.1 General

The Contractor shall be responsible for all safety, health controls and security and shall submit to the Engineer details of the organization and regulations for these purposes.

1.10.2 Safety Precautions

1.10.2.1 General

The Contractor shall comply with any safety instruction given by the Engineer. In the performance of the Works, the Contractor shall exercise every reasonable precaution to protect from injury persons or property. The Contractor shall erect and maintain all necessary temporary fencing, barricades, barriers, signs and lights and provide fire alarm, fire extinguishing and fire fighting services at strategic points on the Site and adequate ventilation, lighting and safe working conditions for his workmen engaged in the performance of the Works. The Contractor shall adopt and enforce such rules and regulations as may be necessary and desirable in the work and in its supervision. Safety measures shall include but shall not be limited to those measures mentioned in this Clause.

1.10.2.2 Safety Officer

In amplification of the requirements of the General Conditions of Contract Part II, Sub-Clause 34.10, the Contractor shall constantly employ during the progress of the Works an employee qualified in safety, and familiar with the type of work being performed, whose assignment shall include initiation of measures for the protection of health and the prevention of accidents and who shall see, by personal inspection, that all safety rules and regulations are enforced. The Contractor shall hold regularly scheduled safety meetings at least once each month with his engineers, supervisors and foremen and, when directed, with the Engineer. The Contractor shall keep the Engineer advised as to when these meetings are to be held and shall provide the Engineer with a copy of the proposed agenda.

1.10.2.3 Temporary Fencing

It is anticipated that all of the public living on the island on which the site is located shall be relocated by the Government of Vietnam prior to the commencement of the Works. However, in the event that local inhabitants remain in the area adjacent to the Site during the construction period, the following provisions shall apply.

The Contractor shall erect, maintain and remove suitable and approved temporary fencing to enclose such areas of the Permanent Works and areas of land occupied by the Contractor within the Site as may be necessary to implement his obligations under the Contract in approved manner. Where any temporary fence has to be erected, it shall be of the type required by and shall be erected to the satisfaction of, the Government authority concerned.

1.10.2.4 Lighting

(a) In the event of night work being carried out, the Contractor shall provide sufficient lighting to ensure that in all places where work is in progress :

(i) safe working conditions are provided for the Contractor's personnel and the Engineer;

(ii) the Works can be constructed in complete compliance with the Contract; and

(iii) a complete inspection of all Works in progress can be made by the Engineer.

(iv) Lighting of vessels shall be in accordance with the International Regulations for Prevention of Collision at Sea and any special requirements applicable to vessels engaged in activities related to the Contract.. In addition adequate deck lighting shall be provided on all dredgers, barges and tugs operating at night.

(b) Unless otherwise directed by the Engineer, the minimum illuminance on ground or working surfaces to be provided for the various operations or work areas shall be as tabulated below :

ILLUMINANCE		
OPERATION OR AREA	Design Value (Lux)	Minimum Measured Value (Lux)
Construction Site in General	50	20
Concrete placing	100	50
Maintenance shops and Auxiliary Buildings	300	200
Maintenance shops and Auxiliary Buildings	300	200
Underground Works	100	50

(c) All moving equipment or plant used during night operations shall be equipped with sufficient lights and reflectors.

(d) Not less than fourteen (14) days before the start of any night operations, the Contractor shall submit to the Engineer his proposals for lighting in the areas in which he proposes to work at night. The Contractor shall modify the proposals if directed and shall not begin operations at night, until the proposals for lighting have been approved.

(e) The submission to or approval by the Engineer of the Contractor's proposals for lighting shall not relieve the Contractor of any of his liabilities or obligations under the Contract.

1.10.2.5 Signs

(a) The Contractor shall provide all necessary signs for the Works. These shall include, but not be limited to
- standard road signs;
- warning signs;
- danger signs;
- control signs;
- safety signs; and
- direction signs.

(b) Wording on all signs shall be in the Vietnamese and English languages. The size, colour, lettering and location of all signs will be subject to approval, and attention shall be paid to international system of signs.

(c) The Contractor shall maintain all signs placed by himself as well as those placed by the Employer.

(d) If the Engineer considers that the system of signs provided by the Contractor is inadequate to ensure safety, or unsatisfactory in other respects, the Contractor shall add to, amend, or otherwise change the system to the satisfaction of the Engineer.

1.10.2.6 Other Safety Measures

(a) When working in the vicinity of electrical equipment and in the interest of safety and security, the Contractor shall complete the erection of any safety fencing around electrical and mechanical equipment by the time that the said apparatus is connected to any electrical supply.

(b) Use of Lasers - The use of lasers on the Site shall be done with due regard to eye hazard and all personnel working on the site shall be warned accordingly.

(c) Safety instructions - Within 56 days of receiving the notice to proceed the Contractor shall, at his own cost, supply and issue to his employees, those of his subcontractors and the Engineer, in English, Vietnamese and in other languages used by his employees at the Site, a booklet containing safety regulations based on good practice. The booklet shall be pocket size and issued to each person employed at the Site. Proof copies of the booklet shall be submitted to the Engineer for approval before printing and amendments shall be made to the booklet to his entire satisfaction. The Contractor shall issue the booklet immediately after printing and ensure that all employees are fully conversant with the instructions. Safety instructions shall deal with all safety including but not limited to the following items where relevant to the Works :

(i) protective clothing, headgear and footwear;
(ii) use of lifting equipment;
(iii) earthmoving;
(iv) formwork and reinforcement erection;
(v) concreting;
(vi) routine for accidents or fires; and
(vii) watchman, warning notices and barriers
(viii) electrical safety;
(ix) welding and painting.

The Contractors shall allow for ten (10) booklets in the English language for the use of the Engineer.

(d) Accident Report - The Contractor shall promptly report to the Engineer, in a form to be prescribed, all accidents involving death or serious injury to staff or workmen, and shall furnish monthly reports of all accidents to staff or workmen involving loss of time, giving such information as may be directed.

1.10.2.7 Provision of Safety Equipment

All persons employed on the Works are to be provided with safety equipment appropriate to the tasks upon which the are engaged such as helmets and safety equipment shall be compulsory as deemed necessary by the Engineer.

1.10.2.8 Payment

Separate payment will not be made for complying with the provisions of Sub- Clause 1.10.2 and all costs shall be deemed to be included in the rates and lump sum prices entered in the Bill of Quantities.

1.10.3 Sanitary Arrangements

1.10.3.1 Scope of Work

The Contractor shall keep the Site in a clean and hygienic condition, and shall provide and maintain sanitary conveniences for use of the persons employed in the Works to the extent, in the manner and at such places as approved by the Engineer and by any Government health authority concerned. All persons connected with the Works shall be enjoined to use these conveniences. Sewage shall be disposed of in a hygienic manner.

1.10.3.2 Payment

Separate payment will not be made for complying with the requirements of Sub-Clause 1.10.3 and all costs shall be deemed to be included in the item in the Bill of Quantities for Establishment

1.10.4 Fuel Storage

1.10.4.1 General

(a) The Contractor shall make arrangement for the transportation, storage and handling of fuels in a safe manner to protect the public in accordance with the laws and security regulations of the Socialist Republic of Vietnam.

(b) Above-ground gasoline and liquefied petroleum gas storage tanks shall not be located within 100 meters of any building.

1.10.4.2 Payment

Separate payment will not be made for complying with the requirements of Sub-Clause 1.10.4 and all costs shall be deemed to be included in the item in the Bill of Quantities for Establishment.

1.10.5 Fire Prevention

1.10.5.1 General

The Contractor shall take every precaution to prevent fire occurring on or about the Site. The Contractor shall comply with the laws and regulations of the appropriate Government authority relating to fires and shall provide fire fighting equipment, which the Engineer considers to be suitable and adequate, ready to use in all structures, buildings or the works under construction, including his labour camps and ancillary buildings. The Contractor shall maintain such equipment and such additional fire fighting equipment as may be required, in good working condition until the Works are accepted by the Employer.

The Contractor shall extinguish promptly any fire which may occur on the Site wherever the fire may originate. In this regard, he shall employ all requisite equipment and manpower for fire fighting up to the limits of his equipment and manpower employed at the Site including the equipment and manpower of his subcontractors.

1.10.5.2 Payment

Separate payment will not be made for complying with the requirements of Sub-Clause 1.10.5 and all costs shall deemed to be included in the various rates and lump sums entered in the Bill of Quantities.

1.10.6 Earthing

1.10.6.1 General

All appliance and facilities which are possibly subject to lightning strikes shall be electrically grounded and the effectiveness of such grounding shall be periodically checked by the Contractor.

1.10.6.2 Payment

Separate payment will not be made for complying with the requirements of Sub-Clause 1.10.6 and all costs shall deemed to be included in the various lump sums and rates entered in the Bill of Quantities.

1.10.7 Medical and Health Services

1.10.7.1 General

(a) The Contractor shall provide a person qualified in first aid at all working hours on the Site.

(b) The Contractor shall provide a first aid unit on the Site for treatment of casualties in conformity with the requirements of all duly constituted medical and health authorities. The Contractor shall provide such first aid units and shall responsible for and bear all costs in connection with the first aid services including removal by ambulance of injured or sick employees to hospital in Ho Chi Minh City or other places.

(c) The Contractor shall provide first aid services for the Employer's and Engineer's staff working on the Site.

1.10.7.2 Payment

Separate payment will not be made for medical and health facilities provided by the Contractor for his employees, for his subcontractors and the Employer's and Engineer's staff, as required by this Clause, and all costs shall deemed to be included in the various rates and lump sums entered in the Bill of Quantities.

1.10.8 Security

1.10.8.1 Responsibility of the Contractor

(a) The Employer will specify overall security requirements for the project and the Contractor shall perform to such requirements and be responsible for such action of his personnel in respect of such requirements.

(b) The Contractor shall be responsible for the security of the Works and the at Site and shall provide and maintain continuously and adequate security force to fulfil these obligations. The duties of the Contractor's security force shall include, but not be limited to, maintenance of order on the Site, provision of all lighting, fencing, guards, flagmen, all other measures necessary for the protection of the Works within the Site, all material delivered to the Site, the public, and all persons employed in connection with the Works, continuously throughout working and non-working periods, including nights, Sundays and holidays, for the duration of the Contract.

1.10.8.2 Payment

(a) Separate payment will not be made for the provisions of security services and all costs shall be deemed to be included in the various rates and lump sum prices entered in the Bill of Quantities.

1.11 SURVEY AND MEASUREMENT OF THE WORKS

1.11.1 General

1.11.1.1 Bench Mark and Reference Points

Reference points have been established on the Site by the Employer as shown on the Drawings or as advised by the Engineer. The Contractor shall use the co-ordinates and elevations of such reference points in setting out the Works. Any reference points damaged as the result of action by the Contractor shall be replaced by the Contractor at his own expense.

The Contractor may establish temporary reference points for his own convenience but each point shall be of a design and at a location approved by the Engineer. Each point shall be accurately related to the points established by the Employer.

At least 3 bench marks shall be established well clear of the any zone of influence of the works to avoid the effects of consolidation settlement or other disturbance.

1.11.1.2 Responsibility for Setting Out

The Contractor shall be solely responsible for the correct setting out of the Works and shall employ experienced and qualified surveyors approved by the Engineer.

The Contractor shall furnish all materials, labour and equipment including stakes, templates, patterns, platforms and special labour that may be required by the Contractor in setting out any part of the Works. The Contractor shall use survey equipment of the type and accuracy to permit correct setting out and control of the Works.

The Contractor's obligations for surveying shall include the surveying of the original surface levels where works are to be performed. The method used and spacing of cross-sections or grid spacing shall be agreed by the Engineer prior to commencement of the survey.

Before performing the pre-construction surveys the Contractor shall give the Engineer at least 7 days notice before commencing such survey in order that the Engineer or his representative can witness and verify levels and other data so determined. The original surface level determined shall be subject to the Engineer's approval.

The Contractor shall co-operate with the Engineer in checking the setting-out and in performing the measurement surveys for record and payment purposes. The Contractor shall render all necessary assistance to the Engineer and shall provide, as required for the use of the Engineer, sufficient quantities of pegs, poles, straight edges, stagings, moulds, templates, profiles, survey assistants, labourers and transport (including boats where required) for checking the Contractor's setting-out and for measurement of the Works.

1.11.2 Survey Data and Calculations

The Contractor shall submit all survey data, information, calculations, results and records to the Engineer as soon as they are available.

1.11.3 Topographical Survey on Completion

The Contractor shall conduct a topographical survey of the Works shortly prior to final completion to confirm that all earthworks have been constructed to levels not less than those shown on the Drawings and that roads and drains etc. have been constructed to the levels shown on the Drawings. Any deviations shall be advised to the Engineer who shall direct action to be taken. The final actual levels shall be shown on the As-built Drawings.

1.11.4 Payment

Payment for surveying shall be made at the lump sum entered in the priced Bill of Quantities. Monthly progress payments shall be made in proportion to the progress of the Work.

1.12 OTHER ITEMS

1.12.1 Information Board

The Contractor shall provide three free-standing boards for the purpose of providing information in English and Vietnamese about the project to the public.

The boards shall be not less than 2500 x 2500 and shall be of galvanized steel construction. The lower edge of the board shall be 1200 above adjacent ground level and shall be mounted on suitable posts with struts in concrete footings. The paint to be used shall be sunshine resistant. The Contractor shall be responsible for the repair and maintenance of the boards until completion of the Works.

The information to be displayed and the locations shall be directed by the Engineer and the design of the supporting structures shall be subject to the Engineer's approval.

1.12.2 Securities and Insurance

1.12.2.1 Performance Security and Advance Payment Security

The Contractor shall furnish an Advance Payment Security and a Performance Security and in accordance with Sub-Clauses 60.7 and 10.1 of the Conditions of Contract to ensure the refund of the Advance Payment and for the due performance of the Contract respectively.

1.12.2.2 Insurance

The Contractor shall effect certain insurances relating to the Contract in accordance with of the Conditions of Contract.

In handling compensation to workmen under the above Clauses, the Contractor shall arrange that any compensation amount determined shall be paid without delay by the Contractor to the workmen entitled to such compensation irrespective of the time for payment of insured amount from the Insurance company to the Contractor.

1.12.2.3 Payment

Separate payment will not be made for complying with Sub-Clause 1.12.2 and the Conditions of Contract and all costs shall be deemed to be included in the rates and lump sums for the various items entered in the Bill of Quantities.

1.12.3 Audits by the Employer

1.12.3.1 General

The Employer shall be entitled at his discretion to conduct audits as necessary for his own investigation in connection with :

Costs incurred in the event of termination of the Contract as provided in Clause 65 and 66 of the Conditions of Contract;

Other costs that the Contractor may claim to the Employer, which are not specifically covered by the terms of the Contract.

1.12.3.2 Records

The Contractor is obligated to keep accurate and up-to-date accounts and records concerning the above items.

1.12.3.3 Payment

Separate payment will not be made for complying with the requirements of this Clause and all costs shall be deemed to be included in the rates and lump sums entered in the Bill of Quantities.

1.12.4 Liquidated Damages

1.12.4.1 Amount of Liquidated Damages

If the Contractor should fail to complete the Works within the Time of Completion as stated in the Appendix to Bid, the Contractor shall pay to the Employer liquidated damages pursuant to Clause 47 of the Conditions of Contract.

1.12.4.2 Maximum Damages

The maximum amount of liquidated damages payable or allowable to the Employer will be limited to the amount stated in the Appendix to Bid.

1.12.4.3 Other Rights of the Employer

Nothing contained in this Clause shall prejudice or affect any other rights of the Employer under the Contract.

1.12.5 Monthly Statement

1.12.5.1 General

The Contractor shall submit a monthly statement in accordance with the requirements of Clause 60 of the Conditions of Contract. The monthly statement shall be accompanied by copies of all survey notes, records of measurements and calculation which the Engineer has directed to be prepared by the Contractor in support of the amounts claimed for the work executed.

1.12.5.2 Payment

All costs associated with the submission of the monthly statement shall be deemed to be included in the rates and lump sum prices entered in the Bill of Quantities.

1.12.6 Hours and Days of Working

Before commencement of work on the Contract, the Contractor shall notify the Engineer, in writing, of the days, hours and of the number of shifts that he proposes to work and shall give at least 48 hours notice to the Engineer of any changes to such hours of working and/or number of shifts that may be necessary during the currency of the Contract.

1.12.7 Prevention of Water Pollution

1.12.7.1 Scope

The Contractor's construction activities shall be performed by methods that prevent entrance or accidental spillage of solid matter, contaminants, debris and other objectionable pollutants and wastes into streams, flowing or dry water courses and underground water sources. Such pollutants and wastes include but not restricted to refuse, garbage, cement, concrete, bentonite slurry, sewage effluent, industrial waste, oil and other petroleum products. The Contractor shall submit his plan showing the location and design of the water pollution prevention systems and facilities to the Engineer for approval.

1.12.7.2 Payment

Separate payment will not be made for complying with the provisions of this Clause, and the costs shall be deemed to be included in the rates and lump sum prices entered in the Bill of Quantities.

1.13 MEASUREMENT AND PAYMENT (GENERAL)

1.13.1 General

The method of measurement shall be in accordance with the methods and procedures stipulated in the particular Clauses and as set forth herein.

The various unit rates and lump sums for each work item entered in the Bill of Quantities shall be deemed to have included full compensation for supplying all materials, labour, equipment consisting of owning, operation and repair costs, and other expenses necessary to complete the work in accordance with the Drawings, the Specifications, the instructions of the Engineer and compliance with all other obligations, including rectification of defects, as required under the Contract.

1.13.2 Measurement and Tolerances

This Clause explains the tolerance for measuring the dimensions of the work and the method of calculation of the quantity of the work completed in the following categories:

Category - 1 (linear metres, m)

The work item shall be measured to the second decimal place of a metre and be approved by the Engineer at every work stage on an inspection sheet.

The amount of payment will be determined by multiplying the measured length by the unit rate and then rounding the result to the nearest integer.

Category - 2 (square metres, m^2)

The work item shall be measured to the second decimal place of a square metre by multiplying the two dimensions, measured to two decimal places, and rounded off, and approved by the Engineer at every work stage on an inspection sheet.

The amount of payment will be determined by multiplying the measured area by the unit rate and then rounding the result to the nearest integer.

Category - 3 (Hectare, ha)

The work item shall be measured to the nearest square metre then expressed in hectares to three decimal places, and approved by the Engineer at every work stage on an inspection sheet.

The amount of payment will be determined by multiplying the measured area by the unit rate and then rounding the result to the nearest integer.

Category – 4 (cubic metres, m^3)

The work item shall be measured to the second decimal place of a cubic metre by multiplying the three dimensions, measured to two decimal places of a metre, and rounded off and approved by the Engineer at every work stage on an inspection Sheet.

The amount of payment will be determined by multiplying the measured volume by the unit rate and then rounding the result to the nearest integer.

Category - 5 (Lump Sum Item)

Not used.

Category - 6 (mass)

(a) (Mass in kg)

The work item shall be measured to the second decimal place of a metre and multiplied by the approved mass per metre at every work stage on an inspection sheet.

The amount of payment will be determined by multiplying the calculated quantity by the unit rate and then rounding the result to the nearest integer.

(b) (Mass in tonne, Note: 1 tonne = 1000 kg mass)

The mass shall be determined by reference to delivery notes from the specialised supplier, duly approved by the Engineer or his representative, to the accuracy of the third decimal place of a tonne (1 kg).

The amount of payment will be determined by multiplying the approved quantity by the unit rate and then rounding the result to the nearest integer.

Category - 7 Number (No.), Set, Unit, Lot

The work item shall be measured to the exact, integer number of complete items installed (or item of work performed) and approved by the Engineer at every work stage on an Inspection Sheet.

The amount of payment will be determined by multiplying the number by the unit rate.

Category – 8 Litre

The volume shall be determined by reference to dip sticks before and at the end of spraying work and shall be recorded on an inspection sheet and approval by the Engineer at every stage of the work.

The amount of payment will be determined by multiplying the whole number of litres by the unit rate.

Category – 9 Month

The applicable time shall be measured in months. Fractions of a month shall be calculated on the basis of 1 day equal 1/30 month.

The amount of payment will be determined by multiplying number of months, expressed to 3 decimal places by the unit rate.

APPENDIX: REQUIREMENTS FOR ENGINEER'S OFFICE

Location	On the Site of the Works
Gross Area (minimum)	230 m^2
Air Conditioning	Required throughout
Utility Rooms	Kitchen fitted with sink and tea and coffee making facilities, Male and female toilets Store room fitted with shelving
External Works	Paving, lighting, car parking area, security fencing
Office Furniture and Equipment, general	All shall be new and of good quality
Office furniture required	Desks with lockable drawers complete with chairs for 20 persons Meeting table with 10 chairs Book shelves (4 units) Filing cabinets (4 units)
Equipment Required	10 Desktop computers (IBM-type, 700 MHz or greater, 128 Mb DRAM, 30 GB Hard disk plus all devices for network operation) 1 Server (complete with all necessary software) and local area network connecting all computers and output devices. Each desktop computer shall be loaded with the following software: • Microsoft Windows latest version. • Microsoft Office latest version • Virus Protection Program latest version • AutoCAD latest version • Any other software necessary for proper network operation 1 Laser Jet Printer capable of printing A3 size, complete with all accessories and consumables 1 Inkjet Plotter capable of plotting A1 size Drawings complete with all accessories and consumables 1 Inkjet Colour Printer capable of printing A3 size 1 Photo copy machine of commercial quality capable of copying A3 size and collating 1 facsimile machine 1 Potable water cooler/dispenser Miscellaneous office equipment including hole punches, scissors, staplers etc.

DIVISION B

TECHNICAL SPECIFICATION

SECTION 2. PREPARATORY WORKS

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SECTION 2. PREPARATORY WORKS

2.1 GENERAL

2.1.1 Scope

This section covers the general and specific requirements for preparation of the Site for the various works to be completed under Package E.

The preparatory works include the following:

- Clearing and Grubbing
- Demolition
- Care of Water
- Soil Improvement Works
- Protection of Power Tower
- Temporary Access Road
- Earthworks

2.1.2 Constraints on Earthworks

Owing to the weak nature of the existing soil, the execution of earthworks at the site of the Wastewater Treatment Plant shall be constrained as follows.

- The maximum height of fill within 70 m of the bank of the Tac Ben Ro Canal shall be EL +0.500 until the soil improvement works as described in Clause 2.5 are completed
- Placement of spoil material in the designated disposal areas shall not extend beyond the outer boundary shown on the Drawings.
- Spoil shall not be placed higher than EL 2.200 in the designated spoil disposal areas
- Spoil shall not be placed within 65 m of the south side of the sedimentation tank area nor within 50 m of the west side of the sedimentation tank area.
- The permanent dike along the bank of the Tac Ben Ro canal shall not be constructed until all soil improvement works described in Clause 2.5, including timber piling, have been completed and approved.

2.2 CARE OF WATER

2.2.1 General

The Contractor shall be responsible for the removal of all water encountered during the execution of the whole of the Works.

The Contractor shall design, construct and maintain all temporary diversion and protective works which are necessary for construction and to prevent surface, drainage, groundwater and river water from entering excavations and shall furnish all materials required therefore.

The Contractor shall be responsible for and shall repair, at his expense, any damage to foundations, excavation slopes or any other parts of the Works caused by water, floods or by his failure to protect the Works in accordance with the requirements of this Clause

2.2.2 Dealing with Water

Where it is required that construction shall proceed with flow of water in rivers, canals, sewers etc. (e.g. as in the case of bridge construction in the Tac Ben Ro River) it shall be necessary to isolate the site of the structure to be constructed from the flow of water. Suitable coffer dams, drains or other temporary diversion and protection works shall be constructed without interruption or interference with the flow of water in the rivers, canals, etc. and without impeding normal local boat traffic. The Contractor shall construct sufficient temporary works as described above to deal adequately with surface and groundwater sources to enable the construction of the Permanent Works to the satisfaction of the Engineer. The temporary works shall include a temporary cofferdam (or dike) around the site of the wastewater treatment plant and a comprehensive pumping system.

The Contractor shall submit drawings and calculations showing his proposed method, dimensions and sizes of cofferdam construction. Approval of the drawings and calculations 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.

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.

Cofferdams that tilt or move laterally during construction shall be corrected as necessary at the expense of the Contractor. In case the structure is damaged it shall be repaired as directed by the Engineer at the expense of the Contractor.

Unless otherwise provided, cofferdams shall be removed after the completion of the structure in a manner so as not to disturb or mar the finished work.

2.2.3 Removal of Water

Much of the Works are located below the normal water level in the canals surrounding the site (which are tidal) and removal of water from excavations is required in order to carry out all construction operations under dry conditions.

Water from excavations shall be disposed of by pumping or gravity diversion directly to the canals or river.

Before commencement of excavation for foundation works, the Contractor shall submit the method for removal of water, installation and details of the proposed dewatering system he proposes to use.

Any dewatering system adopted by the Contractor shall be operated in such a way that the groundwater level outside the excavation is not reduced to the extent that would cause damage or endanger adjacent structures or property or loss of fines from adjacent ground which could cause adverse effects.

The Contractor shall be required to ensure that the bottom of excavations are free of water prior to placement of concrete or embankment/filling material. Such controls may require supplementary approved dewatering methods by the use of perforated pipe or under drains leading to sumps from which water shall be pumped. The water pumped out from the foundation shall be diverted directly to the river/canals or through existing drains or pipes without allowing it to flow overland causing inundation of properties, or other parts of the site.

Cofferdams shall be constructed so as to protect newly cast concrete from sudden rising of the water and to prevent damage to the foundation by erosion.

Pumping and dewatering 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 dewatering 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. The wall shall be extended sufficiently far below the bottom of the sump so that no material from the concrete can penetrate into the well. The design of this sump shall be made to the Engineer's satisfaction.

Excavations shall be kept dry down to at least 100 mm below foundation level prior to and during placing concrete. Placing concrete under water will only be permitted if indicated on the Drawings or permitted by the Engineer.

2.3 CLEARING AND GRUBBING

2.3.1 General

The Contractor shall carry out clearing and grubbing of the areas directed by the Engineer in accordance with this Clause.

2.3.2 Definition of Extent

The extent of the area for clearing and grubbing shall be agreed by the Engineer prior to commencement by the Contractor.

2.3.3 Requirements

The Contractor shall remove and dispose of all stumps, veins, brush, grass, roots, vegetation, fences, rocks, masonry, trash, debris, building rubble, building foundations and other objectionable matter within the area to be occupied by the permanent works.

Where directed by the Engineer, the holes resulting from grubbing operations shall be filled with approved materials which shall be placed and compacted to the same density as the adjoining soil.

All waste materials resulting from the clearing and grubbing work shall be transported to the designated spoil disposal area then spread and buried to the approval of the Engineer.

Any combustible material shall be removed from the site and burnt. Burning on site shall not be permitted.

All salvageable materials shall remain the property of the Employer and shall be transported and stacked at locations as directed by the Engineer.

2.4 DEMOLITION WORKS

2.4.1 General

The Contractor shall carry out demolition works in accordance with the requirements of this Clause.

2.4.2 Scope

The work consists of the complete demolition and removal of existing concrete and masonry and timber structures which are required to be removed for the purpose of clearing the site for the construction of the

Wastewater Treatment Plant, the bridge or the temporary access road or as directed by Engineer.

Items to be measured and paid under this category shall be agreed by the Engineer prior to demolition.

2.4.3 Method of Execution

Structures to be demolished shall be broken into units of sufficiently small size so as to be safely handled and removed from the site.

All waste materials resulting from the demolition work shall be transported to the designated spoil disposal area and then buried to the approval of the Engineer.

Any combustible material shall be removed from the site and burnt. Burning on site shall not be permitted.

All salvageable materials shall remain the property of the Employer and shall be transported and stacked at locations as directed by the Engineer.

2.5 SOIL IMPROVEMENT WORKS

2.5.1 General

The Contractor shall complete soil improvement works along the bank of the Tac Ben Ro Canal by means of the soil cement mixing method in the lower zone, sand replacement in the upper zone and by timber piling, all in accordance with the Drawings, the specification, the Contractor's approved method statements and the directions of the Engineer. The soil improvement works are intended to prevent slip failure of the river bank due to the increased loads from the Works.

The completion of soil improvement works shall be scheduled to relieve the constraints to site filling to permit timely completion of site filling activities.

2.5.2 Submittals

Not less than 60 days prior to commencing this portion of the Works the Contractor shall submit method statements of his proposed methods for soil improvement works for the Engineer's approval.

The method statement shall include a proposal for quality control and appropriate record sheets.

2.5.3 Soil Improvement of Lower Zone

2.5.3.1 General

The lower zone, which extends from EL –4.000 to a minimum of 1,000 mm below the top of the underlying clay layer, shall be improved by a soil-cement mixing method to achieve the soil improvements specified herein.

2.5.3.2 Mix Design

Trial mixes of soil and cement shall be made to determine mix proportions required to achieve a 28 day compressive strength of not less than 4 MPa based on the testing of 150 mm cubes in accordance with AASHTO T22 and 23.

The Engineer or his representative shall witness all trial mixes and testing used in determining the method to be adopted and copies of all results shall be appended to the methods statements submitted.

2.5.3.3 Construction

Cement-strengthened soil zones shall be prepared perpendicular to the bank of the Tac Ben Ro Canal and extending from EL- 4.000 down to a minimum of 1,000 mm below the top of the clay layer, as determined by the soil survey and as instructed by the Engineer. The spacing of zones shall be not less than that which will achieve an improvement ratio of not less than 30% (i.e. Area of improved soil/Gross Area). Each column of cement-soil mixing shall overlap with the adjacent columns so as to form a continuous zone.

2.5.3.4 Testing and Acceptance

Undisturbed samples from completed zones of soil cement mixing shall be tested in order to confirm that the required strength has been achieved.

10 bore holes shall be made at locations selected by the Engineer and in each location, 3 specimens shall be taken from each of the lower third, the middle third and the upper third. (i.e. 30 locations each with 3 specimens = total of 90 specimens).

The strength of each location shall be the average unconfined compression strength of the 3 samples taken from the location.

The strength of all locations shall be greater than 1MPa (10 kg/cm^2) and no specimen shall have a strength less than 0.85 MPa (8.5 kg/cm^2).

In the event of failure to meet the above strength criteria additional zones of soil-cement mixing shall be prepared in accordance with the Engineers instructions.

2.5.4 Soil Improvement of the Upper Zone

2.5.4.1 General

The upper zone, which extends from the top of the completed soil improvement works in lower zone referred to in Clause 2.5.3 to EL + 0.500, shall be improved by sand replacement of existing soil.

2.5.4.2 Materials

Sand shall conform to the requirements specified in Clause 3.3.2. (3) or as otherwise approved by the Engineer.

2.5.4.3 Construction

For any region in which soil improvement for the upper zone is to be performed, the soil improvement works for the lower zone shall be completed and approved by the Engineer first.

The zones of improvement shall have an improvement ratio of not less than 30% (i.e. Plan Area of Sand/Gross Plan Area) and shall conform to the configuration of the underlying improvements in the lower zone.

All work shall be carried out in accordance with the Contractor's method statement which shall have had the prior approval of the Engineer.

2.5.5 Timber Piling

2.5.5.1 General

The Contractor shall drive timber piling in the region of the toe of the permanent dike along the bank of the Tac Ben Ro Canal in accordance with the Drawings, the specifications and the directions of the Engineer.

2.5.5.2 Materials

Refer to Section 5

2.5.5.3 Construction

4,500 mm long timber piles shall be driven at a density of 16 per m^2 in accordance with the requirements of Section 5.

2.6 PROTECTION OF POWER TOWERS

2.6.1 General

The Contractor shall carry out protection works for two existing electric power towers which exist on the Site and shall monitor their alignment.

In addition the Contractor shall take all measures necessary to prevent damage to the towers or their foundations during the execution of the Works. Care shall also be taken to ensure that construction works will not cause tilting or misalignment of the towers.

2.6.2 Materials

Concrete shall be class E in accordance with Section 4.

Reinforcement shall be in accordance with Section 4.

Waterproofing membrane shall be proposed by the Contractor and shall be subject to approval by the Engineer and the tower owners.

2.6.3 Construction

All metal work to be encased in concrete shall be wire brushed to remove all loose paint and rust.

Cages of steel reinforcement shall be constructed around the existing steel structure as shown on the Drawings.

Concrete shall be placed in accordance with the requirements of Section 4.

Waterproofing membrane shall be applied in accordance with the manufacturer's recommendations.

Backfilling shall be carried out by hand methods to ensure that the waterproof membrane is not damaged.

2.6.4 Other Precautionary Measures

Site filling in the vicinity of the towers shall be carried out by hand methods for the region shown on the Drawings and no mechanical equipment other than hand-operated compactors etc. shall be permitted to operate in those areas.

The Contractor shall place temporary barriers around the electric towers to prevent machinery working close to them.

2.6.5 Monitoring of Tower Alignment

The Contractor shall monitor the alignment and levels of the towers throughout the construction period by surveying methods.

Initial surveys shall be made of elevations of permanent reference marks on the lower parts of each tower. Such elevations shall be related to a permanent, reliable benchmark away from the influence of construction activities. Such survey shall be repeated at 2-monthly intervals until completion.

Initial and regular 2-monthly surveys of the verticality of the towers shall also be made.

All monitoring results shall be promptly submitted to the Engineer.

2.7 EARTHWORKS FOR SITE PREPARATION

All excavation, filling and embankment construction for site preparation shall be carried out in accordance with the requirements of Section 3, Earthworks subject to the constraints specified in Clause 2.1.2

2.8 TEMPORARY ACCESS ROAD

2.8.1 General

The Contractor shall construct and maintain a temporary access road from the bridge abutment to the Chanh Hung Street over a distance of approximately 464 m.

The purpose of the road shall be to permit vehicular access to the bridge site and to the Wastewater Pumping Station site following completion of the bridge.

2.8.2 Construction

The road shall be constructed generally in accordance with the levels and dimensions shown on the Drawings which shall be construed as to mean minimum dimensions. Materials shall be of the type shown on the Drawings or better.

2.8.3 Maintenance

The Contractor shall maintain the road for the duration of the construction period or until such time as the Engineer permits the use of the new, permanent road to the bridge abutment (to be constructed by others).

2.8.4 Treatment at Completion

Prior to Completion the temporary access road shall be completely removed and the area reinstated to as close to its original condition as practicable.

2.9 MEASUREMENT AND PAYMENT

2.9.1 Care of Water

The Contractor shall provide a breakdown of the lump sums for Care of Water in accordance with Sub-Clause 57.2 of the General Conditions of Contract. The breakdown shall be arranged such that it includes not more than ten (10) sub-items which can be readily recognised and measured for payment purposes.

Payment for care of water will be made at the lump sum price entered in the Bill of Quantities. Progress payments for work under each sub-item will be made as follows:

(a) Coffering and Dewatering

Where the approved breakdown of the lump sum includes a component for coffering and dewatering, payment shall be made for the section of coffering and for the dewatering of the its enclosed area and the subsequent removal of the section of cofferdam and all associated equipment as follows:

- 40 % on completion of the cofferdam
- 30 % on completion of all dewatering following completion of the permanent works protected by the cofferdam
- 30 % on the complete removal of the section of cofferdam to the approval of the Engineer

(b) Other Items

Other items included in the Contractor's breakdown of the lump sum for Care of Water shall be paid in proportion to their completion.

Items to be paid under this Clause are as follows:

Pay Item No.	Description	Unit of Measurement
2.1.11	Care of Water	L.S.

2.9.2 Clearing and Grubbing

Measurement for payment will be made in square metres of the area actually cleared and grubbed and approved by the Engineer.

Payment will be made at the rate entered in the Bill of quantities and include the entire cost of completing the work including materials, labour, equipment, transportation and disposal of material and all associated costs. Clearing in excess of the approved area shall not be paid for.

Items to be paid under this Clause are as follows:

Pay Item No.	Description	Unit of Measurement
2.1.1	Clearing and Grubbing: including hauling and disposal in designated area	m^2

2.9.3 Demolition Works

Measurement shall be made of the net volume of existing structures (i.e. after deducting the volume of internal voids) demolished and removed in accordance with the specification and to the approval of the Engineer.

Payment shall be made at the rate entered in the Bill of Quantities which shall include the entire cost of completing the work including materials, labour, equipment, transportation and disposal material and all associated costs.

Items to be paid under this Clause are as follows:

Pay Item No.	Description	Unit of Measurement
2.1.1.3	Demolition: including hauling to designated disposal area	m^3

2.9.4 Soil Improvement Works

2.9.4.1 Soil Improvement by Soil Cement Mixing Method

Payment shall be made at the lump sum price entered in the Bill of Quantities which shall include the cost of all materials, labour, equipment, the complete cost of all preparing the mix design, testing of trial mixes and drilling and retrieving samples for testing and their testing, and all other associated costs for completing the work to the extent that it achieves the required degree of soil improvement as specified to the Engineer's approval.

Items to be paid under this Clause are as follows:

Pay Item No.	Description	Unit of Measurement
2.1.6	Soil Improvement of Lower Zone by Soil Cement Mixing Method	LS.

2.9.4.2 Soil Improvement of the Upper Zone

Measurement shall be made of the net, in-situ, volume of sand placed to the elevations and horizontal extent shown on the Drawings and to the 30% improvement ratio as specified. No measurement shall be made of sand which achieves an improvement ratio over 30% unless the Engineer has instructed such increase.

Payment shall be made at the rate entered in the Bill of Quantities which shall include the cost of all materials, labour, equipment, testing and any other associated costs for completing the soil improvement of the upper zone to the Engineer's approval.

Items to be paid under this Clause are as follows:

Pay Item No.	Description	Unit of Measurement
2.1.7	Soil Improvement of the Upper Zone by Sand Replacement Method	m^3

2.9.5 Protection of Power Towers

Payment for protection of power towers shall be made at the lump sum price entered in the Bill of Quantities which shall include the cost of all materials, labour, equipment and any other associated costs for completing the concrete protection and waterproof membrane, monitoring of level and verticallity, and other precautionary measures as specified, to the Engineer's approval.

Payment shall not include the cost of sand filling around the tower which shall be paid under earthworks.

Items to be paid under this Clause are as follows:

Pay Item No.	Description	Unit of Measurement
2.1.10	Protection of Power Towers	L.S.

2.9.6 Temporary Access Road

Measurement shall be made of the length of the centreline of the temporary access road constructed in accordance with the specification, the Drawings and to the approval of the Engineer.

Measurement shall include the distance from the abutment of the bridge to the edge of Chanh Hung Street. In the event that a portion of the permanent road has been constructed by others (under Package D works) in the vicinity of the bridge, such portion shall not be included in the above measurement.

Payment shall be made at the rate entered in the Bill of Quantities which shall include the complete cost of all materials, labour, equipment, transport and all associated costs for completing the road, maintaining the road and its removal and reinstatement of the site at the end of the Contract.

Payment shall be made as follows:

- 50 % on completion of the construction
- 40 % to be made in regular payments for the duration for which the road shall be used and maintained
- 10 % on completion of removal and reinstatement

Items to be paid under this Clause are as follows:

Pay Item No.	Description	Unit of Measurement
2.1.5	Temporary Access Road (6,000 wide gravel pavement): including construction, maintenance, removal and reinstatement of the site	m

2.9.7 Earthworks for Site Preparation

Earthworks for site preparation shall be measured and paid for in accordance with Section 3, Earthworks

2.9.8 Timber Piling

Timber piling for site preparation works shall be measure and paid for in accordance with Section 5, Piling Works.

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SECTION 3. EARTHWORKS

3.1 GENERAL

3.1.1 Scope

This section covers the general and specific requirements for all earthworks to be carried out under the Contract for Package E.

The earthworks shall include but not be limited to the following:

- Earthworks for site preparation for the wastewater treatment plant comprising excavation of unsuitable soil, placement of sandy soil fill and construction of an earth embankment dike.
- Earthworks for buildings and facilities for the wastewater treatment plant comprising excavation, sand backfill earth backfill and cobble stone bedding.
- Earthworks related to bridge construction
- Earthworks for the conveyance sewer comprising excavation of trenches, excavation of shafts for pipe jacking works, sandy soil backfill and sand bedding.

3.1.2 Constraints on Execution of Site Preparation Earthworks

The execution of earthworks for the site preparation of the wastewater treatment site shall be subject to the constraints described in Clause 2.1.2 of Section 2, Site Preparation.

3.1.3 Character of Strata

The Contractor shall acquaint himself with all available data regarding earthworks and the character of strata and materials to be excavated and used as filling. He shall satisfy himself as to :

- the general circumstances at the Site of the Works
- any obstructions thereon
- the form of river or canal bed and banks
- his obligations for diversion and care of water
- the flow of water in the river or canals
- tidal effects
- springs, subsoil and river water
- the surface of the ground
- possible subsidence of soft ground
- poor materials
- possibility of floods
- slipping clay
- running sand
- trees, brushwood, timber and debris
- floating debris
- obstructions of any kind and material of whatever nature.

Results of soil borings on the site are recorded in the report "Final Report on Soil Investigation of Wastewater Treatment Plant Site II a" to which the Contractor may refer. It is noted that existing data is insufficient hence the requirement for further soil survey as required under the Contract.

Rates entered in the Bill of Quantities shall reflect the Contractor's own assessment of risk and influence that the above matters may have on his costs and no subsequent adjustments shall be made to rates for any reason.

3.1.4 Earthworks to Dimensions, Lines and Levels

All earthworks shall be carried out to the dimensions, lines and levels as shown on the Drawings, or to such other dimensions, lines and levels as may be ordered by the Engineer. Dimensions and lines, which are based on or related to ground levels, shall be referred to the Engineer before commencing earthworks at any location.

For the purpose of the Specification the term original surface level shall refer to the natural surface before the start of earthworks, as measured by the Contractor and approved by the Engineer in accordance with Clause 1.11 of the General Specification.

The Contractor shall be completely and solely responsible for setting out the works and establishing an adequate number of bench marks and reference points. Surveys to be performed by the Contractor are described in Clause 1.11 of the General Specification.

3.1.5 Method of Excavation

The Contractor shall carry out excavation in whatever material may be encountered and by any method or combination of methods he considers most suitable subject to any restrictions herein.

The Contractor shall give due consideration to the matters in Clause 3.1.1 (Character of Strata), Clause 2.2 (Care of Water) of Section 2, location and access to soil disposal areas, fill and stock pile areas and all other relevant factors.

3.1.6 Unsuitable Materials

Excavated materials which, in the opinion of the Engineer, do not meet the required specifications for fill, embankment or backfill shall not be used for such purpose and shall be transported to the designated spoil disposal area.

3.1.7 Transportation of Excavated Material

The transportation of excavated material to fill, embankment, backfilling or stockpile site or disposal of excess or unsuitable materials shall be carried out in accordance with the approved schedule of earthworks operations. The Contractor shall transport material by the most appropriate route between excavation and placement or disposal areas. Protective measures shall be made and maintained throughout the duration of the Works for the safety of operations both on-site and off-site.

When hauling by road is done off-site loads shall be trimmed to prevent spillage. Wet materials to be hauled shall be dried sufficiently prior to loading to prevent spillage by leaking. Any damage or unsightly appearance on the

surface of any road caused by the Contractor's hauling operation shall be reinstated by the Contractor at his own expense.

When hauling by barge is carried out it shall be done in accordance with the safety provisions of the General Specification.

3.1.8 Disposal of Excavated Materials

Excavated material which, in the opinion of the Engineer, is suitable for use in filling, embankment or backfill may be transported directly to its final position, stock piled, or placed as otherwise approved by the Engineer.

Unsuitable soil or surplus excavated materials shall be disposed of in the designated spoil disposal area. The Contractor shall trim and grade spoil tips to profiles, heights and levels approved by the Engineer. He shall also maintain without interruption the flow of water courses affected by tips and comply with any other arrangement at the site existing between the Engineer and any other parties involved.

The elevation of the top of spoil banks in the disposal areas adjacent to the wastewater treatment plant site shall not exceed that specified in Clause 2.1.2

3.1.9 Submittals

Pursuant to Clause 1.4.7 of Section 1, prior to the commencement of any earthworks operation the Contractor shall submit to the Engineer for his approval method statements. Such method statements shall include, but not be limited to the following:

- Equipment to be used
- Materials to be procured and their sources and properties
- Haul routes
- Stock pile areas
- Safety measures to be taken
- Detailed drawings of all temporary works with particular attention given to the shoring of trenches and deep excavations including, but not limited to, those for shafts for pipe jacking, manhole structures pumping stations and the like.
- Computations to support the design of temporary works
- Dewatering methods
- Lighting and ventilation to be used in deep excavations and confined spaces
- Proposed working hours

3.2 EXCAVATION

3.2.1 Common Excavation

3.2.1.1 General

This Clause 3.2.1 refers to all common excavation to be carried out under the Contract and shall be read in conjunction with Clause 3.1.

Common excavation is the open-cut excavation of all materials including, but not limited to soil, sand, gravel, clay, silt, sediments, etc. excluding rock as determined by the Engineer. Any excavation without a classification of the material generally means common excavation.

The Contractor shall carry out all common excavation in whatever material may be encountered in accordance with these Specifications, Drawings and any directions of the Engineer. The Contractor shall provide and operate all necessary excavating, lifting, hauling, transport and other equipment to deal with any type of material encountered. Excavation for the various works shall be carried out to such widths, lengths, depths and profiles as shown on the Drawings, or to such other dimensions as may be ordered by the Engineer in writing.

3.2.1.2 Support of Excavation

Where necessary the sides of all excavations shall be properly shored up and supported with strutting and planking, and the sides shall be close sheeted where necessary to prevent the entry of running sand, mud and the like.

Where excavation is being carried out in trenches, pits or other confined spaces the Contractor shall give particular care to the safety of workers and shall follow the appropriate recommendations in BS 6031 – Code of Practice for Earthworks.

Excavation of shallow foundations for certain waste water treatment plant buildings or facilities may be made without shoring subject to space limitations, demonstration of batter slope stability by the Contractor and the Engineer's approval.

3.2.1.3 Inspection of Excavation

When any excavation has been completed and trimmed, the Engineer shall be informed so that he may make a formal inspection. No excavation shall be backfilled or covered with concrete until it has been inspected and the Contractor has been authorised to proceed.

3.2.1.4 Ventilation

The Contractor shall provide adequate ventilation and efficient apparatus to keep all excavations, headings and places of work free from all gasses, whether generated in the strata or otherwise, and he shall take precautions to ascertain that they are in a safe condition before allowing workmen to enter.

3.2.1.5 Excavation Beyond True Line

Where any over-excavation occurs for whatever reason or cause, unless as a result of the Engineer's direction, the Contractor shall, at his own expense, make good those excavations to the required line and level with:

1) approved material and in such manner as the Engineer may direct where the excavation is other than for concrete work; or
2) concrete of the same grade as that to be used in the true excavated shape, unless directed otherwise by the Engineer, where the excavation is for concrete work.

3.2.2 Excavation of Unsuitable Soil at Wastewater Treatment Plant Site

Excavation of unsuitable soil at the Wastewater Treatment Plant Site, as required as part of the site preparation works, shall be carried in accordance with the requirement of Clause 3.2.1, this Clause 3.2.2 and the directions of the Engineer.

Excavation shall be carried out to a depth where the underlying material has a bearing capacity qc 100 kPa as determined by a hand held penetrometer, or as otherwise directed by the Engineer.

The Contractor shall provide all testing equipment and personnel to conduct the above testing. Reports of all tests shall be forwarded to the Engineer for his review and further directions regarding the extent of excavation. The cost of the soil testing shall be deemed to be included in the rate for excavation.

No area shall be backfilled until the Engineer, or his representative, has approved the extent of excavation of unsuitable soil.

3.2.3 Excavation of Trench for Sewer Construction

3.2.3.1 General Requirements

Excavation of the trench for the construction of the conveyance sewer shall be performed in accordance with the requirements of Clause 3.2.1 and this Clause 3.2.3.

Excavation methods and equipment to be used for trenches shall be suitable for the particular work. Trenching shall be to the lines and grades shown on the Drawings and to the required width and depth. Excavation of trench in this specification shall include excavation, installation of temporary supports, provision of adequate working space, disposal of surplus material and ensuring a safe environment for workers at all times. Excavation to the final trench bottom shall be done in such a way as to leave the bottom undisturbed. All trench excavation shall be done in the dry.

No trench excavation shall be carried out until the Contractor's method statement has been approved by the Engineer. Approval of the Contractor's method statement shall not relieve the Contractor of his obligations or liabilities under the Contract.

3.2.4 Excavation of Shafts for Pipe Jacking

Excavation of shafts for pipe jacking shall be carried out with the same provisions as specified in Clause 3.2.3.and as follows.

No excavation of shafts for pipe jacking shall be commenced until the Contractor's method statement for pipe jacking, has been approved by the Engineer. Approval of the Contractor's method statement shall not relieve the Contractor of his obligations or liabilities under the Contract.

The method statement shall include those items listed in Clause 3.1.9 and, in addition, the method of ground treatment for the floor of shafts and for the driving/receiving face where jacking pipes are to penetrate through sheeting.

All excavation for shafts for pipe jacking shall be carried out in accordance with the approved method statement.

This clause shall be read in conjunction with Clause 7.9.2.

3.3 FILL

3.3.1 General

The work described in this clause shall consist of the furnishing of necessary materials and selecting, stockpiling and blending if required, transporting, placing, spreading, adjustment of moisture content, compaction, shaping and doing incidental items of work to construct the finished fill to the lines, grades and profiles as shown on the Drawings or as directed by the Engineer.

The Contractor shall make due allowance for consolidation and settlement whether compaction is specified or not, such that the levels, widths and dimensions of the finished surfaces at the end of the Defects Liability Period shall not be less than the levels and dimension shown on the Drawings.

All filling and embankments shall be constructed to the lines and levels shown on the Drawings or established by the Engineer.

Backfilling of trenches and filling adjacent to structures is also included in this category of work.

Accumulation of material at the base of embankment slopes will not be permitted.

The permanent dike to be constructed for the wastewater treatment plant shall regarded as an embankment for the purposes of this specification.

3.3.2 Materials

Materials to be used for the various types of fill, backfill or bedding shall conform to the requirements specified herein or as approved by the Engineer.

1) Earth Fill (selected from Common Excavation)

   Material to be used shall be extracted and selected from excavated material from common excavation, and shall not contain roots, turf or clod exceeding 75 mm in size or organic matter of any kind and shall be approved by the Engineer.

2) Sandy Soil Fill

   Sandy soil fill material (locally known as black sand) shall be clean well graded sand, free of organic or other deleterious matter conforming to the following requirements:

   - The percentage, by weight passing the 0.075 mm sieve shall be less than 35%
   - The uniformity Coefficient (Uc), defined as D_{60}/D_{10} shall not be less than 4

3) Sand

   Sand, for use as sand bedding or sand backfill (locally known as yellow sand) shall consist of natural sand, having clean, hard and durable particles, and it shall be free from clay, organic matter, and other deleterious materials. It shall meet the following grading requirements

Sieve Size (mm)	Cumulative Passing Percentage by Weight
9.5	100
4.75	95 - 100
2.36	80 - 100
1.18	50 - 85
0.600	25 - 60
0.300	10 - 30
0.150	2 - 10

4) Cobble

Cobble shall consist of hard durable natural or crushed stone which will not break down or deteriorate in service with particle size between 75 mm and 300 mm or as directed by the Engineer and shall be clean and free from organic or other deleterious material.

5) Free Draining Gravel

Gravel for use in Free Draining Gravel shall consist natural gravel or crushed stone which shall be hard and durable and which will not break down or deteriorate in service and shall be clean and free from clay, organic matter or other deleterious materials. The maximum particle size shall be 40mm and the minimum particle size shall be 20mm.

6) Gravel

Gravel for use in gravel bedding or gravel fill shall consist natural gravel or crushed stone which shall be hard and durable and which will not break down or deteriorate in service and shall be clean and free from clay, organic matter or other deleterious materials. The plasticity index shall be not greater than 10 and the grading shall comply with the following requirements.

Sieve Size (mm)	Cumulative Passing Percentage by Weight
50	100
4.5	25 - 90
.075	0 -10

3.3.3 Soil Tests

Tests on materials for use as fill or backfill materials shall be performed by the Contractor and shall enable determination of soil characteristics, suitability, dry density/moisture content relationships and the like. A formal report of all tests shall be prepared by the Contractor and approved by the Engineer. Tests shall be performed by the Contractor prior to commencement of earthworks, and every time soil characteristics change. Tests shall include but not be limited to the following :

1) Compaction (AASHTO T 99) (Dry Density)
2) Particle size distribution
3) Specific gravity
4) Moisture content
5) Plastic limit, Liquid limit
6) Direct shear

Test results shall be submitted to the Engineer for approval.

Field compaction tests of compacted filling shall be made on each layer and at a frequency of one test for every 300 m².

For backfilling of trenches, field compaction tests shall be made for every layer in each section of work undertaken or as otherwise directed by the Engineer.

The Contractor shall prepare a soil test programme in conjunction with his earthworks operation schedule and submit it to the Engineer for approval.

3.3.4 Placing, Compaction and Moisture Content of Fill

This clause relates to the earth fill, sandy soil fill and construction of embankments as shown on the Drawings.

Prior to commencement of filling, the Contractor shall carry out, under direct supervision and to the satisfaction of the Engineer, a series of field tests to determine optimum conditions and minimum number of passes of each type of equipment required to achieve the specified compaction for each type of fill material.

Fill material shall not be placed when, in the opinion of the Engineer, satisfactory results cannot be achieved due to heavy rain or other adverse conditions.

Fill shall be spread and compacted in approximately horizontal layers of uniform moisture content and uniform compacted thickness not exceeding 200 mm (or to lesser thickness as specified elsewhere). Filling operations shall be such as to ensure that materials will be blended sufficiently to achieve the highest practicable dry density, impermeability and stability. Where the surface of any layer of filling is too dry or too smooth to bond properly with the next layer of material, it shall be moistened and/or scarified in an approved manner to provide a satisfactory bonding surface before the next layer is placed.

The moisture content of filling shall be carefully controlled, either by natural drying or wetting with a fine spray, to achieve optimum values. Fill material shall be compacted to a density of not less than 90% maximum standard dry density determined in accordance with AASHTO T 99. For portions of fill upon which road pavements are to be constructed the upper 300 mm of fill material directly below the road pavement shall be compacted at optimum moisture content to a compaction of 95% maximum dry density in accordance with AASHTO T 99 for the full width of the roadway. Where practical, as determined by the Engineer, moistening of the material shall be performed at the site of stockpiles but such moistening shall be supplemented by fine spraying at the time of compaction, if necessary. Where moisture content is beyond the optimum range, the operation shall not proceed except with the specific approval of the Engineer, until the material has been conditioned by wetting or drying to achieve a moisture content in the required range.

All compaction equipment shall be approved by the Engineer in writing before commencement of any filling operations.

3.3.5 Preparation of Surface under Fill and Embankment

Filling shall not be placed on any portion of embankment foundation until such foundation has been cleared, stripped of topsoil, suitably prepared and has been approved by the Engineer. Tests pits, trenches and cavities resulting from the removal of unsound foundation materials or for inspection of sub-surface conditions shall be filled with selected materials.

Foundation material which does not have a density in the undisturbed condition as specified for the fill material to be placed upon it shall be moistened and compacted to specified dry density or shall be removed, filled and compacted or shall be treated in a manner as directed by the Engineer.

3.3.6 Filling Adjacent to Structures

Filling adjacent to structures shall be placed and compacted to avoid damage to such structures. Compaction adjacent to structures shall be carried out by hand or with suitable hand-operated equipment in horizontal layers not exceeding 150 mm thickness after compaction.

Unless otherwise specified or permitted by the Engineer, filling shall not be placed and compacted adjacent to concrete until at least fourteen (14) days after the placing of the concrete.

3.3.7 Backfilling

Backfill comprising approved materials complying with the specification for filling provided in Clause 3.3.2, shall be placed and compacted adjacent structures or in trenches generally in accordance with Clause 3.3.4, as shown on the Drawings or as directed by the Engineer.

Prior to commencement of backfilling adjacent to structures, the area shall be cleared of all formwork and other temporary works. Compaction shall be carried out by hand or with suitable hand operated equipment so as to achieve specified compaction without damage to structures. Backfilling material shall be wetted or allowed to dry in order to achieve optimum moisture content for compaction.

Backfilling shall be placed and compacted in continuous horizontal layers of not more than 150 mm compacted thickness. Unless otherwise specified, backfilling shall be compacted to 90% of the maximum dry density as determined in the laboratory compaction test referred to in Clause 3.3.3.

Unless otherwise specified or permitted by the Engineer, backfilling shall not be placed and compacted adjacent to concrete until at least fourteen (14) days after the placing of concrete.

Compaction of backfilling material placed above buried concrete, however, shall not be permitted to be carried out with vibrating equipment except with the prior approval of the Engineer.

3.3.8 Backfilling of Trenches, Pits and Shafts

The backfilling of trenches for sewers or stormwater drainage pipes, pits for manholes or diversion chambers, shafts for pipe jacking or other excavations where shoring has been used to support excavation, backfilling shall be done in accordance with Clause 3.3.7 and the following requirements.

For trenches less than 4 m deep and where timber sheeting is used, backfill shall be placed in layers as described in Clause 3.3.7 while trench support being concurrently partly withdrawn.

For deeper trenches, where sheet piling support has been used, backfilling shall be completed up to the subgrade level before sheet piling is withdrawn.

3.3.9 Gravel Placement

This clause covers the requirements for placing gravel bedding or free draining gravel in the locations as shown on the Drawings or as directed by the Engineer.

Materials shall comply with the requirements of Clause 3.3.2

Gravel shall be placed and compacted in continuous horizontal layers of not more than 150 mm compacted thickness. Each layer shall be compacted until it is stable and dense and shows no movement under compaction.

Unless otherwise specified or permitted by the Engineer, backfilling shall not be placed and compacted adjacent to concrete until at least fourteen (14) days after the placing of concrete.

Compaction of backfilling material placed above buried concrete, however, shall not be permitted to be carried out with vibrating equipment except with the prior approval of the Engineer.

3.4 RIP RAP

3.4.1 General

This clause refers to the construction of rip rap for protection of the outlet of the effluent pipe as shown on the Drawings or directed by the Engineer.

3.4.2 Material

Stone shall be clean, hard, and durable with a specific gravity not less than 2.5.

Samples of stone proposed for use in rip rap construction shall be submitted to the Engineer for his approval.

3.4.3 Preparation

Where applicable, surfaces on which rip rap is to be placed shall be completed to the satisfaction of the Engineer prior to placing rip rap.

3.4.4 Selection and Placement

Stones of size 250 mm to 300 mm in maximum dimension in accordance with Clause 3.4.2 shall be selected for use.

Stones shall be carefully placed such they are stable, closely interlock with adjacent stones and are arranged such that they comply with the lines, levels and profiles of the stone facing as shown on the Drawings to a tolerance of + or – 100 mm. Particular care shall be taken not to damage other parts of the Permanent Woks when placing rip rap. Any such damage caused shall be rectified by the Contractor at his expense.

3.5 GEOTEXTILE CLOTH

3.5.1 General

This clause covers the requirements of geotextile filter cloth for use in revetment construction or as directed by the Engineer.

3.5.2 Materials

Geotextile filter cloth shall be a polyester, staple fibre, needle punched felt with a minimum mass of 250 g/m^2 and shall comply with AASTHO M 288 'Geotextiles used for Subsurface Drainage Purposes'.

3.5.3 Construction

The surface on which the geotextile filter cloth is to be laid shall be completed to the satisfaction of the Engineer and then the cloth shall be laid out uniformly taking care not to puncture the cloth. Laps shall be a minimum of 300 mm.

Placement of material above the geotextile cloth shall be made carefully so as not to cause puncturing or dislodgement.

3.6 MEASUREMENT AND PAYMENT

3.6.1 Excavation

3.6.1.1 Common Excavation

Measurement of the volume of common excavation will be made using the average end area method.

Measurement for payment shall not be made of over-excavation beyond the lines, levels and profiles shown on the Drawings except as provided herein.

For common excavation of trenches, the trench width shown on the Drawings, which includes allowance for working space and the thickness of shoring (i.e. sheeting and waling and any other bracing of the trench), shall be used as the basis for measurement.

Where the Engineer has permitted open cut excavation without shoring, the volume shall include working space around the structure to be constructed plus battering of the cut slope to an angle approved by the Engineer. The working space around structures in such cases shall be 600 mm unless otherwise approved by the Engineer.

Payment shall be made at the rate entered in the Bill of Quantities and shall include the entire cost of completing the excavation from the approved original surface levels down to the lines, levels and profiles shown on the Drawings including materials, labour, equipment, transportation and any other associated costs.

No payment shall be made for over-excavation

Payment shall be deemed to include allowance for the cost of:

1) excavation through any material and to any depth
2) trimming to the correct profiles, lines and levels as shown in the Drawings

3) separating and setting aside those excavated materials suitable for re-use for other purposes and transporting to spoil those materials unsuitable for re use or surplus to requirements

4) transporting excavated materials to the designated spoil disposal areas, stockpiles or to areas to be filled with approved material

5) preparation, clearing and operation of spoil disposal areas

6) designing, furnishing, installing and subsequent removal of all temporary shoring for the support of excavation.

The following pay items shall be measured and paid under this clause:

Pay Item No.	Description	Unit of Measurement
2.1.3	Common Excavation: including testing by penetrometer and hauling to designated disposal area	m^3
2.3.1 2.15.3.10	Common Excavation: including shoring, hauling and disposal within the Site	m^3
2.3.2	Common Excavation : including shoring, hauling and disposal in designated area outside the Site	m^3
2.22.1.1	Common Excavation for Conveyance Sewer (Depth <= 3 m) : including shoring, hauling and disposal in designated area	m^3
2.22.1.2	Common Excavation (3 m < Depth) of Conveyance Sewer: including shoring, hauling and disposal in designated area	m^3

3.6.1.2 Excavation of Shafts for Pipe Jacking

Measurement of the volume of excavation for shafts for the purpose of pipe jacking based on the dimension of shafts shown in the Contractor's method statement approved by the Engineer or as directed by the Engineer.

Measurement for payment shall not be made of over-excavation beyond above dimensions.

Payment shall be made at the rate entered in the Bill of Quantities and shall include the entire cost of completing the excavation from the approved original surface levels down to the approved lines, levels and profiles including materials, labour, equipment, transportation and any other associated costs.
No payment shall be made for over-excavation

Payment shall be deemed to include allowance for the cost of:

1) excavation through any material and to any depth

2) separating and setting aside those excavated materials suitable for re-use for other purposes and transporting to spoil those materials unsuitable for re-use or surplus to requirements

3) transporting excavated materials to the designated spoil disposal areas, stockpiles or to areas to be filled with approved material

4) preparation, clearing and operation of spoil disposal areas

5) designing, furnishing, installing and subsequent removal of all temporary shoring for the support of excavation.

6) designing, furnishing and completing chemical grouting ground stabilization as required for excavating shafts.

The following pay items shall be measured and paid under this clause:

Pay Item No.	Description	Unit of Measurement
2.22.1.3	Excavation of Shafts: including shoring, ground improvement, hauling and disposal of spoil in designated area	m^3

3.6.2 Fill

3.6.2.1 Earth Fill or Earth Backfill

Measurement of the volumes of earth fill or earth backfill shall be made of the actual volume in cubic meters as determined by the measurement taken before and after filling operation. No measurement and payment shall be made for unauthorised filling outside the lines shown on the Drawings.

For backfilling of trenches, measurement of trench width shall be that permitted for excavation.

For filling, where the Engineer has permitted open cut excavation without shoring, the volume shall include working space around the structure to be constructed plus battering of the cut slope to an angle approved by the Engineer as for excavation.

Payment shall include the cost, hauling from stockpile, placing, watering, levelling, compacting and testing of the materials of in-situ fill. Payment shall also include cost of preparation of surface and trimming of slopes and all labour, materials and equipment necessary to complete the work.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
2.1.9	Earth Fill Embankment for Permanent Dike: including hauling selected soil from stockpile and placement	m^3
2.3.4	Earth Backfill: including hauling selected soil from stockpile and placement	m^3

3.6.2.2 Sandy Soil Fill or Sandy Soil Backfill

Measurement of the volumes of earth fill shall be made of the actual volume in cubic meters as determined by the measurement taken before and after filling operation. No measurement and payment shall be made for unauthorised filling outside the lines shown on the Drawings.

For backfilling of trenches, measurement of trench width shall be that permitted for excavation.

For filling, where the Engineer has permitted open cut excavation without shoring, the volume shall include working space around the structure to be constructed plus battering of the cut slope to an angle approved by the Engineer as for excavation.

Payment shall include the cost of procurement, hauling, placing, watering, levelling, compacting and testing of the materials of in-situ material. Payment shall also include cost of preparation of surface and trimming of slopes and all labour, materials and equipment necessary to complete the work.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
2.1.4	Sandy Soil Fill: including supply and placement	m^3
2.22.1.4	Sandy Soil Backfill: including supply and placement	m^3

3.6.2.3 Sand Backfill or Sand Bedding

Measurement shall be made of the volume of sand backfill or sand bedding with materials as described in Clause 3.3.2. to the lines and levels as shown on the Drawings.

For backfilling of trenches, measurement of trench width shall be that permitted for excavation.

Payment will be made at the rate entered in the Bill of Quantities and shall include the entire cost of completing the work including material, labour, equipment, transportation and any other associated costs.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
2.3.3 2.3.10 2.15.3.11 2.17.1 2.22.1.5 2.22.5.4	Sand Backfill: including supply and placement	m^3

3.6.2.4 Cobble Stone Bed

Measurement shall be made of the volume of cobble stone bed with materials as described in Clause 3.3.2. to the lines and levels as shown on the Drawings.

Payment will be made at the rate entered in the Bill of Quantities and shall include the entire cost of completing the work including material, labour, equipment, transportation and any other associated costs.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
2.8.10	Cobble Stone Bed (t= 500): including supply and placement	m^2

3.6.2.5 Free Draining Gravel

Measurement shall be made of the volume of free draining gravel with materials as described in Clause 3.3.2. to the lines and levels as shown on the Drawings.
Payment will be made at the rate entered in the Bill of Quantities and shall include the entire cost of completing the work including material, labour, equipment, transportation and any other associated costs.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
2.15.3.13	Free Draining Gravel: including supply and placement	m^3

3.6.2.6 Gravel Bedding

Measurement shall be made of the volume of gravel bedding with materials as described in Clause 3.3.2. to the lines and levels as shown on the Drawings.
Payment will be made at the rate entered in the Bill of Quantities and shall include the entire cost of completing the work including material, labour, equipment, transportation and any other associated costs.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
2.15.3.9	Gravel Bed Layer: including supply and placement	m^3

3.6.2.7 Rip Rap

Measurement shall be made of the volume of rip rap with materials as described in Clause 3.4.2. to the lines and levels as shown on the Drawings.
Payment will be made at the rate entered in the Bill of Quantities and shall include the entire cost of completing the work including material, labour, equipment, transportation and any other associated costs.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
2.8.10	Rip Rap (t=500) : including supply and placement	m^3

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SECTION 4. CONCRETE STRUCTURES

4.1 GENERAL

This section covers the general and specific requirements for the mixing, placing and use of concrete of the various classes to be used in the structures, precast concrete units and non-structural applications in the Works for Package E.

Concrete works to be completed by the Contractor include the following structures and facilities:

- Lift pump station
- Primary sedimentation tank, aeration tank and final sedimentation tank
- Disinfection tank
- Water supply facility
- Effluent pipe
- Pipe gallery
- Main building substructure
- Blower building substructure
- Dewatering building substructure
- Gravity thickener
- Compost plant facilities including fermentation tank, deodorizing soil filter tank and weigh bridge
- Bridge across the Tac Ben Ro Canal
- Conveyance Sewer
- All buildings where concrete is called for
- Drainage pipes and structures
- All other works in which concrete is specified, shown on the Drawings or directed to be used by the Engineer

This section shall be read in conjunction with special requirements for concrete or concrete structures specified elsewhere.

All concrete works shall be constructed in accordance with the specifications, to the lines, grades and dimensions shown on the Drawings, and as directed by the Engineer.

4.2 CONCRETE

4.2.1 Description

4.2.1.1 Scope

Portland cement concrete shall consist of a mixture of cement, water and coarse and fine aggregates.

4.2.1.2 Concrete Classes and their Use

The use of each class of concrete shall be as follows unless otherwise specified, shown on the Drawings, or directed by the Engineer :

Table 4.2.1.2

CLASS	USE OF EACH CLASS OF CONCRETE	STRENGTH* MPa
A	Jacking pipes	50
B	Prestressed concrete for bridge girders	42
C	Diaphragm wall	30
D	Precast concrete	25
E	General use reinforced concrete	21
F	Plain (unreinforced) concrete	18
G	Levelling concrete	10

* Note: Minimum 28-day compressive strength by cylinder test (300 mm x 150 mm diameter).

4.2.1.3 Mix Design

No structural concrete shall be placed in the Works until the relevant mix has been approved by the Engineer.

The Contractor shall submit to the Engineer for his consent details of the concrete mix design, including the water-cement ratio proposed to be used for each class of concrete. These details shall be supplied six (6) weeks in advance of placing that particular class of concrete in the work so as to permit strength tests to be made from trial mixes.

The maximum aggregate size shall be 25 mm for reinforced concrete and 15 mm for secondary concrete unless otherwise directed by the Engineer.

(a) Trial Mixes

The trial mixes shall be carried out using samples of the materials submitted, and in the proportions proposed, by the Contractor. Alternatively the Engineer may request the Contractor to prepare, at the Contractor's expense, a trial mix of each class of concrete proposed to be used incorporating only such materials as have been tested and their use consented to by the Engineer. The trial mixes shall be made in the presence of the Engineer or his representative using the plant and the degree of quality control proposed for the work. Each mix shall be tested for slump, workability and strength.

If the coarse aggregate or fine aggregate is composed of more than one material or size of material the mix proportions of each shall be specified separately. Samples of each type of material and/or each size of material shall also be supplied by the Contractor as specified in Clause 4.2.2

The Proportions of the concrete mixes shall be designed by the Contractor to satisfy the specified requirements of strength, grading and consistency.

Unless otherwise specified or consented to by the Engineer, slump, water cement ratio and cement content shall conform to the values in Table 4.2.1.3.

Table 4.2.1.3

Class **/1**	Strength MPa /2	Minimum Cement Content **(kg/m^3)** **/3**	Maximum Water/Cement Ratio by mass	Slump (mm) **/4**
A /5	50			
B	42	470	0.375	80 ± 20
C /6	30	370	0.45	180 ± 25
D	25	330	0.60	80 ± 20
E	21	268	0.60	80 ± 20
F	18	280	0.60	80 ± 20
G	10	200	0.60	80 ± 20

Notes:

1. Class of concrete shall be applied as shown in Clause 4.2.1.2.
2. Minimum 28-day compressive strength by cylinder test (300 mm x 150 mm diameter) determined in accordance with the requirements of AASHTO T22 and 23.
3. Concrete to be placed under water shall have a minimum cement content of 400 kg/m^3.
4. Slump will be determined in accordance with AASHTO T119 or JIS A 1101.
5. Concrete Class A shall not be batched by the Contractor but shall be supplied by a specialist manufacturer of jacking pipes
6. Concrete Class C, which is to be used exclusively for diaphragm wall construction, shall contain admixtures subject to the provisions of Clause 4.2.2.3.

(b) Trial Mix Results

Prior to consent being given to a mix by the Contractor its compressive strength and shrinkage at 28 days will be checked from trial mixes.

A minimum of 20 specimens shall be cast for the purpose of ascertaining the compressive strength of the trial mix.

Laboratory test results on samples from trial mixes shall show an adequate working strength margin, in accordance with normal good practice, so that the probability of site working strength test values falling below the minimum specified strength shown in Table 4.2.1.2 is reduced to a value not exceeding 5%.

In the case of urgency or for mixes which contain special admixtures, or are stream cured the Engineer may give a provisional consent based on tests at an earlier age than 28 days but tests at age 28 days shall be the basis of final consent.

No change in the source or character of the materials shall be made without due notice to the Engineer and no new materials shall be used until the Engineer has accepted such materials and has designated new proportions based on tests or trial mixes as provided herein. Should the changes due to the new materials require an increase in the amount of cement, no additional payment shall be made to the Contractor for the cost of such additional cement.

4.2.1.4 Sampling of Concrete

In order to asses compliance of concrete during construction, the Contractor shall prepare and cure test specimens which shall be tested at 7 days and 28 days as determined by the Engineer, or at any other interval that may be deemed necessary to determine the strength of concrete. (Site Working Strength).

(a) Specimens shall be made in pairs as follows:

(i) For batches for Individual Pours

- $< 1\ m^3$:

  Not more than one sample shall be taken from which not less than 2 specimens shall be tested.

- For batches $> 1\ m^3$ $< 20\ m^3$:

  Not more than two samples shall be taken from which not less than 4 specimens shall be tested.

(ii) Continuous Pours

For any given section of the work that does not qualify as bulk concrete i.e. > 20 m^3 < 100 m^3 a minimum of three random samples shall be taken from which not less than 6 specimens shall be tested.

For any given section of the work that is considered as bulk concrete i.e. > 100 m^3 a minimum of four random samples shall be taken for every 100 m^3 of concrete or fraction thereof greater than 100 m^3 placed during one day's work or as deemed necessary by the Engineer from which not less than eight specimens shall be tested.

(b) Irrespective of the quantity, every day's production of concrete shall be tested both for strength and for slump and every structure and every component of every structure shall likewise be so tested for strength and for slump. The checking and testing of the concrete shall be the prerogative of the Engineer, and he may increase the specified strength and condition as required for the project.

The concrete test specimens will be tested by the Contractor at a conveniently located and properly equipped laboratory.

The Contractor shall take, on his own responsibility, every precaution to prevent injury to the test specimens during handling, transporting and storing.

4.2.1.5 Strength Requirements

(a) Specimen Preparation

The ultimate compressive strength of the concrete shall be determined on specimens obtained and prepared in accordance with AASHTO T141 (ASTM C 172) and AASHTO T23 (ASTM C 31). Test cylinders shall conform to AASHTO T126 (ASTM C 192).

The compression test performed on cylinders shall be according to specifications AASHTO T22 (ASTM C 39).

(b) Compressive and Flexural Strength

The average site working strength value of any 4 consecutive results of the 28 day tests shall not be less than the minimum strength specified in Table 4.2.1.2 for the respective class of concrete. In the event of failure to comply with this requirement all of the concrete in all the batches represented by such samples and specimens, including any batches within the sequence which were not sampled shall be deemed not to comply with the strength requirement of this clause.

If at any time the average of any 4 consecutive results of 7 day tests falls below 70% of the prescribed minimum value at 28 days for compressive strength or below 80% of the prescribed minimum value at 28 days for flexural strength the cement content of the concrete will be increased by at least 20 kg per cubic metre of compacted concrete, without extra payment, until any necessary mix modifications have been agreed following examination of 28 day tests.

(c) Characteristic Strength

The characteristic strength of the various classes of concrete shall be determined as soon as the first 30 test results of each class become available.

The characteristic strength shall be calculated by the equation:

$$\overline{X}_0 = X - kS$$

Where :

$\overline{X}_0$: characteristic strength

X : mean or average of the series of results

k : a factor depending upon the percentage of results that fall below the characteristic strength

S : standard deviation given by the equation :

$$S = \left[\frac{\sum \left(X - \overline{X} \right)^2}{\left(N - 1 \right)} \right]^{\frac{1}{2}}$$

Where :

X : the individual result

N : the total number of results

The values for the factor k are :

Percentage of results falling below the minimum	Value of k
0.1	3.09
0.6	2.50
1.0	2.33
2.5	1.96
5.0	1.64

If the characteristic strength so determined falls below the minimum site working strength the Contractor shall increase the cement content in the same manner as described in Item (b) above until such time as adjustments shall be made in the mix proportions or improvements made in the quality control measures to raise the average strength or reduce variation to the satisfaction of the Engineer.

(d) Failure to Comply with Compressive Strength Requirements

In the event of compressive strength results not complying with the strength requirements of this clause or in the event of doubtful results, the Engineer will proceed to check the sample compressive strength by means of crushing tests performed on test specimens taken with a rotary core borer at suitable points indicated by the Engineer on the structure already constructed.

Such tests shall be carried out by an agreed authority having suitable test facilities. If such tests show strength in compliance with the requirements herein specified, the concrete will be considered satisfactory. If such tests do not comply with the requirements, the Engineer may direct the Contractor to cut out and make good the defective work at the Contractor's expense.

(e) Care of Specimens

The cost of taking specimens and performing the tests including the cost of providing stout, substantial packing cases and the cost of shipping or transporting the test specimens from the site to the laboratory shall be included as part of the price bid for Portland cement concrete. The Contractor shall take, on his own responsibility, every precaution to prevent injury to the test specimens during handling and transporting.

(f) Records

The original records of all tests shall be kept by the Engineer and a copy retained by the Contractor. The Contractor shall be responsible for making such adjustments as may be necessary to produce specification concrete and the test results shall include whether or not the concrete is satisfactory.

4.2.2 Materials

4.2.2.1 General

All materials to be furnished and used that are not covered in this clause shall conform to the requirements stipulated in other applicable sections.

4.2.2.2 Cement

Unless specified to the contrary or otherwise permitted by the Engineer the Contractor shall use only one brand of any one type of cement having uniform quality for the Works. All cement used in the Works shall be Ordinary Portland Cement (ASTM Type-I) conforming to the minimum requirements of JIS R 5210, AASHTO-M 85, BS 12: 1978 or TCVN 2682 - 1992 for PC-40 Cement.

4.2.2.3 Admixtures

Admixtures may only be used if consented to by the Engineer and then only in such quantities and manner as he may consent to in writing.

Such admixtures shall conform with the requirements of:

- AASHTO M 194 (ASTM C 494) “Specification for Chemical Admixtures for Concrete”:
  - Type A - Water-reducing
  - Type B - Retarding
  - Type C - Accelerating
  - Type D - Water-reducing and retarding
  - Type E - Water-reducing and accelerating
  - Type F - Water-reducing (high range) and
  - Type G - Water-reducing(high range) and retarding
- AASHTO M 154 (ASTM C 260) “Specification for Air-entraining Admixtures for Concrete”.

Admixtures shall not reduce the strength of concrete below that specified. Shrinkage and dosage sensitivity characteristics will be taken into account, if relevant.

Admixtures shall not contain chlorides, chlorine, sulphides or sulphites, or any other substance which may be detrimental to concrete or steel.

Use calcium chloride or admixtures containing calcium chloride will not be permitted.

4.2.2.4 Water

All water used in concrete shall be subject to the Engineer's approval. Water used in mixing, curing, or other designated applications shall as a general rule be potable, otherwise reasonably clean and free from oil, salt, acid, alkali, sugar, vegetable, or any other substance injurious to the finished product. If required by the Engineer, water shall be tested by comparison with distilled water. Comparison shall be made by means of standard cement test for soundness, time of setting and mortar strength. Indication of unsoundness, change in time of setting of plus or minus 30 minutes or more, or decrease of mortar strength more than 10 percent compared with distilled water shall be sufficient cause for rejection of the water that is being tested.

Where the source of water is relatively shallow, the intake shall be so enclosed as to exclude silt, mud, grass, or other foreign materials.

4.2.2.5 Fine Aggregate

(a) The fine aggregate for concrete shall consist of natural sand or, subject to approval of the Engineer, other inert materials with similar characteristics, having clean, hard and durable particles, and it shall be free from objectionable quantities of dust, silt, clay, organic matter, and other impurities.

(b) The fine aggregate shall be uniformly graded and shall meet the following grading requirements :

Grading of Fine Aggregate:

Sieve Size (mm)	Cumulative Passing Percentage by Weight
9.5	100
4.75	95 – 100
2.36	80 – 100
1.18	50 – 85
0.600	25 – 60
0.300	10 – 30
0.150	2 – 10

Sieve analysis of fine aggregate shall be made in accordance with JIS A 1102 (Method of Test for Sieve Analysis of Aggregate) or AASHTO - T 27.

The gradation requirements given above are the extreme limits to be used in determining the suitability of material from all possible sources of supply. The gradation of materials from any one source shall not vary in composition beyond the range of values that govern the selection of a source of supply. For the purpose of determining the degree of uniformity, a fineness modulus determination shall be made upon representative samples, submitted by the Contractor, from such sources as he proposes to use. If fineness modulus of fine aggregate varies more than 0.2 from the value used in selecting concrete proportions, the fine aggregate shall be rejected unless suitable adjustment of the mix proportions are made with the approval of the Engineer.

(c) The amount of deleterious substances in fine aggregate shall not exceed the limits specified in Table 4.2.2.5. Treatment of other deleterious substances which are not shown in the above table shall be determined by the direction of the Engineer.

Tests for material finer than 0.075 mm sieve shall be made in accordance with JIS A 1103 (Method of Test for Amount of Material Passing Standard Sieve 0.074 mm in Aggregates), or AASHTO - T 11.

Table 4.2.2.5

Limits for Deleterious Substances in Fine Aggregates

Item	Maximum % by Weight
* Clay lumps	1.0
* Material finer than 0.075 mm sieve:	
Concrete subject to abrasion	3.0 1/
All other concrete	5.0 1/
* Material coarser than 0.300 mm sieve floating on a liquid having a specific gravity of 1.95	0.5 2/

Note :

1/ In the case of crushed aggregate, if the material finer than 0.075 mm sieve consists of the dust of fracture essentially free from clay or shale, these percentages may be increased to 5 and 7 percent respectively.

2/ This requirement does not apply to manufactured sand produced from blast furnace slag.

(d) All fine aggregate shall be free from injurious amounts of organic impurities. Approximate determination of the presence of injurious organic impurities in natural sand shall be in accordance with JIS A 1105 (Method of Test for Organic Impurities in Sands) or AASHTO T 21. Aggregate subjected to the colourimetric test for organic impurities, and producing a colour darker than the standard, shall be rejected.

However, any sand that fails to meet the above requirement may be used provided that the compressive strength of mortar specimens using such sand is more than 95% of that of mortar specimens using the same sand which is washed by 3% solution of sodium hydroxide and then by water, and approved by the Engineer. Testing age of mortar specimens shall be 7 and 28 days for normal Portland cement.

Compressive strength of mortar specimens shall be determined by AASHTO T 71, "Effect of Organic Impurities in Fine Aggregate on Strength of Mortar".

4.2.2.6 Coarse Aggregate

(a) The coarse aggregate shall consist of one or more of the following: crushed stone, gravel, blast-furnace slag, or other approved inert materials of similar characteristics having clean, hard, durable pieces. It shall be free from objectionable quantities of flat or elongated particles, organic matter or other deleterious matter.

(b) Sieve analysis of coarse aggregate shall be made in accordance with JIS A 1102 (Method of Test for Sieve Analysis of Aggregate) or AASHTO T 27 and material shall meet the following grading requirements:

Grading of Coarse Aggregate

SIZE	PERCENTAGE BY WEIGHT (JIS A 1102)										
	AMOUNTS FINER THAN EACH STANDARD SIEVE (mm)										
mm	100	80	60	50	40	25	20	15	10	5	2.5
50 - 5	-	-	100	95-100	-	37-70	-	10-35	-	0-5	-
40 - 5	-	-	-	100	95-100	-	35-70	-	10-30	0-5	-
25 - 5	-	-	-	-	100	95-100	-	30-70	-	0-10	0-5
20 - 5	-	-	-	-	-	100	90-100	-	20-55	0-10	0-5
15 - 5	-	-	-	-	-	-	100	90-100	40-70	0-15	0-5
80 - 40	100	90-100	45-75	-	0-15	-	0-5	-	-	-	-
60 - 40	-	100	90-100	35-70	0-15	-	0-5	-	-	-	-
50 - 25	-	-	100	90-100	35-70	0-15	-	0-5	-	-	-
40 - 20	-	-	-	100	90-100	20-55	0-15	-	0-5	-	-

The amount of deleterious substance in coarse aggregate shall not exceed the limits prescribed in Table 4.2.2.6

(c) Treatment of the other deleterious substances which are not shown in the table shall be determined by the direction of the Engineer.

Table 4.2.2.6

Limits of Deleterious Substance (Percent by Weight) in Coarse Aggregate

Item	Maximum
Clay lumps	0.25
Soft particles	5.0
Material finer than 0.075 mm sieve	1.0 1/
Material floating on a liquid having a specific gravity of 1.95	1.0 2/

Note :

1/ In the case of crushed aggregate, if the material finer than 0.075 mm sieve consists of the dust of fracture essentially free from clay or shale, this percentage may be increased to 1.5.

2/ This requirement does not apply to manufactured sand produced from blast furnace slag.

(d) Test for material finer than 0.075 mm sieve shall be made in accordance with JIS A 1103 (Method of Test for Amount of Material Passing Standard Sieve 0.075 mm in Aggregates), or AASHTO T11. Test for soft particles shall be made in accordance with JIS A 1126 (Method of Test for Soft Particles in Coarse Aggregate by Use of Scratch Tester), or AASHTO T 112.

4.2.2.7 Lightweight Aggregate

Lightweight aggregate for use in concrete shall conform to the requirements of AASHTO M 195 (ASTM C 330). The Engineer shall direct the required grading. The Contractor shall submit samples of proposed lightweight aggregate for the Engineer's approval.

4.2.2.8 Test of Aggregate

Before use, results of the foregoing tests of aggregate from each source shall be submitted to and approved by the Engineer. Coarse aggregate shall meet the requirements ASTM C39 for Compressive Strength and the percentage of wear of the Aggregate shall not be greater than 50 as determined by AASHTO T96 . Tests for aggregate in use shall be made when required by the Engineer.

4.2.2.9 Expansion Joint Materials

Jointing materials, joint filler, sealants etc. shall comply with ASTM D 2125, Class 1, Grade15, or BS 8007: 1987 and BS 6213, AASHTO M 33 or other equivalent standards

Expansion joint filler shall consist of formed polythene elastic material sheet material 20 mm thick and with asphaltic sealant on the external surfaces as shown on the Drawings.

Cut-off plate for water stops used for the expansion joints shall be flexible PVC to JIS K 6773

All expansion joint materials shall be subject to approval by the Engineer following submission of samples and technical specifications by the Contractor of proposed materials.

4.2.2.10 Storage of Materials

(a) Storage of cement - Cement may be shipped from pre-tested and approved bins at the mill. Cement shall be stored in a damp-proof warehouse with a floor raised at least 300 mm from the ground so as to permit easy access for inspection and for use in the delivered order. Bagged cement shall not be piled more than 13 sacks high. Cement which has become damp, lumpy or otherwise not in proper condition shall not be used. Cement stored by the Contractor for a period longer than 60 (sixty) days shall require the Engineer's approval before being used on the work.

(b) Storage of aggregate - Fine and coarse aggregates shall be stored separately to prevent contamination by foreign material. Aggregate shall be stored in such a manner as to keep the moisture content as uniform as possible, and shall be handled in such a manner as to prevent segregation. Aggregate shall be stored so as to protect it from the direct rays of the sun. Aggregate from different sources of supply shall not be stored in the same place without permission from the Engineer.

4.2.3 Equipment and Tools

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 direction of the Engineer.

4.2.3.1 Batching Plant and Equipment

(a) General - All material in the mix shall be proportioned wholly by weight. The batching plant shall include bins, weighing hoppers and scales for the fine aggregate and for each separated size of coarse aggregate. If cement is used in bulk, a bin, hopper and scales for the cement shall be included. The container shall be watertight. Provision satisfactory to the Engineer shall be made for batching other components of the mix at the batching plant, which may be either stationary or mobile type. It shall be always properly levelled within the accuracy required for the proper operation of weighing mechanisms.

(b) Bins and hoppers - Bins with adequate separate compartments for fine aggregate and for each required size of coarse aggregate shall be provided in the batching plant. Each compartment shall discharge efficiently and freely into the weighing hopper. Means of control shall be provided so that as the quantity desired in the weighing hopper is being approached, the material may be added slowly and shut off with precision. A port or other opening for removing any overload of the several materials from the hopper shall be provided. Weighing hopper shall be constructed so as to discharge completely.

(c) Scales - The scales for weighing aggregates and cement shall be of either the beam type or the spring-less dial type. They shall be accurate within one-half of 1% under operating conditions throughout the range of use. Ten weights of 25 kilograms each shall be available for checking accuracy. All exposed fulcrums, clevises and similar working parts of scales shall be kept clean. When beam-type scales are used, provision shall be made for indicating to the operator that the required load in the weighing hopper is being approached. The device shall indicate at least the last 100 kilograms of load and up to 25 kilograms overload.

All weighing and indicating devices shall be in full view of the operator while charging the hopper and he shall have convenient access to all controls.

Cement may be measured by weight, or in standard sacks considered to weigh 50 kilograms net. When measured by weight a separate, satisfactory scale and hopper shall be provided together with a boot or other approved device to transfer the cement from the weighing hopper. Satisfactory methods of handling shall be employed.

Batching shall be so conducted as to result in the weights of material required, within tolerances of 1% for cement and 2% for aggregates.

4.2.3.2 Mixers

(a) General - All concrete shall be mixed in batch mixers. It may be mixed at the site of construction, at a central plant, or in transit.

(b) Each mixer shall have attached to it in a prominent place a manufacturer's plate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of mixing drum.

(c) Mixers at site of construction - Mixers at the site shall be approved drum-type capable of combining the aggregate, cement and water into a thoroughly mixed and uniform mass within the specified mixing period and of discharging the mixture without segregation. The mixer shall be equipped with a suitable charging hopper, water storage, and a water measuring device, accurate within 1%. Controls shall be so arranged that the water can be applied only while the mixer is being charged. The discharge level shall lock automatically until the batch has been mixed the required time after all materials are in the mixer.

(d) Suitable equipment for discharging the concrete on the roadbed shall be provided. The mixer shall be cleaned at suitable intervals. The pick-up and throw-over blades in the drum shall be replaced when they have lost 10% of their depth.

(e) Central plant mixers - These mixers shall be of approved drum type capable of combining the aggregate, cement and water into the thoroughly mixed and uniform mass within the specified mixing period and of discharging the mixture without segregation. Central plant mixers shall be equipped with an acceptable timing device that will not permit the batch to be discharged until the specified mixing time has elapsed. The water system for a central mixer shall be either a calibrated measuring tank or a metre and shall not necessarily be an integral part of the mixer.

The mixers shall be cleaned at suitable intervals. They shall be examined daily for changes in interior condition. The pick-up and throw-over blades in the drum shall be replaced when they have lost 10% of their depth.

(f) Truck or transit mixers - These shall be equipped with electrically actuated counters by which the number of revolutions of the drum or blades may readily be verified and the counters shall be actuated at the commencement of mixing operations at designated mixing speeds. The mixer when loaded shall not be filled to more than 60% of the drum gross volume. The mixer shall be capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity.

Except when intended for use exclusively as agitators, truck mixers shall be provided with a water measuring device to measure accurately the quantity of water for each batch. The delivered amount of water shall be within plus or minus 1% of the indicated amount.

4.2.3.3 Vibrators

Unless otherwise directed, the concrete shall be consolidated with approved mechanical vibrators operating within the concrete. When required, vibrating shall be supplemented by hand spading with suitable tools to assure proper and adequate compaction.

The vibrators shall be of a type approved by the Engineer, with a minimum frequency of 3500 impulses per minute and shall be capable of visibly affecting a properly designed concrete with a 20 mm slump over a circular area of 450 mm radius. The number of vibrators used shall be sufficient to consolidate the concrete properly within 10 minutes after it is deposited in the forms and in addition at least 3 spare vibrators shall be available on standby at the site of the pour to maintain immediate continuity in case of breakdown.

4.2.3.4 Forms

(a) Forms shall be made of metal, timber or other approval material and shall conform to the shape, lines and dimensions of the members shown on the Drawings, and shall be so constructed as to prevent deformation due to load, vibration, and other causes.

(b) Forms shall be properly equipped with braces, ties and other devices, so as to maintain them in the positions and the shape as shown on the Drawings.

(c) Forms shall be so constructed that they can be removed easily and safely. Joints in linings or panels shall be either horizontal or vertical as far as possible, and shall be sufficiently tight to prevent any leakage of mortar.

(d) Curved forms shall be of the radius called for on the Drawings and acceptable flexible forms shall be installed with that radius.

(e) After forms have been set in the correct location, they shall be inspected and approved by the Engineer before concrete is placed.

(f) Care shall be exercised to keep forms free from dust, grease or other foreign matter. No material or treatment that will adhere to concrete or discolour concrete shall be used. All forms shall be treated with an approved form-release-oil prior to placing reinforcement.

(g) For narrow walls, columns, etc., where the bottom of the form is inaccessible, lower form boards or parts thereof shall be left loose so that they may be removed for cleaning out extraneous material immediately before placing concrete.

(h) Forms for exposed surfaces shall be constructed with triangular fillets not less than 25 mm x 25 mm attached so as to prevent mortar runs and to produce smooth straight chamfers at all sharp external edges of the concrete.

4.2.3.5 Batching and Transporting Materials

For mixing at site of construction, aggregates shall be transported from the batching plant to the mixer in batch boxes, vehicle bodies, or other containers adequate in design and construction to properly carry the batch required. Partitions separating batches shall be adequate and effective to prevent spilling from one compartment to another while in transit or while being dumped.

Cement in original shipping containers may be transported on top of the aggregates. The number of sacks of cement required for each batch shall be placed on the aggregates for that batch. Sacked cement shall be emptied into the aggregates prior to dumping into mixer.

Batches shall be delivered to the mixer separately and intact. Each batch container shall be dumped cleanly into the mixer without loss of cement or mixing or spilling of material from one batch compartment into another.

4.2.3.6 Mixing Concrete

(a) General - Concrete shall be mixed at the construction site, at a central mixing plant, in a truck mixer, or by a combination of central plant and truck mixing. Hand-mixing may be used only when approved by the Engineer. No concrete shall be mixed, placed, or finished when the natural light is insufficient, unless an adequate and approved artificial lighting system is operated.

(b) Mixing at site of concrete construction - Concrete shall be mixed in a batch mixer of the type and capacity approved by the Engineer. Mixing time shall be determined by the Engineer in accordance with JIS A 1119 (Method of Test for Variation in Unit Weight of Air Free Mortar in Freshly Mixed Concrete). When results of the above tests are not available, the mixing time shall be longer than 1 1/2 minutes after all the materials have been introduced into the mixer, but in no case shall the mixing time exceed three times the mixing time prescribed above. Charging of water into the mixer shall begin before the cement and aggregates enter the drum. During mixing, the drum shall be operated at speeds specified by manufacturers. Pick-up blades in the drum of the mixer which are worn down 20 mm or more at any part must be replaced.

The volume of a batch shall not exceed the manufacturer's rated capacity of the mixer without written permission of the Engineer. No mixer whose rated capacity is less than a one-bag batch shall be used.

Concrete shall be mixed only in such quantities as are required for immediate use, and concrete which is not of the required consistency at the time of placement shall not be used.

Re-tempering of concrete will not be permitted. Entire content of the mixer shall be removed from the drum before materials for the next batch are placed therein. Upon cessation of mixing for a considerable length of time, the mixer shall be cleaned thoroughly. Upon resumption of mixing, the first batch of concrete material placed in the mixer shall contain sufficient sand, cement, and water to coat the inside surface of the drum without diminishing the required mortar content of the mix.

(c) Central plant mixing - When mixed at a central plant, the mixer and methods used shall be in accordance with the requirements of Sub-Clause 4.2.3.6 (b). Mixed concrete shall be transported from the central mixing plant to the site of work in agitator or non-agitator trucks approved by the Engineer.

Agitator trucks shall be equipped with a water-tight revolving drum, and shall be capable of transporting and discharging concrete without segregation. The agitation speed of the drum shall be between 2 and 6 revolutions per minute. The volume of mixed concrete permitted in the drum shall not exceed the manufacturer's rating nor exceed 70% of the gross volume of the drum. Upon approval of the Engineer, truck mixers may be used in lieu of agitator trucks for transportation of central plant mixed concrete. Gross volume of agitator bodies, expressed in cubic metres, shall be as determined by the mixer manufacturer. The interval between introduction of water into mixer drum and final discharge time shall be a maximum of 45 minutes unless the use of additives have been approved. Depending on the type and usage of the approved additives this interval may be extended up to a maximum of 2 hours. During this interval the mixture shall be agitated continuously.

Bodies of non-agitator trucks shall be smooth and water-tight. Covers shall be provided when needed for protection against rainfall. The non-agitator trucks shall deliver concrete to the work site in a thoroughly mixed and uniform mass. Uniformity shall be deemed satisfactory if samples from the one-quarter and three-quarter points of the load do not differ more than 25 mm in slump. Placing of concrete shall be completed within 30 minutes after introduction of mixing water into the cement and aggregates or if admixture is used at a time to be determined by the Engineer.

(d) Truck mixing - Concrete may be mixed in truck mixers of approved design. Truck mixing shall be in accordance with the following provisions. The truck mixer shall be either a closed, water-tight, revolving drum or an open-top revolving-blade or paddle type. It shall combine all ingredients into a thoroughly mixed and uniform mass, and shall discharge the concrete with satisfactory uniformity. A maximum difference of 25 mm between slumps of samples from the one-quarter and three-quarter points of the discharge load shall be deemed satisfactory.

Mixing speed for revolving drum type mixers shall not be less than 4 revolutions per minute of the drum nor greater than a speed resulting in a peripheral velocity of the drum of 1 metre per second. For the open-top type mixer, mixing speed shall be between 4 and 16 revolutions per minute of the mixing blades or paddles. Agitation speed for both the revolving-drum and revolving blade type mixers shall be between 2 and 6 revolutions per minute of the drum or mixing blades or paddles.

The capacities of truck mixer shall be in accordance with the manufacturer's ratings except that they shall not exceed the limitation herein. Standard for normal rated capacity, expressed as percentage of the gross volume of the drum, shall not be more than 50% for truck mixing and 70% for agitating.

The concrete shall be delivered to the site of the work and discharge shall be completed within 45 minutes after the introduction of the mixing water into cement and aggregates unless the use of additives have been approved by the Engineer. Depending on the type and usage of the approved additives this interval may be extended up to a maximum of 2 hours During this interval the mixture shall be agitated continuously.

When the concrete is mixed in a truck mixer, the mixing operation shall begin within 30 minutes after the cement has been mixed with the aggregates. Except when intended for use exclusively as agitators, truck mixers shall be provided with a water measuring device which will measure accurately the quantity of water for each batch. The delivered amount of water shall be within plus or minus 1% of the indicated amount when the tank, if mounted on the truck mixer, is satisfactorily and practically level.

(e) Hand mixing - Hand mixing will not be permitted, except in case of emergency, without written permission from the Engineer. When permitted, it shall be performed only on water-tight mixing platforms made of metal, etc. Concrete shall be turned and returned on the platform at least six times and until all particles of the coarse aggregate are covered thoroughly with mortar and the mixture is uniform.

4.2.3.7 Retempering Concrete

Retempering concrete by adding water will not be permitted under any circumstances. Concrete that is not within the specified slump limits at the time of placement shall not be used. Admixtures for increasing the workability or for accelerating the set will be permitted only with the written approval of the Engineer.

4.2.3.8 Consistency

Slump will be measured in accordance with AASHTO T 119 or JIS A 1101 and shall be in accordance with Table 4.2.1.3.

4.2.4 Construction

4.2.4.1 General

The Contractor shall maintain an adequate number of trained and experienced supervisors and foremen at the site to supervise and control the work. All construction, other than the concrete, shall conform to the requirements prescribed in other sections or clauses for the several items of work entering into the complete structure.

4.2.4.2 Foundation

Preparation of foundations shall conform to the details as shown on the Drawings in accordance with the requirements of Section 3, Earthworks. The Engineer may order further excavation as necessary to obtain satisfactory foundations in the event that unsuitable foundations are encountered at the depths shown on the Drawings.

Pile foundations shall be constructed in accordance with the provisions set out in the other relevant clauses and as shown on the Drawings.

4.2.4.3 Falsework

Falsework shall be built on foundations of sufficient strength to carry the loads without appreciable settlement. Falsework that cannot be founded on solid footings must be supported by ample falsework piling provided at the Contractor's expense.

Before constructing forms or falsework the Contractor, if required, shall submit detailed drawings of proposed forms or falsework for approval by the Engineer, but such approval shall not relieve the Contractor of any of his responsibilities under the Contract for the successful completion of the structure.

4.2.4.4 Formwork

Before concrete is placed the Engineer shall inspect all formwork and falsework and no concrete shall be placed until the Engineer has inspected and approved such formwork and falsework. Such approval shall not relieve the Contractor of any of his responsibilities under the Contract for the successful completion of the structure.

Internal formwork for hollow slab construction shall be made of plywood, thin metal plate or other materials. These materials shall have sufficient strength to resist the pressure and the buoyancy effects of fresh concrete.

Type and structure of joint and cover for the cylindrical form shall be tight to prevent any leakage of concrete, and shall be approved by the Engineer. Nominal diameter of cylindrical forms shall be the outer diameter, or the outer diameter of projecting portion in case of thin metal plate having projection. The height of the projection shall be less than 10 mm.

Internal forms shall be fixed in the correct position such that they will not displace or deform during placing concrete. U-shape bolts shall be used to fix the internal forms and the method of supporting and fixing the internal forms shall be approved by the Engineer. Care shall be taken to ensure that U-shape bolts and other items can resist the buoyancy forces on the formwork.

In falsework, bridge camber shall be considered in accordance with the Working Drawings prepared by the Contractor and approved by the Engineer.

4.2.4.5 Reinforcement

The Engineer shall inspect and approve all reinforcement in place in accordance with the requirements of Clause 4.3, before concrete is placed. An experienced steel fixer shall be present while all concrete is placed to ensure that no reinforcement becomes displaced during placing and if it does to reposition reinforcement before placing continues.

4.2.4.6 Placing Concrete

(a) General - All concrete shall be placed within the time specified in Sub-clause 4.2.3.6. Concrete shall be placed in such a manner as to avoid segregation and the displacement of reinforcing bars and shall be spread in horizontal layers where practicable. Concrete shall be placed where necessary inside forms by hand shovels and in no instance shall vibrators be so manipulated to transport concrete inside formwork. Care shall be taken to prevent mortar from spattering forms and reinforcing steel and from drying ahead of the final covering with concrete. When spattering has occurred the forms and steel shall be

cleaned with wire brushes or scrapers before concrete is placed around steel or in forms which have been spattered.

Troughs, pipes, or short chutes used as aids in placing concrete shall be positioned in such a manner that segregation of the concrete will not occur. All chutes, troughs, and pipes shall be kept clean and free from coating of hardened concrete or mortar. Concrete shall not be dropped freely over a vertical distance of more than 1.5 metres.

Concrete shall generally be placed continuously throughout each section of the structure or between indicated joints if shown on the Drawings or as directed by the Engineer.

If in an emergency it is necessary to stop placing concrete before a section is completed, bulkheads shall be placed as the Engineer may direct and the resulting joint shall be deemed a construction joint, and treated as specified herein below.

(b) Concrete columns - Concrete in columns, bents or walls shall be placed in one continuous operation subject to a maximum height of 4m unless shown on the Drawings or otherwise permitted by the Engineer.

(c) Concrete slab and girder spans - Slabs and girders having spans of 10 metres or less shall be placed in one continuous operation unless otherwise stated on the Drawings. Concrete preferably shall be deposited by beginning at the centre of the span working from the centre toward the ends.

Concrete in slab spans shall be placed in one continuous operation and in one layer for each span, unless otherwise stated on the Drawings.

Concrete in girders spanning more than 10 metres may be placed in two operations, the first operation being the placing of concrete in the girder stems to the bottom of the slab haunches or the bottom of the slab whichever is applicable. A period of at least 24 hours shall elapse between the completion of placing concrete in the girder and the commencement of placing concrete in slab.

The construction procedure for the concrete deck slab on steel box girders shall be so arranged as to eliminate excessive stress in new or recently placed concrete.

Immediately before placing concrete, the top surface of the previously placed concrete shall be hammered with a sharp hand tool (scrabbled) until the aggregate is exposed and cleaned. The Contractor shall check all falsework for shrinkage and settlement, and shall tighten all wedges to ensure minimum deflection of all formwork.

(d) Walls, piers, etc. - Where walls, piers, columns, struts, posts and other such structural members allow horizontal construction joints, concrete shall not be placed on top of other concrete which has not been allowed to set for 12 hours or more.

Work shall not be discontinued within 450 mm of the top of any face, unless provision has been made for a coping less than 450 mm thick, in which case, if permitted by the Engineer, the construction joint may be made at the underside of the coping.

(e) Culverts - The slabs of box culverts shall be placed for their full depth in one mass or layer and allowed to set not less than 12 hours before any additional work is done on them.

Before concrete is placed in sidewalls, bottom slabs shall be cleaned of all shavings, sticks, sawdust and other extraneous material.

The Contractor shall submit to the Engineer for approval his proposals for pouring culvert walls before commencing culvert construction. Concrete shall not be placed in layers more than one metre high relative to the concrete already placed. Deposition shall proceed in a systematic manner.

(f) Depositing concrete underwater - Concrete shall not be deposited in water except with the approval of the Engineer and with his immediate supervision, and by the method described in this paragraph.

To prevent segregation, the concrete shall be carefully placed in a compact mass in its final position by means of a tremie tube or pipe, or a closed bottom-dump bucket, or by other means, and shall not be disturbed after being deposited. Special care must be exercised to maintain still water at the point of deposit. Concrete shall not be placed in running water. The method of depositing concrete shall be so regulated as to produce approximately horizontal surfaces. Concrete seals shall be placed in one continuous operation. When a tremie tube or pipe is used, it shall consist of a tube or pipe not less than 250 mm in diameter, constructed in sections having flanged couplings fitted with gaskets.

The means of supporting the tremie shall be such as to permit free movement of the discharge end over the entire top of the concrete and permit its being lowered rapidly when necessary to choke off or retard the flow. The tremie shall be filled by a method that will prevent washing of the concrete. The discharge end shall be completely submerged in concrete at all times and the tremie shall contain sufficient concrete to prevent any water entry.

When concrete is placed with a bottom-dump bucket, the bucket shall have a capacity of not less than 1.20 cubic metres and shall be equipped with loose-fitting top covers. The bottom door shall open freely downward and outward when tripped. The bucket shall be completely filled and be lowered gradually and carefully until it rests on the surface upon which the concrete is to be deposited. It shall then be raised very slowly during the discharge travel, the intent being to maintain, as nearly as possible, still water at the point of discharge and to avoid agitating the mixture.

Dewatering shall proceed only when the concrete seal is considered strong enough to withstand any pressures to be exerted upon it. This time will be decided by the Engineer. All laitance or other unsatisfactory material shall be removed from the exposed surface by scraping, jetting, chipping or other means which will not unduly injure the seal.

(g) Construction joints - Construction joints shall be located where shown on the Drawings or permitted or instructed by the Engineer. Construction joints shall be perpendicular to the principal lines of stress and in general shall be located at points of minimum shear.

At horizontal construction joints, details shall be as approved by the Engineer. Before placing fresh concrete, the surfaces of construction joints shall be scabbled, sandblasted or washed and scrubbed with a wire brush to expose clean aggregate, drenched with water until saturated, and kept saturated until the new concrete is placed. Immediately prior to placing new concrete the forms shall be drawn tight against the concrete already in place and the old surface shall be coated thoroughly with a 1.5 mm thick coating of neat cement mortar.

Concrete in substructures shall be placed in such a manner that all exposed horizontal construction joints will be truly horizontal.

Where vertical construction joints are necessary, reinforcing bars shall extend across the joint in such a manner as to make the structure monolithic. Special care shall be taken to avoid construction joints through panelled wing walls or other large surfaces which are to have an architectural finish. Necessary dowel, load-transfer devices, and bonding devices shall be placed as shown on the Drawings or directed by the Engineer.

(h) Expansion joints – Expansion joints shall comprise formed polythene elastic material with asphaltic sealant, 20mm thick, and shall be located and formed as required on the Drawings. Cut-off plate for water stops used for the expansion joints shall be placed in accordance with the Drawings. The water stops shall be held firmly in place to prevent displacement during concreting. If after placing concrete water stops are materially out of position or shape, the surrounding concrete shall be removed, the water stop reset, and the concrete replaced, all at the Contractor's expense.

Water stop shall be furnished full length for each straight portion of the joint, without field splices. Water stop shall be cut and spliced at changes in direction as may be necessary to avoid buckling or distortion. All field splices shall be performed by heat sealing, hot-air welding or vulcanising the adjacent surfaces in accordance with the manufacturer's recommendations to form continuous watertight joints.

Dowel bars, where required, shall be complete with uPVC sleeves and shall be accurately installed in expansion joints in accordance with the Drawings or as directed by the Engineer. Particular care shall be taken to ensure that concrete cannot enter the uPVC sleeves during casting.

(i) Open joints - Open joints shall be constructed where shown on the Drawings by insertion and subsequent removal of a wooden strip, metal plate, or other approved material. The insertion and removal of the template shall be accomplished without chipping or breaking the corners of the concrete. Reinforcement shall not extend across an open joint unless so specified on the Drawings.

(j) Anchor bolts - All necessary anchor bolts in piers, abutments or foundations of mechanical equipment shall be accurately set in holes formed while the concrete is being placed. Holes may be formed by inserting in the fresh concrete oiled wooden plugs, metal pipe sleeves, or other approved devices, and withdrawing them after the concrete has partially set. Holes so formed shall be at least 100 mm in diameter. Bolts shall be set accurately and fixed with grout completely filling the holes. The grout shall be non-shrink mortar of a type approved by the Engineer.

(k) Shoes and bearing plates – Not applicable. Elastomeric bearing pads are specified elsewhere

(l) Drainage holes and weep holes - Drainage holes and weep holes shall be constructed in the manner and at the locations indicated on the Drawings or required by the Engineer. Ports or vents for equalizing hydrostatic pressure shall be placed below low water.

(m) Forms for weep holes through concrete shall be PVC pipe. Exposed surfaces of weep drain pipe shall be flush with the concrete.

(n) Pipe, conduits, and ducts - Pipes, conduits, and ducts that are to be encased in concrete shall be installed by the Contractor before the concrete is placed. Unless otherwise indicated, pipe embedded in concrete shall be standard, light-weight, non-corrosive pipes. Pipes shall be held or braced rigidly during concrete placement in order to prevent their displacement.

(o) Piers and abutments - No superstructure load shall be placed upon finished bents, piers, or abutments until the Engineer so directs, but the minimum time allowed for the hardening of concrete in the substructure before any load of the superstructure is placed thereon shall be 7 days when normal Portland cement is used.

4.2.4.7 Curing Concrete

Immediately after forms have been removed and finishing work completed, all concrete shall be cured by one of the following methods. The Engineer will specify the concrete surface which may be cured by either method.

(a) Water method - The entire exposed surfaces other than slabs shall be protected from the sun and the whole structure shall be covered with wet burlap, cotton mats, or other suitable fabric for a period of at least seven days. These materials shall be kept thoroughly wet for the entire curing period. Curbs, walls, and other surfaces requiring a rubbed finish may have the covering temporarily removed for finishing, but the covering must be restored as soon as possible. All concrete slabs shall be covered as soon as possible with sand, earth or other suitable material and kept thoroughly wet for at least seven days. This covering material shall not be cleared from the surface of the concrete slabs for a period of twenty one days.

If wood forms are allowed to remain in place during the curing period, they shall be kept moist at all times to prevent them from shrinking.

(b) Membrane forming curing compound - All surfaces shall be given the required surface finish prior to application of the curing compound. During the finishing period, the concrete shall be protected by the water method of curing.

Membrane curing compound shall be applied after the removal of forms, or after the disappearance of surface water. It can be sprayed or applied to the concrete surface by means of an applicator in one or more coats at the rate instructed by the manufacturer.

Should the membrane seal be broken or damaged before the expiration of the curing period, the damaged area shall be immediately repaired by the application of additional membrane material.

The Contractor's proposals for the use of liquid membrane curing compound and the locations shall be subject to the approval of the Engineer.

4.2.4.8 Removal of Formwork and Falsework

(a) Time of removal - formwork and falsework shall not be removed without the approval of the Engineer. The Engineer's approval shall not relieve the Contractor of responsibility for the safety of the work. Blocks and bracing shall be removed at the same time as the forms and in no case shall any portion of wooden forms be left in the concrete.

Falsework removal for continuous or cantilevered structures shall be as approved and directed by the Engineer and shall be such that the structure is gradually subjected to its working stress.

When the time for removal of forms and supports is determined based on concrete strength tests, such removal shall not begin until the concrete has attained the percentage of the specified design strength shown in the table below.

If field operations are not controlled by compressive strength tests, the time shown below for removal of forms and supports shall be used as a minimum:

In continuous structures, falsework shall not be released in any span until the first and second adjoining spans on each side have reached the strength specified herein or in the special provisions. When cast-in-place post-tensioned bridges are constructed, falsework shall remain in place until all post-tensioning has been accomplished

Removal of Formwork and Falsework

Structure	Standard Concrete	Early Strength Concrete	Percentage of Design Strength
Centering under girders, beams, frames or arches	14 days	7 days	80%
Floor slabs	14 days	7 days	70%
Walls	1 day	12 hours	-
Columns	2 days	1 day	-
sides of beams and all other vertical surfaces	1 day	12 hours	-

Falsework under all spans of continuous structures shall be completely released before concrete is placed in railings and bridge parapets or other upper elements depending on the type of structure.

Forms and falsework shall not be released from under concrete without first determining if the concrete has gained adequate strength without regard to the time element. In the absence of strength determinations, the forms and falsework are to remain in place until removal is permitted by the Engineer.

The forms for footings constructed within cofferdams or cribs may be left in place when, in the opinion of the Engineer, their removal would endanger the safety of the cofferdam or crib, and when the forms so left intact will not be exposed to view in the finished structure. All other forms shall be removed whether above or below the ground line or water level.

All formwork shall be removed from the cells of concrete box girders within which utilities are required, and all formwork except that necessary to support the deck slab shall be removed from the remaining cells of the box girder.

To facilitate finishing, forms used on ornamental work, railings, parapets, and exposed vertical surfaces shall be removed at least 12 but not more than 48 hours later depending upon weather conditions.

In order to determine the condition of concrete in columns, forms to columns shall always be removed before releasing supports from beneath beams and girders.

Falsework supporting the deck of rigid frame structures shall not be removed until fill has been placed behind the vertical legs.

(b) Patching - Immediately following removal of the forms all projecting wires or metal devices that have been used for holding the forms in place shall be removed or cut back at least 25 mm beneath the surface of the concrete. Fins or runs of mortar and all irregularities caused by form joints shall be removed. Small holes, depressions, and voids that show on the concrete shall be filled with cement mortar mixed in the same proportions as that used in the body of the work, but without coarse aggregate.

The surface of this mortar shall be floated with a wooden float before initial set takes place. It shall be uniform in colour with the surrounding concrete and neat and workmanlike in appearance.

(c) Cause for rejection - Excessive honeycombing shall be sufficient cause for rejection of portions of the structure containing this honeycombing. The Contractor, on receipt of written orders from the Engineer, shall remove and rebuild such portions of the structure at his own expense.

4.2.4.9 Finishing Concrete

All concrete surfaces exposed in the completed work shall comply with the requirements of Item (c) Ordinary finish herein except where otherwise shown or specified.

(a) Concrete bridge decks - Immediately after placing concrete, concrete decks shall be struck off with templates to provide proper transverse sections and shall be hand finished smooth to the concrete levels. Finish shall be slightly but uniformly roughened by brooming. The finished surface shall not vary more than 10 millimetres from a 4 metre straightedge placed parallel to the centreline of the roadway and 10 millimetres from a transverse template cut to the true cross section of the roadway. (This Item is not applicable to this Package)

(b) Curb, footpath and concrete paved surfaces - Exposed faces of curbs and footpath shall be finished true to lines and grades. The curb surface shall be wood floated to a smooth but non-slippery finish. Footpath surfaces shall be slightly but uniformly roughened by brooming across the direction of travel. Concrete paved surfaces shall be wood float finished.

(c) Ordinary finish - An ordinary finish is defined as the finish left on a surface after the removal of the forms when all holes left by form ties have been filled, and any minor surface defects have been repaired. The surface shall be true and even, free from depressions or projections and of reasonably uniform colour.

Repaired surfaces, the appearance of which is not satisfactory, shall be "rubbed" as specified in Item (d) Rubbed finish.

The concrete in bridge seats, caps, and tops of walls shall be struck off with a straightedge and floated to true grade. Unless shown on the Drawings the use of mortar topping for concrete surfaces will not be permitted.

(d) Rubbed finish - After the removal of forms the rubbing of concrete shall be started as soon as its condition will permit. Immediately before starting this work the concrete shall be kept thoroughly saturated with water. Sufficient time shall have elapsed before the wetting down to allow the mortar used in patching to set thoroughly. Surfaces to be finished shall be rubbed with a medium coarse carborundum stone, using a small amount of mortar on its face. The mortar shall be composed of cement and fine sand mixed in the same proportions as those used in the concrete being finished. Rubbing shall be continued until all form marks, projections and irregularities have been removed, all voids filled, and a uniform surface has been obtained. The paste produced by this rubbing shall be left in place. After all concrete above the surface being treated has been cast, the final finish shall be obtained by rubbing with a fine carborundum stone and water. This rubbing shall be continued until the entire surface is of a smooth texture and uniform colour.

After the final rubbing has been completed and the surface has dried, it shall be rubbed with burlap to remove loose particles and laitance. The final surface shall be free from all unsound patches, paste, powder and objectionable marks.

(e) Backfill and road fills - All spaces which have been excavated and the volumes of which are not occupied by the concrete structure shall be backfilled and compacted with acceptable material in accordance with the provisions of Section 3 of these Specifications.

If there is likelihood of water accumulating behind any wall, the backfill shall not be placed until after the retaining, diaphragm, or spandrel walls are 28 days old. No fill shall be placed over arches and slabs until the concrete is 28 days old or until test specimens indicate the concrete has attained the required 28-day strength.

(f) Loading - Traffic or heavy construction equipment shall not be allowed on reinforced concrete structures until 28 days have elapsed from the last placing of concrete except as noted below. If it is proposed to use the structure at an earlier date, extra test specimens shall be cast. The structure may be used when tests of these specimens show that the concrete has attained its specified 28-day strength.

4.2.4.10 Floor Slab Finishes

(a) General

Floor slabs shall be finished as specified below unless shown otherwise on the Drawings or directed by the Engineer.

(b) Floated finish

After the concrete has been placed, struck off consolidated, and levelled, it shall not be worked further until the water sheen has disappeared, and/or when the mix has stiffened sufficiently to permit the proper operation of a power-driven float. The surface shall then be consolidated with power-driven floats. Hand floating with wood or cork-faced floats shall be by machine. All high spots shall be cut down and all low spots filled to within a tolerance of 1/1000. The surface shall then be refloated immediately to a uniform, smooth, granular texture.

Floated finish shall be required for concrete flat work surfaces that will receive waterproof membranes.

(c) Towelled finish

The surface shall be finished first with power floats as specified above for "Floated Finish", then with power trowels, and finally with hand trowels.

The finished surface shall be dense and smooth, free of any trowel marks, uniform in texture and appearance and shall be in a true plane with a tolerance of 3 mm in 3.0 m. On surfaces intended to receive resilient floor coverings, any defects that would show through the floor covering shall be removed by grinding.

Trowelled finish shall be required for concrete flat work surfaces that will be exposed, or that will receive resilient flooring, carpeting, or any other floor coverings requiring a smooth base slab.

(d) Broomed Finish

Immediately after the concrete has been floated, as specified above under "Floated Finish" to a true plane the surface shall be given a scored texture, at right angles to the direction of traffic, by lightly drawing a broom across the surface. Use a stiff broom for ramps.

Broomed finish shall be required for exposed concrete ramps and walks.

(e) Trowelled Floated Finish

The surface shall be finished first as specified above for "Trowelled Finish", then the surface shall be finished with a wood floats to obtain a uniform, non-directional; grainy or sandy texture.

Trowelled floated finish shall be required for site concrete (borders, bands, curbs, paving, steps).

(f) Hardener and Dustproofer

After the concrete surface has been finished and cured for at least 28 days, apply 3 coats of hardener and dustproofer in accordance with manufacturer's written instruction. Allow to dry between coats.

Hardener and dustproofer shall be required for all exposed interior concrete floor surface that will receive carpeting.

(g) Non-Slip Finish

Trowel abrasive aggregate into the surface at the floating stage at the rate as specified by the manufacturer.

Non-slip finish shall be required at landings or stair treads.

4.2.4.11 Cement Mortar

Cement mortar shall be composed of one part of cement to one part of fine aggregate by volume, or such other proportions as shall be directed by the Engineer, or as shown on the Drawings but not exceeding three parts by volume of fine aggregate to one part of cement mixed with water so that the water-cement ratio does not exceed 0.45 by weight.

Stiff cement mortar shall be as above, but with a water-cement ratio not exceeding 0.35, or to a consistency consented to by the Engineer.

Dry pack cement mortar shall be as above, but with water just sufficient to ensure full hydration of cement.

Where shown on the Drawings, stair treads shall be plastered with a 20 mm thick 1:2 cement : sand mortar screed which shall be finished with a non-slip finish as specified in Clause 4.2.4.10.

Sand-cement mortar surfacing or screed as shown on the Drawings for use in bridge construction shall consist of a 1:3 cement : sand mortar.

4.2.4.12 Cleaning Up

Upon completion of structure and before final acceptance, the Contractor shall remove all falsework, falsework piling, etc., down to 1.0 metre below the finished ground line. Excavated, or useless materials, rubbish, etc. shall be removed from the site and the site shall be left in a neat and presentable condition satisfactory to the Engineer.

4.3 REINFORCING STEEL BARS

4.3.1 Description

This work shall consist of furnishing, fabricating, and placing reinforcing steel bars of the type and size provided in accordance with these Specifications and in reasonably close conformity with the Drawings or as directed by the Engineer.

4.3.2 Materials

Reinforcing steel shall conform to the requirements of the following specifications except that the weights of the standard bar sizes will be taken as per Table 4.4.2.a and Table 4.4.2.b, irrespective of the specification used in manufacture.

Round Bar :

A-I (CT-3) 22TCN 18-79; or
JIS G 3112 (Grade SR 235); or
ASTM A615

Deformed Bars :

A-II (CT-5) 22TCN 18-79; or
JIS G 3112 (Grade SD 295A); or
JIS G 3112 (Grade SD 345); or
ASTM A615

Reinforcing bars shall be kept off the ground, above flood inundation level and stored within a building or provided with suitable cover.

4.3.3 Construction

4.3.3.1 Fabrication

(a) Reinforcing bars shall be accurately formed to the shapes and dimensions indicated in the design, and shall be fabricated in a manner that will not injure the material.

(b) Unless otherwise permitted, all reinforcing bars requiring bending shall be bent cold. When reinforcing bars are bent by heating, the entire operation shall be approved by the Engineer. Should the Engineer approve the application of heat for field bending reinforcing bars, precautions shall be taken to ensure that the physical properties of the steel will not be materially altered.

(c) Reinforcing bars that cannot be straightened by means of fabrication shall not be used. Bars partially embedded in concrete shall not be bent except as shown on the Drawings or otherwise permitted.

(d) Qualified workers shall be employed for cutting and bending, and proper appliances shall be provided for such work.

(e) If it is necessary for the Engineer to ascertain the quality of reinforcing bars, the Contractor shall test reinforcing bars, at his own expense, by means as directed by the Engineer.

4.3.3.2 Placing

(a) Reinforcing bars before being positioned shall be cleaned and free from rust, dirt, mud and loose scale and from paint, oil, or any other foreign substance that destroys or reduces the bond.

(b) Reinforcing bars shall be accurately placed in proper position so that they will be firmly held during placing concrete. Reinforcing bars for erecting shall be used when needed.

(c) Bars shall be tied at all intersections by using annealed iron wire 0.9 mm or larger diameter or suitable clips. Welding will not be permitted for this requirement.

(d) Distances from the forms shall be maintained correctly by means of metal hangers, mortar blocks, metal supports, or other supports approved by the Engineer.

(e) Reinforcing bars shall be inspected by the Engineer after placing. When a long time has elapsed after placing reinforcing bars, they shall be cleaned and inspected again by the Engineer before placing concrete.

4.3.3.3 Splicing

(a) When it is necessary to splice reinforcing bar at points other than shown on the designs, positions and methods of splicing shall be determined based on strength calculations approved by the Engineer.

(b) In lapped splices, the bars shall be lapped the required length and wired together at several points by using annealed iron wire larger than 0.9 mm.

(c) Exposed reinforcing bars intended for bonding with future extensions shall be effectively protected from injury and corrosion.

(d) Welding of reinforcing steel shall be done only if detailed on the Drawings or if authorized by the Engineer in writing.

(e) Substitution of different size bars shall be permitted only upon the specific authorization of the Engineer. If steel is substituted, it shall be of a size equivalent to the design size or larger.

4.4 MEASUREMENT AND PAYMENT

4.4.1 Concrete

(a) Measurement in General

Measurement shall be made of the volume of concrete of the various classes in place and approved by the Engineer.

In computing quantities the dimensions used shall be those shown on the Drawings or ordered in writing by the Engineer but the measurement shall not include any concrete used for the construction of temporary works. No deduction from the measured quantity shall be

made for the volume occupied by pipes less than 200 mm in diameter nor for reinforcing steel, anchors, conduits, weep holes or piling.

No pay allowance shall be made for any increased cement content, for any admixtures nor for any finishing of any description of concrete or concrete floor.

Unless described otherwise, Concrete used for the works on other Pay Items in these Specifications (e.g. precast concrete culverts) will not be measured for payment under this clause.

(b) Payment

Payment for the various classes of concrete shall be paid for at the respective unit rate per cubic metre entered in the Bill of Quantities. The payment shall be full compensation for furnishing and placing all materials, including all labour, tools, equipment, formwork, falsework (scaffolding and supporting; for mixing, placing, finishing and curing the concrete, etc., and all incidental work thereto.

Payment for the reinforce concrete toe block shall, in addition, include the cost of pre-casting, handling, preparation of the bed and any other works to complete its placement in the final location to the approval of the Engineer.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
2.15.4.4	Concrete Class D (for Deck Slab): including supply, placement and formwork	m^3
2.15.5.1	Concrete Class E (for Approach Slabs): including supply, placement and formwork	m^3
2.22.3.4	Concrete Class E (for Box Culvert): including supply, placement and formwork	m^3
2.15.4.3	Concrete Class E (for Parapet Wall): including supply, placement and formwork	m^3
2.17.2	Concrete Class E (U-Channel, Manhole): including supply, placement and formwork	m^3
2.10.2 2.11.2 2.12.2 2.13.2 2.14.1.2 2.14.2.2 2.14.3.2 2.15.2.8 2.15.3.7 2.19.3 2.2.5 2.22.2.1 2.2.4.1 2.22.5.5 2.4.2 2.5.2 2.6.2 2.7.2 2.8.2 2.9.2	Concrete Class E: including supply, placement and formwork	

2.17.3	Concrete Class F (Invert Concrete): including supply, placement and formwork	m^3
2.10.3 2.11.3 2.12.3 2.13.3 2.14.1.3 2.14.2.3 2.14.3.3 2.19.4 2.22.2.2 2.22.5.6 2.4.3 2.5.3 2.6.3 2.7.3 2.8.3 2.9.3	Concrete Class F: including supply, placement and formwork	m^3
2.17.4	Concrete Class G (Levelling Concrete): including supply, placement and formwork	m^3
2.4.1 2.5.1 2.6.1 2.7.1 2.8.1 2.9.1 2.101 2.11.1 2.12.1 2.13.1 2.14.1.1 2.14.2.1 2.14.3.1 2.15.2.7 2.15.3.6 2.19.5 2.22.3.5 2.22.5.7	Concrete Class G: including supply, placement and formwork	m^3
2.15.3.16	Precast Concrete Toe Block (Concrete Class E): including supply and installation	m^3

4.4.2 Reinforcing Steel Bar

(a) Measurement

The quantity of reinforcing steel bar to be paid for shall be the mass (kg) of reinforcing bar erected as shown on the Drawings or ordered by the Engineer in writing. The mass calculated will be based upon the following table :

Table 4.4.2.

Unit Mass of Reinforcing Steel Bars

Nom. Bar Size (diameter mm)	9	10	12	14	16	18	20
Mass per linear metre in kg	0.499	0.617	0.888	1.210	1.580	2.000	2.470

Nom. Bar Size (diameter mm)	22	28	30	32	36	40	-
Mass per linear metre in kg	2.98	4.83	5.55	6.31	7.99	9.89	-

The lengths to be taken in calculating the mass for the purpose of payment shall be shown on the Drawings or ordered in writing by the Engineer.

No measurement or payment will be made for splices added by the Contractor for his convenience or for splices which are not shown on the Drawings and are not approved by the Engineer.

Clips, ties or other material used for positioning and fastening the reinforcing bars in place shall not be measured for payment. Reinforcing steel bars used for precast concrete elements shall not be measured for payment under this clause.

(b) Payment

Payment for reinforcing steel bar shall be made at the unit rate entered in the Bill of Quantities. This payment shall be full compensation for furnishing all labour, equipment, and materials, necessary for fabricating, bending, assembling and erecting reinforcing bar, for unloading at the specific location, storing and handling of reinforcing steel bar and any other associated costs.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
2.2.6 2.4.5 2.5.6 2.6.5 2.7.5 2.8.5 2.9.5 2.10.5 2.11.5 2.12.5 2.13.5 2.15.2.9 2.15.3.8 2.15.4.5 2.15.5.2 2.19.7 2.22.2.3 2.22.3.6 2.22.4.2 2.22.5.8	Deformed Reinforcing Bars: including supply, bending and placement	kg

4.4.3 Cement Mortar

(a) Cement Mortar Surfacing

Measurement shall be made of the area of cement mortar surfacing of the thickness as shown on the Drawings applied in accordance with the Drawings and the Specification.

Payment shall be made at the rate entered in the Bill of Quantities which shall be full compensation for providing all materials, equipment, labour and all incidentals required for completing the cement mortar surfacing to the Engineer's approval.

The following pay items shall be measured and paid under this clause:

Pay Item No.	Description	Unit of Measurement
2.4.4 2.5.4 2.6.4 2.7.4 2.9.4 2.10.4 2.11.4 2.12.4 2.14.1.4 2.14.3.4	Cement Mortar Surfacing (t=20 mm): including supply and placement	m^2
2.13.4	Cement Mortar Surfacing (t=50 mm): including supply and placement	m^2
2.5.5	Cement Mortar Surfacing (t=100 mm): including supply and placement	m^2

(b) Sand Cement Mortar

Measurement shall be made of the volume of sand : cement mortar as shown on the Drawings applied in accordance with the Drawings and the Specification.

Payment shall be made at the rate entered in the Bill of Quantities which shall be full compensation for providing all materials, equipment, labour and all incidentals required for completing the sand : cement mortar to the Engineer's approval.

The following pay items shall be measured and paid under this clause:

Pay Item No.	Description	Unit of Measurement
2.15.13.14	Sand : Cement Mortar	m^3

4.4.4 Joints

4.4.4.1 Waterstop

Measurement shall be made of the length in metres of water stops constructed in accordance with the Drawings and the specification.

Payment shall be made at the rate entered in the Bill of Quantities which shall be full compensation for providing all materials equipment, labour and all incidentals required for completing the water stop and for protecting the waterstop from damage or sunlight exposure, all to the Engineer's approval.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
2.4.6 2.5.7 2.6.6 2.7.6 2.8.6 2.9.6 2.10.6 2.11.6 2.12.6 2.13.6 2.14.1.6 2.14.2.5 2.14.3.6 2.22.3.7	Water Stop: including supply, installation and protection	m

4.4.4.2 Elastic Joint Filler

Measurement shall be made of the area of elastic joint filler placed in accordance with the Drawings and the specification.

Payment shall be made at the rate entered in the Bill of Quantities which shall be full compensation for providing the materials (formed elastic polythene material, equipment, labour and all incidentals required for completing elastic joint filler for the expansion joint to the Engineer's approval.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
2.4.7 2.5.8 2.6.7 2.7.7 2.8.7 2.9.7 2.10.7 2.11.7 2.12.7 2.13.7 2.14.1.7 2.14.2.6 2.14.3.7 2.17.10 2.22.3.8	Elastic Joint Filler (t=20 mm): including supply and installation	m^2

4.4.4.3 Joint Sealant

Measurement shall be made of the volume of joint sealant placed in accordance with the Drawings and the specification. Measurement shall be based on the cross-sectional area of the joint as shown on the Drawings (i.e. 20 x 20 mm) and no measurement shall be made of joints which are wider than specified.

Payment shall be made at the rate per litre entered in the Bill of Quantities which shall be full compensation for providing the material and all incidentals required for completing the joint sealant for the expansion joints to the Engineer's approval.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
2.4.8 2.5.10 2.6.8 2.7.8 2.8.8 2.9.8 2.10.8 2.11.8 2.12.8 2.13.8 2.14.1.8 2.14.2.7 2.14.3.8 2.17.11	Joint Sealant: including supply and installation	litre

4.4.4.4 Dowel Bars

The quantity of dowel bar to be paid for shall be the mass (kg) of dowel bars erected as shown on the Drawings or ordered by the Engineer in writing. The mass calculated will be based upon the tables in Clause 4.4.2.

Payment for dowel bars shall be made at the unit rate entered in the Bill of Quantities. This payment shall be full compensation for furnishing all labour, equipment, and materials, necessary for fabricating, assembling and erecting dowel bars complete with uPVC sleeves and any other associated costs.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
2.4.9 2.5.9 2.7.9 2.8.9 2.9.9 2.10.9 2.11.9 2.12.9 2.13.9 2.14.1.9 2.14.2.8 2.14.3.9	Dowel Bars: including supply and installation complete with PVC sleeves	kg

SECTION 5. PILING WORKS
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SECTION 5. PILING WORKS

5.1 GENERAL

This section covers the general and specific requirements for piling works to be completed in Package E.

The piling works to be carried out by the Contractor, include, but are not limited to, the following:

- Timber piling for site preparatory works, buildings and facilities of the wastewater treatment plant and bridge abutments;
- Reinforced concrete piling for the jetty, buildings and facilities of the wastewater treatment plant, bridge piers and abutments, conveyance sewer and maintenance chambers;
- Steel sheet piling for the jetty;
- Load testing of reinforced concrete piles.

All piling works shall be in accordance with the Drawings, the specification and the directions of the Engineer.

5.2 PRECAST CONCRETE PILING

5.2.1 General

This work shall consist of precast reinforced concrete piling furnished and driven in accordance with these specifications and in close conformity with the requirements shown on the Drawings or elsewhere in the Contract Documents.

Reinforced concrete piles may be manufactured by the Contractor in strict compliance with Drawings and the specifications or may be procured from a specialist supplier provided that the such piles are equivalent or better than those specified herein and that the Engineer has given his approval. Specialist pile suppliers shall manufacture piles under a quality assurance system and shall certify that all piles so supplied meet Contract requirements.

5.2.2 Materials

5.2.2.1 General

Pre-cast reinforced concrete piles shall be constructed in accordance with the details shown on the Drawings, of concrete Class D, mixed and placed in accordance with the provisions of Clause 4.2 of these Specifications. Reinforcement shall comply with the provisions of Clause 4.3 of these Specifications. Main reinforcing bars shall be supplied in one complete length and should this prove impractical separate lengths shall be effectively spliced by a method approved by the Engineer. The straightness of every pile shall be such that 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.

Bearing piles shall not be constructed or ordered until the Engineer instructs the required lengths.

5.2.2.2 Formwork

Forms for pre-cast piles shall conform to the general requirements for concrete formwork as described in Clause 4.2 of these Specifications. 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.

5.2.2.3 Reinforcement

Reinforcement shall be in accordance with the provisions set out in Clause 4.3 and positioned as shown on the Drawings.

5.2.2.4 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, and the top surface finished to a uniform, even texture similar to that produced by the forms.

5.2.2.5 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.

5.2.2.6 Curing

Concrete piles shall be covered with wet burlap immediately after placing is complete and shall be kept continuously wet for at least 7 days.

5.2.2.7 Handling

When raising or transporting pre-cast 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 other than by slinging from the lifting holes, the positions of which shall be submitted to and approved by the Engineer. Piles damaged in handling or driving shall be replaced. Concrete piles shall be so handled at all times to prevent breaking or chipping the edges.

Piles shall not be driven until 28 days have elapsed from the time of casting or such reduced time as the Engineer may decide as a result of tests.

5.2.3 Construction

5.2.3.1 Preparation for Driving

(a) Caps - The heads of all concrete piles, when the nature of the driving is such as to unduly injure them, shall be protected by caps of approved design having a suitable cushion next to the pile head and fitting into a casing which in turn supports a timber shock block. No pile head will be held so firmly that the slight rotation of the pile normally occurring while the pile is being driven will be prevented.

(b) Splicing piles - Splicing of piles shall be made by means of fabricated steel sleeves as shown on the Drawings. The Contractor shall submit to the Engineer for his approval the proposed design of the sleeves and the method of attachment to the pile lengths to be spliced, in accordance with the procedures in Clause 1.3.5 of the Specification

5.2.3.2 Handling, Pitching and Driving

(a) General

The main setting out for the piles is to be completed prior to commencement of driving. Secondary or individual pile setting out is to be completed and agreed not less than 8 hours prior to commencing work on the piles concerned. All main setting out points, lines and stations are to be maintained safe and undisturbed until the work is complete.

Piles shall be pitched accurately in the positions and driven to the lines shown on the Drawings or fixed by the Engineer. Piles deflected from the vertical or proper line shall, where ordered by the Engineer, be withdrawn and re-pitched until the correction of the position or line of any pile will be permitted. Any pile damaged by reason of improper driving or driven out of its proper location or driven below the elevation fixed by the Drawings or by the Engineer, shall be corrected at the Contractor's expense by one of the following methods approved by the Engineer for the pile in question :

- The pile shall be withdrawn and replaced by a new and, if necessary, longer pile. Any holes from which piles are withdrawn shall be packed with approved non-plastic material before re-driving takes place; or
- A second pile shall be driven adjacent to the defective or low pile.

All piles pushed up by the driving of adjacent piles or by any other cause shall be driven again.

(b) Batter piles

Where batter piles are called for they shall be driven accurately to the batter shown on the Drawings. The pile frame employed for the driving of the batter piles shall have leads capable of adjustment to the required angle. When piles have to be driven below the level of the bottom of the leads extension leads shall be provided except where the use of a follower is specifically permitted by the Engineer.

(c) Driving equipment

Before any piling work is commenced the Contractor shall submit to the Engineer full details of the pile driving equipment and the method of carrying out the work he intends to use. All piles shall be provided with caps for driving as specified in Clause 5.2.3.1 above. For special types of piles, driving head mandrels, or other devices in accordance with these requirements shall be provided so that piles may be driven without damage.

Piles shall be driven with steam, air or diesel hammers, a combination of hammers with water jets or gravity hammers.

In general:

- Where diesel hammers are used for driving pre-cast concrete piles, the energy of the hammer shall numerically approximate one half of the weight of pile plus 4000 kg.

- When gravity hammers are used for driving pre-cast concrete piles, the drop of the hammer shall not exceed 2.5 metres and the hammers shall have a weight of not less than half the weight of the pile. The fall shall be regulated so as to prevent injury to the pile.
- Equipment furnished for steam and air hammers shall have sufficient capacity to maintain, under working conditions, the pressure in the manner specified by the manufacturer. The boiler or tank shall be equipped with an accurate pressure gauge, and another gauge shall be supplied at the hammer intake.

(d) Driving

Piles shall be supported in line and position with leads while being driven. Pile drive leads shall be constructed so as to afford freedom of movement of the hammer, and they shall be held firmly in position to ensure rigid lateral support to the pile during driving. Except where piles are driven through water, the leads shall be of sufficient length to make the use of a follower unnecessary, and shall be so designed as to permit the proper placing of batter piles. Once started driving shall be continuous.

When water jets are considered by the Engineer to be necessary, the number of jets and the nozzle volume and pressure shall be sufficient to freely erode the material adjacent to the piling. The plant shall have at all times a pressure of at least 7 kPa (7kg/cm2) at two 20 mm dia jet nozzles. Before the required penetration is reached, the jets shall be shut off and the piles driven by hammer to final penetration.

A detailed accurate record of the driving of all piles shall be kept by the Engineer. The Contractor shall give every assistance to the Engineer to help him keep this record which will include the following : pile numbers, positions, types, sizes, actual lengths, dates driven, lengths in footings, penetration under final blows of the hammer, striking energy of the hammer, length cut off, and final pay lengths. No pile shall be driven near freshly placed concrete.

(e) Bearing values

Piles shall be driven to a bearing value of not less than that shown on the Drawings or advised by the Engineer. The Engineer will specify the penetration and the Contractor shall drive the piles to the penetration specified, but if the Engineer is not satisfied that the desired bearing value has been attained, he may instruct action as for a defective pile as detailed in Clause 5.2.3.2. of this section. Provided that the pile is not defective because of the failure of the Contractor to fulfil his obligations under this Contract, both the first pile and its replacement will be measured for payment under this clause.

(f) Pile Head Treatment

Concrete piles shall be cut off as indicated on the Drawings or as directed by the Engineer at such elevation that the pile reinforcement will extend into and connect with the cap or footing.

Unless otherwise specified, pile cut-off length shall become the property of the Contractor and shall be removed from the Site.

Reinforced concrete piles may be cast the full length of the reinforcing bars, provided that the concrete is cut off to expose the steel as shown on the Drawings after the piles have been driven.

5.2.3.3 Test Piles

The Engineer may order the execution of test piles as he may consider necessary to ascertain the type of the foundation for the project. The Contractor shall furnish and execute test piling at the locations designated by the Engineer.

The lengths of the piles shown on the Drawings are based on information obtained from previous site investigations. However, piles of different lengths may be required as directed by the Engineer. Before final pile lengths are settled, the Contractor shall construct to the lengths shown on the Drawings, such pilot piles as may be found necessary. These piles shall be driven in the positions specified by the Engineer and the Contractor shall assist the Engineer in making a full, detailed record of the driving of all test piles throughout the full depth of driving.

After attaining the approved set, driving shall be continued until the Engineer directs that it shall cease. Driving of test piles beyond the point at which the approved set is obtained will be called for to demonstrate that driving resistance continues to increase. The Contractor shall then furnish the remainder of the piles in the structure. In determining the lengths of piles the Contractor shall base his list on the lengths assumed to remain in the completed structure.

5.2.4 Test Loading

5.2.4.1 General

Where required by the Engineer the bearing capacity of the piles shall be checked by test loading on a pile, and by measurement of settlement of the pile and of the adjacent piles in the pile group, which shall remain unloaded during the testing operation.

Test loading shall be carried out as described in this Clause and in general accordance with ASTM D 1143.

The test piles shall be the first piles driven at the Site.

Loading of the test pile shall be achieved by jacking against kentledge. Adjacent piles shall not be used as jacking restraints.

The Contractor shall provide, at his own expense, all materials, equipment and labour required for the test loading of piles, including the provision of kentledge (together with any horizontal restraints required), the placing of kentledge and jacks in position, and all such work and material as may be incidental to the conduct of the test loading procedure as specified.

Bidders shall submit with their Bids details of the method of loading which they propose to use.

The method of test loading, and the loading and measurement procedures followed shall be subject to the consent of the Engineer.

Suitable, apparatus for determining the load on the pile and the settlement of the pile under each increment of load shall be supplied by the Contractor. The apparatus shall have a working capacity of three times of the design load shown on the Drawings or as directed by the Engineer for the pile being tested. Reference points for measuring pile settlement shall be sufficiently removed from the test pile to preclude the possibility of disturbance. All pile load settlement shall be measured by adequate devices, such as gauges, and shall be checked by means of a levelling instrument.

5.2.4.2 Procedure

- The test loading procedure shall comply with the following requirements:

  The initial loadings, and the subsequent increments and decrements of loading shall be achieved instantaneously or as nearly so as may be practicable.

  Settlements shall be measured to an accuracy of 0.5 mm, and shall be recorded at the following intervals of time for a period of at least one hour, and until the rate of settlement shall have reduced to not more than 0.5 mm per hour:

  15 seconds
  30 seconds
  1 minute
  2 minutes
  3 minutes
  4 minutes
  5 minutes
  30 minutes
  1 hour
  and at intervals of one hour thereafter as required.

- Test loading shall follow the sequence set out hereunder, unless otherwise directed by the Engineer:

  (a) An initial load of the magnitude shown on the Drawings or directed by the Engineer shall be applied to the test pile and shall be maintained as long as may be necessary to satisfy the requirements stated above.

  (b) The initial load shall be removed and the recovery of the test pile shall be measured not less than 10 minutes after removal of the load.

  Recovery shall be measured to an accuracy of 0.5 mm.

  (c) The initial load shall then be reapplied, and the load shall be increased subsequently by increments of an amount as shown on the Drawings to a maximum of not less than the maximum value shown on the Drawings on directed by the Engineer.

  Settlements shall be measured in accordance with the provisions of this Clause following re-application of the initial load and each subsequent increment of load.

  (d) The maximum test load shall be maintained for at least 24 hours or until the rate of settlement reduce to 0.5 mm per hour (whichever is the loner) or as the Engineer may direct.

  (e) The test load shall then be removed from the test pile in successive decrements until the load is reduced to the minimum value shown on the Drawings or as directed by the Engineer, when the remainder of the load shall removed.

  The recovery of the test pile shall be measured during the unloading process in accordance with the provisions of (b) above.

  (f) Measurements of settlement and recovery of adjacent unloaded piles shall be taken concurrently of the loaded pile at each stage of the testing procedure.

5.2.4.3 Report

The Contractor shall prepare a report on each load test as outlined below and shall submit a report to the Engineer within four (4) days of completion of the rest.

The report shall include at least the following information:

- Pile Construction and installation.

  A description of the pile type, length as driven, length as tested, length embedded, will thickness, head and tip details and dimensions, date pile was driven and pile mass.

  A description of the forming or driving of the pile including details of concreting, driving records and description of drilling.

- Test Layout and Equipment

  Sketches and if possible photographs showing location and size of reaction and loading equipment, deflection measuring equipment, test pile and cap and position of reference level marks.

  An assessment of the accuracy of the deflection measurement and results of calibrations of the load measuring apparatus.

- Test Procedure and Results

  A tabulation of the readings during and unloading of the pile together with the relevant times and dates.

  A graphical representation of the test results in the form of load-settlement and time-settlement curves (together with all necessary corrections for calibration, movement of datum pints and other influences).

  An assessment of the effect of the reaction system on the deflections and the ultimate bearing capacity.

5.2.4.4 Acceptance

The criterion for acceptance of the pile shall be total settlement of the test pile under the maximum test load shall not exceeding the value shown on the Drawings when the rate of settlement has reduced to not more than 0.5 mm per hour or as directed by the Engineer.

Where not shown on the Drawings this settlement may be taken as 6 mm at a maximum test load of 150 % of the maximum pile load shown on the Drawings.

The settlement of adjacent pile shall be within limits acceptable to the Engineer.

Should the test fail to comply with this criterion, tow additional piles shall be tested.

If both of the additional piles subsequently comply with the test criterion, all piles shall be deemed acceptable.

Should either of two piles subsequently tested fail to pass the test, the Contractor shall construct such additional piles as the Engineer may deem to be necessary to provide the required load capacity.

5.3 TIMBER PILING

5.3.1 General

Timber piles of the required lengths shall be driven to the depths and at the spacing (or density) as shown on the Drawings for the foundations of the various works or as directed by the Engineer.

5.3.2 Materials

Timber Piles (Wooden Piles) shall be cut from Paper Bark or other locally available timber which, subject to the Engineer's approval, is suitable for the intended application. Piles shall be of single length, not shorter than 4500 mm and with diameter not less than 80 mm at any point in the length and not greater than 150 mm and shall be straight to a tolerance of 50 mm over their full length, stripped of any branches and of sound condition. Piles which do not comform to the foregoing requirements shall be removed from the Site. Splicing shall not be permitted.

5.3.3 Construction

Timber piles shall be driven at the density per square metre shown on the Drawings to depths such that the pile heads, after allowing for trimming off the top 100 mm correspond to the lines and levels 100 mm below the underside of the upper surface of the sand layer as shown on the Drawings where piles are used under structures or as otherwise shown on the Drawings.

Piles shall be driven true and plumb and spacings shall be regular. Any pile which is split, broken, or is more than 300 mm out of position shall be replaced at the Contractor's expense.

5.4 STEEL SHEET PILING

5.4.1 General

This clause covers the supply and driving of steel sheet piles.

5.4.2 Materials

Steel sheet pile shall be of U-shape profile Type FSP IV in accordance with JIS A 5528 with section properties as shown in the following table with a yield point strength of 300 MPa (30 kgf/mm^2), or equivalent approved by the Engineer.

Properties of Steel Sheet Pile JIS A 5528 Type FSP

Type	Width (mm)	Height (mm)	Thickness (mm)	Section Modules (cm^3)
Type I	400	85	8.0	88
Type II	400	100	10.5	152
Type III	400	125	13.0	223
Type IV	400	170	15.5	362
Type V	400	200	24.3	520

All piles shall be supplied by the Contractor

5.4.3 Driving

Steel sheet piles be pitched and driven accurately in the positions shown on the Drawings and to the required depths as directed by the Engineer.

The piles shall be pitched inside a braced template and carefully aligned and positioned before driving. Particular care shall be taken to ensure the interlocking of adjacent sheet piles. The piles shall then be driven to the required penetration in such a manner as to ensure that the vertically of the piles is maintained. In the event of any misalignment developed during driving, the Contractor shall take appropriate action to correct the condition during driving.

Piles driven out of alignment in excess of 10 mm, per meter of pile length or damaged during driving may be rejected, if, in the opinion of the Engineer, the improperly aligned or damaged pile adversely affects the structure. The Contractor shall propose the corrective measures to be taken for approval by the Engineer. All corrective measures shall be at the Contractor's own expense. Rejected piles shall be extracted, re-driven, replaced or cut-off at all a level approved by the Engineer.

Extension piles shall be spliced by full penetration butt welds in accordance with the requirements of Section, Metal Work. Welded joints of adjacent sheet piles shall be staggered by at least 2000 mm.

A detailed accurate record of the driving of steel sheet piles shall be kept in the same manner as described in Clause 5.3.3.2. (d) para. 3 or as directed by the Engineer.

5.5 MEASUREMENT AND PAYMENT

5.5.1 Reinforced Concrete Piling

5.5.1.1 Supply of Reinforced Concrete Piles

Measurement shall be made of the length of precast reinforced concrete piles furnished in compliance with the Drawings, the Engineer's instructions and the requirements of these specifications and stockpiled in good condition at the site of the work by the Contractor, and approved by the Engineer.

No allowance will be made for the length of piles furnished by the Contractor to replace piles previously accepted by the Engineer that are subsequently lost or those that are damaged prior to completion of the Contract while in stockpile, or during handling or driving, and are ordered by the Engineer to be removed from the Site or disposed of otherwise.

The length to be cut back to expose reinforcement for incorporation in the pile cap shall not be included for measurement.

Payment shall be made for at the rate per linear metre entered in the Bill of Quantities. The rate shall constitute full compensation for supply of piles, hardware, splicing collars and all other materials, labour, equipment, transportation and stacking on the Site and other incidental equipment and work.

The following pay items shall be measured and paid under this clause:

Pay Item No.	Description	Unit of Measurement
2.3.11 2.22.3.1 2.22.5.1	Reinforced Concrete Pile (300 x 300): including supply, transportation and stacking	m
2.3.6	Reinforced Concrete Test Pile (300 x 300): including supply, transportation and stacking	m
2.2.2 2.3.14 2.15.2.4 2.15.3.3	Reinforced Concrete Pile (400 x 400): including supply, transportation and stacking	m
2.3.8 2.15.2.1 2.15.3.1	Reinforced Concrete Test Pile (400 x 400): including supply, transportation and stacking	m

5.5.1.2 Driving Reinforced Concrete Piles

Measurement shall be made of the length of pre-cast reinforced concrete piles actually driven and accepted. The pay lengths of the satisfactorily driven piles shall be measured from the tip to the cut-off.
Payment for shall be made at the rate per linear metre entered in the Bill of Quantities. The rate shall constitute full compensation for labour, equipment, transportation including driving, jetting, welding, splicing and all related tools, rigs, cranes, hammers, jets, and other incidental equipment and work.

The following pay items shall be measured and paid under this clause:

Pay Item No.	Description	Unit of Measurement
2.3.7 2.3.12 2.22.3.2 2.22.5.2	Driving of Reinforced Concrete Piles (300 x 300): including handling pitching, driving to required bearing value	m
2.2.3 2.3.15 2.15.2.5 2.15.3.4	Driving Reinforced Concrete Pile (400 x 400): including handling pitching, driving to required bearing value	m
2.3.9 2.15.2.2 2.15.3.2	Driving Reinforced Concrete Test Pile (400 x 400)	m

5.5.1.3 Pile Head Treatment

Measurement shall be made of the number of pile heads cut back and with reinforcement bent as shown on the Drawings and approved by the Engineer.

Payment shall be made at the rate entered in the Bill of Quantities which shall constitute full compensation for labour, equipment, transportation and all other incidental requirements to complete the work.

The following pay items shall be measured and paid under this clause:

Pay Item No.	Description	Unit of Measurement
2.3.13 2.22.3.3 2.22.5.3	Pile Head Treatment (for 300 x 300 RC pile): including breaking back pile head and bending of reinforcement	No.
2.2.4 2.3.16 2.15.2.6 2.15.3.5	Pile Head Treatment (for 400 x 400 RC Pile): including breaking back pile head and bending of reinforcement	No.

5.5.1.4 Test Loading

Payment for test loading of piles will be made at the rate per test entered in the priced Bill of Quantities which shall be full compensation for materials, labour, tools, equipment including kentledge, temporary structural framing, gauges, jacks, preparation of report and all other items for completing the work in accordance with the specification and the directions of the Engineer.

The following pay items shall be measured and paid under this clause:

Pay Item No.	Description	Unit of Measurement
2.3.10 2.15.2.3	Test Loading of RC Pile: including provision of all equipment, instruments, kentledge and preparation of report	No.

5.5.2 Timber Piling

Measurement shall be made of the length of timber piling driven and approved by the Engineer.

The length of any pile above the level of the head of the pile shown on the Drawings shall not be measured for payment. Piles, which after cutting off to the required level, are shorter than 4500 mm similarly shall not be measured unless the Engineer consents to shorter lengths, in which case actual driven lengths shall be measured

Payment shall be made at the rate per metre entered in the Bill of Quantities which shall include full payment for providing all labour, materials, tools, equipment and any other works incidental to the completion of the timber piling.

The following pay items shall be measured and paid under this clause:

Pay Item No.	Description	Unit of Measurement
2.3.5	Timber Piling 80-100 dia x 3,000: including supply and installation	m
2.1.8 2.15.3.12	Timber Piling 80-100 dia x 4,500: including supply and installation	m

5.5.3 Steel Sheet Piling

Measurement shall be made of the length of steel sheet piles in place and accepted by the Engineer. The length measured shall include the length of any portion cut off as the result of the specified length of pile not being driven to the toe elevation as shown on the Drawings following a directive of the Engineer to cease driving for whatsoever reason.

Payment for steel sheet piles will be made at the rate entered in the priced Bill of Quantities which shall be full compensation for materials, labour, tools, equipment including furnishing, handling, pitching, driving and cutting and all other items for completing the work in accordance with the specification.

The following pay items shall be measured and paid under this clause:

Pay Item No.	Description	Unit of Measurement
2.2.1	Steel Sheet Pile: including supply and installation	m^2

SECTION 6. ROADS AND PAVEMENTS

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SECTION 6. ROADS AND PAVEMENTS

6.1 GENERAL

This section covers the requirements for the construction of roadworks in Package E.

Roadworks to be completed by the Contractor include the following:

- Roads and paved areas within the wastewater treatment plant including the bridge approach road
- Paving of the bridge deck

All roadworks shall be constructed to the lines, grades and levels shown in the Drawings and the directions of the Engineer.

The Contractor shall liaise closely with the Engineer regarding the construction of roadworks in the vicinity of the interface with roadworks constructed under Package D near the northern bridge abutment.

6.2 EARTHWORKS FOR ROADS

All earthworks for road construction shall be carried out in accordance with the requirements of Section 3.

6.3 PREPARATION OF SUBGRADE

6.3.1 General

This Clause specifies the requirements for the preparation of the surface on which the sub-base for road construction is to be constructed.

6.3.2 Testing and Preparation

Before placing any sub-base or base course the sub-grade shall be prepared as follows.

(a) All surfaces below carriageway, footways and hard shoulders shall, after reinstatement of any soft areas, be well cleaned and free from mud and slurry.

(b) The surface if dry shall be watered and compacted by 4 passes of a smooth wheeled roller having load of 45 kN/m (45 kg/cm) width or 8/10 tonne tire roller.

(c) The formation shall be regulated and trimmed to the road width as shown on the Drawings by using a motor grader.

(d) The trimmed formation shall be rolled by 1 pass of a smooth wheeled roller having and load of 22kN/m (22 kg/cm) width or a vibratory roller having a static load of 8kN/m (8 kg per cm) width or vibratory plate compactor having a static pressure under base plate of not less than 14kPa

The sub-grade shall be in such a condition that it will carry 8 to 10 ton smooth wheel roller without any deformation and/or visible springing effect.

Any portion of the subgrade which shows deformation under the above loading shall be replaced with sub-base course material and re-rolled until no deformation occurs under rolling.

6.4 SUB-BASE COURSE

This item comprises the supply and placement of granular sub-base material in accordance with the following:

6.4.1 Materials

Aggregates for sub-base shall consist of hard, durable particles or fragments of crushed stone, crushed slag, or crushed or natural gravel and filler of natural or crushed sand or other finely divided mineral matters. The composite material shall be free from organic matters and lumps or balls of clay, and shall be of such nature that can be compacted readily to form a firm, stable sub-base.

Materials for sub-base shall conform to the requirements for sub-base as specified below or directed by the Engineer.

Grading Requirements of Sub-Base Course

AASHTO Designation No.	Percentage Passing by Weight
2 inch	100
1 1/2 inch	70 - 100
1 inch	55 - 85
3/4 inch	50 - 80
3/8 inch	40 - 70
No. 4 (5 mm)	30 - 60
No. 10 (2 mm)	20 - 50
No. 40 (0.4 mm)	10 - 30
No. 200 (0.074 mm)	5 - 15

The percentages passing the various sieves are subject to appropriate correction by the Engineer when aggregates of varying specific gravities are used.

Other Requirements of Sub-Base Course

Liquid Limit (AASHTO T89)	25 max
Plasticity Index (AASHTO T91)	6 max.
Sand Equivalent (AASHTO T176) :	25 min.
Loss by Abrasion of particles retained on ASTM No. 12 sieve (AASHTO T96) :	40% max.
Soaked CBR at the required density (100% of the maximum dry density according to AASHTO T180) :	60% max.

6.4.2 Placing and Spreading

(a) Sub-base material shall be placed as a uniform mixture on the prepared subgrade in a quantity which will provide the required compacted thickness. When more than one layer of sub-base material base is required, each layer shall be shaped and compacted before the succeeding layer is placed. When uniformly mixed, the sub-base material shall be spread to the required thickness as shown on the Drawings or as directed by the Engineer.

(b) Sub-base material shall be distributed in a continuous uniform layer or windrow of such size that, when spread and compacted, the finished layer shall be equal to or slightly greater than the nominal thickness of sub-base shown on the Drawings.

(c) When hauling is done over previously placed sub-base material, hauling equipment shall be dispersed uniformly over the entire surface of the previously constructed layer to minimise rutting or uneven compaction.

(d) Where the required thickness is 150 mm or less, the material may be spread and compacted in one layer. Where the required thickness is more than 150 mm, sub-base material shall be spread and compacted in two or more layers of approximately equal thickness, and the maximum compacted thickness of any one layer shall not exceed 150 mm. All subsequent layers shall be spread and compacted in a similar manner.

(e) The moisture content of sub-base material shall be adjusted before compaction by watering with approved sprinklers mounted on trucks or by drying out, as required, in order to obtain the required compaction.

6.4.3 Compacting the Sub-base

(a) Immediately after each layer of the sub-base has been spread, the full width shall be compacted by approved compaction equipment. Compaction shall progress gradually from the sides to the centre, parallel to the centreline of the road, and shall continue until the whole surface has been compacted. All irregularities or depressions that develop shall be corrected by loosening material at these places and adding or removing material until the surface is smooth and uniform. At all places not accessible to the compaction equipment, the sub-base material shall be compacted thoroughly with approved tampers or compactors.

(b) Each layer of the sub-base shall be compacted to a density of at least one hundred percent (100%) of the maximum dry density determined in accordance with AASHTO T180, Method D. In-situ density of the compacted sub-base shall be measured in accordance with AASHTO T191 at the location directed by the Engineer.

6.4.4 Tolerances

Tolerances for the sub-base course shall be as specified in the following table:

Tolerances for Sub-Base Course:

Feature	Tolerance
Permitted variation from thickness of layer	± 20 mm
Permitted variation from design level of surface	+ 10 mm - 20 mm
Permitted surface irregularity measured by 3-m straightedge	20 mm
Permitted variation from design crossfall or camber	± 0.3%
Permitted variation from design longitudinal grade over 25 m in length	± 0.1%

6.5 BASE COURSE

This item comprises the supply and placement of granular base course material in accordance with the following:

6.5.1 Materials

Aggregate for base course shall consist of hard, durable particles or fragments of stone or gravel crushed to the size and of the quality requirements of this Clause. It shall be clean and free from organic matters, lumps or balls of clay and other deleterious substances. The material shall be of such nature that it can be compacted readily to form a firm, stable base.

All base course aggregate shall conform to the following physical requirements:

Physical Requirements of Base Course Material

(i)	Toughness (ASTM D3)	6 min.
(ii)	Loss by Sodium Sulphate Soundness Test (AASHTO T104)	10% max.
(iii)	Loss by Magnesium Sulphate Soundness Test (AASHTO T104)	12% max.
(iv)	Loss by Abrasion after 100 revolutions (AASHTO T96)	10% max.
(v)	Loss by Abrasion after 500 revolutions (AASHTO T96)	40% max.
(vi)	Thin and elongated pieces, by weight (pieces larger 1 inch., with thickness less than 1/5 of length)	5% max.
(vii)	Soft fragments (AASHTO T189)	5% max.
(viii)	Clay lumps (AASHTO T112)	0.25% max.

Aggregate for base course shall conform to the requirements as specified herein. Crushed gravel or rock fragments for base course shall consist of the product obtained by crushing gravel or rock, which, if directed by the Engineer, has first been screened in such a manner that when the aggregate is produced from gravel, not less than eighty percent (80%) by weight of the coarse aggregate shall be of particles having at least one fractured face.

Base course material shall be crushed rock or crushed gravel conforming to the following grading requirements:

Grading Requirements for Base Course

AASHTO Designation No.	Percentage Passing by Weight
2 1/2 inch	100
2 inch	90 - 100
1 1/2 inch	35 - 70
1 inch	0 - 15
1/2 inch	0 - 5

Blending

material shall be quarry screenings or natural sand of suitable binding quality as approved by the Engineer. Blending material shall be free from foreign or organic matter, dirt, shale and clay lumps or other deleterious matter and shall conform to the following requirements:

Grading Requirements of Blending Materials for Base Course

AASHTO Designation No.	Percentage Passing by Weight
3/8 inch	100
No. 4 (5 mm)	85 - 100
No. 100 (0.15 mm)	10 - 30
Plasticity Index (AASHTO T90)	6 max.
Sand Equivalent (AASHTO T176)	30 min.

The percentage of crushed aggregate composed of elements having at least one fractured face shall be at least eighty percent (80%) by weight of the material retained on sieve No. 4.

6.5.2 Spreading and Compacting

The course and fine components of the base course material shall be mixed in proportions as directed by the Engineer

Base course material shall be spread and compacted in the same manner as specified above for Sub-base Course.

6.5.3 Tolerances

Tolerance for the base course shall be as specified in the following table.

Tolerances for Base Course

Feature	Tolerance
Permitted variation from thickness of layer	± 10 mm
Permitted variation from design level of surface	+ 5 mm -10 mm
Permitted surface irregularity measured by 3-m straightedge	5 mm
Permitted variation from design crossfall or camber	± 0.2%
Permitted variation from design longitudinal grade over 25 m in length	± 0.1%

6.6 BITUMINOUS PRIME COAT

6.6.1 General

This work shall consist of furnishing and applying bituminous material to the completed and approved base course or to other areas shown on the Drawings, in accordance with this Clause and/or as directed by the Engineer.

6.6.2 Material

Asphalt for the prime coat shall be either AC-20 grade asphalt cement (which is approximately equivalent to 60/70 Pen.) diluted with kerosene or cutback asphalt MC-70 conforming to the requirements of AASHTO M82 or equivalent.

6.6.3 Surface Preparation before Prime Coating

Immediately before applying the asphalt material all loose dirt and other objectionable material shall be removed from the surface with a power broom and blower as required. Such cleaning shall continue until the entire surface shows a pattern of exposed large particles well wedged together and free from dust. When so ordered by the Engineer a light application of water shall be made just before the application of asphaltic material. No application shall be made during wet weather.

6.6.4 Application of Prime Coat

(a) Asphaltic materials shall be applied by means of a pressure distributor or other equipment approved by the Engineer, at a temperature between 40.5°C and 85°C. in accordance with the following table:

Spraying Temperatures of Prime Coat

Type of Material	Temperature Range
Cutback, 50 pph kerosene (MC-70 grade cutback)	70 ± 10 deg. C
Cutback, 75 pph kerosene (MC-30 grade cutback)	45 ± 10 deg. C
Cutback, 100 pph kerosene	30 ± 10 deg. C
Cutback, more than 100 pph kerosene	Not Heated

(b) The rate of application of the liquid asphalt shall be from 0.8 to 2.5 litre per square meter, but the exact rate shall be as directed by the Engineer.

(c) The prime coat shall be left undisturbed for at least 24 hours and shall not be opened to traffic until the prime coat has penetrated and cured sufficiently so that it will not be picked up by the wheels of passing vehicles. The primed area shall be maintained until the next course is applied. Care shall be taken that the application of bituminous material is not in excess of the specified amount; any excess shall be blotted with sand or removed as directed.

(d) All areas inaccessible to the distributor shall be sprayed manually using the device for hand spraying from the distributor.

(e) Structures and trees adjacent to the area being treated shall be protected to prevent their being spattered or marred.

6.7 TACK COAT

6.7.1 General

This work shall consist of furnishing and applying asphaltic material to an existing pavement, in accordance with the specification and to the width and area required by the Engineer prior to construction of so surfacing, so as to provide a bond between the binder course and the surface course or other layers as directed by the Engineer.

6.7.2 Materials

Material for tack coat shall be either AC-20 grade asphalt cement (which is approximately equivalent to 60/70 Pen.) diluted with between 25 and 30 parts per hundred of kerosene per hundred parts of asphalt cement by volume, or slow setting emulsified asphalt conforming to the requirements of

AASHTO M 140 or M 208. The Engineer may permit or require dilution of the emulsion with 1 part clean water per 1 part of emulsion.

6.7.3 Construction Method

6.7.3.1 Equipment

The equipment shall be as for bituminous prime coat.

6.7.3.2 Surface Preparation

When, in the opinion of the Engineer, it is necessary, the full width of surface to be treated shall be cleaned with a power broom or power blower to remove loose dirt and other objectionable material. The surface to be treated shall be dry.

6.7.3.3 Application of Tack Coat

Immediately after cleaning the surface, asphaltic material shall be applied by means of a distributor at the rates directed by the Engineer, but not to exceed 0.45 litre per square meter and at the temperature within the range specified in the following table:

Spraying Temperatures of Tack Coat

Type of Material	**Temperature Range**
Cutback, 50 pph kerosene	110 ± 10 deg. C
Emulsified Asphalt or Diluted Emulsified Asphalt	20 to 70 deg. C

The tack coat shall be applied only when the surface is dry except with the permission of the Engineer.

The surfaces of structures and trees adjacent to the areas being treated shall be protected in such a manner as to prevent their being spattered or marred. No asphaltic material shall be discharged into a 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 so far in advance of surface course placement as is necessary to obtain this proper condition of tackiness. Until the surface course is placed, the Contractor shall protect the tack coat from damage.

6.8 ASPHALT BINDER AND WEARING COURSES

6.8.1 General

The work shall consist of providing dense durable binder course and wearing course hot asphaltic mixtures composed of aggregate and bituminous materials mixed in a central plant, and of spreading and compacting the mixtures in accordance with this Specification and in conformity with the lines, grades and cross sections shown on the Drawings or as required by the Engineer.

6.8.2 Materials for Asphaltic Mixtures

6.8.2.1 Composition of mixtures

The bituminous material shall be composed of a mixture of aggregate, filler and hydrated lime-if required, and asphalt cement. The several aggregate fractions shall be size, uniformly graded and combined in such proportions that the resulting composite blend meets the job-mix formula and the following index of retained strength as determined in accordance with AASHTO T 245

Requirements for Binder and Wearing Courses

Stability (kg)	900
Flow (mm)	2.5 – 4.0
Void in total mix (%)	3 - 5
Void Filled with Asphalt (%)	75 - 85

In calculating the void characteristics of the mixture the Contractor shall allow for the asphalt absorbed by the aggregate and use the effective specific gravity of aggregate and the maximum specific gravity of the loose paving mixture (AASHTO T 209)

The several aggregate and filler fractions for the mixture shall be sized, graded, and combined in such proportions that the resulting composite blend meets one of the grading requirements in the following table

Aggregate Grading Requirements

Sieve Designation (mm)	*Percentage Passing by Weight*	
	For Asphalt Binder Course	For Asphalt Wearing Course
50	-	-
37.5	-	-
25	100	-
19	95-100	100
12.5	68-86	95-100
9.5	56-78	74-92
4.75	38-60	48-70
2.36	27-47	33-53
1.16	18-37	22-40
0.600	11-28	15-30
0.300	6-20	10-20
0.075	0-8	4-9

The Contractor shall submit a proposed job-mix formula in writing, for use by the Engineer in setting the job-mix to be used with the proposed materials. The formula submitted shall propose definite single values for:

- The percentage of aggregate passing each specified sieve.
- The percentage of bituminous material to be added, on the total aggregate basis.
- The temperature of the mixture leaving the mixer.
- The temperature of the mixture delivered on the road.
- The grade of bituminous material.

Values shall be proposed within the limits specified for the particular type of bituminous concrete called for. The Engineer will determine a job-mix formula with single values for the above- mentioned and so notify the Contractor in writing.

The mixture furnished by the Contractor shall conform to this job- mix formula, within the following range of tolerances and within the grading ranges shown in the following table:

Tolerances for Mixture

Aggregate passing the 4.75 mm and large sieve	± 7 percent
Aggregate passing the 2.36 mm through the 0.150 mm sieve	± 4 percent
Aggregate passing the 0.075 mm sieve	± 2 percent
Bituminous material	± 0.4 percent
Temperature leaving the mixer	± 6 deg. C
Temperature delivered on the road	± 6 deg. C

When unsatisfactory results make it necessary, the Engineer may establish a new job-mix formula and notify the Contractor in writing. Should a change in sources of material be proposed, a new job-mix formula will be established before the new material is used.

The plant mixed material will be tested after blending or mixing at the plant or prior to final incorporation in the work.

6.8.2.2 Coarse aggregate

The coarse aggregate (retained on the 2.36 mm sieve) shall consist of clean tough, durable fragments free from an excess of flat, elongated, soft or disintegrated pieces and free from stone coated with dirt or other objectionable material. The percentage of wear when tested according to AASHTO T 96 , shall be as follows:

For use in asphalt binder and wearing course – not more than 40

The sodium sulphate soundness loss shall not exceed 9 percent and the magnesium sulphate soundness loss shall not exceed 12 percent. When crushed gravel is used, not less than 50 percent of the particles by weight retained on the 4.75 mm sieve shall have at least one fractured face.

6.8.2.3 Fine aggregate

The fine aggregate (passing a 2.36 mm sieve), shall have General Characteristics and Soundness in accordance with AASHTO M 29.

6.8.2.4 Filler

Mineral filler, when required, shall consist of limestone dust, Portland cement or other non plastic mineral matter from sources approved by the Engineer. Mineral filler shall be dry, free flowing, free from lumps and other objectionable material and when tested by means of laboratory sieve, shall meet the following gradation requirement:

Sieve Designation (mm)	*Percentage Passing by Weight*
0.600	100
0.180	95 – 100
0.075	65 – 100

6.8.2.5 Asphalt cement

Asphalt cement shall be of penetration grade 60 – 80, and shall conform with the requirements of AASHTO M 20.

6.8.3 Preparation of Sub-base

The prime coat shall be applied in accordance with the Clause 8.6.

Twenty-four (24) to forty-eight (48) hours after application of the prime coat, when it has sufficiently dried, it shall be broomed. A limited amount of sand, as directed by the Engineer, may be sprinkled on the prime coat to make further work possible if it is necessary to perform further work without waiting for the prime coat to dry sufficiently. Excess sand shall be removed by brooming before spreading the binder course

6.8.4 Preparation of the Bituminous Mixture

(a) Aggregates shall be dried and heated at the paving plant so that, when introduced into the mixer, the moisture content does not exceed 0.5%.

(b) Water in aggregates shall be removed by heating to the extent that there is no subsequent foaming in the mixture before placing and spreading. Aggregates shall be heated to the temperature designated by the job formula with the specified job tolerance, with a maximum temperature and a rate of heating that will not cause permanent damage to the mixture.

(c) Particular care shall be taken so that aggregates high in calcium or magnesium content are not damaged by overheating. The quantity of bituminous material for each batch or the calibrated amount for continuous mixer, as determined by the Engineer, shall be measured by weight and introduced into the mixer, at the specified temperature, using the lowest rate possible for adequate mixing and spreading.

(d) For batch mixers, all mineral aggregates shall be placed in the mixer before the bituminous material is added. The exact temperature within the specified range shall be as directed by the Engineer.

(e) Mixing shall continue for the time necessary to coat all particles uniformly, as directed by the Engineer. This time is dependent upon the mix design and type of mixing equipment used.

6.8.5 Transportation and Delivery of the Mixture

(a) Trucks used for hauling bituminous mixtures shall have tight, clean and smooth metal beds. To prevent mixtures from adhering, beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. Each truck shall have a suitable cover to protect the mixture from adverse weather and an insulated bed to maintain the mixture at the specified temperature.

(b) The mixture shall generally be placed at a temperature of between 120°C to 150°C when asphalt cement is used. When the mixture is placed during warm weather and the Engineer has determined that satisfactory results can be obtained at a lower temperature, he may direct that the mixture be mixed and delivered at the lower temperature.

(c) Loads shall not be dispatched from the mixer if it is expected that spreading and compaction of the mixture cannot be completed under conditions of adequate lighting.

(d) Mixtures shall be delivered to the point of placement at a temperature within the tolerances required by the Job Mix Formula.

6.8.6 Spreading

(a) Immediately before placing the bituminous mixture, the prime coat shall be cleaned using a power sweeper equipped with a blower, supplemented with hand brooms if necessary, or by other approved means.

(b) The mixture shall be laid upon an approved surface which is thoroughly dry and in suitable condition, and only when weather conditions are fair unless otherwise directed by the Engineer.

(c) Placing shall commence at points farthest from the mixing plant and progress continuously toward the plant, unless otherwise directed by the Engineer. Traffic shall not pass over the base course until it has been thoroughly compacted as specified, and allowed to cool to atmospheric temperature.

(d) Upon arrival the mixture shall be dumped into an approved bituminous paver, immediately spread to the full width required, and struck off in a uniform layer at such thickness that, when work is completed, the layer will have the required thickness conforming to the specified grade and surface profile.

(e) The bituminous paver shall be a self-contained, power propelled unit with an activated screed or strike-off assembly heated as necessary. The paver shall be capable of spreading and finishing courses of bituminous plant mix material of the specified thickness, smoothness and grade, and shall also be equipped with an automatic line and grade controlling device.

(i) The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation, and the hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed.

(ii) The screed or strike-off assembly shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging.

(iii) The paver shall be capable of operating at forward speeds consistent with the satisfactory laying of the mixture and the paver speed shall be regulated to eliminate pulling and tearing of bituminous material.

(f) The mixture shall be placed in strips not less than 3 meters wide. To ensure proper drainage, spreading shall begin along the pavement centreline on a crowned section, or on the high side of a pavement with a one-way slope.

(i) After the first strips has been compacted, the second strip shall be placed, finished, and compacted in the same manner as the first strip. After the second strip has been placed and rolled, a 5-meter straightedge shall be placed across the longitudinal joint to determine if the surface conforms to the grade and contour requirement.

(g) In areas where use of mechanical spreading and finishing equipment is impractical because of irregularities or unavoidable obstacles, the mixture may be hand-spread.

6.8.7 Compaction of the Mixture

(a) After spreading, the mixture shall be thoroughly and uniformly compacted with power rollers. Sufficient rollers shall be furnished and operated to handle plant output.

(b) Rolling shall begin as soon as the mixture can bear the roller without undue displacement or hair cracking, and shall start from the centre of the first strip and continue toward either edge. On subsequent strips, rolling shall start from the edge adjacent to the previously laid material and continue toward the opposite edge.

(c) The speed of roller shall, at all times, be slow enough so as to avoid displacement of the hot mixture. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once by rakes and by applying fresh mixture where needed.

(d) Rolling shall continue until all roller marks are eliminated, the surface is of uniform texture and true to grade and cross section, and the in-situ density is not less than ninety-eight percent (98%) of the specified laboratory density as obtained from laboratory compacted specimens of the same materials and same proportions used in the asphalt mixture as determined by AASHTO T166. The method of sampling the mixture and the compaction of specimens shall be in accordance with AASHTO T168 and AASHTO T245, respectively. Field density tests shall be made at least twice daily.

(e) In areas not accessible to the roller the mixture shall be thoroughly compacted with hot mechanical tampers.

(f) Any mixture which becomes loose and broken, contaminated with dirt, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding areas, all at Contractor's expense. Skin patching will not be permitted.

6.8.8 Trimming and Clean-up

(a) Placing of the bituminous mixture shall be as continuous as possible. Rollers shall not pass over the unprotected and freshly laid mixture unless authorized by the Engineer.

(b) Transverse joints shall be formed by cutting back on the previous run to expose the full depth of the course. When so directed by the Engineer, a brush coat of bituminous material shall be used on contact surfaces of transverse joints just before additional mixture is placed against the previously rolled material.

(c) The exposed edges of the completed pavement shall be cut true to the required lines. Material trimmed from the edges and any other discarded or rejected bituminous mixture shall be removed from the roadway and disposed of in an approved manner.

6.8.9 Application of Asphalt Wearing Course

Prior to placing the asphalt wearing course a tack coat shall be applied in accordance with Clause 6.7.

(a) The mixture shall be spread at a temperature of not less than 107°C and all initial rolling shall be done immediately after spreading. The mixture shall not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling and finishing.

(b) Asphalt pavers shall be self-propelled, mechanical, spreading and finishing equipment, provided with a screed or strike-off assembly capable of distributing the material to not less than the full width of a traffic lane.

(c) Screed action shall include any cutting, crowning or other practical action which is effective on the mixture without tearing, shoving or gouging, and which produces a surface texture of uniform appearance. The screed shall be adjustable to the required section and thickness. The paver shall be provided with either a full width roller or tamper or other suitable compacting device. Pavers that leave ridges, indentations or other marks in the surface that cannot be eliminated by rolling or prevented by adjustment in operation shall not be used.

(d) Where a course previously laid is joined to a course to be laid later, the first course shall be cut back and painted with asphalt as directed.

(e) The mix shall be compacted immediately after placing. Initial rolling with a tandem steel roller or a three-wheeled steel roller shall follow the paver as closely as possible. Immediately following the sealing of the longitudinal joints, rolling shall commence at the outside edges and progress towards the centreline. Rolling with a pneumatic-tired roller shall be done immediately behind the initial rolling. In areas too small for the roller, a vibrating plate compactor or hand tamper shall be used to achieve thorough compaction.

(f) Rolling shall continue as long as required to attain a minimum compaction of ninety-seven percent (97%) of the Marshall density of the approved Job Mix.

6.8.10 Completion Test

(a) Surface Test : Tests for conformity with the specified crown, grade and width shall be made by the Contractor immediately after initial compaction. Any deviation shall be corrected by removal or addition of materials and continuous rolling.

(b) After completion of final rolling, the smoothness of the course shall again be tested along the whole distance. Humps or depressions that exceed the specified tolerances or that retain water on the surface shall be immediately corrected by removing defective work and replacing it with new material at the Contractor's expense.

(c) Finished surfaces shall not vary from the design elevations by more than 5 mm when tested with a crown template and a 3 m straightedge furnished by the Contractor. Tests shall be performed at 10 m intervals along the road centreline.

(d) The width shall not be less than 25 mm of the design section measured at 20 m intervals.

(e) Thickness Tests : The total thickness of each completed course of asphalt treated base shall be determined by cores taken by the Contractor for each completed layer at places designated by the Engineer. One core test shall be performed for every 200 m2 of paved area. The thickness shall not be 5 mm less than the design depth for any one test, and not less than 2.5 mm for an average of 10 tests.

(f) When deficiencies in either elevation or thickness exceed the specified tolerance, the Contractor shall remove and replace the asphalt treated base with new material.

6.9 CONCRETE CURB AND CHANNEL

6.9.1 General

Concrete curb and channel, consisting of precast elements, cast in-situ concrete and mortar shall be constructed in the locations shown on the Drawings or as directed by the Engineer.

All curb and channel shall be constructed in advance of the upper road pavement layers to ensure good compaction against them.

6.9.2 Materials

Precast concrete elements shall be made from concrete class D and levelling concrete shall be class G in conformity with the requirements of Section 4.

6.9.3 Excavation

Trenches for curbs shall be excavated to the depths and dimensions shown on the Drawings in accordance with the requirements of Section 3. The bottom width of trenches shall not exceed the widths shown on the Drawings or as directed by the Engineer.

6.9.4 Levelling Concrete

The bottom of the trench shall be tamped with hand operated equipment following which levelling concrete shall be placed to the lines and dimension shown on the Drawings.

6.9.5 Concrete Curbs

Precast concrete curbs of the profile and dimensions as shown on the Drawings shall be accurately set in the correct locations in a 20 mm bed of 1:3 cement : sand mortar. The finished curb line shall be regular without abrupt change in direction or elevation.

6.9.6 Channels

Precast concrete slabs (denoted as ditch plate on the Drawings) shall be laid in a bed of mortar concurrently with the laying of the curbs. The elevation of the precast slabs shall be accurately set to ensure that the road-side edge is at the correct elevation for road construction and that the inner edge is properly located to ensure correct falls for drainage.

6.10 GUIDE POSTS

6.10.1 General

The work shall include the supply and installation of precast reinforced concrete guide posts in close conformity to the specifications, the drawing or as directed by the Engineer.

6.10.2 Materials

Concrete shall be class D and reinforcement shall be deformed bars in accordance with the requirements of Section 4.

6.10.3 Construction

Guide posts shall be set true and plumb in the locations indicated on the Drawings. Backfill around posts shall be rammed with hand-operated equipment to ensure that posts are firmly bedded. Each post shall be painted using a painting system and colour approved by the Engineer.

6.11 ROAD MARKING

6.11.1 General

This work shall consist of furnishing and applying painted road markings on the finished paved area in accordance with these Specifications, at the locations and of the dimensions shown on the Drawings, or as directed by the Engineer.

6.11.2 Materials

Paint shall be white ready-mixed traffic paint conforming to AASHTO M248 or equivalent.

6.11.3 Construction

The surface area to be marked shall be clean, dry and free from loose particles. Setting out and location of all markings shall be approved by the Engineer before work begins. Except where approved by the Engineer, all marks shall be laid by self propelled machines equipped with cut-off valves and nozzles capable of forming clean and sharp edged lines and markings, of the specified thickness.

Paint shall be applied by spray type machine equipped with a mechanical agitator. Each nozzle shall be equipped with suitable guide lines consisting of metallic shrouds or air blasts, and with a satisfactory cut-off valve capable of applying broken or skip lines automatically. Spread rate shall be not less than 40 litres/ 100 m^2. In areas where machine laying is impracticable, the Engineer may give approval to brush application.

6.12 MEASUREMENT AND PAYMENT

6.12.1 Subgrade Preparation

Measurement shall be made of the area in m^2 of subgrade preparation made on original ground on which the sub base was constructed. No measurement for payment shall be made of areas of subgrade comprising fill or backfill.

Payment shall be made at the rate entered in the Bill of Quantities which shall be full compensation for the cost of all labour, materials and incidental items necessary to complete the subgrade preparation in accordance with the Specification and the instructions of the Engineer.

The cost of subgrade preparation for sub base constructed on fill is deemed to be included in the cost of fill, specified elsewhere.

Items to be paid under this Clause are as follows:

Pay Item No.	Description	Unit of Measurement
2.16.1	Subgrade Preparation	m^2

6.12.2 Sub-Base Course

Measurement shall be made of the volume of sub base course material placed and compacted to the lines grades and dimensions shown on the drawing or as directed and approved by the Engineer.

Payment shall be made at the rate entered in the priced Bill of Quantities which shall be full compensation for the cost of materials labour, tools, equipment and incidental items necessary to complete the Works in accordance with the Specifications and instructions by the Engineer.

Items to be paid under this Clause are as follows:

Pay Item No.	Description	Unit of Measurement
2.16.2	Sub Base Course : including supply and placement	m^3

6.12.3 Base Course

Measurement shall be made of the volume of Base Course material placed and compacted to the lines grades and dimensions shown on the drawing or as directed by the Engineer and approved by the Engineer.

Payment shall be made at the rate entered in the priced Bill of Quantities which shall be full compensation for the cost of materials labour, tools, equipment and incidental items necessary to complete the Works in accordance with the Specifications and instructions by the Engineer.

Items to be paid under this Clause are as follows:

Pay Item No.	Description	Unit of Measurement
2.16.3	Base Course (Crushed Aggregate): including supply and placement	m^3

6.12.4 Asphalt Binder Course

Measurement will be made of the mass in tonne (1 tonne = 1000 kg mass) of asphalt binder course, based on certified delivery notes from the supplier, placed to the lines, grades and dimensions as shown on the Drawings or directed by the Engineer and approved by the Engineer. Materials placed outside the limits shown on the Drawings shall not be measured for payment.

Payment shall be made at the rate entered in the priced Bill of Quantities which shall be full compensation for the cost of materials labour, tools, equipment and incidental items necessary to complete the asphalt binder course in accordance with the Specifications and instructions by the Engineer.

Items to be paid under this Clause are as follows:

Pay Item No.	Description	Unit of Measurement
2.16.4	Asphalt Binder Course : including supply and placement	tonne

6.12.5 Asphalt Wearing Course

Measurement will be made of the mass in tonne (1 tonne = 1000 kg mass) of asphalt wearing (surface) course, based on certified delivery notes from the supplier, placed to the lines, grades and dimensions as shown on the Drawings or directed by the Engineer and approved by the Engineer. Materials placed outside the limits shown on the Drawings shall not be measured for payment.

Payment shall be made at the rate entered in the priced Bill of Quantities which shall be full compensation for the cost of materials labour, tools, equipment and incidental items necessary to complete the asphalt wearing course in accordance with the Specifications and instructions by the Engineer.

Items to be paid under this Clause are as follows:

Pay Item No.	Description	Unit of Measurement
2.16.5	Asphalt Surface Course : including supply and placement	tonne

6.12.6 Bituminous Prime Coat

Measurement shall be made of the actual volume in litres of bituminous prime coat material placed on the prepared subgrade at the rate of application directed by the Engineer.

Payment shall be made at the rate entered in the Bill of Quantities which shall be full compensation for all labour, materials, equipment and all incidentals necessary for the completion of bituminous prime coat in accordance with the Specification and the instructions of the Engineer.

Items to be paid under this Clause are as follows:

Pay Item No.	Description	Unit of Measurement
2.16.6	Prime Coat: including supply and application	litre

6.12.7 Tack Coat

Measurement shall be made of the actual volume in litres of tack coat material placed on the binder course or bridge deck as the case may be, at the rate of application directed by the Engineer.

Payment shall be made at the rate entered in the Bill of Quantities which shall be full compensation for all labour, materials, equipment and all incidentals necessary for the completion of tack coat in accordance with the Specification and the instructions of the Engineer.

Items to be paid under this Clause are as follows:

Pay Item No.	Description	Unit of Measurement
2.16.7	Tack Coat: including supply and application	litre

6.12.8 Concrete Curb and Channel

Measurement shall be made of the completed length in m of concrete curb and channel constructed in accordance with the Drawings, the specifications, and approved by the Engineer.

Payment shall be made at the rate entered in the Bill of Quantities which shall be full compensation for all labour, materials, equipment and all incidentals necessary for the completion of curb and channel. Payment shall specifically include the cost of excavation, levelling concrete, supply, handling and laying precast units, cast in-situ concrete and sand : cement mortar. No payment shall be made for replacement of curb or channel damaged by the Contractor during the execution of adjacent activities.

Items to be paid under this Clause are as follows:

Pay Item No.	Description	Unit of Measurement
2.16.8	Concrete Curb and Channel	m

6.12.9 Guide Posts

Measurement shall be made of the number of guide posts completed and installed in accordance with the Drawings and the specification and approved by the Engineer.

Payment shall be made at the rate entered in the Bill of Quantities which shall be full compensation for all labour, materials, equipment and incidentals necessary for the supply, installation and painting of the guide posts to the approval of the Engineer.

Items to be paid under this Clause are as follows:

Pay Item No.	Description	Unit of Measurement
2.16.9	Precast Concrete Guide Posts: including supply, installation and painting	No.

6.12.10 Road Marking

Measurement shall be made of the area of road marking completed in accordance with the Drawings, the specification and the directions of the Engineer.

Payment shall be made at the rate per m^2 entered in the Bill of Quantities which shall be full compensation for all labour, materials, equipment and incidentals necessary for the painting of road marking to the approval of the Engineer.

Items to be paid under this Clause are as follows:

Pay Item No.	Description	Unit of Measurement
2.16.10	Road Marking	m^2

SECTION 7. SEWERS AND STORMWATER DRAINAGE

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SECTION 7. SEWERS AND STORMWATER DRAINAGE

7.1 GENERAL

This section covers the requirements for sewerage and stormwater drainage works to be furnished and constructed under the Contract.

7.2 SCOPE OF WORK

The work to be completed by the Contractor consists of the following:

(a) Conveyance Sewer CM 38 – CM 41 comprising double box section sewer, maintenance chambers and pipe sewers to be installed by pipe jacking

(b) Sanitary Sewer comprising inlet chambers, reinforced concrete pipes, manholes and PCV sewer pipes

(c) Stormwater Drainage Works comprising concrete roadside ditches, with removable precast concrete covers, catch basins with precast concrete covers, reinforced concrete pipes and outfall structures,

(d) Effluent Pipe comprising reinforced concrete pipe, outfall structure and protection works

(e) Connection Pipe comprising a steel pipe with 2 flexible joints

The Works shall be constructed in accordance with the Drawings, the specification and the directions of the Engineer.

7.3 WORKS SPECIFIED ELSEWHERE

Care of Water shall be in accordance with Section 2

Demolition shall be in accordance with Section 2

Earthworks shall be in accordance with Section 3

Concrete work shall be in accordance with Section 4

Piling work shall be in accordance with Section 5

Metal work shall be in accordance with Section 8

Elements of sewage and drainage works specified in the above sections shall be measured and paid for in accordance with the relevant Clauses of those sections.

7.4 SUBMITTALS

The Contractor shall prepare a method statements for each division of the works which shall be submitted for the Engineer's approval in accordance with the procedures in Clause 1.3.5

The method statements shall provide comprehensive descriptions of the materials, equipment, construction methods, quality control procedures and safety measures to be used and shall be supported by material specifications, detailed drawings of temporary works and calculations of their structural and functional adequacy.

7.5 MATERIALS

7.5.1 Concrete

Concrete shall be of the following classes in accordance with the requirements of Section 4:

Cast in-situ concrete: - Class E

Plain Concrete: - Class F

Precast Concrete Sewer and Stormwater Drainage Pipes: - Class D

Precast Concrete Jacking Pipes: - Class A

7.5.2 Reinforcement

Reinforcement shall be deformed bars of the sizes shown on the Drawings.

7.5.3 Earthworks Materials

Earth fill, sandy soil fill sand bedding and rip rap shall be in accordance with Clause 3.3.2 of Section 3, Earthworks.

7.5.4 Reinforced Concrete Pipes

The requirements for reinforced concrete pipes listed hereunder shall apply to all such pipes to be used for sanitary sewers, effluent pipe and stormwater drainage pipes.

Reinforced concrete pipes shall be of spigot and socket type Class 1 or Class 2 as shown on the Drawings complying with the requirements of JIS A 5372.

Concrete and reinforcement shall comply with the requirements of Section 4.

Dimensional tolerances shall be in accordance with Annex 2, Table 6 of JIS A 5372.

Permeability shall be in accordance with Clause 5.1 of JIS A 5372.

Strength (cracking and crushing loads) shall meet the requirements of Annex 2, Table 3 of JIS A 5372.

Testing for compliance with the requirements for dimensional tolerance, permeability and strength shall be in accordance with the methods and limits stated in Annex 2 of JIS A 5372. Prior to the procurement of pipes the Contractor shall submit for the Engineer's approval, a quality assurance programme for pipe quality which will include testing of pipes (including destructive testing). The cost of the quality assurance programme including the cost of testing shall be borne by the Contractor. Pipes which have not been manufactured under a quality assurance programme approved by the Engineer shall be subject to rejection.

Pipes in a batch shall be considered as meeting the strength test requirements when all test specimens conform to the test requirements. Should any of the test specimens fail to meet the test requirement the Contractor shall be allowed a retest on two additional specimens for each specimen that failed and the pipes shall be acceptable only when all of the retest specimens meet the strength requirements.

The following information shall be clearly marked on each section of pipe.

- Pipe class and standard of manufacture
- Date of manufacture
- Name or trade mark of the manufacture
- Where tests have been successfully carried out on representative samples from the batch in which the unit was made

The quality of materials, the process of manufacture and the finished pipe shall be subject to inspection and approval by an inspector of the Engineer. Pipes shall be subject to rejection on account of failure to conform to any of the specification requirements. Pipes may be rejected because of any of the following:

- Fractures or cracks passing through the wall, except for a single end crack that do not exceed the depth of the joint.
- Defects that indicate imperfect proportioning mixture and moulding.
- Surface defects indicating honeycombed or open texture.
- Damaged ends where such damage would prevent the making of a satisfactory joint.

Pipes may be repaired, if necessary, because of occasional imperfections in manufacture or accidental damage during handling and will be acceptable if, in the opinion of the Engineer, the repairs are sound and properly finished and cured and the repaired pipes conform to the requirements of the specification.

Joint rings for spigot and socket pipes shall be manufactured from ethylene propylene rubber (EPM or EPDM) or styrene butadiene rubber (SBR) or natural rubber and shall comply with the requirements of BS 2494. They shall be suitable for use in sewerage pipelines at an ambient temperature of 30^0 C and shall be of size, shape that, when joined, will provide a watertight seal.

Lubricant for application to rubber rings to assist jointing shall be in accordance with the manufacturer's recommendations.

7.5.5 Reinforced Concrete Jacking Pipes

Reinforce concrete jacking pipes shall comply with the requirements of JSWAS-A-1991 and shall be of the following classifications:

Standard Pipe: Class 1-500 (Mark 1-5)

Intermediate Pipe: class 1-500 (Mark ET1-5)

All proposed pipes and associated fitting and couplings for incorporation in the Works shall be certified by the manufacturer that they comply with the above standard.

Notwithstanding such certification, any pipe found to be defective by visual examination shall be rejected. Such defects which shall included cracks, honeycombing or effects of incorrect handling.

Pipe joints shall be galvanized steel collars with rubber jointing rings recommended by the pipe manufacturer for use in sewerage pipelines.

7.5.6 Manhole Covers

Manhole covers shall be of the following type:

TYPE	DESCRIPTION	DIMENSIONS Lid Dimensions (Opening Dimensions)	APPLICATION
Type A	1 cast iron, 30 ton design load cover comprising a cast iron inner frame and circular removable lid and an outer frame consisting of precast concrete and fabricated, galvanized steel	900 x 900 (800 x 800)	Manholes in roadway

All manhole covers and their respective frames shall be made in accordance with the Drawings, the directions of the Engineer and the Specification.

Cast iron components shall comply with the requirement of the Ho Chi Minh City Urban Drainage Company.

Fabricated steel components shall comply with the requirements of Section 8, Metal Work.

All fabricated steel components shall be galvanized in accordance with the requirements of Section 8, Metal Work.

7.5.7 PVC Pipes and Fittings

Pipes shall be of unplasticized polyvinyl chloride (uPVC) with spigot and socket rubber rings joints of 225 mm diameter.

PVC pipes and fittings shall conform to the requirements of the following standards:

JIS K 6739 Unplasticized Polyvinyl Chloride pipe fittings for drain

JIS K 6741 Unplasticized Polyvinyl Chloride (uPVC) pipes.

7.6 CONVEYANCE SEWER CM 38 – CM 39 BY PIPE JACKING METHOD

7.6.1 General

(a) The Contractor shall construct sewer pipelines using the jacking method for the section of siphon in the conveyance sewer, between maintenance chambers 38 and 39 as indicated in the Drawings to the lines and grades as shown on the Drawings or as directed or approved by the Engineer.

(b) Excavation shall be carried out by equipment capable of maintaining and adjusting alignment as necessary.

(c) Equipment and systems shall be designed to provide the forces necessary for the installation of the full pipe string between driving and receiving pits

(d) Provision shall be made for closing up the exposed excavation face at all times.

(e) The method of jacking shall be in accordance with the Contractor's approved method statement which shall be in accordance with the *Guide to best practice for the installation of pipe jacks and microtunnels* published by the Pipe Jacking Association.

7.6.2 Thrust and Reception Shafts

(a) Thrust and reception shafts shall be designed and constructed to allow the safe operation of equipment and handling of materials and to withstand all loadings imposed by ground pressure, superimposed loads from surface structures and the maximum anticipated trust forces.

(b) If the Contractor intends to use permanent works for thrust arrangements he shall consult with the Engineer to establish the adequacy of the structure and to ensure that it will not sustain damage as the result of such use.

(c) In all case the Contactor shall submit his proposals including calculations to the Engineer for approval.

(d) The horizontal dimensions of shafts shall be determined by considering the dimensions required for the jacking operation or the subsequent construction of the manhole structure, whichever are greater.

This Clause 7.6.2 shall be read in conjunction with Clause 3.2.4

7.6.3 Operation

(a) All key personnel shall be experienced in pipe jacking.

(b) Before any particular pipe jack length commences sufficient numbers of standard and intermediate pipes and intermediate jacking assemblies shall be available to ensure continuous operation.

(c) Previously jacked pipes shall not be used without the approval of the Engineer. Cut pipes shall not be jacked.

(d) The jacking force applied by thrust pit jacks or an intermediate jacking station shall not exceed the design allowable distributed or deflected load for any pipe being jacked.

(e) Thrust loads shall be transferred to pipes through a thrust ring which shall be sufficiently rigid to ensure even distribution of the load.

(f) Intermediate jacking stations shall be inserted no later than when the main thrust pit jacking force reaches an agree level, typically 66% of the pipe design load or 66% of the available jacking thrust, whichever is the lesser, unless otherwise agreed with the Engineer during the jacking operation.

(g) Pipe jacking, once commenced, shall be performed as one continuous operation until completion, unless otherwise agreed with the Engineer.

(h) Means shall be provided to ensure that the pipeline remains stationary when any jacking rams are retracted even when face balance pressure is maintained.

(i) Where agreed for use by the Engineer as part of the Contractor's method statement, a lubrication or ground support fluid , such as bentonite, shall be injected into the annulus between the exterior of the pipe and the ground. This fluid shall be maintained until grouting is carried out.

7.6.4 Sealing and Packing

(a) Pipe joints shall comply with all relevant provisions of JSWAS-A-1991

(b) Joint packing material, in accordance with the pipe manufacturer's recommendations shall be inserted at each pipe joint and at any jacking station.

(c) After completion of jacking, cavities behind jacked pipes shall be filled with grout injected under pressure, unless otherwise agreed with the Engineer. All lifting holes and grouting holes shall be sealed with a 1:3 cement: sand mortar with plasticiser, or a purpose-made plug.

7.6.5 Monitoring and Instrumentation

(a) The Contractor shall survey, monitor and record all jacking work as it proceeds so as to form a complete record of the work which shall include records of jacking loads, line and level measurements, the distance moved and the relationship between them. Copies of all records shall be supplied to the Engineer at agreed intervals.

(b) The jacking force instrumentation shall be calibrated at intervals agreed prior to the commencement of jacking by the Engineer.

(c) During grouting the type, consumption and pressure of grout shall be recorded.

(d) All changes in conditions including, but not limited to change of jacking force, ingress of water, etc shall be recorded.

7.6.6 Tolerances

Pipe jacking shall be carried out to the following tolerances:

Horizontal Alignment : + / - 50 mm

Vertical Alignment : + / - 50 mm from the given grade line of the invert and without low points.

Notwithstanding the above alignment tolerances, the rate of change of direction in any plane, or combination of planes, shall not exceed the maximum value agreed by the Engineer, taking into account the pipe length, diameter, jacking loads and the pipe manufacturer's recommendations.

7.6.7 Disposal of Spoil

The Contractor shall dispose of spoil in accordance with the requirements of Section 3.

7.6.8 Connection with Maintenance Chambers

Jacking pipes shall be cut back such that the ends of pipes will be embedded in the walls of the maintenance chambers 50 mm beyond the inner faces.

7.7 MAINTENANCE CHAMBERS AND MANHOLES

Preparatory works, excavation, piling (where applicable), bed preparation and backfilling shall be carried out in accordance with the referenced specifications in Clause 7.3.

Maintenance chambers and manholes shall be constructed in the locations and to the lines and levels shown on the Drawings or as directed by the Engineer. Care shall be taken to ensure a complete seal of the cast-in-situ concrete of the chambers with the precast concrete pipes which join into them.

The maintenance chambers and manholes shall be constructed such that they are watertight.

Benching consisting of plain concrete (Concrete Class F) shall be placed in the bottom of manhole or diversion structures as shown on the Drawings. A 20 mm thick granolithic topping shall be provided to the surface of the concrete benching. Granolithic coating shall consist of cement : granite mix approximately 1: 2 by weight. The granite chips shall be hard, non-weathered granite, free of clay or other deleterious matter of maximum size 6 mm. Prior to application the benching surface shall be wire brushed to remove all laitance and loose material and the surface thoroughly wetted. The granolithic topping shall be steel trowel finished to produce a smooth surface and shall provide a uniformly graded channel through the manhole from inlet to outlet.

Block-outs for guide frames for trash screens and stop logs (for the case of the maintenance chambers) shall be allowed for during placement of concrete. Metalwork items including embedded guide frames, ladder rungs, trash racks and flap gates shall be placed in accordance with the requirements of Section 8.

Manhole frames shall be solidly bedded in 1:3 cement : sand mortar so that the covers, when in position, are fair and even with the adjacent finished surfaces.

7.8 CONVEYANCE SEWER CM 38 – CM 42

7.8.1 General

The Contractor shall construct the portion of the conveyance sewer from CM 38 up to the inlet of the lift pumping station designated as CM 42.

Works shall be carried out in accordance with the requirements of other sections of the Specification as noted in Clause 7.3, as specified in this Clause and the directions of the Engineer.

7.8.2 Tolerances

The conveyance sewer shall be constructed to the following tolerances:

Horizontal Alignment :		+ / - 50 mm
Vertical Alignment of Invert	:	+ / - 15 mm from the given grade line of the invert and without low points.
Internal Width		+ 50 mm, - 0 mm

7.8.3 Manholes

Manholes shall be constructed as shown on the Drawings. Manhole covers, Type A, shall be constructed such that the upper surfaces are flush with the adjacent finished surface levels.

7.9 CONSTRUCTION OF SEWERS BY OPEN CUT METHOD

7.9.1 General

The requirements specified in this Clause 7.9 apply to the construction of the reinforced concrete pipes for the sanitary sewer and the effluent pipe.

Preparatory works, excavation, piling (where applicable), bed preparation and backfilling shall be carried out in accordance with the referenced specifications in Clause 7.3.

All reinforced concrete sewer pipes shall be laid to the lines and levels as shown on the Drawings or as directed by the Engineer. Laying of pipes shall start from the downstream end unless otherwise agreed to by the Engineer. Pipes shall be laid to a tolerance of + or - 15 mm from the given grade line of the invert and without low points.

All work shall be carried out in the dry and the Contractor shall keep excavations dewatered in accordance with his obligations for care of water under Section 2.

The method of pipe bedding shall differ according to the type of pipe support as shown on the Drawings.

7.9.2 Pipes with Sand Bedding and Surround

The following procedure applies to the construction of the sanitary sewer line.

Where sand bed and sand surround is to be provided, after bottoming up the trench, sand bedding material shall be carefully placed and compacted in layers not exceeding 100 mm thickness to the required thickness for the full width of the trench. The material shall preferably be compacted by vibrating plate type plant using a minimum of one pass per layer. Should hand tamping be allowed by the Engineer the Contractor shall demonstrate by means of in-situ test to the approval of the Engineer that his proposed method of compaction will achieve a minimum of 90% of the maximum dry density as determined by the AASHTO T 99 test or equivalent.

The bedding shall be constructed so as to ensure even and continuous support throughout the length of the barrel of each pipe. Recesses shall be formed in the bedding to accommodate pipe sockets.

After laying and jointing pipes, the bedding shall be placed and hand compacted in layers not exceeding 100 mm thick. Care should be taken that the bedding material is well rammed into the cavities under the two lower quadrants of the pipe and that the bedding is brought up simultaneously and evenly on both sides of the pipe. Sand bedding shall be placed and compacted up to a minimum of 200 mm above the crown of the pipe.

Backfilling of the trench above this level shall be performed in accordance with the requirements of Section 3.

7.9.3 Pipes with Concrete Base or Concrete Encasement

The following procedure applies to the construction of the reinforced concrete effluent pipe.

Timber piling, the sand layer and a the levelling concrete layer shall be constructed in accordance with drawings and their respective specifications.

Pipes shall be jointed and accurately laid to the required level and gradient with supporting chocks, wire cradles or wedges.

Concrete bedding (Concrete Class F) or reinforced concrete (Concrete Class E) as the case may be, shall then be placed in accordance with the requirements of Section 4, taking care that concrete fully supports the pipe and that the pipe is not dislodged during casting. Concrete cover to reinforcement shall be 50 mm.

Where the design calls for concrete base support backfilling shall be carried out in the manner specified for pipes with sand bedding and surround, above. Such backfilling shall not commence until the concrete has reached an age of at least 7 days or as otherwise approved by the Engineer.

Where pipes are fully encased backfilling of the void between the concrete encasement and the trench walls shall be carried out using hand tamping in layers not thicker than 100 mm up to the top of the encasement. Above this level backfilling shall be in accordance with the requirements of Section 3.

7.9.4 PVC Sewer Pipes

PVC pipes and fittings shall be protected against the harmful effects of sunlight prior to installation.

PVC pipe shall be installed in the manner described in Clauses 7.9.1.1 and 7.9.1.2 except that mechanical compaction shall not be used for backfilling.

7.10 CONSTRUCTION OF STORMWATER DRAINAGE

7.10.1 General

The stormwater drainage system, comprising U-drains with covers and outfall structures, shall be constructed in accordance with the Drawings, the relevant specifications listed above and the directions of the Engineer. The invert screed shall be accurately placed and finished such that the fall is continuous to the outfalls and that there are no low points where water will pond.

7.10.2 Precast Concrete Cover Slabs

Precast concrete cover slabs for U-channels and catch basins shall be made to the dimensions shown on the Drawings and shall be regular, flat and without defects such as porosity.

All slabs which are do not pass the Engineer's visual inspection shall be removed from the site.

Concrete shall be Class D as specified in Section 4

Slabs shall stored and handled such that they are not damaged or chipped.

Slabs shall be installed in their respective locations such that they are positively engaged in the lips provided in the supporting drain or catch basin and that they do not rock or move under load. Any such movement shall be rectified by replacing deformed slabs or rectifying irregularities in the supporting surface.

7.10.3 Outfall Structures

Reinforced concrete outlet structures of the various types for the stormwater drainage system shall be constructed at the locations, and to the dimensions and elevations shown in the Drawings, in accordance with the relevant specifications listed in Clause 7.3, the Drawings and the directions of the Engineer.

It is noted that the cost of all works (including earthworks, piling, concrete and incidental work) required for their completion are deemed to be included in the prices for outfall structures entered in the Bill of Quantities.

7.11 INSPECTION, TESTING AND CLEANING OF SEWERS

7.11.1 General

All sewers and, stormwater drainage systems shall be tested, inspected and cleaned in accordance with this Clause 7.11.

Should the visual inspection or tests fail, the Contractor shall, at his own cost, replace defective pipes, make good any leaking joint, or otherwise re-execute defective work, after which cleaning, inspection and testing shall be repeated.

Only sewers or stormwater drainag systems which have undergone inspection and testing and have received the Engineer's approval shall be approved for payment.

The Contractor shall provide all equipment and personnel for carrying out tests and assisting the Engineer or his Representative in performing inspections.

All costs incurred by the Contractor in complying with the requirements of this Clause 7.11 shall be deemed to be included in the unit rates for the respective sewer elements.

7.11.2 Scope of Inspection and Testing

Testing and inspection shall be performed in accordance with the following schedule:

Sewer Type Or Element	Size	Test(s) and Inspections to be carried out
RC Pipe uPVC Pipe	All	Visual Inspection Leakage Test
RC Box Culvert Section	All	Visual Inspection Leakage Test
Manholes and Maintenance Chambers	All	Visual Inspection Leakage Test

7.11.3 Visual Inspection

All joints, including joints between pipes and manholes, shall be subject to inspection by the Engineer or his Representative.

7.11.4 Leakage Test

After completion of backfilling and restoration of normal sub-soil conditions, all sewers and manholes shall be inspected for infiltration. Acceptance criterion for this test is infiltration not exceeding 0.5 litre per linear metre per metre of nominal bore (for circular sections) or 0.5 litre per linear metre per metre width (for rectancular sections including manholes).

7.11.5 Cleaning and Inspection of Sewers

The Contractor shall at all times take reasonable measures to prevent the ingress of solid matter into sewers. Such steps shall include, but not be limited to the provision of temporary plugs where appropriate.

Following completion of sewers and manholes, the interior of pipelines and box culvert sections shall be cleaned of all silt and debris and inspected by the Engineer.

Pipelines of 600 mm diameter or smaller shall be demonstrated to be clear or all obstructions by drawing a sphere 25 mm smaller than the internal diameter of the pipe throughout the length of the section under inspection.

Should the Contractor fail to keep an inspected sewer satisfactorily isolated after it has been inspected and shown to be free of obstruction, he shall repeat cleaning and demonstrate to the Engineer's satisfaction that it is clear of obstruction, all at his expense, shortly before taking over.

7.12 CONNECTION PIPE

7.12.1 General

The Contractor shall design, supply and construct the 2,500 mm diameter steel connection pipe complete with two flexible joints in accordance with the Drawings, the specification and the directions of the Engineer.

7.12.2 Submittals

The Contractor shall submit method statements and material specifications in accordance with the procedures in Clause 1.3.5.

7.12.3 Steel Pipe

The steel pipe shall be made from structural steel and all welds, including site welds, shall be full strength butt welds. Materials, workmanship and testing shall be in accordance with the requirements of section 8, Metalwork

Internal coating shall be proposed by the manufacturer and subject to the approval of the Engineer. It shall be a durable, factory-applied material appropriate for providing a high degree of corrosion protection for the pipe in its intended application. The internal coating shall be capable of site repair and coating for areas where site welding or other mechanical work has been performed during installation.

Externally the pipe shall be cleaned by means of grit blasting to bright metal, primed and wrapped for the purpose of providing a high degree of protection against corrosion. Primer and pipe wrap shall be proposed by the Contractor and is subject to the Engineer's approval.

7.12.4 Flexible Joints

A flexible joint shall be provided at each end of the connection pipe for the purpose of permitting differential movement between the pipe and the structures of 200 mm in any direction without imposing loads on the pipe or the structure, leaking, disrupting the flow in the pipe or any other adverse effect.

The flexible joints shall be capable of being removed and replace without the need for cutting, breaking or welding.

7.12.5 Construction

Supporting structures shall be constructed in accordance with the Drawings and as specified elsewhere.

The pipe shall be set such that it invert level equal to that shown on the Drawings + or – 10 mm.

Backfilling around and above the upper portion of the pipe shall be by sand, hand compacted, and done with care so as not to damage the wrapping.

7.13 MEASUREMENT AND PAYMENT

7.13.1 Preparatory Works

The cost of all preparatory works is included in payment items in Section 2.

7.13.2 Earthworks

Common excavation, sandy soil fill, shall be measured and paid in accordance with the respective Clauses in Section 3, Earthworks.

7.13.3 Concrete

Concrete shall be measured and paid in accordance with the applicable Clause in Section 4, Concrete.

7.13.4 Precast Reinforced Concrete Pipes

Measurement shall be made of the length of the various diameters of precast reinforced pipes completed, in place and approved by the Engineer. Lengths cut off shall not be measured.

Payment shall be made at the respective rates per metre entered in the Bill of Quantities which shall include full payment for providing all labour, materials, tools, equipment and any other works incidental to the completion of precast reinforced concrete pipes. Bedding, backfilling and concrete encasement shall be paid for separately.

The following pay items shall be measured and paid under this Clause:

Pay Item No.	Description	Unit of Measurement
2.8.4	Precast Concrete Pipe (2,500 dia.): including supply and laying	m
2.19.1	Precast Reinforced Concrete Pipe (300 dia.): including supply and laying	m

7.13.5 Precast Reinforced Concrete Jacking Pipes

Measurement shall be made of the length of the various diameters of precast reinforced concrete jacking pipes completed, in place and approved by the Engineer. The distance between the inner faces of the manholes at each end of a completed run of pipe shall be used as the basis of measurement.

Payment shall be made at the respective rates per metre entered in the Bill of Quantities which shall include full payment for providing all labour, materials, tools, equipment and any other works incidental to the completion of precast reinforced concrete jacking pipes and shall specifically include the cost of the thrust blocks, ground treatment, cutting sheeting of pits, excavation and disposal of spoil, lubrication fluids, grouting, cutting pipes to length and all fittings.

The following pay items shall be measured and paid under this Clause:

Pay Item No.	Description	Unit of Measurement
2.22.2.4	Precast Reinforced Jacking Concrete Pipe (1,200 dia): including supply, pipe jacking, ground treatment and all associated works	m

7.13.6 Manhole Covers

Measurement shall be made of the number manhole covers of the various types described in Clause 7.5.6 completed, installed and approved by the Engineer.

Payment shall be made at the rate entered in the Bill of Quantities which shall be full compensation for the cost of all materials, labour, equipment and incidental costs (including the cost of the frame and its bedding), for completing the manhole covers in accordance with the Drawings and the Specification.

The following pay items shall be measured and paid under this Clause:

Pay Item No.	Description	Unit of Measurement
2.19.8 2.22.4.3 2.22.5.9	Cast Iron Manhole Cover (Type A): including supply and installation	No.

7.13.7 PVC Pipes

Measurement shall be made of the length of the various diameters of PVC pipe completed to the approval of the Engineer. Measurement shall be made along the centreline of the respective pipes and shall include the length of fittings where relevant (e.g. bends and elbows).

Payment shall be made at the rate entered in the Bill of Quantities which shall be full compensation for the cost of all materials, labour, equipment and incidental costs (including the cost of all fittings including bends, elbows, for completing the PVC pipe in accordance with the Drawings and the Specification.

The following pay items shall be measured and paid under this Clause:

Pay Item No.	Description	Unit of Measurement
2.19.2	PVC Pipe (225 dia.): including supply, installation and support	m

7.13.8 Granolithic Topping

Measurement shall be made of the plan area of granolithic topping in manholes or diversion chambers completed and approved by the Engineer.

Payment shall be made at the rate entered in the Bill of Quantities which shall be full compensation for the cost of all materials, labour, equipment and incidental costs, for completing the granolithic topping in accordance with the Drawings and the Specification.

The following pay items shall be measured and paid under this Clause:

Pay Item No.	Description	Unit of Measurement
2.19.6	Granolithic Topping: including supply and placement	m^2

7.13.9 Precast Concrete Cover Slabs

Measurement shall be made of the number of precast concrete cover slabs of the various types and sizes, completed and set in place and approved by the Engineer.

Payment shall be made at the rate entered in the Bill of Quantities which shall include full payment for providing all labour, materials, tools, equipment and any other works incidental to the completion of the precast concrete cover slabs.

The following pay items shall be measured and paid under this Clause:

Pay Item No.	Description	Unit of Measurement
2.17.5	Precast Concrete Cover (600Wx1000L, t=100) for U-Channel: including supply and placement	No.
2.17.6	Precast Concrete Cover (800Wx1000L, t=150) for U-Channel: including supply and placement	No.
2.17.7	Precast Concrete Cover (1200Wx1000L, t=150) for U-Channel: including supply and placement	No.
2.17.8	Precast Concrete Cover of Catch Basin Type 1 (400x400): including supply and placement	No.
2.17.9	Precast Concrete Cover of Catch Basin Type 2 (1000x1000): including supply and placement	No.

7.13.10 Connection Pipe

Measurement shall be made of the length of the completed connection pipe, in place and approved by the Engineer. Measurement shall be the actual length of the pipe including any portion within the flexible joints.

Payment shall be made at the rate entered in the Bill of Quantities which shall be full compensation for all materials, transport, equipment and labour and all incidentals for completing the connection pipe. The rate shall specifically include the costs of internal coating, external surface treatment, priming, wrapping, site welding, site repair of coatings, inspection and testing.

The following pay items shall be measured and paid under this Clause:

Pay Item No.	Description	Unit of Measurement
2.6.10	Connection Pipe (Steel Pipe 2,500 dia. x t=18): including fabrication, internal and external coating, wrapping and installation	m

7.13.11 Flexible Joints

Payment for flexible joints shall be made at the lump sum entered in the Bill of Quantities which shall be full compensation for all materials, labour, equipment, transport and all incidental costs for designing, furnishing and installing two flexible joints in accordance with the Drawings, the specification and to the approval of the Engineer.

The following pay item shall be measured and paid under this Clause:

Pay Item No.	Description	Unit of Measurement
2.6.11	Flexible Joints (Rubber & Steel 2,500 dia.): including design, supply and installation	L.S.

7.13.12 Outfall Structures

Measurement shall be made of the number of outfall structures of each type completed in accordance with the Drawings, the specifications and the directions of the Engineer.

Payment shall be made at the respective rates entered in the Bill of Quantities which shall be full compensation for the cost of all materials, transport, labour and all incidental costs for completing the outfall structures to the Engineer's approval. The rates shall specifically include the cost of completing all excavation, backfill, rip rap, concrete works, timber piling and joining the outfall structures to the drains.

The following pay items shall be measured and paid under this Clause:

Pay Item No.	Description	Unit of Measurement
2.17.12	Outfall Structure Type 1 (BxH=600x1450)	No.
2.17.13	Outfall Structure Type 2 (BxH=1000x1450)	No.

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SECTION 8. METAL WORK

8.1 GENERAL

8.1.1 Scope

This Section covers the general requirements for designing, manufacturing, transporting, installing, coating and other common requirements incidental to all metal work to be furnished under the Contract.

The metal works herein specified shall mean steel works such as steel fences, steel gates, ladder rungs, fabricated steel manhole covers, steel balustrades, steel grating covers, etc. as shown on the Drawings or as directed by the Engineer.

The provisions of Clauses 8.1 and 8.2 shall apply to all metalwork furnished under the Contract.

8.1.2 Submittals

The Contractor shall prepare Shop Drawings showing complete details, sections and plans of all parts, assemblies, materials lists, components, connections and supports, and relations to the structures based on the Drawings. The Shop Drawings are subject to approval by the Engineer in accordance with Clause 1.3.5 of Section 1.

8.1.3 Standards

Unless otherwise specifically provided in this Specification, the metal works shall be manufactured, fabricated and installed in accordance with the latest provisions of JIS, or other equivalent standards approved by the Engineer.

All materials to be furnished by the Contractor shall be new and shall have the best quality of their respective kinds.

Unless otherwise specified in this Specification, all materials and methods of fabrication shall conform to the standards listed in the following table.

Standards for Metalwork

Item	Standard
Structural Steel	ASTM A36, JIS G3101 or JIS G3106
Structural Steel Pipe	ASTM 120 or JIS G3444
Steel Pipe	JIS G3452
Bolt and Nut	ASTM A307 Grade A or JIS B1180
Arc Welding Electrode	AWS, JIS Z3211
Hollow Steel Sections	JIS 3466

8.2 FABRICATION AND CONSTRUCTION

8.2.1 General

The Contractor shall be responsible for the correctness and completeness of the Shop Drawings and for shop fit and field connections. The work shall be shop-fitted and shop-assembled where practicable, conforming to the details on the approved Shop Drawings.

Where necessary, metals shall be insulated to prevent electrolysis due to contact between dissimilar metals and to prevent corrosion due to contact between metals and masonry or concrete. Insulation shall be by means of bituminous paint or other approved means.

All fastening, anchors and accessories required for fabrication and erection shall be provided by the Contractor. Exposed fastenings shall be kept to an absolute minimum, evenly spaced and neatly set out. Wood plugs will not be permitted.

Workmanship in fabrication shall conform to the best modern shop and field practice. All joints and intersecting members shall be accurately fitted and all works shall be fabricated on true planes with adequate fastenings.

8.2.2 Welding

All welding shall be in accordance with the requirements of Section 12, Mechanical Works, and as specified below.

All welds shall be visually inspected by the Engineer and shall be subject to his approval.

When so directed by the Engineer, welds shall be tested by radiographic tests specified in JIS 3104 or other testing method approved by the Engineer.

Field welding shall not normally be permitted. However, when expressly authorised by the Engineer it shall not be performed under adverse weather conditions of rain, temperature, moisture and wind unless the welding work is protected in a manner approved by the Engineer.

Welds disapproved by the Engineer shall be chipped out to sound metal, tested and repair-welded and subject to the Engineer's approval using a procedure approved by the Engineer prior to carrying out the repair.

8.2.3 Protective Treatment of Metalwork

8.2.3.1 Galvanizing

Unless otherwise noted all metalwork shall be hot dip galvanised in accordance with the requirements this Clause.

(a) Galvanizing, where required, shall be at a rate of 0.6 kilograms per square meter and shall be performed in accordance with ASTM A123, JIS H8641, or equivalent.

(b) In metalwork which is to be galvanized:

  (i) after fabrication, all joints which are not already welded shall be seal-welded; and

(ii) tapped holes shall be tapped slightly oversize and tapped again to the correct size after galvanizing.

(c) For galvanized metal for handrails, ladders and fence, red lead prime painting will not be required except for welded joints where one coat of cold galvanizing paint shall be applied.

(d) Where painting is called for, galvanized metal surfaces shall be acid-etched prior to the application of the finishing surface coats.

8.2.3.2 Painting

Where painting is required, the Contractor shall submit his proposed painting system for the Engineer's approval.

Stairs for the jetty are to be treated as follows:

Metal shall be wire brushed to remove all dirt, rust, mill scale and cleaned with solvent to remove grease or any other deleterious matter.

Painting shall consist of the application of 3 coats of tar epoxy applied in accordance with the manufacturer's recommendations and the approved painting system.

8.2.4 Check Sheets

At least seven (7) days before placing concrete in any structure or installing any metal work, the Contractor shall submit, for approval, three (3) copies of an approved checkout sheet detailing all items of metalwork to be installed including unit masses and dimensions for materials to be furnished and installed and receipted invoices or other approved documentary evidence detailing the mass of any item which has been furnished and installed.

8.2.5 Installation

Metal works to be embedded in concrete shall be embedded when the concrete is being placed or, if shown on the Drawings or directed by the Engineer, recesses or block-outs shall be made in the concrete and the metalwork shall be grouted in place using cement or embedded in second-stage concrete.

The surfaces of all metal works to be in contact with concrete shall be thoroughly cleaned immediately before the grout or concrete is placed.

Metal works shall be accurately positioned and aligned in the locations as shown on the Drawings, and shall be held securely in the correct position during placing and setting of the concrete.

Where it is impracticable to place anchors or anchor bolts required for the installation of metal work when the concrete is placed, holes shall be drilled into the concrete after the concrete has set for 28 days and expansion bolts, adhesive anchor bolts, or other approved anchors shall be installed.

Field welding, cutting or drilling of prefabricated galvanised metalwork items shall not be permitted without the written approval of the Engineer.

8.3 LADDER RUNGS

Ladder rungs shall be fabricated to the size and dimensions as shown on the Drawings and galvanized.

Ladder rungs shall be installed accurately to the lines and spacings shown on the Drawings in the walls of manholes, maintenance chambers and in the walls of other structures as shown on the Drawings.

All materials, workmanship, coating and installation shall be in accordance with the requirements specified in Clauses 8.1 and 8.2.

8.4 FABRICATED MANHOLE COVERS

Manhole covers, complete with steel support frame, lifting handles etc. for use in the Wastewater Treatment Plant shall be fabricated to the size and dimensions as shown on the Drawings and shall be hot dip galvanized.

Manhole frames shall be accurately installed in the locations as shown on the Drawings taking care to ensure that the finished cover shall be flush with the adjacent finished floor level.

All materials, workmanship, coating and installation shall be in accordance with the requirements specified in Clauses 8.1 and 8.2.

8.5 STEEL BALUSTRADE

The Contractor shall provide galvanized steel balustrades and safety chains in accordance with the details and at the locations shown on the Drawings or as directed by the Engineer.

Units of balustrade shall be fabricated in units such that the need for site welding is minimal. Site welds shall be painted with cold galvanizing paint.

All materials, workmanship, coating and installation shall be in accordance with the requirements specified in Clauses 8.1 and 8.2.

8.6 GRATING COVERS

The Contractor shall furnish and install steel grating in accordance with the Drawings, the specification and the directions of the Engineer.

All grating covers shall be designed for a live load of 3.6 kPa and an allowable deflection of span/300.

Grating covers shall comprise factory-made panels of pressure-welded steel grating complete with edge bars all around each panel and supported on steel supports embedded into the surrounding concrete or fixed with anchors as shown on the Drawings.

All steel components shall be hot dip galvanized. Panels shall be fastened to supports with clips or fasteners recommended by the supplier and shall be easily released in order to be able to remove any individual panel.

The grating covers shall be of generally of the dimensions shown on the Drawings but may be modified to suite particular layouts. Such details shall be shown on the Contractor's Shop Drawings which shall be subject to the Engineer's prior approval.

All materials, workmanship, coating and installation shall be in accordance with the requirements specified in Clauses 8.1 and 8.2.

8.7 MEASUREMENT AND PAYMENT

8.7.1 Ladder Rungs

Measurement shall be made of the number of ladder rungs completed and installed and approved by the Engineer.

Payment shall be made at the rate entered in the priced Bill of Quantities which shall be full compensation for the cost of all materials, labour, equipment and incidental costs for completing ladder rungs in accordance with the Drawings and the Specification.

The following pay item shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
2.20.2	Ladder Rungs: including supply and installation in wall of manholes and others	No.

8.7.2 Fabricated Manhole Covers

Measurement shall be made of the mass of fabricated steel manhole covers completed and installed and approved by the Engineer. Measurement of the mass may be made by calculation or by weighing at the discretion of the Engineer.

Payment shall be made at the rate entered in the priced Bill of Quantities which shall be full compensation for the cost of all materials, labour, equipment and incidental costs for completing the fabricated manhole covers in accordance with the Drawings and the Specification. The rate shall specifically include the cost of installation including the cost of the steel support frame and its embedment in concrete and mortar bedding where required.

The following pay item shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
2.20.4	Fabricated Manhole Cover: including supply, fabrication and placement	kg

8.7.3 Other Metalwork Items

Measurement for payment shall be made of the masses of the respective metalwork items. Measurement may be made by calculation or by weighing at the Engineer's discretion.

Payment shall be made at the respective rates entered in the priced Bill of Quantities which shall be full compensation for the cost of all materials, labour, equipment and incidental costs for completing the metalwork item in accordance with the Drawings and the Specification. The rates shall specifically include the cost of surface protection and installation including the cost of setting in support frames, anchors, any mortar or secondary concrete or fixings required for installation.

The following pay item shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
2.20.1	Balustrade: including supply, fabrication and installation	kg
2.15.4.8	Galvanized Steel Guard Rail and Posts: including supply and installation	kg
2.20.3	Grating Covers: including fabrication and installation	kg
2.2.7	Steel Stairs : including fabrication, painting and installation	kg

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SECTION 9. LANDSCAPING WORKS

9.1 GENERAL

This section covers the requirement for landscaping works to be carried out under the Contract for Package E, by the Contractor, at the Wastewater Treatment Plant.

For the purposes of this specification, landscaping works shall include planting works, gates and fencing.

9.2 PLANTING WORKS

9.2.1 General

The Contractor shall perform the planting works, consisting the planting and maintenance of grass, shrubs and trees, in accordance with the Drawings, the specification and the directions of the Engineer.

9.2.2 Grassing

9.2.2.1 General

The Contractor shall plant and maintain grass in the areas shown on the Drawings or directed by the Engineer. All grass shall be Axonopus Compressus.

The method of planting grass shall be as shown on the Drawings and shall be either sodding or sprigging as specified herein.

9.2.2.2 Sodding

(a) General

This work shall consist of furnishing, placing and compacting topsoil and laying grass sods in accordance with the specification where shown on the Drawings or directed by the Engineer.

(b) Material Requirements

(i) Topsoil

Topsoil shall be clean friable soil, free of stones larger than 20 mm and free of weed or other deleterious matter.

(ii) Grass Sod

The sod shall consist of a healthy, dense and well rooted growth of living grass with roots surrounded by topsoil and shall not contain weeds or other undesirable plants.

The grass sod shall be cut into uniform squares approximately 300 mm and shall have a minimum thickness of 50 mm (excluding grass blades). The type of grass to be used shall be subject to the approval of the Engineer.

(c) Method of Planting

The surface of the area to be sodded shall be trimmed to the profile as shown on the Drawings to the approval of the Engineer.

Units of grass sod shall be placed in uniform rows with the sides of adjacent sods in close contact to each other.

The areas to be sodded shall be as shown on the Drawings or as specified by the Engineer. The surface of the areas to be sodded shall be loosened and brought to a reasonably fine texture to a depth of approximately 20 mm. The bed upon which the sod is to be placed shall be moistened to the loosened depth, if not naturally sufficiently moist, and the sod shall be placed thereon within 24 hours after having been cut.

After the placement has been completed, the surface shall be cleared of loose sod, excess soil, or other foreign material, whereupon a thin layer of topsoil shall be scattered over the sod as a top dressing and the areas shall then be thoroughly moistened by sprinkling with water.

The Contractor shall regularly water and maintain sodded areas in satisfactory condition for the duration of the Contract and until final acceptance of the Works.

9.2.2.3 Sprigging

(a) General

This work shall consist of furnishing, placing and compacting topsoil and planting grass sprigs in accordance with the Specification where shown on the Drawings or directed by the Engineer.

(b) Material Requirements

(i) Topsoil

Topsoil shall be clean friable soil free of stones larger than 20 mm and free of weed or other deleterious matter.

(ii) Grass Sprigs

These shall be healthy living stems (stolons or rhizomes) with attached roots.

(c) Method of Planting

The surface of the area to be grassed by sprigging shall be trimmed to the profile as shown on the Drawings to the approval of the Engineer.

Before harvesting of the sprigs, the grass shall be mowed to a height of 50 to 75 mm and all clippings and waste materials removed. Sprigs shall then be loosened by cross disking, shallow ploughing or other acceptable methods. After loosening the sprigs from the soil they shall be promptly gathered into small piles or windrows, watered and kept moist until they are planted. The time between harvesting and planting shall not exceed 24 hours. Sprigs that have been heaped in stockpiles, permitted to dry out or otherwise damaged shall be rejected.

Sprigging shall not be done during windy weather, or when the ground is dry, excessively wet, or otherwise untillable.

Sprigs shall be broadcast by hand or by suitable equipment in a uniform layer with spacing between sprigs not to exceed 150 mm. The sprigs shall then be forced into the soil to a depth of 50 to 100 mm with a straight spade or similar tool, or with a disk harrow or other equipment set to cover the sprigs to the required depth.

9.2.2.4 Maintenance

The Contractor shall protect the newly grassed areas by means of barriers or warning signs. The Contractor shall maintain watering and other incidental operations and all treated areas will be subject to special inspections at 2 and 12 months after they have been laid. Any areas in which grass is not maintaining a healthy growth shall be repaired or re-furnished by the Contractor at his own expense. The Contractor will be responsible for cutting and keeping clean any grassed areas until Completion of the whole of the Works.

9.2.3 Trees and Shrubs

9.2.3.1 General

The work to be performed by the Contractor consist of the supply, planting and maintenance of trees, shrubs, ground cover in the areas shown on the Drawings.

The supply, planting and maintenance of trees and shrubs shall be by a specialist subcontract with extensive experience in similar work and shall be subject to the approval of the Engineer.

9.2.3.2 Materials

(a) Plants

Trees, shrubs, ground cover and grass shall be of the types shown in the planting list in the Drawings. Each plant or shrub shall meet the acceptable size range indicated in the planting list for height, diameter of trunk and diameter of root ball.

All plants shall be healthy living plants, free from disease, insects and fungi and shall not be broken or torn.

(b) Fertilizers

Well rotted animal manure, shall be free of grass and weeds shall be used for improving the soil in which plants are to grown.

Chemical fertiliser containing N,P and K elements such as shall be used to develop the growth of root.

Chemical fertilisers containing Urea shall be used for grass.

(c) Planting Medium

A planting medium (shown as “agricultural soil” on the Drawings) consisting a 1:1 mixture of clean soil, free of stones, building rubble or other deleterious matter and animal manure as noted in (b) shall be used.

9.2.3.3 Planting of Trees, Shrubs and Ground Cover

All planting shall be done in late afternoon or at night to prevent plants drying out.

Holes shall be excavated to the sizes and depths shown on the Drawings and backfilled with the planting medium (Agricultural Soil) specified above.

Subsequently, holes shall be dug of sufficient size and depth to accept the root balls of trees or plants to be planted. Trees or shrubs shall be removed from their containers and carefully placed in their respective holes and planting medium carefully placed around the roots ensuring all air voids are filled. Water shall be applied and tamping applied.

Hardwood staking, as shown on the Drawings shall be applied to all trees.

9.2.3.4 Maintenance

The Contractor shall regularly water and maintain all trees, shrubs and ground cover plants in good, healthy condition for the duration of the Contract and until final acceptance of the whole of the Works. Any unhealthy or dead plant shall be promptly replaced.

9.3 GATES AND FENCING

9.3.1 General

The Contractor shall construct gates and fencing for the Wastewater Treatment Plant as shown in the Drawings or as directed by the Engineer.

9.3.2 Materials

Concrete materials shall be in accordance with Section 4, Concrete Works

Metalwork items shall be in accordance with Clause 8.2. with all steelwork galvanized.

9.3.3 Fabrication and Construction

The gates, fence posts, panels, related steel items and other required steel materials shall be fabricated and constructed in accordance with Clause 8.2 and as specified hereunder..

The gates and fences shall be accurately set out in accordance with the layout shown in the Drawings and approved by the Engineer prior to installation.

Posts shall be installed vertically as shown on the Drawings. The posts shall be installed in holes excavated to the dimensions shown on the Drawings or as directed. The holes shall be backfilled with approved material which shall be compacted by tamping until the post is firmly held in the vertical position. Otherwise, posts shall be embedded in concrete foundations as shown in the Drawings.

Gate rails shall be placed accurately in their concrete footings to an accuracy of + or -5 mm in the length of the rail.

Sliding gates shall be installed such that they run smoothly.

Entrance gates shall be furnished complete with rollers, rails, padbolt catches as shown on the Drawings or as directed.

9.4 MEASUREMENT AND PAYMENT

9.4.1 Grassing

Measurement shall be made of the areas of grassing of completed by each of the respective methods in accordance with Clause 9.2.2

Payment will be made at the respective rates entered in the priced Bill of Quantities which shall include the entire cost of completing the work including materials, labour, equipment, transportation, maintenance and any other associated costs:

Payment will be made as follows:

- On completion of planting 60% of the rate in the Bill of Quantities.
- After satisfactory establishment of the grass, a further 20 % of the rate in the Bill of Quantities
- The remaining 20% shall be paid on satisfactory maintenance of the grassing on Completion of the whole of the Works.

The following pay items shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
2.18.6	Grassing (by sodding method) : including supply, planting and maintenance	m^2
2.18.7	Grassing (by sprigging method): including supply, planting and maintenance	m^2

9.4.2 Trees and Shrubs (individual planting)

Measurement shall be made of number of trees or shrubs of the specified types as shown in the Drawings completed in accordance with Clause 9.

Payment will be made at the various rates per unit entered in the priced Bill of Quantities and shall include the entire cost of completing the work including materials, labour, equipment, transportation, maintenance and any other associated costs including planting medium and fertilizers.

Payment will be made as follows:

- On completion of planting, 60% of the rate in the Bill of Quantities.
- After satisfactory establishment of the trees a further 20 % of the rate in the Bill of Quantities

The remaining 20% shall be paid following satisfactory maintenance of the flowering shrubs and ground cover plants on Completion of the whole of the works.

The following pay items shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
2.18.9	Flowering Shrubs (individual planting H=1,000): including supply, planting and maintenance	No.
2.18.10	Tree (excluding palms) 3,000 to 4,000 high: including supply, planting and maintenance	No.
2.18.11	Coconut Palm (H=1,500): including supply, planting and maintenance	No.
2.18.12	Palm Tree (H=2,500): including supply, planting and maintenance	No.

9.4.3 Trees and Shrubs (group planting)

Measurement shall be made of the area of flowering shrubs of the specified types as shown in the Drawings completed in accordance with Clause 9.2.3.

Payment will be made at the various rates per unit entered in the priced Bill of Quantities and shall include the entire cost of completing the work including materials, labour, equipment, transportation, maintenance and any other associated costs including planting medium and fertilizers.

Payment will be made as follows:

- On completion of planting, 60% of the rate in the Bill of Quantities.
- After satisfactory establishment of the trees a further 20 % of the rate in the Bill of Quantities

The remaining 20% shall be paid following satisfactory maintenance of the flowering shrubs and ground cover plants on Completion of the whole of the works.

The following pay items shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
2.18.8	Flowering Shrubs (group planting) : including supply, planting and maintenance	m^2

9.4.4 Gates and Fences

(a) Gate Posts, Gates and Doors

Measurement shall be made of the number of main gate fence posts, the number of sliding gate leaves and the number of swing doors complete with their reinforced concrete columns, completed in accordance with the Drawings, the specifications and to the approval of the Engineer

Payment shall made at the appropriate unit rates entered in the Bill of Quantities which shall be full compensation for all materials, transport, labour and all incidental costs for fabricating and galvanizing all of the steel components, for the construction of all concrete elements and erecting the items all in accordance with the Drawings, the specification and the instructions of the Engineer.

The following pay items shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
2.18.1	Main Gate Posts : including fabrication and construction	No.
2.18.2	Sliding Gate Leaf (Type-2) complete with track: including fabrication and construction	No.
2.18.3	Swing Door complete with reinforced concrete columns: including fabrication and construction	No.

(b) Fences

Measurement shall be made of the length of the various types of fences completed in accordance with the Drawings, the specifications and to the approval of the Engineer.

Payment shall made at the unit rate entered in the Bill of Quantities which shall be full compensation for all materials, transport, labour and all incidental costs for fabricating and galvanizing all of the steel components, for the construction of all concrete elements and erecting the fences all in accordance with the Drawings, the specification and the instructions of the Engineer.

The following pay items shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
2.18.4	Grid Fence (Type-A): including fabrication and construction	m
2.18.5	Wire Net Fence (Type-B) complete with concrete columns: including fabrication and construction	m

SECTION 10 BRIDGE WORKS
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SECTION 10. BRIDGE WORKS

10.1 GENERAL

This section covers the specific requirements for the bridge to be constructed across the Tac Ben Ro canal.

Bridge works shall comply with the specifications referred to in Clause 10.3 and to the requirements of this section, which, in the event of conflict, shall govern.

In any event, the payment clauses referred to in the Bill of Quantities shall apply to all measurement and payment for items relating to bridge works.

10.2 SCOPE OF WORK

The Contractor shall construct the bridge across the Tac Ben Ro canal and rectify all defects therein in accordance with the Drawings, the specification and the directions of the Engineer.

The bridge work comprises the following main elements:

- Reinforced concrete piled foundations
- Reinforced concrete piers and abutments
- Superstructure comprising prestressed girders with reinforced concrete deck, concrete parapet walls, steel guard rails and asphalt paving.

10.3 WORKS SPECIFIED ELSEWHERE

Care of Water shall be in accordance with Section 2

Soil improvement shall be in accordance with Section 2

Demolition shall be in accordance with Section 2

Earthworks shall be in accordance with Section 3

Concrete work shall be in accordance with Section 4

Piling work shall be in accordance with Section 5

Metal work shall be in accordance with Section 8

10.4 MATERIALS

Materials for bridge construction shall comply with the following local standards and requirements:

Cement Concrete	Procedure 22 TCN-60-84 by The Ministry of Transportation
Reinforced Rubber Bearings	Procedure 22 TCN-217-94 by the Ministry of Transportation
Water in Concrete Work	Procedure 22 TCN-217-84 by the Ministry of Transportation
Asphalt Concrete	Procedure 22 TCN-22-90 by the Ministry of Transportation

Cement Procedure	TCVN-4029-85 to 4202-86
Sand and Stone for Construction	TCVN 1770-86 to TCVN 1772-86
Plain Round Steel Bar	CT3: Ra = 1900 kg/cm^2, E= 2.1x10^6
Deformed Round Steel Bar	CT 5: Ra = 2400 kg/cm^2, E= 2.1x10^6
Steel plate and Sections	CT 3 Steel Structures
Bridge Girders	990 mm x 650 mm prestressed concrete cellular girders produced by the precast concrete factory of the 68 Bridge Company to the approved design of the Ministry of Transportation.

10.5 SUBMITTALS

The Contractor shall prepare a method statements for each part of the works which shall be submitted for the Engineer's approval in accordance with the procedures in Clause 1.3.5

The method statements shall provide comprehensive descriptions of the materials, equipment, construction methods, quality control procedures and safety measures to be used and shall be supported by material specifications, detailed drawings of temporary works and calculations of their structural and functional adequacy.

10.6 TEMPORARY WORKS FOR BRIDGE CONSTRUCTION

The Contractor shall design, furnish, erect, maintain and, after completion of the bridge, completely demolish, temporary works for the test piling, piling, substructure construction, launching of girders and all other activities in relation to the construction, completion and rectification of defects in the bridge.

10.7 CONSTRUCTION

10.7.1 General

Construction will be carried out in accordance with the approved method statement, the requirements of the various sections of the specification referred to in Clause 10.3 and as specified hereunder for additional requirements or for specifications of items not described elsewhere.

10.7.2 Soil Stabilization of Abutments

The soil in the banks of the canal around the abutments, as shown on the Drawings, shall be stabilized in accordance with the requirements of Section 2 and shall be approved by the Engineer prior to commencing bridge construction.

10.7.3 Survey Control

Further to the Contractor's obligations for survey specified in section 1, the Contractor shall establish reference marks outside the area which will not be disturbed by the works for the vertical and horizontal control of construction of the bridge.

10.7.4 Bridge Girders

10.7.4.1 General

Bridge girders, complying with the requirements specified in Clauses 10.3, 10.4 and the Drawings, shall be procured by the Contractor from the specified source. The girders shall be certified, by the supplier, that they meet the design requirements and satisfy Ministry of Transport regulations.

10.7.4.2 Handling

Girders shall, at all times be handled in a manner which will not cause them to be overstressed or damaged.

10.7.4.3 Erection

Girders shall be erected in accordance with the approved method statement.

10.7.5 Piling

Test piling shall be carried in accordance with the Engineer's instructions to establish the required length of piles.

Load testing shall be carried out if so directed by the Engineer.

10.7.6 Bridge Bearings

(a) Pedestals

The 50 mm thick pedestals shall be cast monolithically with the substructure concrete and shall be finished in accordance with the requirements of 4.2.4.9. , Sub-Clause c.

The bearing pedestals shall not loaded before 10 days after casting.

Tolerances on line and level of the bearing surfaces shall in accordance with the requirements of Section 4 of this Specification with the additional requirement that the permissible deviation at any point under a 300 mm straight edge placed level in any direction is 1mm.

(b) Bearing Installation

Elastomeric bearings shall be accurately aligned on the pedestals in the positions shown on the Drawings.

The bridge girders shall be placed directly onto the elastomeric bearing. If any gaps greater than 1 mm occur then the member shall be lifted to permit coating the top of the bearing with an excess amount of an approved epoxy mortar and the member re-seated.

Placing of the bearing shall be done in the presence of the Engineer's Representative.

Bearings shall be temporarily restrained as necessary to avoid any disturbance in position during the girder placing operations.

10.7.7 Deck Expansion Joints

Expansion joints shall be constructed between adjacent deck slabs as shown on the Drawings.

Metal components shall be embedded in the concrete of the deck slabs during casting of the slabs.

Low density sand-cement mortar or other temporary filler shall be placed in the expansion gap during paving operation. This material shall subsequently be removed prior to completion of the joint.

10.7.8 Wet Stone Masonry

10.7.8.1 General

Wet stone masonry protective facing, 200 mm thick shall be constructed on the abutment embankments as shown on the Drawings.

10.7.8.2 Materials

(a) Stone

Stone for all masonry shall be clean, hard, and durable.

Samples of stone proposed for use in masonry construction shall be submitted to the Engineer for his approval.

(b) Mortar

Sand, cement and water for mortar shall comply with the requirements of Clause 10.4.

10.7.8.3 Construction

(a) Preparation

The embankment shall be trimmed to the profile shown on the Drawings and the 100 mm thick gravel layer placed and tamped such that it is firm and stable.

(b) Placing of Stone

Stone shall be dressed to remove any thin or weak portions and shall be dressed to provide bed and joints lines that do not vary more than 20 mm from true lines and to ensure the meeting of bed and joints lines without the rounding of the corners of the stones in excess of 30 mm in radius. Bed surfaces shall be normal to the faces of the stones.

Stones shall be pitched to line along all beds and joints. The maximum projections of rock faces beyond the pitch lines shall not be more than 10 mm.

All stones shall be cleaned thoroughly and wetted immediately before being set, and the bed which is to receive them shall be cleaned and moistened before the mortar is spread. They shall be laid with their longest faces horizontal in full beds of mortar, and the joint shall be flushed with mortar.

The exposed faces of individual stones shall be parallel to the faces of the walls in which the stones are set. The stones shall be so handled as not to jar or displace the stones already set.

(c) Pointing

Joints not pointed at the time the stone is laid shall be thoroughly wet with clean water and filled with mortar. The mortar shall be well driven into the joints and finished with an approved pointing tool. The wall shall be kept wet while pointing is being done and in hot or dry weather the pointed masonry shall be protected from the sun and kept wet for a period of at least 3 days after completion.

After the pointing is completed and the mortar set, the wall shall be thoroughly cleaned and left in a neat and workmanlike condition.

10.7.9 Deck Drains

10.7.9.1 General

Deck Drains shall be installed as shown on the Drawings.

10.7.9.2 Material

Deck drains shall be 100 mm dia steel, galvanized pipe as approved by the Engineer. All surfaces, including cut surfaces shall be galvanized.

10.7.9.3 Installation

Deck drains shall be set placed and cast integrally with the surrounding concrete.

During the laying of the wearing course care shall be taken to ensure that scuppers are formed to ensure clear entry of water to the inlet of the deck drains.

10.7.10 Painting

10.7.10.1 General

The parapet of the bridge shall be painted.

10.7.10.2 Painting System

The Contractor shall proposes a coating system which shall be appropriate for application to concrete surfaces and with long life expectancy. The system shall include at least one primer coat and two application of finishing coat.

The colour shall be selected by Engineer.

10.7.10.3 Application

Paint shall be applied in accordance with the manufacturer's recommendations.

The Contractor shall shield all surfaces adjacent to the surfaces to be painted from paint drips and spillage.

10.8 MEASUREMENT AND PAYMENT

10.8.1 Earthworks

Refer to Section 3

10.8.2 Concrete Works

Refer to Section 4

10.8.3 Piling Works

Refer to Section 5

10.8.4 Roadworks

Refer to Section 6

10.8.5 Wet Stone Masonry

Measurement shall be made of volume of wet stone masonry completed in accordance with the Drawings, the specification and to the approval of the Engineer.

Payment shall be made at the rate entered in the Bill of Quantities which shall be full compensation for the cost of all materials, labour, equipment and incidental costs, for completing the work.

The following pay items shall be measured and paid under this Clause:

Pay Item No.	Description	Unit of Measurement
2.15.3.15	Wet Stone Masonry: including supply and construction	m^3

10.8.6 Temporary Works

Payment for temporary works for bridge construction shall be made at the lump sum entered in the Bill of Quantities which shall be full compensation for all materials, labour, equipment, transport and all incidental costs for designing, furnishing, installing, maintaining, and demolishing all of the temporary works required for all stages of bridge construction. The lump sum shall not include the cost of care of water which is included in pay item 2.1.11.

Payment shall be made in accordance with the Contractor's approved breakdown of the lump sum provided that such breakdown provides a minimum of 10% of the lump sum for removal and demolition of the temporary works prior to Completion of the Works which shall only be paid following the Engineer's certification that all such works, including underwater portions, have been satisfactorily removed.

The following pay item shall be measured and paid under this Clause:

Pay Item No.	Description	Unit of Measurement
2.15.1.1	Temporary Works for Bridge Construction: including all temporary structures for bridge construction works and removal after completion of bridge	L.S.

10.8.7 Bridge Bearings

Measurement shall be made of the number of elastomeric bridge bearings completed in accordance with the Drawings, the specifications and the directions of the Engineer.

Payment shall be made at the rate entered in the Bill of Quantities which shall be full compensation for the cost of all materials, transport, labour and all incidental costs for completing the bridge bearings to the Engineer's approval. The rate shall specifically include the cost of preparing the surface of concrete, furnishing materials for and constructing pedestals and adhesives.

The following pay item shall be measured and paid under this Clause:

Pay Item No.	Description	Unit of Measurement
2.15.4.1	Elastomeric Bridge Bearings: including supply and installation	No.

10.8.8 Prestressed Concrete Bridge Girders

Measurement shall be made of the number of prestressed concrete bridge girders completed in accordance with the Drawings, the specifications and the directions of the Engineer.

Payment shall be made at the rate entered in the Bill of Quantities which shall be full compensation for the cost of all materials, transport, labour and all incidental costs for furnishing and erecting the bridge girders to the Engineer's approval. The price shall not include the cost of launching girders or other temporary structures which is deemed to be included in pay item 2.15.1.1.

The following pay item shall be measured and paid under this Clause:

Pay Item No.	Description	Unit of Measurement
2.15.4.2	Prestressed Concrete Bridge Girders: including supply, transportation and installation	No.

10.8.9 Deck Drains

Measurement shall be made of length of deck drains completed in accordance with the Drawings, the specifications and the directions of the Engineer.

Payment shall be made at the rate entered in the Bill of Quantities which shall be full compensation for the cost of all materials, transport, labour and all incidental costs for furnishing and installing the deck drains to the Engineer's approval.

The following pay item shall be measured and paid under this Clause:

Pay Item No.	Description	Unit of Measurement
2.15.4.6	Deck Drains (100 mm dia galv. pipe): including supply and installation	m

10.8.10 Painting of Parapet

Measurement shall be made of the area of bridge parapet painted with 3 coats of approved paint and approved by the Engineer.

Payment shall be made at the rate entered in the Bill of Quantities which shall be full compensation for the cost of all materials, labour, equipment and incidental costs, for completing the painting in accordance with the Drawings and the Specification. The rate shall specifically include the cost of surface preparation, protection of unpainted areas and cleaning up.

The following pay item shall be measured and paid under this Clause:

Pay Item No.	Description	Unit of Measurement
2.15.4.7	Painting of Parapet: including supply of materials and application	m^2

SECTION 11 MISCELLANEOUS WORKS
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SECTION 11. MISCELLANEOUS WORKS

11.1 GENERAL

This section covers the requirements for the supply and installation and construction of various miscellaneous items not specified elsewhere.

Technical data or samples of proprietary items to be supplied under this section shall be supplied to the Engineer for his review and approval in accordance with the procedures in Clause 1.3.5.

11.2 PRECAST CONCRETE COVER SLABS

11.2.1 General

The Contractor shall design, supply and install precast concrete cover slabs complete with steel supporting frame in accordance with the Drawings, the specification and the directions of the Engineer.

The Contractor shall be responsible for the design of the slabs to meet the following criteria:

Design Load:	3.6 kPa
Permissible Concrete Stresses:	Not exceeding permissible stresses as defined in the JSCE Standard Concrete Code or equivalent.
Allowable Deflection:	Span/400

The design shall be subject to the Engineer's approval.

Slab may be prestressed or reinforced concrete.

11.2.2 Materials

The materials shall be equal or better than the following:

Concrete: Class D as specified in Clause 4.1

Reinforcement: As specified in Clause 4.3.2

Steel Support Frame: As specified in Clause 8.1.3, galvanized in accordance with the requirements of Section 8.

Lifting Handle: Stainless Steel SUS 304

11.2.3 Construction

Galvanized steel support angle frame shall be installed in accordance with the requirements of Section 8 such that cover slabs, when installed shall be flush with the adjacent finished surface and stable.

Slabs shall be installed in the completed support frames with the clearances between adjacent slabs as shown on the drawing.

Slabs which move or rock under weight due to irregularity shall be replaced or made stable in a manner approved by the Engineer.

11.3 FORGED STEEL HOOKS

11.3.1 General

The Contractor shall furnish and install galvanized, forged steel hooks as shown on the Drawings or as directed or approved by the Engineer.

11.3.2 Materials

Galvanized forged steel.

Hooks shall be certified by the manufacturer that they have a safe working load of 2 t (2,000 kg)

11.3.3 Construction

Hooks shall be embedded in their supporting concrete at the time of placing the concrete.

11.4 OVERFLOW WEIRS

11.4.1 General

The Contractor shall furnish and install overflow weirs in accordance with the Drawings, the specification, or as directed or approved by the Engineer.

11.4.2 Materials

Weir Plates:	4 mm thick fibre reinforced plastic
Metal Components and Fastenings:	Stainless steel SUS 304
Joint Filler:	Resin treated filler as recommended by the manufacturer and approved by the Engineer

11.4.3 Construction

Stainless steel anchor bolts shall be cast into the concrete structure on which the weirs are to be mounted during casting using templates to ensure accuracy of location.

Joint filler shall be place against the concrete ane the weir plates installed and adjusted in height such that they are at the specified levels and horizontal to an tolerance of 2mm over their lengths.

11.5 STOP LOGS

11.5.1 General

Stop logs of various profiles and dimensions, complete with guide frames, lifting handles and rubber packing complying with the Drawings, the specification and as approved by the Engineer shall be furnished and installed by the Contractor.

11.5.2 Materials

Stop Logs:	Timber of a species which is hard, durable with high strength in bending and subject to the Engineer's approval prior to procurement.
All metal components:	Stainless steel SUS 304
Packing:	Natural rubber or neoprene

11.5.3 Construction

Guide frames shall be installed in the manner specified in Clause 8.2.5.

Stop logs shall be inserted into the completed guide frames and checked to ensure ease of insertion, removal and watertightness.

Following test installation and commissioning, stop logs shall be removed and stacked at locations directed by the Engineer.

All stop logs shall be clearly marked using a system which clearly indicates their respective applications.

11.6 SKY LIGHTS

11.6.1 General

The Contractor shall furnish and install skylights in accordance with the Drawings, the specification, or as directed or approved by the Engineer.

11.6.2 Materials

Skylights shall be purpose-made units of the dimensions shown on the Drawings meeting the following requirements:

Material:	Fibre Reinforced Plastic
Design Load:	1.2 kPa or 1 kN point load whichever is more severe
Colour:	White, translucent

11.6.3 Construction

Skylights shall be installed in accordance with the manufacturer's recommendations using stainless steel bolts and silicon sealant between the supporting surface and the flange of the skylight. The joint shall be watertight.

11.7 TAR EPOXY RESIN COATING

11.7.1 General

The Contractor shall apply tar epoxy resin coating to the inner surface of concrete various wastewater tanks as indicated in the Drawings.

11.7.2 Materials

The waterproofing material shall be a two-component, coal tar epoxy resin such as Sika Inertol Poxitar or equivalent.

11.7.3 Submittal

The Contractor shall submit the technical specification and method statement of the proposed product for the Engineer's approval.

The method statement shall also include a proposed testing method for checking adhesion of the coating to the substrate (e.g. cross-cut test as used for paint)

11.7.4 Application

Concrete substrate shall have a minimum age of 14 days or as recommended by the manufacturer, whichever is the greater, before application of the coating.

The substrate shall be cleaned of all dirt, irregularities, grease or any other deleterious material.

Any porosity shall be filled with a product compatible with the coating material.

The moisture content of the concrete to which the coating is to be applied shall be checked to ensure that is within the acceptable range for the coating. If not the manufacturer's recommendations shall be followed.

The components of the coating material shall be thoroughly mixed by mechanical stirrers then applied to the surface at the rate of application, and using the method recommended by the manufacturer. The rate of application shall not be less than 0.4 kg/m^2 per coat.

Three coats shall be applied as above.

11.7.5 Testing and Approval

The Contractor shall conduct adhesion tests in accordance with the manufacturer's recommendations, at locations nominated by the Engineer, in the Engineer's presence.

Any work, for which a representative adhesion test fails shall be removed, re-coating and re-tested.

Only work which has been subjected to visual inspection and has passed adhesion testing (where requested by the Engineer) shall be approved for payment.

11.8 LABORATORY EQUIPMENT

11.8.1 General

The Contractor shall supply and install laboratory equipment in the laboratory located in the Main Building of the Wastewater Treatment Plant.

11.8.2 Submittal

Technical brochures and specifications of proposed equipment shall be submitted to the Engineer for his approval prior to procurement.

11.8.3 Specification

All equipment shall conform to the requirements listed below and as instructed or approved by the Engineer.

No.	Equipment	Specification	Quantity
01	Electronic Balance	Weighing capacity: 210 g Precision: 0.1 mg Automatic calibration Voltage: 220 V/50 Hz	1
02	pH meter	Range/Accuracy: 0 ~ 14 pH/± 0.01 pH -1999 ~ 1999 mV/± 1mV -5.0 ~ 105 ^{o}C /± 0.2 ^{o}C	2
03	DO meter	DO range: 0 ~ 200% 0 ~ 19,99 mg/l Temperature range: -30 ~ 150 ^{o}C	2
04	Binocular microscope	Optics head two eyepieces 10 x Eyepiece 10 x with focal length 25 mm The four achromatic objectives 4x, 10x, 40x and 100 x give a magnification 1000 times. Filter blue and green color.	2
05	Drying cabinet	Max temperature: 230 ^{o}C Capacity: 281 Automatic flare Voltage: 220 V/50 Hz	1
06	Hot Bath Facility	Capacity: 2.2 l Temperature range: 0 ~ 100 ^{o}C Inside dimensions: 120 x 140 x 130 mm Power Supply: 220 V – 1400 W	1
07	Electric fireplace	Power supply: 220 V – 2 ~ 4 kW	1
08	Incubator	Temperature range: 0 ~ 50 ^{o}C Tolerance: ± 0.5^{o}C Electronic temperature control Visualisation liquid erystal display Capacity: 220 l	1
09	Double Water Distiller	Distilling capacity: 4 l/h Quartz heated 4 x 1.5 kW Voltage: 220 V / 50 Hz	1
10	Centrifuge	Speed max: 6000 rpm Capacity max: 15 ml Fixed angle rotor 12 x 15 ml Voltage: 220 V/50 Hz	1
11	Vacuum Pump	Flow rate: 34 l/min Vacuum limit: 650 mmHg Voltage: 220 V / 50 Hz	1
12	Refrigerator	Capacity: 120 l Voltage: 220 V / 50 Hz	1

13	Draft chamber	1500^{W} x 750^{L} x 235^{H}	1
14	Kettle Facility	300^{W} x 150^{L} x 600^{L}	1
15	Central Testing Bench	3000^{W} x 1500^{L} x 800^{L}	1
16	Side Wall Testing Bench	2400^{W} x 750^{L} x 800^{H}	1
17	Balance Stand	1200^{W} x 750^{L} x 750^{H}	1
18	Microscope Stand	1400^{W} x 75^{L} x 750^{H}	1
19	Medicines Cabinet	1800^{W} x 400^{L} x 1800^{H}	1
20	Tool Cabinet	1800^{W} x 750^{L} x 200^{H}	1
21	Sink (Floor)	1800^{W} x 750^{L} x 200^{H}	1
22	Stainless Steel Sink	900^{W} x 750^{L} x 800^{H}	1

All fixed item which are to be built-in or require plumbing or ventilation shall be completed concurrently with the building works specified elsewhere.

All movable equipment shall be delivered to the completed laboratory, put into working order and tested.

11.9 MEASUREMENT AND PAYMENT

11.9.1 Precast Concrete Cover Slabs

Payment for precast concrete cover slabs will be made at the lump sum price entered in the Bill of Quantities which shall be full compensation for all materials, transport, labour and all incidental costs for completing this item in accordance with the specification, the Drawings and to the approval of the Engineer. Payment shall specifically include the costs of designing and testing of slabs and supplying and installing steel support frames.

The following pay items shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
2.21.1	Precast Concrete Cover Slabs complete with support frames: including supply and installation	L.S.

11.9.2 Forged Steel Hooks

Measurement shall be made of the number of forged steel hooks completed in accordance with the Drawings, the specifications and to the approval of the Engineer

Payment shall made at the unit rate entered in the Bill of Quantities which shall be full compensation for all materials, transport, labour and all incidental costs for supplying, galvanizing and embedding the hooks in their supporting structural concrete all in accordance with the Drawings, the specification and the instructions of the Engineer.

The following pay items shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
2.21.5	Forged Steel Hook: including supply and installation	No.

11.9.3 Overflow Weirs

Payment for overflow weirs will be made at the lump sum price entered in the Bill of Quantities which shall be full compensation for all materials, transport, labour and all incidental costs for completing the weirs accordance with the specification, the Drawings and to the approval of the Engineer.

The following pay items shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
2.21.2	Overflow Weir: including supply and installation	L.S.

11.9.4 Stop Logs

Payment for stop logs will be made at the lump sum price entered in the Bill of Quantities which shall be full compensation for all materials, transport, labour and all incidental costs for furnishing all of the stop logs complete with all of the specified accessories in accordance with the specification, the Drawings and to the approval of the Engineer.

The following pay items shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
2.21.3	Stop Logs: including supply and installation	L.S.

11.9.5 Sky Lights

Payment for sky lights will be made at the lump sum price entered in the Bill of Quantities which shall be full compensation for all materials, transport, labour and all incidental costs for furnishing and installing skylights in accordance with the specification, the Drawings and to the approval of the Engineer.

The following pay items shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
2.21.4	Sky Lights: including supply and installation	L.S.

11.9.6 Tar Epoxy Resin Coating

Measurement shall be made of the surface area coated in accordance with the Drawings, the specifications and to the approval of the Engineer

Payment shall made at the unit rate entered in the Bill of Quantities which shall be full compensation for all materials, transport, labour and all incidental costs for supplying the materials, preparing the surface for coating, applying the coatings and testing, all in accordance with the Drawings, the specification and the instructions of the Engineer.

The following pay items shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
2.4.10 2.5.11 2.12.10 2.13.10	Tar Epoxy Resin Coating: including surface preparation and application of 3 coats	m^2

11.9.7 Laboratory Equipment

Payment for laboratory equipment shall be made at the Lump Sum price entered in the Bill of Quantities which shall be full compensation for supplying, installing, making operational and testing of all of the items listed, and to the specified requirement stated, in Clause 11.8. The price shall include the price of constructing and fitting of fixed items such as draft chamber and sinks. However, built-in plumbing and electrical connections for the equipment shall be included in the prices for building works specified elsewhere.

The following pay items shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
2.21.6	Laboratory Equipment	L.S.

SECTION 12. MECHANICAL WORKS
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SECTION 12. MECHANICAL WORKS

12.1 GENERAL

This section covers the requirements for the mechanical works for the Wastewater Treatment Plant to be completed by the Contractor. It also includes requirements for minor items in the conveyance sewer.

This Specification for mechanical works is structured as follows:

- General Specification for Mechanical Works, Clause 12.2
- Particular Specification for Mechanical Works, Clauses 12.3 to 12.18
- Standard Specification for Mechanical Works, Appendix to Section 12.

This section shall also be read in conjunction with Section 1: General Specification.

The term “equipment” shall have the same meaning as “Plant” as defined in the General Conditions of Contract.

12.1.1 Scope of Work

The Mechanical Works defined in this section covers the mechanical portion of the wastewater treatment plant, and includes the engineering and design, procurement of the equipment and materials, fabrication of the structures which are not included in the civil and building works, shop inspection and testing, shipping and transportation to the site, erection and installation at site, field inspection and testing, training of operators and maintenance staff, commissioning and operational testing, for the following:

- Grit Chamber Equipment
- Lift Pump Equipment
- Distribution Tank Equipment
- Blower Equipment
- Primary Sedimentation Tank Equipment
- Aeration Tank Equipment
- Final Sedimentation Tank Equipment
- Disinfection Equipment
- Treated Water Supply Equipment
- Filtered Water Supply Equipment
- Gravity Thickening Equipment
- Centrifugal Thickening Equipment
- Sludge Dewatering Equipment
- Recycle Flow Equipment
- Compost Facility Equipment
- Piping
- Others as specified hereunder

The wastewater treatment plant shall produce effluent water meeting the minimum requirements of BOD_5 50 mg/l and SS 100 mg/l.

Note: Electrical works specified in the Section 13: Electrical Works, are not included in the scope of Mechanical Work.

12.1.2 Clarification

The Contractor shall understand and verify all the Specifications and Drawings, and shall develop all the Specifications and Drawings together with the information from the vendors from whom the Contractor will procure the equipment and materials, and the local condition with which the Contractor shall be familiar.

However, any discrepancy between the documents and such development shall be notified to the Engineer for Engineer's clarification and approval.

12.2 GENERAL SPECIFICATION FOR MECHANICAL WORKS

12.2.1 Applicable Codes and Standards

All materials to be furnished and tests to be carried out under the Contract shall conform to the following standards as applicable.

(a) Japanese Industrial Standard (JIS)
(b) International Standard Organization (ISO)
(c) American National Standards Institute (ANSI)
(d) British Standards Institution (BS)
(e) Vietnam Standard (TCVN)

Other international standards may be accepted, provided that the requirements therein are equivalent to the latest issue of the relevant Japanese Industrial Standard (JIS). If the Contractor proposes an equivalent standard the Contractor shall state the exact nature of the differences between the proposed standard and the Japanese Industrial Standard and shall submit the complete standard, and the information and data on the materials in English for the Engineer's approval.

If no standard is indicated, then the relevant Japanese Industrial Standard shall apply.

12.2.2 Design

The design, dimension and materials of all parts shall be such that they will not suffer damage under the most adverse conditions nor result in deflections and vibrations, which might adversely affect the operation of the equipment. Mechanisms shall be so constructed to avoid sticking due to rust or corrosion.

The Contractor shall design the equipment in careful consideration of the tropical climate and shall also pay attention both to the optimum material selection and to the construction in order to ensure their long reliable service life and efficient operation.

All parts which will have to be dismantled or which might have to be dismantled, for purposes of servicing or replacement shall be fastened with non-corrosive fasteners. The type, material and size of all fasteners shall be selected to safely withstand the maximum superimposed direct, alternating, kinetic and thermal loads and all load induced by workmen when installing or removing the fasteners during the life of the equipment.

The design shall be such that the installation, replacement and general maintenance may be undertaken with the minimum of time and expense. The tolerances used for dimensions and finishes shall be selected with due consideration to the particular properties and functions of the parts and the corresponding accuracy to obtain proper operation and tight sealing.

Wherever possible, the parts of the same material and dimension including spare parts shall be made interchangeable. Such parts shall be of the same materials and workmanship and shall be constructed to such tolerances as to enable substitutions or replacement of spare parts to be made easily and quickly.

Suitable structural steel bases or frames shall be provided where necessary to transmit to the concrete foundations all loads imposed by the various parts of the Plant. Such bases or frames shall be supplied complete with suitable anchor bolts and shall be so proportioned that the bearing loads imposed in the concrete foundations shall not exceed 5MPa (50 kg/cm^2)

The wastewater treatment plant shall be designed to minimize the risk of fire and consequential damage, to prevent ingress of vermin, dust and dirt, and accidental contact with electrically energized or moving parts. It shall be capable of continuous operation with minimum attention and maintenance in the exceptionally severe conditions likely to occur in the Site.

12.2.3 Materials

Materials for the equipment shall be used as specified in the Particular Specifications (Clauses 12.2 to 12.18) and in the Standard Specification for Mechanical Works appended. However, materials, which are not specified in the Particular Specifications or the Standard Specifications, shall be selected from the materials listed below. The materials shall meet with the requirements of the Japanese industrial standards (JIS) or equivalent.

Material list

(1)	Cast Iron	FC 200 ~ 250
(2)	Ductile Iron	FCD 400 – 15 ~ 600 - 3
(3)	Carbon Steel Castings	SC 450 ~ 480
(4)	Carbon Steel Forgings	SF 440 ~ 540
(5)	Bronze Castings	CAC 402 ~ 406
(6)	Shape steel, Steel plate	SS 400
(7)	Bronze Castings	PBC 2 – 3
(8)	Shaft, Key , etc	S30C ~ S50C
		SUS 304 or SUS 403
(9)	Bolts, Nuts in general	S25C
		SS400
		FCD 400 – 15
		FCD 400 – 10
(10)	Foundation Bolts,	SUS304
(11)	Phosphor Brass, Bolts, Nuts	BS BM – 1
(12)	Rivets	SV400

12.2.4 Equipment

(a) The equipment shall be designed and fabricated in accordance with the Particular Specifications, Standard Specifications and the Contract Drawings.

(b) Bearings shall be designed to meet with the conditions of the equipment in which the bearings are to be applied, and to be high quality and high accuracy.

(c) Welding.

(i) In general, the joints of the steel shall be arc-welded. For special case, riveting or bolting may be allowed.

(ii) For joints requiring high strength such as air-tight parts, foundation bases, bearings, etc., the joints of the steel shall be continuously welded. Where the joints do not require high strength, continuous welding is not required.

(iii) The size and materials of the welding rods shall meet with specification of the base metal to be welded. During the welding work, caution shall be taken on monitoring and controlling electrical current, voltage, welding speed, in order to avoid defects of the welding.

(iv) During welding, the fillet length, excess metal and intermittent welding length shall meet with specifications for the requirement of the base metal.

(v) The welder shall be skilled. If the welding work is required under some regulation, the welder shall be qualified by such regulation.

(vi) After welding, inspection shall be done, to check for the presence of any crack, pin–hole, overlap, end–cut, insufficient welding thickness. Excess metal, slugs, spatter, etc. shall be repaired by grinding to remove such defects

(vii) Welding condition shall be kept safe, to protect the workers against electrical short circuit, electrical shock, fire, etc…

(d) Gears

Gears for shall be made and finished by advanced machinery cutting.

(e) Lubricating system shall be designed to meet with the required operation such as rotating speed, load, etc.

Valves and piping shall be fitted and arranged in the lubricating system in order to fill and withdraw the oil easily

(f) Match marks must be applied to the parts that need to take care for furnishing or assembly for easy assembly or disassembly.

12.2.5 Foundation of Mechanical Equipment

Foundation of mechanical equipment shall be executed by the Contractor under his obligation for completion of civil work. All necessary information for the foundations such as detail dimensions, anchor holes, insert steel, loading conditions, and etc, shall be obtained from the equipment suppliers and the Contractor shall take these into account when constructing the civil works.

12.2.6 Erection of equipment

(a) The equipment shall be located so as to ensure the easy monitoring, operation and maintenance. If required, necessary measures shall be taken to keep the safety.

(b) The Contractor shall include the cost for the temporary works in his price for installation and the cost for the works needed for temporary movement and restoration of structure when necessary.

(c) The Contractor shall submit the erection procedure of the heavy and/or large equipment, including time schedule, method of entrance into the site and the building, method of erection, etc. to the Engineer. The work shall proceeds after the Engineer's approval.

(d) Before setting the equipment

The Contractor shall check the location of the equipment on the foundation with the Engineer carefully and after setting out, confirm the Engineer and install with accuracy.

(e) After setting the equipment

On the foundation, equipment shall be set and adjusted at vertically and horizontally correct position using steel wedge and/or steel liner, within the correct tolerances shown on the drawing.

After adjustment of the equipment, the Contractor shall submit the inspection report of the major equipment to the Engineer for record.

(f) Before setting the equipment with the anchor bolts, the concrete foundation shall be cured for enough period.

(g) The rotating machinery shall be set in correct alignment without causing any noise and vibration

(h) Double nuts and/or spring washer shall be used for the equipment of which vibration or expansion/stress may cause nuts to loosen.

12.2.7 Finishing of Foundation

Cement mortar screeds, as specified in the Specification for civil works shall be applied following the installation of equipment in the following locations:

- All mechanical equipment foundation
- All piping support foundation
- Bottom floor for primary sedimentation tank, Final sedimentation tank & gravity thickener.

12.2.8 Piping works

12.2.8.1 General

All pipes used in the works shall be in accordance with the following table unless otherwise specified.

TYPE	CAST IRON PIPE	STEEL PIPE		STEEL PIPE WITH LINING	STAIN-LESS PIPE	COPP-ER PIPE	VINYL PIPE		
JIS symbol	DCIP	SGPW	STPY	SGPFVA	SUS304	Cut	HIVP	VP	VU
Sewage pipe	°				°				
Grit pipe	°	°			°				
Floor drainage pipe		°			°		°	°	
Drainage pipe		°			°		°	°	
Raw sludge pipe	°	°			°			°	
Return sludge pipe	° >350$^{\phi}$	°			°			°	
Excess sludge pipe	°	°			°			°	
Scum pipe		°			°			°	
Air pipe		°	°		°				
Treated water pipe		°			°				
Anti-foaming pipe		°			°				

Filtered water pipe		°			°				
Thickener effluent pipe	°	°			°			°	
Mixed sludge pipe	°	°			°				°
Overflow pipe		°			°		°	°	
Polymer feed pipe				°			°	°	
Sodium hypo-chlorite pipe				°			°	°	

Note) ---Recommended, °---Subject to the Engineer's approval

All necessary studs, bolts, screws, nuts, washers, gaskets, packings, supports, etc., required in connection with the field assembly of the piping system shall be supplied by the Contractor. All gaskets and packings shall be of approved material and of a type that has proved satisfactory for the service of the piping. 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 during concrete placement. Pipe supports to be embedded in concrete shall be made of the material, which will not deteriorate, weaken or cause damage to the pipe.

12.2.8.2 Pipe installation

(a) The piping shall be installed on route and layout as shown on the contract Drawings, in general.

The contractor shall prepare the detailed construction and fabrication piping drawings, following up with the requirements mentioned below.

(i) Piping shall be arranged neatly and run the route near the floor level in general. Contractor shall consider the space for future pipe installation work.

(ii) Inspection and maintenance space for the piping shall be considered.

(iii) Contractor shall design the walkways for the operator and maintenance worker to access easily for operation monitor, inspection and maintenance.

(iv) The piping must be easily disassembled and removed for test and inspection if required.

(v) The supports for piping and valves shall not be taken from the equipment to avoid damage to the equipment, in general.

(b) Piping support.

(i) Piping support shall be designed so as to be rigid structure together with pipe and support.

Support of heavy valves, etc… shall be designed to support such equipment independently as possible.

(ii) Interval between supports on straight piping shall be within 3m. However, in case of air piping only installed, the interval between supports of air piping shall be within 4m for air pipe size 350mm ~ 600mm dia, and for air pipe size over 650mm dia to be within 5m.

(c) Flexible tube and expansion joints.

(i) In piping made of cast iron and steel, the flexible tube shall be inserted at the joints of building wall, if required.

(ii) The expansion joints shall be used on the piping that cause large expansion and shrinkage due to the thermal change, in order to reduce the piping stress.

(d) Piping pass through the wall

(i) Insert pipe where piping run through the wall, shall be supplied by the contractor under his obligations for mechanical works.

Where the water-proof required, the water-stop-plates shall be installed to avoid leakage.

(ii) The concrete mortar shall be filled to the clearance at the place where piping run through the wall hole, after installation of piping.

For protection against water leakage, water-proof-mortar shall be filled in to both sides of wall.

If required the flanges shall be provided at both sides of the wall for easy maintenance.

(iii) In the fire protection area, the wall passing clearance shall be filled with non–combustible materials.

(e) If required, vent valves and/or drain valves shall be provided on the piping where the air or drains are accumulated, at such place as top of piping or bottom of piping.

(f) Piping shall be installed in order not to cause stress. For the bending and cutting of the piping, care shall be taken without crack, stress, damage on the piping. After the fabrication of piping, foreign materials such as soil, sand shall be removed and cleaned from inside of the piping.

(g) The piping shall have any slope to waste water easily by gravity, if required. Also sampling connection shall be installed on the piping, if required.

12.2.8.3 Test of piping system

The Contractor shall test all piping after installation and shall supply all labour, material, pumps, plugs, gauges, etc., required to make the complete test. Piping lines shall be tested in convenient section by section if required for easy control of work volume of testing. In the case of failure found during the test such as material defect or leaks, Contractor shall repair such defect and leaks, replacing the faulty parts if required, and retest the piping until the test results satisfied. Test reports shall be submitted to the Engineer.

Before testing, all anchor blocks, thrust supports, and hangers shall be set in place. If piping is tested in section-by-section, temporary end caps shall be fitted if required. Each section piping shall be slowly filled with the test medium, care being taken to expel all air from the piping if liquid is used. The test pressure shall remain constant for the period without pressure-up during the test. If the pressure reduce during the test, that means there is the defect on the piping and shall be rectified. And the pipeline shall be tested again until loss of pressure is not recognized. The expansion joint and pressure gauge shall not be hydraulic-tested with pipe.

12.2.8.4 Test pressure

The piping shall be tested with the following test pressure:

(a) Piping subject to water pressure:

Test pressure to be 2 times of the total lift head of pumps for a testing period of 10 minutes

(b) Piping subject to air pressure:

Test pressure to be 1.1 times of maximum design pressure for a testing period of 10 minutes

All pressure is shown in gauge pressure.

12.2.9 Test and Inspection of Equipment at Manufacturer's Shop

12.2.9.1 Test at the Manufacturer's Factory

Before start the fabrication of the equipment at the shop, the Contractor shall submit the time schedule for Inspection and/or test to the Engineer. Tests and/or inspection shall include, but not limited to, the items listed in the Table below.

	EQUIPMENT	TEST/INSPECTION	WITNESS	RECORD
1	Lift Pump	Performance test	yes	yes
		Dimension	yes	yes
		Hydrostatic test	no	yes
		Material	no	yes
2	Motor for Lift Pump	Temperature rise	no	yes
		Winding resistance	no	yes
		Efficiency	no	yes
		Withstand voltage	no	yes
3	Blower	Performance test	yes	yes
		Material	no	yes
4	Motor for Blower	Temperature rise	no	yes
		Winding resistance	no	yes
		Efficiency	no	yes
		Withstand Voltage	no	yes
5	Sludge scraper for Primary	Performance test	no	no
	sedimentation	Material	no	no
	Tank equipment	Dimension	yes	yes
6	Diffuser for	Performance test	no	no
	aeration	Material	no	no
	Tank equipment	Dimension	no	yes
7	Sludge scraper	Performance test	no	no
	for final sedimentation	Material	no	no
	tank equipment	Dimension	yes	yes
8	Clarifier for gravity	Performance test	no	no
	thickening	Material	no	no
	equipment	Dimension	yes	yes
9	Centrifugal thickener	No-load running test	yes	yes
	for centrifugal	Material	no	yes
	thickening equipment	Dimension	yes	yes
10	Centrifugal dehydrator	No-load running test	yes	yes
	for sludge dewatering	Material	no	yes
	equipment	Dimension	yes	yes

11	Pipes	Material	no	yes
12	Valves	Hydrostatic test	no	yes
		Dimension	no	yes
		Material	no	yes
13	Auxiliary pump	Performance test	no	yes
14	Crane	Dimension	no	yes
		Function	no	yes
15	Gate and Weir	Dimension	no	yes
		Material	no	yes
16	Mixer	Performance test	no	yes
17	Compressor	Performance test	no	yes
18	Tank – FRP	Dimension	no	yes
19	Hopper	Dimension	no	yes

During the shop test and inspection, the Contractor shall perform an operational test at the factory under simulated field operating conditions, if required.

Equipment and materials for Wastewater Treatment Plant shall be inspected and tested in accordance with the Manufacturer's Standards.

Mill sheets shall be submitted for the major parts of the equipment and materials.

12.2.9.2 Witness Inspection

The Contractor shall invite two (2) mechanical inspectors, nominated by the Engineer, for a total of twenty (20) man-days for the purpose of witnessing the tests in the suppliers' workshops.

All necessary expenses for the said inspectors including round-trip air tickets, per-diem living allowance and land transportation charges shall be borne by the Contractor and the cost of such shall be deemed to be included in the cost of the equipment being tested.

12.2.10 Coating and Painting

All metal parts shall be protected from corrosion and painted in accordance with the following specification.

All parts, other than machined parts, which will be exposed in corrosive condition after erection, shall be thoroughly cleaned, coated and/or painted according to the specification given herein..

The Contractor shall repair "at the Site" the painting on the surface of the equipment, which are damaged during transportation and installation. The Contractor shall supply painting materials, and necessary tools for such repair.

The materials of paint shall be applied using the methods and equipment recommended by the manufacturer.

12.2.10.1 Surfaces not to be painted:

The following surfaces shall not be painted:

- Surface which will be buried in concrete

- Parts made of stainless steel, bronze or brass
- Surfaces in rolling or sliding contact
- Surfaces such as gear teeth
- Wire ropes

12.2.10.2 Colours:

The Contractor shall propose a colour scheme for all items of Plant and shall submit colour chips or paint samples. A colour chip shall be included with the colour schedule, for each type of finish to be applied on the equipment, piping, structural parts, etc.. The colours of the vendor's standards are acceptable for the equipment.

12.2.10.3 Surface Preparation:

All oil, paraffin, grease and dirt shall be removed from the surfaces to be painted, using solvents and or other means. All weld splatter, slag, burrs, loose rusted mill scale and other foreign substances shall be removed by shot, sand blasting, wiring disk grinder, scraper, sand paper, or other means according to the grade of the surface preparation on the metal.

12.2.10.4 Painting Systems:

The painting systems for the various items of Plant shall comply with the minimum requirements shown the following table, in general.

Area	Equipment to be applied	Coating and painting schedule
Indoor	Equipment and materials which are not immersed in the water	One coat of anti-corrosive primer Two coats of lead sub-oxide paint Two coats of phenolic resin type paint
Outdoor	Equipment and materials which are not immersed in the water	One coat of anti-corrosive primer Two coats of lead sub-oxide paint Two coats of phenolic resin type paint
Corrosive atmospheric area	Equipment and materials which are not immersed in water but in corrosive area..	One coat of anti-corrosive primer Four coats of chlorinated rubber type paint
Submerged in water area	Equipment and materials which are immersed in the water	One coat of anti-corrosive primer Three coats of epoxy or tar epoxy paint

12.2.11 Lagging

The Contractor shall provide the lagging on the following piping by means of hot-insulation materials such as poly-styrene, urethane form, rock wool, glass wool, plastic sheet and tape, etc.:

- Hot Piping for protection of personnel not to be burn
- Hot Piping to prevent the release of the thermal heat into the room where the heat causes increasing of the higher temperature.
- Underground Piping to be protected against the corrosion.

12.2.12 Spare parts

The Contractor shall furnish the spare parts specified in the Particular Specifications. The Contractor shall recommend the spare parts used for maintaining the plant for 2 years operation. After the recommended spare parts approved by the Engineer, Contractor shall supply the recommended spare parts. Any spare parts shall be packed or treated in such a manner as to be suitably stocked in the climate condition at the Site for a period of not less than two years, and each part shall be clearly marked with its description and purpose attached on the outside of the packing.

Spare parts so provided must be delivered into the warehouse designated by the Engineer. The spare parts shall be transferred to the Employer from the Contractor and witnessed by the Engineer.

12.2.13 Special Tools

The Contractor shall supply the special tools for disassembly and assembly for the maintenance of the equipments if necessary. One set of special tools shall be provided for each machine.

12.2.14 Temporary works

The Contractor shall provide, install, control and maintain the temporary facilities required for the Mechanical work.

The Contractor shall submit detail plan of the facilities, including layout, installation schedule, and any other requirements for Engineer's approval.

If the Contractor intends to install the Temporary facilities outside of the Site, cost required for such facilities shall be borne by the Contractor, including right of way, rent of land and the like.

The Contractor shall have the responsibility to prepare and maintain the land required for the temporary facilities after the place provided. The Engineer shall approve the location of the temporary facilities proposed by the Contractor. After the completion of the mechanical work, the Contractor shall remove all of the temporary facilities from the site.

12.2.15 Training

The Contractor shall provide and carry out the technical guidance and training in the operation and maintenance services to the operation and maintenance staff designated by the Employer. The Contractor shall submit to the Engineer for approval the training program. The technical guidance and training program recommended by the Contractor shall include, but not necessarily be limited to, the following basic requirements.

(a) The period: One (1) month in total for operation staff and maintenance staff.

(b) Commencement time: Suitable time during the installation period.

(c) Subject: The Contractor shall propose training categories, for the approval of the Engineer, covering at least the following work sections:

- Technology principles in pumping system,
- Construction & function all systems and sub-systems in the wastewater treatment plant,
- Operation and maintenance of the above-mentioned systems

(d) Method: Lecture and on the job training in the Site

(e) Trainer(s): Contractor's Training expert/operation Engineer
(f) Trainees: Employer's staff shall include Mechanical Engineers, Electrical Engineers, operators and maintenance staffs.
(g) Place of training: on the Site.
(h) Program: Detailed training program shall be submitted by the Contractor for the Engineer's approval, three (3) months prior to the commencement of guidance and training.

The Contractor shall submit operation and maintenance manuals and training texts to the Engineer, two (2) months prior to the commencement of training.

12.2.16 Mechanical Completion

12.2.16.1 Test during the construction

During and after the installation of Plant and the Equipment and Facilities are mechanically completed, the Contractor shall perform the following preliminary tests step by step to ensure the accuracy of the assembly, the condition to operate under no-load and to prove the adequacy of the materials and the workmanship. Contractor shall submit the test procedures before test.

- Insulation tests and drying out of equipment, if required
- Ground continuity tests
- Circuit continuity tests
- Testing and setting up of all relays and other protective equipment
- Hydrostatic tests on the piping
- Running tests of auxiliary equipment
- Running tests of the pump, blower and motor, to check bearing operation, running clearances
- High voltage test
- Other tests required, if any.

12.2.16.2 Test at Mechanical Completion

After the above-mentioned tests have been performed, the equipment and auxiliaries adjusted and successfully completed for the mechanical run, and the Contractor and Engineer agree that the equipment, facilities and/or the Plant are able to start up, the Contractor shall perform the operational tests with assistance of Operators and Maintenance staff of Employer.

The Contractor shall make all final adjustment to the control and detection devices. The Contractor shall be responsible for the operation of the Plant during the test. All the tests shall be carried out by the instructions of the Contractor under the supervision of the Engineer.

The Contractor shall perform the operational tests shown below and confirm the function of the Wastewater Treatment Plant.

The operational tests shall be carried out after completion of tests of units and assemblies by operating the series of facilities for a definite period (time) in an overall way to confirm the working condition of interlocked operation of equipment and facilities and the function as an overall plant.

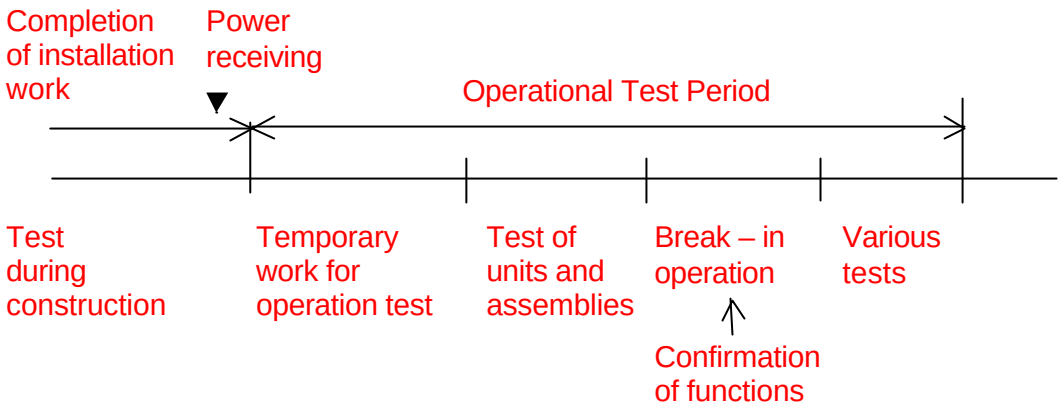
(1) The operational tests shall be carried out for the following items.
   a) Break-in operation and initial troubleshooting by continuous operation of equipment.
   b) Confirmation of plant functions by interlocked operation of equipment and facilities.

c) Guidance for the operation and maintenance services to the operation and maintenance staff designated by the Employer.

(2) The operational tests of the Wastewater Treatment Plant shall be carried out using river water. Temporary equipment for a river water intake shall be provided by the Contractor.

(3) Time of implementation

The test operation shall be implemented with the commercial power supply after completion of all installation work and completion of tests of units and assemblies, as shown in the following time line.



(4) The time of test operation shall be two (2) months.

(5) Operational Test Report

After completion of the operational test, the Contractor shall submit five (5) copies of the report of the operational test results to the Engineer for his approval.

12.2.17 Real Load Operation and Water Quality Analysis Report

After completion of the operational tests specified in the preceding clause, the Contractor shall perform real load operation of the wastewater treatment plant using sewage water from the interceptor sewer. The treatment performance by the modified activated sludge method shall be confirmed and water quality analysis shall be carried out to confirm that effluent water meets the minimum requirements for BOD_5 and suspended solids (SS) specified in Clause 12.1.1. The results of real load operation and water quality analysis shall be submitted to the Engineer for his approval.

During the real load operation period, the responsibility for operation and maintenance of the wastewater treatment will remain with the Contractor but he shall permit the Employer's operation and maintenance staff to fully participate in all operational and maintenance activities under the close supervision of the Contractor's suitably skilled and experienced personnel.

The Contractor shall prepare and submit, for the Engineer's approval, the real load operation manuals two (2) months prior to its scheduled commencement.

The real load operation shall be implemented under the following conditions:

(a) Period: Four (4) months

(b) Operation and maintenance staff of the Employer: The Contractor shall propose the required number to be involved as described above.

(c) Supervisors: The Contractor shall provide the required number of suitably skilled and experienced supervisors.

The issuance of the Taking-Over Certificate shall be subject to the completion of the real load operation test as described above and confirmation that the plant is operating in accordance with the specified requirements.

12.2.18 Operation and Maintenance Manual

At least three (3) months prior to the date of site testing and commissioning of the Wastewater Treatment Plant, the Contractor shall submit three (3) copies of the Operation and Maintenance Manual which shall contain comprehensive data for the operation and maintenance of the treatment plant in addition to comprehensive information for the operation and maintenance of each system, sub-system and individual item of Plant, for the Engineer's review and comments. Following approval by the Engineer, and within the time requirements stated in Clause 12.2.15, ten (10) copies of the final Operation and Maintenance Manual shall be submitted by the Contractor for the Employers reference.

PARTICULAR SPECIFICATION:

12.3 GRIT CHAMBER EQUIPMENT

12.3.1 Inflow Gate

12.3.1.1 Purpose of Use

This gate shall be installed at the grit chamber inlet and be used for water flowing and water sealing.

12.3.1.2 Specifications

Item	Specifications	Remarks
(1) Type	Square Gate	Outside screw type Made of cast iron
(2) Dimensions	W1500 mm x H1500 mm	
(3) Design water depth	Front: 6700 mm Rear: 0 mm	With regard to inlet bottom
(4) Lifting height	About 1.5m	
(5) Quantity	2	

12.3.1.3 Applicable Standard Specification

2.2

12.3.2 Coarse Screen

12.3.2.1 Purpose of Use

This screen shall be installed to block, and make easy to scrape up, refuse, garbage, fibre, sticks and other inclusions and coarse suspended substances contained in the influent sewage.

12.3.2.2 Specifications

Item	Specifications	Remarks
(1) Type	Bar screen	
(2) Basin dimensions	Water channel W 3500 mm x depth Ø2800 mm x 2 basins	
(3) Screen	Slit width 100 mm x mounting angle 60°	
(4) Quantity	Screen x 2	

12.3.2.3 Applicable Standard Specification

5.1

12.3.3 Chain Block

12.3.3.1 Purpose of Use

This chain block shall be used for the carry-in, carry-out, installation, assembly, maintenance and check of the equipment and apparatus installed in the building and the materials necessary therefor.

12.3.3.2 Specifications

Item	Specifications	Remarks
(1) Type	Manual type	Fixed type
(2) Rated load	1t	
(3) Lift head	3m	
(4) Quantity	1	

12.3.3.3 Applicable Standard Specification

3.4

12.4 LIFT PUMP EQUIPMENT

12.4.1 Lift Pump (1)

12.4.1.1 Purpose of Use

This pump shall be used to lift up the sewage which has been passed through the screen and removed of sand, etc.

12.4.1.2 Specifications

Item	Specifications	Remarks
(1) Type	Submerged sewage pump	
(2) Pump bore diameter	Ø700 mm	
(3) Discharge flow	66.7m m^3/min	
(4) Total lift head	14m	
(5) Motor output	220 kW	
(6) Frequency	50 Hz	
(7) Voltage	380V	
(8) Quantity	3	

12.4.1.3 Applicable Standard Specification

1.1

12.4.2 Connecting Gate

12.4.2.1 Purpose of Use

This gate shall be installed at the discharge tank and be used for connection.

12.4.2.2 Specifications

Item	Specifications	Remarks
(1) Type	Square Gate	Outside screw type Made of cast iron
(2) Dimensions	W1500 mm x H1500 mm	
(3) Design water depth	Front: 13510 mm Rear: 13510 mm	With regard to inlet bottom
(4) Lifting height	About 1.5m	
(5) Quantity	1	

12.4.2.3 Applicable Standard Specification

2.2

12.4.3 Hoist

12.4.3.1 Purpose of Use

The hoist shall be used for the carry-in, carry-out, installation, assembly, maintenance and check of the equipment and apparatus installed in the building and the materials necessary therefor, and all or part of traverse and hoist-up (hoist-down) motions shall be motor-driven.

12.4.3.2 Specifications

Item	Specifications	Remarks
(1) Type	Normal type	
(2) Rated load	10t	
(3) Lift head	12m	
(4) Power source	380V and 50 Hz	
(5) Hoist-up speed	3m/min	(Reference)
(6) Traverse speed	10m/min	(Reference)
(7) Hoisting motor	6kW	(Reference)
(8) Traversing motor	0.55kW	(Reference)
(9) Quantity	1	

12.4.3.3 Applicable Standard Specification

3.3

12.4.4 Floor Drainage Pump

12.4.4.1 Purpose of Use

This pump shall be used to lift up the wastewater collected in the floor drainage pit.

12.4.4.2 Specifications

Item	Specifications	Remarks
(1) Type	Submerged wastewater pump	
(2) Discharge bore diameter	Ø65 mm	
(3) Discharge flow	0.3 m^3/min	
(4) Lift head	10m	
(5) Motor	2.2 kW x 380V x 50 Hz	
(6) Quantity	14	

12.4.4.3 Applicable Standard Specification

1.4

12.5 DISTRIBUTION TANK EQUIPMENT

12.5.1 Distribution Weir

12.5.1.1 Purpose of Use

This movable weir shall be used to control, as necessary, the quantity of sewage flowing into each train of the water treatment facility.

12.5.1.2 Specifications

Item	Specifications	Remarks
(1) Type	Movable Weir	Outside screw type Made of cast iron
(2) Dimensions	W1000 mm x H1000 mm	
(3) Design water depth	Front: 1000 mm Rear: 0 mm	With regard to inlet bottom
(4) Lift head	About 1.0m	
(5) Quantity	4	

12.5.1.3 Applicable Standard Specification

2.3

12.6 BLOWER EQUIPMENT

12.6.1 Blower (1)

12.6.1.1 Purpose of Use

This blower shall be installed to perform advanced treatment of sewage by aeration.

12.6.1.2 Specifications

(a) Blower

Item	Specifications	Remarks
(1) Type	Gear-accelerated single-stage turbo blower	
(2) Gas handled	Air	
(3) Connection bore diameter	Suction side Ø600 mm Discharge side Ø500mm	
(4) Air flow	360 m^3/min (30^0C, 101.3 kPa (1atm), 90% RH)	
(5) Suction air temperature	Min. 21^0C, max. 33.4^0C	
(6) Pressure	Suction -1.96 kPa (-200 mmAq) Discharge 66.6 kPa (6800mmAq) (30^0C, 90% RH)	
(7) Quantity	2	
(8) Overall adiabatic efficiency	77% min.	

(b) Lubricating oil cooler (individual oil supply)

Item	Specifications	Remarks
(1) Cooling water flow	About 140 L/min	
(2) Cooling water temperature difference	About 4^0C	
(3) Cooling water kind and quality	Sand filtered water	
(4) Cooling water pressure	50 kPa	

12.6.1.3 Applicable Standard Specification

4.1

Motor for Blower (1)

12.6.1.4 Purpose of Use

This motor shall be used to drive the blower for air sending.

12.6.1.5 Specifications

Item	Specifications	Remarks
(1) Type	Horizontal shaft 3-phase induction motor	Wound rotor type
(2) Output	480 kW	
(3) Voltage	3300V	
(4) Frequency	50 Hz	
(5) Quantity	2	

12.6.1.6 Spare Parts (per Unit)

(1) Brush For 1 unit

(2) Bearing For 1 unit

12.6.2 Discharge Valve (1)

12.6.2.1 Purpose of Use

This discharge valve shall be installed on the blower discharge side to keep air-tightness when closed.

12.6.2.2 Specifications

Item	Specifications	Remarks
(1) Type	Motor-operated, outside screw, sluice valve	
(2) Bore diameter	Ø500 mm	
(3) Motor	0.75 kW x 3Ø x 380V x 50 Hz	
(4) Quantity	2	

12.6.2.3 Applicable Standard Specification

2.1

12.6.3 Check Valve (1)

12.6.3.1 Purpose of Use

This check valve shall be installed in the blower discharge side piping.

12.6.3.2 Specifications

Item	Specifications	Remarks
(1) Type	Swing type	
(2) Bore diameter	Ø500 mm	
(3) Quantity	2	

12.6.3.3 Applicable Standard Specification

2.1

12.6.4 Air Filter

12.6.4.1 Purpose of Use

This filter shall be used to reduce clogging of the diffuser.

12.6.4.2 Specifications

Item	Specifications	Remarks
(1) Type	Streaming dry type air filter	
(2) Treated air volume	360 m^3/min	
(3) Motor	0.2 kW x 3 Ø x 380 V x 50 Hz	
(4) Quantity	2	

12.6.4.3 Spare Parts (common for all Units)

(1) Filter media cartridge For 2 units

12.6.5 Crane

12.6.5.1 Purpose of Use

This overhead crane system shall be installed in the building of blower equipment and as all or part of traverse, travel and hoist-up (hoist-down) motions shall be motor-driven, shall be used for the installation, assembly, maintenance and check of blowers and other equipment and apparatus.

12.6.5.2 Specifications

Item	Specifications	Remarks
(1) Rated load	10t	
(2) Lift head	14m	
(3) Power source	380V and 50 Hz	
(4) Hoisting speed	2.5 m/min	(Reference)
(5) Traversing speed	8.3 m/min	(Reference)
(6) Travelling speed	20 m/min	(Reference)
(7) Hoisting motor	6 kW	(Reference)
(8) Traversing motor	0.55 kW	(Reference)
(9) Travelling motor	0.75 kW x 2	(Reference)
(10) Span	About 14.6m	
(11) Quantity	1	

12.6.5.3 Applicable Standard Specification

3.1

12.6.6 Floor Drainage Pump

12.6.6.1 Purpose of Use

This pump shall be used to lift up the wastewater collected in the floor drainage pit.

12.6.6.2 Applicable Standard Specification

Item	Specifications	Remarks
(1) Type	Submerged wastewater pump	
(2) Discharge bore diameter	Ø 65 mm	
(3) Discharge flow	0.3m m^3/min	
(4) Lift head	10m	
(5) Motor	2.2 kW x 380V x 50 Hz	
(6) Quantity	2	

12.6.6.3 Applicable Standard Specification

1.4

12.7 PRIMARY SEDIMENTATION TANK EQUIPMENT

12.7.1 Inflow Weir

12.7.1.1 Purpose of Use

This movable weir shall be used to control, as necessary, the quantity of sewage flowing into the primary sedimentation tank.

12.7.1.2 Specifications

Item	Specifications	Remarks
(1) Type	Movable Weir	Outside screw type Made of cast iron
(2) Dimensions	W500 mm x H400 mm	
(3) Design water depth	Front: 0 mm Rear: 400 mm	With regard to inlet bottom
(4) Lift head	About 0.4m	
(5) Quantity	10	

12.7.1.3 Applicable Standard Specification

2.3

12.7.2 Bypass Gate

12.7.2.1 Purpose of Use

This gate shall be used to control, as necessary, the quantity of sewage flowing into the primary sedimentation tank.

12.7.2.2 Specifications

Item	Specifications	Remarks
(1) Type	Square Gate	Outside screw type Made of cast iron
(2) Dimensions	W1000 mm x H1000 mm	
(3) Design water depth	Front: 3100 mm Rear: 0 mm	With regard to inlet bottom (square)
(4) Lift head	About 1.0m	
(5) Quantity	1	

12.7.2.3 Applicable Standard Specification

2.2

12.7.3 Sludge Scraper

12.7.3.1 Purpose of Use

This sludge scraper shall be used to scrape the sludge settled in the primary sedimentation tank into the hopper provided by the side of the tank.

12.7.3.2 Specifications

Item	Specifications	Remarks
(1) Type	Chain flight type	
(2) Tank dimensions	W5000 mm x L13000 mm x water depth 3000 mm	Dimensions of one basin
(3) Scraping speed	About 0.6 m/min	
(4) Motor	1.5 kW	(Reference)
(5) Power source	380V x 50 Hz	
(6) Drive system	2-Tank 1-drive	
(7) Quantity	10	

12.7.3.3 Applicable Standard Specification

6.1

12.7.4 Scum Skimmer

12.7.4.1 Purpose of Use

This skimmer shall be used to remove scum produced on the water surface in the primary sedimentation basin.

12.7.4.2 Specifications

Item	Specifications	Remarks
(1) Type	Manual pipe skimmer	Lever type
(2) Skimmer dimensions	Ø 300 mm x about L4500 mm	
(3) Operation method	Manual	
(4) Quantity	20	

12.7.4.3 Applicable Standard Specifications

7.1

12.7.5 Scum Pump

12.7.5.1 Purpose of Use

This pump shall be used to transfer the scum from the scum pit into the distribution tank.

12.7.5.2 Specifications

Item	Specifications	Remarks
(1) Type	Non-clogging type	
(2) Suction bore diameter	Ø 80 mm	
(3) Discharge flow	0.8 m^3/min	
(4) Total lift head	10m	
(5) Motor output	5.5 kW	
(6) Power source	380V x 50 Hz	
(7) Quantity	2	

12.7.5.3 Applicable Standard Specification

1.2

12.7.6 Raw Sludge Pump

12.7.6.1 Purpose of Use

This pump shall be used to transfer the raw sludge into the gravity thickening equipment.

12.7.6.2 Specifications

Item	Specifications	Remarks
(1) Type	Non-clogging type	
(2) Suction bore diameter	Ø 80 mm	
(3) Discharge flow	0.5 m^3/min	
(4) Total lift head	14m	
(5) Motor output	5.5 kW	
(6) Power source	380V x 50 Hz	
(7) Quantity	3	

12.7.6.3 Applicable Standard Specification

1.2

12.7.7 Raw Sludge Valve

12.7.7.1 Purpose of Use

This valve shall be mounted to the raw sludge pipe and shall open and close in the automatic operation of the raw sludge pump.

12.7.7.2 Specifications

Item	Specifications	Remarks
(1) Type	Motor-operated sluice valve	
(2) Bore diameter	Ø150 mm	
(3) Normal working pressure	0.14 MPa	Pump discharge pressure
(4) Motor output	0.2 kW	
(5) Power source	380V x 50 Hz	
(6) Quantity	10	

12.7.7.3 Applicable Standard Specification

2.1

12.7.8 Comminuter

12.7.8.1 Purpose of Use

This comminuter shall be installed in the sludge piping to comminute inclusions contained in the sludge so as to prevent clogging of the centrifugal dehydrator.

12.7.8.2 Specifications

Item	Specifications	Remarks
(1) Type	Vertical 2-axis rotation type	
(2) Treated water flow	1.0 m^3/min	
(3) Drive unit	3ö x 0.75 kW x 380V x 50 Hz	Motor
(4) Quantity	1	

12.7.8.3 Applicable Standard Specification

5.2

12.8 AERATION TANK EQUIPMENT

12.8.1 Inflow Weir

12.8.1.1 Purpose of Use

This movable weir shall be used to control, as necessary, the quantity of sewage flowing into the aeration tank.

12.8.1.2 Specifications

Item	Specifications	Remarks
(1) Type	Movable Weir	Outside screw type Made of cast iron
(2) Dimensions	W500 mm x H500 mm	
(3) Design water depth	Front: 0 mm Rear: 500 mm	With regard to inlet bottom
(4) Lift head	About 0.5m	
(5) Quantity	10	

12.8.1.3 Applicable Standard Specification

2.3

12.8.2 Step Feeding Weir

12.8.2.1 Purpose of Use

This movable weir shall be used to control, as necessary, the quantity of sewage flowing into the aeration tank.

12.8.2.2 Specifications

Item	Specifications	Remarks
(1) Type	Movable Weir	Outside screw type Made of cast iron
(2) Dimensions	W500 mm x H500 mm	
(3) Design water depth	Front: 0 mm Rear: 500 mm	With regard to inlet bottom
(4) Lift head	About 0.5m	
(5) Quantity	30	

12.8.2.3 Applicable Standard Specification

2.3

12.8.3 Diffuser

12.8.3.1 Purpose of Use

This diffuser shall be used to make aeration for the sewage treatment in the aeration tank.

12.8.3.2 Specifications

Diffuser (1)

Item	Specifications	Remarks
(1) Type	Diffuser tube	
(2) Standard air flow	120 to 150 L/min • tube	
(3) Riser pipe bore diameter	100 mm(A)	
(4) Unit quantity	24 tube/header x 1 header/riser	
(5) Total quantity	20 sets	Number of riser pipes

Diffuser (2)

Item	Specifications	Remarks
(1) Type	Diffuser tube	
(2) Standard air flow	120 to 150 L/min • tube	
(3) Riser pipe bore diameter	100 mm(A)	
(4) Unit quantity	18 tube/header x 1 header/riser	
(5) Total quantity	140 sets	Number of riser pipes

12.8.3.3 Applicable Standard Specification

8.1

12.8.4 Air Flow Control Valve

12.8.4.1 Purpose of Use

This control valve shall be used for the purpose of air-tightness, flow adjustment, etc.

12.8.4.2 Specifications

Item	Specifications	Remarks
(1) Type	Motor-operated butterfly valve	
(2) Bore diameter	Ø 350 mm	
(3) Working pressure	0.07 MPa	
(4) Motor output	0.4 kW	
(5) Frequency	50 Hz	
(6) Voltage	380V	
(7) Quantity	10	

12.8.4.3 Applicable Standard Specification

2.1

12.9 FINAL SEDIMENTATION TANK EQUIPMENT

12.9.1 Inflow Gate

12.9.1.1 Purpose of Use

This gate shall be used to control, as necessary, the quantity of sewage flowing into the final sedimentation tank.

12.9.1.2 Specifications

Item	Specifications	Remarks
(1) Type	Square Gate	Outside screw type Made of cast iron
(2) Dimensions	W500 mm x H500 mm	
(3) Design water depth	Front: 1700 mm Rear: 0 mm	With regard to inlet bottom
(4) Lift head	About 0.5m	
(5) Quantity	10	

12.9.1.3 Applicable Standard Specification

2.2

12.9.2 Sludge Scraper

12.9.2.1 Purpose of Use

This sludge scraper shall be used to scrape the sludge settled in the final sedimentation tank into the hopper provided by the side of the tank.

12.9.2.2 Specifications

Item	Specifications	Remarks
(1) Type	Chain flight type	
(2) Tank dimensions	W5000 mm x L2600 mm x water depth 3500 mm	Dimensions of one basin
(3) Scraping speed	About 0.3 m/min	
(4) Motor	2.2 kW	(Reference)
(5) Power source	380V x 50 Hz	
(6) Drive system	2-tank 1-drive	
(7) Quantity	10	

12.9.2.3 Applicable Standard Specification

6.1

12.9.3 Scum Skimmer

12.9.3.1 Purpose of Use

This skimmer shall be used to remove scum produced on the water surface in the final sedimentation tank.

12.9.3.2 Specifications

Item	Specifications	Remarks
(1) Type	Manual pipe skimmer	Lever type
(2) Skimmer dimensions	Ø 300 mm x about L4500 mm	
(3) Operation method	Manual	
(4) Quantity	20	

12.9.3.3 Applicable Standard Specifications

7.1

12.9.4 Scum Pump

12.9.4.1 Purpose of Use

This pump shall be used to transfer the scum from the scum pit into the distribution tank.

12.9.4.2 Specifications

Item	Specifications	Remarks
(1) Type	Non-clogging type	
(2) Suction bore diameter	Ø 80 mm	
(3) Discharge flow	0.8 m^3/min	
(4) Total lift head	10m	
(5) Motor output	5.5 kW	
(6) Power source	380V x 50 Hz	
(7) Quantity	2	

12.9.4.3 Applicable Standard Specification

1.2

12.9.5 Return Sludge Pump (25%)

12.9.5.1 Purpose of Use

This pump shall be used to transfer the sludge from the final sedimentation tank hopper portion into the aeration tank.

12.9.5.2 Specifications

Item	Specifications	Remarks
(1) Type	Centrifugal screw impeller pump	
(2) Suction bore diameter	Ø 250 mm	
(3) Discharge flow	5.6 m^3/min	
(4) Total lift head	6m	
(5) Motor output	11 kW	
(6) Power source	380V x 50 Hz	
(7) Quantity	4	

12.9.5.3 Applicable Standard Specification

1.3

12.9.6 Return Sludge Valve

12.9.6.1 Purpose of Use

This valve shall be mounted to the return sludge pipe and shall open and close in the automatic operation of the return sludge pump.

12.9.6.2 Specifications

Item	Specifications	Remarks
(1) Type	Motor-operated sluice valve	
(2) Bore diameter	Ø 350 mm	
(3) Normal working pressure	0.06 MPa	Pump discharge pressure
(4) Motor output	0.4 kW	
(5) Power source	380V x 50 Hz	
(6) Quantity	10	

12.9.6.3 Applicable Standard Specification

2.1

12.9.7 Excess Sludge Pump

12.9.7.1 Purpose of Use

This pump shall be used to transfer the excess sludge into the excess sludge tank.

12.9.7.2 Specifications

Item	Specifications	Remarks
(1) Type	Non-clogging type	
(2) Suction bore diameter	Ø 100 mm	
(3) Discharge flow	1.2 m^3/min	
(4) Total lift head	13m	
(5) Motor output	11 kW	
(6) Power source	380V x 50 Hz	
(7) Quantity	3	

12.9.7.3 Applicable Standard Specification

1.2

12.9.8 Excess Sludge Valve

12.9.8.1 Purpose of Use

This valve shall be mounted to the excess sludge pipe and shall open and close in the automatic operation of the excess sludge pump.

12.9.8.2 Specifications

Item	Specifications	Remarks
(1) Type	Motor-operated sluice valve	
(2) Bore diameter	Ø 150 mm	
(3) Normal working pressure	0.13 MPa	Pump discharge pressure
(4) Motor output	0.2 kW	
(5) Power source	380V x 50 Hz	
(6) Quantity	10	

12.9.8.3 Applicable Standard Specification

2.1

12.9.9 Sluice Valve

12.9.9.1 Purpose of Use

This valve shall be mounted in the return sludge pump suction piping and discharge piping for water sealing, water flow adjustment, etc.

12.9.9.2 Specifications

Item	Specifications	Remarks
(1) Type	Outside screw type	
(2) Bore diameter	Ø 350 mm	
(3) Working pressure	0.06 MPa	
(4) Quantity	14	

12.9.9.3 Applicable Standard Specification

2.1

12.9.9.4 Purpose of Use

This comminuter shall be installed in the sludge piping to comminute inclusions contained in the sludge so as to prevent clogging of the centrifugal thickener.

12.9.9.5 Specifications

Item	Specifications	Remarks
(1) Type	Vertical 2-axis rotation type	
(2) Treated water flow	2.4 m^3/min	
(3) Drive unit	3 Ø x 3.7 kW x 380V x 50 Hz	Motor
(4) Quantity	1	

12.9.9.6 Applicable Standard Specification

5.2

12.9.10 Floor Drainage Pump

12.9.10.1 Purpose of Use

This pump shall be used to lift up the wastewater collected in the floor drainage pit.

12.9.10.2 Specifications

Item	Specifications	Remarks
(1) Type	Submerged wastewater pump	
(2) Discharge bore diameter	Ø 65 mm	
(3) Discharge flow	0.3 m^3/min	
(4) Lift head	10m	
(5) Motor	2.2 kW x 380V x 50 Hz	
(6) Quantity	12	

12.9.10.3 Applicable Standard Specification

1.4

12.10 DISINFECTION EQUIPMENT

12.10.1 Inflow Gate

12.10.1.1 Purpose of Use

This gate shall be used for water flowing and water sealing of the treated water into the disinfection tank.

12.10.1.2 Specifications

Item	Specifications	Remarks
(1) Type	Square Gate	Outside screw type Made of cast iron
(2) Dimensions	W2000 mm x H2000 mm	
(3) Design water depth	Front: 6230 mm Rear: 0 mm	With regard to inlet bottom
(4) Lifting height	About 2.0m	
(5) Quantity	1	

12.10.1.3 Applicable Standard Specification

2.2

12.10.2 Bypass Gate

12.10.2.1 Purpose of Use

This gate shall be used for water flowing and water sealing of the treated water into the bypass waterway.

12.10.2.2 Specifications

Item	Specifications	Remarks
(1) Type	Square Gate	Outside screw type Made of cast iron
(2) Dimensions	W2000 mm x H2000 mm	
(3) Design water depth	Front: 6230 mm Rear: 0 mm	With regard to inlet bottom
(4) Lifting height	About 2.0m	
(5) Quantity	1	

12.10.2.3 Applicable Standard Specification

2.2

12.10.3 Sodium Hypochlorite Tank

12.10.3.1 Purpose of Use

This tank shall be used for the storage of sodium hypochlorite solution.

12.10.3.2 Specifications

Item	Specifications	Remarks
(1) Type	Vertical stationary type	
(2) Liquid handled	Sodium hypochlorite 12% solution	
(3) Material	FRP (internal surface with hard vinyl chlorite plate)	
(4) Capacity	Maximum storage capacity 13 m^3	
(5) Quantity	2	

12.10.3.3 Applicable Standard Specification

9.2

12.10.3.4 Note

The chemical resistant coating in the dike shall be provided by the mechanical portion.

12.10.4 Sodium Hypochlorite Pump

12.10.4.1 Purpose of Use

This pump shall be installed to feed sodium hypochlorite into the effluent treated water in the disinfection tank for the purpose of disinfection..

12.10.4.2 Specifications

Item	Specifications	Remarks
(1) Type	Diaphragm pump	
(2) Fluid handled	Sodium hypochlorite 12% solution	
(3) Bore diameter	Suction side: 25 mm, discharge side : 25 mm	
(4) Feeding rate (max.)	0.81~1.62 L/min	
(5) Discharge pressure	0.2 MPa	
(6) Power source	380V x 50 Hz	
(7) Motor	0.4 kW	
(8) Quantity	3	

12.10.4.3 Applicable Standard Specification
9.1

12.11 TREATED WATER SUPPLY EQUIPMENT

12.11.1 Secondary Effluent Gate

12.11.1.1 Purpose of Use

This gate shall be used for water flowing and water sealing of the treated water into the secondary effluent tank.

12.11.1.2 Specifications

Item	Specifications	Remarks
(1) Type	Square Gate	Outside screw type Made of cast iron
(2) Dimensions	W1000 mm x H1000 mm	
(3) Design water depth	Front: 5500 mm Rear: 5500 mm	With regard to inlet bottom (angular)
(4) Lifting height	About 1.0m	
(5) Quantity	1	

12.11.1.3 Applicable Standard Specification
2.2

12.11.2 Treated Water Supply Pump (1)

12.11.2.1 Purpose of Use

This pump shall be used to send the treated water.

12.11.2.2 Specifications

Item	Specifications	Remarks
(1) Type	Horizontal shaft volute pump	
(2) Suction bore diameter	Ø 150 mm	
(3) Discharge flow	3.2 m^3/min	
(4) Total lift head	30m	
(5) Fluid handled	Fluid name: secondary treated water	
(6) Output	30 kW	
(7) Power source	380V x 50 Hz x 3Ø	
(8) Quantity	2	

12.11.2.3 Applicable Standard Specification

1.5

12.11.3 Treated Water Strainer (1)

12.11.3.1 Purpose of Use

This strainer shall be used to remove inclusions contained in the secondary treated water, etc. to obtain water to be used in the plant.

12.11.3.2 Specifications

Item	Specifications	Remarks
(1) Type	Automatic washing strainer	
(2) Water flow	6.4 m^3/min • unit	
(3) Motor	0.4 kW	
(4) Power source	380V x 50 Hz	
(5) Quantity	1	

12.11.3.3 Applicable Standard Specification

10.2

12.11.4 Treated Water Supply Pump (2)

12.11.4.1 Purpose of Use

This pump shall be used to send the treated water to the sludge treatment facilities.

12.11.4.2 Specifications

Item	Specifications	Remarks
(1) Type	Horizontal volute pump	
(2) Suction bore diameter	Ø 125 mm	
(3) Discharge flow	2.2 m^3/min	
(4) Total lift head	30m	
(5) Fluid handled	Fluid name: secondary treated water	
(6) Output	22 kW	
(7) Power source	380V x 50 Hz x 3ö	
(8) Quantity	2	

12.11.4.3 Applicable Standard Specification

1.5

12.11.5 Treated Water Strainer (2)

12.11.5.1 Purpose of Use

This strainer shall be used to remove inclusions contained in the secondary treated water, etc. to obtain water to be used in the plant.

12.11.5.2 Specifications

Item	Specifications	Remarks
(1) Type	Automatic washing strainer	
(2) Bore diameter	6.6 m^3/min • unit	
(3) Motor	0.4 kW	
(4) Power source	380V x 50 Hz	
(5) Quantity	1	

12.11.5.3 Applicable Standard Specification

10.2

12.11.6 Crane

12.11.6.1 Purpose of Use

This overhead crane system shall be installed in the building of pump equipment, etc. and as all of traverse, travel and hoist-up (hoist-down) motions shall be artificially operated, shall be used for the installation, assembly, maintenance and check of pumps and other equipment and apparatus.

12.11.6.2 Specifications

Item	Specifications	Remarks
(1) Rated load	2.0t	
(2) Lift head	4.5m	
(3) Span	About 6.5m	
(4) Quantity	1	

12.11.6.3 Applicable Standard Specification

3.2

12.11.7 Floor Drainage Pump

12.11.7.1 Purpose of Use

This pump shall be used to lift up the wastewater collected in the floor drainage pit.

12.11.7.2 Specifications

Item	Specifications	Remarks
(1) Type	Submerged wastewater pump	
(2) Discharge bore diameter	Ø 65 mm	
(3) Discharge flow	0.3 m^3/min	
(4) Lift head	10m	
(5) Motor	2.2 kW x 380V x 50 Hz	
(6) Quantity	8	

12.11.7.3 Applicable Standard Specification

1.4

12.12 FILTERED WATER SUPPLY EQUIPMENT

12.12.1 Filtration Supply Pump

12.12.1.1 Purpose of Use

This pump shall be used to send the treated water to the sand filter.

12.12.1.2 Specifications

Item	Specifications	Remarks
(1) Type	Horizontal shaft volute pump	
(2) Suction bore diameter	Ø 80 mm	
(3) Discharge flow	0.7 m^3/min	
(4) Total lift head	10m	
(5) Fluid handled	Fluid name: secondary treated water	
(6) Output	3.7 kW	
(7) Power source	380V x 50 Hz x 3Ø	
(8) Quantity	2	

12.12.1.3 Applicable Standard Specification

1.5

12.12.2 Filtration Supply Strainer

12.12.2.1 Purpose of Use

This strainer shall be used to remove inclusions contained in the secondary treated water, etc.

12.12.2.2 Specifications

Item	Specifications	Remarks
(1) Type	Automatic washing strainer	
(2) Water flow	0.7 m^3/min • unit	
(3) Motor	0.4 kW	
(4) Power source	380V x 50 Hz	
(5) Quantity	2	

12.12.2.3 Applicable Standard Specification

10.2

12.12.3 Sand Filter

12.12.3.1 Purpose of Use

This filter shall be used to remove inclusions contained in the secondary treated water by pressure sand filtration, to obtain water to be used in the plant.

12.12.3.2 Specifications

Item	Specifications	Remarks
(1) Type	Two-layer type pressure sand filter	
(2) Raw water flow	36 m^3/h • unit	
(3) Raw water	Secondary treated water	
(4) Quantity	2	

12.12.3.3 Applicable Standard Specification

10.1

12.12.4 Filtered Water Supply Pump

12.12.4.1 Purpose of Use

This pump shall be used to send the sand filtered water.

12.12.4.2 Specifications

Item	Specifications	Remarks
(1) Type	Horizontal shaft volute pump	
(2) Suction bore diameter	Ø80 mm	
(3) Discharge flow	1.0 m^3/min	
(4) Total lift head	30m	
(5) Fluid handled	Fluid name: sand filtered water	
(6) Output	11 kW	
(7) Power source	380V x 50 Hz x 3Ø	
(8) Quantity	2	

12.12.4.3 Applicable Standard Specification

1.5

12.12.5 Backwash Pump

12.12.5.1 Purpose of Use

This pump shall be used for the backwash of the sand filter.

12.12.5.2 Specifications

Item	Specifications	Remarks
(1) Type	Horizontal shaft volute pump	
(2) Suction bore diameter	Ø125 mm	
(3) Discharge flow	2.7 m^3/min	
(4) Total lift head	10 m	
(5) Fluid handled	Fluid name: sand filtered Water	
(6) Output	7.5 kW	
(7) Power source	380V x 50 Hz x 3Ø	
(6) Quantity	2	

12.12.5.3 Applicable Standard Specification

1.5

12.12.6 Air Wash Blower

12.12.6.1 Purpose of Use

This blower shall be used for the air wash of the sand filter.

12.12.6.2 Specifications

Item	Specifications	Remarks
(1) Type	Roots blower	
(2) Gas handled	Air	
(3) Connection bore diameter	Discharge side Ø100 mm	
(4) Air flow	4.5 m^3/min (30°C, 101.3 kPa (1 atm), 90% RH)	
(5) Suction air temperature	Min. 21°C, max. 33.4°C	
(6) Pressure	Suction -1.47 kPa (-150 mmAq) Discharge 44.1 kPa (4500 mmAq) (30°C, 90% RH)	
(7) Motor	7.5 kW x 3Ø x 380V x 50 Hz	
(8) Quantity	2	

12.12.6.3 Applicable Standard Specification

4.2

12.12.7 Backwash Wastewater Pump

12.12.7.1 Purpose of Use

This pump shall be used to send the backwash wastewater.

12.12.7.2 Specifications

Item	Specifications	Remarks
(1) Type	Non-clogging type	
(2) Suction bore diameter	Ø80 mm	
(3) Discharge flow	0.4 m^3/min	
(4) Total lift head	10m	
(5) Fluid handled	Fluid name: backwash Wastewater	
(6) Output	3.7 kW	
(7) Power source	380V x 50 Hz x 3Ø	
(8) Quantity	2	

12.12.7.3 Applicable Standard Specification

1.2

12.12.8 Air Compressor

12.12.8.1 Purpose of Use

This air compressor shall be used for the air-operated valves and others.

12.12.8.2 Specifications

Item	Specifications	Remarks
(1) Type	Transportable small-size air compressor	
(2) Delivery air flow	400 L/min	At normal working pressure
(3) Normal working pressure	0.83 MPa	
(4) Output	3.7 kW	
(5) Power source	380V x 50 Hz x 3Ø	
(6) Quantity	2	

12.12.8.3 Applicable Standard Specification

4.3

12.12.9 Dehumidifier

12.12.9.1 Purpose of Use

This dehumidifier shall be used to remove the humidity contained in the instrumentation compressed air so as to obtain dry air.

12.12.9.2 Specifications

Item	Specifications	Remarks
(1) Type	Refrigeration type	
(2) Air flow	400 L/min	At normal working pressure
(3) Normal working pressure	0.83 MPa	
(4) Motor output	About 0.25 kW	
(5) Power source	220V x 50 Hz x 1Ø	
(6) Quantity	1	

11.9.3 Standard Accessories (per Unit)

(1) Auto drain trap x 1set

(2) Mounting bolt and nut x 1set

12.13 GRAVITY THICKENING EQUIPMENT

12.13.1 Gravity Thickener

12.13.1.1 Purpose of Use

This thickener shall be used to thicken the sludge, etc. by allowing the solids contained in the sludge to settle due to the difference of specific gravity by making use of gravity.

12.13.1.2 Specifications

Item	Specifications	Remarks
(1) Type	Centre-driven suspended type	
(2) Tank dimensions	Ø14000 mm x side water depth 3500 mm	
(3) Peripheral speed	About 2 to 3 m/min	
(4) Motor output	1.5 kW	
(5) Power source	380 V x 50 Hz	
(6) Quantity	1	

12.13.1.3 Applicable Standard Specification

6.2

12.13.2 Scum Skimmer

12.13.2.1 Purpose of Use

This skimmer shall be used to remove scum produced on the water surface in the gravity thickener

12.13.2.2 Specifications

Item	Specifications	Remarks
(1) Type	Manual pipe skimmer	
(2) Skimmer pipe bore diameter	Ø250 mm	
(3) Operation method	Manual (lever type)	
(4) Quantity	1	

12.13.2.3 Applicable Standard Specification

7.2

12.13.3 Thickened Sludge Pump

12.13.3.1 Purpose of Use

This pump shall be used to transfer the sludge from the gravity thickener into the mixed sludge tank.

12.13.3.2 Specifications

Item	Specifications	Remarks
(1) Type	Non-clogging type	
(2) Suction bore diameter	Ø80 mm	
(3) Discharge flow	0.7 m^3/min	
(4) Total lift head	10m	
(5) Motor output	5.5 kW	
(6) Power source	380V x 50 Hz	
(7) Quantity	2	

12.13.3.3 Applicable Standard Specification

1.2

12.13.4 Thickener Effluent Pump

12.13.4.1 Purpose of Use

This pump shall be used to transfer the thickener effluent from the thickener effluent tank into the pump well.

12.13.4.2 Specifications

Item	Specifications	Remarks
(1) Type	Non-clogging type	
(2) Suction bore diameter	Ø80 mm	
(3) Discharge flow	0.4 m^3/min	
(4) Total lift head	15m	
(5) Motor output	5.5 kW	
(6) Power source	380V x 50 Hz	
(7) Quantity	2	

12.13.4.3 Applicable Standard Specification

1.2

12.13.5 Floor Drainage Pump

12.13.5.1 Purpose of Use

This pump shall be used to lift up the wastewater collected in the floor drainage pit.

12.13.5.2 Specifications

Item	Specifications	Remarks
(1) Type	Submerged wastewater pump	
(2) Discharge bore diameter	Ø65 mm	
(3) Discharge flow	0.3 m^3/min	
(4) Lift head	10m	
(5) Motor	2.2 kW x 380V x 50 Hz	
(6) Quantity	2	

12.13.5.3 Applicable Standard Specification

1.4

12.14 CENTRIFUGAL THICKENING EQUIPMENT

12.14.1 Excess Sludge Mixer

12.14.1.1 Purpose of Use

This mixer shall be used for the mechanical agitation to prevent sludge settling in the excess sludge tank.

12.14.1.2 Specifications

Item	Specifications	Remarks
(1) Type	Vertical mixer	
(2) Fluid	Kind of sludge: excess sludge concentration: about 0.6%	
(3) Capacity	Maximum storage capacity 208 m^3	Tank
(4) Vane diameter	Ø2000 mm	
(5) Motor output	11 kW	
(6) Power source	380V x 50 Hz x 3Ø	
(7) Quantity	1	

12.14.1.3 Applicable Standard Specification

11.4

12.14.2 Excess Sludge Feed Pump

12.14.2.1 Purpose of Use

This pump shall be used to feed the excess sludge to the centrifugal thickener.

12.14.2.2 Specifications

Item	Specifications	Remarks
(1) Type	Progressing cavity pump	
(2) Bore diameter	Suction side Ø250 mm	
(3) Discharge flow	35 to 105 m^3/h	
(4) Total lift head	10m	
(5) Fluid handled	Fluid name: excess sludge concentration 0.6%	
(6) Motor output	30 kW	
(7) Power source	380V x 50 Hz x 3Ø	
(8) Quantity	2	

12.14.2.3 Applicable Standard Specification

1.6

12.14.3 Centrifugal Thickener

12.14.3.1 Purpose of Use

This thickener shall be used for the centrifugal thickening of the excess sludge.

12.14.3.2 Specifications

Item	Specifications	Remarks
(1) Type	Horizontal continuous centrifugal thickener	
(2) Sludge properties	Concentration: 0.6%, SVI:200 max.	
(3) Treated flow	70 m^3/h	
(4) SS recovery ratio	90% min.	
(5) Thickened sludge concentration	4% WB min.	
(6) Motor output	About 112.75 kW	Overall Output
(7) Power source	380V x 50 Hz x 3 Ø	
(8) Quantity	2	

12.14.3.3 Applicable Standard Specification

11.1

12.14.4 Sluice Valve

12.14.4.1 Purpose of Use

This valve shall be mounted to the centrifugal thickened sludge pipe.

12.14.4.2 Specifications

Item	Specifications	Remarks
(1) Type	Outside screw type	
(2) Bore diameter	Ø350 mm	
(3) Working pressure	0.06 MPa	
(4) Quantity	2	

12.14.4.3 Applicable Standard Specification

2.1

12.14.5 Crane

12.14.5.1 Purpose of Use

This overhead crane system shall be installed in the sludge building and as all or part of traverse, travel and hoist-up (hoist-down) motions shall be motor-driven, shall be used for the installation, assembly, maintenance and check of the centrifugal thickener.

12.14.5.2 Specifications

Item	Specifications	Remarks
(1) Rated load	20t	
(2) Lift	14m	
(3) Power source	380V and 50 Hz	
(4) Hoisting speed	2.3 m/min	(Reference)
(5) Traversing speed	8.3 m/min	(Reference)
(6) Travelling speed	20 m/min	(Reference)
(7) Hoisting motor	11.5 kW	(Reference)
(8) Traversing motor	0.75 kW	(Reference)
(9) Travelling motor	1.5 kW x 2	(Reference)
(10) Span	About 12m	
(11) Quantity	1	

12.14.5.3 Applicable Standard Specification

3.1

12.15 SLUDGE DEWATERING EQUIPMENT

12.15.1 Mixed Sludge Mixer

12.15.1.1 Purpose of Use

This mixer shall be used for the mechanical agitation to prevent sludge settling in the mixed sludge tank.

12.15.1.2 Specifications

Item	Specifications	Remarks
(1) Type	Vertical mixer	
(2) Fluid	Kind of sludge: mixed sludge Concentration: About 3.35%	
(3) Capacity	Maximum storage capacity 312 m^3	Tank
(4) Vane diameter	Ø 2000 mm	
(5) Motor output	11 kW	
(6) Power source	380V x 50 Hz x 3 Ø	
(7) Quantity	2	

12.15.1.3 Applicable Standard Specification

11.4

12.15.2 Mixed Sludge Feed Pump

12.15.2.1 Purpose of Use

This pump shall be used to feed the mixed sludge to the centrifugal dehydrator.

12.15.2.2 Specifications

Item	Specifications	Remarks
(1) Type	Progressing cavity pump	
(2) Bore diameter	Suction side Ø125 mm	
(3) Discharge flow	15 to 45 m^3/h	
(4) Total lift head	10m	
(5) Fluid handled	Fluid name: mixed sludge concentration 3.35%	
(6) Motor output	11 kW	
(7) Power source	380V x 50 Hz x 3 Ø	
(8) Quantity	2	

12.15.2.3 Applicable Standard Specification

1.6

12.15.3 Centrifugal Dehydrator

12.15.3.1 Purpose of Use

This dehydrator shall be used for the continuous dewatering of the sludge sent from the mixed sludge tank.

12.15.3.2 Specifications

Item	Specifications	Remarks
(1) Type	Horizontal continuous centrifugal dehydrator High efficiency type	
(2) Sludge properties	Kind: mixed sludge TS: 3.35%, VTS:77.0 to 75.0% Fibrous substances(100mesh): 20%	
(3) Treated flow	30 m^3/h	
(4) Chemical feeding rate	1-component prepared Polymer 1% max.	
(5) Cake water content	80% WB max.	
(6) Motor output	About 147.4 kW max.	Overall output
(7) Power source	380V x 50 Hz x 3 Ø	
(8) Quantity	2	

12.15.3.3 Applicable Standard Specification

11.2

12.15.4 Cake Hopper

12.15.4.1 Purpose of Use

This hopper shall be used for the storage of cake sent from the centrifugal dehydrator.

12.15.4.2 Specifications

Item	Specifications	Remarks
(1) Type	Motor-driven square type	
(2) Effective capacity	10 m^3	
(3) Motor output	1.5 kW x 2	
(4) Power source	380V x 50 Hz x 3Ø	
(5) Cake carry-out vehicle	10t truck	
(6) Quantity	2	

12.15.4.3 Applicable Standard Specification

11.3

12.15.5 Dump Truck

12.15.5.1 Purpose of Use

This dump truck shall be used for the carry-out of the sludge cake.

12.15.5.2 Specifications

Item	Specifications	Remarks
(1) Type	Dump Truck	
(2) Live load	10t	
(3) Quantity	2	

12.15.6 Polymer Hopper and Polymer Feeder

12.15.6.1 Purpose of Use

This equipment shall be used for the temporary storage of polymer and the continuous constant-rate supply of water and chemical to the polymer dissolution tank.

12.15.6.2 Specifications

(a) Polymer hopper

Item	Specifications	Remarks
(1) Material	SUS304	
(2) Dimensions	Ø 1350 mm x H1850 mm	Approximate dimensions
(3) Capacity	Maximum storage capacity 1500L	
(4) Quantity	2	

(b) Polymer feeder

Item	Specifications	Remarks
(1) Type	Variable continuous constant-rate feeder	1-train type
(2) Feeding rate	Maximum 2 L/min	
(3) Output	0.4 kW	Reference
(4) Power source	380V x 50 Hz x 3 Ø	
(5) Quantity	2	

12.15.6.3 Applicable Standard Specification

12.1

12.15.7 Polymer Dissolution Tank

12.15.7.1 Purpose of Use

This tank shall be used for the dissolution of the polymer supplied by the polymer feeder to the specified concentration and store the solution in it.

12.15.7.2 Specifications

Item	Specifications	Remarks
(1) Type	Vertical agitation tank	
(2) Dimensions	Ø 2400 mm x H2400 mm	Approximate dimensions
(3) Capacity	Maximum storage capacity 10 m^3	
(4) Mixer	5.5 kW	
(5) Quantity	2	

12.15.7.3 Applicable Standard Specification

12.2

12.15.8 Polymer Feed Pump

12.15.8.1 Purpose of Use

This pump shall be used to feed the polymer solution at constant-rate to the dehydrator.

12.15.8.2 Specifications

Item	Specifications	Remarks
(1) Type	Progressing cavity pump	
(2) Bore diameter	Ø 65 mm	
(3) Discharge flow	40 to 130 L/min	
(4) Total lift head	10m	
(5) Fluid handled	Fluid name: polymer coagulant concentration 0.2%	
(6) Motor output	3.7 kW	
(7) Power source	380V x 50 Hz x 3 Ø	
(8) Quantity	2	

12.15.8.3 Applicable Standard Specification

12.3

12.15.9 Treated Water Inflow Valve

12.15.9.1 Purpose of Use

This valve shall be mounted to the treated water pipe in the sludge building.

12.15.9.2 Specifications

Item	Specifications	Remarks
(1) Type	Motor-operated ball valve	
(2) Bore diameter	Ø 250 mm	
(3) Normal working pressure	0.1 MPa	
(4) Motor output	0.1 kW	
(5) Power source	380V x 50 Hz x 1Ø	
(6) Quantity	1	

12.15.9.3 Applicable Standard Specification

2.1

12.15.10 Water Supply Pump Unit

12.15.10.1 Purpose of Use

This pump unit shall be used for the cooling and washing of the centrifugal thickener and the centrifugal dehydrator.

12.15.10.2 Specifications

Item	Specifications	Remarks
(1) Type of tank	Circular horizontal type	Parallel alternative running
(2) Type of pump	Multistage volute pump	
(3) Bore diameter	Ø 200 mm	Unit discharge side
(4) Discharge flow	2.62 m^3/min	Unit discharge side
(5) Total lift head	35m	Unit discharge side
(6) Fluid handled	Fluid name: secondary treated water	
(7) Tank capacity	12 m^3	
(8) Output	18.5 kW x 2	
(9) Power source	380V x 50 Hz x 3 Ø	
(10) Quantity	1	2 pumps/unit

12.15.10.3 Applicable Standard Specification

1.7

12.15.11 Air Compressor

12.15.11.1 Purpose of Use

This air compressor shall be used for the polymer feeder..

12.15.11.2 Specifications

Item	Specifications	Remarks
(1) Type	Transportable small-size air compressor	
(2) Delivery air flow	600 L/min	At normal working pressure
(3) Normal working pressure	0.83 MPa	
(4) Output	5.5 kW	
(5) Power source	380V x 50 Hz x 3 Ø	
(6) Quantity	2	

12.15.11.3 Applicable Standard Specification

4.3

12.15.12 Dehumidifier

12.15.12.1 Purpose of Use

This dehumidifier shall be used to remove the humidity contained in the instrumentation compressed air so as to obtain dry air.

12.15.12.2 Specifications

Item	Specifications	Remarks
(1) Type	Refrigeration type	
(2) Air flow	600 L/min	At normal working pressure
(3) Normal working pressure	0.83 MPa	
(4) Motor output	About 0.25 kW	
(5) Power source	220V x 50 Hz x 1 Ø	
(6) Quantity	1	

12.15.12.3 Standard Accessories (per Unit)

(1) Auto drain trap x 1set
(2) Mounting bolt and nut x 1set

12.15.13 Crane

12.15.13.1 Purpose of Use

This overhead crane system shall be installed in the sludge building and as all or part of traverse, travel and hoist-up (hoist-down) motions shall be motor-driven, shall be used for the installation, assembly, maintenance and check of the centrifugal dehydrator.

12.15.13.2 Specifications

Item	Specifications	Remarks
(1) Rated load	20t	
(2) Lift	14m	
(3) Power source	380V and 50 Hz	
(4) Hoisting speed	2.3 m/min	(Reference)
(5) Traversing speed	8.3 m/min	(Reference)
(6) Travelling speed	20 m/min	(Reference)
(7) Hoisting motor	11.5 kW	(Reference)
(8) Traversing motor	0.75 kW	(Reference)
(9) Travelling motor	1.5 kW x 2	(Reference)
(10) Span	About 12m	
(11) Quantity	1	

12.15.13.3 Applicable Standard Specification

3.1

12.15.14 Chain Block

12.15.14.1 Purpose of Use

This chain block shall be used for the carry-in, carry-out, installation, assembly, maintenance and check of the equipment and apparatus installed in the building and the materials necessary therefor.

12.15.14.2 Specifications

Item	Specifications	Remarks
(1) Type	Manual type	With geared trolley
(2) Rated load	1t	
(3) Lift	13m	
(4) Quantity	1	

12.15.14.3 Applicable Standard Specification

3.4

12.16 RECYCLE FLOW EQUIPMENT

12.16.1 Recycle Flow Mixer

12.16.1.1 Purpose of Use

This mixer shall be used for the mechanical agitation to prevent sludge settling in the recycle flow tank.

12.16.1.2 Specifications

Item	Specifications	Remarks
(1) Type	Vertical mixer	
(2) Fluid	Kind of sludge: recycle flow	
(3) Capacity	Maximum storage capacity 208 m^3	Tank
(4) Vane diameter	Ø 2000 mm	
(5) Motor output	11 kW	
(6) Power source	380V x 50 Hz x 3 Ø	
(7) Quantity	1	

12.16.1.3 Applicable Standard Specification

11.4

12.16.2 Recycle flow Pump

12.16.2.1 Purpose of Use

This pump shall be used to transfer the wastewater from the recycle flow tank into the pump well.

12.16.2.2 Specifications

Item	Specifications	Remarks
(1) Type	Non-clogging type	
(2) Suction bore diameter	Ø 200 mm	
(3) Discharge flow	5.1 m^3/min	
(4) Total lift head	15m	
(5) Motor output	30 kW	
(6) Power source	380V x 50 Hz	
(7) Quantity	2	

12.16.2.3 Applicable Standard Specification

1.2

12.17 COMPOST FACILITY

12.17.1 Mixing Machine

12.17.1.1 Purpose of Use

This machine shall be used to mix, crush and transfer the thrown raw material and perform the aerobic fermentation of the material.

12.17.1.2 Specifications

Item	Specifications	Remarks
(1) Type	Automatic traverse and travel paddle type	
(2) Fermentation vessel dimensions (effective)	Width 15 m x length 58 m effective depth 2.3 m/vessel	
(3) Agitation and transfer rate	243 m^3/d · unit	
(4) Paddle diameter	2.2 m	
(5) Drive power	90 kW	
(6) Power source	380V x 50 Hz	
(7) Effective volume	2346 m^3/vessel	

(8) Retention time	10 days	
(9) Travel distance	About 75 m	
(10) Traverse distance	About 16.5 m	
(11) Paddle rotation speed	Inverter controlled (50 to 65 min^{-1})	
(12) Travel drive power	1.5 kW x 2/unit (inverter controlled)	
(13) Traverse drive power	1.5 kW x 1/unit (inverter controlled)	
(14) Control panel (accessory)	1set for 2 mixing machines	
(15) Quantity	2	

12.17.1.3 Applicable Standard Specification

13.1

12.17.2 Suction Fan

12.17.2.1 Purpose of Use

This fan shall be used to do ventilation inside the fermentation tank.

12.17.2.2 Specifications

Item	Specifications	Remarks
(1) Type	Single-suction turbo fan	
(2) Air flow	45 m^3/min	
(3) Static pressure	3.5 kPa	
(4) Motor output	5.5 kW	
(5) Power source	380V x 50 Hz	
(6) Quantity	4	

12.17.2.3 Applicable Standard Specification

4.4

12.17.3 Humidifying Pump

12.17.3.1 Purpose of Use

This pump shall be used to lift up the wastewater collected in the drainage pit into the fermentation vessel.

12.17.3.2 Specifications

Item	Specifications	Remarks
(1) Type	Submerged wastewater pump	
(2) Discharge bore diameter	Ø 50 mm	
(3) Discharge flow	0.1 m^3/min	
(4) Pump head	20 m	
(5) Motor	1.5 kW x 380V x 50 Hp	
(6) Quantity	2	

12.17.3.3 Applicable Standard Specification

1.4

12.17.4 Dump Truck

12.17.4.1 Purpose of Use

This dump truck shall be used to transfer the compost inside the compost plant facility.

12.17.4.2 Specifications

Item	Specifications	Remarks
(1) Type	Dump truck	
(2) Movable load	10 t	
(3) Quantity	4	

12.17.5 Shovel Loader

12.17.5.1 Purpose of Use

This shovel loader shall be used to transfer the sludge cake, chaff, compost, etc. inside the compost plant facility.

12.17.5.2 Specifications

Item	Specifications	Remarks
(1) Type	Shovel loader	
(2) Bucket capacity	2 m^3	
(3) Quantity	9	

12.17.6 Deodorization Soil Filter

12.17.6.1 Purpose of Use

This deodorization soil equipment shall be used to bring the odour gas into contact with the filler packed in the equipment (to allow the odour component to be adsorbed and then decomposed by micro-organisms, etc.) for deodorization by circulated water spray.

12.17.6.2 Specifications

Item	Specifications	Remarks
(1) Type	Forced ventilation	
(2) Air flow	500 m^3/min	
(3) Gas passing speed	20 mm/s	
(4) Dimensions	Width 10 m x length 42 m (tank depth 1.6 m)	
(5) Type of water spray	Automatic water spray	
(6) Filler	420 m^3	
(7) Air diffuser pipe (accessory)	1 set	
(8) Water spray pipe (accessory)	1 set	
(9) Quantity	1 set	

12.17.6.3 Applicable Standard Specification

13.2

12.17.7 Deodorization Fan

12.17.7.1 Purpose of Use

This fan shall be used to suck the odour gas generated in the fermentation vessel and send it into the deodorization equipment.

12.17.7.2 Specifications

Item	Specifications	Remarks
(1) Type	Single-suction turbo fan	
(2) Air flow	250 m^3/min	
(3) Static pressure	3.0 kPa	
(4) Motor output	30 kW	
(5) Power source	380V x 50 Hz	
(6) Quantity	2	

12.17.7.3 Applicable Standard Specification

4.4

12.17.8 Spray Pump

12.17.8.1 Purpose of Use

This pump shall be used to spray water over deodorization soil equipment.

12.17.8.2 Specifications

Item	Specifications	Remarks
(1) Type	Submerged wastewater pump	
(2) Discharge bore diameter	Ø 50mm	
(3) Discharge flow	0.2 m^3/min	
(4) Pump head	25 m	
(5) Motor	3.7 kW x 380V x 50 Hz	
(6) Quantity	1	

The recirculation tank shall be provided with a level switch and automatic valves for water supply, circulation and drainage (3 valves).

12.17.8.3 Applicable Standard Specification

1.4

12.17.9 Wastewater Drainage Pump

12.17.9.1 Purpose of Use

This pump shall be used to return the wastewater collected in the drainage tank.

12.17.9.2 Specifications

Item	Specifications	Remarks
(1) Type	Submerged wastewater pump	
(2) Discharge bore diameter	Ø 50 mm	
(3) Discharge flow	0.2 m^3/min	
(4) Pump head	25 m	
(5) Motor	3.7 kW x 380V x 50 Hz	
(6) Quantity	1	

12.17.9.3 Applicable Standard Specification

1.4

12.17.10 Truck Scale

12.17.10.1 Purpose of Use

This truck scale shall be used to measure weight of the truck and the load.

12.17.10.2 Specifications

Item	Specifications	Remarks
(1) Type	Load cell type	
(2) Measurement range	0 to 20 tons	
(3) Quantity	1	

12.17.10.3 Standard Accessories

(1) Go-stop signal x 1set (Site)
(2) Card reader (post type) x 1set (Site)
(3) Weight indicator x 1set (Site)
(4) Data treatment P.C. x 1set (Electric room)
(5) Printer x 1set (Electric room)

12.17.10.4 Spare Parts

(1) Cards x 200 pieces

12.18 PIPING

12.18.1 Piping Specifications and Work Execution Range

No.	Name of piping	Material	Work execution range	Remarks (Piping lagging, etc.)
1	Sewage pipe	DCIP	Refer to design drawings.	
2	Raw sludge pipe	DCIP	ditto	
3	Return sludge pipe	DCIP, VP	ditto	Bore diameter larger than 350: DCIP
4	Excess sludge pipe	VP	ditto	
5	Scum pipe	DCIP, VP	ditto	Outdoor: DCIP
6	Tank drainage pipe	VP	ditto	
7	Thickened sludge pipe	DCIP	ditto	
8	Centrifugal thickened sludge pipe	DCIP	ditto	
9	Mixed sludge pipe	DCIP	ditto	
10	Thickener effluent pipe	VP	ditto	
11	Recycle flow pipe	VP	ditto	
12	Overflow pipe	VP	ditto	
13	Drainage pipe	VP	ditto	

14	Floor drainage pipe	VP	ditto	
15	Air pipe	SS400, STPY400, SGPW	ditto	Indoor: With lagging. SS400, STPY400; with galvanization equivalent to SGPW
16	Treated water pipe	SGPW	ditto	
17	Antifoaming water pipe	SGPW	ditto	
18	Filtration supply pipe	SGPW	ditto	
19	Filtered water pipe	SGPW	ditto	
20	Air wash pipe	SGPW	ditto	Indoor: With lagging
21	Backwash pipe	SGPW	ditto	
22	Backwash wastewater pipe	VP, SGPW	ditto	Outdoor: SGPW
23	Cooling water pipe	SGPW	ditto	
24	Instrumentation air pipe	SGPW	ditto	
25	Sodium hypochlorite pipe	HIVP, SGP-FVA	ditto	Outdoor: SGP-FVA
26	Receiving pipe	HIVP	ditto	
27	Return pipe	HIVP	ditto	
28	Exhaust pipe	HIVP	ditto	
29	Polymer feed pipe	HIVP	ditto	
30	Deodorization duct	VP,VU, PVC	ditto	~300 VP, 350~500 VU,550~PVC Welding Pipe(t8)
31	Humidifying pipe	VP	ditto	
32	Spray water pipe	VP	ditto	

12.19 PAYMENT

12.19.1 Supply of Mechanical Equipment

Payment for the supply of mechanical equipment will be made on the basis of equipment delivered, installed, tested, commissioned and approved by the Engineer.

Payment shall include the cost of engineering, design, supply, shop testing, witnessing by Engineer's or Employer's representative, shipping, insurance, inland transport, storage, fees and any other incidental costs related to the supply of mechanical equipment.

All equipment shall be delivered to the Site complete with spare part as specified, its respective documentation including manufacturer's certificates and shop test records. Upon certification by the Engineer that the equipment complies with specified requirements seventy-five percent (75%) of the respective prices per complete set entered in the Bill of Quantities, shall be authorised for payment.

The remaining twenty-five percent (25%) shall be authorized for payment following the completion, testing and commissioning of the complete waste water treatment plant mechanical system.

The following pay items shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
4.1.1.1	Inflow Gate with 1,500mm W x 1,500mm H	set
4.1.1.2	Coarse Screen with screen gap 100mm	set
4.1.1.3	Chain Block with 1 t	set
4.1.2.1	Lift Pump (1) with 700mm dia x 66.7m3/min x 14m	set
4.1.2.2	Connecting Gate with 1,500mm W x 1,500mm H	set
4.1.2.3	Hoist with 10t	set
4.1.2.4	Floor Drainage Pump with 65mm dia x 0.3m3/min x 10m	set
4.1.3.1	Distribution Weir with 1,000mm W x 1,000mm ST	set
4.1.4.1	Blower (1) with 600mm dia x 360m3/min x 6.8mAq	set
4.1.4.2	Discharge Valve (1) with 500mmdia	set
4.1.4.3	Check Valve (1) with 500mm dia	set
4.1.4.4	Air Filter with opening 2.3m W x 2.8m H	set
4.1.4.5	Crane with 10t	set
4.1.4.6	Floor Drainage Pump with 65mm dia x 0.3m3/min x 10m	set
4.1.5.1	Inflow Weir with 500mm W x 400mm ST	set
4.1.5.2	Bypass Gate with 1,000mm W x 1,000mm ST	set
4.1.5.3	Sludge Scraper with(5.0m W x 13.0m L x 3.0m H) x 2 channel	set
4.1.5.4	Scum Skimmer with 300mm dia	set
4.1.5.5	Scum Pump with 80mm dia x 0.8m3/min x 10m	set
4.1.5.6	Raw Sludge Pump with 80mm dia x 0.5m3/min x 14m	set
4.1.5.7	Raw Sludge Valve with 150mm dia	set

4.1.5.8	Comminuter	set
4.1.6.1	Inflower Weir with 500mm W x 500mm ST	set
4.1.6.2	Step Feeding Weir with 500mm W x 500mm ST	set
4.1.6.3	Diffuser with 120 l/min, 24 tube/header	set
4.1.6.4	Diffuser with 120l/min, 18tube/header	set
4.1.6.5	Air Flow Control Valve with 350mm dia	set
4.1.7.1	Inflow Gate with 500mm W x 500mm ST	set
4.1.7.2	Sludge Scraper with (5.0m W x 26.0m L x 3.5m H) x 2 channel	set
4.1.7.3	Scum Skimmer with 300mm dia	set
4.1.7.4	Scum Pump with 80mm dia x 0.8m3/min x 10m	set
4.1.7.5	Return Sludge Pump (25%) with 250mm dia x 5.6m3/min x 6m	set
4.1.7.6	Return Sludge Valve with 350mm dia	set
4.1.7.7	Excess Sludge Pump with 100mm dia x 1.2m3/min x 13m	set
4.1.7.8	Excess Sludge Valve with 150mm dia	set
4.1.7.9	Sluice Valve with 350mm dia	set
4.1.7.10	Comminuter with 200mm dia	set
4.1.7.11	Floor Drainage Pump with 65mm dia x 0.3m3/min x 10m	set
4.1.8.1	Inflow Gate with 2,000mm W x 2,000mm H	set
4.1.8.2	Bypass Gate with 2,000mm W x 2,000mm H	set
4.1.8.3	Sodium Hypochlorite Tank with $13m^3$	set
4.1.8.4	Sodium Hypochlorite Pump with 25mm dia x 0.82 ~ 1.62 l/min	set
4.1.9.1	Secondary Effluent Gate with 1,000mm W x 1,000mm ST	set
4.1.9.2	Treated Water Supply Pump (1) with 150 x 125mm dia x $3.2m^3$/min x 30m	set

4.1.9.3	Treated Water Strainer (1) with 250mm dia x 6.4m^3/min	set
4.1.9.4	Treated Water Supply Pump (2) with 125 x 100mm dia x 2.2m^3/min x 30m	set
4.1.9.5	Treated Water Strainer (2) with 250mm dia x 6.6m^3/min	set
4.1.9.6	Crane with 2 t safe working load x span 6.5m	set
4.1.9.7	Floor Drainage Pump with 65mm dia x 0.3m^3/min x 10m	set
4.1.10.1	Filtration Supply Pump with 80 x 65mm dia x 0.7m^3/min x 10m	set
4.1.10.2	Filtilation Supply Strainer with 80mm dia x 0.7m^3/min	set
4.1.10.3	Sand Filter with 0.6m3/min	set
4.1.10.4	Filtered Water Supply Pump with 80 x 65mm dia x 1.0m^3/min x 30m	set
4.1.10.5	Backwash Pump with 125 x 100mm dia x 2.7m^3/min x 10m	set
4.1.10.6	Air Wash Blower with 100mm dia x 4.5m^3/min x 4.5kPa	set
4.1.10.7	Backwash Wastewater Pump with 65 x 50mm dia x 0.35m^3/min x 15m	set
4.1.10.8	Air Compressor with 400 l/min	set
4.1.10.9	Dehumidifier with 400 l/min	set
4.1.11.1	Gravity Thickener with 14m dia	set
4.1.11.2	Scum Skimmer with 7,000mm L	set
4.1.11.3	Thickened Sludge Pump with 80mm dia x 0.7m^3/min x 10m	set
4.1.11.4	Thickener Effluent Pump with 80mm dia x 0.4m^3/min x 15m	set
4.1.11.5	Floor Drainage Pump with 65mm dia x 0.3m^3/min x 10m	set
4.1.12.1	Excess Sludge Mixer with 140m^3	set
4.1.12.2	Excess Sludge Feed Pump with 250mm dia x 35 ~ 105m^3/h x 10mAq	set
4.1.12.3	Centrifugal Thickener with 70m^3/h	set
4.1.12.4	Sluice Valve with 350mm dia	set

4.1.12.5	Crane with safe working load of 20 t	set
4.1.13.1	Mixed Sludge Mixer with 180m^3	set
4.1.13.2	Mixed Sludge Feed Pump with 125mm dia x 15 ~ 45m^3/h x 10mAq	set
4.1.13.3	Centrifugal Dehydrater with 30m^3/h	set
4.1.13.4	Cake Hopper with 10m3	set
4.1.13.5	Dump Truck	set
4.1.13.6	Polymer Hopper and Polymer Feeder with 1,500l and 2,000cc/min	set
4.1.13.7	Polymer Dissolution Tank with 10m^3	set
4.1.13.8	Polymer Feed Pump with 0.04 ~ 0.13m^3/min	set
4.1.13.9	Treated Water Inflow Valve	set
4.1.13.10	Water Supply Pump Unit with 2.62m^3/min x 35mAq	set
4.1.13.11	Air Compressor	set
4.1.13.12	Dehumidifier	set
4.1.13.13	Crane with safe working load of 20 t	set
4.1.13.14	Chain Block	set
4.1.14.1	Recycle Flow Mixer	set
4.1.14.2	Recycle Flow Pump	set
4.1.15.1	Mixing Machine	set
4.1.15.2	Suction Fan	set
4.1.15.3	Humidifying Pump	set
4.1.16.1	Dump Truck	set
4.1.16.2	Shovel Loader	set
4.1.16.3	Truck Scale	set

4.1.17.1	Deodorization Soil Filter	set
4.1.17.2	Deodorization Fan	set
4.1.17.3	Spray Water Pump	set
4.1.17.4	Wastewater Drainage Pump	set
4.1.18.1	Materials for Piping	lot
4.2.1	Installation of Equipment and Piping	L.S.
4.2.2	Site Testing and Commissioning	L.S.

12.19.2 Supply of Piping Materials

Payment for piping materials shall be made at the lump sum price entered in the Bill of Quantities which shall be full compensation for the provision of all materials for every piping system and sub-system in the wastewater treatment plant including, but not limited to pipes, bends, elbows, tees, valves, flanges, bolt, nuts, studs, washers, gaskets, welding consumables, pipe supports, hangers, wall brackets delivered to the Site and certified by the Engineer that such piping materials are complete and comply with specified requirements.

The following pay item shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
4.1.18.1	Materials for Piping	lot

12.19.3 Installation of Mechanical Equipment

Payment will be made at the lump sum price entered in the Bill of Quantities for the installation of all mechanical equipment which shall be full compensation for completing the installation in accordance with the Drawings, the Specification and to the approval of the Engineer and shall include the cost of all labour, tools, equipment and all other related costs.

The following pay item shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
4.2.1	Installation of Equipment and Piping	L.S.

12.19.4 Testing and Commissioning

Payment will be made at the lump sum price entered in the Bill of Quantities upon completion of the testing and commissioning of all mechanical equipment which shall be full compensation for the cost of all testing and commissioning of all items of mechanical equipment, sub-systems and the total wastewater system all in accordance with the Specification and to the approval of the Engineer and shall include the cost of all labour, tools, equipment and all other related costs.

The following pay item shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
4.2.2	Site Testing and Commissioning	L.S.

APPENDIX TO SECTION 12
STANDARD SPECIFICATIONS FOR MECHANICAL WORKS

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APPENDIX TO SECTION 12
STANDARD SPECIFICATIONS FOR MECHANICAL WORKS

SECTION 1. PUMP EQUIPMENT

1.1 SUBMERGED SEWAGE PUMP (BORE DIAMETER NOT LESS THAN 150 MM)

1.1.1 General

This pump shall be used to pump up the sewage and shall be constructed sturdy to endure continuous operation in water.

The pump shall be constructed to produce less vibration and noise and operate smoothly. Especially, it shall not produce harmful phenomenon of cavitation.

1.1.2 Manufacturing Conditions

(1) The influent water shall be sewage which has been passed through the screen and removed of sand, etc.

(2) It shall be permitted for no-discharge operation

1.1.3 Construction and Materials Used

(1) Volute casing

Volute casing of the pump shall be made of cast iron conforming to the requirements of JIS FC250 or equivalent material. These parts shall be free from blow holes, porosity, shrinkage cracks or other defects.

Suction inlet shall be designed to minimize entrance losses and shall keep the suction water surface as stable as possible so that harmful vortices are not formed. Volute casing shall have enough water passage to minimize friction losses and efficiently reduce the flow velocity. Liner ring shall be removable and renewable, and made of stainless steel conforming to the requirements of JIS SUS304 or equivalent special steel alloy.

(2) Impeller

Impeller shall be of mixed flow type and shall be made of JIS designation stainless steel casting (SCS5) or equivalent special steel alloy of at least 14% chromium and 3.5 to 4.5% nickel stainless steel with a Brinell Hardness of 230 to 270 to resist abrasive and corrosive effect of silt, sludge and sand. The impeller shall be designed to operate satisfactorily through the expected range of static head without any noise, cavitation and vibration. The impeller shall be of smooth finished all over and shall be locked securely to the shaft and be capable of being easily removed. An optimum clearance shall be provided between the impeller and liner ring so as to maximize the efficiency of the pump. The liner ring shall be fitted and locked with flush fitting screw and shall be made of stainless steel with a Brinell Hardness of 150 to 180.

(3) Shaft

The shaft shall be made of JIS designation stainless steel (SUS403) or equivalent stainless steel. The shaft shall be a one piece construction, accurately machined throughout the entire length, properly finished at the bearing surfaces and stepped for ease of assembly of bearings, mechanical seals, etc. The shaft shall be supported by two (2) sets of ball or roller bearings and the bearing life shall have a minimum design life of 50,000 hours.

(4) Mechanical seals

The pump shall be provided with a cartridge type double mechanical rotating shaft seal system running in an oil reservoir having separate, constant hydro-dynamically lapped seal faces of silicon carbide. The lower seal separating the pumping liquid media and the oil reservoir shall be made of silicon carbide/silicon carbide. The upper seal shall be made of silicon carbide/silicon carbide and it seals the electric motor from the oil reservoir. The mechanical seals shall comprise of one positively driven rotating ring and one stationary ring, with the interface held in contact by its own spring system supplemented by external liquid pressures. The seals shall require neither maintenance nor adjustment but shall be easily inspected and replaced if necessary. The shaft sealing system shall be capable of operating at a minimum pressure equivalent to twice the shut off pressure produced by the impeller and no damage shall result from operating the pumping unit out of its liquid environment.

(5) Quick discharge connector

The quick discharge connector (QDC) shall be of JIS designation close grained cast iron (FC250) or equivalent high grade cast iron. The QDC shall be designed to adequately support the guide rails, discharge pipe and pumping unit with support legs that are suitable for anchoring it to the floor. The discharge flange of the QDC shall conform to JIS G 5527 PN7.5 class or higher class flange. The pump design shall include an integral self-aligning sliding bracket. Sealing of the pumping unit to the QDC shall be accomplished by a single, linear, downward motion of the pump. The entire weight of the pump shall be guided to and wedged tightly against the inlet flange of the QDC, making metal to metal contact with the pump discharge forming a seal without the use of bolts, gaskets or o-rings.

(6) Motor

The motor shall be 3 phase, 380V, 50Hz air-filled type squirrel cage induction motor. Winding temperature detectors for each phase shall be furnished in the motor. The motor shall be designed for continuous duty at a maximum sump temperature of 40^0 and be capable of up to 10 starts per hour. Motor insulation shall be Class F. Voltage and frequency tolerances shall be a maximum 10/5% respectively. The motor shall be non-overloading over the expected range of operation and be able to operate at full load continuously with the motor unsubmerged in air.

The cable entry system shall comprise of primary, secondary, and tertiary sealing methods. The primary seal shall be achieved by a cylindrical elastometric grommet made of NBR material. Compression and subsequent sealing shall preclude specific torque requirements. The system shall also include tertiary sealing to prevent leakage into

the motor housing due to capillary action through the insulation if the cable is damaged or cut. The cable entry system shall be the same for both the power and control cables. Twenty (20) meters power and control cable shall be connected to the motor.

The motor design shall also include an integral cooling jacket constructed of steel. The cooling medium shall be the pumping water. Re-circulation through the jacket shall be achieved by discharging the pumping water into the cooling jacket from the periphery, high pressure area, of the impeller, and returning into the low pressure behind the impeller, at the hub. Riser pipes within the jacket shall be utilized to facilitate circulation. The cooling passage ways shall be non clogging by virtue of the dimension.

(7) Leakage Detection

Leak detection chamber shall be provided between the shaft seal and the motor body so that, even in the unlikely event that the water leaked to the chamber because of worn-out double mechanical seal, leakage is collected in the chamber and an alarm is triggered by the float-type detector provided inside the chamber.

Leakage detector for mechanical seals shall be both float type switches, detecting for water penetration and for oil leakage. Moisture switch shall not be acceptable. The leakage detector shall be installed in a chamber separated from motor coil chamber and thermal detector shall be installed in a motor.

1.1.4 Standard Accessories (per unit)

(1)	Submerged cable (up to terminal box)	x 1 set
(2)	Lifting chain	x 1 set
(3)	Quick discharge connector	x 1 set
(4)	Foundation bolt and nut	x 1 set
(5)	Compound pressure gauge (diaphragm type)	x 1 set
(6)	Automatic air vent valve (if necessary)	x 1
(7)	Power cable terminal box	x 1
(8)	Special disassembly tool	x 1 set (common for all units)

1.1.5 Spare Parts (per Unit)

(9)	Mechanical seal	For 1 unit

1.2 NON-CLOGGING CENTRIFUGAL PUMP

1.2.1 General

This pump shall be installed for the transfer of the sludge.

1.2.2 Manufacturing Conditions

(1) This pump shall be a non-clogging sludge pump. As a rule, it shall be the pulley-driven type, or as the case may be, direct-coupled type

(2) This pump shall be manufactured to have stable performance to various kinds of sludge, to be free from clogging with sludge and not to cause overloading of the motor.

(3) This pump shall have small variations of discharge flow with variations of lift head.

1.2.3 Construction of Various Portions

The construction of various portions shall be as follows.

(1) The pump casing shall be volute type. It shall be made of good quality of cast iron free from blowhole and have smooth cast surface. It shall be sturdy and have a wall thickness with ample allowance to shock, wear, corrosion and piping load.

(2) The impeller shall be shaped to pass solids of foreign substances without trouble. It shall be well in balance and not produce abnormal vibration during operation.

(3) The portion at which the main shaft penetrates through the shell shall be provided with a stuffing box.

The shaft seal water system shall be gland packing system, water spray mechanical seal system or no-water spray mechanical seal system.

(4) The pump casing shall be provided with a hand hole on the suction side and on the shell to facilitate internal inspection. Moreover, it shall be provided with a drain pipe.

(5) The bearing shall have been constructed best suited to loads. It shall have a sufficient supporting capacity, and shall be durable because of complete lubrication and freedom from overheating, etc. It shall have a sufficient capacity to axial thrusts as well.

(6) The pump shall be provided with loose joints and loose joint short pipes for suction pipe and discharge pipe.

(7) If the pump discharges in a vertical direction, loads of valve, check valve, etc. shall be supported firmly.

(8) The motor specifications shall be totally enclosed fan-cooled type and of continuous rating. Moreover, the terminal box shall be given consideration on its position according to the position of pump installation so that lead wires, pipe lines, etc. may not interfere with pump carry-in, carry-out and checking operations.

(9) The suction pipe shall have a flange joint. Especially, the suction port horn pipe in the sludge pit shall not be supported by metal means extended from the bottom. Pipe loads shall be supported by a frame of channel steel provided at an intermediate of the sludge pit.

(10) In the area where the suction pipe penetrates through the tank wall, a water sealing plate shall be provided and concrete shall be placed.

(11) The suction pipe shall be provided with a main valve without fail. The master valve shall be mounted at a position as near the sludge pit wall as possible, and a support stand shall be provided for the valve.

(12) The pump flange shall be JIS 10K or equivalent.

(13) For sealing water drain, casing drain and air vent, separate piping shall be made respectively up to the nearest side drain.

(14) The sludge pump discharge piping shall be provided with a sampling valve and a vinyl hose shall be arranged up to the side drain.

(15) Pressure gauges shall be mounted to loose joint short pipes.

1.2.4 Materials Used

Material used shall be as follow.

Casing	:	Cast iron
Impeller	:	High chromium cast iron
Suction cover	:	High chromium cast iron
Main shaft	:	Carbon steel (with stainless steel sleeve)

1.2.5 Standard Accessories (per Unit)

(1)	Common base	x 1
(2)	V-belt (in the case of pulley drive)	x 1
(3)	V-pulley (in the case of pulley drive)	x 1
(4)	Coupling (in the case of the motor direct coupling)	x 1 set
(5)	Belt cover or coupling cover	x 1
(6)	Pressure gauge (diaphragm type) (compound pressure gauge if necessary)	x 1
(7)	Air vent valve	x 1
(8)	Drain pipe (piping around the pump)	x 1 set
(9)	Foundation bolt and nut	x 1 set
(10)	Loose joints and loose joint short pipes for suction pipe and discharge valve	x1 sets

1.2.6 Spare Parts (per Unit)

(1)	V-belt (in the case of pulley drive)	For 2 units
(2)	V-pulley (of different or same diameter) (in the case of pulley drive)	For 1 unit
(3)	Gland packing (in the case of gland packing system)	For 1 unit
(4)	Sliding material for mechanical seals (in the case of mechanical sealing system)	For 1 unit

1.3 CENTRIFUGAL SCREW IMPELLER PUMP

1.3.1 General

This pump shall be installed for the transfer of the sludge.

1.3.2 Manufacturing Conditions

(1) The impeller shall be screw type having a non-clogging single vane.

(2) It shall be permitted for no-discharge operation during the discharge valve startup time (within 30s).

(3) The pump suction side shall require no hand hole.

Details shall be the same as in “1.2 Non-clogging Centrifugal Pump”.

1.4 SUBMERGED WASTEWATER PUMP

1.4.1 General

This pump shall be used to discharge the wastewater held in the pipe gallery, etc. It shall be constructed to be sturdy to endure continuous operation in water. It shall have the minimum bore diameter of 50 mm.

The pump shall be constructed to produce less vibration and noise and operate smoothly, and especially, shall not produce harmful phenomenon of cavitation.

1.4.2 Manufacturing Conditions

(4) The influent water shall be wastewater which has been collected in the floor drain pit of the pipe gallery, etc.

(5) It shall be permitted for no-discharge operation.

1.4.3 Construction of Various Portions

Drive unit

(1) The motor to be used with the pump shall be a submersible motor.

Main body

(2) Casing

The casing shall be made of good quality of cast iron considering the mechanical strength to internal pressure, vibration, etc. as well as the resistance to corrosion and wear.

The casing shall be constructed for easy disassembly and assembly.

(a) Removable type

The casing discharge flange shall be of slide type, and when mounting the pump, shall be connected positively along the discharge bend flange surface.

(b) Stationary type

A support stand shall be provided at the underside of the casing, and the pump shall be installed on the floor inside the pit.

(3) Impeller

The impeller shall be a stout product of good quality and shall be sturdy to ingress of solids.

The impeller shall be constructed with a minimum number of blades and well in balance, and the surface shall be finished smooth.

(4) Main shaft

The main shaft is an extension of the motor shaft. It shall be strong enough to the transmission torque and torsional vibration.

(5) Shaft sealing equipment

The shaft sealing portion shall consist of mechanical seals and it shall be a two-stage structure with oil sealed in an intermediate portion to prevent foreign substances from ingress into the motor whether the motor in operation or at stop. It shall be constructed for easy replacement of seals, etc.

(6) Bearing

The bearing installed in the motor shall bear the weight of rotary portions and the hydraulic thrust. It shall be constructed to endure a long time of continuous operation and be capable of smooth self-lubrication.

(7) Flange

Flanges for piping connection shall be in accordance with JIS B 2239 (10K) or equivalent. Bolts and nuts for pit inside piping and disassembling flanges shall be made of stainless steel.

1.4.4 Materials Used

Materials used shall be as follows.

(1)	Casing	: Cast iron
(2)	Impeller	: Cast iron
(3)	Main shaft	: Stainless steel

1.4.5 Protection Equipment

(1) A thermal switch to detect abnormal temperature, etc. shall be built in.

(2) A water pocket room to prevent oil and water from ingress into the motor section shall be provided.

1.4.6 Standard Accessories (per unit)

(1)	Submerged cable (up to terminal box)	x 1 set
(2)	Lifting chain	x 1 set
(3)	Pump removable equipment (in the case of removable type)	x 1 set
(4)	Foundation bolt and nut	x 1 set
(5)	Compound pressure gauge (diaphragm type)	x 1
(6)	Automatic air vent valve (if necessary)	x 1
(7)	Power cable terminal box	x 1

1.4.7 Spare Parts (per Unit)

(1)	Mechanical seal	For 1 unit

1.5 FEED WATER PUMP

1.5.1 General

This pump shall be a single-stage or multistage volute pump for elevated water tank storage, filter cloth washing water, compression, etc.

1.5.2 Construction of Various Portions

(1) The pump shall have wall thickness having an adequate allowance for shock, wear and corrosion.

(2) The pump shall be constructed to produce no vibration and noise during operation and endure continuous operation for a long time sufficiently.

(3) The motor specifications shall be totally enclosed fan-cooled type and of continuous rating.

1.5.3 Materials Used

(1) Casing : Cast iron

(2) Impeller : Cast iron or bronze casting

(3) Main shaft : Carbon steel with stainless steel sleeve or stainless steel shaft

1.5.4 Standard Accessories (per unit)

(1)	Coupling cover	x 1
(2)	Common base	x 1
(3)	Pressure gauge or compound pressure gauge	x 1 set
(4)	Foundation bolt and nut	x 1 set
(5)	Air vent valve	x 1
(6)	Small piping around the pump	x 1 set
(7)	Loose flange and short pipes to be installed on suction pipe and discharge pipe	x 1 set

1.5.5 Spare Parts (per Unit)

(1)	Gland packing	For 1 unit
(2)	Rubber for coupling	For 1 unit

1.6 PROGRESSING CAVITY PUMP

1.6.1 General

This pump shall be a progressing cavity pump used to supply sludge at a constant rate to the coagulation-mixing tank or the dehydrator.

1.6.2 Manufacturing Conditions

This pump shall be constructed to have stable performance to sludge of water content 95 to 98%, to be free from clogging with sludge and not to cause overloading of the motor.

1.6.3 Construction of Various Portions

(1) The pump casing shall have smooth cast surfaces and be sturdy and shall have wall thickness having an adequate allowance for shock, wear, corrosion and piping loads.

(2) The rotor shall be one-axis eccentric screw type and shall not cause vibration during operation.

(3) The portion of the shell where the main shaft penetrates through shall be provided with a stuffing box and the shaft sealing equipment shall be a gland packing or mechanical system.

(4) To facilitate replacement of the stator, the pump shall be constructed to permit removal of suction casing and discharge casing and the piping and replacement space shall be determined.

(5) The bearing shall have been constructed to have an adequate supporting capacity to the load. Because of complete lubrication, it shall be free from overheating, etc. Moreover, it shall have an adequate allowance for axial thrust.

(6) The motor specifications shall be outdoor totally-enclosed splashproof type, air-cooled housing surface self-cooling type and of continuous rating.

1.6.4 Materials Used

(1)	Common base	Cast iron or rolled steel
(2)	Casing	Cast iron
(3)	Rotor	Alloy tool steel + hard chromeplating or Stainless steel + hard chromeplating
(4)	Stator	Synthetic rubber
(5)	Shaft	Stainless steel

1.6.5 Standard Accessories (per Unit)

(1)	Safety cover	x 1 set
(2)	Common base	x 1 set
(3)	Pressure gauge (diaphragm type)	x 1
(4)	Foundation bolt and nut	x 1 set
(5)	Special disassembly tool	x 1 set (common for all units)

1.6.6 Spare Parts (per Unit)

(1)	Stator	x 2
(2)	O-ring for pump	For 2 units
(3)	Seal packing for joint	For 2 units
(4)	Mechanical seal (consumable one, only)	For 1 unit
	or gland packing	For 5 units

1.7 PRESSURE TANK TYPE FEED WATER UNIT

1.7.1 General

(1) This unit shall be a pressure tank combined with horizontal shaft volute pumps and shall include a control panel for automatic operation, as well.

(2) The tank shall be installed to store pressurized water in it to accommodate variations of the water usage.

1.7.2 Manufacturing Conditions

(1) This unit shall be constructed to produce less vibration and noise and to endure a long time of continuous operation.

(2) The tank shall be a product conforming to the applicable laws and regulations.

(3) The pressure tank shall have a sufficient capacity selected considering the frequency of motor startup.

(4) Pump operation shall be automatic parallel and alternate operation in accordance with the tank internal pressure.

(5) The condition of suction of the horizontal volute pump shall be forced suction.

(6) The quantity of pumps to be mounted in the feed water pump unit shall be 2 as standard.

1.7.3 Construction of Various

(1) The pump shall be sturdy and shall have a wall thickness having an adequate allowance for wear and corrosion.

(2) The tank shall be a air make-up type tank and shall have sufficient strength.

(3) The control panel shall be composed of a control circuit for automatic operation and a drive-power circuit.

1.7.4 Materials Used

Materials to be used shall be as follows.

(1) Horizontal shaft volute pump

Casing	Cast iron
Impeller	Bronze casting or cast iron
Motor	Totally enclosed fan-cooled type and continuous rating

(2) Tank Rolled steel

1.7.5 Standard Accessories (per Unit)

(1)	Common base	x 1 set
(2)	Foundation bolt and nut	x 1 set
(3)	Coupling and cover	x 1 set
(4)	Pressure gauge or compound pressure gauge	x 1 set
(5)	Pressure switch	x 1 set
(6)	Control panel	x 1 set

1.7.6 Spare Parts (per Pump)

(1)	Gland packing (in the case of gland packing type)	For 1 unit

SECTION 2. VALVE AND GATE EQUIPMENT

2.1 VALVE

2.1.1 Applications and Types

The valve to be used in this project shall be of such type which is suited for the fluid with which it is to be used. The following Table shows the criteria for its selection.

Fluid	Sluice or check valve	Butterfly valve	Bronze valve
Sewage	O	O	
Treated water	O	O	O
Sludge	O		
Air	O	O	O

2.1.2 Construction, Materials, etc.

Construction, materials, etc. of the valve shall be in accordance with the following standards or equivalent thereto.

(1) Cast iron sluice valves: JIS B 2031 or JIS B 2062 or equivalent

(2) Cast iron check valves: JIS B 2031 or equivalent

(3) Butterfly valves: JIS B 2064 or JIS B 2032 or equivalent

(4) Bronze gate, globe, angle and check valves: JIS B 2011 or equivalent

(bore diameter not larger than 65 mm)

2.2 CAST IRON GATE

2.2.1 General

The cast iron gate shall be composed of the gate main body, a spindle, an open-close device, etc. It shall be installed in the water treatment facility for the purpose of water sealing and influent flow adjustment.

The gate shall be constructed to be watertight on four sides. It shall be opened and closed by manual operation. Its spindle shall be of outside screw type.

2.2.2 Design Conditions

(1) The gate leaf shall be made of cast iron of good quality free from cast blowhole. Strength calculations shall be made under the assumption that a water pressure of the indicated water level (lowest water level 5m with reference to the intake bottom) is applied on the pressure side and there is no water on the opposite side.

(2) The force which is required to operate the gate shall be calculated from the water pressure and the load of self-weight including the spindle, etc.

2.2.3 Construction of Various Portions

The construction of various portions shall be as follows.

(1) The main portion of the gate leaf shall have the calculated wall thickness added with a corrosion allowance.

(2) Watertight sheet, wedge block, spindle connection bracket, etc. shall be provided. However, the spindle connection bracket may be cast integral with the main body.

(3) Guide portions for gate leaf open-close shall be provided.

The guide portion may be cast integral with the guide frame.

(4) The spindle shall be made from a stainless steel rod. It shall be able to move the gate leaf up and down smoothly and safely.

(5) If a pin is to be used in the connection between the gate leaf and the spindle, it shall be made of stainless steel.

(6) If a vibration-preventing metal is to be provided at an intermediate of the spindle length, it shall be made of cast iron or steel.

2.2.4 Manual Open-close Device

(1) The open-close device shall be of horizontal handle type or gear type (bevel gear type, worm gear type).

(2) The stand and the hand wheel shall be made of cast iron. The hand wheel shall be marked to indicate the direction of turning. When the handle is turned counterclockwise, the gate leaf shall be opened.

(3) At the top of the open-close device, a spindle cover shall be mounted.

(4) To indicate the degree of opening, a clock type rotary opening-degree meter shall be provided in the case of gear type (bevel gear type, worm gear type), or an opening-degree meter shall be provided to the spindle cover or the stand in the case of the horizontal handle type. The opening-degree meter shall have a scale calibrated in mm and the major portions of the opening-degree meter shall be made of stainless steel.

2.2.5 Materials Used

Materials used shall be as follows.

(1)	Gate leaf	Cast iron
(2)	Guide frame	Cast iron
(3)	Watertight sheet	Bronze casting or stainless steel
(4)	Wedge block	Bronze casting + stainless steel
(5)	Spindle	Stainless steel
(6)	Spindle cover	Steel pipe or stainless steel

2.2.6 Standard Accessories (per Unit)

(1) Coupling for spindle x 1 set

(2) Foundation bolt and nut x 1 set

2.3 CAST IRON MOVABLE WEIR

2.3.1 General

The cast iron movable weir shall be composed of the movable weir main body, a spindle, an open-close device, etc. It shall be installed in the water treatment facility for the purpose of water sealing and influent flow adjustment.

The cast iron movable weir shall be constructed to be watertight on three sides. It shall be opened and closed by manual operation. Its spindle shall be of outside screw type.

2.3.2 Design Conditions

(1) The weir leaf shall be made of cast iron of good quality free from cast blowhole. Strength calculations shall be made under the assumption that a water pressure of the water level corresponding to the indicated lift head is applied on the pressure side and there is no water on the opposite side.

(2) The force which is required to operate the movable weir shall be calculated from the water pressure and the load of self-weight including the spindle, etc.

2.3.3 Construction of Various Portions

The construction of various portions shall be as follows.

(1) Regarding the specifications for the movable weir, the following requirements shall be observed.

1) The movable weir shall be constructed to provide sufficient watertightness at each degree of opening.

2) On each of three sides of the opening, a weir plate suited for flow measurement shall be provided.

3) The watertight sheet shall be made of stainless steel or bronze casting. The movable weir shall be constructed to be watertight on three sides, as standard.

(2) The main portions of the weir leaf shall have the calculated wall thickness added with a corrosion allowance.

(3) Watertight sheet, weir plate, spindle connection bracket, etc. shall be provided. However, the spindle connection bracket may be cast integral with the main body.

(4) Guide portions for weir leaf open-close shall be provided.

The guide portion may be cast integral with the guide frame.

(5) The spindle shall be made from a stainless steel rod. It shall be able to move the weir leaf up and down smoothly and safely.

(6) If a pin is to be used in the connection between the weir leaf and the spindle, it shall be made of stainless steel.

(7) If a vibration-preventing metal is to be provided at an intermediate of the spindle length, it shall be made of cast iron or steel.

2.3.4 Manual Open-close Device

In accordance with 2.2.4.

2.3.5 Materials Used

Materials used shall be as follows.

(1)	Weir leaf	Cast iron
(2)	Guide frame	Cast iron
(3)	Watertight sheet	
	1) Weir leaf side	Stainless steel or bronze casting
	2) Guide frame side	Stainless steel or bronze casting
(4)	Spindle	Stainless steel
(5)	Spindle cover	Steel pipe or stainless steel

2.3.6 Standard Accessories (per Unit)

(1)	Coupling for spindle	x 1 set
(2)	Foundation bolt and nut	x 1 set

SECTION 3. CRANE EQUIPMENT

3.1 DOUBLE-RAIL HOIST TYPE OVERHEAD CRANE

3.1.1 General

The overhead crane system shall be used for the installation, assembly, maintenance and check of the pump system and other equipment and apparatus installed in the building. All or part of traverse, travel, hoist-up and hoist-down motions shall be motor-driven and operated by means of push-button switches hanging down from the crane on the floor inside the building. This crane shall be intended to handle shape steel beam structures.

3.1.2 Manufacturing Conditions

The crane shall be manufactured to operate safely and accurately, as well as to be durable and convenient for maintenance structurally. The main dimensions of the crane shall be determined by adequate survey of the building construction, etc.

3.1.3 Construction of Various Portions

(1) Main girder

The main girder shall be an I-shape steel structure. When the rated load is applied at its mid point, the deflection measured shall be not more than 1/800 of the span. At the top, a check walkway and handrails shall be provided.

(2) Travel rails

The rail to be used shall be safe in full-load operation. Rails shall be mounted to runway girders installed by civil and architectural works. They shall be adjusted in horizontal and parallel centering and shall be mounted safely and firmly by means of hook bolts. At both ends of the rail, wheel stoppers or stoppers shall be provided.

(3) Traverse rails

The traverse rail to be used shall be a square steel or railway's rail and shall be safe even in full-load operation. Rails shall be mounted on main girders. They shall be adjusted in horizontal and parallel centering and shall be mounted safely and firmly by arc welding or by means of grip bolts. At both ends of the rail, wheel stoppers or stoppers shall be provided.

(4) Saddle

The saddle to be used shall be constructed with shape steel and steel plate by welding them in a box form. It shall be provided with travel wheels and the load shall be applied uniformly to the wheels.

(5) Motor-driven hoist

The hoist shall be a double-rail hoist constructed with hoisting equipment and traverse equipment arranged in compact. Its construction and function shall be in accordance with JIS C 9620 "Electrical Hoists" or equivalent.

(6) Gears

The gear to be used shall be a machine cut gear having sufficient strength.

(7) Shafts

The shaft to be used shall be made of materials of good quality. The major portions shall be finished carefully. The gear shall be fit accurately and fixed to the shaft.

(8) Motors

The motor to be used shall be manufactured specifically for hoists and cranes. It shall have minimum moment of inertia and adequate mechanical strength as well as heat capacity enough to endure severe working conditions. Motors shall be in accordance with related standards.

(9) Controller

The on-floor controller shall be a push-button type used for starting and stopping motors.

(10) Electromagnetic brakes

The braking force shall resort mostly to the spring. In the event of unexpected power service interruption or otherwise current being shutdown, this brake shall be able to brake the motor by the spring force positively.

(11) Switch box

The switch box shall be a case made of steel plate to accommodate circuit breakers, electromagnetic contactors and relays.

(12) Lubricating equipment

The lubricating equipment shall be a grease sealing type and shall bear for a long time of use.

(13) For transition into the crane

For transition from the architectural stage into the crane, frames, handrails, open-close fences, stairways, etc. shall be provided for safe walking.

3.1.4 Materials Used

Main beam	:	Rolled steel
Gear	:	Carbon steel
Shaft	:	Carbon steel
Drum	:	Rolled steel
Brake drum	:	Cast iron

3.1.5 Protection equipment

(1) Mechanical protection equipment

Traverse rails and travel rails shall be provided with wheel stoppers or stoppers.

(2) Electrical protection equipment

Over-hoist prevention equipment, electromagnetic brake, current-application confirmation lamp, etc. shall be installed.

3.1.6 Operation Control

Push-button controls shall be used for operation control.

3.1.7 Standard Accessories (per Unit)

(1)	Lubricator	x 1 set
(2)	Grease	x 1 can
(3)	Disassembly tool	x 1 set (common for all units)

3.2 MANUAL OPERATION TYPE OVERHEAD CRANE (GEARED TROLLEY CHAIN BLOCK TYPE)

3.2.1 General

The overhead crane system shall be used for the installation, assembly, maintenance and check of the pump system and other equipment and apparatus installed in the building. It shall be of manual operation type and all of traverse, travel, hoist-up and hoist-down motions shall be artificially operated. This crane shall be a plate girder type.

3.2.2 Manufacturing Conditions

The crane shall be manufactured to operate safely and accurately, as well as to be durable and convenient for maintenance structurally. The main dimensions of the crane shall be determined by adequate survey of the building construction, etc.

3.2.3 Construction of Various Portions

(1) Main girder

The main girder shall be an I-shape steel structure or a welded structure of steel plate and I-shape steel. When the rated load is applied at its mid point, the main beam deflection measured shall be not more than 1/800 of the span. At both ends, stoppers for chain block shall be provided.

(2) Travel rails

The rail to be used shall be safe in full-load operation. Rails shall be mounted to runway girders installed by civil and architectural works. They shall be adjusted in horizontal and parallel centering and shall be mounted safely and firmly by means of hook bolts. At both ends of the rail, wheel stoppers shall be provided.

(3) Saddle

The saddle to be used shall be constructed with shape steel and steel plate by welding them in a box form. It shall be provided with travel wheels and the load shall be applied uniformly to the wheels.

(4) Traverse equipment (geared trolley)

By handling the hand chains mounted to the hand wheel, the hand wheel shall be turned and the gear mounted to the hand wheel shall drive the traverse wheels.

(5) Hoisting equipment

This equipment shall be a chain block which shall be mounted to the traverse equipment (geared trolley) and operated on the floor.

(6) Speed reducer gears

The gear to be used shall be a machine cut gear having sufficient strength.

(7) Shafts

The shaft to be used shall be made of materials of good quality. The major portions shall be finished carefully. The gear shall be fit accurately and fixed to the shaft.

(8) Bearings

Rolling bearings shall be used. They shall be durable for a long time of operation even with no lubrication.

(9) Operating chains

For hoisting, traversing and travelling, separate chains shall be used. These chains shall have length for operations up to about 30 cm above the floor. They shall have been given adequate consideration to be free from bouncing, coming-off, etc. when operated.

3.2.4 Materials Used

Main beam	:	Rolled steel
Saddle	:	Rolled steel
Gear	:	Carbon steel
Shaft	:	Carbon steel

3.2.5 Protection equipment

(1) Mechanical protection equipment

Traverse rails and travel rails shall be provided with wheel stoppers.

Mechanical brakes shall be installed.

3.2.6 Standard Accessories (per Unit)

Lubricator	x 1 set
Grease	x 1 can
Disassembly tool	x 1 set (common for all units)

3.3 HOIST

3.3.1 General

The hoist shall be used for the installation, assembly, maintenance and check of the pump system and other equipment and apparatus installed in the building. All or part of traverse, hoist-up and hoist-down motions shall be motor-driven and operated by means of push-button switches hanging down from the hoist on the floor inside the pump station.

3.3.2 Manufacturing Conditions

The hoist shall be manufactured to operate safely and accurately, as well as to be durable and convenient for maintenance structurally.

3.3.3 Construction of Various Portions

(1) Hoisting equipment

The hoisting equipment shall be constructed to drive the drum through gear speed reducer from the motor. The motor shaft shall be provided with an electromagnetic brake for holding the load.

(2) Traversing equipment

The traversing equipment shall be arranged on traverse rails and traverse wheels are turned through gear speed reducer from the motor.

(3) Gears

The gear to be used shall be a machine cut gear having sufficient strength.

(4) Shafts

The shaft to be used shall be made of materials of good quality. The major portions shall be finished carefully. The gear shall be fit accurately and fixed to the shaft.

(5) Drum

The drum shall be a steel plate welded or cast iron one with mechanically cut grooves suited for ropes around the periphery.

(6) Motors

The motor to be used shall be manufactured specifically for hoists. It shall have minimum moment of inertia and adequate mechanical strength as well as heat capacity enough to endure severe working conditions.

(7) Controller

The on-floor controller shall be a push-button type used for starting and stopping motors.

3.3.4 Materials Used

Gear	:	Carbon steel
Shaft	:	Carbon steel
Drum	:	Rolled steel or cast iron

3.3.5 Protection equipment

Over-hoist prevention equipment, etc. shall be installed.

3.3.6 Operation Control

Push-button controls shall be used for operation control.

3.3.7 Standard Accessories

(1)	Cabtyre cable	x 1 set
(2)	On-floor control	x 1
(3)	Cable hanger	x 1 set

3.4 MANUAL OPERATION TYPE CHAIN BLOCK

3.4.1 General

The chain block shall be used for the carry-in and carry-out, installation, maintenance and check of the equipment and apparatus and the materials required therefor installed in the building. It shall be of manual operation type and all of hoist and traverse motions shall be artificially operated.

3.4.2 Manufacturing Conditions

The chain block shall be manufactured to operate safely and accurately, as well as to be durable and convenient for maintenance structurally.

3.3.8 Construction of Various Portions

(1) Hoisting equipment

The hoisting equipment shall be composed of a gear mechanism constructed with a combination of spur gears, a control mechanism, a hand chain wheel mechanism and a take-up mechanism. When the hand chain is operated by manual operation, the force is transmitted to the gear mechanism which turns the load sheave to wind up the load chain.

(2) Load sheave

The load sheave to be used shall be a forged or cast one and be fabricated and treated not to damage the load chain during the load chain being wound up.

(3) Load chain

The load chain to be used shall be made of selected special alloy steel. It shall present excellent rust prevention and corrosion prevention effects.

(4) Operating chains

For hoisting and traversing, separate chains shall be used. These chains shall be long enough for reach up to about 30 cm above the floor. They shall have been given adequate consideration to be free from bouncing, coming-off, etc. during operation.

(5) Hooks

The hook shall be a single-hook type and be provided with a safety lever.

(6) Traversing equipment (geared trolley)

When the hand chain mounted to the hand wheel is operated, the hand wheel is turned so that the spur gear mounted on the opposite side may drive half of the traverse wheels (on one side).

3.3.9 Materials Used

(1) Load chain : Corrosion resisting specially treated chain
(2) Hand chain : Stainless steel

3.3.10 Protection equipment

Braking equipment

When the hand chain operation is stopped, the hoisting equipment shall be stopped at once by the mechanical braking mechanism.

3.3.11 Standard Accessories (per Unit)

(1) Spare hook for re-hoisting (as necessary) x 1 set

SECTION 4. BLOWER EQUIPMENT

4.1 GEAR-ACCELERATED SINGLE-STAGE TURBO-BLOWER

4.1.1 General

The gear-accelerated single-stage turbo-blower shall be used to supply air to the aeration tank. It shall be constructed with blower main body, gear and forced lubrication equipment mounted on the common base. The blower shall be driven by motor through increasing gear.

The suction air shall pass through an air filter of wet type, dry type, etc. into the blower.

The air flow shall be controlled by inlet vanes.

4.1.2 Manufacturing Conditions

(1) Application : For sewage aeration

(2) Type : Gear-accelerated single-stage turbo-blower
(3) Gas handled : Air
(4) Suction air temperature: 21 to 33.4 oC
(5) Operation : Continuous
(6) Air flow : 600 m3/min max
Set conditions: 30 , 101.3 kPa (1 atm), 90% RH
(7) Suction pressure : -1.0 to -2.0 kPa (about -100 to about -200mmAq)
(8) Discharge pressure : 49 to 69 kPa (about 5000 to about 7000 mmAq, 30oC)
(9) Number of blower rotations : 4000 to 30000min-1
(10) Number of operated units : 1 or more
(11) Number of motor rotations : 900 to 3600 min-1 (synchronous)

4.1.3 Performance

The blower performance shall be as shown in Particular Specification. Common specifications and the range of performance shall be as follows.

(1) Discharge pressure, air flow capacity and shaft power shall meet the specifications sufficiently when inspected at the factory in accordance with JIS B 8340 or equivalent.
(2) Air flow capacity control range
  (a) Set conditions : Specification discharge pressure
  (b) Performance : Inlet vane control 55 to 100%
(3) Noise
  (a) Set conditions : Measuring standards: JIS B 8340 (Scale A) or equivalent
  At installation place 1.0m above the floor and 1.5m from the blower cover
  (b) Performance : Below 85 dB (A) per unit including motor and gear noise
(4) Vibration
  (a) Set conditions : Measuring standards: JIS B 8340 or equivalent
  Measuring place: above the bearing box
  (b) Performance : Good in accordance with JIS B 8340 or equivalent per unit including motor and gear vibration
(5) Efficiency
  (a) Set conditions : Measured at specification air flow and air pressure and converted to specification temperature conditions
  (b) Performance : Overall adiabatic efficiency. Not less than specification efficiency.

4.1.4 Construction of Various Portions

(1) Casing

The casing shall be made of cast iron free from blowhole, air bubble and uneven wall thickness. It shall be bolted to the gear box and be constructed dividable in axial direction. The portion of the casing which faces the blade (front) of the impeller shall be entirely machined, and the area where the shaft passes through shall be provided with labyrinth seals to reduce air leakage.

(2) Impeller

The impeller shall be of single-suction centrifugal or mixed flow type and be constructed to be mounted to the high-speed shaft end of the gear. The pinion shaft with the impeller shall be tested on dynamic balancing. The rotor unbalance shall be corrected to JIS B 0905 Class G2.5 or equivalent. Moreover, it shall be subjected to the overspeed test at not less than 110% of the normal operation speed to confirm the strength prior to assembly.

The impeller shall be manufactured by a forged aluminum alloy which considers corrosion resistance.

(3) Air flow capacity controller

The air flow capacity shall be controlled by constant air flow capacity control or constant air pressure control using the inlet vane. The inlet vane shall be mounted on the upstream side of the impeller and the air flow capacity shall be changed by controlling its angle.

Especially, the variable guide vane whose temperature may rise shall be constructed to be strong enough to thermal expansion, vibration, etc.

The inlet vane shall be operated with an electric signal input from an air flow capacity or pressure setter, and the air flow capacity is controlled through an operating arm from an electro-hydraulic actuator.

The inlet vane shall be able to be confirmed of its angle from outside and also to be operated manually. To indicate the vane angle, a transmittal potentiometer, etc. shall be mounted.

(4) Gear box

The gear box shall accelerate the number of rotations of the motor up to a value necessary for the blower.

(a) Casing

The casing shall be made of cast iron or steel plate as a two-split structure. The high-speed output shaft side should be provided with a blower casing mounting seat. The casing shall be able to be easily checked separately from the blower casing.

The area of the casing where the input/output shaft penetrates through shall be provided with an oil slinger, labyrinth, or the like to prevent oil leakage.

(b) Gears

Gears shall be made of special steel or carbon steel and shall be parallel or planetary gears of helical type with gear teeth finished by grinding and shaving after heat treatment.

The pinion gear shall be integral or assembled with the high-speed shaft.

The gear contact ratio shall be not less than 2.0 and two or more teeth shall be in contact at all times and produce very small noise.

Regarding the thrust acting direction of the high-speed shaft, gears shall be mounted in such a way that the gear thrust and the air thrust are in opposite directions to reduce the resultant thrust.

Gears shall be designed to make the face pressure low and ensure long life of gears.

(c) Gear shafts

Gear shafts shall be made of special steel or carbon steel. The high-speed shaft shall be provided with the impeller and the bull gear shaft shall be direct-coupled at one end to the motor shaft

through a flexible coupling, etc. and at the other end provided with a direct-coupled oil supply pump driving portion.

The primary critical speed on the high-speed shaft shall be separated sufficiently from the rated number of rotations to avoid resonance.

(d) Bearing

The bearing shall be mounted to the gear box casing, and the bearing metal shall be made of carbon steel with lining of white metal or kelmet.

(5) Shaft coupling

The gear shaft and the motor shaft shall be direct-coupled through a flexible coupling. The shaft coupling shall have sufficient strength for power transmission and shall be provided with a safety cover.

(6) Common base

The common base shall be a welded structure of shape steel or steel plate and have sufficient strength to loads. The common base shall be partly partitioned to form an oil tank which shall hold lubricating oil enough for oil supply to the bearing and gears. The oil tank shall be provided with oil level gauge, drain, gas vent, inspection port, oil port, etc.

Vibrationproof rubber shall be provided on the underside of the common base. This rubber shall be highly durable and provide adequate effects of vibration prevention. Additional consideration shall be given, such as providing stoppers at the four corners of the common base to resist horizontal loading in the event of earthquake.

(7) Forced oil supply equipment

A set of forced oil supply equipment shall be installed for each blower unit. By this equipment, lubrication oil shall be supplied by oil supply pump through lubrication oil cooler to the bearing and gears of the gear box, and as necessary to the bearing of the motor, from which the oil shall be returned to the oil tank.

The oil pump shall be composed of an auxiliary oil pump which is motor-driven to operate at the time of blower startup and a main oil supply pump which is driven from the bull gear during the blower operation.

The main oil pump shall have a capacity enough to prevent burn-out of bearings, etc. even during the blower inertia operation in the event of power service interruption.

The lubrication oil cooler shall be of multipipe type and heat exchange shall be made between oil on the outside and water on the inside.

(8) Anti-surge equipment

The anti-surge prevention equipment shall be composed of a set of electro-hydraulic actuator for each blower unit. The function of this safety equipment is as follows. As the operating point approaches the surging flow at the time of blower startup or during the blower operation, the butterfly valve connected to the air discharge pipe shall be opened to allow the air to be partly discharged along the surging characteristic curve so that the blower may continue its operation always in the safe region.

(9) Soundproof cover

The blower and the gear box shall be covered to reduce noise. The soundproof cover shall be made of steel plate and constructed with an internal lining of a sound absorber such as glass wool.

It shall be easily removable and shall be provided with an inspection window, a lifting hook, etc.
For any rotating portion of the blower which is exposed, a safety cover shall be provided.

4.1.5 Accessories (per Unit)

(1) Silencer x 1 set
Connection bore diameter : Same as piping bore diameter
Mounting place : In suction piping
In discharge piping
In blowoff piping
Type : Cylindrical or angular
Loss : 0.5 kPa (about 50 mmAq) max in suction piping
1.0 kPa (about 100 mmAq) max in discharge piping

(2) Oil mist pipe (gas vent) x 1 set

4.1.6 Protection Measuring Instruments

The following protection measuring instruments shall be provided for each blower unit.

Instrument	Object of detection	Q'ty
Pressure gauge	Suction pressure	1
	Discharge pressure	1
	Supply oil pressure	1
	Control oil pressure	1
Pressure switch	Supply oil pressure	2
	Control oil pressure or control oil flow	1
Flow relay	Cooling water pressure	1
Dial thermometer	Supply oil temperature	1
	High-speed bearing temperature	2
	Suction temperature	1
	Discharge temperature	1
Temperature switch	Supply oil temperature	1
Bar thermometer	Oil cooler cooling water inlet/outlet	2
	Oil cooler lubricating oil inlet/outlet	2
	Low-speed bearing	2
Vibration monitoring equipment	Gear box casing	1
Thrust movement detection equipment	Impeller shaft	1
Limit switch	Blowoff valve	1
	Inlet vane	1
Level switch	Oil tank oil level	1

4.1.7 Applicable Laws and Regulations

The lubrication oil equipment and piping shall be in accordance with the fire fighting related laws and regulations, and according to the capacity, shall be provided with the following items.

(1) Fire extinguisher (for load installed)

(2) Use of increased safety explosion-proof type of motors for lubrication oil pump, etc.
(3) All valves of the oil system made of cast steel, nodular graphite cast iron or malleable cast iron

4.1.8 Standard Accessories (per Unit)

(1) Special disassembly tool (common for all units) x 1 set

4.1.9 Spare Parts (per Unit)

(1) Bearing for gear x 1 set
(2) Consumables for coupling x 1 set
(3) Consumables for oil filter x 1 set

4.2 ROTARY (ROOTS TYPE) BLOWER

4.2.1 General

The rotary (Roots type) blower shall be used to supply air to the sand filter. It shall be constructed with common base, blower main body, etc. The blower shall be driven through V-belts from the motor. The suction air shall pass through filter provided for each blower into the blower.

4.2.2 Manufacturing Conditions

(1) Application : For air washing of sand filter
(2) Type : Rotary (Roots type)
(3) Gas handled : Air
(4) Suction air temperature : 21 to 33.4^{0}C
(5) Operation : Continuous
(6) Air flow : 40 m^3/min max.
Set conditions: 30^{0}C, 101.3 kPa (1 atm), 90% RH
(7) Suction pressure : -1.0 to -2.9 kPa (about -100 to about -300 mmAq)
(8) Discharge pressure : 49 to 69 kPa (about 5000 to about 7000 mmAq)
(9) Number of blower rotations : 400 to 2000min-1
(10) Number of operated units : 1 or more
(11) Number of motor rotations : 1000 to 1800min-1 (synchronous)

4.2.3 Construction of Various Portions

(1) Casing

The casing shall be made of cast iron. It shall be constructed with the internal surfaces finished by machining precisely not to produce abnormality due to friction with the rotor, compression heat, etc.

(2) Rotor

The rotor shall be made of cast iron integral with or separate from the main shaft. Since air suction, compression and discharge processes are done between the casing and the rotor, consideration shall be given to corrosion resistance, freedom from breakage due to heating, high efficiency, etc.

(3) Bearing

The bearing shall be rolling type. It shall be sealed with oil seal, etc. to prevent oil leakage and air suction.

(4) Gear

The gear shall be made of special steel, and after machining, shall be applied with cementation, etc.

(5) Lubrication system

The bearing shall be lubricated either in oil bath or with grease.

(6) Cooling system

According as the pressure rise is less than or not less than 59 kPa (about 6000 mmAq), air cooling or water cooling shall be applied.

(7) Common base

The common base shall be made of steel plate or cast iron and shall be sturdy enough to endure loads. The common base or the motor base plate shall be considered so that the motor may slide with V-belt expansion. On the underside of the common base, a vibrationproof rubber shall be provided.

(8) Main shaft

The main shaft shall be made of carbon steel or malleable cast iron.

(9) Suction/discharge air silencer

The silencer shall be made of steel plate and constructed with an internal lining of a sound absorber such as glass wool.

The necessity of the silencer will be shown on the Particular Specification.

(10) Filter

This filter shall be used to remove dust, etc. contained in the suction air. For this purpose, the filter in the filter room shall be used or a filter shall be mounted directly to the suction silencer of each blower.

The filter element shall be non-textile cloth or equivalent, and the element passage speed shall be 2 m/s max.

4.2.4 Standard Accessories (per Unit)

(11) V-belt and pulley	x 1 set
(12) Discharge expansion pipe	x 1 set
(13) Pressure gauge	x 1 set
(14) Special tool (common for all units)	x 1 set
(15) Safety valve	x 1 set

4.2.5 Spare Parts (common for all Units)

(1) Lubricating oil (grease, oil)	x 2 cans
(2) Bearing	x 1 set
(3) Oil seal	x 1 set
(4) Air filter or filter media, etc. (to be mounted to the suction silencer)	x 3 sets

4.3 TRANSPORTABLE SMALL-SIZE AIR COMPRESSOR

4.3.1 General

This transportable air compressor shall be provided with an air tank and be used for air-operated valve, etc.

4.3.2 Manufacturing Conditions

(1) For the air compressor, the quantity of air to be used at maximum pressure shall be calculated with an allowance from the quantity of air to be used for each portion.

The maximum pressure shall be 0.69 to 0.93 MPa. The control differential pressure shall be 0.15 MPa min. As a rule, the air compressor shall be no oil supply type.

(2) The air tank shall conform to the related laws and regulations. The storage pressure shall be 0.69 to 9.3 MPa.

4.3.3 Construction of Various Portions

(1) The air compressor shall be reciprocating type as a rule, and shall be driven by the crank shaft by motor direct-coupling or through V-belts and V-pulleys from the motor. In the case of the belt drive, front and back sides of the pulley shall be covered with a e metal cover of expanded metal, etc.

(2) The air tank shall be horizontal cylindrical type and shall be provided with air inlet/outlet pipe mounting seats, pressure gauge mounting seats, drain pipe mounting seats, and other necessary apparatus.

(3) The motor specifications shall be totally enclosed fan-cooled type and continuous rating.

4.3.4 Materials Used

Air tank : Rolled steel

4.3.5 Protection Equipment

Safety valve and unloader device or pressure switch type

4.3.6 Operation

In this machine, the pressure in the air tank shall be kept automatically within a definite range.

4.3.7 Test and Inspection

The air compressor shall be subjected to performance test (pressure, discharge air flow), based on JIS B 8341 or equivalent and the air tank shall be subjected to the pressure test, both at the factory.

4.3.8 Standard Accessories (per Unit)

(1)	Unloader device or pressure switch	x 1 set
(2)	Suction silencer (with filter)	x 1 set
(3)	V-belt and V-pulley, and their covers (belt-drive only)	x 1 set
(4)	Air tank	x 1 set
(5)	Pressure gauge	x 1 set

(6) Safety valve x 1 set
(7) Electromagnetic valve type auto drain trap x 1 set

4.3.9 Spare Parts (per Unit)

(1) V-belt (belt-drive only) x 1 set
(2) Suction filter x 1 set
(3) Packing (air valves) x 1 set

4.4 SUCTION FAN

4.4.1 General

This fan shall be used to suck the odor gas.

4.4.2 Manufacturing Conditions

(1) This fan shall be constructed to produce less vibration and noise and endure continuous operation on 24 hours per day basis.
(2) This fan shall be designed to have an adequate allowance for both air flow and wind pressure and shall meet the following conditions.
    1) Air flow: As specified under the set conditions of 30°C, 0.1 MPa (1 atm) and 90% RH.
    2) Wind pressure: With a sufficient allowance to cover duct loss and deodorization equipment loss.
    3) Motor: With a sufficient allowance to prevent overloading under varying air temperature, relative humidity, etc.

4.4.3 Construction of Various Portions

(1) This fan shall be a single-suction turbo fan. The impeller shall be made of corrosion-resisting material (FRP) and be well balanced in rotation to produce less noise and vibration and be highly efficient.
(2) The impeller shall have wall thickness having an allowance of strength enough to endure the specified wind pressure.
(3) The shaft shall be made of carbon steel and the sleeve used in the portion which comes into contact with the gas shall be made of FRP.
(4) The casing shall be made of corrosion-resisting material (FRP) and be constructed to be sturdy.
(5) The portion of the casing where the shaft penetrates through shall be sealed to prevent odor gas leakage.
(6) The fan motor shall be installed on the common base and be driven by V-belts.
(7) The suction side and the discharge side of the fan shall be provided with respective vibration-preventing joints.
(8) In the bottom portion of the casing, a water drain valve shall be provided and be piped to the destination of discharge.
(9) The common base shall be provided with an vibration isolator device (such as vibration isolator spring).
(10) The shaft shall be protected with a cover and the oil supply port of the bearing shall be separated sufficiently from the shaft.
(11) Motor specifications shall be totally-enclosed fan-cooled type and continuous rating.

4.4.4 Materials Used

Impeller	Fiber reinforced plastic (FRP)
Shaft	Carbon steel
Casing	Fiber reinforced plastic (FRP)
Common base	Rolled steel or cast iron

4.4.5 Standard Accessories

(1)	Safety cover	x 1 set (per fan)
(2)	Vibration isolator joint	x 1 set (per fan)
(3)	Common base	x 1 set (per fan)
(4)	Vibration isolator device	x 1 set (per fan)
(5)	Manometer	x 1 set (per facility)
(6)	Hot wire anemometer	x 1 set (per facility)

4.4.6 Spare Parts

(1)	V-belt	x 1 set (per unit)

SECTION 5. SCREEN EQUIPMENT

5.1 COARSE SCREEN

5.1.1 General

The screen shall be a bar screen of flat steel grid type and be installed to block refuse, garbage, fiber, sticks and other inclusions and coarse suspended substances.

5.1.2 Manufacturing Conditions

(1) Strength calculations of the screen shall be made by considering the influent water flow, influent suspended solids and the difference of water level around the screen.

(2) For the strength of the screen, an adequate safety factor shall be taken.

5.1.3 Construction of Various Portions

(1) The screen shall be constructed with flat steels. The steels shall be removed of strains completely, then with spacers inserted to separate them at equal intervals, shall be tightened and assembled together by means of through-bolts which have screws at both ends.

(2) The screen shall be mounted to the support shape steel by means of bolts. The support shape steel shall be fixed by means of anchor bolts at both ends to the water channel side wall.

(3) The anchor bolt shall be welded to the reinforcing bars of the structure and have an adequate strength.

(4) The screen shall be split into two halves if the basin width exceeds 2.5m.

5.1.4 Materials Used

(1) Screen — Flat steel and shape steel (Rolled steel)

(2) Other important portions in contact with water

Spacer	Stainless steel
Pin, bolt, through-bolt, etc.	Stainless steel

5.1.5 Standard Accessories

(1)	Anchor bolt	x 1 set
(2)	Fire hook and rake	x 1 set each
(3)	Transport carrier	x 1 set
(4)	Container (made of synthetic resin or stainless steel)	x 1 set

5.2 COMMINUTER (TWO-SHAFT DIFFERENTIAL OPERATION TYPE)

5.2.1 General

This comminuter shall be composed of a casing, shafts, a comminuting portion, a drive unit, etc. and shall be installed in the influent water channel or sludge piping to crush and finely cut the inclusions contained in the influent sewage.

5.2.2 Manufacturing Conditions

(1) This machine shall crush and finely cut the inclusions contained in the sewage to those sizes which do not interfere with the operation of the sewage pump.

(2) The comminuting portion shall be made of materials and in the construction to be less worn and endure a long time of use.

(3) For the strength of various portions, a sufficient safety factor shall be taken.

5.2.3 Construction of Various Portions

(1) This machine shall be constructed so that the 2-shaft type rotary cutting portion is driven through a vertical motor direct-coupled type speed reducer.

(2) The casing shall be a cast iron product of good quality considering mechanical strength as well as corrosion and wear resistance.

(3) The cutting portion shall be made of special steel having excellent wear resistance and be constructed to permit easy replacement.

5.2.4 Materials Used

(1)	Casing	Cast iron
(2)	Cutting portion	Special steel having excellent wear resistance
(3)	Shaft	Carbon steel or chromium-molybdenum steel

5.2.5 Standard Accessories

(1)	Foundation bolt and nut (stainless steel)	x 1 set
(2)	Special tools	x 1 set

5.2.6 Spare Parts(per Unit)

(1)	Cutter	x 10 % for one unit

SECTION 6. SLUDGE SCRAPER EQUIPMENT

6.1 SLUDGE SCRAPER (CHAIN FLIGHT TYPE: SYNTHETIC RESIN CHAINS)

6.1.1 General

The sludge scraper shall be a chain flight type and be installed for the purpose of scraping the settled sludge into the hopper provided by the side of the tank.

The sludge scraper shall be constructed with endless chains having flights mounted at definite intervals. The endless chain shall be driven through sprockets on the drive shaft and driven shaft to move the flights along the rail surfaces on the tank bottom so that the sludge may be scraped into the sludge hopper.

In this construction, the scum generated on the water surface in the sedimentation tank is scraped from the return side of the sludge scraper so that it may flow into the scum skimmer.

6.1.2 Manufacturing Conditions

(1) Scraper chain

Type	:	Synthetic resin chain
Pitch	:	About 150 to 200 mm
Rupture strength (Guaranteed minimum):		15 kN
(Average)	:	20 kN

(2) Sprocket wheel

Pitch	:	About 150 to 200 mm
Number of teeth	:	Not less than11

(3) Scraping speed

Primary sedimentation tank	:	About 0.6 m/min
Final sedimentation tank	:	About 0.3 m/min

(4) Flight mounting pitch

About 3 m

6.1.3 Construction of Various Portions

Construction and materials of various portions shall be as follows.

(1) Drive unit

The drive unit shall be a horizontal cycloidal reduction gear or planetary reduction gear. Power shall be transmitted by chain transmission system and the speed shall be reduced to the predetermined sludge scraping speed. The transmission chain shall be arranged on the sprockets with the return side up, as a rule.

The drive chain which will be submerged in water shall be a stainless steel bushed chain or synthetic resin chain. Or, a chain tightener shall be provided, as necessary.

The cover for the exposed chain shall be made of stainless steel plate.

(2) Scraper chain

The chain shall be a synthetic resin chain with high wear resistance and corrosion resistance. It shall be constructed easy to disassemble and adjustable in chain elongation.

(3) Sprocket wheel

(a) For the sprocket wheel for the drive chain, a special pin type wheel, shall be used considering wear.

(b) For the sprocket wheel for the scraper chain, a special pin type wheel, shall be used for the drive shaft considering abrasion, and a synthetic resin sheave type wheel with no tooth for the driven shaft.

(4) Flight

1) Flight material shall be synthetic resin (fiber reinforced plastic, FRP).

2) For each tank, rubber plates to scrape the sludge to the tank bed surface shall be mounted at ends of two flights.

3) Regarding guide shoes, adequate consideration shall be given to their mounting intervals, etc. and an adequate allowance for wear shall be provided, so that the flight may not contact the concrete wall, bearing stand, rail holder, etc. and the flight strength may not be damaged.

4) The flight mounting bolt shall be a stainless steel bolt with locking device.

(5) Shaft

The mid portion of the drive shaft shall be made of stainless steel pipe. The driven shaft shall be made of stainless steel pipe and be an cantilever type shaft.

(6) Bearing

The bearing for drive shaft shall be made of synthetic resin.

(7) Adjustment of chain elongation

Adjustment of chain elongation shall be made by pulling off chain links, as a rule. The chain shall be installed such that the sludge may be scraped up to the end portion of the tank.

(8) Tank bottom rails

On the bottom surface of the tank, rails (made of synthetic resin) to guide the flights shall be mounted.

(9) Guide rails

Return guide rails shall be mounted from the side wall. They shall be somewhat adjustable and have adequate strength. If there is a possibility of abnormal vibration, or the flight contacting the beam, scum skimmer, etc. and being broken, guide rails, etc. shall be provided even over the flights.

(10) Lubricating equipment

No oil supply type.

6.1.4 Materials Used

Materials used shall be as follows

(1) Scraper chain		
Chain main body	:	Synthetic resin
Pin	:	Synthetic resin
(2) Shaft		
Drive shaft	:	Stainless steel
Driven shaft	:	Stainless steel
(3) Bearing		
Drive shaft bearing	:	Synthetic resin

(4) Sprocket wheel

For drive chain	:	Stainless steel + synthetic resin
For scraper chain for drive shaft:		Stainless steel + synthetic resin
For scraper chain for driven shaft:		Synthetic resin

(5) Flight
Fiber reinforced plastic (FRP)
(6) Guide rail
Stainless steel
(7) Tank bottom rail
Synthetic resin
(8) Guide rail bracket
Rolled steel
(9) Guide shoe
Synthetic resin
(10) Anchor bolt and nut
Stainless steel

6.1.5 Protection Equipment

(1) Electrical protection equipment
Overcurrent detector for overload protection (electrical equipment work)
(2) Mechanical protection equipment
Speed reducer built-in torque limiter for overload protection

6.1.6 Standard Accessories

(1)	Steel plate common base	x 1 set
(2)	Drive unit and chain cover	x 1 set
(3)	Mounting bolt and nut	x 1 set
(4)	Special disassembly tool	x 1 set
(5)	Anchor bolt and nut	x 1 set

6.1.7 Spare Parts

(1)	Scraper chain	x 2 links (per train)
(2)	Flight (shoe, bolt, nut, attachment)	x 1 set (per train)
(3)	Oil	
	Gear oil (if used) and grease	x 1 can each (common for all units)

6.2 SLUDGE SCRAPER (CENTER-DRIVEN SUSPENSION TYPE)

6.2.1 General

The sludge scraper for thickeners of not more than 15m in diameter shall be composed of drive unit, main shaft, feed well, steel bridge rake, scum skimmer, etc. The turning force shall be given from the drive unit through the main shaft to the rake arm so that the sludge on the thickener bottom may be scraped by means of the rake mounted to the rake arm continuously to the sludge pit provided at the center of the thickener. The scum generated on the water surface of the thickener shall be collected by the scum blade mounted to the skimmer arm into the pipe skimmer for scum removal. In the center-driven suspension construction, the drive unit shall be installed on the bridge, and the main shaft and the rake arm shall be suspended from the bridge.

6.2.2 Manufacturing Conditions

(1) This equipment shall be safe sufficiently to the scraper load and startup time load, be free from vibration, heating, abnormal sound, etc. during operation, and shall withstand continuous operation.
(2) Each portion of the equipment shall have ample strength and wall thickness to corrosion and abrasion.
(3) The peripheral speed shall be about 2 to 3 m/min.

6.2.3 Construction of Various Portions

(1) Drive unit
  (a) This unit shall be composed of motor, cycloidal reduction gear or planetary reduction gear or gear and chain, etc. and transmit the power safely and positively. The speed shall be reduced to the predetermined scraping speed. The main shaft shall be turned through coupling and bearing stand.
  (b) The bearing shall be able to support the load of the scraper main body and the vibration due to turning sufficiently.
  (c) The cover for the exposed chain shall be made of stainless steel plate.
(2) Steel bridge
  (a) The bridge shall be a welded structure and be provided with main beam, auxiliary beam, etc. It shall be sturdy.
  (b) The check walkway on the bridge surface shall be not less than 1m in width. Around the central driving portion, an ample space for check, repair, etc. shall be provided and lined with checkered steel plates. For important portions, a check cover shall be provided and on both sides of the bridge, handrails shall be provided.
(3) Rake and rake arm
  (a) The rake shall be mounted firmly to the rake arm. Rakes shall be overlapped each other not to leave areas where the sludge is not scraped.
  (b) Under the rake, a replaceable adjusting blade shall be mounted and the clearance to the thickener bottom shall be adjustable.
  (c) The rake arm shall have two blades (auxiliary blades may be provided). It shall be constructed by truss structure of steel material and shall have adequate strength to bending loads, etc.
  (d) The clearance to the rake thickener bottom surface shall be not more than about 50 mm at the mid point of the blade and rubber shall be mounted to the blade end.
(4) Feed well
  (a) The feed well shall be mounted firmly to the thickener wall by means of supports. It shall reduce the flow speed promptly and have large effect of straightening.
  (b) The feed well shall be made of stainless steel.
  (c) The feed well shall be provided with a small window with baffle and the scum in the feed well shall be able to be discharged through the window.
(5) Main shaft and bearing
  (a) The main shaft shall be suspended from the bearing stand and have a sufficient allowance for torsional loads. The bearing shall be a rolling bearing constructed to support thrust loads.

(6) Scum skimmer
   (a) The skimmer arm shall be mounted firmly to the main shaft, and the scum blade shall pass above the pipe shimmer.
   (b) The scum blade shall be of movable type and scum discharge to the pipe skimmer shall be smooth.
   (c) The baffle plate shall be constructed to be suited to prevent scum from flowing out.
   (d) The scum blade shall be constructed for efficient collection of scum considering undercurrents, etc.
   (e) The pipe skimmer shall be of manual operation (lever) type. For the details, refer to "7.2 Manual Operation Type Pipe Skimmer for Circular Thickener".
(7) Oil supply equipment
   (a) The drive unit shall be constructed for easy oil supply and check.
   (b) A grease nipple shall be provided at a position of easy oil supply.
(8) The motor specifications shall be outdoor totally-enclosed fan-cooled type and continuous rating.

6.2.4 Materials Used

(1)	Blade	Stainless steel
(2)	Submerged bolt and nut	Stainless steel
(3)	Rake and rake arm	Rolled steel
(4)	Main shaft	Carbon steel pipe for pressure service or Carbon steel tube for machine structural purposes
(5)	Feed well	Stainless steel
(6)	Feed well support	Rolled steel
(7)	Bridge	Rolled steel
(8)	Handrail	Steel pipe
(9)	Skimmer arm	Stainless steel
(10)	Scum blade	Stainless steel
(11)	Baffle plate	Stainless steel
(12)	Bracket for baffle plate	Stainless steel

6.2.5 Protection Equipment

(1) Mechanical protection equipment
Protection equipment for overload protection
(2) Electrical protection equipment
Overcurrent detector for overload protection
(electrical equipment work)

6.2.6 Standard Accessories

(1)	Anchor bolt	x 1 set
(2)	Drive unit and chain cover	x 1 set

3.3.12 Spare Parts

(1) Oil
Gear oil (if used) and grease x 1 can each (common for all units)

SECTION 7. SCUM SKIMMER EQUIPMENT

7.1 MANUAL OPERATION TYPE PIPE SKIMMER FOR RECTANGULAR TANK

7.1.1 General

This skimmer shall be installed in front of the primary sedimentation tank overflow weir. The scum generated on the water surface shall be scraped by the return side flights of the sludge scraper and shall be taken in together with supernatant and removed out of the tank as the manual operation type pipe skimmer shall be turned in normal and reverse directions within a definite angle.

This pipe skimmer shall be constructed with manual operating handle, support stand, bearing, etc.

7.1.2 Manufacturing Conditions

(1) This skimmer shall be strong enough to endure water pressure, torsion during rolling motion, etc.

(2) The bearing portion shall be constructed to accommodate thermal elongation and contraction of steel pipes.

(3) For any portion which may corrode or wear, wall thickness shall be given consideration.

7.1.3 Construction of Various Portions

The construction of various portions shall be as follows.

(1) Operating equipment

An operating handle mounting metal shall be provided at the end of the pipe skimmer main body, and the pipe skimmer shall be able to be turned within a definite angle by means of the operating handle (lever).

(2) Pipe skimmer main body

The pipe skimmer shall be made of a steel pipe having diameter not less than 250 mm. It shall have an opening necessary to remove the scum. This skimmer shall be constructed to be strong enough to endure torsion and deflection caused by double-end supporting even it is mounted across the width of the tank. As necessary, an adjusting means shall be provided to make adjustment of the skimmer main body easy.

(3) Operating handle

The operating handle shall have adequate strength and skimmer main body adjustment by means of this handle shall be easy. The handle shall be dismountable.

(4) The main body of the bearing portion shall be made of good quality of cast iron and shall be constructed with a bush provided on its inside to prevent water leakage. The bearing shall have optimum construction for the load and have an adequate bearing capacity. It shall have complete function of lubrication.

(5) It shall be easy to supply oil to the bearing portion from a place above the tank. This piping shall be made of a stainless steel pipe or a covered copper pipe or a pressure-resisting rubber hose, all being arranged neatly.

7.1.4 Materials Used

The materials used shall be as follows.

(1)	Skimmer main body	:	Steel pipe
(2)	Bearing portion main body	:	Cast iron
(3)	Frame	:	Rolled steel or cast iron

7.1.5 Protection Equipment

The mechanical protection equipment shall be as follows.

The skimmer shall be provided with stoppers to prevent turning beyond a definite angle.

7.1.6 Standard Accessories (per Unit)

(1)	Mounting bolt and nut	x 1 set
(2)	Oil supply equipment	x 1 set

7.2 MANUAL OPERATION TYPE PIPE SKIMMER FOR CIRCULAR TANK

7.2.1 General

This skimmer shall be installed along the total length of radius (except the feed well) of the circular tank. The scum generated on the water surface shall be scraped by the skimmer arm and the scum blade mounted to the main shaft or the center cage of the scum scraper. It shall be taken in together with supernatant and removed out of the tank as the manual operation type pipe skimmer shall be turned in normal and reverse directions within a definite angle.

This pipe skimmer shall be constructed with manual operation handle, support stand, bearing, etc.

7.2.2 Manufacturing Conditions

(1) This skimmer shall be strong enough to endure water pressure, torsion during rolling motion, etc.

(2) The bearing portion shall be constructed to accommodate thermal elongation and contraction of steel pipes.

(3) For any portion which may corrode or wear, wall thickness shall be given consideration.

7.2.3 Construction of Various Portions

The construction of various portions shall be as follows.

(1) Operating equipment

An operating handle mounting metal shall be provided at the end of the pipe skimmer main body, and the pipe skimmer may bee turned within a definite angle by means of the operating handle (lever).

(2) Pipe skimmer main body

The pipe skimmer shall be made of a steel pipe having diameter not less than 250 mm. It shall have an opening necessary to remove the scum. This skimmer shall be constructed to be strong enough to endure torsion and deflection caused by double-end supporting even when it is mounted along the radius of the tank.

(3) Operating handle

The operating handle shall have adequate strength and skimmer main body adjustment by means of this handle shall be easy. The handle shall be dismountable.

(4) The main body of the bearing portion shall be made of good quality of cast iron and shall be constructed with a bush provided on its inside to prevent water leakage. The bearing shall have optimum construction for the load and have an adequate bearing capacity. It shall have complete function of lubrication.

(5) It shall be easy to supply oil to the bearing portion from a place above the tank. This piping shall be made of a stainless steel pipe or a covered copper pipe or a pressure-resisting rubber hose, all being arranged neatly.

7.2.4 Materials Used

The materials used shall be as follows.

(1)	Skimmer main body	:	Steel pipe
(2)	Bearing portion main body	:	Cast iron
(3)	Bearing frame	:	Rolled steel or cast iron

7.2.5 Protection Equipment

The mechanical protection equipment shall be as follows.

The skimmer shall be provided with stoppers to prevent turning beyond a definite angle.

7.2.6 Standard Accessories (per Unit)

(1)	Mounting bolt and nut	x 1 set
(2)	Oil supply equipment	x 1 set

SECTION 8. AERATION TANK DIFFUSER EQUIPMENT

8.1 POROUS DIFFUSER TUBE

8.1.1 General

This equipment shall have optimum functions to dissolve oxygen contained in air efficiently into the sewage in order for the effective removal of BOD, SS, etc. based on the modified aeration process. It shall be constructed to

retain the stable diffusion effect for a long time and to be suited for easy maintenance.

8.1.2 Design Conditions

The diffuser tube shall be constructed with moulded porous cylinder of ceramic particles or synthetic resin particles of uniform particle diameters. It shall generate fine air bubbles from the pores having a high efficiency of oxygen dissolution. Also it shall have excellent shock resistance and durability and maintain the stable aeration performance for a long time.

(1) Scope of this Specification and design conditions

(a)	Application	Aeration for sewage treatment
(b)	Gas-handled	Air
(c)	Air pressure	49 to 69 kPa (5000 to 7000 mmAq)
(d)	Diffuser tube specifications	
(e)	Operation	24h continuous per day

8.1.3 Performance and Construction of Various Portions

(1) The performance of the diffuser tube shall be as follows.

(a)	Pore diameter	200 to 450ìm
(b)	Porosity	29 to 40%

(2) Diffuser tube holder

The diffuser tube holder shall be made of stainless steel or synthetic resin and be provided with an orifice suited for uniform air passage flow.

The diffusion tube holder shall be installed with adequate care about levelness so that the diffuser tube center line may be set at the same water level.

(3) The header pipe shall be made of stainless steel constructed for a set of 8 to 24 diffuser tubes. The connection with the riser pipe shall be made by means of flange joints. The header pipe shall be fixed to a stainless steel stand by means of stainless steel bolts and nuts.

(4) The riser pipe shall be a stainless steel pipe.

For the stabilization of the aeration tank diffuser, the header pipe and the diffuser tube holder shall be provided with stainless steel legs.

(5) The main valve for riser pipe shall be a butterfly valve (important portions made of stainless steel). The valve opening degree shall be adjusted in notch type (stepwise). The handle of the valve shall be constructed to be easily operated from the slab.

8.1.4 Materials Used

(1)	Diffuser tube	Ceramic or synthetic resin
(2)	Diffuser tube holder	Stainless steel or synthetic resin
(3)	Holder accessory metal	Stainless steel

SECTION 9. DISINFECTION EQUIPMENT

9.1 SODIUM HYPOCHLORITE FEED PUMP

9.1.1 General

This pump shall be used to pump the solution supplied from the sodium hypochlorite storage tank up to the feeding point to be fed into the water to be discharged.

9.1.2 Manufacturing Conditions

(1) This feed pump shall have a feeding range (stroke length control) having the maximum to minimum ratio of about 4:1, and the measuring precision shall be ±5% at each point.

(2) For this feed pump, stroke length control, number of rotations control, or stroke length and number of rotations combination control shall be selected according to the feeding rate.

9.1.3 Construction of Various Portions

The construction of various portions shall be as follows.

(1) This machine shall be constructed to be easy to operate and highly safe and durable.

(2) This feed pump shall be constructed to adjust the sodium hypochlorite feeding rate automatically to a constant value for the sewage flow to be discharged, or to permit manual operation as well.

Moreover, it shall be possible to control the feeding rate by means of a feed adjusting device capable of adjusting to any arbitrary feeding rate.

(3) Basic components

(a) Feed pump

(b) Control devices

(c) Strainer

(d) Valves

9.1.4 Materials Used

Materials used shall be as follows.

(1)	Feed pump	:	PVC (liquid contact portions)
(2)	Bolt and nut	:	Stainless steel

9.1.5 Protection Equipment

The protection equipment shall be as follows.

(1) Back pressure valve or check valve

Used to prevent the final effluent from flowing back into this pump when the pump stops.

(2) Gas vent pipe or tube

Used to vent gas generated on the suction side of the feed pump.

9.1.6 Standard Accessories

(1)	Pressure gauge	x 1
(2)	Strainer	x 2
(3)	Back pressure valve	x 1
(4)	Foundation bolt and nut	x 1

9.2 SODIUM HYPOCHLORITE STORAGE TANK

9.2.1 General

This tank shall be used to store the sodium hypochlorite solution.

9.2.2 Manufacturing Conditions

(1) This tank shall have a storage capacity sufficient for disinfection of the quantity of final effluent.

9.2.3 Construction of Various Portions

The construction of various portions shall be as follows.

(1) This storage tank shall be made of materials having excellent safety and durability to the sodium hypochlorite solution and shall be constructed to be strong enough and free from leakage. The main body shall be made of bisphenol type FRP and shall have a plate thickness of 5 mm minimum and a glass content of not less than 15%. Moreover, the main body internal surface shall have a hard polyvinyl chloride plate.

(2) This tank shall be of vertical stationary type.

(3) The tank main body shall be constructed with solution acceptance inlet, effluent outlet, drain, air vent, direct-viewing type liquid level gauge, washing water inlet, liquid level transmitter seat, manhole, external inspection ladder, etc.

(4) Above and below the direct-viewing type liquid level gauge, a ball built-in type check valve shall be provided to prevent leakage caused by pipe breakage.

(5) At all connection to the vinyl chloride lining pipe, flexible pipe joint shall be mounted.

9.2.4 Materials Used

(1)	Main body	: Fiber reinforced plastic (internal surface with hard vinyl chloride plate)
(2)	Liquid level gauge	: Clear PVC
(3)	External inspection ladder (with guard)	: Rolled steel or steel pipe

9.2.5 Standard Accessories

(1) Direct-viewing type liquid level gauge x 1 set
(scale display in m3)

(2) External inspection ladder x 1 set

(3) Manhole x 1 set

(4) Foundation bolt and nut x 1 set

(5) Section 10 Water Supply Equipment

SECTION 10. WATER SUPPLY EQUIPMENT

10.1 PRESSURE SAND FILTER

10.1.1 General

This sand filter shall receive the secondary treated sewage supplied under pressure by the raw water pump and filter it under pressure to obtain the water to be used in the plant. It shall be composed of the main body portion, filter media portion, etc.

10.1.2 Manufacturing Conditions

(1) This filter shall be a vertical 2-layer type pressure filter.

(2) The filtration rate shall be 200 m/d max.

(3) If the raw water has BOD concentration below 20 mg/L and SS concentration 20 to 30 mg/L, the filtered water shall have SS concentration below 15 mg/L.

(4) The design pressure of this filter shall be 0.3 MPa.

(5) The backwash rate shall be 0.6 to 0.8 m3/min°m2.

(6) The air wash rate shall be about 1.0 m3/min°m2.

10.1.3 Construction of Various Portions

(1) Main body portion

(a) The main body shall be a steel plate welded structure and be provided with raw water inlet/outlet and backwash water port, backwash air port, air vent port, etc.

(b) For filtration, the raw water shall be distributed from above uniformly and passed through filter media, and the filtered water shall be taken out of the filtered water outlet.

(c) The main body shall have a filter media supporting portion in the lower portion.

(d) The main body shall have a filter media filling and checking manhole in the upper portion and a sight window and a filter media takeout port on the side portion.

(2) Washing portion

(a) Washing shall be done with valve switched in accordance with a timer.

(b) Washing shall be done by backwash and air wash.

(c) The automatic valve shall be a motor-driven or air-operated flangeless butterfly valve or the like.

(d) Internal piping shall be made of stainless steel.

(3) Filter media portion

(a) The filter media portion shall have water collecting device, gravel, sand and Anthracite placed in layers on the filter media supporting portion, as follows.

Bed	Filter media	Diameter	Uniformity coefficient	Thickness
Supporting bed	Gravel	2 to 75 mm		300 mm min.
Filter bed	Sand	Effective dia. about 0.65 mm	Less than 1.4	400 mm min.
	Anthracite	Effective dia. about 1.5 mm	Less than 1.4	600 mm min.

(b) Sand shall have ignition loss below 0.75% and specific gravity 2.57 to 2.67.

(c) Anthracite shall have specific gravity above 1.4.

10.1.4 Materials Used

(1) Main body : Rolled steel

(2) Liquid contact portion bolt and nut : Stainless steel

(3) Liquid contact portion parts : Rolled steel or stainless steel

10.1.5 Standard Accessories (per Unit)

(1) Differential pressure gauge x 1 set

(2) Influent/effluent pressure gauge (with cock, diaphragm type) x 1 set

(3) Influent valve, effluent valve, backwash valve, air wash valve, exhaust valve, etc. x 1 set

(4) Flowmeter (for filtration: local indication, for backwash water: local indication) x 1 set

(5) Electromagnetic valve and box (in the case of air-operated valve) x 1 set

(6) Small piping around the filter x 1 set

10.2 AUTOMATIC WASHING STRAINER

The automatic washing strainer shall be used to remove inclusions contained in the secondary treated sewage supplied under pressure by the raw water pump.

10.2.1 Manufacturing Conditions

(1) The mesh width of the strainer shall be about 0.4 mm.

(2) The design pressure shall be 1.0 MPa.

10.2.2 Construction of Various Portions

(1) The backwash portion shall be screen rotation type or backwash nozzle rotation type, and the rotating body shall be rotated through the speed reducer from the motor by the rotating shaft fixed at the upper bearing.

(2) The opening portion of the strainer shall be in a shape suited especially for removing fibrous substances.

(3) The casing shall be made of cast iron or steel.

(4) Automatic washing in accordance with timer setting (variable) and differential pressure shall be possible.

(5) The automatic wash equipment shall be of self-washing type and the automatic valve shall be operated by an air cylinder or motor.

(6) The control panel shall be composed of an operation panel and a relay panel to control the interlocking circuit between the main body and the backwash valve. The operation panel and the relay panel may be constructed integral with each other.

(7) The connection flange shall be in accordance with JIS B 2212 (JIS 10K) or equivalent.

10.2.3 Materials Used

(1)	Liquid contact portion parts	:	Rolled steel or stainless steel
(2)	Strainer	:	Synthetic resin or stainless steel
(3)	Shaft	:	If the shaft has a submerged sliding portion, it shall be made of stainless steel or provided with sleeve (stainless steel).
(4)	Liquid contact portion bolt and nut	:	Stainless steel

10.2.4 Standard Accessories (per Unit)

Automatic backwash equipment	x 1 set
Differential pressure switch	x 1 set
Pressure gauge (diaphragm type)	x 1 set
Backwash valve	x 1 set
Small piping around the equipment	x 1 set
Control panel (indoor wall-mounted type)	x 1 set

SECTION 11. SLUDGE TREATMENT EQUIPMENT

11.1 CENTRIFUGAL THICKENER

11.1.1 General

This thickener shall be used for the continuous centrifugal thickening of the excess sludge generated in the final sedimentation tank. It shall be composed of centrifugal separator main body and soundproof cover, accessory equipment and control panel.

11.1.2 Manufacturing Conditions

This thickener shall meet the following specifications as an assembly of machined screw, bowl, etc.

(1) Shall be horizontal continuous type.

(2) The thickener performance shall be as follows.

(a) Conditions of sludge

Kind of sludge	:	Excess sludge
Concentration	:	0.6 to 0.8%
SVI	:	200 max.

(b) Performance (in the case of no chemical feeding)

Thickened sludge concentration	:	4% min.
SS recovery ratio	:	85 to 95%
Treated water flow rate	:	In accordance with Particular Specification

11.1.3 Construction of Various Portions

(1) The centrifugal thickener shall be composed of bowl, screw, back drive device, feed pipe, bearing, chute, base, safety device, drive unit and back drive device, etc. It shall be manufactured to endure high speed rotation, to be well in balance static and dynamic, and further given consideration for wear resistance and corrosion resistance.

(2) Vibration isolator device

To prevent excessive vibration caused by rotation from being transmitted to the outside, this thickener shall be supported by vibration isolator device, etc.

(3) Rotor

The rotor shall be composed of bowl and screw, and the screw blade end shall be made of a material having excellent wear resistance such as ceramic or tungsten carbide.

(4) Casing

The bowl of the thickener shall be contained in the casing. The casing shall be constructed to permit easy check and maintenance of the inside and also to close well to prevent leakage of sludge mist and offensive odours to the outside.

(5) Drive Unit

The drive unit shall have a capacity enough to rotate the main body up to the specified number of rotations and endure the load. The motor shall be totally enclosed fan-cooled type and be inverter-driven, as standard.

(6) Soundproof cover

(a) As a noise counter measure, the thickener shall be covered with a soundproof cover. In order to prevent temperature rise in the soundproof cover, a ventilation device shall be provided.

(b) The soundproof cover shall be provided with a door, cover, etc. of sufficient size for easy maintenance check and repair of contained apparatus. The inside shall be provided with lighting.

(7) Internal piping

Various kinds of piping in the package shall be neatly arranged and be free from impeding internal check. Connections to movable parts shall be made using flexible joints, etc. to prevent propagation of vibration.

(8) Sludge piping

The sludge supply piping shall be provided with an electromagnetic flowmeter (covered by a separate electrical work) for flow measurement. The flowmeter shall be provided outside the package.

(9) Internal washing

At the end of the centrifugal thickening operation, it shall be possible to wash the inside of the rotor body.

(10) Lubrication system

The lubrication system shall be as follows.

(a) Bearing box (main bearing) : Grease-sealed, oil bath, forced lubrication

(b) Screw supporting portion bearing: Grease-sealed lubrication

11.1.4 Materials Used

(1)	Bowl	:	Stainless steel
(2)	Screw	:	Stainless steel
(3)	Chute	:	Stainless steel
(4)	Base	:	Rolled steel
(5)	Soundproof cover	:	Rolled steel (with sound absorber on the inside surface)
(6)	Soundproof cover internal piping		
	Sludge, separated liquid	:	Stainless steel
	Water	:	Steel pipe

11.1.5 Protection Equipment

(1) If any abnormal vibration or abnormal temperature occurs, the thickener shall stop automatically.

11.1.6 Standard Accessories (per Unit)

(1)	Drive unit	x 1 set
(2)	Back drive device (if necessary)	x 1 set
(3)	Vibration isolator unit	x 1 set
(4)	Oil pressure pump unit (if necessary)	x 1 set
(5)	V-belt and belt cover	x 1 set
(6)	Soundproof cover internal piping and valves	x 1 set
(7)	Washing wastewater transfer valve (motor valve)	x 1 set
(8)	Local power control panel	x 1 set
(9)	Soundproof cover (with ventilating fan and lighting)	x 1 set

(10) Special disassembly tool	x 1 set (common for all units)
(11) Soundproof cover internal thickened sludge chute	x 1 set
(12) Foundation bolt and nut	x 1 set

11.1.7 Spare Parts (per Unit)

(1) Main bearing	x 2
(2) Oil seal	x 1 set
(3) V-belt	For 1 unit
(4) Lamp and fuse	x 100%
(5) Grease	x 2 cans

11.2 CENTRIFUGAL DEHYDRATOR

11.2.1 General

This dehydrator shall be used for the continuous centrifugal dewatering treatment of the sewage sludge and shall be composed of mechanical equipment of the centrifugal separator main body and accessory equipment necessary for the operation.

11.2.2 Manufacturing Conditions

The centrifugal separator shall be manufactured to rotate well in even at high-speed operation and have adequate strength to centrifugal forces, and also given adequate consideration for wear resistance and corrosion resistance.

11.2.3 Construction of Various Portions

(1) Centrifugal separator

This machine shall be composed of rotor, back drive device, bearing, base, casing, liquid feed pipe, driving motor control panel, etc.

(a) Rotor

The rotor shall be composed of bowl and screw, and the bowl shall be constructed to be properly adjustable in the height of the separated water weir. The screw blade end shall be made of a material having excellent wear resistance such as ceramic, tungsten carbide, surface hardened metal or the like.

(b) Back drive device

The back drive device shall be constructed to take the difference of rotation between the bowl and the screw smoothly and endure the high-load continuous operation sufficiently. This device shall adopt the inverter control system, as standard and include accessories necessary for the back drive control

The motor specifications shall be totally enclosed fan-cooled type and continuous rating.

(c) Casing

The casing shall be constructed for easy check and maintenance of the inside and also to close well to prevent leakage of sludge mist and offensive odours to the outside. The cake discharge chute shall be made of stainless steel, and in the connection to the cake discharge device, flexible joints shall be provided.

(d) Base and vibration isolator device

The base shall be made of stainless steel or cast iron and be constructed to endure mechanical vibration. Moreover, vibration isolation measures shall be taken sufficiently, for example, by mounting a vibration isolator device, etc. between the base and installation frame.

(e) Bearing

The bearing shall have a life enough to endure continuous high-speed load operation.

(f) Safety device

A safety device shall be installed to stop the operation of the dehydrator in the event of abnormal loading caused by ingress of foreign substances into the inside of the rotor and producing a braking effect or in the event of abnormal vibration of the rotor.

(g) Liquid feed pipe

Structurally, it shall be possible to feed the liquid through or corrosion resisting pipe into the inside of the rotor from the outside.

(h) Lubrication system

The lubrication system shall be as follows.

Main shaft (bearing box)	:	Oil forced lubrication or grease-sealed, oil bath
Screw supporting portion bearing:		Grease-sealed

The motor specifications for the lubrication oil unit shall be totally-enclosed fan-cooled type and continuous rating.

(i) Drive unit

The drive unit shall have a capacity enough to rotate the main body up to the specified number of rotations and endure the load. The motor shall be totally enclosed fan-cooled type and be inverter-driven, as standard.

(2) Accessory equipment

(a) Soundproof cover

The soundproof cover shall be a folded structure of steel plate and shall be provided with a cover at the top and doors on right and left sides for internal check, repair, etc. The inside surface shall be applied with soundproof treatment.

(b) Washing device

After completion of dewatering operations, it shall be possible to wash the centrifugal separator inside, etc. with feed water.

(c) Lighting and ventilation devices

In the soundproof cover, lighting and air intake and exhaust devices shall be provided.

(d) Package internal piping

Considering sludge properties and properties of chemical, pipes of adequate bore diameter free from clogging shall be used. For the connection to the centrifugal separator main body, flexible joints, etc. shall be used for elastic connection. All pipelines and valves necessary for operation in the noise reducing package shall be included.

11.2.4 Material Used

(1) Centrifugal dehydrator

Bowl	:	Stainless steel or equivalent
Screw	:	Stainless steel or equivalent
Chute	:	Stainless steel
Base	:	Rolled steel or cast iron
Soundproof cover (inside surface with lining of sound absorber)	:	Rolled steel

Any part subjected to wear shall be made of wear-resisting materials and ensure a long time of operation.

(2) Piping, etc.

Sludge and separated water	:	Stainless steel
Feed water	:	Steel pipe

11.2.5 Standard Accessories (per Unit)

(1) Vibration isolator device	x 1set
(2) Lubricating device	x 1 set
(3) Back drive device	x 1 set
(4) Motor	x 1 set
(5) V-belt, V-perlley, cover	x 1 set
(6) Soundproof cover (with sound absorber, lighting, ventilation)	x 1 set
(7) Dewatered cake chute	x 1 set
(8) Separated water chute	x 1 set
(9) Local power control panel	x 1 set
(10) Soundproof cover internal piping, valves, expansion pipes	x 1 set
(11) Foundation bolt and nut	x 1 set
(12) Special disassembly tool	x 1 set (common for all units)

11.2.6 Spare Parts (per Unit)

For centrifugal dehydrator

(1) Main bearing	x 1set
(2) Oil seal	x 1 set
(3) V-belt	x 1 set
(4) Lubrication oil	x 2 cans
(5) Lamp and fuse	x 100%

11.3 CAKE HOPPER

11.3.1 General

This hopper shall be provided to store, and further to discharge from the bottom, the object carried out of dehydrator, etc. It shall be composed of hopper main body, frame, checking walkway, stairway, open-close gate, motor-driven open-close units, etc.

11.3.2 Manufacturing Conditions

Prevention of arching phenomenon shall be considered. The hopper shall be manufactured to have a total capacity of nominal capacity (m3) plus 5%.

11.3.3 Construction of Various Portions

(1) The hopper shall be a welded structure of steel plate and shape steel, and its frame shall be mounted firmly to the concrete foundation by means of foundation bolts.
(2) Open and close of the gate shall be made by cut-gate method driven by motor.
(3) The hopper shall be able to indicate the weight by means of a load cell type weight detector. For each hopper, four detecting elements and an instrument container panel (V/I converter, indicator) shall be provided as accessories. However, the instrument container panel may be a composite with the local control panel.
(4) Under the hopper, a movable drain receiving trough shall be provided in a position not interfering with passage of the carrying vehicle. Drain pipes also shall be installed.
(5) In the case of a floor installation type hopper, an opening between the hopper and the foundation shall be covered with checkered steel plates.
(6) The local control panel shall be self-standing type.

11.3.4 Materials Used

(1) Main body, frame, walkway, stairway : Rolled steel

11.3.5 Protection Equipment

(1) Mechanical protection equipment
Speed reducer built-in torque limiter

11.3.6 Standard Accessories

(1)	Frame	x 1 set
(2)	Open-close device	x 1 set
(3)	Walkway, stairway	x 1 set
(4)	Foundation bolt and nut	x 1 set
(5)	Weight detector	x 1 set
(6)	Discharge side skirt (made of rubber or fabric vinyl)	x 1 set
(7)	Water cutting trough	x 1 set
(8)	Control panel	x 1 set

11.4 SLUDGE STORAGE TANK MIXER

11.4.1 General

This mixer shall be used for mixing inside the sludge storage tank to prevent sludge settling.

11.4.2 Manufacturing Conditions

(1) This mixer shall be manufactured to endure tank internal level variation sufficiently.
(2) This mixer shall be of fixed type, as a rule.

11.4.3 Construction of Various Portions

(1) The drive unit shall be vertical speed reducer direct-coupled type.

(2) Blades and main shaft shall have excellent corrosion resistance, and especially, the blade shall be constructed in the shape free from easy entangling with inclusions.

(3) Basically, this mixer shall be constructed to endure dry operation although dry operation prevention shall be provided in a separate electric equipment work.

(4) Bolts to be used in the liquid contact portion shall be made of stainless steel and shall be provided with locking.

(5) Blades shall be provided in two stages.

(6) Structurally, the lower bearing shall be unnecessary.

11.4.4 Material Used

(1) Main shaft : Stainless steel

(2) Blade : Stainless steel

11.4.5 Protection Equipment

Liquid level gauge for dry operation prevention (to be prepared by electric work)

11.4.6 Standard Accessories (per Unit)

(1) Foundation bolt and nut x 1 set

11.4.7 Spare Parts (common for All Units))

(1) Gland packing For 5 units

SECTION 12. CHEMICAL GROUTING EQUIPMENT

12.1 POLYMER HOPPER AND POLYMER FEEDER

12.1.1 General

This equipment shall be used for the continuous constant-rate supply of water and chemical so as to prepare a constant concentration in the polymer dissolution tank. It shall be composed of acceptance hopper, weighing device, feeder main body, adjustable speed drive unit, mixer, dry air supply device, feed water supply device, etc. The feeder shall be of 1-train system.

12.1.2 Manufacturing Conditions

The maximum and minimum values of the quantity of chemical to be used shall be calculated, and the equipment shall be manufactured to supply for that calculated range with a high precision of supply. The specific gravity of chemical shall be 0.4 to 1.0.

12.1.3 Construction of Various Portions

(1) The equipment shall be constructed not to be largely affected on the supply precision even with variations of powder pressure in the hopper.

(2) The supply rate shall be adjustable through the adjustable speed reducer of the drive unit and the supply range shall be covered sufficiently.

(3) The equipment shall be constructed not to cause powder flow-out easily with flushing.

(4) The acceptance hopper shall have the total capacity of its effective capacity plus 5% minimum.
(5) In the case of chemical to be thrown out of paper bag, a throwing chute shall be provided.
(6) The equipment shall be constructed to be effective for humidity shutoff, and as a rule, dry sir shall be supplied.
(7) The chemical throwing portion shall be constructed not to produce lumps easily.

12.1.4 Materials Used

(1)	Acceptance hopper	:	Stainless steel or PVC
(2)	Agitation blade	:	Stainless steel
(3)	Weighing device (powder contact portion)	:	Stainless steel or equivalent
(4)	Speed reducer case	:	Cast iron
(5)	Agitation blade shaft	:	Carbon steel
(6)	Mixer	:	Stainless steel (important portions) or clear resin
(7)	Flexible joint	:	Clear soft vinyl

12.1.5 Standard Accessories (per Unit)

(1)	Common base	x 1 set
(2)	Feed water motor-driven ball valve	x 1
(3)	Flowmeter (area type or direct-reading type)	x 1
(4)	Flow adjusting valve	x 1
(5)	Dry air electromagnetic valve and manual valves	x 1 set
(6)	Air regulator, air mist separator, air filter	x 1 each
(7)	Feed water, dry air piping (machine side 1m)	x 1 set
(8)	Powder level gauge (if necessary)	x 1
(9)	Special disassembly tool (if necessary)	x 1 set

12.1.6 Spare Parts (per Unit)

(1)	Oil seal	For 1 unit

12.2 POLYMER DISSOLUTION TANK

12.2.1 General

This tank shall be used to dissolve the polymer supplied by the polymer feeder to a constant concentration and feed the solution to the dewatering equipment. It shall be a vertical tank and shall be composed of tank main body, mixer, mixer frame, manhole, feeder frame, various level gauges, etc.

12.2.2 Construction of Various Portions

(1) The tank shall be a welded structure of steel plate, as a rule, and the tank internal surface shall be painted with tar epoxy resin for corrosion resistance treatment.
(2) The tank shall be provided with a removable cover to prevent chemical scattering, and also with a vent pipe.
(3) If the tank has a capacity of not less than 8 m2 (total capacity), the tank shall be provided with a checking ladder. (This ladder is not necessary if there is a checking walkway.)

(4) The tank shall be provided with necessary mounting seats for overflow pipe, etc.
(5) The motor-driven mixer shall be belt speed reducing type of 2-stage propeller type, as a rule and shall be constructed to endure continuous operation free from vibration, etc. The mixer shall be at the center or at a position off the center according as the tank being angular or circular.
(6) The mixer shall be protected by electrical prevention of dry operation.
(7) The tank shall be constructed to seal gas and splash from below at the area where the agitator shaft drive portion passes through.

12.2.3 Material Used

(1)	Main body	:	Rolled steel + internal surface tar epoxy painting
(2)	Mixer frame	:	Rolled steel
(3)	Mixer shaft	:	Stainless steel
(4)	Blade	:	Stainless steel
(5)	Belt cover	:	Rolled steel

12.2.4 Standard Accessories (per Tank)

(1)	Foundation bolt and nut	x 1set
(2)	Air vent pipe	x 1 set
(3)	Mixer	x 1

12.3 POLYMER FEED PUMP (PROGRESSING CAVITY PUMP)

12.3.1 General

This pump shall be used to supply polymer solution from the polymer dissolution tank at an adjusted feed rate to the dehydrator.

12.3.2 Manufacturing Conditions

This pump shall be constructed to have stable performance to chemical concentration 0.1 to 0.3%, to feed the chemical solution of the concentration shown satisfactorily and not to cause overloading of the motor.

12.3.3 Construction of Various Portions

(1) The pump casing shall have smooth cast surfaces and be sturdy and shall have wall thickness with an adequate allowance for shock, wear, corrosion and piping loads.
(2) The rotor shall be progressing cavity type and shall not cause vibration during operation.
(3) The portion of the shell where the main shaft penetrates through shall be provided with a stuffing box and the shaft sealing device shall be a mechanical system.
(4) To facilitate replacement of the stator, the pump shall be constructed to the suction casing and discharge casing to be remove and the piping and replacement space shall be determined.
(5) The bearing shall have been constructed to have an adequate supporting capacity to the load. Because of complete lubrication, it shall be free from overheating, etc. and durable. Moreover, it shall have an adequate allowance for axial thrust.

12.3.4 Materials Used

(1)	Common base	Cast iron or rolled steel
(2)	Casing	Cast iron
(3)	Rotor	Stainless steel
(4)	Stator	Synthetic rubber
(5)	Shaft	Stainless steel

12.3.5 Standard Accessories (per Unit)

(1)	Safety cover	x 1 set
(2)	Common base	x 1 set
(3)	Pressure gauge (diaphragm type)	x 1
(4)	Foundation bolt and nut	x 1 set
(5)	Special disassembly tool	x 1 set (common for all units)

12.3.6 Spare Parts (per Unit)

(1)	Stator	x 1
(2)	O-ring for pump	For 2 units
(3)	O-ring for joint	For 2 units
(4)	Mechanical seal sliding material	For 1 unit

SECTION 13. COMPOST EQUIPMENT

13.1 MIXING MACHINE

13.1.1 General

The fermentation vessel agitating equipment shall be used so that a mixture of sludge, additives, etc. conditioned suitably for aerobic fermentation may be well fermented. Therefore, this equipment shall be constructed to be able to automatically turn the mixture in the vessel continuously.

The mixing machine shall be horizontal paddle type.

This equipment shall consist mainly of two portions, agitating machine and travelling machine. The agitating machine shall scatter the raw material by paddle rotation. The travelling machine shall support the agitating machine and also transfer the raw material by repeated traverse and travel zigzag operations.

The raw material scattered by paddles is piled up in a soft way so that consolidation and setting may be prevented and good gas permeability be maintained.

13.1.2 Manufacturing Conditions

(1) The agitating machine shall be started automatically and manually at the local.

(2) The agitating machine shall be operated automatically inside the fermentation vessel.

(3) The agitating machine shall be able to turn the mixture continuously thrown into the fermentation vessel without short-pass.

(4) During the fermentation period, the mixture shall be agitated within 16 hours per day excluding the throw and carry-out time (8 hours per day).

13.1.3 Main Materials

(1)	Agitating machine	:	Rolled steel
(2)	Travel machine	:	Rolled steel

13.1.4 Standard Accessories

(1)	Control panel with inverter and sequencer	x 1 set (for 2 mixing machines)
(2)	Emergency stop switch	x 2 set (per unit)
(3)	Cables and cable carrier	x 1 set (per unit)
(4)	Limit switches	x 1 set (per unit)

13.2 DEODORIZATION SOIL FILTER

13.2.1 General

The deodorization soil equipment shall be used to bring the odor gas into contact with the filler packed in the equipment to allow the odor component to be adsorbed and then decomposed by microorganisms, etc. for deodorization. It shall be composed of the main body and a water spray equipment.

13.2.2 Manufacturing Conditions

(1) The filler to be used shall be a synthetic filler having good gas permeability and water permeability and shall have deodorization effects through good growth of microorganisms.

(2) The passage speed in the filler shall be about 20 mm/s.

(3) The deodorization soil tank shall be constructed to allow the exhaust gas to be dispersed uniformly.

Deodorization layer	:	Synthetic filler	100 cm
Support layer	:	Small crushed stone	15 cm
		Crushed stone	60 cm

(4) A water spray and drainage system shall be provided to insure that the deodorization equipment may maintain suitable water content at all times.

13.2.3 Construction of Various Portions

(1) The water spray equipment shall have water spray piping and water spray nozzles. The water spray nozzle shall be able to spray water uniformly over the filler and operate with timer.

(2) Water supply, water spray and water discharge shall be done by automatic operation in accordance with the water level in the recirculation tank and with timer, and automatic valves shall be installed.

13.2.4 Materials Used

Filler	:	Synthetic filler
Duct pipe	:	VU, VP
Spray pipe	:	VP

13.2.5 Standard Accessories

(1)	Duct pipes	x 7 set
(2)	Spray nozzles	x 20 pieces
(3)	Spray pipe	x 1 set

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SECTION 13. ELECTRICAL WORKS

13.1 GENERAL

This section covers the requirements for the design, furnishing, installation, testing and commissioning of the electrical works for the Wastewater Treatment Plant.

The term “Equipment” shall have the same meaning as “Plant” as defined in the General Conditions of Contract.

13.2 GENERAL REQUIREMENTS

This Clause 13.2 specifies the scope of works and general requirements which apply to the items specified in this section.

13.2.1 Scope of Works

The work to be completed by the Contractor includes the completion of electrical system for Wastewater Treatment Plant and supply of spare parts for the electrical equipment which consist of the following items:

(a) 22 kV Substation

(b) Emergency Generator

(c) Electrical equipment for the Waste Water Treatment Plant comprising the following:

Main office electrical equipment
Lift pump facility electrical equipment
Blower facility electrical equipment
Water treatment facility electrical equipment
Chlorination facility electrical equipment
Dewatering facility electrical equipment
Compost facility electrical equipment
Communication system
Lighting system for plant area
Lightning protection system

(d) Spare parts for 2 years operation

An outline of each of the above major items is as follows:

(a) 22 kV Substation

(1) Equipment to be installed:

24 kV Gas insulated switchgear (2L-1B)
Billing meter equipment
15(22)kV/3.3kV, 5000kVA main transformer
3.6 kV switchgears
Control and protection panels
Installation materials
Cables, terminals and fittings
Earthing materials
Miscellaneous materials

(2) Civil and Foundation works

The Contractor shall provide all civil works associated with the electrical works specified herein. Such civil works shall be included in the Contractor's obligations for civil works specified elsewhere.

The Contractor shall design and prepare all necessary calculations and Drawings for civil and foundation works.

(3) Installation and Erection works

Installation/erection works mean works to install and erect the equipment which are stated in item "Equipment to be installed" specified in above item (1).

The Contractor shall complete the following works:

- Necessary design and calculation
- Installation and erection of the equipment
- Laying and connection of all necessary power and control cables
- Connection works for grounding wires to the equipment
- Installation and erection of outdoor lighting facilities and boundary fences
- Adjustment of the each equipment
- Miscellaneous works relating to the installation and erection of equipment including
- Safety protection

(4) Tests

The tests shall include, but not be limited to, the following tests.

- Shop tests (Factory tests):
  Electrical equipment shall be tested manufacturer's standard test procedure.
- Tests on completion (Field tests):
  After completion of individual adjustment and tests of each equipment during installation and erection and upon all equipment being ready for operation, the Contractor shall carry out the field tests of the items to be required in the Specifications in the presence of the Employer and the Engineer.
  In the event of the tests do not satisfy the requirements of the Specifications or any defects attributable to the Contractor are found in the test, the Contractor shall promptly repair, replace, adjust or make good, and retest equipment at his own expenses to an extent satisfactory to the Specification.

(b) Emergency Generator

(1) Equipment to be installed:

3phase 3.3kV, 750kVA diesel engine generator
Air compressor and air tank for starter
Cooling unit
Fuel tank
Control and protection panels
Installation materials
Cables, terminals and fittings
Earthing materials
Miscellaneous materials

(2) Generator room, civil, foundation and architecture works

Generator room construction works, such as soil excavation and backfilling for main earthing meshes, ventilation system, concrete foundations for generator, cubicles, cooling unit, fuel tank, interior lighting, cable, pipe trenches and covers, and architecture works shall be furnished by the Contractor under his obligations specified elsewhere.

However, supply of earthing materials are included in the electrical scope of work.

The Contractor shall design and prepare all necessary calculations and Drawings for civil and foundation works of generator room.

(3) Installation and Erection works

Installation/erection works mean works to install and erect the equipment which are stated in item "Equipment to be installed" specified in above item (i).

The Contractor shall complete the following works:

- All necessary design and calculations
- Installation and erection of the equipment
- Laying and connection of all necessary power and control cables
- Connection works for earthing wires to the equipment
- Adjustment of the each equipment
- Miscellaneous works relating to the installation and erection of equipment including
- safety protection

(4) Tests

The tests shall include, but not be limited to, the following tests.

- Shop tests (Factory tests):
  Electrical equipment shall be tested in accordance with manufacturer's standard test procedure.
- Tests on completion (Field tests):
  After completion of individual adjustment and tests of each equipment during installation and erection and upon all equipment being ready for operation, the Contractor shall carry out the field tests of the items to be required in the Specifications in the presence of the Employer and the Engineer.

  In the event of the tests do not satisfy the requirements of the Specifications or any defects attributable to the Contractor are found in the test, the Contractor shall promptly repair, replace, adjust or make good, and retest equipment at his own expenses to an extent that specified requirements are met.

(c) Electrical equipment for the Waste Water Treatment Plant

(1) Equipment to be installed:

3.3kV switchgears
Transformers
Low voltage switchgears
Motor starter panels
Motor control centres

Local motor control panels
AC distribution panels
Un-interruptible power supply system
DC supply equipment
Supervisory panels
Instrument panels
Data logging system
Installation materials
Cables, terminals and fittings
Earthing materials
Outdoor lighting
Pipe galley lighting
Lightning protection system
Communication system
Miscellaneous materials

(2) Civil and foundation works

All the civil works shall be shall be furnished by the Contractor under his obligations specified elsewhere.

The Contractor shall design and prepare all necessary calculations and Drawings for civil and foundation works and ensure that civil works are constructed such they are compatible with electrical equipment requirements.

(3) Installation and erection works

Installation/erection works mean works to install and erect the equipment which are stated in item “Equipment to be installed” specified in above item (i).

The Contractor shall cover the following works:

- Necessary design and calculation
- Installation and erection of the equipment
- Laying and connection of all necessary power, control and instrumentation cables
- Connection works for earthing wires to the equipment
- Installation and erection of outdoor lighting, load lighting and pipe gallery lighting facilities
- Adjustment of the each equipment
- Miscellaneous works relating to the installation and erection of equipment including safety protection

(4) Tests

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

- Shop tests (Factory tests)

  Electrical equipment shall be tested in accordance with the manufacturer’s standard test procedure.

- Tests on completion (Field tests)

  After completion of individual adjustment and tests of each equipment during installation and erection and upon all equipment being ready for operation, the Contractor shall carry out the field tests of the items to be required in the Specifications in the presence of the Employer and the Engineer.

In the event of the tests do not satisfy the requirements of the Specifications or any defects attributable to the Contractor are found in the test, the Contractor shall promptly repair, replace, adjust or make good, and retest equipment at his own expenses to an extent that specified requirements are met.

13.2.2 Applicable Codes and Standards

The equipment, materials, design and test and installation of the electrical facilities shall conform to the local laws and regulations and the applicable portions of the latest edition of the following standards and codes.

- International Electrotechnical Commission (IEC)
- Japanese Industrial Standards (JIS)
- Standards of Japanese Electrotechnical Committee (JEC)
- Standards of the Japanese Electrical Manufactures Associations(JEM)
- Vietnam Standards (TCVN)

13.2.3 Materials

The materials used in all works shall be new, unused and as hereinafter specified. All materials shall be of the very best of their respective kinds. Samples of materials or manufacture's specifications shall be submitted for approval when required by the Engineer prior to the installation.

Electrical equipment shall at all times during construction be adequately protected against mechanical injury or damage. If any equipment has been damaged, such damage shall be repaired by the Contractor at his own cost and expense.

13.2.4 Site Conditions (Design base)

(a) Altitude : less than 1,000m above sea level.

(b) Ambient temperature :

- Maximum : 45^{o}C
- Minimum : 5^{o}C
- Design temperature : 40^{o}C

(c) Relative humidity:

- Maximum : 95%

(d) Climatic atmosphere : Tropical

(e) Wind pressure : 45 m/s

(f) Salt contamination :

Unless otherwise specified, under the contract, design for salt contamination of the insulators and bushings shall be applied the following conditions: 0.03 mg/sq.cm.

13.2.5 Design Criteria

The design of the electrical system shall be carried out with the following clarifications.

13.2.5.1 Electrical system

(a) Power distribution trough out the plant shall be 50Hz, at the following voltage levels with earthing system. :

Power Distribution System

Service	Rated voltage	Phase/Wire	Earthing	Remarks
Power receiving (Transmission line)	15(22) kV	3/3	Solid	with earthing wire
High voltage distribution	3,3 kV	3/3	Solid	
Low voltage distribution				
- Power	380 V	3/4	Solid	
- Lighting & Miscellaneous	380/220 V	3/4	Solid	

(b) Equipment and load voltage rating shall be as follows:

Equipment and Load Voltage

Service	Rated voltage	Phase/Wire	Remarks
Motor 150kW and above	3,300 V	3/3	except lift pump
Motor 0.2kW to 149kW	380 V	3/3	
Lighting fixtures & Convenient sockets	220 V	1/2 + E	E: Earthing

13.2.5.2 Allowable Voltage Drop

The maximum allowable voltage drops in cables, as a percentage of system nominal line to line voltage, a full load shall be as follows:

(a) Main power distribution :
- 3,300 volt motor : 3%
- 380 volt motor : 5%

(b) Total voltage drop at the terminal of low voltage motor shall not exceed 20% during staring period.

(c) Voltage drop between lighting board and the furthest fixture shall not exceed 3%.

(d) Voltage drop between main distribution board in substation and local lighting board shall not exceed 2%.

13.2.5.3 Transformer sizing

The transformer shall be sized for the maximum demand of load connected to the associated switchgear plus 10 to 15% spare capacity for design allowance and/or future expansion.

The maximum demand of load shall be calculated by summing up the following loads.

- The normally running loads.
- 30% of the intermittent loads (i.e. pumps, etc.).

13.2.5.4 Cable sizing

The cable shall be sized based on the thermal limits in normal service conditions, and the maximum allowable voltage drops in the circuit.

The current carrying capacity (thermal limit) of cables in normal service condition shall take account of the de-rating due to the laying conditions or grouping.

The cables for main power distribution system shall be sized also to withstand without damage the maximum short circuit thermal stress for the full clearance time of the protective devices (i.e. fuses, or circuit breakers with protection relays).

The current rating of the circuit for cable sizing shall be as follows:

- The transformer primary and secondary cables shall be coved on the rated current of the transformer.
- For switchgear/panel feeder circuit without a transformer, cables shall have a current carrying capacity equal to the maximum demand of loads connected to the switchgear/panel with 10% surplus.
- The motor feeder cables shall be sized based on 110% of the motor name-plated rated current.
- Other cables not mentioned above shall be covered to the maximum current demand.

13.2.5.5 Lighting Arrangement

The lighting fixture shall be designed and arranged for required areas so as to meet the following illumination levels:

Illumination Level

Installation Location	* Illumination Level (Lux)	Elevation	Remarks
Office	300	Floor	Architecture Works
Meeting Room	250	Floor	Architecture Works
Worker Room	100	Floor	Architecture Works
Security Room	150	Floor	Architecture Works
Laboratory	300	Floor	Architecture Works
Library	300	Floor	Architecture Works
Tea Room	100	Floor	Architecture Works
Night Duty	50	Floor	Architecture Works
Locker	50	Floor	Architecture Works
Lobby	50	Floor	Architecture Works
Toilet	50	Floor	Architecture Works
Storage Room	50	Floor	Architecture Works
Stairway	50	Floor	Architecture Works
Corridor	50	Floor	Architecture Works
Control Room	250	Floor	Architecture Works
Electric Room	100	Floor	Architecture Works
Substation (Outdoor)	20	Floor	Electrical Works
Generator Room	100	Floor	Architecture Works
Pump Room	50	Floor	Architecture Works
Blower Room	50	Floor	Architecture Works
Guard Room	250	Floor	Architecture Works
Pipe Gallery	50	Floor	Electrical Works
Outdoor Area	10	Floor	Electrical Works

*: Averaged illumination levels

13.2.6 Test and Inspection

(a) Shop Tests

Electrical equipment shall be tested in accordance with the manufacturer's standard test procedures based on requirements of applicable standard.

The type test for electrical equipment shall not be required at shop test.

(b) Field Tests

The following tests shall be executed by the Contractor in the presence of the Engineer after completion of the installation of electrical equipment and instrumentation equipment.

Prior to the commencement of the test, the Contractor shall submit the test schedule in a suitable stage.

The test result shall be submitted to the Engineer for approval.

(1) Individual tests

Individual tests shall include following items;

- Visual inspection
- Measuring of insulation resistance for all equipment
- Withstand voltage test of insulation oil
- Circuit continuity test
- Checking of relays
- Polarity test
- Phase rotation test

(2) Test on completion

The completion tests shall include following items;

- Visual inspection
- Measuring of insulation resistance for all equipment
- Checking of relays
- Phase rotation test
- Total sequential test

  Operation test for each equipment
  Interlock sequence test
  Indication test
  Fault alarm test

13.2.6.1 Test at the Manufacturer's Factory

After completion of the equipment at the shop, the Contractor shall submit five (5) copies of Inspection and/or testing schedule to the Engineer for his approval. Tests and/or inspection shall include, but not limited to, the items listed in the Table below.

Equipment	Test/Inspection	Witness	Record
22 kV C-GIS	Apply to standard	Yes	Yes
Transformer	Apply to standard	Yes	Yes
High voltage switchgear	Apply to standard	Yes	Yes
Low voltage switchgear	Apply to standard	No	Yes
Motor control center	Apply to standard	No	Yes
Control and protection panel	Apply to standard	Yes	Yes
Data logging system	Apply to standard	No	Yes
Emergency generator	Apply to standard	Yes	Yes
Instrument equipment	Apply to standard	No	Yes
DC supply system	Apply to standard	Yes	Yes
UPS	Apply to standard	Yes	Yes

During the shop test and inspection, the Contractor shall perform an operational test at the factory under simulated field operating conditions, if required.
Equipment and materials for Wastewater Treatment Plant shall be inspected and tested in accordance with the Manufacturer's Standards.

13.2.6.2 Witness Inspection

The Contractor shall invite two (2) electrical inspectors, nominated by the Engineer, for a total of twenty (20) man-days for the purpose of witnessing the tests in the suppliers' workshops.
All necessary expenses for the said inspectors including round-trip air tickets, per-diem living allowance and land transportation charges shall be borne by the Contractor.

13.2.7 Spare Parts

The Contractor shall furnish the spare parts for 2 years operation to be required for plant maintenance as listed in Clause 13.7.

13.2.8 Special Tools

The Contractor shall furnish the special tools for plant maintenance as listed in Clause 13.6.6.

13.2.9 Training

The Contractor shall provide the on-job training for The operators and maintenance staff of Employer during the erection of the Equipment and running test after the installation of the facilities.

13.2.10 Electrical Completion

13.2.10.1 Tests during Construction

Refer to Clause 13.5: Detailed Specification for Electrical Works, Sub-Clause 13.5.5.2, Field Tests.

13.2.10.2 Tests on Electrical Completion

After the electrical equipment has been installed, tested, approved and each mechanical unit is fully installed, adjusted and successfully completed its mechanical run, the Contractor shall conduct operational tests in the Engineer's presence, and with the involvement of the Employer's maintenance and operation personnel, to demonstrate that the entire work is properly installed and correctly adjusted to operate as specified.
The Contractor shall make all final adjustment to the control and detection devices. The Contractor shall be responsible for the operation of the plant during the tests. All the tests shall be carried out by the Contractor at his responsibility and costs including necessary testing equipment and instruments.
The final results of all tests including tests run by the Contractor shall be subject to acceptance by the Engineer.

Unless otherwise specified, the Contractor shall submit to the Engineer five (5) copies of test or inspection reports.

Testing of all electrical equipment shall be incorporated into the Contractor's programme of testing as described in Clause 12.2.16.2

13.3 DETAILED SPECIFICATION FOR ELECTRICAL EQUIPMENT

The Contractor shall furnish and install all equipment and devices as hereinafter specified and shown on the Drawings.

13.3.1 Design Condition

(a)	Frequency	:	50 Hz
(b)	Phases	:	3 phase
(c)	Rated highest system voltage		
	High tension 15 (22) kV	:	17.5 (24) kV
	Medium tension 3.3kV	:	3.6 kV
	Low tension	:	600 V
(d)	Nominal voltage		
	High tension	:	15 (22) kV
	Medium tension	:	3.3 kV
	Low tension	:	380 V (Three (3) phases)
			220 V (Single phase)
(e)	Rated lightning impulse withstand voltage		
	22 kV equipment	:	125 kV
	3.3 kV equipment	:	30 kV
(f)	Neutral grounding system		
	22 kV	:	Solidly grounded
	3.3 kV	:	Solidly grounded
(g)	AC operating voltage		
	Three phase	:	AC 380 V
	Single phase	:	AC 220 V
(h)	DC voltage for control circuit	:	DC 110 V
(i)	Control voltage for instrumentation	:	DC 110 V
		:	DC 24 V
		:	AC 100 V
(j)	Rated CT secondary current	:	5 A

13.3.2 22 kV Substation Equipment

13.3.2.1 24kV Gas Insulated Switchgear

The 24kV Metal-enclosed SF6 Gas Insulated Switchgear installed in the substation shall be of outdoor use cable connected cubicle type, corrosion resistant, vermin-proof and be mounted on steel base channels.

Unless specified hereunder, the metal-enclosed SF6 gas insulated switchgear shall conform to the requirements stated in JIS, JEC, JEM or IEC standard.

Each cubicle shall have hinged doors in the front including locks and shall have well-considered self-ventilating device.

Each cubicle shall be complied with JIS, JEC, JEM or IEC standard, and provided with all necessary control, measuring, indicating and protective apparatuses, fuses, whether or not expressly specified.

The cubicles shall have over current strength to sustain for two (2) seconds corresponding to the interruption capacity of circuit breakers.

(a) Ratings

Rated voltage	:	24 kV
Rated normal current	:	1200 A, 600A
Rated short-circuit breaking current	:	31.5 kA, 25kA

AC power frequency withstand voltage	:	50 kV
Rated lightning impulse withstand voltage	:	125 kV
Rated duration of short-circuit	:	2 seconds
Motor operating voltage	:	DC 110 V
Control circuit voltage	:	DC 110 V
AC circuit voltage	:	AC 220 V

(b) Operating device

Operating mechanism for circuit breaker and isolator shall be provided with local and remote electrically operated and local manual controls.

A low pressure lockout relay shall be provided to prevent operation of the circuit breaker and isolator when the internal gas pressure drops to a value which cannot obtain the rated interrupting capacity.

Gas insulated switchgear shall be provided with a gas density detector responding to gas density and pressure.

(c) Quantity

The following facilities shall be supplied :

(1)	24 kV Incoming unit	2 units
(2)	Bus tie unit	1 unit
(3)	Transformer primary unit	1 unit
(4)	Billing metering unit	1 unit

(d) Equipment and devices to be provided in switchgear

(1) 24 kV Incoming unit

Circuit breaker	1 set
Isolator with earthing switch	2 sets
Current transformer	3 sets
Voltage detector	1 set
Lightning arrester	3 sets
Earthing switch for incoming line	1 set
Incoming cable head and plug-in type connector	3 sets

(2) Bus-tie unit

Circuit breaker	1 set

(3) Transformer primary unit

Circuit breaker	1 set
Isolator with earthing switch	1 set
Earthing switch for transformer bay	1 set
Incoming cable head and plug-in type connector	3 sets

(4) Billing metering unit

Current transformer	3 sets
Voltage transformer	3 sets

(5) Accessories

Each cubicle shall be provided with the following accessories:

- Mechanical position indicator for CB, isolators and earthing switches
- Mechanical spring charge position indicators and auxiliary contacts for CB (if spring charged operation type)
- Auxiliary contacts for CB, isolators and earthing switches
- Operation counter for CB
- Local – Remote change over switch
- Control switch for CB and isolator
- Fault indicator
- Space heater

- Gas leak detector
- Pressure relay
- Name plate(s)
- Steel base channels with anchors
- Holding pocket for drawings
- Earthing terminal(s)
- Lifting lugs
- Special tools for checking and testing
- Other necessary accessories

(e) Ratings for each equipment to be provided in switchgear

(1) Circuit breaker

The circuit breaker to be installed in switchgears shall be of 50 Hz, three-pole, elector-hydraulic or charged spring operated, vacuum type or SF6 type, trip-free in any position, complete with operating mechanism and be in accordance with JEC or IEC standard unless specified hereunder.

(i) Ratings

Rated voltage	:	24 kV
Rated normal current	:	1200 A, 600A
Rated short-circuit breaking current	:	31.5 kA, 25kA
Rated duration of short-circuit	:	2 seconds
Rated operating sequence	:	0-1 minute-CO-3 minutes-CO
Rated interrupting time	:	5 cycles

(2) Isolator and earthing switch

The isolators to be installed in switchgears shall be of 50 Hz, three-pole, motor operated, complete with operating mechanism and be in accordance with JEC or IEC standard unless specified hereunder.

The 24 kV earthing switches to be installed in switchgears shall be of 50 Hz, three-pole, manual operated, mechanical and electrical interlock with isolator, complete with operating mechanism and be in accordance with JEC or IEC standard unless specified hereunder.

(i) Ratings

Rated voltage	:	24 kV
Rated normal current	:	1200 A, 600A
Rated short-circuit breaking current	:	31.5 kA, 25kA
Rated duration of short-circuit	:	2 seconds

(3) Current transformer

The current transformers to be installed in switchgears shall be 50 Hz, single phase indoor use, epoxy resin moulded, core type and be in accordance with JEC or IEC standard.

(i) Ratings

The current transformer shall be of adequate burden and 40 times for over current strength for one (1) second.

Rated voltage	:	24 kV
Current ratio	:	1200 – 600/5A
Accuracy class	:	1 P

(4) Lightning arrester

The lightning arrester to be installed in switchgears shall be of 50 Hz, metal oxide type, indoor use and shall be in accordance with JEC or IEC standard.

(i) Ratings

Rated voltage		
For line voltage 15 kV	:	15 kV
For line voltage 22 kV	:	24 kV
Nominal discharge current	:	10 kA

(5) Voltage transformer

The voltage transformer to be installed in switchgears shall be of 50 Hz, three-phase, indoor use, epoxy resin moulded, core type and shall be in accordance with JEC or IEC standard.

(i) Ratings

Rated primary voltage	:	15(22) / 3 kV
Rated secondary voltage	:	110 / 3 V
Rated secondary burden	:	200 VA
Polarity	:	Subtractive
Accuracy class	:	1 P

13.3.2.2 Billing Meter Cubicle

Billing meter cubicle shall be of indoor use cubicle type, corrosion resistant, vermin-proof and be mounted on steel base channels.

Billing meter cubicle shall have hinged doors, glass window in the front including locks and shall have well-considered self-ventilating device.

Ratings for watt-hour meter and other necessary equipment shall be informed by the Engineer after the Contract.

13.3.2.3 Power Transformer

The 15(22)kV/3.3kV 5,000kVA main transformer installed in the substation shall be of 50 Hz, outdoor use, three-phase, oil-immersed, self-cooled with diaphragm conservator and on-load tap changer and be in accordance with JEC or IEC standard unless specified hereunder.

(a) Ratings

Rated primary voltage	:	15(22) kV
Rated secondary voltage	:	3.3 kV
Continuous rated capacity	:	5,000 kVA
Type of cooling	:	ONAN
Number of phase	:	3
Rated frequency	:	50 Hz
Primary auxiliary tap	:	15kV (22kV)
OLTC Tap voltage	:	15 kV ±5%, (22 kV ±5%)
Number of taps	:	9 taps
Step voltage	:	1.25 %
Impedance voltage (design value)		
15 kV	:	15 %
22 kV	:	8.5 %
No load loss (design value)		
15 kV	:	Less than 2.5 kW
22 kV	:	Less than 8.0 kW

Winding connection

(Primary)	:	Delta
(Secondary)	:	Star with neutral brought out to grounding terminal

The 5,000kVA capacity rating specified above shall be obtained on rated tap for continuous service on the secondary side under the self-cooled condition.

The winding shall be connected in accordance with vector symbol Dyn 11 of JEC or IEC standard.

(b) On-load tap changer

Tap-changer shall be of design which enables tap changing on the primary side and which maintains basic voltage automatically.

Tap-changer shall be designed to enable automatic and manual electrical operation, hand mechanical operation and future parallel operation.

Tap-changer shall be constructed in conformity with the following requirements

Rated motor operating voltage	:	AC380V (Three phase) or AC220V (Single phase)
Rated control voltage	:	DC 110 V
Operation	:	Available for control from a control panel and for local manual operation with an adequate interlock device which means that and manual and electrical operation is impossible during hand mechanical tap changing operation.
Mechanism	:	To prevent intermediary position between taps even on the occasion of electric power failure.
Accessories	:	Indicator of tap position and other requirements to indicate the position of a tap for providing full effect on tap changer mechanism.

(c) On-load tap changer panel

The on-load tap changer panel for 15(22)/3.3 kV 5,000kVA transformer installed in the main office electric room shall be indoor use, metal enclosed and self-standing type.

The following components shall be mounted on the OLTC panel.

Voltage regulating relay	1 set
Tap position indicator	1 set
Voltmeter with selector switch	1 set
Operation switch	1 lot
Test terminal for VT	1 lot
Auxiliary relay	1 lot
Other necessary items	1 lot

(d) Oil conservators

Oil conservators to isolate the oil from air with diaphragm or another kind of the device and dehydrating breathers with transparent containers shall be provided. Oil level indicators with alarm contacts, buchholz relay with 2-stage alarm contacts, all valves and others necessary for the oil preservation system shall be equipped with transformers.

(e) Bushing type current transformers (BCT)

Bushing type current transformers shall be provided as accessories. Burden of each current transformer shall be not less than 15 VA.

Ratings for bushing type current transformers as follows;

Primary side BCT	:	200/5A class 1 P, 3 pcs.
Secondary side BCT	:	800/5A class 1 P, 5 pcs.
Secondary side Neutral BCT	:	800/5A class 1 P, 1 pc.

(f) Temperature rise

The maximum temperature rise shall not exceed:

(1) 55 degrees for oil by thermometer

(g) Insulating oil

Insulating oil for power transformer shall be of non-sludge, refined mineral oil and in accordance with JIS or IEC standard.

(h) Accessories

The following accessories shall be supplied ;

- Oil level indicators with alarm contacts
- Oil temperature indicators with alarm contacts (2 stages)
- Silica gel breather
- Lifting lugs and pulling eyes
- Earthing terminals
- Foundation bolts
- Name and rating plates
- Terminal boxes
- Pressure relief device
- Radiators
- Necessary terminals for primary and secondary circuits
- Other necessary accessories

13.3.2.4 TR secondary 3.6 kV Metal-Enclosed Switchgear

The TR secondary 3.6 kV metal-enclosed switchgear installed in main office electric room shall be of indoor use cubicle type, and air insulated, corrosion resistant, vermin-proof and be mounted on steel base channels.

Unless specified hereunder, the metal-enclosed switchgear shall conform to the requirements stated in JEM or IEC standard.

The switchgear shall have hinged doors in the front including lock and shall have well-considered self-ventilating device.

The switchgear shall be provided with all necessary control, measuring, indicating and protective apparatuses, fuses, whether or not expressly specified.

The switchgear shall have over current strength to sustain for two (2) seconds corresponding to the interruption capacity of circuit breakers.

(a) Ratings

Rated voltage	:	3.6 kV
Rated normal current	:	1200 A
Rated short-circuit breaking current	:	25 kA
AC power frequency withstand voltage	:	10 kV
Bus bar rating	:	3 phase 3 wire, 1200 A, 25kA (2sec)

(b) Quantity : 1 set

(c) Equipment and devices to be provided in switchgear

Switchgear shall be equipped with the following major equipment and devices.

- Circuit breaker : 1 set
- Current transformer : 3 sets
- Voltage transformer : 3 sets
- Lightning arrester : 3 sets
- Over current relay with instantaneous element : 3 sets
- Over current ground relay : 1 sets
- Over voltage relay : 1 set
- Lockout relay : 1 set
- Indicating lamp : 1 set
- Control switch : 1 lot
- Change over switch : 1 lot
- Test terminal for CT and PT : 1 set
- Moulded case circuit breaker : 3 sets
- Accessories
  - Name plate(s)
  - Fluorescent lighting fixture (provided in cubicle inside)
  - Steel base channels with anchors
  - Holding pocket for drawings
  - Earthing terminal(s)
  - Lifting lugs
  - Other necessary accessories

(d) 3.6 kV Circuit breaker

The 3.6 kV circuit breaker to be installed in cubicles shall be of 50 Hz, three-pole, horizontal drawout, indoor use, vacuum type or SF6 type, trip-free in any position, complete with electrical spring charge operating mechanism and be in accordance with JEC or IEC standard.

(1) Ratings

Rated voltage	:	3.6 kV
Rated normal current	:	1200 A
Rated short-circuit breaking current	:	25 kA
Rated duration of short-circuit	:	2 seconds
Rated operating sequence	:	0-1 minute-CO-3 minutes-CO
Rated interrupting time	:	5 cycles
Control circuit voltage	:	DC 110 V

(2) Accessories

One set of circuit breaker shall be provided with the following accessories.

- Name plate
- Position indicators
- Auxiliary contacts for position indicator and interlock
- Operation counter
- Earthing terminal(s)
- Manual operating handle
- Other necessary accessories

(e) 3.6 kV Current transformer

The 3.6 kV current transformer to be installed in cubicles shall be 50 Hz, single phase indoor use, epoxy resin moulded, core type and be in accordance with JEC or IEC standard.

(1) Ratings

The 3.6 kV current transformer shall be of adequate burden and 40 times for over current strength for one (1) second.

Rated voltage	:	3.6 kV
Current ratio	:	1200/5A
Accuracy class	:	1 P

(2) Accessories

Each 3.6 kV current transformer shall be provided with the following accessories:

- Name plate
- Other necessary accessories

(f) 3.6 kV Lightning arrester

The 3.6 kV lightning arrester to be installed in cubicles shall be of 50 Hz, metal oxide type, indoor use and shall be in accordance with JEC or IEC standard.

(1) Ratings

Rated voltage	:	3.6 kV
Nominal	:	10 kA

(2) Accessories

Each 3.6 kV lightning arrester shall be provided with the following accessories:

- Name plate
- Other necessary accessories

(g) 3.6 kV Voltage transformer

The 3.6 kV voltage transformer to be installed in cubicles shall be of 50 Hz, three-phase, indoor use, epoxy resin moulded, core type and shall be in accordance with JEC or IEC standard.

(1) Ratings

Rated primary voltage	:	3.3 / 3 kV
Rated secondary voltage	:	110 / 3 V
Rated Secondary burden	:	200 VA
Polarity	:	Subtractive
Accuracy class	:	1 P

(2) Accessories

Each potential transformer shall be supplied with the following accessories:

- Primary protection fuse 3.3 kV, 1A
- Name plate
- Other necessary accessories

13.3.2.5 Control and Protection Relay Panel

The control and protection relay panel(s) installed in the main office electric room shall be indoor use, metal enclosed and self-standing type.

The mimic buses and equipment symbols shall be provided on the panel(s) to form single line diagrams which will simulate actual electrical connections.

(a) Facilities and quantity

The following components shall be mounted on the panel(s).

- Over current relay with instantaneous element 6 sets
- Over current ground relay 2 sets

-	Ratio differential relay	3 sets
-	Auxiliary current transformer	3 sets
-	Lockout relay	1 set
-	Ammeter with selector switch	1 lot
-	Voltmeter with selector switch	1 lot
-	Volt indicator	1 lot
-	Watt meter	1 lot
-	Watt hour meter	1 lot
-	Power factor meter	1 lot
-	Frequency meter	1 lot
-	Control switch for circuit breaker	1 lot
-	Control switch for isolator	1 lot
-	Indicator	1 lot
-	Fault indicator	1 lot
-	Mimic bus	1 lot
-	Test terminal for CT and VT	1 lot
-	Auxiliary relay	1 lot
-	Other necessary items	1 lot

(b) Meters and wiring

Indicating meters shall be of flush mounted and back connected type, dust-proof, and wide angle scale type.

Each indicating meter shall have a removal transparent cover or a cover with a transparent window.

Wiring for secondary of voltage and current transformers to be installed in cubicles shall be coloured respectively according to appropriate standards and terminated with terminals and marked corresponding to the wiring diagrams. Each meter and wiring shall be suitable for operation with the voltage and current transformers under both normal and short circuit conditions.

(c) Protective relays

The Protective relay shall be of semi-flush, back-connected dust-proof switchboard type with rectangular case. Each relays shall have a removable transparent cover or a cover with a transparent window, with provision for sealing. Each relays shall be of a draw-out type from the front of the panel with sliding contacts, without opening the current transformer secondary circuits, disturbing circuits, or requiring disconnection of leads on the rear of the panels.

Each relays shall have suitable operation indicator(s).

(1) Performance of relays

Each protection relay shall have the following basic performance;

- Possessing high ability of withstanding electrical and mechanical stress and constant performance under the circumstance of long term operation.
- No occurrence of chattering or reverse during maintenance or miss operation due to mechanical vibration.
- Easiness of adjustment and inspection.

(2) Setting of relays

Setting of protective relays shall be performed in such manners;

- Each relay shall be as quick as possible respond to failure condition exactly and shall not be miss-operated due to normal load current or inrush current.

- Each relay shall have superior selection capability against failure out of protection zone. Operating time of each relay shall be kept within minimum value in view of system stabilization or preventing damage of equipment.

13.3.3 Emergency Generator Equipment

The emergency generator installed in main office generator room shall be of normally on stand-by, manually started and connected to the 3.6 kV switchgear when the normal power supply is lost.
The emergency generator shall be rated suitable for continuous operation for at least 3 hrs and shall supply power to the one (1) 220kW lift pump loads through a distribution panel.

13.3.3.1 Emergency Generator

One (1) set of emergency generator shall be of indoor use, medium speed heavy duty, water cooled, soundproof enclosed type, three phases AC synchronous generators with the following specification.

(a) Diesel engine

Type	:	4 cycle, water cooled
Application	:	Emergency use
Output	:	More than 670 kW
Engine starter	:	Compressed air
Rated speed	:	1,500 rpm
Fuel	:	Diesel fuel oil
Governor	:	Electro static type

(b) Generator

Type	:	Horizontal shaft, self ventilated type
Rated capacity	:	750 kVA
Rated voltage	:	3,300 V
Rated frequency	:	50 Hz
Number of pole	:	4 poles
Number of phase	:	3 phase
Number of wire	:	4 wire
Power factor	:	80% (lagging)
Excitation	:	Brushless
Insulation	:	Class F
Temperature rise	:	Class B
Rated speed	:	1,500 rpm
Standard	:	JIS, JEC, IEC

13.3.3.2 Generator Control Panel

The generator control panel(s) installed in the main office generator room shall be of indoor use, metal enclosed and self-standing type, and shall include necessary generator start and control equipment with protection device, generator circuit breaker and accessories.
The following components shall be mounted on the control panel(s).

- Automatic voltage regulator 1 lot
- Ammeter with selector switch 1 lot
- Voltmeter with selector switch 1 lot
- Watt meter 1 lot

- Watt-hour meter 1 lot
- Power factor meter 1 lot
- Frequency meter 1 lot
- Protection relays 1 lot
- Control switch for generator 1 lot
- Control switch for circuit breaker 1 lot
- Indicator 1 lot
- Fault indicator 1 lot
- Other necessary items 1 lot

13.3.3.3 Generator Auxiliary Equipment

The following equipment shall be installed with generator.

Fuel tank (Capacity for 3 hrs operation)	1 set
Cooling unit	1 set
Air compressor with air tank	1 set

13.3.4 Electrical Equipment for Plant

13.3.4.1 3.6 kV Metal-Enclosed Distribution Switchgear

The 3.6 kV metal-enclosed distribution switchgear installed in main office electric room, shall be of indoor use double circuit breakers cubicle type, and air insulated, corrosion resistant, vermin-proof and be mounted on steel base channels.

Unless specified hereunder, the metal-enclosed switchgear shall conform to the requirements stated in JEM or IEC standard.

The switchgears shall have hinged doors in the front including lock and shall have well-considered self-ventilating device.

All switchgears shall be designed and constructed in such manner that any switchgear may have the same dimensions.

Each switchgears shall be provided with all necessary control, measuring, indicating and protective apparatuses, fuses, whether or not expressly specified.

The switchgears shall have over current strength to sustain for two (2) seconds corresponding to the interruption capacity of circuit breakers.

(a) Ratings

Same as Clause 13.3.2.4 (a).

(b) Quantity

The following facilities shall be supplied as follows;

(1) 3.3 kV feeder switchgear : 6 sets
(2) Section panel : 1 set

(c) Equipment and devices to be provided in the feeder switchgears

Switchgear shall be equipped with the following major equipment and devices.

- Circuit breaker : 2 sets
- Current transformer : 2 sets
- Am-meter : 2 sets
- Watt-meter : 2 sets
- Watt-hour meter : 2 sets
- Over current relay with instantaneous element : 4 sets
- Directional over current ground relay : 2 sets
- Lockout relay : 2 sets

- Indicating lamp : 1 set
- Control switch : 1 lot
- Change over switch : 1 lot
- Test terminal for CT and VT : 1 lot
- Accessories
  - Name plate(s)
  - Flourescent lighting fixture (provided in cubicle inside)
  - Steel bese channels with anchors
  - Grounding terminal(s)
  - Lifting lugs
  - Other necessary accessories

(d) Equipment and devices to be provided in the section switchgear

Switchgear shall be equipped with the following major equipment and devices.

- Circuit breaker : 1 set
- Current transformer : 2 sets
- Am-meter : 1 set
- Over current relay with instantaneous element : 2 sets
- Over current ground relay : 1 set
- Lockout relay : 1 set
- Indicating lamp : 1 set
- Fault indicators : 1 lot
- Control switch : 1 lot
- Change over switch : 1 lot
- Test terminal for CT and VT : 1 lot
- Accessories
  - Name plate(s)
  - Fluorescent lighting fixture (provided in cubicle inside)
  - Steel base channels with anchors
  - Grounding terminal(s)
  - Lifting lugs
  - Other necessary accessories

(e) 3.6 kV Circuit breaker

The 3.6 kV circuit breaker to be installed in cubicles shall be of 50 Hz, three-pole, horizontal drawout, indoor use, vacuum type or SF6 type, trip-free in any position, complete with electrical spring charge operating mechanism and be in accordance with JEC or IEC standard.

(1) Ratings

Rated voltage	:	3.6 kV
Rated normal current	:	600 A
Rated short-circuit breaking current	:	25 kA
Rated duration of short-circuit	:	2 seconds
Rated operating sequence	:	0-1 minute-CO-3 minutes-CO
Rated interrupting time	:	5 cycles
Control circuit voltage	:	DC 110 V

(2) Accessories

Same as Clause 13.3.2.4 (d) (2).

(f) 3.6 kV Current transformer

The 3.6 kV current transformer to be installed in cubicles shall be of 50 Hz, single phase indoor use, epoxy resin moulded, core type and be in accordance with JEC or IEC standard.

(1) Ratings

The 3.6 kV current transformer shall be of adequate burden and 40 times for over current strength for one (1) second.

Rated voltage	:	3.6 kV
Current ratio	:	600-300/5A
Accuracy class	:	1 P

(2) Accessories

Same as Clause 13.3.2.4 (e)(2).

13.3.4.2 3.6kV Static Capacitor and Series Reactor Cubicle

The static capacitor and series reactor cubicle(s) installed in the main office electric room shall be of indoor use, metal enclosed and self-standing type, and shall include necessary automatic power factor control equipment with protection devices.

Type and ratings

(a) Static capacitor (SC)

Type	:	Indoor, hermetically sealed
Number of phase	:	3
Capacity	:	Improved power factor 0.9 (Contractor shall be calculated capacity depend on power factor of motor and pump)
Rated voltage	:	3.6 kV
Accessories	:	Alarm contact

(b) Series reactor (SR)

Type	:	Indoor, oil-immersed and self-cooled or dry type
Number of phase	:	3
Capacity	:	Improved power factor 0.9 (Contractor shall be calculated capacity depend on power factor of motor and pump)
Rated voltage	:	3.6 kV
Accessories	:	Alarm contact

(c) Vacuum switch (VS)

Type	:	Vacuum contactor with fuse, 3 phase
Rating	:	3.6 kV, 100A, 12.5kA
Operation charge	:	Manual – Remote with electrical spring mechanism
Control voltage	:	DC 110V
Accessories	:	Alarm contact Aux. contact

13.3.4.3 3.6 kV Transformer Primary Cubicle

The 3.6 kV transformer primary cubicle installed in the lift pump transformer primary shall be of outdoor use, and installed in the each electrical rooms

shall be of indoor use cubicle type, and air insulated, corrosion resistant, vermin-proof and be mounted on steel base channels.

Each cubicles shall have hinged doors in the front and back respectively including locks and shall have well-considered self-ventilating device.

Each cubicles shall be provided with all necessary control, measuring, indicating and protective apparatuses, fuses, whether or not expressly specified.

The cubicles shall have over current strength to sustain for two (2) seconds corresponding to the interruption capacity.

(a) Quantity

The following facilities shall be supplied :

(1) For Main office electric room	:	1 set (FDS type)
(2) For Lift pump electric room	:	1 set (FDS type)
(3) For Water treatment electric room	:	1 set (FDS type)
(4) For Chlorination electric room	:	1 set (FDS type)
(5) For Dewatering electric room	:	1 set (CB type)
(6) For Compost electric room	:	1 set (FDS type)

(b) Equipment and devices to be provided in the cubicle

Cubicle shall be equipped with the following major equipment and devices.

- Fuse switch-discconector (FDS) or circuit breaker
- Indicating lamp
- Accessories
  - Name plate(s)
  - Fluorescent lighting fixture (provided in cubicle inside)
  - Steel base channels with anchors
  - Earthing terminal(s)
  - Lifting lugs
  - Other necessary accessories

(c) 3.6 kV Fuse switch-disconnector(On-load isolating fuse switch)(FDS)

The 3.6 kV Fuse switch-disconnector to be installed in cubicles shall be of 50 Hz, three-pole, indoor use, manual operation with blow fuse (striker fuse) trip type, complete with operating mechanism and be in accordance with JEC or IEC standard.

(1) Ratings

Rated voltage	:	3.6 kV
Rated normal current	:	200A, 400A

(2) Accessories

- Name plate
- Position indicators
- Auxiliary contacts for position indicator
- Grounding terminal(s)
- Manual operating rod
- Other necessary accessories

(d) 3.6 kV Circuit breaker

Same as Clause 13.3.4.1 (e)

13.3.4.4 Low Voltage Metal-Enclosed Switchgear

The low voltage metal-enclosed switchgears installed in the each electric room shall be of indoor use, metal enclosed and self-standing type, and shall include necessary protection devices, circuit breakers and accessories.

(a) Ratings

-	Rated voltage	:	600 V
-	Rated normal current	:	1200A, 2500A, 4000A
-	Rated short-circuit breaking current	:	50 kA, 65 kA,
-	AC power frequency withstand voltage	:	2,200 V
-	Bus bar rating	:	3 phase 1200A, 2500A, 4000A

(b) Quantity

Main office LV switchgear (LV1)	:	1 set
Lift pump TR secondary switchgear (LV2)	:	1 set
Water treatment LV switchgear (LV3)	:	1 set
Chlorination LV switchgear (LV4)	:	1 set
Dewatering LV switchgear (LV5)	:	1 set
Compost LV switchgear (LV6)	:	1 set

(c) Ratings for circuit breaker

Circuit breaker for Main office LV switchgear (LV1)

-	Type	:	Air circuit breaker, 3 phase, with alarm contact
-	Ampere frame	:	1200A
-	Rating	:	600V, 1200A, 50 kA
-	Operation	:	Manual and electrical spring charge mechanism
-	Control voltage	:	DC 110V

Circuit breaker for Lift pump TR secondary switchgear (LV2)

-	Type	:	Air circuit breaker, 3 phase, with alarm contact
-	Ampere frame	:	2500A
-	Rating	:	600V, 2500A, 65 kA
-	Operation	:	Manual and electrical spring charge mechanism
-	Control voltage	:	DC 110V

Circuit breaker for Water treatment LV switchgear (LV3)

-	Type	:	Air circuit breaker, 3 phase, with alarm contact
-	Ampere frame	:	1200A
-	Rating	:	600V, 1200A, 50 kA
-	Operation	:	Manual and electrical spring charge mechanism
-	Control voltage	:	DC 110V

Circuit breaker for Chlorination LV switchgear (LV4)

-	Type	:	Air circuit breaker, 3 phase, with alarm contact
-	Ampere frame	:	1200A
-	Rating	:	600V, 1200A, 50 kA
-	Operation	:	Manual and electrical spring charge mechanism
-	Control voltage	:	DC 110V

Circuit breaker for Dewatering LV switchgear (LV5)

-	Type	:	Air circuit breaker, 3 phase, with alarm contact
-	Rating	:	600V, 4000A, 65 kA
-	Operation	:	Manual and electrical spring charge mechanism
-	Control voltage	:	DC 110V

Circuit breaker for Compost LV switchgear (LV6)

- Type : Air circuit breaker, 3 phase, with alarm contact
- Ampere frame : 1200A
- Rating : 600V, 1200A, 50 kA
- Operation : Manual and electrical spring charge mechanism
- Control voltage : DC 110V

(d) Accessories for each switchgear

Components	LV1	LV2	LV3	LV4	LV5	LV6
Current transformer	2 sets	3 sets	2 sets	2 sets	2 sets	2 sets
Voltage transformer	2 sets	3 sets	2 sets	2 sets	2 sets	2 sets
Over voltage relay	1 set	1 set	1 set	1 set	1 set	1 set
Under voltage relay	-	1 set	1 set	1 set	1 set	1 set
Over current relay	2 sets	2 sets	2 sets	2 sets	2 sets	2 sets
Over current ground relay	1 set	1 set	1 set	1 set	1 set	1 set
Ammeter with selector switch	1 set	1 set	1 set	1 set	1 set	1 set
Voltmeter with selector switch	1 set	1 set	1 set	1 set	1 set	1 set
Watt hour meter	-	1 set	1 set	1 set	1 set	1 set
Watt meter	-	1 set	1 set	1 set	1 set	1 set
Power factor meter	-	1 set	1 set	1 set	1 set	1 set
CB position indicator	1 set	1 set	1 set	1 set	1 set	1 set
Fault indicator	1 set	1 set	1 set	1 set	1 set	1 set
Moulded case circuit breaker	1 lot	1 lot	-	1 lot	1 lot	1 lot
Other necessary items	1 lot	1 lot	-	1 lot	1 lot	1 lot

13.3.4.5 Low Voltage Distribution Panel

The low voltage distribution panels installed in the each electric room shall be of indoor use, metal enclosed and self-standing type, and shall include necessary protection devices, circuit breakers and accessories.

(a) Ratings

Rated voltage	:	600 V
Rated normal current	:	1200A, 4000A
Rated short-circuit breaking current	:	50 kA, 65kA
AC power frequency withstand voltage	:	2,200 V
Bus bar rating	:	3 phase 1200A, 4000A

(b) Quantity

Main office LV distribution panel (LD1)	:	1 set
Lift pump LV distribution panel (LD2)	:	1 set
Water treatment LV distribution panel (LD3)	:	1 set
Chlorination LV distribution panel (LD4)	:	1 set
Dewatering LV distribution panel (LD5)	:	1 set
Compost LV distribution panel (LD6)	:	1 set

(c) Ratings for circuit breaker

Circuit breaker for Main office LV switchgear (LV1)

Type	:	Moulded case circuit breaker, 3 phase, with alarm contact
Ampere frame	:	According to the load
Rating	:	According to the load
Operation	:	Manual
Control voltage	:	DC 110V

13.3.4.6 Low Voltage Static Capacitor and Series Reactor Panel

The static capacitor and series reactor panel(s) installed in the lift pump electric room shall be of indoor use, metal enclosed and self-standing type, and shall include necessary automatic power factor control equipment with protection devices.

Type and ratings

(a) Static capacitor (SC)

Type	:	Indoor, hermetically sealed
Number of phase	:	3
Capacity	:	Improved power factor 0.9 (Contractor shall be calculated capacity depend on power factor of lift pump)
Rated voltage	:	380 V
Accessories	:	Alarm contact

(b) Series reactor (SR)

Type	:	Indoor, oil-immersed and self-cooled or dry type
Number of phase	:	3
Capacity	:	Improved power factor 0.9 (Contractor shall be calculated capacity depend on power factor of lift pump)
Rated voltage	:	380 V
Accessories	:	Alarm contact

(c) Vacuum switch (VS)

Type	:	Vacuum contactor, 3 phase
Rating	:	600V, 1000A, 25kA
Operation	:	Manual and electrical spring charge mechanism
Control voltage	:	DC 110V
Accessories	:	Alarm contact Aux. contact

13.3.4.7 Lift Pump Transformer

The Lift pump Transformer installed in the lift pump outdoor electric equipment area shall be of 50 Hz, 3.3 kV/380 V, 1500kVA, outdoor use, three-phase, oil-immersed, self-cooled with No-load tap changer and be in accordance with JEC or IEC standard unless specified hereunder.

(a) Ratings

Rated primary voltage	:	3.3 kV
Rated secondary voltage	:	380 - 220 V
Continuous rated capacity	:	1,500 kVA
Type of cooling	:	ONAN

Number of phase : 3
Rated frequency : 50 Hz
Tap voltage : F3375V - R3300V - F3225V - F3150V - 3075V
Winding connection
(Primary) : Delta
(Secondary) : Star with neutral brought out to grounding terminal
Temperature rise : Maximum 55 degrees for oil

The winding shall be connected in accordance with vector symbol Dyn 11 of JEC or IEC standard.

(b) Insulating oil

Insulating oil for power transformer shall be of non-sludge, refined mineral oil and in accordance with JIS or IEC standard.

(c) Primary and secondary bus duct

(1) Primary bus duct

Transformer primary bus duct shall be air insulated, 3 phase, copper bar conductor and connected to transformer primary fuse switch-disconnector cubicle.

Rated of bus duct as follows;

- Rated voltage : 3.3 kV
- Rated current : 300 A

(2) Secondary bus duct

Transformer secondary bus duct shall be air insulated, 3 phase copper bar conductor and connected to transformer secondary low voltage metal-enclosed switchgear.

Rated of bus duct as follows;

- Rated voltage : 600 V
- Rated current : 2500 A

(d) Accessories

The following accessories shall be supplied ;

- Oil level indicator
- Oil temperature indicators
- Oil valves
- Silica gel breather
- Lifting lugs
- Earthing terminals
- Foundation bolts
- Name and rating plates
- Radiators
- Necessary terminals for primary and secondary circuits
- Other necessary accessories

13.3.4.8 Transformer Enclosed Cubicle

The Transformer enclosed cubicle installed in the each electric rooms shall be of indoor use, metal enclosed self-standing type, and enclosed 3.3 kV/380 - 220 V transformer.

The transformer shall be of 50 Hz, three-phase, oil-immersed, self-cooled with no-load tap changer and be in accordance with JEC or IEC standard unless specified hereunder.

(a) Ratings for transformer

Rated primary voltage	:	3.3 kV
Rated secondary voltage	:	380 - 220 V
Type of cooling	:	ONAN
Number of phase	:	3
Rated frequency	:	50 Hz
Tap voltage	:	F3375V - R3300V - F3225V - F3150V - 3075V
Winding connection		
(Primary)	:	Delta
(Secondary)	:	Star with neutral brought out to grounding terminal

The winding shall be connected in accordance with vector symbol Dyn 11 of JEC or IEC standard.

(b) Rated capacity of transformer

Main office electric room transformer	:	750 kVA
Water treatment electric room transformer	:	750 kVA
Chlorination electric room transformer	:	750 kVA
Dewatering electric room transformer	:	2500 kVA
Compost electric room transformer	:	750 kVA

(c) Insulating oil

Insulating oil for power transformer shall be of non-sludge, refined mineral oil and in accordance with JIS or IEC standard.

(d) Accessories

The following accessories shall be supplied:

- Oil level indicator
- Oil temperature indicator
- Oil valves
- Silica gel breather
- Primary and secondary bus bar
- Lifting lugs
- Earthing terminals
- Foundation bolts
- Name and rating plates
- Radiators
- Necessary terminals for primary and Secondary circuits
- Other necessary accessories

13.3.4.9 Lift Pump Starter Panel

The lift pump starter panels installed in the lift pump electric room shall be of indoor use, metal enclosed and self-standing type, local remote operation and shall include necessary motor starting equipment with protection device and accessories.

(a) Quantity : 3 sets
(b) Type and ratings for starter panel

Type	:	Circuit transition auto-transformer starting type
Motor capacity	:	220 kW
Motor voltage	:	380 V
Rated voltage	:	600 V
Rated frequency	:	50 Hz
Circuit breaker		
Type	:	Air circuit breaker, 3 phase, with alarm contact
Rating	:	600V, 1000A, 25kA
Operation	:	Manual and electrical spring charge mechanism
Control voltage	:	DC 110V
Contactor	:	Vacuum type contactor
Accessories	:	Current transformer Ammeter Overcurrent relay Overcurrent grounding relay Thermal relay Cooling fan for transformer Operation indicator Fault indicator Other necessary accessories

13.3.4.10 Motor Control Centre (CC)

The motor control centre installed in the each electric room shall be of indoor use, metal enclosed and self-standing type, and shall include necessary motor starting equipment with protection device, accessories and motor control relay panel(s).

Each moulded case circuit breaker unit shall be housed inside a separate compartment and shall be closed on front side. The hinged lockable door shall be provided at the front. The hinged door shall be interlocked with the breaker positions, such that the door cannot be opened unless the breaker is in “isolated” position.

Type and ratings

(a) Incoming unit

Horizontal bus bar rating	:	3 phase-4 wire, 600 A, 35kA (0.5 sec)
Vertical bus bar rating	:	3 phase-4 wire, 600 A, more than 35kA (0.5 sec)
Current rating	:	According to the load
Operation	:	Local manual operation
Accessories	:	Voltmeter with changeover switch Ammeter with changeover switch Fault indicator Other necessary accessories

(b) Feeder unit

Type of start circuit		
Motor capacity less than 30kW	:	Direct start circuit (Reversible / Non-reversible)
Motor capacity over 30kW	:	Star – Delta start circuit (Reversible / Non-reversible)
Motor voltage	:	380 V

Bus bar rating	:	3 phase-4 wire, 600 A, 35kA (0.5 sec)
Rated current	:	According to the load
Rated frequency	:	50 Hz
Contactor	:	Electromagnetic type contactor
Operation	:	Local manual and remote operation
Accessory	:	Operation indicator Fault indicator

13.3.4.11 Local Motor Control Panel and Switch Box

The local motor control panel and switch box shall be metal enclosed, corrosion resistant, vermin-proof and shall include necessary motor control equipment, meters and accessories.

All motor control devices such as control switches, meters and indication lamps shall be mounted on panel. Outdoor type local motor control panel shall be weatherproof and shall have self-ventilating device.

(a) Local control panel

(1) Indoor type local control panel:
Wall mounted type or self-standing type or stand type

(2) Outdoor type local control panel:
Wall mounted type or self-standing type or stand type

(b) Switch box:

Wall mounted type or self-standing type

13.3.4.12 DC Power Supply System

The DC power supply system installed in the each electric room shall be of indoor use, metal enclosed and self-standing type, and shall include necessary protection device and accessories.

The DC power supply system shall be rated 110V DC (nominal voltage), un-earthed (floating earth), with a back-up battery bank for a 30 minute period.

The DC power supply system shall be provided with voltage compensation circuit such as a voltage dropper and DC distribution circuit breakers.

(a) Power supplied equipment

Electric room	**Equipment**
Main office electric room	: Switchgear, Supervisory panel and Instrumentation control
Lift pump electric room	: Switchgear and Instrumentation control
Water treatment electric room	: Switchgear and Instrumentation control
Chlorination electric room	: Switchgear, Supervisory panel and Instrumentation control
Dewatering electric room	: Switchgear, Supervisory panel and Instrumentation control
Compost electric room	: Switchgear, Supervisory panel and Instrumentation control

(b) Charger

The battery charger shall be of a silicon controlled automatic rectifier type designed for continuous use.

The battery charger shall include complete with automatic voltage regulator, load voltage dropper, moulded case circuit breakers, voltmeters, ammeters, relays, warning lamps and other necessary components for the correct operation. The battery charger shall be of continuous operation system. The battery charger shall be of sufficient capacity to supply the normal current required for plant operation so as to maintain the battery in fully charged condition.

Type and ratings of battery charger

Type	:	Silicon controlled automatic rectifier type for continuous use
AC input voltage	:	380V ± 10%, three phase
DC output voltage	:	DC 110 V ± 2%
DC current	:	According to the load
Accessories	:	DC distribution moulded case circuit breakers Other necessary accessories

(c) Storage battery

The battery shall be of a stationary sealed lead-acid type. Batteries shall be installed metal enclosed panel. The minimum electrolyte temperature of the battery for calculation shall be 5 degrees. The cell construction of the batteries shall be designed for none requirement of water topping-up and specific gravity measurement.

Type and ratings of battery

Type	:	Stationary sealed lead-acid storage type battery, Gas recombination on negative electrode type
Nominal output voltage	:	DC 110V
Capacity	:	According to the load
Accessories	:	Inter-cell connectors and necessary terminals Other necessary accessories

(d) DC distribution board

The DC distribution panels installed in the each electric room shall be of indoor use, metal enclosed and self-standing type.

Ratings

Type of circuit breaker	:	Moulded case circuit breaker with alarm contact
Capacity	:	According to the load

13.3.4.13 AC Uninterruptible Power Supply System (UPS)

The uninterruptible power supply system (UPS) installed in the each electric room shall be of indoor use, metal enclosed and self-standing type, and shall include necessary protection device and accessories, and power supply for essential instrument and data logging system circuits.

The UPS shall be of a inverter(s) system with backup battery and a bypass circuit, and include complete with automatic voltage regulator, moulded case circuit breakers, voltmeters, ammeters, relays, warning lamps and other necessary components for the correct operation.

The battery capacity shall be so designed to supply power to the inverter for 30 min when the power supply to the UPS is lost.

Type of battery shall be preferably same as that of DC system, and no of cells, and cell voltage, etc. shall be in accordance with the Contractor's standard application.
The bypass circuit shall serve as hot stand-by and automatically cut into power output without harmful interruption by a static switch system when the inverter supply is in abnormal conditions.
The bypass circuit shall be also provided with a manual changeover switch of make-before-break operation.

(a) Power supplied equipment

Electric room		Equipment
Main office electric room	:	Supervisory panel, Data logging system, Communication system and Instrumentation control
Lift pump electric room	:	Instrumentation control
Water treatment electric room	:	Instrumentation control
Chlorination electric room	:	Supervisory panel and Instrumentation control
Dewatering electric room	:	Supervisory panel and Instrumentation control
Compost electric room	:	Supervisory panel and Instrumentation control

(b) Type and ratings

Type	:	Normally using inverter method
Rated capacity	:	According to the load
AC input voltage	:	AC 380V, three phase
AC output voltage	:	AC 100 V ± 2%
Frequency	:	50 Hz
Accessories	:	AC distribution moulded case circuit breakers Other necessary accessories

13.3.4.14 Communication System

The Communication system installed in the plant area shall be of indoor use, rack mounted exchanger with paging speakers, and master and local station intercom system.
The Communication system shall be provided following function;

- Individual zone broadcast and paging
- Paging announcement with microphone
- Paging announcer for intercom station
- Master – Local and Local - Local communication
- Public telephone interface

(a) Type and ratings

Type	:	Rack mounted exchanger type
Master station	:	Desk mount type hand set (One set)
Local station	:	Wall mount type hand set (More than 20 sets)
Horn speaker	:	Outdoor type (More than ten sets)
AC input voltage	:	AC 220V, single phase
Power output	:	240 W
Frequency	:	50 Hz
Accessories	:	Paging microphone Wall mount telephone cable connector box Other necessary accessories

13.4 DETAIL SPECIFICATIONS FOR INSTRUMENTATION

The Contractor shall furnish and install all equipment and devices as specified hereinafter and shown on the Drawings.

13.4.1 Level Meter

The level meter installed in the plant area shall be as following quantity and type;

No.	Location	Quantity	Type
LIA-102	Lift pump well	1	Submerged diaphragm type
LIA-401	Sodium hypochlorite tank	2	Diaphragm type
LIA-501	Sand filtration effluent tank	1	Submerged diaphragm type
LIA-601	Excess sludge tank	1	Diaphragm type
LIA-602	Mixed sludge tank	1	Diaphragm type

13.4.1.1 Submerged Diaphragm Type Level Meter

The submerged diaphragm type level meter shall be measured the water level by detecting water pressure with detection element installed in the water.

Ratings

Accuracy	:	Not less than +/- 0.5% of full scale
Output signal	:	DC 4 to 20 mA and DC 1 to 5 V
Measurement Range	:	0 to 10 m by water level
Ambient temperature	:	- 5 to 50 degrees
Power supply	:	AC 100 V or DC 24 V
Material		
- Detection parts	:	Stainless steel SUS 304/316 Polyethylene resin
- Pressure detecting parts	:	Stainless steel SUS 304/316 Chloroprene rubber and silicon rubber
- Unfilled tube (External sheath)	:	Polyvinylchloride
Installation method	:	Throw into the water with guide pipe
Accessory	:	Signal converter Interface Box Wave protection pipe

13.4.1.2 Diaphragm Type Level Meter

The diaphragm type level meter shall be measured the water level by the difference between water pressure capacity and air.

Ratings

Accuracy	:	Not less than +/- 0.2% from 10 % to 100 % scale
Output signal	:	DC 4 to 20 mA
Measurement Range	:	250 to 10000 mm by water level (2.5 – 100 kPa)
Ambient temperature	:	- 40 to 85 degrees
Power supply	:	DC 24 V
Material	:	Aluminium
Installation method	:	With flange installation, (Flange size JIS 10 K)
Accessory	:	Signal converter Interface box

13.4.2 Flow Meter

The flow meter installed in the plant area shall be as following quantity and type;

No.	Location	Quantity	Type
FIQ-201	Blower suction air flow	2	600 m/m orifice type
FIQ-202	Aeration tank air flow	10	350 m/m orifice type
FIQ-301	Raw sludge flow	1	100 m/m electromagnetic type
FIQ-302	Return sludge flow	2	350 m/m electromagnetic type
FIQ-303	Excess sludge flow	1	150 m/m electromagnetic type
FIQ-401	Sodium hypochlorite	1	25 m/m electromagnetic type
FIQ-501	Treated water effluent	1	Ultrasonic type with weir
FIQ-601	Gravity thickened sludge	1	80 m/m electromagnetic type
FIQ-602	Excess sludge feed	2	100 m/m electromagnetic type
FIQ-603	Mixed sludge feed	2	80 m/m electromagnetic type
FIQ-604	Polymer feed	2	50 m/m electromagnetic type

13.4.2.1 Orifice Type Flow Meter

The orifice type flow meter shall be measured flow volume of air based on pressure difference between in front and rear of orifice plate.

The orifice type flow meter consist of two parts of orifice plate and differential pressure converter.

(a) Ratings for orifice plate

1) Applicable pipe size : 350 m/m, 600 m/m
   Type : Concentric orifice
   Material : Stainless (SUS304/316)
   Installation : Insert between pipe with flange (Installation works to be done by the mechanical works)
   Accessory : Pipe manifold
   Gas hole and drain hole

(b) Ratings for differential pressure converter

Type : Electrostatic capacity type
Accuracy : +/- 0.5 %
Output signal : DC 4 to 20mA
Ambient temperature : - 40 to 85 degrees
Power supply : DC 24 V
Installation method : Pipe mount

13.4.2.2 Electro Magnetic Flow Meter

The Electro magnetic type flow meter shall be measured flow volume of fluid based on Faraday's electromagnetic induction law.

The Electro magnetic type flow meter consist of two parts of magnetic flow transmitter and converter.

(a) Ratings for transmitter

Applicable pipe size : 25m/m, 50m/m, 80m/m, 100m/m, 150m/m, 350m/m

Material

- Measurement tube : Stainless (SUS304) and steel (SS 400)

-	Tube inning	:	Teflon or polyurethane
-	Electrode	:	Stainless (SUS316L)
-	Terminal box	:	Aluminium
	Ambient temperature	:	- 10 to 65 degrees
	Power supply	:	Supplied from converter
	Installation	:	Wafer between pipe (Installation works to be done by the mechanical works)
	Accessory	:	Interface cable

(b) Ratings for converter

Accuracy	:	+/- 1.0 %
Output signal	:	Pulse signal, DC 4 to 20mA, alarm signal
Ambient Temperature	:	- 10 to 60 degrees
Power supply	:	DC 24 V or AC 100-220 V, single phase
Installation method	:	Wall mount or rack mount or pipe mount

13.4.2.3 Ultrasonic Flow Meter

The Ultrasonic flow meter shall be measured a time difference continuously between transmission signal and received signal reflected from the water. The received signal shall be amplified in the converter unit combined with water flow of fixed weir, and actual water flow come out as DC signals.

Ratings for ultrasonic flow meter

- Material	:	Stainless(SUS304/316), aluminium, polyester resin
- Ambient temperature	:	- 30 to 60 degrees
- Accuracy	:	+/- 2.0 %
- Output signal	:	DC 4 to 20mA
- Power supply	:	AC 100 V, single phase
- Measurement range	:	0.5 m to 19.5 m
- Installation	:	Wall mount or pipe mount
- Accessory	:	Interface cable Converter

13.4.3 Density Meter

The density meter installed in the plant area shall be as following quantity and type;

No.	Location	Quantity	Type
DIA-301	Raw sludge	1	100 m/m Ultrasonic (Non deforming type)
DIA-302	Return sludge	2	350 m/m Ultrasonic (Non deforming type)
DIA-601	Gravity thickened sludge	1	80 m/m Ultrasonic (Deforming type)
DIA-602	Excess sludge feed	1	200 m/m Ultrasonic (Deforming type)
DIA-604	Mixed sludge feed	1	150 m/m Ultrasonic (Deforming type)

13.4.3.1 Ultrasonic Density Meter

The ultrasonic density meter shall be measured the sludge density continuously by the sensing of varying ultrasonic attenuation.

(a) Ratings for ultrasonic density meter (Non deforming type)

Measuring range	:	0 to 10% (suspended matter)
Accuracy	:	+/- 3.0 %
Repeatability	:	Less than 4 %
Output signal	:	DC 4 to 20mA
Power supply	:	AC 100 V, single phase
Ambient temperature	:	0 to 50 degree
Material		
- Ultrasonic sensor	:	Stainless steel (SUS 316)
- Main pipe	:	Stainless steel (SUS 316)
Installation method	:	With pipe (100m/m, 350m/m)
Accessory	:	Control unit Interface cable

(b) Ratings for ultrasonic density meter (Deforming type)

Measuring interval	:	0.1 min to 99.9 min
Accuracy	:	+/- 3.0 %
Repeatability	:	Less than 4 %
Output signal	:	DC 4 to 20mA
Power supply	:	AC 100 V (single phase) or AC 380 V (three phase)
Ambient temperature	:	0 to 50 degree
Material		
- Deforming cylinder	:	Stainless steel (SUS 304)
- Main pipe	:	Steel (FC-20)
Installation method	:	Direct assemble with pipe (80m/m, 150 m/m, 200m/m)
Accessory	:	Control unit (Indoor type, self-type) Interface cable

13.4.4 Level Control Switch

The level control switch installed in the plant area shall be as following quantity and type;

No.	Location	Quantity	Type
LC-101-6	Floor drainage pit for lift pump facility	6	Electrode type
LC-201	Floor drainage pit for blower	1	Electrode type
LC-301	Scum tank	2	Float type
LC-302-8	Floor drainage pit for water treatment facility	7	Electrode type
LC-501	Secondary effluent tank	1	Electrode type
LC-502	Backwash wastewater tank	1	Float type
LC-503-6	Floor drainage pit for water supply facility	4	Electrode type
LC-601	Thickener effluent tank	1	Float type
LC-602	Recycle flow tank	1	Float type
LC-603	Treated water tank	1	Electrode type
LC-605	Floor drainage pit for gravity thickening equipment	1	Electrode type
LC-701-1	Floor drainage pit for compost facility	1	Float type
LC-701-2	Wastewater tank for compost facility	1	Float type
LC-701-3	Recirculation tank for compost facility	1	Float type

13.4.4.1 Electrode Type Level Control Switch

The electrode type level control switch shall be measured the water level by the difference between energizing of the electrode and interruption of electrode.

Ratings

- Output signal : No voltage contact (4 contacts)
- Ambient temperature: - 20 to 50 degree
- Material : Stainless steel SUS 316 or Hastelloy B, C or Titanium and Polyethylene sheath
- Installation method : With flange installation, (Flange size JIS 10 K)
- Accessory : Alarm setter

13.4.4.2 Float Type Level Control Switch

The float type level control switch shall be measured the water level by the float.

Ratings

- Output signal : No voltage contact (4 contacts)
- Ambient temperature: - 10 to 50 degrees
- Material : ABS (acrylonitrile butajien styrene)
- Installation method : With flange installation, (Flange size JIS F 20a)

13.4.5 Instrumentation Panel

The Instrumentation panel installed in the main control room, chlorination electric room and dewatering electric room shall be of indoor use, metal enclosed and self-standing type.

The following components shall be mounted on the Instrumentation panel.

(a) Process variable indicator

Type	:	Moving coil type, Single point indicator
Indication range	:	0 to 100%
Accuracy	:	+/- 1% of span
Input signal	:	DC 1 to 5 V or DC 4 to 20mA
Others	:	Zero adjustment and span adjustment
Accessories	:	Alarm setter Scale plate

(b) Integrating counter

(1) Counter

Type	:	Electromechanical, manual reset type
Indication	:	At least six (6) digits
Input signal	:	Voltage pulse, DC 24V

(2) Integrator

Type	:	Proportional integral type or square integral type
Accuracy	:	+/- 0.5% of span
Input signal	:	DC 1 to 5V
Output signal	:	Voltage pulse, DC 24V
Power supply	:	AC 100 V, single phase

(c) Isolator

Input signal	:	DC 1 to 5 V and DC 4 to 20 mA
Output signal	:	Isolated DC 1 to 5 V and DC 4 to 20 mA
Accuracy	:	+/- 0.2% of span
Power supply	:	AC 100 V, single phase

(d) Distributor

Transmission voltage	:	DC 24V
Distribution signal	:	Isolated DC 1 to 5 V and DC 4 to 20 mA
Accuracy	:	+/- 0.2% of span
Power supply	:	AC 100 V, single phase

(e) Arrester

The arrestors shall be protected electronics instruments from lightning induced surge voltage.

13.4.6 Supervisory Panel

The Supervisory panel installed in the main control room, chlorination electric room, dewatering electric room and compost electric room shall be of indoor use, metal enclosed and self-standing mini graphic type.

(a) Facilities and Quantity

The following components shall be mounted on the supervisory panel(s).

Graphic indication for water flow system	1 lot
Operation indicators	1 lot
Fault indicator	1 lot
Fire alarm indicator	1 lot
Other necessary items	1 lot

(b) Wiring

Wiring for secondary of voltage and current transformers to be installed in supervisory panels shall be coloured respectively according to appropriate standards and terminated with terminals and marked corresponding to the wiring diagrams. Wiriness shall suitable for operation with the voltage and current transformers under both normal and short circuit conditions.

13.4.7 Data Logging System

The Contractor shall be furnished and install all equipment and devices as specified hereinafter and shown on the Drawings.

The Data logging system installed in the main office control room shall be of indoor use, microprocessor controlled optical fibber cable data link system.

The Data logging system shall be supervised and collected each data such as operating conditions of equipment, fault indications, measurement signals of instrumentation equipment, and also shall have printed out and data saving function for necessary data above mentioned as daily log, weekly log and monthly log with easy operation.

(a) Facilities and quantity

The following components shall be included in the Data logging system.

Main Processing Unit	1 lot

CRT (21 inch)	2 sets
Printer	1 lot
Central Interface panel	1 lot
Local Interface panel	1 lot
Data link cable	1 lot

(b) Signal quantities to be collected including future extension.

- Input signals for equipment condition and fault alarm : More than 6,000 points
- Pulse measurement : More than 500 points
- Analogue measurement : More than 500 points

(c) Accessories : Paper for printer each size
Spare ink or toner for printers
Floppy disks

13.5 DETAIL SPECIFICATIONS FOR ELECTRICAL INSTALLATION WORKS

13.5.1 Materials

This Clause covers cables, conduits, pull boxes, cable ducts and trays which will be used for the main circuit and secondary circuit of power, control, instrumentation and other requirement.

In designing the length of cables, some allowance thereof shall be taken into consideration by the Contractor.

13.5.1.1 Power Cables, Control Cables and Instrument Cables

Conductor size for cables shall be adequate for the load requirements, voltage drop, short circuit current, and diversity factor for individual circuit application.

(a) Power cables

(1) 22 kV power cables shall be of copper conductor cross-linked polyethylene insulated PVC (polyvinyl chloride) sheathed type with suitable cable heads with terminals.

(2) 3.3 kV power cables shall be of copper conductor cross-linked polyethylene insulated PVC sheathed type with suitable cable heads with terminals.

(3) 600V power cables for motor circuit, heater circuit and other power circuits shall be of jacket type, 600 V cross-linked polyethylene insulated PVC sheathed type (CV).

600 V cross-linked polyethylene insulated PVC sheathed, welded and corrugated steel armoured PVC sheathed power cable (CVMAZV) shall be used for burred portion in the ground of outdoor lighting power cables.

Section area of cores for 600 V power cables shall not be less than 3.5sq.mm.

(b) Control and instrumentation cables

Except for small wiring of equipment, control cables shall be of jacket type, 600 V polyvinyl chloride insulated and sheathed control cable with copper tape shielding (CVV-S).

The Contractor shall design the number of cores and the size and length of cable based on the proper drawings or diagrams prepared by the Contractor.

The individual cores shall be identified by following different colour scheme and numbers of figure.

4 cores or less

2-cores : Black and white

3-cores : Black, white and red

4-cores : Black, white, red and green

5 cores or more : Individual cores shall be identified by surface printing of numbers in figure on the black insulation.

Section area of cores for control and instrumentation cables shall not be less than 2.5sq.mm. In case of important circuits, such as section areas of CT and VT circuits shall be 3.5sq.mm or more. In consideration of cables, the Contractor shall, if possible, design in such a manner that the size of cores or cables shall be unified.

13.5.1.2 Steel Conduits and Flexible Conduits

Steel conduits shall be steel, hot-dipped galvanized and equipped with couplings and thread protector caps. All surfaces and threads shall be coated with zinc. The sectional areas of a steel conduit shall be, at least, 2.5 times the total cross sectional area of cables to be pulled in.

- Rigid steel conduits shall be installed for all exposed cable route.
- PVC coated conduits shall be installed for corrosive area cable route.
- Couplings and elbows shall be of the same materials as conduit pipes.

Flexible metal conduits shall be used for flexible cable connection route. Flexible metal conduits shall have a interlocked flexible galvanized steel core with a permanently bonded outer polyvinyl chloride jacket.

13.5.1.3 Cable Trays and Wiring Ducts

The cable trays shall be made by hot-dipped galvanized steel or aluminium alloy with adequate strength and equipped with proper fittings, connectors and supports. The support interval for the cable tray rungs shall be 300mm or less. The grounding terminals shall be provided in the connecting section of cable tray.

Wiring ducts shall be of heavy-duty, hot-dipped galvanized steel and equipped with proper fittings, connectors and supports. The grounding terminals shall be provided in the connecting section of wiring duct.

13.5.1.4 Boxes and Fittings

The pull boxes, outlet boxes, fittings and covers shall be of mild steel and/or cast iron alloy with adequate strength and have sufficient size to provide free space for all conductors enclosed.

- Pull boxes shall be sufficient size to accommodate the connected conduits and enclosed conductors.
- Boxes and fittings shall be plated by melting zinc or coated with rust-preventive paint and tow or more finish coatings.

- Outlet boxes shall be of galvanized steel, square and of sufficient size to accommodate all the required conductors enclosed in the box.

13.5.1.5 Supporting Steel Materials

The supporting steel materials shall be of hot-dipped galvanized steel with adequate strength for support conduits, cable tray and/or wiring duct.

13.5.1.6 Outdoor Lighting and Pipe Gallery Lighting

The wastewater treatment plant shall be equipped with outdoor lighting, pipe gallery lighting, emergency lighting apparatuses at appropriate areas. The Contractor shall provide all necessary materials and furnish complete lighting systems.

Lighting fixtures to be used shall be of incandescent, fluorescent, and high pressure sodium types as shown on following sub-section (a) and (b).

In the selection of lamps and fittings consideration should be given to ensure the maximum lamp life, the minimize likelihood of internal moisture accumulation, and also effects of vibration, operating temperature, and breathing. The number of makes and types of fittings shall be kept to a minimum for easy maintenance and minimize of spare parts.

(a) Outdoor lighting

Types of outdoor lighting fixture for each area shall be as follows;

Road lightings between bridge and public Road (distances approx. 150m)	:	High way type pole with horizontal type lighting fixture with high pressure sodium lump
Road lightings for plant area and water treatment area	:	Straight type pole with pole head type lighting fixture with high pressure sodium lump
Compost area and jetty cargo loading area	:	Flood light lighting fixture with high pressure sodium lump

The outdoor type lighting fixtures shall be equipped with screwed base lamp holders, and shall be of high power factor suitable for stable operation in tropical climate and weatherproof type. The lamp shall be of high pressure sodium type and approximately 360 W rating.

Lighting supports for outdoor lighting shall be of base plate type steel poles painted with suitable colour. Ballast, cut out switch and terminals shall be equipped in the pole and other attachments necessary for wiring and fixing of the lighting fixtures shall also be provided with the pole.

The Contractor shall provide suitable outdoor lighting switch box for lighting systems. The lighting switch box shall be of indoor use, metal enclosed wall mounted type and switching operated by manual at guard room. The Contractor shall be provided enough capacity of branch circuit breakers for high pressure sodium lights to avoid tripped by increase of starting current.

600 volt PVC insulated wires of 3.5sq.mm in size shall be laid in the lighting pole for connection from the lighting switch box to the lighting fixtures.

(b) Pipe gallery lighting

The pipe gallery lighting system shall consist of fluorescent lightings for normal lightings, emergency lightings, exit sign lightings and lighting distribution board.

The fluorescent lighting fixtures shall be moisture-proof type with protection guard. The lamp shall be rapid star type, and approximately 20 W rating..

Emergency lighting for pipe gallery shall be approximate 20 percent of the lighting fixtures to enable safe access and egress by personnel, monitoring of equipment, instruments and switching operation.

Exit sign lights shall be furnished at exit doors in the pipe gallery.

The emergency lighting fixtures and exit sign lights shall be provided with self-contained battery backup for 30 min to obtain the minimum illumination for operator movement.

The Contractor shall provide suitable lighting distribution board and switch box for pipe gallery lighting system.

The lighting distribution board shall be indoor use, metal enclosed wall mounted type, three phase four wire 380/220V or single phase two wire. Each lighting circuit shall be connected to phase and neutral with miniature circuit breakers. Single phase branch circuits shall be provided with earth leakage breakers.

All convenience outlet circuits shall be provided with earth leakage breaker installed in the lighting distribution board.

Power supply to the lighting distribution boards shall be supplied from individual MCCB units in low voltage distribution switchgear at each control rooms.

Minimum two nos. of spare circuits shall be provided in the initial design for each lighting distribution board. Loads connected to each branch circuit shall not exceed 80% of the branch breaker rating.

Cables for external branch circuits shall be PVC insulated, steel wire armoured and PVC sheathed type of 2 core (1P+1N), 3 core (1P+1N+1PE) or 5 core (3P+1N+1PE).

Minimum size of conductor in lighting circuit shall be 2.5sqmm.

13.5.1.7 Miscellaneous Materials

(a) Lightning protection rod

The Contractor shall be provided tow (2) sets of lightning protection rods on the dewatering building with earthing conductor, grounding rods and plate.

(b) Socket outlet and Plug

The socket outlets or receptacle boxes shall be provided in the plant as follows;

- Convenience (lighting) socket outlet : 220V, 2P+PE
- Convenience (3 phase) socket outlet : 380V, 3P+PE
- Welding outlet : 380/220V, 3P+N+PE

Socket outlet and receptacle plugs operating at different voltage levels must not be interchangeable.

Convenience socket outlets (for lighting and three phase outlets) in the outdoor areas shall be provided in the local motor control panels.

Convenience socket outlets (for lighting and three phase outlets) and welding outlet in the pipe gallery shall be provided in every 50 m distances.

Power supply for any socket outlet circuits shall be of earth leakage protected moulded case circuit breakers.

Installation height of socket outlets in pipe gallery shall be in generally 300mm above form floor level.

(c) Others

All other miscellaneous materials necessary for completion of the work shall be supplied and installed by the Contractor's responsibility.

13.5.2 Installation Works

13.5.2.1 General

Installation and erection works for electrical equipment shall be carried out in compliance with the related laws and regulations of the Vietnam, as in addition to the Specifications.

(a) Work schedule

The Contractor shall prepare the work schedule and submit to the Engineer for information. The said work schedule shall be carefully worked-out for each system, in such detail that the timetable for design, manufacture, transportation, testing, labours and supervisor arrangement and so on can be easily understood.

(b) Materials and workmanship

All materials to be used for the work should be new and free from defects and imperfections. The materials to be used shall be accurately furnished, and in accordance with the highest current technical standards. All parts as well as spare parts shall be perfectly interchangeable.

(c) Storage of equipment and materials

The Contractor shall provide a waterproof space for storage of all necessary cases, boxes, etc., containing delicate components, small items as bolts, screws, etc. All materials, intended for outdoor installation such as cables, earth-wires, outdoor equipment, etc., may be stored in a protected uncovered storage space.

(d) Erection and testing equipment

All necessary equipment and tools shall be provided for unloading, storing, unpacking, moving, erecting, setting, securing and connecting all materials to be used for the construction by the Contractor.

Measuring and testing instruments shall also be provided for the construction by the Contractor.

(e) Accident prevention

All personnel engaged in the construction works shall be provided with appropriate protective clothes, helmets, rubber boots, welding glasses and masks, etc.

Persons working at heights exceeding 2 m above the ground level shall be equipped with approved safety belts.

(f) Necessary design and calculation

The Contractor shall furnish a complete design of electrical equipment, equipment positioning and wiring route etc. The design works shall include, but not be limited to, technical calculations, preparation of drawings and specifying materials and/or equipment not specified in the Specifications but necessary for the completion of the Works.

The Contractor shall calculate and examine the electrical system conditions and shall design the protective relaying system, relay settings and cable size.

13.5.2.2 Installation of Electrical Equipment

The assembly of power transformers, switchgears, panels, motor starter panels, motor control centres and instrumentation panels etc., shall be carried out under the supervision of the Contractor's erection supervisor in accordance with the approved Contractor's drawings and erection manuals..

The equipment and panels to be installed on a concrete foundation shall be securely set after completion of hardening of concrete, and the surface of the concrete foundation shall be finished by mortar.

The equipment and panels to be installed on the outdoor ground, the surface of the foundation shall be not less than 200 mm above the ground level.

If the equipment base-plates would show errors which would result in verticality errors for the equipment, the Contractor shall place suitable spaces between base-plates and supporting structures to restore verticality.

To fasten the equipment to its supporting structure, galvanized steel bolts or other equivalent materials shall be used.

The Contractor shall check that all the equipment shall operate without any vibration.

At the end of erection works and after the final checking of connections, the Contractor shall clean all porcelains, conducting parts, moving parts, inside and outside of equipment in order to remove all dirt.

13.5.2.3 Laying and Termination of Cables

Power, control and instrumentation cables shall be installed in wiring ducts, cable trays and conduits.

Cables pulled through conduits or trenches shall be supported in an acceptable manner to the Engineer so as to avoid damage to the insulation. Grease or oily substances shall not be used to facilitate the passage of the cables in conduits.

The cables shall be laid in an orderly and neat manner in cable ducts or trenches.

Cable splices in the trench, conduits or elsewhere between equipment terminals or connection terminals shall be not permitted.

The cable insulating jackets shall be cut and removed at the ends to allow neat and secure terminations. The insulation of each core shall be cut back to allow terminating without leaving any exposed bare cables. Before terminating, each core wire of control and instrument cables shall be identified with core mark number tube.

The shield tape of 600 V CVV-S cables shall be grounded at both ends.

Connection of each terminals shall be done with solderless terminals and terminals for high-voltage cable termination and low voltage termination section area over 325 sq.mm shall be done with compression terminals.

The 600V power cables section area over 38 sq.mm shall be use cable termination.

Each core wire of power cables shall be identified with colour index.

Incoming cables to the panels shall be firmly secured with proper support to avoid excess stress and load on the termination.

The gaps in the cable hole of the panel bases, walls, etc., shall be filled with putty or other materials to prevent entry of moisture, insects and others.

High voltage cables shall be kept away from other cables such as low voltage cables, control cables and instrumentation cables more than 30cm or more.

Special considerations for flexibility shall be taken for conduit pipes and cable trays which pass through the expansion joints of structure.

13.5.2.4 Piping Work

Radius of curvature of conduits shall be over 6 times of inside diameter and bending angle shall not exceed 90 degrees. Bending in one section shall not exceed 4 points and total of bending angle shall not exceed 270 degrees.

Messenger wire of 1.2 mm or more shall be inserted into spare pipes.

When one section of conduit length exceed 30 m, pull box(es) shall be provided each 30 m span.

Conduits and boxes shall be fitted securely to structures. Fittings of conduits to a place without access for inspection shall not be permitted.

The conduit connectors and couplings shall be screwed type.

All conduits and boxes shall be connected to earthing conductor and all connection point of each conduits shall also be connected with earthing bonded wire or earthing clamp each other.

13.5.2.5 Wiring Duct and Cable Tray Works

The wiring ducts shall be arranged to protect with dust and moisture infiltration.

Horizontal and vertical support span for wiring duct shall be as follows;

Width of duct	Maximum distances between supports
Below 300 mm	2400 mm
300 – 600 mm	2000 mm
Over 600 mm	1800 mm

For cable branching outlet from duct, flexible conduit or metal conduit shall be used to protect cable.

Horizontal support span for cable tray shall be maximum 2 m, and vertical support span shall be maximum 3 m.

Metal fittings for cable tray supports shall be of galvanized steel with adequate strength, and rigidly constructed against swings.

The wiring ducts shall be connected to earthing conductor and all connection point of each ducts shall also be connected with earthing bonded wire or earthing clamp each other.

13.5.2.6 Cable Work in Cable Pit

Cable laying works into the cable pit, the Contractor shall arrange suitable cable separator and supports in the cable pit to separate cable route between power cables and control, instrumentation cables.

13.5.2.7 Underground Cable Laying Work

The Contractor shall responsible for identifying the underground structures and obstacles prior to excavation and shall take necessary measures to avoid damage.

The Contractor shall provide cable buried marker on the ground and underground hazard tape on the buried cable to indicate the buried conduits or cables.

13.5.3 Earthing system

(a) General

The Contractor shall furnish and install a complete grounding systems as shown on the Drawings and specified hereinafter.

The exposed metal frames of all electrical apparatus and machinery not forming parts of the electric circuits, neutral of transformers, etc., shall be grounded.

(b) Grounding conductor, plate and rods

The following materials shall be used for grounding systems;

(1) Grounding conductor

Annealed copper stranded conductor.

The Contractor shall be calculated and selected the adequate size of conductors for main mesh, arrester, transformer neutral connection and each equipment grounding conductors.

(2) Grounding plate

90 cm square, 1.5 mm thickness copper plate or equivalent

(3) Grounding rods

16 mm diameter, 3 m length copper clad steel rod with coupling

(4) Connectors

Compression type connectors which shall be able to connect the annealed copper stranded conductors each other, grounding plate and rod.

(c) Grounding works

The necessary soil excavation and backfiring works for grounding conductors and rods shall be executed by the Civil works.

The Contractor shall submit full details and Drawings for grounding system to the Engineer for approval.

The Contractor shall, referring to IEEE Guidance for safety in substation grounding, calculate the ground resistance based on specific ground resistively to be measured by the Contractor on the Site. The Contractor shall be responsible for prepare the above calculated value.

Grounding rods, plate and conductors shall be buried deeper than 0.6 m or more from the ground surface.

The connection between grounding conductor and earthing rod, plate and equipment connection conductor shall be electrically and mechanically rigid.

Grounding systems of the following equipment/systems shall be done by separately from common earthing.

- Lightning protection
- Instruments earthing for instrumentation equipment

The grounding for transformer neutrals and lightning arresters, grounding rod shall be installed in additionally for interconnections with earthing mesh.

Boundary fences shall be earthed by means of grounding rods, separately from the main grounding mesh of the substation.

13.5.4 Other Miscellaneous Works

Other miscellaneous works including installation of identification plates for completion of Works shall be carried out by the Contractor.

13.5.5 Tests

13.5.5.1 Shop Tests

Electrical equipment shall be tested manufacturer's standard test procedure based on requirement of applicable standard.

The type test for electrical equipment shall not be required at shop test.

13.5.5.2 Field Tests

The following tests shall be executed by the Contractor in the presence of the Engineer after completion of the installation of electrical equipment and instrumentation equipment.

Prior to the commencement of the test, the Contractor shall submit the test schedule in a suitable stage.

The test result shall be submitted to the Engineer for approval.

(a) Individual tests

Individual tests shall include following items;

- Visual inspection
- Measuring of insulation resistance for all equipment
- Withstand voltage test of insulation oil
- Circuit continuity test
- Checking of relays
- Polarity test
- Phase rotation test

(b) Test on completion

The completion tests shall include following items;

- Visual inspection
- Measuring of insulation resistance for all equipment
- Checking of relays
- Phase rotation test
- Total sequential test

  Operation test for each equipment
  Interlock sequence test
  Indication test
  Fault alarm test

13.6 SPECIAL REQUIREMENTS FOR EQUIPMENT

Quantities of electrical and instrumentation equipment are listed in the Bill of Quantity. Various dimensions of electrical and instrumentation equipment shown on the Drawings are approximate only. The Contractor shall refer to these dimensions, and proposed for approval the exact size in their design and manufacturing works.

13.6.1 Outdoor 22 kV Substation Equipment (MSUB)

22 kV substation equipment to be installed outdoor as follows;

(1) 22 kV Incoming unit	2 units
(2) Bus tie unit	1 unit
(3) Transformer Primary unit	1 unit
(4) Billing metering unit	1 unit
(5) 15(22)/3.3 kV 5000kVA Transformer	1 unit

22 kV outdoor equipment to be considered for future extension in near future.

13.6.2 Emergency Generator Equipment (GENR)

Emergency generator equipment installed in the generator room is as follows:

(1) 750kVA engine generator	1 set
(2) Generator control panel	1 lot
(3) Fuel tank	1 set
(4) Air compressor with air tank	1 set
(5) Cooling unit (outdoor)	1 set

Emergency generator and generator control panels to be considered for future extension of another 1500kVA engine generator and parallel operation with both generator.

The emergency generator shall be operated manually only without automatic operation.

13.6.3 Electrical room equipment

The electrical equipment installed in each electric rooms is as follows:

(a) Main electric room (ELCR)

(1)	3.3kV Incoming switchgear	1 set
(2)	3.3kV Feeder switchgears	5 sets

(3)	3.3kV Section panel	1 set
(4)	3.3kV Capacitor panels	1 lot
(5)	3.3kV Transformer primary panel	1 set
(6)	3.3kV/380-220V, 750kVA Transformer cubicle	1 set
(7)	Low voltage switchgear	1 set
(8)	AC distribution panel	1 set
(9)	Motor control centre and Ry panels	1 lot
(10)	DC Power Supply System	1 set
(11)	UPS	1 set
(12)	22kV Substation control & protection panel	1 set
(13)	OLTC control panel	1 set
(14)	Pipe gallery lighting distribution board	1 set
(15)	Outdoor lighting lighting distribution board	1 set
(16)	Pipe gallery ventilation fan control board	1 set
(17)	Local station hand set	1 set

(b) Main control room (CCTR)

(1)	Supervisor panels	1 lot
(2)	Instrumentation panels	1 lot
(3)	Data logging system	1 lot
(4)	Interface panels	1 lot
(5)	Bill metering panel	1 lot
(6)	Communication panel	1 set
(7)	Master station telephone set	1 set

(c) Lift pump electric room (LFER)

(1)	3.3kV Transformer primary panel	1 set (Outdoor)
(2)	3.3kV/380-220V, 1500kVA Transformer	1 set (Outdoor)
(3)	Transformer primary and secondary ducts	1 lot (Outdoor)
(4)	Low voltage switchgear	1 set
(5)	AC distribution panel	1 set
(6)	Lift pump starter panels	3 sets
(7)	380V Capacitor panel	1 lot
(8)	Motor control centre and Ry panels	1 lot
(9)	DC Power Supply System	1 set
(10)	Interface panel	1 set
(11)	Lighting distribution board for outdoor lighting	1 set
(12)	Local station hand set	1 set

(d) Wastewater treatment electric room (WTER)

(1)	3.3kV Transformer primary panel	1 set
(2)	3.3kV/380-220V, 750kVA Transformer cubicle	1 set
(3)	Low voltage switchgear	1 set
(4)	AC distribution panel	1 set
(5)	Motor control centre and Ry panels	1 lot
(6)	DC Power Supply System	1 set
(7)	UPS	1 set
(8)	Interface panel	1 set
(9)	Pipe gallery lighting distribution board	1 set
(10)	Outdoor lighting lighting distribution board	1 set
(11)	Local station hand set	1 set

(e) Chlorination electric room (CHER)

(1)	3.3kV Transformer primary panel	1 set
(2)	3.3kV/380-220V, 750kVA Transformer cubicle	1 set
(3)	Low voltage switchgear	1 set
(4)	AC distribution panel	1 set
(5)	Motor control centre and Ry panels	1 lot
(6)	DC Power Supply System	1 set
(7)	UPS	1 set
(8)	Supervisory panel	1 set
(9)	Instrumentation panels	1 lot
(10)	Interface panel	1 set
(11)	Pipe gallery lighting distribution board	1 set
(12)	Outdoor lighting lighting distribution board	1 set
(13)	Local station hand set	1 set

(f) Dewatering electric room (DCER)

(1)	3.3kV Transformer primary panel	1 set
(2)	3.3kV/380-220V, 2500kVA Transformer cubicle	1 set
(3)	Low voltage switchgear	1 set
(4)	AC distribution panel	3 sets
(5)	Motor control centre and Ry panels	1 lot
(6)	DC Power Supply System	1 set
(7)	UPS	1 set
(8)	Supervisory panel	1 set
(9)	Instrumentation panels	1 lot
(10)	Interface panel	1 set
(11)	Pipe gallery lighting distribution board	1 set
(12)	Local station hand set	1 set

(g) Compost electric room (CPER)

(1)	3.3kV Transformer primary panel	1 set
(2)	3.3kV/380-220V, 750kVA Transformer cubicle	1 set
(3)	Low voltage switchgear	1 set
(4)	AC distribution cubicle	1 set
(5)	Motor control centre and Ry panel	1 lot
(6)	DC Power Supply System	1 set
(7)	UPS	1 set
(8)	Supervisory panel	1 set
(9)	Interface panel	1 set
(10)	Outdoor lighting lighting distribution board	1 set
(11)	Local station hand set	1 set

13.6.4 Control Equipment

13.6.4.1 Requirements

The Control Equipment installed in each electric rooms shall have a following functions;

(a) Main control room (CCTR)

Main control room equipment shall be indicated pump operating condition, fault indication and instrument indication for substation, emergency generator, lift pump equipment, water treatment equipment and blower equipment.

Data logging system shall be collected data for all facilities such as substation, emergency generator, lift pump equipment, water treatment equipment, blower equipment, chlorination equipment, dewatering equipment and compost equipment.

(b) Chlorination electric room (CHER)

Chlorination electric room equipment shall be indicated pump operating condition, fault indication and instrument indication for chlorination and water supply equipment.

(c) Dewatering electric room (DCER)

Dewatering electric room equipment shall be indicated pump operating condition, fault indication and instrument indication for dewatering equipment.

(d) Compost electric room (CPER)

Compost electric room equipment shall be indicated pump operating condition, fault indication and instrument indication for compost equipment.

(e) Others

Outdoor lighting switch board and fire alarm board shall be installed in guard house.

13.6.4.2 Local Control Panel

The Quantity and accessories for local control panels shall be as follows;

Notes:

[Meter]	A: Ammeter, L: Level meter, F: Flow meter, W: Weight meter, Z: Positioner
[COS]	Change over switch for center-local, auto-manual, etc.
[CS]	Control switch for start-stop, open-close, etc.
[PBS]	Push button switch for emergency stop, alarm stop, reset, etc.
[Indication]	Operation indication, alarm indication, etc.

Item No.	Name of pump or equipment	Quantity	Meter	COS	CS	PBS	Indication
	< Lift pump equipment >						
LP121	Lift pump	3	A, L	1 lot	1 lot	1 lot	1 lot
LP125	Floor drainage pump	6	A	1 lot	1 lot	1 lot	1 lot

	<Blower equipment>						
LP211	Blower and aux. equipment	2	A, F	1 lot	1 lot	1 lot	1 lot
LP215	Air filter	2	A	1 lot	1 lot	1 lot	1 lot
LP216	Floor drainage pump	1	A	1 lot	1 lot	1 lot	1 lot
	<Water treatment facility> [Primary sedimentation tank]						
LP312	Sludge scraper	10	A	1 lot	1 lot	1 lot	1 lot
LP314	Scum pump	1	A	1 lot	1 lot	1 lot	1 lot
LP315	Raw sludge pump	1	A	1 lot	1 lot	1 lot	1 lot
LP316	Raw sludge valve	10	-	1 lot	1 lot	1 lot	1 lot
	[Aeration tank]						
LP324	Air flow control valve	10	F, Z	-	1 lot	1 lot	1 lot
	[Final sedimentation tank]						
LP332	Sludge scraper	10	A	1 lot	1 lot	1 lot	1 lot
LP334	Scum pump	1	A	1 lot	1 lot	1 lot	1 lot
LP335	Return sludge pump	2	A	1 lot	1 lot	1 lot	1 lot
	[Final sedimentation tank]						
LP337	Return sludge valve	2	-	1 lot	1 lot	1 lot	1 lot
LP338	Excess sludge pump	2	A	1 lot	1 lot	1 lot	1 lot
LP339	Excess sludge valve	2	-	1 lot	1 lot	1 lot	1 lot
LP351	Floor drainage pump	7	A	1 lot	1 lot	1 lot	1 lot
	<Disinfection facility>						
LP414	Sodium hypochlorite pump	1	A, F	1 lot	1 lot	1 lot	1 lot
	<Water supply facility>						
LP512	Treated water supply pump (1)	1	A	1 lot	1 lot	1 lot	1 lot
LP514	Floor drainage pump	4	A	1 lot	1 lot	1 lot	1 lot
LP516	Treated water supply pump (2)	1	A	1 lot	1 lot	1 lot	1 lot
LP521	Filtration supply pump	1	A	1 lot	1 lot	1 lot	1 lot
LP523	Sand filter	2	-	1 lot	-	-	-
LP524	Filtered water supply pump	1	A	1 lot	1 lot	1 lot	1 lot
LP525	Backwash pump	1	A	1 lot	1 lot	1 lot	1 lot
LP526	Air wash blower	1	A	1 lot	1 lot	1 lot	1 lot

LP527	Backwash wastewater pump	1	A	1 lot	1 lot	1 lot	1 lot
	<Sludge treatment facility>						
LP611	Gravity thickener	1	A	-	1 lot	1 lot	1 lot
LP613	Thickened sludge pump	1	A	1 lot	1 lot	1 lot	1 lot
LP614	Thickener effluent pump	1	A	1 lot	1 lot	1 lot	1 lot
LP615	Floor drainage pump	1	A	1 lot	1 lot	1 lot	1 lot
LP621	Excess sludge mixer	1	A	-	1 lot	1 lot	1 lot
LP622	Excess sludge feed pump	1	A	1 lot	1 lot	1 lot	1 lot
LP631	Mixed sludge mixer	1	A	-	1 lot	1 lot	1 lot
LP632	Mixed sludge feed pump	1	A	-	1 lot	1 lot	1 lot
LP634	Cake hopper	2	A, W	-	1 lot	1 lot	1 lot
LP635	Polymer feeder	1	A	1 lot	1 lot	1 lot	1 lot
LP636	Polymer dissolution tank	1	A	1 lot	1 lot	1 lot	1 lot
LP637	Polymer feed pump	1	A	1 lot	1 lot	1 lot	1 lot
LP638	Water supply pump unit	1	A	1 lot	1 lot	1 lot	1 lot
LP639	Air compressor	1	A	1 lot	-	-	1 lot
LP643	Treated water inflow valve	1	-	1 lot	1 lot	1 lot	1 lot
LP651	Recycle flow mixer	1	A	-	1 lot	1 lot	1 lot
LP652	Recycle flow pump	1	A	1 lot	1 lot	1 lot	1 lot
	<Compost facility>						
LP712	Suction fan	2	A	1 lot	1 lot	1 lot	1 lot
LP713	Humidifying pump	2	A	-	1 lot	1 lot	1 lot
LP732	Deodorization fan	2	A	-	1 lot	1 lot	1 lot
LP733	Spray water pump	1	A	-	1 lot	1 lot	1 lot
LP734	Wastewater drainage pump	1	A	-	1 lot	1 lot	1 lot

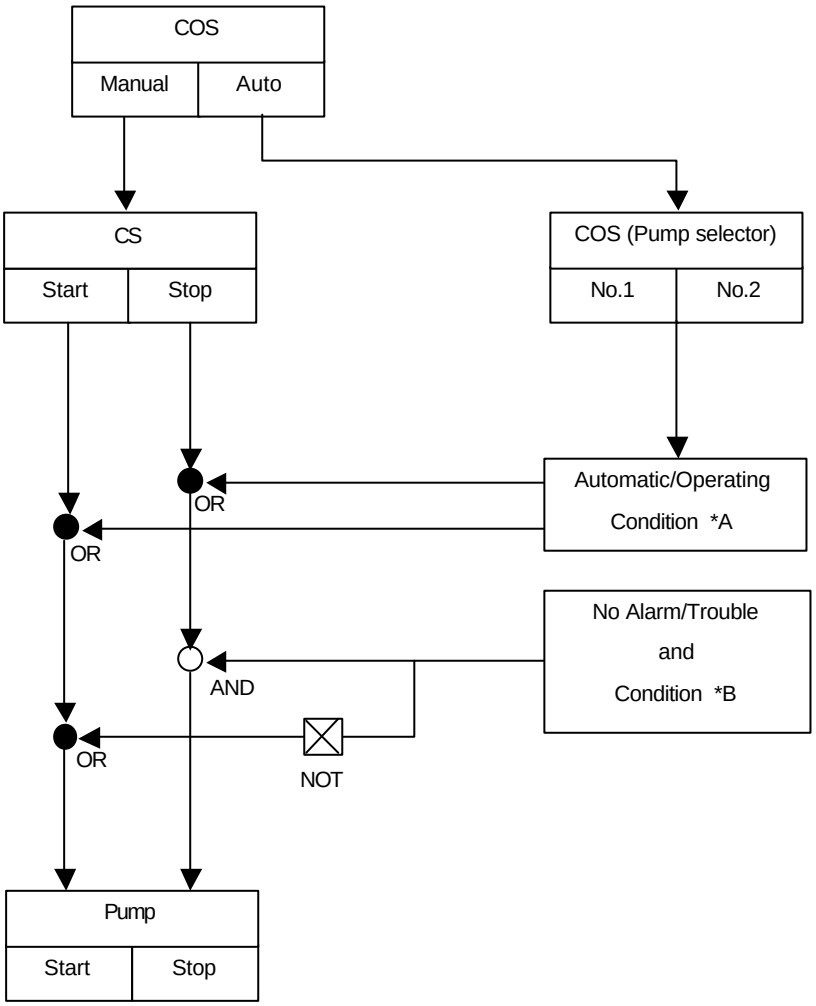
13.6.5 Operation and Control Method for Each Equipment.

13.6.5.1 Operation Flow [Type A]

The operation of the equipment shall be controlled by the local control panel at the each equipment location and operating condition, fault alarm shall be indicated on supervisory panel at the each control room.

Local control panel for the equipment shall be provided "Auto – Manual" COS, "Start – Stop" CS, "Stand-by pump or pump number selector" COS, operation indicator and fault indicator.

The manual and automatic operation of the equipment flow type A shall be as following sequence.



Equipment lists and conditions *A, *B applied to above sequence shall be as follows;

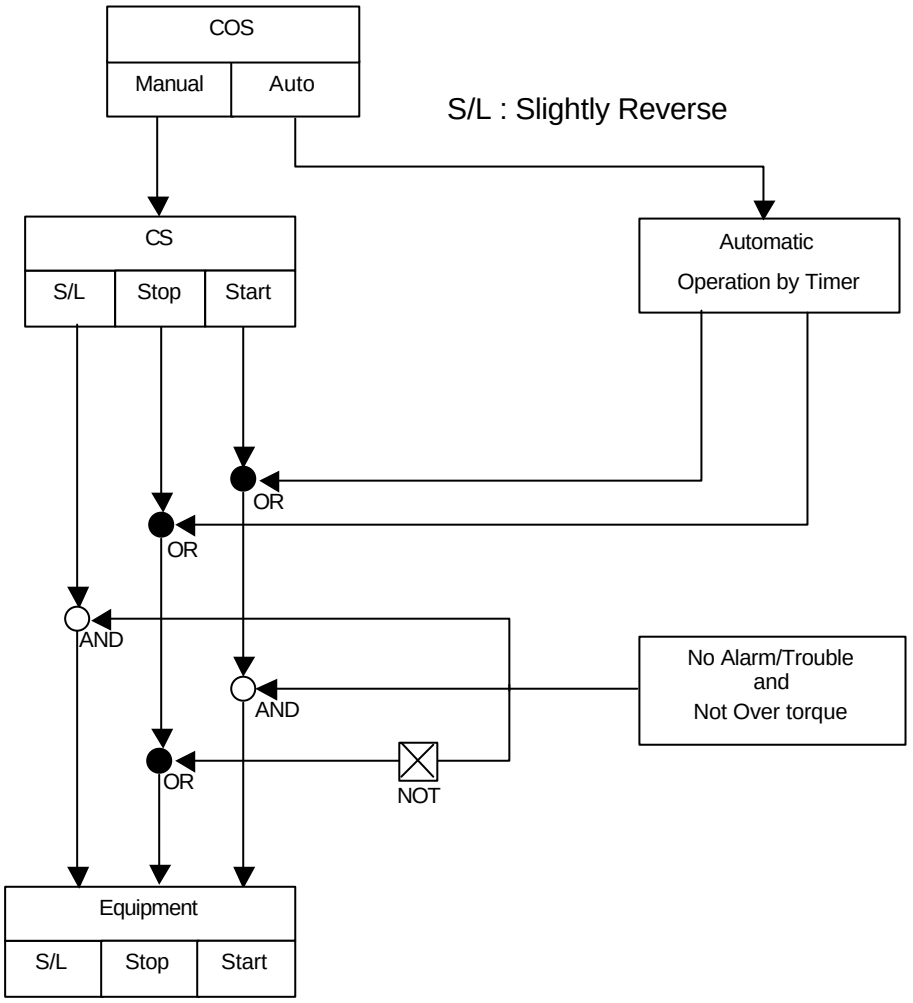
Equipment name	Condition *A	Condition *B
Lift pump facility		
125 Floor drainage pump	LC: Floor water level	Water level Not LL
Blower facility		
216 Floor drainage pump	LC: Floor water level	Water level Not LL
Water treatment facility		
314 Scum pump	LC: Scum pit water level	Water level Not HH
315 Raw sludge pump	24 h timer	-
334 Scum pump	LC: Scum pit water level	Water level Not HH
351 Floor drainage pump	LC: Floor water level	Water level Not LL
Water supply facility		
514 Floor drainage pump	LC: Floor water level	Water level Not LL
512 Treated water supply pump(1)	LIA: Secondary effluent tank water level	-
516 Treated water supply pump(2)	LIA: Secondary effluent tank water level	-
521 Filtration supply pump	Sand filter control unit	Secondary effluent tank Water level Not L
524 Filtered water supply pump	LIA: Sand filter effluent tank water level	-
525 Backwash pump	Sand filter control unit	-
526 Backwash blower	Sand filter control unit	-
527 Backwash waste-water pump	LC: Backwash wastewater tank water level	-
Sludge treatment facility		
613 Thickened sludge pump	24 h timer	-
614 Thickener effluent tank	LC: Thickener effluent tank	-
615 Floor drainage pump	LC: Floor water level	Water level Not LL
652 Recycle flow pump	LC: Recycle flow tank water Level	-
Compost facility		
723 Humidifying pump	LC: Wastewater tank water level	-
745 Floor drainage pump	LC: Floor water level	-
Remarks:	LC mean level control switch	
	LIA mean level indicator instrument	

13.6.5.2 Operation Flow [Type B]

The operation of the equipment shall be controlled by the local control panel at the each equipment location and operating condition, fault alarm shall be indicated on supervisory panel at the each control room.

Local control panel for the equipment shall be provided "Auto – Manual" COS, "Start – Stop – Slightly reverse" CS, operation indicator and fault indicator.

The manual and automatic operation of the equipment flow type B shall be as following sequence.



Equipment operation applied to above sequence shall be as follows;

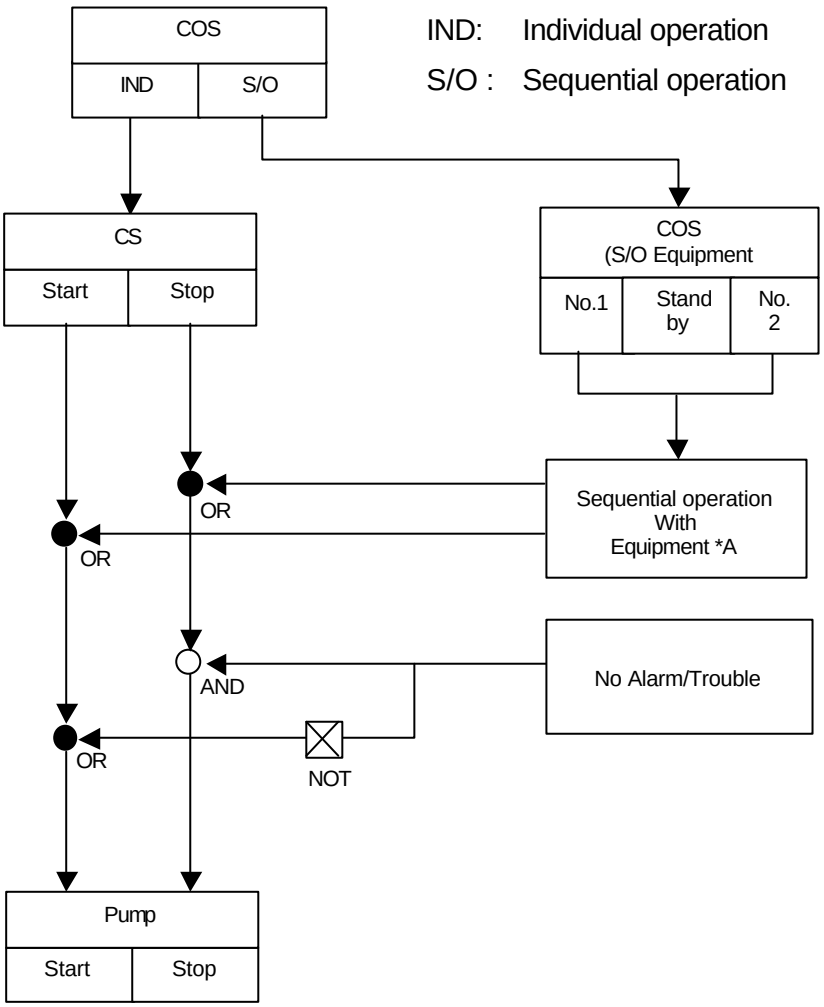
Area name	Equipment name
Water treatment facility	312 Sludge scraper
	332 Sludge scraper

13.6.5.3 Operation Flow [Type C]

The operation of the equipment shall be controlled by the local control panel at the each equipment location and operating condition, fault alarm shall be indicated on supervisory panel at the each control room.

Local control panel for the equipment shall be provided "IND – S/O" COS, "Start – Stop" CS, "Sequential operation equipment number selector" COS, operation indicator and fault indicator.

The manual and automatic operation of the equipment flow type C shall be as following sequence.



Equipment lists and equipment *A applied to above sequence shall be as follows;

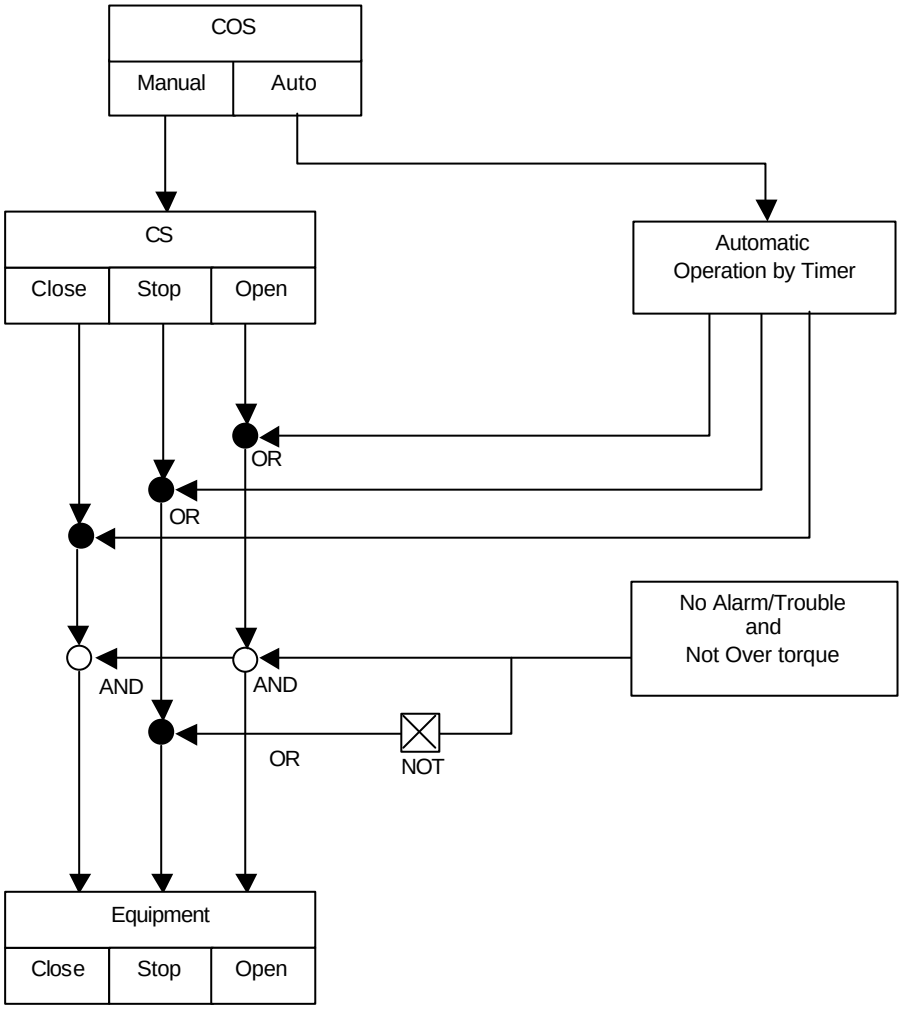
Equipment name	Equipment *A
Sludge treatment facility	
622 Excess sludge feed pump	Selected Centrifugal Thickener
632 Mixed sludge feed pump	Selected Centrifugal Dehydrator
637 Polymer feed pump	Selected Centrifugal Dehydrator

13.6.5.4 Operation Flow [Type D]

The operation of the equipment shall be controlled by the local control panel at the each equipment location and operating condition, fault alarm shall be indicated on supervisory panel at the each control room.

Local control panel for the equipment shall be provided "Auto – Manual" COS, "Close - Stop - Open" CS, operation indicator, fault indicator and Ammeter.

The manual and automatic operation of the equipment flow type D shall be as following sequence.



Equipment operation applied to above sequence shall be as follows;

Area name	Equipment name
Water treatment facility	316 Raw sludge valve
	337 Return sludge valve
	339 Excess sludge valve

13.6.5.5 Operation Flow [Type E]

The operation of the equipment shall be controlled by the local control panel at the each equipment location.

Local control panel for the equipment shall be provided necessary control switch such as “Start - Stop” CS, “Start – Stop - Reverse” CS, “Open – Stop - Close” CS and “1st Start – Stand-by – 2nd Start” CS, operation indicator, fault indicator, etc.

Equipment operation applied to above sequence shall be as follows;

Area name	Equipment name
Water supply facility	528 Air compressor
Sludge treatment facility	611 Gravity thickener
	621 Excess Sludge mixer
	631 Mixed sludge mixer
	634 Cake hopper
	639 Air compressor
	651 Recycle flow mixer
	662 Deodorization fan
Compost facility	742 Deodorization fan
	744 Spray water pump

13.6.5.6 Operation Flow [Type F]

The operation of the equipment shall be controlled by the each equipment control box supplied by mechanical works. The Contractor shall be installed switch box or terminal box at the each equipment location for power supply and provided necessary control and instrumentation cables for machine control.

Equipment operation applied to above sequence shall be as follows;

Area name	Equipment name
Lift pump facility	124 Hoist
Blower facility	217 Crane
Water treatment facility	317 Comminuter
	340 Comminuter
Water supply facility	513 Treated water strainer (1)
	517 Treated water strainer (2)
	522 Filtration supply strainer
	523 Sand filter
	529 Dehumidifier
Sludge treatment facility	623 Centrifugal thickener
	633 Centrifugal dehydrator
	624 Crane
	635 Polymer feeder
	636 Polymer dissolution tank
	638 Water supply pump unit
	640 Dehumidifier
	641 Crane
Compost facility	711 Mixing machine
	712 Suction fan

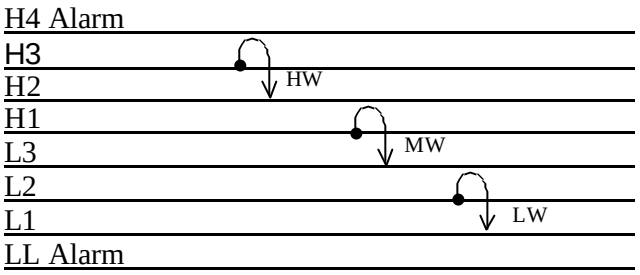
13.6.5.7 Operation Flow for Special Equipment

(a) 121 Lift pump

Three (3) sets of lift pumps (including one (1) stand-by) shall be installed under the mechanical works.

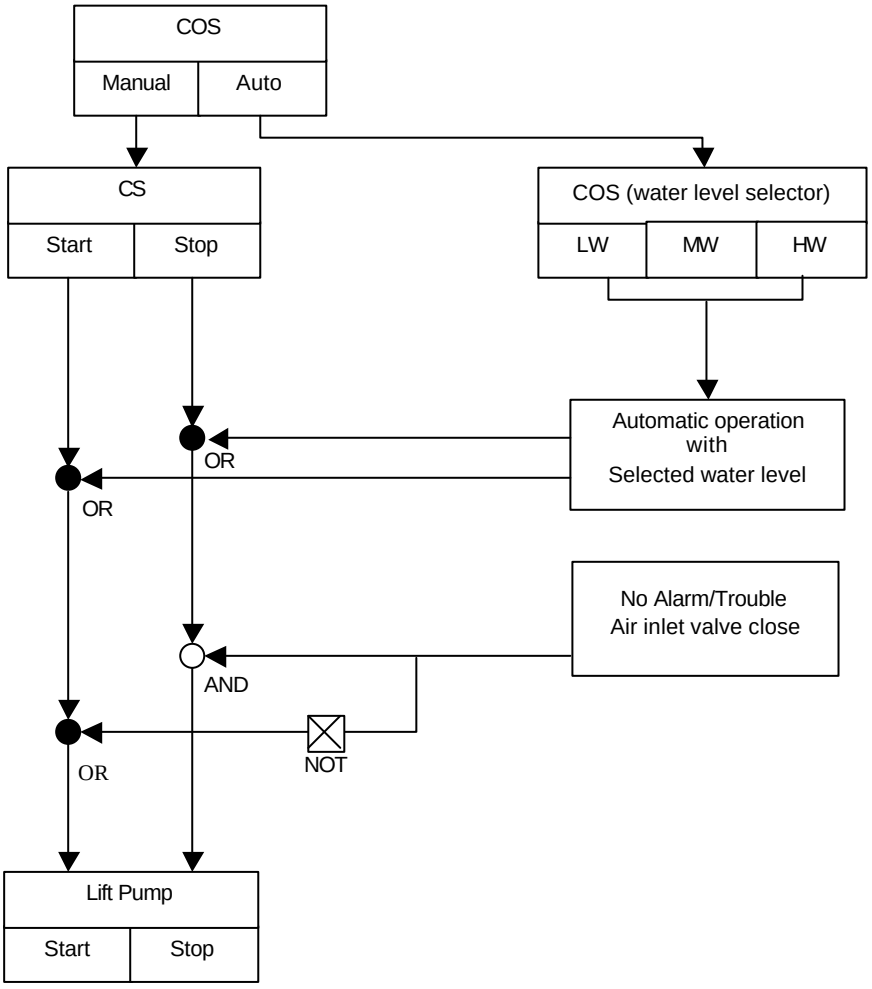
The operation of the lift pumps shall be controlled by the local control panel at the pump well, and operating condition, fault alarm shall be indicated on pump starter panel at the lift pump electrical room and supervisory panel at the main control room.

These pumps shall be automatically operated by the following water level measured by level meter at the pump well.



Pump well water level

The manual and automatic operation of the lift pumps shall be following sequence:



The pump shall be start with time lag to minimise the load for starting transformer and the voltage drop, and pump start sequence shall be related with close signal of the air break valve provided on siphon pipe.

The pump shall be operated cyclic operation between three pumps to secure cooling time lag for starting transformer.

(b) 211 Blower

Two (2) sets of blowers shall be installed under the mechanical works.

The operation of the blower shall be controlled by the blower control panel at the blower building, and operating condition, fault alarms shall be indicated on blower control panel and supervisory panel at the main control room.

The manual and automatic operation of the blowers shall be depend on mechanical operation flow, and following equipment operation shall be related with blower operation.

- Cooling water valve
- Air outlet valve
- Air inlet valve
- Auxiliary hydraulic pump
- Discharge valve
- Air filter

(c) 324 Air flow control valve

The Air flow control valve shall be controlled by the local control panel at the aeration tank pipe gallery, and operating conditions, fault alarms shall be indicated on local control panel and supervisory panel at the main control room.

Local control panel for the air flow control valve shall be provided “Close - Stop - Open” CS, operation indicators, fault indicators and valve opening positioner.

(d) 335 Return sludge pump

The Return sludge pump(s) shall be controlled by the local control panel at the final sedimentation pipe gallery, and operating conditions, fault alarms shall be indicated on local control panel and supervisory panel at the main control room.

Local control panel for the Return sludge pump(s) shall be provided “Auto - Manual” COS, “Start - Stop” CS, “No.1 pump - No.2 pump - parallel operation pump selector” COS, Ammeter, operation indicators and fault indicators.

The manual and automatic operation of the Return sludge pump(s) shall be same as operation flow A sequence, and automatic operating condition shall be of timer control.

(e) 338 Excess sludge pump

The Excess sludge pump(s) shall be controlled by the local control panel at the final sedimentation pipe gallery, and operating conditions, fault alarms shall be indicated on local control panel and supervisory panel at the main control room.

Local control panel for the excess sludge pump(s) shall be provided “Auto - Manual” COS, “Start - Stop” CS, “No.1 pump - No.2 pump operation selector” COS, Ammeter, operation indicators and fault indicators.

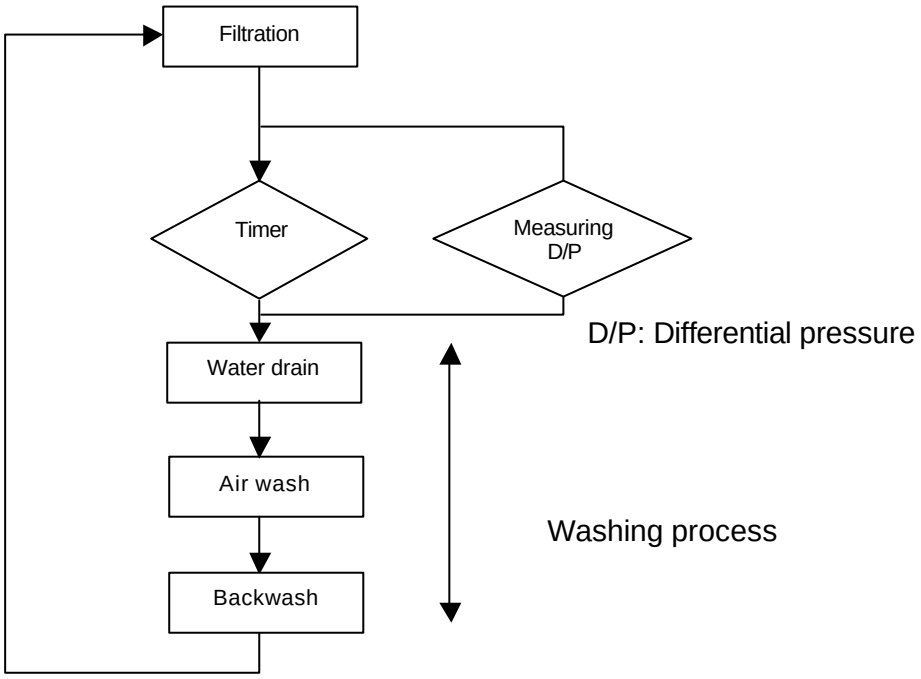
The manual and automatic operation of the excess sludge pump(s) shall be same as operation flow A sequence, and automatic operating condition shall be of timer control and sequential operation with other excess sludge pump train to be supplied future.

(f) 523 Sand filter

The sand filter shall be controlled by the filter control at the Chlorination building, and operating conditions, fault alarms shall be indicated on filter control panel and supervisory panel at the Chlorination electrical room.

Filter control panel for the sand filter shall be provided necessary control switches for solenoid valve, Ammeter, operation indicators and fault indicators.

Operation flow for the sand filter as follows;



Following equipment operation shall be related with sand filter operation.

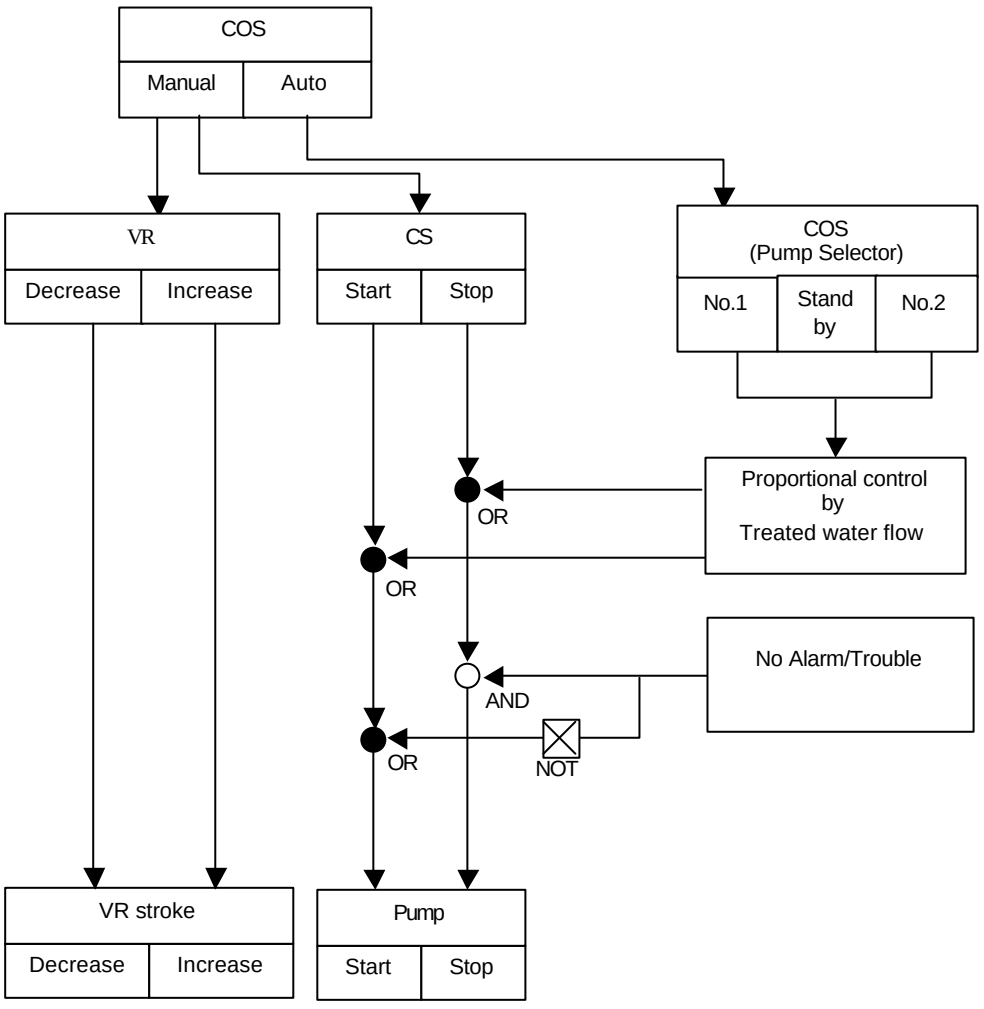
521 Filtration supply pump	(Water supply for filtration water)
527 Backwash pump	(Water supply for backwash water)
526 Air wash blower	(Air supply for air wash air)
528 Air compressor	(Air supply for valve control)
529 Dehumidifier	(Dehumidify compressed air)

(g) 414 Sodium hypochlorite pump

The Sodium hypochlorite pump(s) shall be controlled by the local control panel at the chlorination building, and operating conditions, fault alarms shall be indicated on the local control panel and supervisory panel at the chlorination electrical room.

Local control panel for the sodium hypochlorite pump(s) shall be provided “Auto - Manual” COS, “Sodium hypochlorite volume controller”, “Start - Stop” CS, Sodium hypochlorite level (H&L), Ammeter, operation indicators and fault indicators, and volume control equipment shall be supplied by the mechanical Contractor.

The manual and automatic operations of the sodium hypochlorite pump(s) shall be following sequence:

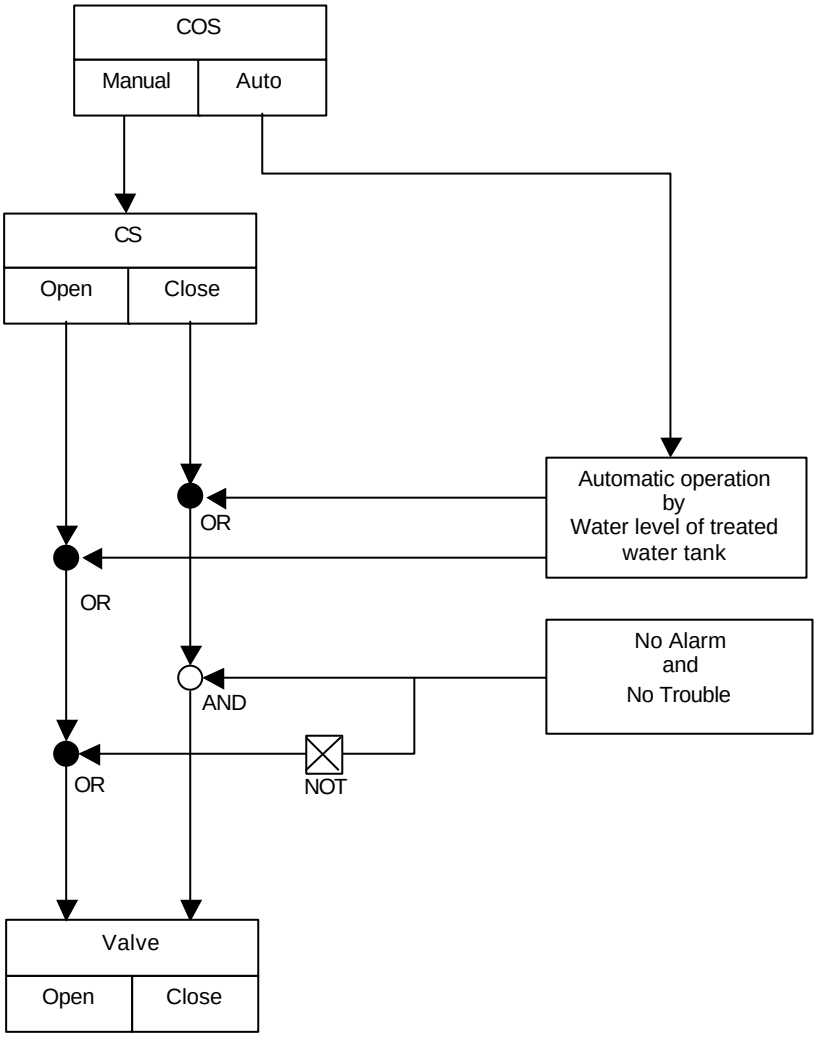


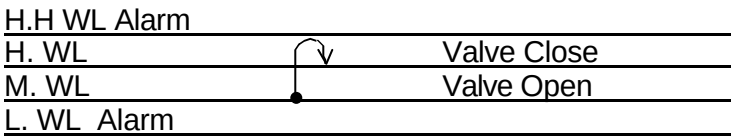
(h) 643 Treated water inflow valve

The treated water inflow valve shall be controlled by the local control panel at the sludge treatment building, and operating conditions, fault alarms shall be indicated on local control panel and supervisory panel at the Dewatering electrical room.

Local control panel for the treated water inflow valve shall be provided “Auto - Manual” COS, “Open - Close” CS, operation indicators and fault indicators.

The manual and automatic operations of the Return sludge pump(s) shall be as following sequence;





Treated water tank water level

13.6.6 Tools and Equipment for Plant

The Contractor shall furnish the tools and maintenance equipment for the wastewater treatment plant as listed below.

These tools may be used for the construction and test by the Contractor, in such case they shall be returned in good condition after use by the Contractor, who shall be responsible for their safe keeping.

(1) Portable pH meter — 2 sets

Power supply	:	Dry cell batteries
Measuring range	:	0 to 14 pH
Accessory	:	Carrying case

(2) Portable DO meter — 2 sets

Power supply	:	Dry cell batteries
Measuring range	:	0 to 19.99 mg/little, 0 to 199 %
Accessory	:	Carrying case

(3) Portable MLSS meter — 2 sets

Type	:	Permeability type
Power supply	:	Single phase AC 220 V, 50 Hz
Measuring range	:	0 to 10,000 mg/little
Accessory	:	Carrying case
		Spare fuse

(4) Portable turbidity meter — 2 sets

Power supply	:	Dry cell batteries or single phase AC 220 V
Measuring range	:	0 to 1,000 NTU
Accessory	:	Carrying case
		Necessary chemical required

(5) Portable oil tester — 1 set

Capacity	:	500VA (for 30 min)
Power supply	:	Single phase AC 220 V, 50 Hz
Output voltage	:	0 to 60 kV
Accessories	:	Power supply cable
		Interconnection cable between controller and step-up transformer
		Earth cable
		Oil cup
		Spare fuse

(6) Voltage detector 23 kV — 1 set

Detecting rated voltage:		AC 3 kV to 23 kV
Indication	:	Light and sound signals
Power supply	:	Dry cell batteries
Accessory	:	Carrying case

(7) Voltage detector 600 V — 2 sets

Detecting rated voltage:		AC 100 V to 600 V
Indication	:	Light and sound signals
Power supply	:	Dry cell batteries
Accessory	:	Carrying case

(8) Portable three phase relay test set 1 set

Power supply	:	Single phase AC 220 V, 50 Hz
Ratings	:	Current output 0 to 50 A
		Voltage output 0 to 750 V
Availability for relay	:	Current relay
		Voltage relay
		Differential relay
		Time limit relay
		Auxiliary relay
Accessories	:	Test clamps and cables

(9) Portable phase angle indicator 1 set

Power supply	:	Three phase AC 380 V, 50 Hz
Ratings	:	Current 0.5 A
		Voltage 0 to 240 V
		Phase angle 0 to 360 degree
Accessories	:	Measurement leads

(10) Portable earth tester 1 set

Power supply	:	Dry cell batteries
Measuring range	:	Earth resistance 0 to 1000 ohm
		Earth voltage 0 to 30 V, AC
Accessories	:	Test clamps and cables
		Carrying case

(11) Insulation tester 5000V/1000M-ohm 1 set

Power supply	:	Dry cell batteries
Testing voltage	:	5000 V / 10000 M-ohm
Measuring range	:	1 to 10000 M-ohm
Accessories	:	Test probes
		Carrying case

(12) Insulation tester 1000V/2000M-ohm 3 sets

Power supply	:	Dry cell batteries
Testing voltage	:	1000 V / 2000 M-ohm
Measuring range	:	2 to 2000 M-ohm
Accessories	:	Test leads
		Carrying case

(13) Insulation tester 500V/1000M-ohm 3 sets

Power supply	:	Dry cell batteries
Testing voltage	:	500 V / 1000 M-ohm
Measuring range	:	0.5 to 1000 M-ohm
Accessories	:	Test leads
		Carrying case

(14) Insulation tester 500V/100M-ohm 3 sets

Power supply	:	Dry cell batteries
Testing voltage	:	500 V / 100 M-ohm
Measuring range	:	0.05 to 100 M-ohm
Accessories	:	Test leads
		Carrying case

(15) Digital multimeter DC/AC/Ohm — 3 sets

Power supply	:	Dry cell batteries
Measuring range	:	
DC voltage		200 mV to 1000V
AC voltage		200mV to 1000V
Resistance		200 ohm to 40M-ohm
DC current		200µA to 10A
AC current		200µA to 10A
Accessories	:	Test leads
		Carrying case

(16) Digital power tester — 1 set

Power supply	:	Single phase AC 220 V, 50 Hz
Measuring range	:	
AC/DC voltage		15V to 600V
AC/DC current		500mA to 20A
Watt		7.5W to 12kW
Frequency		50Hz to 500Hz
Accessories	:	Power supply cable
		Earthing adapter

(17) Universal circuit tester — 5 sets

Power supply	:	Dry cell batteries
Measuring range	:	
DC voltage		400mV to 1000V
AC voltage		400mV to 1000V
Resistance		400 to 40M-ohm
DC current		400µA to 10A
AC current		400µA to 10A
Accessories	:	Test leads
		Carrying case

(18) Clamp on tester — 5 sets

Power supply	:	Dry cell batteries
Measuring range	:	
AC current		30A to 1000V
AC voltage		600V
Accessories	:	Test leads
		Carrying case

(19) DC signal generator — 2 set

Power supply	:	Dry cell batteries
Output range	:	
DC current		0A to 25mA
DC voltage		0V to 25V
Measurement range	:	
DC current		0A to 25mA
DC voltage		0V to 25V
Accessories	:	Test leads
		Carrying case

(20) Lux meter 1 set

Power supply	:	Solar cell batteries
Measurement range	:	0 to 3000 lx
Accessories	:	Carrying case

(21) Capacitance tester 1 set

Power supply	:	Solar cell batteries
Measurement range	:	300pF to 1000 F
Accessories	:	Test leads
		Carrying case

(22) Phase rotation mater 3 sets

Voltage range	:	110 to 480V
Accessories	:	Carrying case

(23) Portable AC V-A meter 3 sets

Measurement range	:	13 range
Voltage		30/75/150/300/750V
Current		0.15/0.3/0.75/1.5/3.0/7.5/15/30A
Accessories	:	Carrying case

(24) Portable DC V-A meter 3 sets

Measurement range	:	17 range
Voltage		3/10/30/100/300/1000V
Current		1/3/10/30/100/300mA /1/3/10/30A
Accessories	:	Carrying case

(25) Circuit tester 5 sets

Power supply	:	Dry cell batteries
Measuring range	:	
DC voltage		6V to 600V
AC voltage		6V to 600V
Resistance		10 to 1M-ohm
Accessories	:	Test leads
		Carrying case

(26) Hydraulic compression terminal machine 1 set

Type	:	Electric operation type
Power supply	:	Single phase AC 220 V, 50 Hz
Compression capacity	:	30 ton
Accessories	:	Dies (each cable size)
		Hydraulic oil hose

(27) Hydraulic terminal pliers 1 set

Type	:	Hand operation type
Applicable range	:	14 to 100 sq.mm
Accessories	:	Dies (14 to 100 sq.mm)
		Steel case

(28) Portable earthing tool set 24 kV — 1 set

Type	:	Fixing type disconnecting hook rod
Phase	:	3 phase
Applicable rated voltage:		24 kV
Accessories	:	Carrying case

(29) Jack type drum stand — 1 set

Lifting capacity	:	6 ton
Stroke	:	450 mm

(30) Hand press terminal pliers — 3 sets

Type	:	Ratchet type
Applicable range	:	1.25 to 8 sq.mm

(31) Torque wrench 600 – 2800 kg — 1 set

Type	:	Ratchet type
Adjustable torque	:	600 to 2800 kg
Accuracy	:	+/- 3%

(32) Chain hoist 1.5 ton — 2 sets

Rated load	:	1500kg
Lifting height	:	2.5 m

(33) Safety rubber gloves — 3 sets

Rated voltage	:	Less than 7 kV
Tested voltage	:	20 kV, 1 min
Size	:	Medium

(34) Safety rubber boots — 3 sets

Rated voltage	:	Less than 7 kV
Tested voltage	:	20 kV, 1 min
Size	:	27 cm

(35) Rubber sheet — 3 sets

Rated voltage	:	Less than 7 kV
Tested voltage	:	20 kV, 1 min
Size	:	L 1.0 m x W 1.0 m x t 6 mm

(36) Hand tool box set — 2 sets

Type	:	General hand tools including as follows; Screw drivers set, open end wrench set, pliers sets, hammer cutter knife, cable stripper, adjustable wrench, etc.

(37) Extension Ladder — 2 sets

Type	:	Slide expansion type
Material	:	Aluminium
Maximum length	:	10 m
Width	:	30 cm

13.7 SPARE PARTS

The Contractor shall be furnished the spare parts for 2 years operation to be required for wastewater treatment plant maintenance as listed below.

(a) 22kV Substation

(1) 22kV C-GIS

SF6 Gas with cylinder (47 litter type cylinder)	3 pcs
Each type of motor for operating mechanism	1 pc
Gas detective meter	1 pc
Closing coil for CB	3 pcs
Tripping coil for CB	3 pcs
Auxiliary switch for each type	1 pc
Auxiliary relay for each type	1 pc
Lightning arrester	1 pc
Converter for Voltage detector	1 pc
Control switch for each type	1 pc
Selector switch for each type	1 pc
Lamp (LED) for each indication	100 %
Fuse for each type	300 %
Fluorescent lamp	100 %

(2) 22kV/3.3kV 5000kVA Transformer

Primary bushing	1 pc
Secondary bushing	1 pc
Bushing CT for each type	1 pc
Oil temperature indicator	1 pc
Oil level indicator	1 pc
Silica gel container for each type	1 pc
Silica gel	200 %

(3) Control and protection panel / OLTC control panel

Meter for each type	1 pc
Tap position indicator	1 pc
Fault indicator for each type	1 pc
Control switch for each type	1 pc
Selector switch for each type	1 pc
Test terminal for each type	1 pc
Protective relay for each type	1 pc
Time relay for each type	1 pc
Auxiliary relay for each type	1 pc
Lamp (LED) for each indication	100 %
Fuse for each type	300 %
Fluorescent lamp	100 %

(b) Emergency generator

Recommended spare parts for 2 years operation.	1 lot

(c) Electrical equipment for plant

(1) Switchgears, Pump Starter Panels, Motor control centre and Ry panels

Fixed and moving contact of CB for each type	1 pc
Closing coil for CB	1 pc
Tripping coil for CB	1 pc
Meter for each type	1 pc
Fault indicator for each type	1 pc
Control switch for each type	1 pc
Selector switch for each type	1 pc
Test terminal for each type	1 pc
Protective relay for each type	1 pc
Time relay for each type	1 pc
Auxiliary relay for each type	1 pc
MCCB for each capacity	1 pc
Static capacitor	1 pc
Series reactor	1 pc
Magnetic contactor for each type	1 pc
Low voltage contactor for each type	1 pc
Instrumentation transformer for each type	1 pc
Lamp (LED) for each indication	100 %
Fuse for each type	300 %
Fluorescent lamp	100 %

(2) Battery and battery charger

Lamp (LED) for each indication	100 %
Fuse for each type	300 %
D/D converter (110V/24V)	1 pc
Fluorescent lamp	100 %

(3) Supervisory panels and Instrumentation panels

Level indication meter for each type	1 pc
Isolator for each type	1 pc
Arrester for each type	1 pc
Distributor for each type	1 pc
Meter for each type	1 pc
Fault indicator for each type	1 pc
Control switch for each type	1 pc
Selector switch for each type	1 pc
Test terminal for each type	1 pc
Auxiliary relay for each type	3 pc
MCCB for each capacity	1 pc
Lamp (LED) for each indication	100 %
Fuse for each type	300 %
Fluorescent lamp	100 %

(4) Outdoor and Pipe gallery lighting

Lamp	100 %
Ballast	100 %

(5) Others

Recommended spare parts for 2 years operation.	1 lot

13.8 TRANSMISSION LINE

13.8.1 General

This section covers the requirements for construction of the 22kV transmission line works for power supply for Wastewater Treatment Plant (WWTP) to be carried out by the Power company.

Payment for this work shall be made by the Contractor, who in turn shall be paid from the provisional sums in the Contract.

13.8.1.1 Basics Requirements

In operating, WWTP will get wastewater from Intermediate Wastewater Pumping Station (IWPS), Project Management Unit for water environment improvement Ho Chi Minh City (PMU) proposed Power Company of Ho Chi Minh City on agreeing to supply power to project including substation of WWTP.

The capacity of WWTP substation is as follows :

- Phase-1 : 1x5000kVA - 15(22)/3.3kV transformers
- Phase-2 : 2x5000kVA - 15(22)/3.3kV transformers

13.8.1.2 Power supply alternative

Based on the project and WWTP characteristic, substation will receive power from two sources :

Source 1 : From 110kV Phu Dinh substation 15 (22) kV line
(see drawing No. PE-WWTP-501-1, 501-2).

Source 2 : From 110kV Chanh Hung substation through Intermediate Wastewater Pumping Station (IWPS)
(see drawing No. PE-WWTP-501-1, 501-2).

13.8.1.3 Scope of works

Underground cable line

From Phu Dinh substation to WWTP

XLPE 24kV-2circuit (240 sq.mm –3core) : 4,375 m

13.8.2 Specification

(a) Over-voltage protection equipment

Using LA with the following parameter :

		For 15kV	For 22kV
- System voltage	:	15kV	22kV
- Frequency	:	50Hz	50Hz
- Rated voltage	:	12kV	18kV
- BIL pulse (pulse wave 1,2/5μs)	:	110kV	110kV
- Rated discharge current	:	10kA	10kA

- Max. 0.5μs discharge voltage
  (10kA impulse) : 35kV 35kV
- Max. switching surge protective level
  (500A surge of 45μs time to crest) : 23,5kV 23,5kV
- Rated power frequency withstand voltage
  Wet in 1 minute : 50kV 50kV
  Dry in 10 second : 40kV 40kV
- Creepage distance : 20mm/kV 20mm/kV
- Housing : Porcelain/Polymer Porcelain/Polymer

(b) Underground cable

- Type : XLPE
- Rated voltage : 24kV
- Material conductor : Copper
- Core type : Twist type of several wires
- Square : 240sq.mm
- Withstand corrosion for burying under ground.
- Structure of cable
  Core number : 3 core
  Each cover : semiconductor
  Tapes of copper
  Filler
  PVC layer
  Protection layer
  Outside protection : Steel plate or twist steel-wire
- Max. working temperature of core : 90^0C
- BIL : 12,5kV
- Rated power frequency withstand voltage in 5 minute : 35kV
- Dielectric loss at max. voltage : 0,4%
- Cable terminal : XLPE 24kV
  3x240 SHRINXABLE

(c) Earthing system

Erecting grounding-pole at connection position of cable. Grounding-wire is connected to pole at grounding-hole of pole by bolt 12x40.

(d) Cable Trend

Cable trend is constructed under ground for cable-span. Cable is erected in trend at 0.9m from ground-surface, inside is sand layer 0.3m thickness, above trend is constructed brick for marking. Road-surface is re-constructed as the previous stage.

Structure of cable trend: Steel pipe of dia.200m/m is erected crossing road and burying 1.0m from road-surface, inside is sand layer 0.3m thickness, above trend is constructed brick for marking. Road-surface is re-constructed as the previous stage.

Cable trend in control house : it is 800mm width, 850mm depth and coated by concrete, inside erecting 3 cable supporting structure.

13.8.3 Construction Safety Measurement

- Construction items are not in area of the existing part should constructing first.
- Construction Team shall co-operate to Binh phu Power Department, Cho lon Power Department, High-voltage Management Enterprise, Chanh Hung substation and Phu Dinh substation for cutting and closing power.
- Construction Team shall carry out to connect ground at site when constructing electrical work.
- It is necessary to obey safety and security regulation on site.

13.9 PAYMENT

13.9.1 Supply of Electrical Equipment

Payment for the supply of electrical equipment will be made on the basis of equipment delivered, installed, tested, commissioned and approved by the Engineer.

Payment shall include the cost of supply, shop testing, witnessing by Engineer's or Employer's representative, shipping, insurance, inland transport, storage, fees and any other incidental costs related to the supply of electrical equipment.

All equipment shall be delivered to the Site complete with spare part as specified, its respective documentation including manufacturer's certificates and shop test records. Upon certification by the Engineer that the equipment complies with specified requirements seventy-five percent (75%) of the respective prices per unit, lot, set or lump sum, as the case may be, entered in the Bill of Quantities, shall be authorised for payment.

The remaining twenty-five percent (25%) shall be authorized for payment following the completion, testing and commissioning of each respective item of electrical equipment.

The following pay items shall be measured and paid for under this Clause:

- All pay items listed under 5.1 in the Bill of Quantities

13.9.2 Installation Works

(a) Supply of Cables and Bulk Materials

Payment for the supply of cables and bulk materials shall be made at the lump sum price entered in the Bill of Quantities which shall be full compensation for the provision of all items required for the installation of the electrical works including, but not limited to wiring, cables, cable trays, supports, delivered to the Site and certified by the Engineer that

such cables and bulk materials are complete and comply with specified requirements.

(b) Installation of Equipment, Cables and Bulk Materials

Payment will be made at the lump sum price entered in the Bill of Quantities for the installation of all equipment, cables and bulk materials which shall be full compensation for completing the installation in accordance with the Drawings, the Specification and to the approval of the Engineer and shall include the cost of all labour, tools, equipment and all other related costs.

The following pay items shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
5.2.1	Supply of Cables and Bulk materials	L.S.
5.2.2	Installation of Equipment, Cables and Bulk Materials	L.S.

13.9.3 Testing and Commissioning

(a) Supervision, Field Inspection and Testing

Payment will be made at the lump sum price entered in the Bill of Quantities for the installation of all equipment and bulk materials which shall be full compensation for the cost of completing the installation in accordance with the Drawings, the Specification and to the approval of the Engineer and shall include the cost of all labour, tools, equipment and all other related costs.

(b) Electrical Completion Works

Payment will be made at the lump sum price entered in the Bill of Quantities for the installation of all equipment and bulk materials which shall be full compensation for the cost of completing the installation in accordance with the Drawings, the Specification and to the approval of the Engineer and shall include the cost of all labour, tools, equipment and all other related costs.

(c) Tools

Payment will be made at the lump sum price entered in the Bill of Quantities for the furnishing of tool in accordance with the Specification which shall be full compensation for the cost of furnishing, arranging, packaging, cataloguing and placing the tools in location(s) instructed by the Engineer all to the approval of the Engineer.

The following pay items shall be measured and paid for under this Clause:

Pay Item No.	Description	Unit of Measurement
5.3.1	Supervising, Field Inspection & Testing	L.S.
5.3.2	Electrical Completion Works	L.S.
5.3.3	Tools	L.S.

13.9.4 Transmission Line

Payment for the transmission line shall be paid from the provisional sums following completion of the work in accordance with the directions, and to the approval, of the Engineer.

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SECTION 14. BUILDING WORKS

14.1 GENERAL

This section covers the requirements for the construction of buildings for Package E.

General requirements specified in section 1 apply to all building works.

14.2 SCOPE OF WORK

The Contractor shall construct the following buildings at the site of the Wastewater Treatment Plant :

(a) Lift pumping station

(b) Chlorine storage building

(c) Blower building

(d) Main office building

(e) Dewatering and centrifugal thickener building

(f) Compost plant facility buildings comprising:

- First fermentation tank building
- Second fermentation tank building
- Storage vessel building
- Sub-storage vessel building
- Compost control building

(g) Guard House

(h) Stair Houses for stairs A, B, C

The Contractor shall be responsible for completion each of the above mentioned building which include architectural, structural, mechanical, plumbing and electrical works and the completion of the ventilation works for underground civil structures. All work shall be in accordance with the drawings, the specifications and the directions of the Engineer.

The Contractor shall also be responsible for the rectification of all defects in accordance with the Conditions of Contract.

14.3 SPECIFICATION FOR BUILDING WORKS

All building works shall be in accordance with the following specifications:

(a) Section 1. General Specification

(b) Section 4. Concrete Works

(c) Specifications for Building Works appended hereto and comprising the following documents:

- Architectural Works
- Electrical Works

- Plumbing and Drainage
- Structural Steel Works
- Mechanical Ventilation Air-Conditioning

It is noted that the building works specifications are general specifications and that only clauses applicable to the Works shall apply.

14.4 EXTENT OF BUILDING WORKS

(a) Building Works Constructed on Structures

The building works for the Lift Pumping Station, Chlorine Storage Building, Blower Building, Main Office Building, Dewatering and Centrifugal Thickener Building, First Fermentation Tank Building and Stair Houses refer to those works above EL 2.50. Works above this level shall be constructed in accordance with the specifications for building works and payment shall only include works above that level. The works below EL 2.500 is regarded as civil works which are specified, measured and paid for separately from those of building works. Notwithstanding the above separations of specifications and payment, the Contractor shall be responsible for the completion of the whole of the Works and for the correct interfacing of the building and civil works.

(b) Building Works Independent of Other Structures

Other buildings, namely Second Fermentation Tank Building, Storage Vessel Building, Sub-storage Vessel Building, Compost Control Building and Guard House are complete buildings which include footings. They shall be constructed in accordance with the specifications for building works as noted above and payment shall include the cost of the complete buildings, including their footings.

14.5 MEASUREMENT AND PAYMENT

14.5.1 Architectural and Structural Works

Payment shall be made at the lump sum entered in the Bill of Quantities which shall be full compensation for providing all materials, labour, transport and equipment for completing the architectural and structural works in accordance with the drawings, the specification and to the approval of the Engineer.

Payment shall not include the cost of civil work, upon which some of the buildings are founded. (Refer clause 14.4), which is measured and paid for elsewhere.

Interim payments shall be in proportion to the progress of the work.

The following pay item shall be measured and paid under this clause:

Pay Item No.	Description	Unit of Measurement
3.1.1 3.2.1 3.3.1 3.4.1 3.5.1 3.6.1.1 3.6.2.1 3.6.3.1 3.6.4.1 3.6.5.1 3.7.1 3.8.1	Architectural and Structural Works	L.S.

14.5.2 Mechanical and Plumbing Works

Payment shall be made at the lump sum entered in the Bill of Quantities which shall be full compensation for providing all materials, labour, transport and equipment for completing the mechanical and plumbing works, and their testing (as required) and commissioning, in accordance with the drawings, the specification and to the approval of the Engineer.

Interim payments shall be in proportion to the progress of the work.

The following pay item shall be measured and paid under this clause:

Pay Item No.	Description	Unit of Measurement
3.1.2 3.2.2 3.3.2 3.4.2 3.5.2 3.6.1.2 3.6.2.2 3.6.3.2 3.6.4.2 3.6.5.2 3.7.2 3.8.2 3.9.1	Mechanical and Plumbing Works	L.S.

14.5.3 Electrical Works

Payment shall be made at the lump sum entered in the Bill of Quantities which shall be full compensation for providing all materials, labour, transport and equipment for completing the electrical works, and their testing (as

required) and commissioning, in accordance with the drawings, the specification and to the approval of the Engineer.

Interim payments shall be in proportion to the progress of the work.

The following pay items shall be measured and paid under this clause:

Pay Item No.	Description	Unit of Measurement
3.1.3 3.2.3 3.3.3 3.4.3 3.5.3 3.6.1.3 3.6.2.3 3.6.3.3 3.4.4.3 3.6.5.3 3.7.3 3.8.3 3.9.2	Electrical Works	L.S.

APPENDIX TO SECTION 14
GENERAL SPECIFICATIONS FOR BUILDING WORKS

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SECTION 1. ARCHITECTURAL WORKS
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SECTION 1. ARCHITECTURAL WORKS

1.1 BLOCKWORK

1.1.1 GENERAL

1.1.1.1 Scope - Blockwork

The work in this section covers blockwork and associated items and generally comprises, but is not limited to, the blockwork to the perimeter landscaping walls, and basement screen walls.

1.1.2 MORTARS

1.1.2.1 Mortar Materials - Blockwork

Cement : To TCVN 4314 : 1986, part 2.1.2..,and JIS, JASS standard

Lime : To TCVN 4314 : 1986, part 2.0.3. ,and JIS, JASS standard

Sand : To TCVN 1770 : 1986,and JIS, JASS standard

Water : To TCVN 4506 : 1987, part 1,and JIS, JASS standard

Admixtures : (Including colouring pigments, plasticisers, workability agents, water thickeners, waterproofing agents, retarders and the like) : To TCVN 4314 : 1986, part 2.1.5. Do not use unless specified or unless prior approval has been obtained.

Water Thickener: To TCVN 4314: 1986, part 2.1.4 and JIS, JASS standard

1.1.2.2 Mortar - Blockwork :

To TCVN 4314 : 1986, part 2.2. and 2.3.. ,and JIS, JASS standard

Mortar Mix : As recommended by the block manufacturer as suitable for the purpose and location of the blockwork and approval by the structural engineer.

Premixed Mortar : Do not use unless prior approval has been obtained.

1.1.2.3 Grout - Blockwork :

Core Filling Grout : To TCVN 4314 : 1986, part 2.2. and 2.3. ,and JIS, JASS standard

1.1.3 BLOCKS

1.1.3.1 Concrete Blocks - Blockwork

To TCVN 2733. ,and JIS, JASS standard

Obtain blocks from an approved source of supply. Provide blocks selected from the manufacturer's range which are purpose-made for their respective uses and locations

Grade 15 total water absorption - less than 210 kg/m^3

1.1.3.2 Fire Rated Blocks - Blockwork

To part 1, TCVN 1475 - appendix C. ,and JIS, JASS standard

1.1.4 WORKMANSHIP

1.1.4.1 Workmanship Generally - Blockwork

To TCVN 1475. ,and JIS, JASS standard

Blockwork and blockwork materials shall be liable to rejection if damaged or disfigures during the course of the work under the contract.

Construct blockwork within the tolerances prescribed in part 1, TCVN 1475,and JIS, JASS standard. If cutting is unavoidable, use a masonry saw. Do not chase blockwork without prior approval. Do not chase hollow blocks. If blocks are moved after the initial placement re-lay in fresh mortar.

1.1.4.2 Cleaning - Blockwork

To part 1, item 5.11, TCVN 1475. ,and JIS, JASS standard

Remove mortar smears progressively from the work as it proceeds

1.1.4.3 Setting out - Blockwork

Set out blockwork so as to maintain the block rod of 3 courses to 600 mm and bond with bed joints and vertical joints of equal and uniform width and with the minimum cutting of blocks.

1.1.4.4 Bonding - Blockwork

To part 1, item 3.10, TCVN 1475. ,and JIS, JASS standard

Stretcher bond, unless otherwise shown on the drawings. Bond walls to intersecting walls either by masonry bonding or by tie bonding, as follows : at least every fourth courses shall be engaged for a minimum distance of 90 mm or with block ties to part 1, item 3.10.4.3, TCVN 1475. ,and JIS, JASS standard

1.1.4.5 Building in - Blockwork

Make provision as the work proceeds for the incorporation of items to be build in or keyed to the blockwork wherever practicable run services in the core holes of blockwork, or otherwise provide holes, sleeves, and the like during the erection of blockwork to avoid cutting away and making good. Fill voids at the back of steel door frames solid with mortar as the work proceeds.

Provide suitable corrosion protection for metal items build into or in contact with brickwork. Galvanize ferrous metal items to AS 1650 ,and JIS, JASS standard, coating mass appropriate to the article, and type A for wire, unless otherwise specified.

1.1.4.6 Jointing - Blockwork

To AS 1475, part 1, clause 5.5.2. ,and JIS, JASS standard, shell or full bedding as applicable.

Cut joints flush in blockwork not exposed to view and not be finished by rendering, tiling or the like where a background key is necessary.

Otherwise joints to be pointed up as necessary.

1.1.4.7 Facework - Blockwork

Commence facework not less than 200 mm below adjacent finished ground level. Keep perpends in alternate courses vertically aligned.

Distribute the approved colour range of face blocks evenly throughout the work. If colour concentrations and banding occur, the facework is liable to rejection.

Select blocks from uniform width and double-face qualities in single leaf blockwork with facework both sides. Before commencement, obtain a ruling as to which is the preferred face, and favour that face should a compromise be unavoidable.

1.1.5 STRUCTURAL ELEMENTS

1.1.5.1 Wall Ties - Blockwork

To TCVN 2699 , and part 1, item 3.8, 3.9, and 3.10, TCVN 1475. ,and JIS, JASS standard

Cavity coated or masonry veneer ties as appropriate to the service conditions.

Zinc coated steel for highly corrosive environments as follows

Ties for normal cavity construction	:	Medium duty
Ties for wide cavities (over 80 mm)	:	Heavy duty
Ties at abutments	:	Medium duty

Minimum embedment of a tie in the mortar joint of a wall : 50 mm generally; 75 mm in cavity walls where the cavity width exceeds 80 mm. Install so that water cannot cross the cavity via the tie.

At engaged piers within the cavity: 400 mm. Locate ties at the piers only, at uniform spacing such that the total number of ties per unit area is not less than that specified in Table 3.3. of AS 1475 Part 1. ,and JIS, JASS standard

Provide an extra row of ties spaced 600 mm maximum in a course not more than 300 mm below the horizontal control joints. Treat vertical control joints as openings.

Tie blockwork to unbounded intersecting walls. Buttresses, structural frames, supports and the like with masonry veneer ties at 250 mm maximum centres fixed as follow :

To timber frames	:	Galvanized clouts or integral spikes.
To concrete	:	Non-corrosive masonry anchors.
To steel frames	:	As shown on the drawings.

1.1.5.2 Flexible Ties - Blockwork

Ties or anchors required to extend across control joints shall transfer the forces necessary to maintain the stability of the blockwork without impairing the effectiveness of the joint.

1.1.5.3 Reinforced Blockwork - Blockwork

To part 2, TCVN 1475, ,and JIS, JASS standard. Reinforce blockwork as shown on the drawings.

Machine cut a hole at the base of each reinforce core, located on the side of the wall which is to be rendered or otherwise concealed. After cleaning out has been inspected and approval, cover the hole with formwork and grout the core.

1.1.6 ENVELOPE ELEMENTS

Fire Rating : In accordance with Building Code of Australia for this class of building, TCVN ,and JIS, JASS standard

Noise Transmission : In accordance with building Code of Australia for this class of building. TCVN, ,and JIS, JASS standard

Weight : Maximum 140 kg/m^2 including plaster finish.

1.1.7 JOINT INSERTIONS

1.1.7.1 Damp-Proof Course - Blockwork

To AS 1475. Part 1, section 2.5. Installation to AS 1475, Part 1 Clause 5.8. ,and JIS, JASS standard

0.5 mm annealed aluminium faced both side with embossed block polyethylene in bitumen (suitable for salt damp conditions). Unless otherwise specified or shown on the drawings, build damp-proof course into the first course above floor level.

Lay in long lengths to full width of wall and piers. Lap full width at angles and intersections and 150 mm at joints. Step as necessary, but not exceeding 200 mm per step. Preserve continuity of damp proofing at junctions of damp-proof course and waterproof membranes.

1.1.7.2 Control Joints - Blockwork

- Location : As shown on the drawings.
- Depth : The full thickness of the blockwork leaf.
- Joint Filler : Sealant and bond breaking back up material of types shown on the drawings, as recommended by the material manufacturers for the location and service conditions, compatible when used together and non-staining to Blockwork. Do not use bituminous materials on absorbent blocks.
- Priming : Unless priming is not recommended by the jointing material manufacturer, apply the appropriate primer to blockwork surfaces in contact with jointing materials.
- Foamed materials (in compressible fillers, backing rods and the like) : Closed-cell or impregnated types which do not absorb water.
- Bond Breaking : Back up materials for sealants, including backing rods and the like, shall not adhere to the sealant, or shall be faced with a non-adhering material.
- Sealant proportions : Depth shall be not greater than the joint width, nor less than two thirds the joint width.

1.1.7.3 Slip Joints - Blockwork

Above all load bearing blockwork for the full thickness of the blockwork leaf.

Provide two layers of 1.6 mm thick galvanized steel sheets separated with graphite grease laid on a 10 mm thick mortar bed.

1.1.8 BLOCKWORK SCHEDULES

1.1.8.1 Mortar Mix Schedule - Blockwork

Mortar mix : Cement : Lime : Sand	Location
2 : 1 : 9	Generally. Concrete blockwork
1 : 1 : 4	Generally. Glass blockwork

1.1.8.2 Concrete Blocks Schedule - Blockwork

Block type	Location
Class C Standard aggregate : 200 mm Nominal thickness	Refer to drawings for locations
Class A Lightweight aggregate : 150 mm Nominal thickness, 2 hour fire rated	Refer to drawings for locations
100 mm Nominal thickness One and half hour fire rated	Refer to drawings for locations

1.1.8.3 Concrete Block Ties Schedule - Blockwork

Tie Type	Location
Galvanized steel flexible masonry anchor ties *equal to* Brunswick Sales Pty. Ltd. distributed by Techpro Pty. Ltd. as follows	
MFA 5/1	Junction of concrete wall or column and blockwork walls
MFA 4/M/CB	Junction of concrete slab soffits and blockwork walls.

1.2 ROOFING

1.2.1 GENERAL

1.2.1.1 Scope - Roofing

This Section generally covers coloured metal roofing, associated flashings, accessories, insulation to the roof of both buildings including penetrations, openings and box gutters. All fixings for Category 2 wind loading.

1.2.1.2 Samples - Roofing

Submit samples of each of the following :

- Stainless steel eaves gutter
- Roofing membrane

1.2.1.3 Inspection - Roofing

Give minimum 7 days notice so that the following may be inspected:

Sub-structure, safety mesh, sarking, insulation, box gutters and concealed gutters, downpipes to be concealed, membrane prior to surface protection finish.

1.2.1.4 Guarantees - Roofing

The Contractor shall provide the Employer with a written 10-year guarantee against any defect or failing in the roofing systems specified hereinafter. The guarantees shall apply to materials and workmanship of the system as installed.

1.2.1.5 Roof Structure - Roofing

Prepare the roof structure so that it is satisfactory for acceptance of specified roofing before commencing fixing or laying.

1.2.1.6 Maintenance Manual - Roofing

On completion, supply two copies of a manual, suitably bound, of recommendations from the roofing manufacturer or supplier for the maintenance of the roofing system, including but not limited to recommendations on restriction of access, where to work or stand (e.g. on ribs, pans, or line of fixings), footwear to be used, methods of repair and replacement, and the like.

1.2.2 MATERIALS AND WORKMANSHIP

1.2.2.1 Protection - Roofing

Protect the roofing materials and roofing system from damage throughout the work and under the contract. Keep the roof surface clear of debris and loose material throughout the work under the contract and leave it clean on completion. Keep the rainwater systems free of foreign matter and leave them unobstructed on completion.

1.2.2.2 Metal Separation - Roofing

Prevent direct contact between incompatible metals and between green hardwood or chemically treated timber and aluminium or coated steel, by either:

Apply a suitably anti-corrosion low moisture transmission coating to contact surfaces. Separate contact surfaces with a suitable separation layer such as Polyethylene film or adhesive tape.

Guide : use table 3.2 of AS 1562, and JIS, JASS and TCVN as a guide to compatibility of metals.

1.2.2.3 Fastenings - Roofing

To AS 1562, Rule 2.2, , and JIS, JASS and TCVN. Do not use incompatible metals in fastenings to metal roofing and accessories.

1.2.2.4 Thermal Movement - Roofing

Provide for thermal movement in the roof installation, including movement in joints and fastenings. Make the provision sufficient to prevent harmful effects from stress and fatigue, such as openings of joints, tearing and buckling of sheet metals and thin sections, and the like.

1.2.3 SARKING

1.2.3.1 Sarking - Roofing

Double sided fire resistant sarking to AS 1903, and JIS, JASS and TCVN installed to AS 1904, and JIS, JASS and TCVN, unless otherwise specified.

Sag between supports : 25 - 65 mm

1.2.3.2 Membrane Support - Roofing

Co-extensive with the extent of the sarking or vapour barrier, as applicable.

Galvanized wire netting 50 mm Mesh size, 1 mm diameter to AS 2423, Section 4, and JIS, JASS and TCVN.

1.2.4 INSULATION

1.2.4.1 Bulk thermal insulation - Roofing

Material in the form of batts, blankets, slabs, loose fill, or foamed in situ. (From AS 2352, , and JIS, JASS and TCVN)

1.2.4.2 Mineral Wool Blanket - Roofing

Mineral wool to AS 2461, and JIS, JASS and TCVN, processed into non-rigid fibrous blankets of approximately rectangular cross-section.

Glass wool 100 mm R : 2.0.

Acoustic Rockwool insulation to AS 2461, and JIS, JASS and TCVN, Glass Wool, 50 mm.

1.2.5 METAL ROOFING

1.2.5.1 Metal Roofing (self supporting) - Roofing

Pre-formed sheet and purpose made accessories, forming part of an approved proprietary metal roofing system to AS 1562 , and JIS, JASS and TCVN .

Material	:	Pre-coated XSE Steel
Finish	:	Colorbond selected colour
Thickness	:	0.53 mm TCT
Profile	:	Klip-Lok Hi Ten
Fixing method	:	Screw fixed KL65 Brackets

Finish visible accessories to match sheet finish.

1.2.5.2 Metal Roofing Installation - Roofing

Laying And Fixing : To AS 1562.

fastenings: To manufacturer's recommendations, unless otherwise specified:

Screws generally : Water head self drilling tapping screw No.10 x 22 mm.

Fixing pierced roofing sheets : Bear heads of fasteners on purpose-made washers to from a weatherproof seal.

1.2.6 RAINWATER GOODS - ROOFING

Provide the flashings, cappings, gutters, outlets, downpipes, and the like necessary to complete the roof system. To AS 2179 and AS 2180, and JIS, JASS and TCVN.

1.2.6.1 Jointing Sheet Metals - Roofing

Standard : To AS 2180, Section 3, and JIS, JASS and TCVN.

Make over a backing strip of the same material.

Seal fasteners and mechanically fastened joints. Fill the holes of blind rivets with sealant of Neutral-cured silicone rubber.

1.2.6.2 Flashings, Cappings - Roofing

Flash roof junctions, upstands, abutments, and projections through the roof with 0.6 mm XSE steel with colorbond finish. Pre-fabricate where possible. Form to required shapes. Notch, scribe, flute or dress down as necessary to follow profiles of adjacent surfaces. Mitre angles neatly. Lap joints in running lengths 300 mm.

Fold the flashing back 40 mm each side of the expansion joints leaving a 10 mm gap. Interleave an expansion cap of the same material with the folds, and welt the whole to the profile of the flashing. Set the joint in a mastic sealant. Do not use fastenings, or fasten one side of the joint only. Expansion joint spacing : 6 mm maximum.

Flash projections above or through the roof with two-part flashings, consisting of a base flashing (apron, baffle, soaker, ...) and a cover flashing (skirt, over flashing, sleeve and the like). Provide for independent movement between the roof and the projection

Base Flashing shall have not less than 150 mm horizontal cover and 150 mm vertical cover. On the upstream side extend the horizontal cover under the next overlap of the roofing material, or seal and fasten to the roof sheeting. Elsewhere fix to the tops of the sheeting corrugations where applicable, with fastenings and washers as recommended for the roofing system. Cover Flashing shall overlap the vertical upstand of the base flashing by nit less than 100 mm.

Turn flashing 25 mm into joints or grooves in masonry or concrete, wedge at 200 mm centres with compatible material, and point up. Step in courses to the roof slope. Interleave with damp-proof course, if any.

Fixing to pipes shall be: soldered, or sealed with neutral-cured silicone rubber and secured with a clamp ring.

1.2.6.3 Gutters Generally - Roofing

Form gutters to the required shape. Mechanically pre-form, mould or fabricate where possible. Form stop ends, bends and returns. Turn down into outlets. Provide accessories as necessary, including joints, bends, returns, outlets (thimbles, spigots and the like) for downpipes and overflows, stop ends, stiffening gussets at corners, supporting brackets, overstraps, and the like, purpose-made if supplied as part of the gutter system. Make provision for overflows where necessary to prevent back flooding into the building.

From expansion joints by stop ending the gutter and saddle flashing over the two stop ends. Spacing to AS 2180, Clause 1.5.2 and Table 1.2, and JIS, JASS and TCVN.

1.2.6.4 Downpipes - Roofing

Refer “Hydraulic Services” for downpipes.

1.2.7 ROOFING SCHEDULES

1.2.7.1 Sarking and Insulation Schedule - Roofing

Sarking	Extent :	All metal deck roofs
	Location :	Lay over purlins
Membrane Support :	Type :	Wire mesh laid over purlin and wired thereto
Bulk Thermal Insulation :	Type:	Mineral wool blanket
	Extent :	All metal deck roofs
	Location :	Laid over sarking
Acoustic Insulation :	Type :	Mineral wool blanket
	Extent :	Under box gutters in false ceilings under wet areas.
	Location :	Laid over plasterboard ceiling

1.2.7.2 Roof Plumbing Schedules - Roofing

Flashings, Cappings :

Material : Colorbond XSE Steel. 0.6 mm cover flashings and base flashings, pre-coated to match preformed roofing sheet

Jointing method : Fasteners

Fixing to masonry or concrete (wedge material) : Zinc rolls

Box Gutters :

Material : Grade 316 stainless steel — Profile : As shown on Drawings

Thickness : 1.2 mm — Overflows: 50mm diameter stainless steel pipe

Rainwater Sumps :

Material : Stainless Steel — Thickness : 0.45 mm

Finish : Paint — Profile : As shown on Drawings

Size : 400 x 400 x 100 mm deep — Leaf Guard : Netting ball guard

1.3 WATERPROOFING AND TANKING

1.3.1 GENERAL

1.3.1.1 Scope - Waterproofing and Tanking

The work contained in this Section includes the supply, delivery and fixing of all waterproofing and tanking materials including all fixings, component parts and masking necessary to make the trade complete.

1.3.1.2 Standards - Waterproofing and Tanking

ASTM E96, and TCVN, JIS, JASS standard Test Methods for water vapour transmission of materials.

1.3.2 WORKMANSHIP

1.3.2.1 Installation - Waterproofing and Tanking

Install waterproof membrane and tanking systems to manufacturer's recommendations. On completion leave waterproof membranes and tanking systems undamaged and in full working order. Provide a written guarantee for the whole of the Waterproofing and Tanking Works as specified herein for a period of 10 years commencing from the date of practical completion.

1.3.3 APPROVED MEMBRANE SYSTEMS

Apply to concrete and masonry walls in shower cubicles and concrete floors in bathrooms, W.C.s and laundries a high performance elastomeric liquid polyurethane based waterproofing membrane.

1.3.4 EXTERNAL MEMBRANES - WATERPROOFING AND TANKING

Apply to concrete slabs, balconies, and areas to receive tiling and paving on first floor level a high performance elastomeric liquid polyurethane based waterproofing membrane.

1.4 METALWORK

1.4.1 GENERAL

1.4.1.1 Scope - Metalwork

This Section comprises the supply, fabrication and installation of metalwork items as shown on the Drawings and including handrails, stair and balcony balustrades, letter box bank, mat and frame, gates and grilles, car park bollard, sunscreens and fire extinguishers, and other sundry items.

1.4.1.2 Samples - Metalwork

Submit samples of the following :

(a) Butt joints and mitre joints, made by the proposed techniques in flats, tubes and sections.
(b) Protective coating finishes such as chrome plating, stainless steel, galvanising, anodizing, powder coating, baked finishes.
(c) Mechanical finishes including polishing, sand blasting and the like.
(d) Sections for use in fabricated work.

1.4.1.3 Shop Drawings - Metalwork

Supply shop drawings where so specified and any additional drawings prepared by fabricators.

1.4.2 MATERIALS AND WORKMANSHIP

1.4.2.1 Materials - Metalwork

Use metals suited to their required function, finish and method of fabrication, in sections of adequate strength and stiffness for their purpose.

1.4.2.2 Workmanship - Metalwork

Fabricate and pre-assemble items in the workshop wherever practicable. Keep edges and surfaces clean, neat and free from burrs and indentations. Remove sharp edges without excessive radiusing. Fit joints accurately to a fine hairline. Form bends in tube without unduly deforming the true cross section. Match colours of sheets, extrusions and heads of fastenings in colour finished work.

Separate incompatible metals by suitable means, including but not necessarily limited to separation layers, sleeves, or gaskets of plastic film bituminous felt, mastic, paint coatings, and the like. Separation materials shall not be visible on exposed surfaces.

Provide for thermal movement in joints and fastenings, and in the installation of assemblies such as frames. Make the provision sufficient to-prevent harmful effects from stress and fatigue, such as opening of joints, tearing and buckling of sheet metals and thin sections, and the like.

1.4.2.3 Welding, Brazing, Soldering - Metalwork

Finish visible joints made by welding, brazing or soldering by grinding, buffing or the like methods appropriate to the class of work before painting, galvanising, or the like further treatment. Aluminium after jointing shall be without visible surface colour variations.

1.4.3 STRUCTURAL MEMBERS

1.4.3.1 Fastenings - Metalwork

Fastenings, including anchors, lugs, screws, rivets and the like, shall be of approved type. appropriate to the work, capable of transmitting the loads and stresses imposed, and sufficient to ensure the rigidity of the assembly.

Fastenings To Aluminium : (including aluminium alloys) : Aluminium alloy or non-magnetic stainless steel unless otherwise specified. Use cadmium-plated steel fastenings only in protected situations subject to approval.

Self-tapping screws :		Stainless steel.
Nails	:	Aluminium or stainless steel.
Rivets	:	Blind rivets.

1.4.3.2 Screws - Metalwork

Tapping And Drive Screws : To AS B 194, and JIS, JASS and TCVN.

Machine Screws : To AS 1427, and JIS, JASS and TCVN

Socket Head Cap Screws : To AS 1420, and JIS, JASS and TCVN

Socket Head Set Screws : To AS 1421, and JIS, JASS and TCVN.

Exposed Screw Heads : Countersunk Philips or socket head unless otherwise specified, finishing flush in counter-sinkings.

1.4.3.3 Masonry Anchors - Metalwork

Patent expansion type of approved manufacture unless otherwise specified.

1.4.4 FINISHES

1.4.4.1 Protection - Metalwork

Protect metalwork during the work under the Contract as necessary to prevent damage or defacement.

Iron and Steel (ungalvanized): Prime as specified for the relevant coating system specified in painting.

Metal Building Sheets : Surface discolouration or other damage resulting from neglect of protective measures shall be cause for rejection**.**

Temporary Coatings: Provide finished surfaces of aluminium and its alloys, stainless steel, chromium plating and the like decorative surfaces with a temporary coating before installation, and remove all trades upon completion of the Works.

1.4.4.2 Hot Dip Coatings - Metalwork

Complete welding, cutting, drilling and other fabrication before coating. Unless otherwise specified, zinc coatings shall be by the hot dip method as follows :

Ferrous articles generally : To AS 1650, and JIS, JASS and TCVN

Ferrous wire : To AS 1650, Section 4, Type A, and JIS, JASS and TCVN

Steel sheet : To AS 1397, coating lass as specified for the particular item, and JIS, JASS and TCVN

Threaded fasteners : To AS 1214, and JIS, JASS and TCVN

1.4.4.3 Anodizing - Metalwork

Anodized coatings on aluminium : To AS 123 1, and JIS, JASS and TCVN

1.4.5 FIRE PROTECTION SYSTEMS

1.4.5.1 Portable Fire Extinguishers - Metalwork

5.5 kg. Carbon Dioxide type in accordance with AS 1847, and JIS, JASS and TCVN and fixing on approved brackets complete with signs indicating directions for use.

1.5 TILING

1.5.1 GENERAL

1.5.1.1 Scope - Tiling

This Section generally comprises the supply and laying of terracotta, marble, granite and ceramic tiles on floors and supply and fixing to walls of ceramic and marble tiles, as shown on Drawings and “Finishes schedule”.

1.5.1.2 Sample Panels - Tiling

Prepare in suitable positions, or where directed, sample panels of sufficient area (not less than $2m^2$) of each type of finish specified. Include samples of specified junction details and trim. Preserve each panel when approved until all work of its type is complete. An approved panel, if suitably located, may be permitted to be incorporated into the Works. Otherwise remove all traces on completion of the Works.

1.5.1.3 Guarantees - Tiling

Provide guarantee against defective material and workmanship for 2 years for the materials specified.

1.5.1.4 Ordering - Tiling

Order tiles in time to avoid delay to the construction programme. Allow sufficient time for importation of tiles required to be ordered from overseas.

1.5.2 MATERIALS

1.5.2.1 Materials Generally - Tiling

Sand	:	To AS CA27, and JIS, JASS and TCVN
Cement	:	To AS 1315, Type A - normal cement, and JIS, JASS and TCVN.
White Cement	:	Free of iron salts, otherwise to AS 1315, Type A, and JIS, JASS and TCVN.
Lime	:	To AS 1672, and JIS, JASS and TCVN
Water	:	To AS CA2, and JIS, JASS and TCVN.

1.5.2.2 Adhesives - Tiling

Use adhesives compatible with the materials and surfaces to be adhered, and in accordance with the adhesive manufacturer's recommendations for the conditions of use.

Organic - Based Adhesives : To AS 2358, Part 1, and JIS, JASS and TCVN

Cement - Based Adhesives : To AS 2358, Part 2, and JIS, JASS and TCVN.

Prohibited uses : Unless otherwise specified, do not use the following combinations :

(a) Cement-based adhesives on wood, metal, painted or glazed surfaces, gypsum-based plaster

(b) Organic solvent-based adhesives on painted surfaces

(c) Organic PVA-based adhesives and organic natural rubber latex adhesives in damp or wet conditions.

1.5.2.3 Bedding Mortar - Tiling

To AS CA27, and JIS, JASS and TCVN, from cement and sand with minimum water.

Do not use mortar after the initial set has occurred. Do not retemper mixes. Select proportions from the range 1:3 to 1:4 cement : sand to obtain satisfactory adhesion. Wet the background as necessary to achieve suitable suction. Alternatively apply a bonding agent to the background to improve adhesion.

1.5.2.4 Grout -Tiling

Cement based proprietary grout : Mix with water. Fine sand may be added as a filler in wider joints.

Portland cement based grout : Mix with fine sand. Use minimum water consistent with workability.

Proportioning : For narrow joints (up to 3 mm) : 1: 2 cement : sand

For wide joints (over 3 mm) : 1: 3 cement : sand.

Pigments for coloured grout : Colour fast fillers compatible with the grout material. For cement-based grouts, lime proof natural or synthetic metallic oxides compatible with cement

1.5.2.5 Sealants - Tiling

Approved silicone sealant.

1.5.3 TILES

1.5.3.1 Tiles Generally - Tiling

To BS 1281, and JIS, JASS and TCVN. Tiles shall be even and regular in size, true to plane, free of warps, cracks, crazing, discolouration or defects and shall have undamaged arises.

1.5.3.2 Ceramic Tiles - Tiling

Tile size	:	300 x 300, 150 x 150, 200 x 100, 100 x 100
Thickness	:	6 mm
Edge type	:	Cushion
Surface	:	Glazed
colour	:	To be selected

1.5.3.3 Accessories - Tiling

Tile accessories, fittings, and fixtures, including but not limited to round edge tiles, cove tiles, step treads, nosings, skirtings, sills, copings, tile vents, tile rebated edgings to drainage channels, and the like, shall generally match the surrounding tiles as to composition, colour and finish, unless otherwise specified or scheduled. Where necessary include matching stop ends, internal and external angle tiles, and the like, moulded for that purpose.

1.5.4 WORKMANSHIP

1.5.4.1 Workmanship Generally - Tiling

Use manufactured items including tiles, adhesives, grout, sealant, caulking compound and the like in accordance with the manufacturers' recommendations. Cut tiles neatly to fit around fixtures and fittings, and at margins where necessary Drill holes without damaging tile faces. Rub edges smooth without chipping. Return tiles into sills, reveals and openings. Butt up to returns, frames, fittings, and other finishes. Strike and point up beds where exposed. Cut recesses where necessary for soap holders and the like. Distribute variations in hue, colour area, or pattern uniformly, by selecting of mixing tiles or tile batches before laying.

1.5.4.2 Falls and Levels - Tiling

Grade floor tiling to even and correct falls where required (e.g. to floor wastes). Make level junctions with walls. Where falls are not required, lay level. Unless otherwise specified, maintain finished floor levels without step or break at changes of floor finish, including carpet. Maximum deviation of the finished floor from its true form (plane, warped plane, camber, and the like) : 1:300.

1.5.4.3 Setting out - Tiling

Set out tiling to the bond or pattern shown on the Drawings or specified, with joints accurately aligned in both directions, level and plumb.

Use only whole tiles at margins where practicable, otherwise set out to give equal margins of cut tiles unless otherwise specified or shown. If margins less than half tile width are unavoidable, locate the cut tiles where they are least conspicuous. If it appears that minor variations in joint widths or overall dimensions will avoid cut tiles, submit proposal for approval. Do not vary unless approved.

Before tiling ensure that fixtures interrupting the tile surface, such as plumbing and electrical items, boxes, access panels, and the like are accurately positioned in their designed or optimum locations relative to the tile layout. Where possible position tiles so that holes for fixtures and the like occur at the intersection of horizontal and vertical joints or on the centre lines of tiles.

On horizontal surfaces make a trial set-out for each area and obtain approval before fixing

1.5.4.4 Preparation of Tiles- Tiling

Adhesive bedding : Fix tiles dry; do not soak.

Mortar bedding : Soak porous tiles in water for not less than half an hour and not more than one hour and then drain until the surface water has disappeared. It is not necessary to soak non-porous (e.g. fully vitrified) tiles.

1.5.4.5 Bedding Generally - Tiling

Bedding methods and materials shall be appropriate to the tile, the background, the conditions of service, and such as to leave the tile firmly and solidly bedded in the bedding material and adhered to the background.

1.5.4.6 Bedding Thickness - Tiling

Thin bed: Minimum thickness 1.5 mm, maximum 3 mm. May be used when the background deviation does not exceed 3 mm when tested with a 2 m straight edge. The entire tile back shall be covered with adhesive when the tile is bedded.

Thick bed: Minimum thickness 3 mm, maximum 12 mm, except that mortar beds for floor tiles may be up to 20 mm thick. Use on backgrounds with deviations up to 6 mm when tested with a 2 m straight edge, and with tiles having deep keys or frogs.

1.5.4.7 Bedding Floor Tiles - Tiling

Floor tiles bedded in cement mortar : Lightly dust the screeded bed surface with dry cement and trowel level until the cement is damp. Alternatively spread a thin slurry of neat cement, or cement based thin bed adhesive, on to he tile back.

1.5.4.8 Tile Joints - Tiling

Joint widths : Set out tiles to give uniform joint widths within the following limits :

Ceramic Tiles : minimum 1 mm maximum 3.0 mm

1.5.4.9 Grouting - Tiling

Before grouting, obtain approval for the proposed grouting methods and materials. Commence grouting as soon as practicable after bedding has set. Clean out joints as necessary before grouting. Protect vulnerable tile faces (e.g. soft glazes) from abrasive grouts, where necessary by masking. Grout exposed edge joints as specified for the face joints.

1.5.4.10 Grouting Methods - Tiling

Fill the joints solid and tool flush. Clean off surplus grout. Wash down when grout has set. When grout is dry, polish the tile surface with a clean cloth.

1.5.4.11 Cleaning and Protection - Tiling

Keep the work clean as it proceeds. Protect finished work from damage. Keep traffic off floors until the bedding has set and attained its working - strength. Remove and replace damaged or defective work. Clean the tiled surface with an appropriate tile-cleaning agent, and polish. Leave the whole of the work clean and free from blemishes.

1.5.5 SUBSTRATE PREPARATION

1.5.5.1 Substrates Generally - Tiling

Preparation : Suitably prepare substrates to receive the bedded finish, including but not necessarily limited to the following:

(a) Remove oils, greases, retarders, loose material and the like and leave the surface dust free and clean;

(b) Allow sufficient time for initial drying out and shrinkage to take place in cementatious substrates and underlays before tiling.

1.5.6 JUNCTIONS

1.5.6.1 Movement Joints - Tiling

Joints shall go right through the tile and bed to the background. Joints to be not less than 6 mm or more than 10 mm, or as shown on the Drawings.

Form joints other than metal edged joints against temporary battens of rectangular section the full width and depth of the joint. Leave the batten in place until ready to fill and seal the joint, and in any case until the tiles are firmly set. Clear extraneous matter such as grout and dust from the joint and leave the joint clear of movement-restricting material. Fill the joint and finish neatly flush with tile surface.

Depth shall be not greater than twice the joint width, nor less than the joint width.

1.5.6.2 Movement Joint Materials - Tiling

Foamed materials : (In compressible fillers, backing rods and the like) : Closed-cell or impregnated types which do not absorb water.

Bond breaking : Back-up materials for sealants, including backing rods and the like, shall not adhere to he sealant, or shall be faced with a non-adhering material.

Priming : Unless priming is not recommended by the jointing material manufacturer, apply the appropriate printer to the cleaned joint edges in contact with jointing materials.

Sealants : Use sealants of approved manufacture, compatible with the application and service conditions, and of the types specified.

One-part polysulphide sealants :	To AS 1526, and JIS, JASS and TCVN
Two-part polysulphide sealants :	To AS 1527, and JIS, JASS and TCVN
One-part silicone sealant :	To 19/GP-18M, and JIS, JASS and TCVN.

1.5.6.3 Caulked Joints - Tiling

Provide caulked joints as follows :

(a) Where tiling is specified to be cut around sanitary fixtures

(b) Around fixtures interrupting the tile surface, for example pipes, brackets, bolts, nibs and the like.

(c) At junctions with window and door frames, built-in cupboards and the like.

(d) At perimeters of floors of all terraces, and external tiled areas.

(e) At maximum 1 0 m centres in large areas.

Size : Width 5 mm.	Depth : equal to tile thickness.	
Sealant :	Walls :	Silicone rubber
	Floors :	Two-part polysulphide

Fill the joint with sealant and finish neatly flush with tile surface.

1.5.7 TILING SCHEDULES

1.5.7.1 Tiling Schedule - Tiling

Location : surface to be tiled :		Bathrooms, ensuites, laundries and kitchens
Tile type :		Ceramic Tile or as selected
Bond :		Stack bond
Bedding :	Type :	Adhesive
	Thickness :	1.5 mm to 3 mm thin bed adhesive
Grout :	Type :	Cement based proprietary
	Colour :	To be selected.
Location : surface to be tiled :		Entries, foyers, lobbies
Tile type :	Polished granite	
Bond :	Stack bond	
Bedding :	Type :	Adhesive
	Thickness :	1.5 mm to 3 mm thin bed adhesive
Grout :	Type :	Cement based proprietary
Colour :	To be selected	

Location : surface to be tiled :		External balconies, terraces, stairs, paths
Tile type :		Unglazed and scaled Terracotta floor tiles or as selected
Bedding :	Type :	Cement mortar
	Thickness :	20 mm
Grout :	Type :	Cement based proprietary
	Colour :	To be selected

1.6 PAINTING

1.6.1 GENERAL

1.6.1.1 Scope - Painting

This Section covers the internal and external painting of the various building elements including but not limited to external exposed cement render and concrete surfaces, internal walls and ceilings, doors and frames, metalwork other than self-finished metalwork, general woodwork, pipework and the like.

1.6.1.2 Definitions - Painting

To AS 2310 , and JIS, JASS and TCVN unless otherwise specified.

1.6.1.3 Samples - Painting

Before commencing painting, provide, on a representative portion of substrate(s), 1m^2 samples of the total coating system which meets the specified requirements for colour, gloss and texture. Coating system physical properties shall also be examined in accordance with AS 1580 at this stage.

1.6.2 MATERIALS

1.6.2.1 Materials Generally - Painting

Paint Materials : Use only premium quality lines from approved manufacturers. The containers of materials shall be labelled as such by the manufacturer.

Notify the proposed brand of paint and paint line prior to placing orders. Change neither the brand nor the paint line without approval. Do not combine paints from different manufacturers in a paint system. Deliver paints to the site in the manufacturers labelled and unopened containers.

Use only the type and quantity of thinners recommended by the paint manufacturer. Colour tinting shall be by the manufacturer unless otherwise approved.

Add tinters or stainers only if approved, and only if in accordance with the manufacturer's recommendations as to type, quality and tinting formula, and provided the tinting produces the required colour without detriment to the durability or aesthetic performance of the product.

Putty : To AS 1263, Type 1 or 2, and JIS, JASS and TCVN, or an equivalent polymeric based putty. Putty may be stained to match the colour of the substrate.

1.6.2.2 Colour Selection - Painting

Provide the paint manufacturer's name and paint lines intended for use so that the Superintendent can make colour selections.

1.6.2.3 Gloss Level - Painting

Definitions : "Flat", "low-gloss", "semi-gloss" , "full-gloss": To AS 2310, 2311, Clause 4.1, and JIS, JASS and TCVN.

1.6.2.4 Primers, Sealers, Undercoats - Painting

Ensure that primers, sealers and undercoats are suitable for the substrate and compatible with the finish coat and each other. Except for stains and other clear or translucent finishes each coating shall be of a noticeably different tint from the preceding coat.

1.6.3 WORKMANSHIP

1.6.3.1 Workmanship Generally - Painting

Unless otherwise specified, before commencing to paint, complete the work of all other trades as far as is practicable within the area to be painted, except for installation of fittings, floor sanding and laying flooring materials.

Do not paint in dusty conditions, or otherwise unsuitable weather. Do not paint when the relative humidity exceeds 85%, or when the surface temperature of the substrate is less than 10^0C or more than 50^0C, unless the paint is suitable and recommended for such conditions.

Before painting in any section of the Works, clean the area out and protect it against dust entry. Use drop sheets and masking wherever necessary to protect finished work or other surfaces liable to damage during painting. Repair or replace any accessories or surfaces that are damaged directly or indirectly as a result of painting. Remove door furniture, switch plates, light fittings and the like and replace on completion of painting.

During preparation of surfaces, painting, and inspection, maintain light levels such that the luminance (photometric brightness) of the surface is at least equal to that produced under daylight and/or maximum permanent artificial illumination conditions. Adequately ventilate the areas in which paining is being carried out.

Store and prepare paint and related materials in the area assigned by the Superintendent. Take necessary precautions to prevent fire and accumulation of solvent fumes. Remove paint-soiled rags, waste, and the like at the end of each day's work or store in airtight metal containers under water. Remove empty cans and other debris arising out of the painting work from the site upon completion of work.

Mix and apply paint in accordance with the manufacturer's recommendations. Do not mix paint in areas or on surfaces liable to damage from spillage. Clean off marks, paint spots and stains throughout, restoring damaged surfaces to their original condition. Where necessary for aesthetic reasons, touch up damaged paint work or misses only with the paint batch used in the original application.

1.6.3.2 Equipment - Painting

To AS 2311 Section 6 and AS 2312 Section 8 , and JIS, JASS and TCVN as applicable.

Use appropriate and properly maintained conventional or airless spray equipment of such capacity as to satisfactorily atomise the paint before applied when fitted with the correct nozzle/tip assembly, without having to thin beyond the maximum amount recommended by the manufacturer. The air supply shall be free from oil, water and other contaminants.

Use drop sheets of adequate size and thickness to prevent marking of areas requiring protection.

Place notices conspicuously and do not remove until paint is dry, unless approval is given and precautions are taken to deny access to all but painting staff.

1.6.3.3 Application - Painting

To AS 2311 Section 6 and AS 2312 Section 8 , and JIS, JASS and TCVN as applicable.

Apply paint and related materials in accordance with the manufacturer's recommendations. Cut in between different finishing coats neatly in straight lines unless otherwise specified. Allow each coat to harden for the drying time (or time between coats) recommended by the manufacturer.

Where recommended by the manufacturer, sand between coats from top to bottom and dust down before recoating.

The application of thinned prime or seal coats, consistent with the paint manufacturer's recommendations, and which may be necessary on porous surfaces,

or of any additional finishing coats necessary to achieve the required colour, opacity, texture or film thickness and/or use of tinted undercoats shall be at the Contractor's expense.

Ensure each coat of paint is uniform in colour, gloss, thickness and texture and free of runs, sags, blisters, or other discontinuities. The standard of workmanship with regard to final colour, gloss and texture shall match the sample area specified in SAMPLES PAINTING.

1.6.4 SUBSTRATES

1.6.4.1 Substrate preparation - painting

To AS 231 1 Sections 2 and 3, and AS 23 12 Section 5, and JIS, JASS and TCVN, as applicable.

Prepare substrates to receive the systems specified. Procedures shall include, but not necessarily be limited to, the following :

- Cleaning : Clean down and remove oil, grease and loose foreign matter, including laitance, efflorescence, moss, lichen, mould, mildew, dirt and corrosion products, in a manner which causes neither undue damage to the substrate nor damage to, or contamination of, the surroundings.
- Glossy surfaces : Adequately scuff and / or solvent or chemically etch as appropriate to provide satisfactory adhesion for subsequent paint coats.
- Filling : Fill cracks and holes with fillers, sealants or grouting cements as appropriate for the finishing system and substrate, and sand smooth.
- Drying : Unless otherwise specified, ensure that surfaces are cured and dry before painting commence.
- Recontamination : Apply the first coat of paint immediately after cleaning and before contamination of the substrate can occur. Where contamination of intermediate coats occurs, clean in accordance with the coating manufacturer's recommendations and to the Superintendent's approval immediately prior to over-coating.

1.6.4.2 Metal Surfaces Generally - Painting

To AS 162, and JIS, JASS and TCVN as appropriate to the requirements of this Specification.

1.6.4.3 Iron and Steel Surfaces - Painting

- Generally : Remove weld spatter, slag, burrs, or any other objectionable surface irregularities.
- Degreasing : To AS 1627 Part 1, and JIS, JASS and TCVN, by solvent or alkaline cleaning.
- Hand or power tool cleaning : To AS 1627 Part 2 or Part 7, and JIS, JASS and TCVN. Provide a final surface at least equal to preparation grade "St2" of AS 1627 Part 9, and JIS, JASS and TCVN.
- Blast Cleaning : To AS 1627 Part 4, and JIS, JASS and TCVN, to the class specified in the specified protective treatment. Provide a surface roughness appropriate for the specified treatment.

1.6.4.4 Masonry, Plaster and Cementatious Surfaces - Painting

Concrete and masonry : Before application to very smooth concrete, brick or masonry, acid etch, grind, or abrasive blast the surface as appropriate to provide a suitable key for the subsequently applied coating and to remove laitance. Remove loose friable matter before filling surface discontinuities.

Set plaster and fibrous plaster surfaces : Do not apply solvent-born paint or other impervious coatings if the moisture content at the surface, tested with a moisture meter, exceeds 12%.

1.6.4.5 Timber Surfaces - Painting

Cut out large resinous knots and decayed areas, and replace with sound timber. Remove any defective putty and punch nails. Spot prime small knots, cracks, open joints, holes and bare timber with specified wood primer.

Fill as necessary with polymeric fillers or oil based putty to AS 1263 Type 1, and JIS, JASS and TCVN,

which in the case of clear or lightly pigmented finishes shall match the substrate. Use appropriate inert filler if the finish is a two-pack epoxy or polyurethane. Lightly sand dressed surfaces in the direction of the wood grain with appropriate grade "free cut paper" and remove powdery deposits. Apply one coat of wood primer to the back of external fascia boards, timber door and window frames, tops and bottoms of external doors, associated trims and glazing beads before fixing in position.

Moisture content of substrate : To AS 2311 Clause 3.2.5, and JIS, JASS and TCVN at time of priming. Test the substrate with a moisture meter if required.

1.6.5 PAINT SYSTEMS

1.6.5.1 Paint Systems Generally - Painting

The clauses specify the number and order of coats, and the paint type for each coat, for the respective substrates to which the system is applicable.

Paint types : To AS 2311, Table 4.1, and JIS, JASS and TCVN. The paint types are specified by the "paint reference number" of that table, and/or by the corresponding GPC specification numbers. GPC numbers are quoted in brackets.

1.6.6 PAINTING SCHEDULES

1.6.6.1 Protective Coatings Schedule- Painting

Location : Refer to Finishes Schedule

1.6.6.2 Exclusions Schedule - Painting

Exclude the following surfaces from paint and corrosion protection systems :

- Flexible duct connections, rubber hoses and mountings and other non metallic flexible fittings;
- Wire rope and machined surfaces
- Metals plated or specially finished for appearance, bronze, brass, copper and stainless steel (except as specified in “Pipe identification plumbing”);
- Aluminium frames;
- Metal floor duct covers;
- Fair faced brickwork, stonework, artificial stone and exposed aggregates
- Sprayed vermiculite;
- Floors, paving, roads unless otherwise specified;
- Inside of service ducts, heat exchangers, pipes and valves;
- Self finished surface such as glass and plastic laminates.

1.7 PLASTERING

1.7.1 GENERAL

1.7.1.1 Scope - Plastering

The work in this Section comprises the supply and application of internal and external cement render, external hard set plaster, internal skim coat plastering, and supply and fixing of plasterboard linings to internal areas; all to walls and ceilings as shown on the Drawings, and on the Finishes Schedule.

1.7.1.2 Definitions - Plastering

The terms "plaster", "plastering" and the like shall include the terms "render", "rendering" and the like except where the context otherwise requires.

1.7.1.3 Sample Panels - Plastering

Prepare in agreed positions, sample panels of sufficient area (not less than 4 m^2) of each of the plaster and render finishes specified in this Section, including examples of the specified junction details and trim. An approved panel, if suitably located, may be permitted to be incorporated into the Works. Otherwise remove all traces on completion.

1.7.1.4 Extent - Plastering

Return plastering into reveals, heads, sills, recesses, niches, and the like. Plaster faces, ends, and soffits of projections in the background, such as string courses, sills, pilasters, corbels and the like. Run throating on soffits of external projections. Trim around openings.

1.7.2 MATERIALS

1.7.2.1 Materials Generally - Plastering

Sand :	To AS CA27, and JIS, JASS and TCVN, graded to the appropriate table of the Appendix to that code
Cement :	To AS 1315, Type A, and JIS, JASS and TCVN - normal cement.
Lime :	To AS 1672, and JIS, JASS and TCVN
Lime putty :	Prepare to one of the two methods in AS CA27, and JIS, JASS and TCVN.
Water :	TO AS CA27, and JIS, JASS and TCVN.
White cement :	To AS 1315, Type A, and JIS, JASS and TCVN, but free from iron salts
Gypsum plaster :	To AS 2592. , and JIS, JASS and TCVN
Admixtures :	Obtain prior approval before using admixtures to retard or accelerate setting, improve workability, reduce water content, or improve waterproofing properties, or the like.
Metal lath :	Sheet steel expanded to a mesh by slitting and stretching, galvanised to AS 1397, and JIS, JASS and TCVN, coating class Z 200.
Self-furring type :	Metal lath with staggered indentations which hold the body of the sheet 1 0 mm clear of the background.

1.7.3 WORKMANSHIP

1.7.3.1 Workmanship Generally - Plastering

To AS CA27, and JIS, JASS and TCVN. Carry out plastering under conditions which will not adversely affect the finished work. Complete in sufficient time to enable subsequent finishes to be applied under proper conditions. Cut out any damaged or faulty work, and make good.

1.7.3.2 Proportioning and Mixing - Plastering

To AS CA27, Section 5, and JIS, JASS and TCVN.

Generally each successive coat shall not be stronger (richer in cement) than the background or undercoat to which it is applied. Do not use mixes after initial set has occurred. Do not retemper mixes.

Make a coarse mix of lime putty and sand 24 hours before use. Prevent from drying out. Mixes specified to contain cement and sand only may be gauged by the addition of lime up to 25% of the cement content (i.e. not as a substitute for the cement) if necessary to improve workability.

1.7.3.3 Application - Plastering

If unavoidable in a large area of work, make junctions so that they are invisible in the finished work. Press plaster through the apertures of metal lath, wings of casing beads, and the like.

1.7.3.4 Tolerances - Plastering

Make finished surfaces even, free from defects, and true to the required surface. Make vertical surfaces plumb and horizontal surfaces level. Finish plane surfaces within a tolerance of 7mm in 3m as determined by a 3 m straight edge placed anywhere in any direction. Finish corners, angles, edges, and curved surfaces within equivalent tolerances.

1.7.3.5 Surface Finishes - Plastering

Provide a smooth dense surface free from texture and free from shrinkage cracks. Finish with a steel float.

1.7.3.6 Protection and Curing - Plastering

Protect adjoining work from damage during plastering. Provide temporary covering if necessary. Remove mortar splashes as the work proceeds. Protect from sun, wind, frost, rain and hail, and from damage by building operations or other causes. Provide temporary coverings if necessary.

- Cement-Based Work : Cure by preventing rapid or uneven drying out.
- Gypsum-Based Work : Do not subject to persistent dampness after work has set.

1.7.4 BACKGROUND PREPARATION

1.7.4.1 Background Defects - Plastering

Before plastering is commenced, make good any defects in the background which may adversely affect the quality of plasterwork. Back off excessive projections. Fill voids, hollows and honeycombs with a mix not stronger than the background nor weaker than the first coat.

Where a one coat application is specified, but the background is not sufficiently true to comply with the thickness limits for one coat, or has excessively uneven section resulting from variations in the composition of the background materials, carry out the work in two coats without extra charge.

1.7.4.2 Preparing Backgrounds - Plastering

To AS CA27, Section 4, and JIS, JASS and TCVN. Suitably prepare the background to receive the plaster finish, including but not necessarily limited to the following:

- Cleaning : Remove oils, greases, retarders, loose material and the like and leave the surface dust free and clean.
- Embedded items : Ensure that water pipes are sheathed to permit thermal movement. Prime paint with zinc-rich metal primer or provide equivalent rust protection to ungalvanised steel items to be embedded in gypsum plaster.
- Chases : If chases or recesses are more than 50 mm wide, cover with expanded metal lath extending not less than 75 mm beyond each side of the recess.
- Suction : Control by dampening, if necessary. Avoid over-wetting.
- Dense concrete backgrounds : If not sufficiently rough to provide a mechanical key, roughen by scabbling or the like to remove 3 mm of the surface and expose the aggregate. Then dash coat.
- Brickwork backgrounds : If not rough-jointed, rake out joints 5 mm deep. If raking out is impracticable, cover with expanded metal lath.
- Concrete blockwork backgrounds : Dash coat.

1.7.5 JUNCTION DETAILS

1.7.5.1 Vee Joints - Plastering

Provide neat vee joints in plaster whenever it crosses junctions between different background materials (for example junctions between brick and concrete backgrounds), except where the junction is bridged as specified in “Metal lath bridging - Plastering”. Rule the vee joint straight and true and cut it right through the plaster to the background exactly on the line of the junction.

1.7.5.2 Edge Terminations - Plastering

Unless otherwise shown or specified, terminate edges of plaster abutting other finishes by bevelling the plaster neatly to a vee joint.

1.7.6 TRIM

1.7.6.1 Corners and Angles - Plastering

Re-entrant corners : Finish square

Salient angles :

Reinforcement : Corner beads to all exposed edges as specified in “Edge trim-Plastering”

1.7.6.2 Edge Trim - Plastering

- Beads : Provide the necessary corner beads, casing beads, stop beads and the like, consisting of purpose-made sections of approved pattern.
- Material : Zinc-coated steel to AS 1397 - G300- Z200, and JIS, JASS and TCVN.
- Thickness : Coated thickness of proprietary PVC beads:
- Corner beads (wings) : 0.53 mm
- Casing beads : 0.63 mm
- Fixing : Nail to structure at 300 mm centres. Wire to metal lath.

1.7.6.3 Finish without Cornice - Plastering

Finish walls to ceilings without cornice by an appropriate method to AS 2186 Clause 1 or AS 25 91 Clause 5.7.1, and JIS, JASS and TCVN.

1.7.7 PLASTER AND RENDER FINISHES

1.7.7.1 Cement Render - Plastering

Proportions :		4:1:16 CEMENT :LIME :SAND
Application	:	Apply direct to background, 12 mm maximum thickness
Finish	:	Wood float

1.7.7.2 White Set Plaster - Plastering

Proportions :		3:1 hard finish gypsum plaster : lime putty
Application	:	Apply a skim coat direct to the background, 4 mm maximum thickness.
Finish	:	Steel trowel

1.7.8 PLASTERBOARD AND FIBROUS PLASTER LININGS

1.7.8.1 Sheet Linings - Plastering

Gypsum plasterboard : To AS 2588, and JIS, JASS and TCVN

Fire-resistant gypsum plasterboard : Gypsum plasterboard with a glass-fibre reinforced mineral core, formulated for additional resistance to fire exposure.

1.7.8.2 Installing Sheet Linings - Plastering

Gypsum plasterboard : (Including water-resistant, insulating, and fire-resistant types): To AS 2589, and JIS, JASS and TCVN.

1.7.9 PLASTERING SCHEDULES

1.7.9.1 Render Finishes Schedule - Plastering

<u>One coat render :</u>

Location	:	Refer to Finishes Schedule
Proportions :		4:1:16 cement : lime : sand
Finish	:	Wood float

<u>Set plaster skim coat :</u>

Location	:	Refer to Finishes Schedule

1.7.9.2 Sheet Linings Schedule - Plastering

Plasterboard ceiling lining

Location	:	Refer to Finishes Schedule
Lining type	:	Gypsum plasterboard
Sheets	:	Thickness : 13 mm and 16 mm
		Edge type : Recessed edge
Joint Finish	:	Flush joint
Fixing Method	:	Adhesive fixing and screw fixing

Moulded Plaster Cornice

Location	:	Refer To Finishes Schedule
Cornice type	:	Refer File Detail
Fixing method	:	Adhesive Fixing

1.8 DOORS

1.8.1 GENERAL

1.8.1.1 Scope - Doors

The work contained in this Section includes the supply, delivery and installation of metal door frames, timber doors, fire door and frame assemblies and roller shutters.

1.8.1.2 Approved Sub-Contractors - Doors

Obtain proprietary door and frame items specified in this Section from approved suppliers.

1.8.1.3 Samples - Doors

Supply two samples of each of the following where applicable:

(a) Sections proposed to be used for frames, louvres, slats and the like
(b) Joints made by proposed techniques
(c) Finishes to prepared surfaces
(d) Hardware items

The approved hardware samples will be made available for incorporation into the Works in locations to be identified by the Superintendent.

1.8.1.4 Guarantees - Doors

The guarantor agrees to rectify without cost to the Principal, faulty materials and workmanship and the consequences thereof including weather penetration, physical deterioration etc. for a period of 2 years from practical completion.

1.8.2 TESTS

1.8.2.1 Testing - Doors

Timber Doors : Test as specified in TIMBER DOOR TESTING - DOORS

1.8.3 MATERIALS AND WORKMANSHIP

Protect surfaces during the work under the Contract as necessary to prevent damage or defacement.

1.8.4 DOORFRAMES

1.8.4.1 Steel Door Frames - Doors

Frames assembled from steel sections, including necessary accessories such as buffers, strike plates, spreaders, mortar guards, fixing ties or brackets- cavity flashing and the like, with suitable provision for fixing specified hardware; pre-finished with protective coatings, built in or fixed to prepared openings.

Form from 1.2 mm or 1.6 mm thick steel sheet for metal door frames or fire door frames respectively, incorporating rebates or double rebates where required for side hung doors. Site assembly from "knocked down" components by mechanical methods, e.g. slot and lug joints. Hot dip galvanised and shop primed for the system specified in PAINTING.

Provide the following as required by the installation :

- Strike plate : Stainless steel strike plate with mortar guard.
- Buffers : Two resilient buffers.
- Cavity flashing : For external frames in cavity masonry in external walls only.
- Hinges : Weld in place or prepare frames for screw fixings.

Installation :

- Building in to masonry: By means of galvanised wire ties attached to stiles at 400 mm maximum centres. Build in and grout up solid as. specified in BUILDING-IN BRICKWORK.
- Building in to concrete : Power tool fixing at sills building in with standard wire ties and solidly grouting up frames.

1.8.5 DOORS

1.8.5.1 Timber Doors - Doors

To AS 2688. Prime timber doors as specified in “Priming dressed timber - Painting” on all surfaces, including top and bottom edges, before hanging.

1.8.5.2 Timber Door Testing - Doors

Provide satisfactory evidence in the form of a report from an independent testing authority, that doors of each AS 2688 ,and TCVN, JIS, JASS standard , type specified have passed the tests applicable to the door type specified in Appendices A, B, C and D of AS 2688, ,and TCVN, JIS, JASS standard.

1.8.5.3 Flush Doors - Doors

To the appropriate Section of AS 2688 ,and TCVN, JIS, JASS standard. Increase the width of stiles and rails above the standard as necessary for sliding door grooves, door closers, and the like. Provide additional frame members where necessary to take fastenings of hardware such as push and kick plates, or to frame openings for panels. Form rebates if required on edges of doors in solid matching edge strips.

Edge Strips	:	To As 2688 ,and TCVN, JIS, JASS standard, thickness 12 mm.
Door Thickness	:	35 mm generally, 40 mm for external doors and where door width exceeds 900 mm.
Solid Core	:	Blockboard core to AS 2688 Section 5, and TCVN, JIS, JASS standard, or Particleboard core to AS2688 Section 6 ,and TCVN, JIS, JASS standard.
Face Veneers	:	As specified in "Door type schedules":
Intermediate rail core	:	To AS 2688 Section 4 ,and TCVN, JIS, JASS standard, with facings of hardboard, particleboard, melamine or plywood with face veneers as specified in “Veneers-woodwork”.

1.8.5.4 Fire-Resistant Door sets - Doors

To AS 1905, Part 1 ,and TCVN, JIS, JASS standard.

Submit evidence of compliance with the Standard, at the required fire resistance rating, to AS 1905 Part 1, Clause 9 ,and TCVN, JIS, JASS standard.

Marking	:	To AS 1905, Clause 10 ,and TCVN, JIS, JASS standard.
Installation	:	To As 1905 Part 1, Clause 8 ,and TCVN, JIS, JASS standard.
Log Book	:	To AS 1905 Part 1, Clause 1 ,and TCVN, JIS, JASS standard.

Provide satisfactory evidence, in the form of a report from an independent testing authority, that the materials used in the construction of the fire resistant door sets have passed the relevant tests to AS 1530 Part 3 ,and TCVN, JIS, JASS standard for the early fire hazard indices specified. Shall consist of inert mineral materials containing no asbestos products. Shall have timber face veneers and edge strips as specified above.

1.8.5.5 Roller Shutters - Doors

Refer to the "Door Schedule" but generally comprising a flexible curtain sliding between vertical guides, raised or lowered by rolling or unrolling around a horizontal drum (barrel) mounted above the opening, inclusive of the necessary operating gear, hardware, and accessories, installed to the manufacturer's recommendations.

The curtain in its closed position shall be capable of withstanding a positive or negative pressure on the surface of not less than 600 Pa without impairment of its ability to function under ambient temperature.

Unless otherwise specified provide standard hardware and accessories purpose-made by the shutter manufacturer for the shutter system, including handles, shoot bolts, locks, limit stops, buffers, and the like.

1.8.6 DOOR SCHEDULES

1.8.6.1 Door Type Schedule - Doors

The Tenderer/Builder is referred to the "DOOR SCHEDULE" for particulars of door types and door locations.

1.9 HARDWARE

1.9.1 GENERAL

1.9.1.1 Scope - Hardware

The work contained in this section includes the supply, delivery and fixing of all door hardware as listed in the Schedules.

1.9.1.2 Definitions - Hardware

Direction of closing and faces of door : To AS 1909 Figs. 1 and 2, and JIS, JASS and TCVN.
Hinge side : The side from which the knuckles of butt hinges are visible when the door is closed.
Closing side : The side closing against the stop bead or rebate.
Outside of a room door including a stairwell door: The corridor or hall side.
Outside of a single communicating door between two rooms (When neither room is a corridor, communication passage or hall): The side from which the knuckles of butt hinges are invisible when the door is closed.
“Right hand” : When the closing edge of the door is to the right when viewed from the outside: Vice Versa for “left hand”.

1.9.2 MATERIALS AND WORKMANSHIP

1.9.2.1 Installation - Hardware

All hardware components and fixings to be of non-ferrous materials. Install hardware to manufacturer’s recommendations. On completion leave hardware clean, undamaged, in working order, and lubricated where appropriate with the correct lubrication. Install hardware with fixings appropriate to the item and of adequate gauge and length to provide firm fixing. Match exposed fixings to the material fixed.
During the work under the Contract protect hardware as necessary to prevent damage including staining, corrosion, scratching or other defacement. Obtain and furnish to the Principal the Manufacturers’ printed recommendations for the maintenance of the hardware items installed.

1.9.3 LOCKS, LATCHES

1.9.3.1 Locks Generally - Hardware

Fabricate locks and latches from non-ferrous materials, free from flaws and defects, with parts firmly joined, and working parts accurately fitted to smooth close bearings, free from rattle or excessive play, appropriately lubricated. If mortise locks or latches are specified to rebated doors, provide purpose-made rebated pattern items. Locks specified for sliding doors shall have a suitable bolt action of the expanding type in which a pair of claws automatically extend vertically into the staple; or approved equivalent. Provide special heavy pattern non-ferrous springs in locks or latches which are specified to be fitted with non-spring-loaded lever handles.

1.9.3.2 Locks : Definitions - Hardware

For the purpose of this specification, the following definitions shall apply :

- Latch : An appliance for fastening a door, gate or the like, which catches automatically when the door closes, and is released by a hand operator (knob, lever handle, turn-button or the like item of fitted door furniture). Hand operation may be restricted for particular purposes (see combination lock, privacy latch, night-latch, vestibule lock).
- Lock : An appliance for fastening a door, gate or the like, which required a key to open
- Combination lock: Combines the functions of lock and latch. The hand operation of the latch may be prevented or released by key or snib. Prevention requiring key to release converts the latch into a lock.
- Deadlock: A lock or latch in which the bolt can not be retracted by end pressure, or by the operation of knobs or the like fitted furniture, unless released by key or snib.
- Double deadlock : A deadlock which can be released only by key.
- Automatic lock : A lock in which the bolt is automatically thrown by a trigger mechanism
- Rimlock (latch) : Lock or latch with a casing designed for fixing to the surface of the door or gate.
- Mortise lock (latch) : Lock or latch designed to be fixed into a mortise or boring in the closing or lock stile of the door or gate.
- Knobset : Mortise lockset or latchset with integral knob furniture, and with keyways, snib buttons, and the like, housed in the knobs.

<u>Functional Types :</u>

- Passage latch : Plain latch. Hand operators (knobs or levers) free at all times.
- Privacy latch : Hand operation prevented or released by inside snib. May include external emergency release slot for screwdriver or coin (“Bathroom latch”).
- Exit latch : Internal hand operator always free. External hand operator prevented or releases by inside snib.
- Night latch nob : Can be opened from outside by key only. Opening from inside by know or snib turn button (“Night latch”), or no means of opening from inside (“lock up shop nightlatch”).
- Vestibule lock : Combination lock in which the inside hand operator is always free.
- Closet latch : Plain latch. Hand operator on outside only.
- Closet lock : Automatic latching lock opened by key only, from outside.
- Budget lock : A bolt operated by turning a follower with a square or hexagonal section key

1.9.4 KEYING

1.9.4.1 Keys - Hardware

Supply keys to all locks. Arrange for the manufacturer or supplier to deliver Grandmaster and master key direct to the Principal. Deliver all other keys to the Principal upon Practical Completion.

Code stamp keys. Code stamp lock cylinders in an approved location. Supply each key with a purpose-made plastic key label legibly marked to identify the key, attached to the key by a metal ring.

All cylinder or pin-tumbler locks shall be nickel alloy, not brass and capable of being master keyed and grandmaster keyed as specified, and of future extensions if required. Key cylinder or pin tumbler locks to the groups scheduled in the “Door schedule”.

Obtain from the lock manufacturer or supplier, and furnish to the Principal, a record of the master keyed and grandmaster keyed as specified, and of future extensions if required.

A “project” or “construction” key may used only if approved, and if used shall be rendered inoperative upon Practical Completion. Otherwise any cylinders installed during construction shall be replaced immediately before Practical Completion.

Unless otherwise specified, supply keys in the following quantities :

- Grandmaster keys : 1 keys.
- Master keys : 2 keys.
- Locks keyed to differ : 2 keys per lock.
- Locks keyed alike : 2 keys per lock.

1.9.5 DOOR FURNITURE

1.9.5.1 Door Furniture Sets - Hardware

If an item of door furniture is referenced elsewhere (for example in the Door schedule) in the plural (e.g. “knobs”), provide the item as a paired set, one to each side of the door. If referenced in the singular, provide a half set. Provide matching blank plates opposite half sets where appropriate.

1.9.5.2 Lock and Latch Furniture - Hardware

Lock and latch furniture shall be suitable for use with the lock or latch to which it is installed. Mount knobs and lever handles on roses or plates of matching material and finish. Lever handles shall have integral springs to counter-act sag.

Provide keyways, snib turnbuttons, cut-outs for lock cylinders, and the like, as required by the lock type. Provide separate matching keyhole plates, escutcheons for cylinder locks, snib turnbuttons, and the like, as required by the lock type.

Provide concealed fixing to exterior plates and roses, by means of metal thread screws passing through the door from inside into tapped blind holes in the plate, or by an equivalent method.

1.9.5.3 Door Stops - Hardware

Provide door stops where doors open to contact surfaces at 90^0. Fix the door stop on the floor or as directed to prevent the door furniture striking the wall or other surfaces.

1.9.6 HARDWARE SCHEDULES

The Tenderer/Builder is referred to the “DOOR SCHEDULE” for particulars and position of hardware sets.

1.10 WINDOW

1.10.1 GENERAL

1.10.1.1 Scope - Window

Natural anodized aluminium windows and doors, sky lights, portico roof glazing, frameless glass walling.

1.10.1.2 Approved Sub-Contractors - Windows

Obtain the items specified in this Section from approved suppliers.

1.10.1.3 Shop Drawings - Windows

Supply two copies of shop drawings showing the following information where applicable to the window installation :

(a) Layout (sectional plan and elevation) of the window assembly.

(b) Full size sections of members.

(c) Methods of assembly.

(d) Methods of installation, including fixings, caulking, flashing.

(e) Provision for vertical and horizontal expansion.

(f) Junctions and trim to adjoining surfaces.

(g) Glazing details including method, tolerances, rebate depths, edge restraint.

1.10.1.4 Samples - Windows

Requirement : Supply two samples of each of the following where applicable to the window installation :

(a) Sections proposed to be used for frames, sashes, louvres, slats and the like.

(b) Joints made by proposed techniques.

(c) Finishes to prepared surfaces.

(d) Colour range samples from pre-finished production material (e.g. anodized or organic coated extrusions and sheet). When the colour selection has been made, supply five sets of samples showing the approved colour range.

(e) Hardware items : Standard hardware plus security locks, security locks, stainless steel hinges to glazed doors and patio sliding door locks to balcony and terrace sliding doors.

1.10.1.5 Prototypes - Windows

Install a prototype of the window system, fully glazed, finished as specified, and incorporating at least one example of each component in the system, including operating hardware, locks, keys, flashing, caulking, sealing and the like. Approved prototypes in appropriate locations may form part of the completed installation; otherwise remove all traces upon completion of the Works.

1.10.1.6 Guarantees - Windows

5 years from practical completion against faulty materials and workmanship and the consequences thereof including weather penetration, air infiltration, physical deterioration, etc.

1.10.2 TESTS

1.10.2.1 Testing - Windows

Provide satisfactory evidence in the form of a report from an independent testing authority that windows of each type specified:

Have passed the tests applicable to that type specified in AS 2047 Section 5 or AS 2146 Section 3, and JIS, JASS and TCVN.

Comply with the requirements of the specified window rating.

Are finished with specified coatings of not less than the specified thickness.

1.10.3 MATERIALS AND WORKMANSHIP

1.10.3.1 Fabrication - Windows

Make junctions so that no fixings, such as pins, screws, pressure indentations, and the like, shall be visible on exposed faces. Moving parts shall operate freely and smoothly without binding or sticking, at correct tensions or operating forces. Protect surfaces during the work under the contract as necessary to prevent damage or defacement. Provide a temporary coating to finished metal or plastic surfaces, and remove all traces on completion of the Works.

1.10.3.2 Installation - Windows

Install the windows by methods which ensure that neither the window frame nor the fixings will carry building loads, including loads resulting from short or long term deflection of slabs or beams.

Metal windows built in to masonry by means of anchor brackets and attachments to AS 2047 Rule 2.3 and AS 2048 Rule 8, 9, 10 and 11, and JIS, JASS and TCVN.

1.10.3.3 Glazing - Windows

Supply the window installations pre-glazed unless otherwise specified. Glass types and thicknesses shall comply with the relevant standards and safety codes for the required locations and pane sizes. Glass generally to be Terrain Category 2.

1.10.3.4 Finishes - Windows

50 microns thick heavy powder coat to selected colour to all metalwork in this trade.

1.10.4 HARDWARE

1.10.4.1 Hardware Generally - Windows

To AS 2047 Rule 2.5 and 3.6, and JIS, JASS and TCVN.

Unless otherwise specified, provide the windows with standard hardware purpose-made by the window manufacturer for the window system, or recommended by the window manufacturer for the purpose. All hardware to be non-ferrous. Where window hardware included key-operated locks, supply keys master-keyed for each residential unit.

1.10.5 WINDOW ASSEMBLIES

1.10.5.1 Openings - Windows

The following terms are used to refer to window opening types (sash, louvres) :

Double hung (vertical slide).

Horizontal-slide (including sliding glazed aluminium framed doors)

Projecting :

(a) Casement (side hung by hinge or stay)

(b) Awning (top hung by hinge or stay)

(c) Hopper (bottom hung)

Locate opening sash and fixed panels in windows as shown on the Drawings.

1.10.5.2 Aluminium Assemblies -Windows

To AS 2047 and AS 2048, and JIS, JASS and TCVN.

1.10.6 JUNCTIONS

1.10.6.1 Junctions with Building - Windows

Install flashings, drips, storm moulds, caulking, pointing or the like so that water is prevented from penetrating the building between the window frame and the building structure under the prevailing service conditions, including normal structural movement of the building.

1.10.6.2 Flashings and Weatherings- Windows

Flashings and weather bars shall be compatible with the other materials in the installation, and coated with a non-staining compound where necessary. Include the non-staining property in any guarantee required of the assembly.

1.10.6.3 Jointing Materials - Windows

If the window frames are to be caulked or pointed to the building structure, use jointing and pointing materials, including sealants, mastics, primers, gaskets, compressible fillers and the like, of the types shown on the Drawings, as recommended by the material manufacturers for the location and function, compatible when used together, and non-staining to finished surfaces. Do not use bituminous materials on absorbent surfaces.

1.10.6.4 Weather Seals- Windows

Polypropylene pile bonded into polypropylene backing, low friction silicone treated and ultraviolet stabilised. A pile weather seal with a central polypropylene fin bonded into the centre of the backing and raised above the level of the pile.

1.10.7 WINDOW SCHEDULES

1.10.7.1 Generally - Windows

The Tenderer/Builder is referred to the "Window Schedule" on Architectural Drawing for type, size and locations of windows.

1.11 GLAZING WORK

1.11.1 GENERAL

1.11.1.1 Scope - Glazing

This section covers glass and glazing to aluminium windows, frameless glazed walls and mirrors to bathroom. The tenderer should note that all glazing to be Terrain Category 2.

1.11.1.2 Guarantees - Glazing

Provide a five year written guarantee covering faulty materials and/or workmanship and the consequences thereof, including leaks, surface deterioration caused by weathering, breakage, etc.

1.11.2 DESIGN

1.11.2.1 Glass Thickness Design - Glazing

Determine the glass thickness as in accordance with AS 1288 ,and TCVN, JIS, JASS standard and the design wind pressure. Terrain Category 2.

1.11.3 MATERIALS

1.11.3.1 Glass - Glazing

To BS 952, Part 1, ,and TCVN, JIS, JASS standard of approved manufacture, and of kinds and grades specified or show on the drawings. Free from defects which detract from appearance or interfere with performance under normal conditions of use.

All glazing shall be of a type and thickness suitable for the work, best quality and shall be the kinds suitable for the purpose and grades specified or shown on the Drawings, and shall be free from cracks, scratches, bubbles, blisters, distortion and other defects which will interfere with the appearance or service, and shall be as follows:

- Clear glass, 6mm thick : for use in all windows and all general glazing screen with all framing in or supporting by 600mm footing wall.
- Laminated glass, 6mm thick : for use in doors with frames as specified in the Drawings.

1.11.3.2 Mirrors - Glazing

Glass of silvering quality backed with a reflective surface layer and protective coatings.

- Glass type : Clear float of silvering quality.
- Glass Thickness : 6 mm
- Edge finish : Rounded and polished.

1.11.3.3 Glazing Materials - Glazing

To AS 1288, Part 2, ,and TCVN, JIS, JASS standard (including putty, glazing compounds, sealants, gaskets, glazing tapes, spacers, setting blocks, compression wedges, and the like), appropriate for the conditions of application and the required performance, and complying with the recommendations of the manufacturer of the glass or glazing system, and as necessary to complete the installation.

All glass shall be set on neoprene packers fully bedded and sealed into all aluminium extrusions with silicone.

1.11.4 WORKMANSHIP

1.11.4.1 Workmanship - Glazing

To AS 1288, Part 2 ,and TCVN, JIS, JASS standard, the completed installation shall be left completely waterproof and weatherproof. Use methods such that building movements resulting from wind and thermal effects are not transferred to the glass.

1.11.4.2 Marking - Glazing

Use a soluble marking compound, and remove all traces on completion. Do not use lime or advertising stickers.

Permanent marking of safety glasses: To AS 2208 ,and TCVN, JIS, JASS standard.

Toughened safety glass: Do not cut, work or permanently mark after manufacture.

1.11.4.3 Safety Marking of Glass - Glazing

Permanently mark transparent glass in doors, side panels, and elsewhere where it might be mistaken for a doorway or the unimpeded path of travel, in the positions shown on the Drawings and by an approved methods.

The glazed wall to the main entrance shall have, on both sides of bottom fixed panels including doors, safety markings comprising 30 mm diameter polished stainless steel safety dots spaced at maximum 150 mm centres adhesive fixed in corresponding parts, perfectly straight and level with an adhesive recommended by the glass suppliers. Dots shall be fixed at heights as directed by the Architect.

1.11.4.4 Cleaning and Replacement - Glazing

On completion replace damaged glass. Clean and hand polish all metalwork and glass, remove all handling and installation marks, remove all protective coatings, and hand over in perfect condition.

1.11.4.5 Glass Installation Methods - Glazing

Standard : To AS 1288, Part 2 ,and TCVN, JIS, JASS standard.

Special Glasses : Including double glazed units, coloured and heat-absorbing glass such as body-tinted and surface modified glass, ceramic enamel glass, toughened glass, laminated glass, and the like. Follow the recommendations of the manufacturers of these glasses in the addition to requirements of AS 1288 ,and TCVN, JIS, JASS standard.

Laminated Glass : Use glazing materials which do not cause deterioration or discolouration of the interlayer.

1.11.4.6 Fixing Mirrors - Glazing

Fix by chrome domed headed screws drilled and plugged to brickwork. All joints between bench tops and mirrored panels sealed with clear structural grade silicone sealant.

1.12 SUSPENDED CEILING

1.12.1 GENERAL

1.12.1.1 Scope - Suspended Ceilings

This Section includes all materials and work required to install proprietary ceiling suspension systems and applied linings comprising sheet plasterboard, and fire resistant plasterboard all as shown on the drawings.

1.12.1.2 Definitions - Suspended Ceiling

- Ceiling : The material forming the main body of the soffit of a ceiling, consisting of sheets, strips, panels or tiles, together with any other material which may be applied.
- Concealed System : Suspended ceiling system on the soffit of which the supporting system is not exposed to view.
- Corridor Supporting System : Suspended ceiling system in which primary support members occur only at walls. The ceiling, or ceiling plus secondary members, spans between the primary support members.
- Supporting System : The tension members (hangers) and the framework of primary or secondary support members that carry the ceiling.
- Suspended Ceiling System : A ceiling and its supporting system, suspended from a supporting structure.

1.12.1.3 Maintenance Manual - Suspended Ceiling

On completion, furnish two copiers of a manual, suitably bound, of recommendations for the care and maintenance of the ceiling, and operating instructions for demounting where applicable.

1.12.2 PERFORMANCE

1.12.2.1 Dimensional Tolerances - Suspended Ceilings under Dead Load

To AS 2785, and JIS, JASS and TCVN

1.12.2.2 Strength - Suspended Ceilings

Ceiling System Generally : To AS 2785, and JIS, JASS and TCVN

1.12.2.3 Fire Resistance - Suspended Ceilings

For each fire resistant property or rating specified, furnish a test report to AS 1530, and JIS, JASS and TCVN from an independent testing authority showing that the ceiling system or material, as applicable, has attained the specified property or rating. The ceiling system shall not contain substances which when subject to fire conditions will emit excessive smoke or dangerous fumes.

If the specified fire resistance rating is a requirement of the building regulatory authority, satisfactory evidence of that authority´s acceptance of the suspended ceiling system may be submitted as alternative proof of the attainment of the specified rating. Modify the installation without extra charge if necessary to satisfy the regulatory authority that the system complies with the specified rating.

1.12.3 PANELS, TILES, SHEETS AND STRIPS

1.12.3.1 Sheet Plasterboard - Suspended Ceilings

Material	:	To AS 2588, and JIS, JASS and TCVN
Edge type	:	Recessed edge
Thickness	:	13 mm
Application	:	To AS 2589, and JIS, JASS and TCVN

1.12.3.2 Fire Resistant Plasterboard - Suspended Ceilings

Material	:	To AS 2588, and JIS, JASS and TCVN
Thickness	:	16 mm (two layers - overall 32 mm thick)

Fire Resistance Rating (Hours) : 1 hour

1.12.4 WORKMANSHIP

1.12.4.1 Installation - Suspended Ceilings

To AS 2785 Section 4, and JIS, JASS and TCVN.

Protect existing work from damage during the installation, and make good any such damage. Erect the ceilings level, on their correct alignments, and firmly fix so that under normal conditions there is no looseness or rattling of ceiling components. Avoid the faults described in Appendix B of AS 2785, and JIS, JASS and TCVN, by providing the relevant features there recommended. Fastenings shall not be visible in the finished ceiling.

1.12.5 STRUCTURE

1.12.5.1 Materials - Suspended Ceiling

To AS 2785 Section 2, and JIS, JASS and TCVN.

1.12.5.2 Support - Suspended Ceiling

Space support members as required by the loads on the system and the type of ceiling, and allow for the installation of service and accessories shown on the Drawings, including ductwork, light fittings, diffusers and the like. Do not suspend from services (e.g. ductwork) unless the service has been designed to accept the ceiling load.

Incorporate in the suspension system suitable and approved means of supporting bulkheads and similar non-horizontal surfaces and the adjacent ceiling.

1.12.5.3 Access Panels - Suspended Ceilings

Provide access panels in non-demountable ceilings at the rate of one per 10 m^2 of ceiling unless otherwise specified or shown on the Drawings. Each access panel shall match the ceiling panel in appearance and performance. Reinforce the back of the access panel by an approved means to prevent warping and facilitate handling. Provide each access panel with an approved identification mark.

1.12.6 TRIM

1.12.6.1 Trim Generally - Suspended Ceilings

Provide trim at junctions with other building elements and surfaces, e.g. walls, beams, penetrations, and the like, consistent with the style, materials and finishes of the ceiling system generally unless otherwise specified.

1.12.6.2 Trim to Plasterboard - Suspended Ceilings

Provide corner beads, casing beads, stop beads and the like, consisting of purpose-made sections of approved material and pattern.

1.12.6.3 Service Penetrations - Suspended Ceilings

Provide openings for, and fit the ceiling system up to, services elements, e.g. light fittings, ventilation outlets, detectors, sprinklers, and the like. Trim as specified in “Trim generally”.

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SECTION 2. ELECTRICAL WORKS

2.1 INTRODUCTION

This specification describes the technical requirements for the electrical installation for Building Works for the Waste Water Treatment Plant, Ho Chi Minh City, Vietnam.

Although each and every item may not be specifically mentioned in this specification, the electrical installation shall be completed in every essential detail. Any of the works which would reasonably, and obviously be inferred as necessary for the complete, safe and satisfactory operation of the installation as whole, whether or nor expressly described or specified, shall be provided and such work executed as part of the contract.

It is intended that equipment purchased be designed and manufactured overseas to a standard which has been proven in service and to be capable of reliable operation. Equipment that is still undergoing development is not acceptable. The component parts of the installation shall be standard products where possible so that prompt and continuous service and delivery of spare parts may be assured.

2.2 SCOPE OF WORK

The work to be carried out is the detailed design, manufacture, supply, delivery, installation, testing, commissioning and warranty of the electrical installation for the Building Works for the Waste Water Treatment Plant, Ho Chi Minh City. This work shall include:

(1) The distribution boards(lighting and power) , panel switchboards (PSs).

(2) The power and lighting cables from the distributions boards to the Luminaries, socket outlets, fans, air-conditioners.

(3) The drilling and tapping of the gland plates for the cable glands.

(4) The lighting final sub-circuits from the switchboards, including switches and switch wires, light fittings, emergency lights, exits signs.

(5) The power final sub-circuits from the switchboards, including power outlets and permanent connections to fixed appliances.

(6) The earthing and lightning system.

(7) The cable ladders, cables trays, conduits, flexible conduits, pipe ducts and trenches to support and protect all cabling.

(8) The Fire Alarm System.

(9) The “As-built Drawings and Maintenance Manuals”.

(10) Assistance as required for the other trades.

2.3 STANDARDS

The electrical installation shall comply with the latest editions, at the time of tendering, of the IEC–364, Electrical Installation Guide and the appropriate edition of the CP Code:1995 or equivalent standard approved by the Engineer .

2.4 AUTHORITIES' REQUIREMENTS

The electrical fire alarm installation shall comply with the requirements of the Local Authorities.

The Contractor shall assist the Engineer with relevant Authorities' approvals as required.

2.5 INSPECTION AND TESTING

The Contractor shall submit a schedule for tensing for the Engineer's approval.

(Refer to Clause "Commissioning", herein)

2.6 TENDER DRAWINGS

The tender drawings are attached in drawing schedule and form part if this specification: The architectural, structural and mechanical services drawings that may have been included with the tender drawings are for reference purposes. These drawings are subject to change.

The drawings show the position and layouts throughout the site. These are to be considered as diagrammatic only. Unless specifically dimensioned relative to others building elements, the exact location shall be ascertained from the Engineer prior to installation.

2.7 SHOP DRAWINGS

Shop drawings including plant and Equipment assembly, schematic wiring diagrams and layout arrangements shall be provided by the Contractor and approved prior to construction. The shop drawings for the cable trays, cables ladders, panels, lighting fixture system, lightning shall include full details including sizes, levels, exact routes, wall penetrations, sections showing cable sixes and configuration on trays ladders, ducts trenches and spare space.

Procedures for drawings shall be in accordance with the requirements of clause 1.3.5 in of the General Specification.

2.8 AS-BUILT DRAWINGS

Refer to Section 1: General Specification

2.9 MAINTENANCE MANUAL

The Contractor shall supply three (3) copies of instruction books describing the electrical installation in detail and including all wiring diagrams, full catalogue data including installation instruction, assembly instructions, detailed circuit diagrams, descriptions of the operation and maintenance. The contractor shall also supply, either incorporated in the instruction books, or as a separate item, three (3) copies of the spares manual, comprehensive lists of the components used, including commercial type numbers and the type numbers of commercially available equivalent components.

Preliminary documentation shall be delivered no later than one (1) month prior to Practical Completion. All deficiencies in the documentation identified by the Engineer shall be promptly rectified by the Contractor.

The maintenance manual shall include the following:

- Full technical data and installation instructions on all equipment
- Maintenance instructions
- Operation instructions
- Test procedures
- As-constructed drawings
- All test results
- Final load schedule.

The manuals shall be A4 size. The binding shall be strong with a durable vinyl cover, clearly labelled on the front and spine. Two ring binders are not acceptable.

All information shall be the manufacture's original printed data sheets.

2.10 BRAND NAMES

Where brand names or manufactures names are used in this Specification they are to be used with the intent of specifying quality, appearance and standard of finish.

Alternatives may be offered provided that where equipment offered is of other manufacture than that indicated in this specification then such alternatives shall be noted on the tender submission.

Under no circumstances will alternative manufactured items be considered unless they are noted at the time of tender.

2.11 EQUIPMENT AND MATERIAL

Equipment and materials used in the execution of this work shall be new and supplied in accordance with the requirements of the Specification.

All equipment shall be rated to operate with supply voltage limits (220/380v).

2.12 SAMPLES

The Contractor shall submit samples of all materials requested by the Engineer.

2.13 COMMISSIONING

Commissioning testing in the presence of the Engineer shall be carried out after the equipment has been installed and tested by the Contractor.

The commissioning tests carried out by the Contractor in the presence of the Engineer shall be consist of :

(1) Tests that are necessary to ensure that the equipment complies with the requirements of the Specification.

(2) Tests designed to demonstrate the reliability of the equipment.

(3) Earthing system and resistance to earth.

(4) Megger testing of all sub-main cables

(5) Phase rotation tests of the complete installation.

(6) Full tests of all emergency lighting.

(7) Illumination (Lux) levels produced by the lighting.

(8) Any other tests deemed necessary by the Engineer.

All commissioning tests shall be completed prior to Practical Completion.

All documentation, in clause ' Maintenance Manual ', shall be delivered prior to the commissioning test.

2.14 SERVICE AND INSTALLATION SITE CONDITIONS

The equipment shall be site rated suitable for operation in ambient conditions as follows:

Maximum temperature: $45^{O}C$

Minimum temperature: $5^{O}C$

Elevation : less than 1000m

Maximum relative humidity : 95%

2.15 VOLTAGE DROP

The voltage drop throughout the installation shall be less than 5% from the transformer to the light fitting, outlets and equipment.

2.16 RATING AND PERFORMANCE OF EQUIPMENT

All equipment which is to be supplied by the Contractor and details of such equipment which have not been covered by any specific rating or performance requirements in this Specification shall be an approved construction and suitable for the duty they are to perform.

For any type of equipment and accessory, the same manufacturer and range shall be used throughout the installation to maintain standardization, unless otherwise specified or approved.

2.17 EARTHING SYSTEM

The earthing system shall be provided by the contractor as detailed on the drawings.

Locations of underground services shall be confirmed before driving in the earth electrodes. Any damage to existing underground service shall be repaired as directed by the Engineer at the Electrical Installation Contractor's expense.

All copper components shall be high conductivity electrolytic cooper. The minimum single conductor size shall be cable $16mm^2$ PVC.

All stainless steel components shall be suitable for direct burial in the ground. The minimum conductor size shall be 25mm by 3mm stainless steel strap.

Jointing of earthing system shall be made using the " CADWELD " process utilizing the correct moulds to suit the joint, unless otherwise specified.

All fixings, bolts nuts, washers spring washers shall be stainless steel or equally corrosion resistant material.

The installation shall be earthed as required by IEC-364 (TN-C/ TN-S) and the local Supply Authority.

The building earthing system shall include the following:

(1) 5.25.8.1 Copper Plated earth electrodes, mechanically driven into the ground nominally 300mm below finished ground level.

(2) An external earth network comprising bare copper cables interconnecting the earth electrodes. The cables shall be Cadwelded to the earth electrodes. The cables shall be direct buried 600mm (min) below finished ground level. Provide a durable orange PVC guard regularly marked 'ELECTRIC CABLE' at 300mm below ground level other the earth cable.

(3) Stainless steel straps from the structural steel shall be Cadwelded to the external earth network. Earth stainless steel strap shall be screw fixed to the structural steel through holes drilled in the centre of the strap if above ground level. Preferably, the straps shall be welded to the reinforcing steel.

(4) The building earthing system shall be bonded to the Main Earth Bar in the L.V. Switch room with a minimum of two (2) green, yellow PVC Insulated conductors.

The main earth mat shall include the following:

(1) A minimum of 4 earth electrodes spaced at 6 meter, nominally 100mm level. The top of the electrode connection shall be accessible through a suitable earth pit cover. The electrodes shall be interconnected with bare copper conductors.

(2) Green/ yellow PVC insulated copper conductors shall be used between the final electrodes and the main earth bar in the L.V. Switch room, as shown on the drawing.

(3) The connections to the earth bars at the main switch room shall be made by inserting cables into lugs, soldering the lug to the cables and bolt fixing the lug to the earth bar so that the two earths remain electrically continuous.

(4) The testing of earth resistance of the earthing systems with a DC and 50Hz injected signal. The test results shall be included in the manuals. The tests shall be carried out after a two week no rain period.

Sub-circuit earthing shall include:

(1) An earth conductor shall be run to all light fittings, even when they are of completely non-metallic construction, so that the metallic light fitting may be substituted in the future.

(2) Earth final sub-circuit shall be provided with its own earth conductor originating from the same distribution board as that which feeds the sub-circuit.

2.18 DISTRIBUTION BOARDS (DBs) AND PANEL SWITCHES (PSs)

The contractor shall supply and install all the distribution boards including the L.V. distribution board(the indoor distribution boards & the outdoor distribution boards), and panel switches as designated the drawings.

The indoor DBs shall be 3mm aluminium construction, manufactured by a recognized manufacturer . They shall be supported from the floor.

The outdoor DBs shall be 3mm aluminium construction, manufactured by a recognized manufacturer. They shall be free standing on concrete plinths provided by the contractor. The paintwork shall be U.V. resistant polyester power, oven baked and suitable for withstanding climatic conditions.

Circuit Breakers, contactors, fuses and other components shall be manufactured by internationally recognizes manufacturers such as Mitsubishi, Hager, Square D or similar.

All busbars shall be tinned copper.

All switchboards shall be front access.

Install all the switchboards in position.

The process services switchboards and control panels shall be fixed to the floor at the bottom and the wall at the top with chemical sitting metal threaded fixings.

All switchboards shall be mounted level. Provided steel packers as required to level the boards. Panels shell be checked to ensure that all doors and catches operate correctly, and that modules rack freely into position.

Where floors have been finished before mounting the switchboards the Contractors shall level the boards as above and the seal, in an approved manner, the space between the switchboards and the floor.

Terminate all cables, providing cable glands and lugs.

The Contractor shall arrange for the cleaning out of the switchboards interior and associated equipment prior to commissioning. All openings shall be sealed to prevent access to vermin.

The Contractor shall clean polish the exterior of the switchboards and associated equipment just prior to Practical Completion.

The Electrical installation Contractor shall install the pit covers for the pits in the main switchboard room, where applicable.

2.19 MAINS AND SUB-MAINS

(1) The Contractor shall provide the mains and sub-mains cables as detailed on the drawings.

(2) The cable from the diesel generator set shall run on the overhead / cable ladder to high level cable entry the main switchboard.

The cables to the generator set shall be fitted with a vibration isolation loop with cleats to support the cable.

(3) The cabling to the outdoor distribution switchboards shall be buried underground, imbedded in clean washed sand, and spaced so as not to reduce the current rating.

(4) The cables within the building shall be supported on the cable tray or ladder throughout their entire length.

(5) Through joints in mains and sub-mains will not be permitted.

(6) All sub-mains shall be neatly run and grouped without any crossovers.

All cables shall be straight and parallel to trench or cable ladder sides.

2.20 FINAL SUB-CIRCUITS

The final sub-circuits shall be run on cable trays, trunkings or in conduit within the buildings, concealed wherever possible.

Switches grouped together to control lights connected to the sub-circuits shall be mounted under a common flush plate.

The circuiting of outlets is outlined on the drawings and the Contractor is to prepare detailed shop drawings.

The entire installation shall be balanced across the three phases, to the satisfaction of the Engineer, to evenly load the diesel generator.

The final connection to fans, air-conditioners to vibration or movement for maintenance shall be made with a short length of flexible conduit.

Cables shall be not be buried direct in render or run in the cavity of cavity walls, without mechanical protection.

All cabling shall be installed so that it is accessible in the future.

Final sub-circuits shall be PVC.

2.21 CABLE IDENTIFICATION

All cables shall be clearly numbered with cable sheath identified and each conductor shall be individually identified with a push-on type cable number or colour sleeve.

All cable identification and conductor numbers be unique throughout installation.

The numbering to be used shall be advised during the contract period. For tendering purpose the Tenderer shall allow all numbers to be four digits.

2.22 CONDUITS

Conduits indoor shall be PVC to IEC standard (BS6099 is reference) complete with purpose made fixtures and fittings.

Conduits outdoor or exposed to direct sunlight or surface mounted in machine rooms and work areas shall be H.D.G. Steel Class 4 to IEC standard (BS4568 is reference).

All conduits shall be erected before any cabling is drawn into the conduits.

Flexible conduits, conduits shall be PVC type, minimum size 20mm diameter and shall be terminated using a positive grip type termination.

Draw-in boxes shall be included in long runs of conduit such that draw-in points are not more than 20m apart.

All conduits shall be fixed in position with a spacer saddle securely fixed to the mounting surface in an approved manner. The spacer saddle shall support the conduit approximately 3 mm off the wall. Saddles shall be provided at 1m intervals.

The Contractor shall be responsible for determining routes and sizes of conduits unless these are already specified and for providing all necessary accessories even though such may or may not be indicated on drawings.

Maximum number of conductors in conduits

CONDUCTOR CROSS-SECTION (mm^2)	MAXIMUM NUMBER OF CONDUCTORS IN THE CONDUITS (mm)								
	20	25	32	38	50	63	75	90	100
1	10	18	31	45	-	-	-	-	-
1.5	10	14	25	35	-	-	-	-	-
2.5	5	9	16	22	38	-	-	-	-
4	5	7	13	18	30	47	-	-	-
6	4	5	10	14	23	36	48	-	-
10	3	4	6	9	15	22	32	44	50
16	2	3	4	5	9	14	21	28	37
25	-	-	3	4	7	11	16	22	28
35	-	-	2	3	5	8	13	18	23
50	-	-	1	2	4	6	9	13	16
70	-	-	1	1	3	5	8	10	13
95	-	-	1	1	2	3	6	8	10
120	-	-	1	1	1	3	6	8	10
150	-	-	1	1	1	3	5	7	9
185	-	-	1	1	1	2	4	5	7
240	-	-	1	1	1	1	3	6	6
300	-	-	-	1	1	1	3	4	5
400	-	-	-	-	1	1	1	3	4
500	-	-	-	-	1	1	1	2	3

Conduits shall generally be run vertically down from the cable tray above to the accessories.

Conduits shall be fixed to the building and structural steel works and shall not cross air space unless approved by the Engineer.

Different supply voltages shall be not be installed in the same duct or conduit.

All PVC conduits shall be cemented together with clear solvent in accordance with the manufacturer's recommendations.

Conduits shall change direction using manufactured bends and elbows. Heat setting of conduit is not permitted and any conduits heat set will be rejected and shall be replaced at the Contractor's expense.

An appropriate approved conduit coupling arrangement shall be provided and suitably fixed to conduits crossing structural expansion joints.

Conduits shall be so arranged that water is not ducted through them into the building.

Single lengths of conduit shall be used where the conduit run is shorter than 3m.

2.23 CABLE LADDER

Cable ladder inside the building shall be HDG Steel or aluminium cable ladder.

Only purpose-made bends, tees, rises, etc, shall be used. Site manufactured fittings will be rejected.

The cable ladder shall be supported to prevent sag or deformation when fully loaded with the maximum capacity of cables.

The cable ladder shall be supported on Unistrut channel and threaded rods provided by the Electrical Contractor. The rod shall be supported from a Unistrut beam clamps at ceiling level. Under no circumstances shall ladder supports be welded to the building structure.

All cables shall be securely fixed to ladder at intervals not exceeding 600mm. PVC cables shall be fixed using PCV cable ties.

Cable ladders shall be sized to provide adequate spacing of the cables so as to not effect the current rating and to provide space for the cable bending radii as recommended by the cable manufacturers.

The sharp edges of cable ladders shall be protected in an approved manner to prevent damage to the cable sheathing where the cable leaves the cable ladders. Generally cables shall sweet up and turn over the side of the cable ladder.

2.24 CABLE TRAY, TRUNKINGS

Cable tray, trunking shall be HDG Sheet steel, 16 gauge return edge type.

Bends, tees, rises, etc, shall be made using the specially manufactured components.

The cable tray, trunking shall be supported on Unistrut channel and threaded rods provided by the Electrical Contractor. The rod shall be supported on from a Unistrut beam clamps at ceiling level. Under no circumstances shall ladder supports be welded to the building structure.

The cable tray, trunking shall be supported to prevent sag or deformation when fully loaded with the maximum capacity of cables.

All cables shall be securely fixed to the tray at intervals not exceeding 600mm.

The sharp edges of the cable tray, trunking shall be protected in an approved manner to prevent damage to the cable sheathing where the cables leaves the cable trays . Generally cables shall sweep up the turn over the side of the cable trays.

2.25 PVC INSULATED CABLES

All cables shall be multi-stranded copper conducted V75 PVC 0.6/1KV insulate, minimum size 2.5sqmm(socket outlet), 1.5sqmm(lighting) unless otherwise specified.

The minimum conductor size given above should not be constructed to mean the minimum acceptable. Because of voltage drop limitations, the actual cable for some circuits may be required to be larger.

Cable insulation colours shall be as follows:

Single phase active	:	red (lighting)
		Yellow (socket outlet)
		Blue (power)
3 phase active	:	red, white and blue or red, yellow and blue
Neutral	:	black
Earth	:	green /yellow

Cables shall be run without joints from the circuit protection device to the points of use. Final sub-circuit cables , unless specified otherwise, shall be employed on the loop-in principle to all points and switches.

Cables shall be protected from direct sunlight and any other harmful substances.

2.26 CABLE TERMINATIONS

All cable terminations shall be carried out in an approved manner.

Cable conductors shall be cleaned prior to making termination.

Crimp type cable lugs shall be crimped using the lug manufacturers recommended crimping tools only.

After completion of laying of cables and making of all required joints and terminations, the cables shall be capable of satisfactorily with standing insulation resistance tests in accordance with the Standards for the type and size of cable.

If any of installations, either cable or joints box or boxes, breaks down under any such test, or otherwise fails to withstand the test voltage for the prescribed time, the installation will be deemed to be unsatisfactory by the Engineer and the faulty joint or joints are to be remade and /or the faulty section of cable replace with new cable or repaired. After such remaking of joints and / or replacing or repairing of cable, the installation shall be retested.

2.27 PHASE SEQUENCE

The phase sequence for the complete installation shall remain constant throughout and shall be demonstrated to the Engineer prior to Practical Completion.

The Contractor shall energize each phase individually from the temporary supply and the correct sequence shall be followed through to each of the distribution boards, multi-phase outlets, multi-phase connections and services switchboard and control panels.

2.28 ACCESSORIES

Flush polycarbonate accessories mounted on matching mounting block shall be used in all areas except external to the building. The accessories shall be standard electric white.

Surface mounted weatherproof accessories shall be used external to the building.

General purpose power outlets (GPO) shall be duplex, single phase universal style, three square pin, 15 ampere outlet and switch combination Special purpose outlets shall be rated as shown on the drawings and shall be labelled to denote the function. All outlets shall be nominally 30mm above finished floor level (excepted emergency light, exhaust fan)

Light switches shall be rate at 20amperees, and shall be mounted 1200mm above finished floor level.

The three phase outlets shall be 5 round pin outlet and switch combination unit, rates at 32 amperes and shall be supplied with a matching plug. The three phase outlets shall be indicated by investor.

All accessories shall be labelled to denote the distribution board and the final sub-circuit breaker supplying the accessories. The labels shall be machine engraved traffolyte fixed with approved adhesive in a position to be approved by the Engineer.

The Contractor shall confirm the location of all accessories relative to door swings, sinks etc, on site prior to commencing installation.

2.29 LIGHT FITTINGS

(1) All fittings shall comply with B.S. 4533 or equivalent standard approved by the Engineer and be marked accordingly as detailed in the specification.

(2) All light fittings shall be of the brand and type specified in the drawings .Alternatives may be proposed at the time of tender, however they must be equivalent or better quality than the fittings specified.

(3) All light fittings shall be adequately ventilated or otherwise designed to ensure that the internal temperature does not exceed the maximum temperature rating of the auxiliaries and to ensure that the surface temperature does not exceed 60^0C.

(4) Fluorescent lamps shall be mounted on a minimum of 70mm centres. There shall be a minimum of two (2) fixings for each fitting.

(5) Power factor correction capacitors of suitable size to correct the power factor to not less than 0.85 lagging shall be fitted into each fitting and connected in shunt across the AC supply. Such capacitors shall be specifically designed and constructed for the purpose.

(6) Ballast shall be low loss constant wattage type and conform with IEE . Tests and approved. Specifications in all respects. Where a single ballast is used to operate two discharge lamps it shall be purposely made for that application. Under no circumstances shall a ballast for operating a single lamp be used for operating two lamps of combined rating equal to that of the single lamp.

(7) Switch start fluorescent fittings shall utilise an Osram starter or equivalent standard approved by the Engineer.

(8) Internal wiring shall have a temperature rating of not less than 105^0C. Wiring shall be run in a neat and orderly manner, without stress, securely fixed and so placed that contact with ballast units is avoided.

(9) The terminal connector block, with each terminal of adequate size to accommodate a minimum of 3 x 7.85 conductors in each terminal, shall be fixed adjacent to the cable entry hole for the connection and looping of fixed wiring. An insulating barrier of synthetic resin bonded paper or equal approved shall be inserted between the terminal block and any metal part of the fitting on which the block is mounted. This barrier shall extend beyond the block by at least 50mm in all directions.

(10) An earth terminal with anti-spread facilities shall be provided adjacent to the connector block and shall be in effective electrical contact with the metallic body of the fitting and auxiliaries and any other exposed metal.

(11) Where diffusers are required the diffuser panel shall be removable in a convenient manner without the use of tools unless otherwise specified. Diffusers shall be of the pattern specified and shall be a mini mum thickness of 3 mm.

(12) Fluorescent lamps shall be high efficiency 25mm diameter with a through life output of no less than 300 lumens per 36 watts, and manufactured by on internationally recognized manufacturer.

The colour temperature of the lamp shall be as selected by the Engineer.

(13) Fittings for external use shall be of the totally enclosed weatherproof type, either having a galvanized finish or be of non-ferrous construction. Supporting brackets shall be hot dip galvanized or non-ferrous construction

(14) The light fittings shall be erected in straight lines, parallel and square.

(15) Prior to Practical Completion, all light fittings shall be thoroughly cleaned of all dust and debris so that they are handed over in a thoroughly clean state.

(16) Emergency lights and exit signs shall contain an integral battery, charger and inverter and shall be provided with an unswitched active. Some emergency lights fittings and all exits signs shall not be switched but serve as security lighting when all the other lights have been switched off.

Self contained, wall mounted, 2x20W tungsten halogen circular spot lamp emergency lighting luminaries of 3 hour duration as Thorn Industrial twin spot.

Self contained single side exit sign with 8 W fluorescent lamp for maintained emergency lighting for 3 hour duration .Steel construction as Thorn EFX3

(17) Metal Halide :

High bay industrial discharge luminaries with vertical lamp, prismatic glass/parabolic vented aluminium reflector. IP 54 body as Thorn Hipak2

Hang 1m under structure beam

2.30 CORROSION PROTECTION

All equipment provided shall be corrosion resistant

The bonding of dissimilar metals needs to be verified for galvanic corrosion prior to installation.

2.31 FIXINGS

All external fixing components shall be stainless steel.

All fixings shall be retained secure by a lock nut, two full nuts, star washer or spring washer, unless otherwise specified.

All equipment shall be securely mounted in a manner approved by the Engineer.

Explosive type fixings are not to be used.

Generally, chemical setting metal threaded type fixings shall be used where equipment is fixed to masonry or concrete.

2.32 WALL PENETRATIONS

(1) The Builder will provide the holes in the walls and floor slabs as require, providing shop drawings are prepared in advance of the building works.

(2) The Contractor shall make any additional wall penetrations required, and “make good” upon completion.

(3) Holes through masonry walls shall generally be made by removal of compete blocks or bricks. Where more than one block or brick is removed a suitably sized hot dip galvanized arch bar shall be fitted.

(4) All penetrations shall be sealed after the installation of the electrical services.

Details of the materials to be used and the method of sealing shall be submitted to the Engineer for approval.

2.33 SPARES

Provide 10% or a carton, whichever is the lesser quantity, of fuses and lamps, including pilot lamps, of each type and size used on the project. The spares shall be handed to the Engineer at Practical Completion in their clearly labelled cartons.

2.34 CIRCUIT SCHEDULES

The Contractor shall provided schedule holders adjacent to each distribution board. The holders shall be complete with a circuit schedule that shall be easily removable.

The Contractor shall be type the circuit details on each of the circuit schedule that shall be easily removable.

A glass framed single line schematic drawing, A2 size shall be provide at the Main Switch room.

2.35 LABELLING

All labelling shall be machine engraved traffolyte using a stencil guide.

The labelling shall be sized in according with the order of importance of the item being labelled.

Dymo tape, making pen, painted or similar type labelling is not acceptable.

2.36 LIGHTNING PROTECTION SYSTEM

The Contractor shall provide and install a lightning protection system, conventional type, as indicated in the drawings and in accordance with IEC standard (Singapore Standard CP33 is reference).

All components shall be purpose made by a reputable manufacturer such as W.I.Furse & Co Ltd, or equivalent.

Connections between lighting conductors shall be made with approved, bolted termination units where ever the joint is accessible. Non-accessible connections shall be made with exothermic welding methods.

2.37 LIGHTNING COLUMNS

Columns shall be of welded steel construction and tapered along their length.

The columns shall be of circular (rolled) or octagonal (folded) cross sectional shape.

Where sections must be joined to form longer lengths these are to be sleeved, bolted flanges are not acceptable in the mid-sections of the pole.

Columns shall be hot dip galvanize.

Foundation designs are to be provided by contractor and based on the soil conditions on site. There shall be submitted for approval.

Light fittings are to be of the type as nominated on the drawings. Each light fitting is to be provided with an individual fuse or circuit breaker at the base of the column.

A securable cover is to be provided for access to the base of the column.

Cabling is to be routed through the foundation in PVC conduit and into the cavity of the column base.

2.38 FIRE DETECTION AND ALARM SYSTEM

(1) The Contractor shall supply and install fire detection and alarm system in accordance with IEC standard , (BS5839 is reference).
IEC standard (or BS5839) specifies locations and the arrangement of detectors, alarm and manual call stations within the buildings.

(2) The Contractor shall also supply and install a Main Fire Alarm panel (MFAP) the Guardhouse. The MFAP shall comply with the requirements of IEC standard (Singapore Standard CP10 is reference).

(3) Provide a framed location diagram to represent the building and the zones within the building.

(4) Provide smoke detectors to the areas as shown on the drawings.

(5) Provide thermal detection to the areas as shown on the drawings.

(6) Provide manual call points in the locations shown on the drawings.

(7) Fire system cabling shall be run separately form other services.

(8) The cabling for detector circuits shall be not less than 1.5sqmm multi-stranded copper conductor PVC insulated cable run in PVC conduits.

(9) The cabling for the audible alarms (bells) shall be fire rated cable not less than 2.5sqmm multi-stranded copper conductor with a fire rate method of support.

(10) Provide an external fire alarm bell outside the front entrance to the guardhouse and wire to the fire indicator panel.

(11) Show the exact location of the end of line resistors on the as-constructed drawings.

(12) Provide one (1) spare thermal fire alarm detector of each type used
Provide one (1) spare smoke detector of each type used.
Provide six (6) indicator lamps and fuses of each size used.

(13) The Contractor shall provided the completed Certificate of installation and Commissioning of a fire Alarm System .

(14) The Contractor shall test the completed installation and provide the Certificate

(15) The Contractor shall test the completed installation and provide the completed Commissioning Test Report .

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SECTION 3. PLUMBING AND DRAINAGE

3.1 GENERAL REQUIREMENTS

(1) All pipework and fittings shall be selected by the Contractor strictly in accordance with this specification.

(2) Pipework, fittings, valves etc. shall refer to British Standards or equivalent standard approved by the Engineer .

(3) The Contractor shall supply all isolating valves and control valves as indicated on the drawings and as required for the proper and efficient operation and maintenance of the entire systems.

(4) All valves supplied shall be suitable for the working pressure and test pressure of the system as specified elsewhere in this Specification.

(5) All valves shall be packed with an approved packing which will be replaceable under pressure. Threads shall be coated with oil and graphite. Packing should be replaced when found deteriorated on site.

(6) The Contractor shall be responsible for the coordination and location of all piping and equipment with other Contractors before installation.

(7) The Contractor shall be responsible before commencing work for checking all levels and gradients shown on the drawings and for relating them to site conditions to ascertain that conditions on site permit execution of work as shown on the drawings.

3.2 PIPEWORK MATERIALS, VALVES AND ACCESSORIES

3.2.1 Water Supply Systems

(a)	Cold water pipe	Galvanised steel pipe
(b)	Irrigation water supply pipe at aboveground	Galvanized steel, medium grade with screwed joints and fittings
(c)	Irrigation water supply pipe at underground	Galvanized steel, heavy grade with screwed joints & fittings

3.2.2 Soil/Waste Water System

(a)	Above ground soil, waste, vertical stacks and horizontal branch pipes, whether or not inside pipe ducts, 80mm diameter to 150mm diameter.	Socket and spigot Cast Iron pipes
(b)	Same as above but 225mm diameter and above	Socket and spigot Cast Iron pipes .
(c)	Soil pipe for urinal concealed in wall and pipe duct	uPVC pipes and
(d)	Same as above but 80mm diameter and above.	uPVC pipes and

(e)	Waste pipes up to 50mm diameter	UPVC Pipe
(f)	Vent stacks larger than 50mm diameter.	UPVC Pipe
(g)	Vent and anti-syphonage pipes up to 50 mm diameter.	uPVC Pipe
(h)	Below ground soil pipes between Inspection Chambers	uPVC pipe

3.2.3 Unions, Joints Flanges and Fittings

3.2.3.1 General

(a) In all pipe systems, long radius bends and pitcher tees shall be used wherever possible. All fittings shall be suitable for a working and test pressure not lower than the specified for the pipework system concerned elsewhere in this Specification.

(b) Reduction in bore of pipe shall be generally made eccentric for horizontal pipes (to prevent air locking) and concentric taper fittings shall be fitted for vertical pipes unless specifically required to achieve the required space and invert levels.

3.2.3.2 Ductile Iron Pipes

(a) The joints shall be of screw on ductile iron flanges for pipes and cast on flanges for fittings. Jointing gaskets shall be of proper full faced coated by approved jointing compound on both faces.

(b) All socket and spigot ductile iron pipes and fittings of tyton joint. Jointing method shall be in accordance with the manufacturer's recommendation.

(c) All ductile iron pipes and fitting shall be metallic zinc coated externally specification and final bitumen material coated. Flanged pipes and fitting shall be cement lined internally while socket and spigot pipes and fitting shall be bitumen material coated.

3.2.3.3 uPVC pipes

(a) All uPVC pipes shall be jointed with sockets and fittings and as recommended by the PVC manufacturer or as a minimum standard solvent welded .

(b) Solvent welding shall be used for all pipework, particular attention must be paid to preparation. Abrasive paper and spirit cleaner must be used. When applying solvent, heat shall be avoided as the cement may dry before chemical bonding between the two surfaces is completed. Mating surfaces shall be turned for even spread of the solvent. Excessive cement shall be wiped off quickly.

(c) Flanged joints shall be used where solvent welding is not practicable and for the connection of valves and at locations to facilitate dismantling. Factory cut neoprene ring gaskets with approved jointing paste shall be used between flanges. The jointing medium must be in accordance with manufacturers recommendation.

3.2.3.4 Galvanized Steel Pipes .

(a) Screw joints shall be used except for connection to cast iron pipes where joints shall be made by molten lead joints. All fittings shall be beaded.

(b) No welded joint shall be allowed

(c) Union Joints shall be used for joints subject to disconnection for future maintenance at a maximum distance of 6m and at connection to equipment.

3.2.3.5 Cast Iron Spigot and Socket Pipes

(a) All joints to be lead caulked in accordance with this specification.

(b) Except for mechanical joints, joints for cast drainage pipework generally shall be made using molten lead and the minimum depth & weight of lead per joint for the various sizes of pipes shall be as follows:

Internal Dia of Pipe (mm)	Dept of Gaskin in Joint (mm)	Weight of Lead per Joint (mm)
50	32	1.00
75	32	1.50
100	32	2.00
150	38	2.00
225	38	2.50
300	38	4.25
375	38	4.50

The spigot shall be cantered in the adjoining socket by tightly caulking in sufficient turns of gaskin to achieve required depth given above. Molten pig lead shall then be poured in to fill remainder of the socket. The lead should be solidly caulked, with suitable tools to make up for the shrinkage of the molten lead on cooling.

(c) Cold caulking compound may be used in individual cases for jointing cast iron spigot and socket pipes together which shall be at the discretion of the Engineer. Depths of gaskin shall be the same as that indicated for run lead joints.

(d) Accesses/ Cleaning eyes shall be provided at the base of all stacks, opposite joints, on bends and elsewhere required whether shown on the Drawings or not and in such a position that they can be conveniently inspected and cleaned at all times.

(e) Cleaning eyes and access covers shall be fitted with neoprene gasket and brass bolts.

(f) Cast iron lead caulked caps should be allowed for future drain pipe connections wherever indicated on the drawings.

3.2.4 Isolating Valves and Cocks

3.2.4.1 General

The Contractor shall supply and install all isolating valves and control valves as indicated on the drawings and as required for the proper and efficient operation and maintenance of the entire systems.

All valves supplied shall be suitable for the working pressure and test pressure of the system as specified elsewhere in this Specification.

All valves other than automatic control valves shall be full line size.

Each valve shall have a purpose made reference number plate or label engraved or stamped indicating the manufacturer's catalogue number, pressure and temperature ratings. Valves shall be arranged so that clockwise rotation of the spindle will close the valve. Plastic Dymo labels are not acceptable.

All valves and accessory material necessary in the piping shall be furnished, whether or not shown on drawings as follows.

All valves shall be packed with an approved packing and threads shall be coated with oil and graphite. Packing should be replaced when found deteriorated on site.

Where possible all valves shall be located at convenient positions or operation from the floor with valve stems upright.

Valves that are flanged shall have flanges to the Table specified for the pipework.

The standard of valves and cocks shall comply with the current local water supply company and the following requirements.

Stainless steel 316 positioner shall be provided to indicate the open/close status of catch valve on the incoming mains to water tanks. Isolating valves shall be provided to isolate the incoming mains, water tank outlets, pumps, main distribution pipes.

3.2.4.2 Isolating Valves

All isolating valves shall be suitable for the pressure ratings specified elsewhere in the Specification.

(a) Cold Water Systems

(i) Up to and Including 50 mm Bore :

Full way gate vale of bronze body construction, wedge and valve seat shall be in bronze, non-rising spindle and screw collar in high tensile bronze. Valves shall have screwed female ends for taper treads.

Above 50 mm Bore :

Full way gate valve of bronze body construction, bolted bonnet, wedge and valve seat in bronze, non-rising spindle and screw collar in high tensile bronze.

(ii) Thermostatic mixer with chromium plated finish provide water controlled temperature 300C - 500C with a locked control for ablutionary purposes as indicated on the drawings. Mixers are virtually instantaneous shut-off in event of cold water failure.

Standard connections are hot water entry on the left, cold right, bottom outlet, when facing the mixer (All inlet and outlet sizes shall refer to the drawings indicated).

3.2.4.3 Stop Cocks/Valves

Stop valves/cocks shall be installed as shown on the drawings to isolate single fittings or groups of fittings. The stop cocks in the fresh water system shall be loose jumper type. Stop cock in the flush water system shall be in PVC and suitable for use with sea water. Samples shall be submitted for approval before ordering.

3.2.4.4 Regulating Valves

Regulating valves shall be installed as shown on the drawings. Regulating valves in cold and hot water systems shall have gunmetal body with screwed female connections for sizes up to 50 mm bore and flanged connections for valves above this size.

3.2.4.5 Bib Taps for Cleansing Purpose

Bib taps shall be provided for cleaning purpose. The bib taps shall comprise a vacuum breaker and suitable for use with rubber hoses with female threaded connection and stainless steel lockable box. The taps shall be chrome plated brass. Pad lock with two sets of key shall be provided.

3.2.5 Tank Fitting and Covers

(1) Cast iron puddle flanged tank connectors with cement line shall be provided for water tanks for connection of inlets, outlets, drains, overflow and vents. Flanges of all fittings shall be drilled and shall be set into position by the Contractor prior to concreting.

(2) Gunmetal puddle flanged tank connectors shall be provided for non-potable and potable water tanks.

(3) Double sealed cast iron covers with lockable facility, lock and keys shall be provided for all water tanks.

3.2.6 Floor Drains

(1) Floor drains shall be provided as shown on the Drawings.

(2) All drains with 80mm water seal shall be provided.

(3) All floor drains inside kitchens, bathrooms, toilets and public areas shall have chromium plated brass gratings to match the floor finishes. Fixing screws shall be of stainless steel or chromium plated brass flat head counter-sunk type.

(4) Floor drains inside plant rooms shall have cast iron grating fitted with stainless steel flat head counter-sunk screw.

3.2.7 Termination of Soil/Waste Vents

All soil/waste vent pipes shall be terminated above roof level as shown on the Drawings. A copper wire vent balloon shall be securely fixed to the open ends of all vent pipes. An approved lead weathering "slate/apron" shall be fitted with minimum upstand of 150 mm.

3.2.8 Clean Outs

(1) The Contractor shall provide where shown and as required, types and sizes as scheduled, floor and wall clean outs with cover plates in finished areas.

(2) All clean outs shall be easily accessible and shall be leak-proof.

3.3 PIPEWORK INSTALLATION

3.3.1 General

(1) Before commencing work, all levels and gradients of connecting pipeworks shall be checked to ascertain that conditions on site permit execution of work.

(2) The Contractor shall note the restricted space available in certain service ducts and the absolute necessity to ensure that all pipework is installed in the correct sequence, manner and position to ensure that operation of all valves and maintenance is possible.

(3) All reductions in pipe sizes shall be made using approved standard reducing fittings. Reducing bushes shall not be used without approval. Connections between lengths of pipes shall be made using standard fittings.

(4) All copper and galvanized steel pipes and fittings where buried in walls or slabs, or installed in direct contact with concrete, the pipework shall be bitumen- coated and wrapped with Denso tape or other suitable materials before installation.

(5) All pipework in the pump room, plant rooms, and on roof level shall be installed with flanges or unions at intervals not exceeding 6m for ease of dismantling.

(6) Changes in direction of pipes shall be made with long radius bends, or elbow. Under no circumstances, the pipes shall be bent without the use of fittings.

(7) All pipe runs when not installed underground or in ducts shall be concealed as far as possible by careful positioning or shall be chased into walls, laid in screed etc, or as directed by the Engineer .

(8) All pipes passing through wall tiling and exposed to sight shall be provided with chromium plated wall flanges plugged and screwed to the wall.

(9) Before concreting, the underground pipes and the floor shall be wetted down. Concrete shall be placed evenly on the entire width of the bedding and to within 25mm of the bottom of the pipe then without stopping, it shall be placed gently on one side of the pipe only and carefully worked under the pipe, ensuring that there is no void left below the pipe. It shall then be brought up equally on each side of the pipe to the required finished height, care must be taken not to force the pipes off their supports. The concrete and pipes shall then be damp until backfilling.

3.3.2 Pipe Supports

(1) All pipework fittings, valves, connections, etc. shall be efficiently supported and bracketed. All pipework shall be supported at intervals not greater than the following on straight runs; and additional supports shall be provided at bends, valves, etc..

Galvanized Steel, Ductile Iron and Copper

Nominal Bore of Pipe in (mm)	Intervals in Meters	
	Vertical Pipes	Horizontal Pipes
15	1.5	0.9
20	1.5	0.9
25	1.8	1.2
32	1.8	1.2
40	2.1	1.5
50	2.1	1.5
65	2.4	1.8
80	2.4	1.8
100	2.4	1.8
125	3.0	1.8
150	3.0	2.4
200	3.0	2.4
225	3.0	2.4
300	3.0	2.4
375	3.0	2.4

uPVC Pipes

Nominal Bore of pipe in (mm)	Intervals in Meters	
	Vertical Pipes	Horizontal Pipes
15	0.8	0.6
20	0.8	0.6
25	1.2	0.6
32	1.2	0.6
40	1.2	0.6
50	1.8	0.6
65	1.8	0.9
80	1.8	0.9
100	1.8	0.9
150	1.8	0.9

(2) All supports for ductile iron, cast iron, galvanized steel and PVC pipe shall be ferrous. Supports for copper pipes shall be split type brass pipe rings (Details shall be submitted with the tender). Support pipes above ground with brackets, etc. cast in concrete piers at each joint and intervals as specified. For pipes run below ground, piers shall be formed of 1:3:6 concrete, minimum area 150mm x 300mm and depth 450mm min below ground. Pier width shall generally be 150mm wider than the total width of pipes supported on top of it.

(3) All pipes supports shall be of such design and type to allow for the removal of any pipe section without the necessity of disconnecting other adjacent pipes.

(4) Where Pipes Rings are used, they shall be split pattern with top and bottom bolts, and with the top ears carried clear of the insulation. For horizontal pipes, the ring boss, where rocking movement of the pipe ring is expected, shall have spherical seating washers.

(5) In all plant and pump rooms discharge pipework from pumps, and all pipework where vibration could be transmitted to the building structure, shall be supported with brackets having a tough rubber lining in contact between the bracket and the pipe or shall have specially designed anti-vibration hangers/supports.

(6) The Contractor shall be responsible for building-in of all supports, etc., required for the work. The Contractor shall allow for using "HILTI Redhead Bolt Fixings" or approved equivalent for cutting away and building in of brackets in brickwork, etc., as required. The Contractor shall particularly note that it may not be possible to fix the bolts directly above pipes and cantilever or sling type supports shall be used where required.

(7) PVC. pipework shall be adequately supported such that no deflection of pipe occurs and supports shall be provided at all joints.

(8) The Contractor shall provide adequate pipe anchors in order at the ends or turning points of PVC. pipes in order to prevent fracture of the pipe resulting from water hammer. Anchor points shall be fixed in a manner that the inertia from the flow will be directly transmitted onto the anchors thus releasing the PVC. pipes from being under stress.

3.3.3 Pipe Sleeves

(1) Where pipes pass through walls, floors, etc., the Contractor shall provide pipe sleeves. Sleeves for ductile iron, cast iron and galvanized steel and copper pipes shall be steel. For plastic pipes the sleeves shall be plastic. Where sleeves are fitted through floors, they shall extend to at least 20 mm clear above the level of the finished floor.

(2) The space between pipe sleeves and the pipe or insulation shall be completely backfilled with materials having the same fire resistant rating as the walls and floors.

(3) Sleeves shall be of sufficient size to allow free movement of pipes and furthermore where pipes are insulated the sleeves shall be oversized to allow the insulation to be carried through the sleeves. The Contractor's attention is drawn to the vertical pipe ducts at all floor levels. Where pipes pass through floors, sleeves shall be provided.

(4) Details of pipes through walls and floors shall be approved by the Engineer before installation.

(5) The Contractor shall set sleeves in walls, floors, etc., and in the shuttering before concrete is poured.

3.3.4 Pipe Movement and Expansion Joints

(1) Wherever possible, advantage shall be taken of changes in direction of pipes to take up expansion and contraction due to temperature changes of the pipe contents.

(2) Expansion joints and movement joints shall be provided in pipes which cross the building expansion joints shall also be provided elsewhere to absorb the effect of expansion on pipes whether shown on the Drawings or not. Special attention shall be paid to the provision of expansion joints in hot water pipework.

(3) Where expansion joints are required, they shall be Bellows type. Bellows shall be stainless steel with stainless steel inner and outer telescopic sleeves. The joints shall be suitable for a test pressure as specified for the pipes. Each joint shall be suitable for a transverse movement of not less than 25 mm and if necessary a joint of larger diameter than the pipe shall be installed with reducing fittings to obtain the allowable required pipe movement.

(4) Where movement points occur, couplings shall be used so that building movement does not cause fracture or stress in the pipework.

(5) Upon sizing and fixing expansion joints on pipes crossing the building expansion joints, the Contractor shall take into account, in addition to the expansion/ contraction of pipes due to temperature changes, the effect of relative horizontal movement between the two parts of the building structure. Pipe guides shall be fitted on each side of each joint to keep the joint and pipe in true alignment according to manufacturer's instruction.

(6) Generally expansion bellows shall be installed mid way on each water riser. Details and location of expansion joints shall be submitted to the Engineer for approval.

3.3.5 Pipe Anchors

(1) All pipes shall be anchored as required to control the movement of pipes due to thermal changes. Generally anchors shall also be fitted at the lower end of vertical pipes. Details of all anchor points shall be submitted to the Engineer for approval.

(2) The anchors shall securely hold the pipe in a rigid position to resist the attempted movement due to expansion and the weight of pipe and contents.

(3) The Contractor shall submit full details to the Engineer of all expansion and anchor joints proposed for use throughout the Building prior to installation.

3.3.6 Pipes Through Roofs

Where pipes pass through concrete roofs, 450mm x 450mm x 1.8 kg lead slates and collars for the pipes shall be provided, the slates being sand whacked between the layers of the asphalt or membrane roofing and collars bound to the pipes with galvanised screw clips, and sealed with approved mastic sealant.

3.3.7 Welding

(1) Where steel pipework is required to be welded, it shall be carried out generally by the electrical are process. Where steel pipework of 50mm dia. and below is to be welded, gas welding by the oxy-acetylene process may be used. Gas welding on pipework 65mm and above will not be permitted unless prior permission from the Engineer is obtained.

(2) Where brazing or bronze welding is undertaken, such welding shall be carried out in accordance with and satisfy the testing procedures described in BS 1723 and BS 1724. In all other respects, particulars relating to the welding of steel pipework shall apply equally to copper.

(3) The Contractor shall employ on the Contract only properly qualified and certificated welders of not less than 6 months experience, and any shop welded fabrications shall be welded by equally qualified welders.

(4) The Contractor shall employ adequate number of competent welding supervisors to ensure that workmanship complies with the requirements of this Specification.

(5) All personnel engaged on welding operations must possess a certificate of competence issued by an approved authority. These certificates must be produced for inspection by the Engineer before any welding is undertaken.

The Contractor will be required to produce evidence that each welder employed on the Contract is qualified in this manner and shall provide the Supervising Officer with the name of the welder, a copy of the welder's qualification certificates and identification mark and six months regularly employed certificate for the required class of work. The Contractor shall present successive six-monthly regularly employed certificates for each man.

(6) The Engineer shall be notified of any change in welding personnel on the Contract and will required examinations of the work of any new welder or additional welder employed.

(7) Test welds on both steel and copper by each welder employer on the site shall be carried out in the presence of the Engineer prior to the operator undertaking any work on the Contract. All such test welds must be made in position as directed by the Architect and shall be subjected to visual examination and bend. Each weld shall be given a suitable mark enabling the operator to be identified.

(8) The quality of welding in steel or copper shall be subjected to careful inspection and testing by the Architect and where so deemed necessary may be subjected to non-destructive and/or destructive tests under the supervision of the Engineer.

(9) Non-destructive testing shall consist of either radio-graphic. The Contractor shall allow for 2% of all welds for testing by this method. This testing shall be carried out only by approved specialists.

(10) The Contractor shall undertake destructive test which will entail cutting out from the completed installation at any time, up to 1% of welded joint for both steel and copper, at the entire discretion of the Engineer and in positions as directed by him. Should any specimen welds so examined be designated un satisfactory, the Contractor shall remove such further work as instructed. all such work shall be replaced and made good at the expense of the Contractor, to a standard acceptable to the Engineer. Where tests welds are removed from a pipeline, it shall be made good by welding in a length of similar bore and class of pipe not less than 300mm long.

(11) Manufactured weld fittings shall be used wherever practicable and the Engineer permission must be obtained where it is intended to fabricate in lieu of using manufactured weld fittings.

(12) Welded branch joints are to be made with manufactured branch fittings accurately profiled to fit the main, the opening of the main being correctly shaped to coincide with the branch, both pieces having bevelled edges. All burrs, etc. are to be removed before welding is commenced and the operator must ensure that the branch piece does not project into the bore of the main but sits closely onto the bevelled surfaces.

(13) Where flanges are welded to steel pipework, the joints shall be hammer tested. Any imperfect welds shall be made good at the Contractor's expense.

(14) Where flanges and weld fittings are used on copper pipework the technique of brazing or bronze welding shall be used, employing the best quality welding rods and flux. The welding rods are to be of a type not subject to dezincification, i.e. "Siltroralloy" or equal.

(15) Brazing and bronze welding is not to be employed for fabricating branch tees.

3.4 CONCRETE AND STAINLESS STEEL WATER TANK

3.4.1 General

(1) Wherever indicated on the drawings, all fresh water and flush water storage tanks constructed by concrete shall be cast by the Main contractor.

(2) The Contractor shall supply and install tank fittings including puddle flange for all necessary pipe work connections and controls.

(3) The Contractor shall be responsible for ensuring that all cast-in fittings are correctly positioned.

(4) All water tanks when indicated as Stainless Steel construction shall also be supplied and installed by the Contractor.

(5) The dimension of the tanks shown on the drawings are indicative only, exact sizes of all tank shall be adjusted to suit site conditions as well as to suit the manufacturing tolerance.

(6) Materials of the Stainless Steel tanks shall be of the type approved by local Authorities. Details of the materials shall be submitted for approval during tendering.

3.4.2 Construction of Stainless Steel Water Tanks

(1) Thickness of each panel shall be adequate to withstand at least three times to static pressure likely to be created by the depth of the water stored therein. Adequate bracings shall be provided to maintain the tanks in shape when fully charged with water. Any leakage/rectification work resulted from inadequate bracing/ supports shall be at the Contractor's costs. Damages to other trades and to the Owner's properties resulted from flooding will also be chargeable to the Contractor.

(2) Tank shall be of reinforced stainless steel sheet with a minimum thickness of 1.5mm. The material of the tank shall not deteriorate due to chemical, atmospheric or thermal action when in contact with chlorinated sea water. Special attention shall be paid to the temperature of the water which will be as high as 35^0C. The jointing material shall also be suitable for the chemical and temperature conditions of the water.

3.4.3 Accessories

(1) Each tank shall be provided with the following :

One 500 x 500 mm or 500 mm diameter access opening with lockable cover to prevent the ingress of dirt.

The required numbers of inlets, outlets, drains, vents, overflow and electrode connections, positions of which shall be determined by the Contractor and submit for approval.

One internal and external cat ladder for maintenance. Ladders shall be constructed in stainless steel suitable for fresh or flush water respectively.

(2) All connections in the tanks shall be made by flanges to B.S. 4504 and the materials of the flanges shall be identical to that of the pipework to be connected.

(3) Adequate supports shall be made to all connecting pipework from the building structure. The tank body shall not be used for supporting the pipework in any case.

(4) All bolts, nuts and washers used in the tanks, whether or not in contact with water, shall be of stainless steel and shall not deteriorate due to chemical or atmospheric actions.

(5) Proper gaskets shall be used in all joints at panel flanges and pipe flanges. Details of gaskets shall be submitted for approval to the Engineer .

3.4.4 Construction Method

(1) Details of construction method of non-concrete tanks shall be submitted at the time of Tender.

(2) In general, tanks shall be supported on steel channels placed on top of concrete plinths. The steel channels shall be anchored to the concrete plinths and in turn bolted to the flanges of the panels as shown on the Drawings.

3.5 PUMPS AND TANK LEVEL CONTROLS

3.5.1 General

(1) All pumps duties shall be checked and where necessary corrected before ordering.

(2) The pumps shall be of adequate strength to withstand the hydraulic and other forces encountered but in any case shall be capable of withstanding a minimum hydrostatic test pressure of 10kg/cm^2 or as specified elsewhere, whichever is the higher.

All pumps and associated equipment shall be self-priming.

3.5.2 Pump Pressures

All pumps shall be constructed to meet the required working conditions and test pressure of the system concerned.

3.5.3 Pump Arrangement

All pumps shall be mounted on a common bed-plate together with the motor and directly driven through a flexible coupling and shall be aligned in the manufacturer's factory. Locally fabricated bed-plates will not be accepted. Base plate shall incorporate a drain pan and is to be provided with a screwed socket outlet for drain connection.

3.5.4 Pump Speed and Noise

Pumps shall be selected for an impeller speed of 1,450 rpm. All pumps shall be quiet in operation such that noise and vibration are not discernible in occupied accommodation of the building. A unit which is considered by the Engineer to be noisy shall be removed from the site and provided an acceptable alternative without cost implication.

3.5.5 Pump Fitting

(1) All pumps shall be fitted with an air-cock and drain plug. Each pump shall have a pressure gauge for suction and delivery connections, the gauges for all pumps shall be mounted on common hardwood gauge board on the wall inside the pump room. Gauges shall have 150mm diameter dial. Pressure gauge piping shall be copper comprising a loop siphon at the junction to the gauge and each gauge shall be supplied through 12mm diameter brass pig tail and pet cock. Drains shall be piped to floor drain or channel.

(2) The Contractor shall supply and install flexible pipe connectors at the pump suction and discharge sides for each pump as in the "Pipework" Clause as detailed.

(3) All flexible connectors shall have flanged joints to the Table specified for the connecting pipework and must be suitable for the working conditions and test pressure of the system concerned.

(4) Gland drains shall be provided in each pump packing gland with suitable nipple/outlet for copper/PVC pipes to be connected. All drains shall have a minimum internal bore of 15mm diameter and arranged in a proper pattern for piping the same to the channels or floor outlets provided inside the pump room.

(5) Where necessary, an automatic air relief valve shall be fitted in the pump to purge any air likely to be trapped inside the pump casing. Suitable fittings shall be used for such connection and the relief valve shall not discharge at a location directly over or near to the pump motor or any other electrical equipment.

3.5.6 Pump Valves

Each pump shall be fitted with valves to enable it to be isolated, and in addition, where shown on the drawings, a silent check/non-return valve shall be fitted in each pump discharge.

3.5.7 Pump Bases

(1) Except for submersible sump pumps, each pump set as indicated in the Tender Drawings shall be mounted on an anti-vibration pump base/inertia block. Details of the same shall be handed over to the Main Contractor for provisions to be made during the manufacture of the structural base. All holding down bolts shall be provided by the contractor.

(2) The structural base shall be formed by the Main Contractor.

(3) Pump inertia bases shall be provided by the Contractor, while the concrete plinth shall be provided by the Main Contractor.

(4) The base plates shall be of approved make with pads machined for correct alignment of the pump and motor. At least two locating dowels shall be fitted to each component after alignment.

3.5.8 Safety Guards

All exposed shafts, couplings and moving parts of pumps shall be provided with suitable galvanized angle iron wire mesh guards which shall be stoutly constructed and easily removable; and shall be provided with lifting handles. Care shall be taken that these guards do not cause "Ringing" sound and/or vibrate so causing noise.

3.5.9 Identification

(1) An identification plate of metal shall be fixed to each pump unit. This plate shall include full details and diameter of the impeller installed, pump size, model and serial number, r.p.m., amps, etc. pump head and delivery for the duty specified, and lubricant required.

(2) All pumps shall bear the manufacturer's designation plate which shall indicate the type of services and serial number of the unit.

3.5.10 Electrical Works for Pumps

(1) All electrical works associated with the pumps shall comply with the current I.E.E. and P.U.I.L. Regulations or equivalent standard approved by the Engineer.

(2) Each pump starter shall be suitable for remote control by the central control and monitoring system and shall be provided with at least one normally open auxiliary dry contact wired to terminals, and provided with a local ON/OFF/AUTO switch for local test and override purposes.

3.5.11 Fresh Water Pumps

(1) Fresh water transfer pumps shall be installed as shown on the Drawings, each pair shall comprise one duty and one standby. The working pumps shall be started and stopped automatically under command of water level controllers fixed in the appropriate cold water tank served as shown on the drawings. Automatic changeover shall be provided in each group or pair of pumps to alternate between the working and standby pumps on each cycle.

(2) A set of fresh water pneumatic booster pumps shall be installed as shown on the drawings, to pressurize the system for the top floors of the building and shall operate on command by the pressure switches mounted in the system pipework.

(3) Fresh Water Pump Construction

(i) The pumps shall be horizontal multi-stage centrifugal type with flanged suction and delivery connections.

(ii) The pump casings shall be of cast iron construction and accurately machined and assembled with metal-to-metal joints.

(iii) The impellers shall be bronze / shrouded gunmetal mechanically balanced and keyed to shaft, with guides to be gunmetal and all water ways shall be finished smooth.

(iv) The shafts shall be 316 stainless steel with grease lubricated roller bearings in cast iron housings. Stuffing boxes shall be of ample length and arranged to have soft packing. The stuffing boxes shall be provided with lantern ring and nipple for gland drain.

(v) The fresh water pneumatic booster pump set shall be comprise of a duty and standby pump complete with a pneumatic vessel and control unit. The pumps shall be vertically mounted, with direct drive motors. The pumps shall be of multi-stage construction and each stage/section shall be interchargable.

(vi) Construction of the pump body, impeller, shaft and other accessories shall be similar to the transfer pumps.

(vii) Motors shall be drip proof totally enclosed fan called.

3.5.12 Pneumatic booster pump unit

(1) One set of cleansing water booster pump set shall be installed as shown on the Drawings.

(2) The pneumatic booster unit shall consist of two identical pumps, one working and one standby, complete with pressure vessel(s) and control unit. Pressure switches located in the common discharge pipework shall start and stop each pump at a predetermined pressure. Should duty pump fail to start and the pressure of the system shall continue to fall, the standby pump shall be initiated to cut into operation.

(3) Automatic changeover shall be provided to alternate between the working and standby pumps on each cycle.

(4) A time delay switch shall be installed in the control of each pump set to provide a time lag between the initiation of signals by the pressure switches (both pump on and off) and the actual start and stop of the pump set to avoid excessively frequent on/off cycles of the pumps.

(5) The constructions of the pump body, impeller, shaft and other accessories shall be similar to the fresh water transfer pumps. Capacity of the pump set is shown on the equipment schedule.

(6) Either pump shall be able to be selected as working/standby. The operating pump shall also be able to be selected as automatic or manual and interlock devices shall be provided to isolate the system for maintenance.

3.5.13 Pump and Tank Levels Control

Cold water transfer pumps shall be arranged for lead/lag operation with the selection made at selector switches in the local pump control panels. Automatic change over shall be provided in each pair of pumps to facilities for changing the lead/lag sequence.

The cold water transfer pumps at Lower Level shall be initiated to run should the water tanks on the upper level require refilling while the low level probe in the sump tanks shall stop the transfer pumps when the water level falls below the low water level.

An overflow alarm signal shall be brought back to the central control and monitoring System and shall sound a buzzer therein. In addition, dry contact for the overflow alarm switch shall be provided in an external relay box by the Contractor.

3.5.14 Level Switches in Tanks

(1) The Contractor shall supply and install level switches in tanks as shown on drawings.

Basically, a complete set of control consists of mercury free float switches for normal function, viz :-

- High level alarm
- High water level cutout for the filling pump
- Low water level cut in for the filling pump
- Low level alarm and cutout for the demanding pump

(2) Not all tanks require all the above units. Details of the numbers of required for each tank and their respective function shall be submitted to Engineer for approval.

(3) Each level switch shall be of the correct length for its particular application and tank location.

(4) The level switch set shall operate with a stepped down voltage at 24V maximum. Stepped down transformers shall be provided for each set of level switches and shall be installed inside centralized control cubicles inside each pump room.

3.5.15 Gauges

Pressure gauges and altitude gauges shall be of bourdon type with copper siphon and cock, and with piping connection to the measuring point. Size shall be 150mm diameter dial. All gauges shall have black pointer, red overrun indicators, and red mark at normal working pressure. The instruments shall be selected for the normal operating range expected and dial calibrations shall not exceed twice the normal working pressure.

3.6 PAINTING, LABELLING AND IDENTIFICATION

3.6.1 General

(1) The Clause specifies the quality, extent of work and the standard of painting and identification for the various systems and shall form part of the work included in this Contract.

(2) Painting and identification shall include prime coating and finishing layers for the installation complete with colour codes for the identification of the various systems.

3.6.2 Painting

(1) In addition to special painting and finishing specified elsewhere, the Contractor shall allow for painting <u>after erection ALL plant and equipment</u> including, but not limited to motors, pumps, piping, hangers, brackets and supports, insulation, etc., provided under this Contract, in accordance with the Engineer's requirements.

(2) All metallic surfaces shall be wire-brushed and cleaned from rust, scale, dirt and grease and shall then be painted one coat approved priming paint, not less than two approved undercoats and approved high gloss finishing coat.

Galvanised steel, copper and uPVC pipework except cast iron pipework in service ducts and false ceiling spaces need not be painted but arrow head to indicate direction of flow shall be marked.

After erection, all cast iron pipework shall be painted with one coat approved priming paint, one approved undercoat and one finishing coat.

(3) The primer shall be genuine red lead paint, the remainder high quality enamelled paint.

(4) All paints shall be heat resisting where required. The type of paint to be used shall be approved by the Engineer before use.

(5) Manufacturer's standard colours for equipment will not necessarily be accepted, unless approved by the Engineer. The Contractor shall change at his own expenses any finishing coat not so approved. Where factory applied finishes are approved, the Sub-contractor shall be responsible for the making good of the equipment finishes damaged during transit, storage, installation and commissioning to the standard equivalent to the factory applied finishing.

3.6.3 Labelling

(1) All plant and equipment provided under the Contract shall be labelled in both English and/or Vietnamese as to duty capacity and services. All such labelling to correspond to schedules, diagrams, etc., which shall be provided as part of the Record Drawings. Labels generally shall be of "Perspex" reverse engraved type with red lettering, or as otherwise required by the Engineer. Plastic dymo labels are not acceptable.

(2) The following refers to specific items (but not by way of limitation) requiring labelling :

(i) All valves, motor starter, tanks, distribution boards, isolators, pumps and water heaters.

(ii) Distribution boards, starters, etc. shall be labelled to indicate the circuit number, phase and item controlled.

(iii) Inside the doors of the starter cubicle an engraved plastic circuit diagram shall be fitted.

(iv) Labelling of valves shall be as described in the "valve" Clause. These labels state the valve number as well as the normally open/closed status of each valve.

(3) A complete valve schedule shall be incorporated in the as-built drawings and this schedule shall clearly indicate the valve number, duty, function, size, flow rate and any other relevant information necessary for future easy operation and maintenance.

Full schematic diagrams and valve schedules for all systems shall be supplied and installed in the plant room by the Contractor and mounted on a rigid base with glass cover.

3.6.4 Identification of Systems

(1) The contractor shall allow for colour banding of pipework.

The contractor shall note that these colours are to be confirmed by the Architect before application.

(2) The colour bands shall be approximately 50 mm wide and paint sign stencilled to pipes or insulation at intervals not exceeding 3 meters. Additional bands shall be provided adjacent to valves, crossovers and elsewhere, where required for identification.

(3) At reasonable intervals on straight pipes and adjacent to valves, coloured arrows shall be stencilled to the pipework to indicate direction of flow. Where painting to the finishes will be impractical, metal bands and discs shall be fitted for colour identification specified above.

3.6.5 Extent of Painting

(1) All plant, materials and equipment forming part of the Works are required to be painted as specified in this Clause, with the sole exception of items specifically excluded in this Specification.

(2) Items which do not require to be painted shall included:

- Galvanized pipework, conduit or cable trays where concealed within duct shafts or false ceilings.

- uPVC pipework or conduit.
- Materials with a factory applied anodized, baked enamel or painted finish, provided that the colours are approved prior to application.

(3) The requirement for painting of all pipework is in addition to the colour coding or banding specified in this Clause.

(4) All finishing to factory assembled plant or equipment shall be factory supplied in accordance with the manufacturer's normal practice and to a standard suitable for the duty and location of the plant.

(5) All plant and materials requiring to be painted on site shall be painted with one coat of an approved primer, one coat of an approved undercoat and two coats of an approved high gloss finishing coat.

3.7 TESTING AND COMMISSIONING OF THE INSTALLATION

3.7.1 General

(1) The Contractor shall carry out all necessary testing and commissioning procedures comprising tests at marker's works, site tests during construction, commissioning, and acceptance tests all as specified below.

(2) Tests shall be carried out in accordance with the appropriate CIBSE commissioning code.

(3) The Contractor shall include in this Tender all costs associated with the testing and commissioning procedures including materials, labour, instruments and the provision of all necessary test points. Such costs shall also include the cost of making good any defects arising out of such tests at maker's works, such costs shall also include the provision of fuel and all other incidental costs.

(4) All tests shall be carried out to the satisfaction of the Engineer and shall also be witnessed by the Engineer. In the case of pressure tests at maker's works the tests at shall be witnessed by an approved independent Insurance Company. The Contractor shall give not less than ten days written notice to the Engineer.

(5) The Engineer shall be entitled at all reasonable times during manufacture to inspect, examine, and test on the Contractor's premises the materials and workmanship of all plant to be supplied under the Contract, and if part of the said plant is being manufactured on other premises, to equally examine and test as if the said plant were being manufactured on the Contractor's premises. Such inspection examination, or testing, if made, shall not release the Contractors from any obligation under the Contract. All costs shall be borne by the Contractor.

3.7.2 Preliminary commissioning checks

(1) The Contractor shall ensure that all equipment included under this Contract is thoroughly cleaned, lubricated and checked for serviceability immediately before setting to work. Particular attention is drawn to the removal of building debris from motors and pipework.

(2) All pipework shall be thoroughly flushed and chemically cleaned to ensure that all foreign matter is removed and internal surfaces are degreased. During all preliminary flushing, plant shall be isolated by means of bypasses to avoid dead legs, and the systems shall be completely isolated from any existing systems to ensure contamination cannot occur.

(3) Further flushing and chemical treatment shall be carried out on isolated systems by connection of temporary diesel driven pumps to circulate water and dosing chemical. The Contractor shall allow for cross-connection of flow and return pipework at the extremities of risers and interface points with existing installations or other contracts.

(4) All automatic controls and safety devices shall be inspected and checked for serviceability before the working fluid or electricity is applied to the system.

3.7.3 Commissioning

(1) When the preliminary commissioning checks have been carried out, the Contractor shall set to work, regulate and calibrate the installations in accordance with a programme to be agreed with the Engineer.

(2) All valves, switches, controls, etc. shall be regulated and capable of proper operation and in the case of valves shall be capable of tight shut off.

(3) All apparatus shall be silent and vibration free in accordance with the requirements of this Specification.

(4) All instruments shall be correctly calibrated and shall read accurately.

(5) Each water system shall be set in operation with the water volumes to each unit measured, regulated and the plant set for the correct duty.

(6) The Contractor shall operate pumps to ensure that all control systems are functioning correctly and are properly sequenced and interlocked.

(7) All instruments shall have been recalibrated within six months of the start of commissioning or testing.

(8) Calibration of all instruments shall be certified by the instrument manufacturer or an approved calibration agency.

3.7.4 Hydraulic Testing of Pipework

(1) The Contractor shall carry out hydraulic test on the complete plumbing systems and the drainage system to show that it is functioning satisfactorily within the requirements of this Specification.

(2) The contractor shall provide suitable test pumps and arrange for a supply of water required in connection with testing of pipework. The test pump shall be fitted with pressure gauges which shall be of suitable range for the pressure being applied.

(3) Hydraulic tests shall be carried out as the pipework is installed and shall be completed before chases in walls and ducts are closed. Also tests shall be carried out prior to false ceilings and other finishes are installed.

(4) All water services pipework, except incoming cold water supply to the water tanks shall be hydraulically tested for a period of not less than 6 hours to a pressure of not less than one and a half times the working pressure. Without leakage or loss of pressure. The maximum working pressure for water systems shall be deemed to be static head plus the total pump head. Minimum testing pressure shall be 7 bars. The contractor must record all test figures together with schedules of pipe lengths and should note that testing shall be witnessed by the Engineer.

(5) With respect to incoming water supply the test Clause shall be charged with water and all air liberated. The pipework shall be allowed to stand for three days before final testing. Test pressure shall be raised slowly to the maximum value. The permissible pressure drop 0.15 kg/sq. c.m. after six hours shall not be exceeded.

(6) Testing apparatus shall be provided by the Contractor.

(7) The Contractor must carry out any additional tests required by the local water supply company.

(8) Remove the blank cap from one of the drain plugs (at the top of the stack if possible) and connect the tube from a manometer gauge to it or by passing the tube through one of the trap seals.

(9) Blow air through the tube and reconnect to the manometer gauge to obtain a reading of 1-1/2"w.g/ the level should remain for a period of not less than three minutes without falling and without further air being added.

(10) If the test is found unsatisfactory, then smoke may be used to help find any leaks with the aid of a smoke pump, whereby a visual and smell check can be made on the stack and with the aid of a jar of soapy water by painting the joints leaks can be detected and rectified.
When this has been completed, the test should be repeated until found satisfactory.

(11) When applying the smoke test to a uPVC stack on no account should be the smoke rocket be in direct contact with this materials as serious damage could occur.

3.7.5 Operation Tests

(1) The Contractor shall ensure to the satisfaction of the Engineer that the installation or portion thereof has been set to work and complies with all requirements including the following :

(i) That the plant and apparatus is of robust construction and of capacity for the duty specified.

(ii) That all valves, switches, controls, etc. are properly regulated and capable of proper operation.

(iii) That all apparatus is silent.

(iv) That all instruments are correctly calibrated and read accurately.

(v) That all services are tested in accordance with the details of the relevant clauses of this Specification.

(2) Should the results of these tests show that the pumps or any other items of equipment fail to perform to the efficiencies or other performance figures as given in this Specification, and as accepted in the contractor's tender, then the Contractor shall adjust, modify and if necessary replace the equipment without additional cost to the Contract in order that the required performance is obtained. Should it be necessary for the contractor to attend to items of plant as described he will be responsible for cost for any damage or deterioration to the building or any other services consequent on such attendance.

(3) The Contractor shall perform all tests and demonstrations as called for by the Government (all departments).

(4) Testing procedures shall be submitted two months after the approval of major equipment to the Engineer for approval.

3.7.6 Electrical Tests

(1) In addition to any electrical tests listed elsewhere in this Specification, the following tests for electrical systems shall be carried out.

(2) The precise method of carrying out all tests shall first be agreed with the Engineer.

(3) The Contractor shall verify polarity of the circuits to ensure that all fuses and single-pole control devices are connected in the "live" conductor only, and that wiring has been correctly connected to the socket-out terminals.

(4) The Contractor shall measure the earth continuity conductor with alternating current in accordance with Item la Appendix 6 of I.E.E. Regulations, 16th Edition.

(5) Tests of effectiveness of earthing shall be made with loop-impedance test in accordance with Item 2 of Appendix 6 of I.E.E. Regulations, 16th Edition.

(6) A 1000V "Megger" tester shall be applied for the measurement of insulation resistance of all L.V. equipment. Measured value shall be recorded as per Regulation E7, E8 and E9 of I.E.E. Regulations, 16th Edition. Motors shall be tested at the works, and tested for insulation resistance on site.

(7) H.V. cables shall be tested to B.S. 148.

(8) Motor control centres shall be tested at the Works and all details of tests shall be certified and submitted for record. On site testing shall include (but need not be limited to) the following :

- Mechanical tests including checking of all mechanical and electrical connections, interlocks, etc.
- high voltage injection and insulation tests;
- testing of overcurrent, and earth fault protection by primary injection, and all other protection devices;
- functional checks of all control and starter circuits;
- calibration of metering instrument, C.T. etc; and
- any other tests as recommended by manufacturers.

3.7.7 Supply of Testing Equipment

(1) The Contractor shall provide all tools, pressure pumps, instruments and recorders required to carry out the tests given in this Clause.

All water and electricity required for testing purpose shall be supplied by the Contractor.

SECTION 4. MECHANICAL VENTILATION AND AIR-CONDITIONING

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4.1 DESIGN CRITERIA AND SCOPE

4.1.1 Air Conditioning and Mechanical Ventilation

4.1.1.1 Extent of Air conditioning and Mechanical Ventilation Installation.

Air conditioning shall be design for all offices, worker room, Laboratory, reception.. The system shall be air cooled spit units with the indoor units of wall mounted or ceiling suspended.

Ventilation shall be design for all Pump rooms, Blower room, Electrical rooms, Generator room, Toilets..

4.1.1.2 Design Criteria

- Outdoor Conditions

  Meteorological data of Ho Chi Minh City:

  Summer Dry-bulb : 33.9°C.
  Coincident Wet-bulb : 29.4°C.
  Winter Dry-bulb : 18.3°C.

- Indoor Conditions

  - Air Conditioning

Office	Temperature (°C) DB	Relation Humidity % RH
1. Offices	24 ± 1°C	65 ± 5
2. Lobby	26 ± 1°C	65 ± 5
3. Worker room	25 ± 1°C	65 ± 5

  - Mechanical Ventilation

Space	Total air supply Air Change per hour	Min. Fresh air for Air Conditioning Spaces (l/s/m²)
1. Pantry	15	1.30
2. Office		
3. Pump rooms	3 - 5	
4. Electrical rooms	3 - 5	
5. Locker rooms	10	
6. Toilets	15	

4.1.1.3 Codes and Regulations

The air conditioning and ventilation system shall be design in accordance with :

- American Society of Heating, Ventilating and Air Conditioning Engineers (ASHRAE)
- Sheet Metal & Air conditioning National Association (SMACNA).

4.2 PIPEWORK

4.2.1 Materials

(a) Condensate drain pipe: uPVC pipe.

- Resistance in internal pressure : 42 kgf/cm^2.
- Longitudinal reversion : ≤ 5.

Nominal size (mm)	*Outside Diameter* (mm)	*Wall thickness* (mm)
ϕ25	33.3 ± 0.1	2.1 ± 0.2
ϕ32	42.3 ± 0.1	2.1 ± 0.2
ϕ40	48.5 ± 0.1	2.5 ± 0.2

(b) Refrigerant pipework :

Requirements for this section shall be applied to refrigerant piping connected to the outdoor/indoor units of an air-conditioning machine of a separate type. Installation shall be so made that the refrigerant and lubrication oil circulation does not interfere with normal operation.

The material for refrigerant pipework shall be of Light gauge copper tube with the specification as follows :

- Tensile Strength : 21 kgf/mm^2.
- Elongation : 40 % Min.
- Hardness Value : 60 Max.

Nominal size (inch)	*Wall thickness* (mm)
3/8	0.64
1/2	0.71
3/4	0.81
1	0.89
1-1/4	1.07
1-1/2	1.24
2	1.47

4.2.2 PIPE CONNECTION

(1) Refrigerant pipework : Solder-connected

(2) uPVC pipework : uPVC .

4.2.3 PIPE SUPPORTS

Refrigerant pipe shall be run in trunking c/w cover as in drawing.

Centre of supports shall be of 2m.

4.2.4 PIPEWORK INSULATION

All Refrigerant pipe and condensate drain pipe shall be insulated with Closed cell insulation tube, which shall have physical properties as follows :

Average Physical Properties	**Rating**
Density	0.08 –0.12 g/cm^3.
Thermal Conductivity at 20°C	0.0374 W/mK.
Temperature Limits °C	-40°C to +105°C
Water Absorption (% by weight)	3
Water Vapour Permeability	0.033
Ozone Resistance	Excellent
Thermal Stability (% shrinkage)	
7 days (200°F)	4.5
7 days (220°F)	5.5
Average time of burning	Less than 5 seconds
Average extend of burning	15mm
Flexible	Excellent
Weather and Ultraviolet Rays Resistance	Good

(3) Refrigerant pipe : Closed cell insulation tube 13mm THK

(4) Condensate drain: Closed cell insulation tube 9mm THK

4.3 DUCTWORK AND FITTINGS

4.3.1 Materials

All ductwork shall be of galvanized steel sheet.

4.3.2 Duct Thickness

4.3.2.1 Rectangular duct.

(1) Seams for long ducts shall be button punch snaps not more than 2250 mm in length. Ducts in excess of that length and ducts with complex bends shall have *Pitsburg* seams.

(2) Seams in air flow direction shall have internal grooved seams when use of standard sheeting is not possible.

(3) Sheet thickness of duct shall be as listed in following Table, with deformed ducts being the largest dimension.

Greatest duct dimension (mm)	*Thickness(mm)*
Not more than 300	0.5
301 to 450	0.6
451 to 750	0.7
751 to 1500	0.8

4.3.2.2 Round duct.

Round ducts shall be spiral ducts, galvanised steel sheet shall be spiralled with over-lapped machine seams and nominal sized shall indicate the interior diameters. Sheet thickness and seam pitch shall be as listed in following Table and seam folds shall have minium width of 5mm.

Diameter (mm)	*Thickness(mm)*
Not more than 450	0.5
451 to 750	0.6
751 to 1000	0.8
Greater than 1000	1.0

Diameter (mm)	*Seam pitch(mm)*
Not more than 100	Not more than 100
101 to 1000	Not more than 150

4.3.3 Duct Hangers and Supports

4.3.3.1 Rectangular duct:

Rectangular ducts shall be supported as shown in figure below and support shall be shaped steel having dimensions as follows :

Longer side of duct (mm)	*Hanger for lateral run*		*Supports for pipe risers*	
	Shape steel & steel rod (mm)	*Maximum interval (m)*	*Shape steel & steel rod (mm)*	*Maximum interval (m)*
750 or less	25x25x3 Diameter 9	3.0	25x25x3	3.6
751 to 1500	30x30x3 Diameter 9	3.0	30x30x3	3.6
1501 to 2250	40x40x3 Diameter 9	3.0	40x40x3	3.6
Over 2250	40x40x3 Diameter 9	3.0	40x40x3	3.6

4.3.3.2 Round duct :

Round duct shall be supported as shown in figure below and supports shall be as listed in following Table :

Duct Dia. (mm)	*Steel flat (mm)*	*Steel rods (m)*	*Maximum interval (m)*
1500 or less	25 x 3	Dia. 0.9	3.0
Over 1500	30 x 3	Dia. 0.9	3.0

4.3.4 Volume Control Damper

Volume control dampers shall be provided for the proper regulation of the air conditioning and mechanical ventilating system. In general, dampers shall be provided as follows :

(a) In all main supply and exhaust air ducts, branches, supply air connection to the indoor packaged units.

(b) Behind all supply and exhaust air diffusers / grilles.

Structure and Finish

- Casing and blades in galvanized steel sheet 0.8mm to 1.5mm thickness.
- Shaft is made of steel with the bronze bushings.
- Antirust under coated. Finished in black or custom picked colours .

4.3.5 Access Panel

Access panel shall be provided at every point in ductwork system where access for checking, servicing and cleaning of equipment is required including fire dampers, volume control dampers etc. The minimum size shall be 450mm x 450mm or 50mm narrower than the duct whichever is smaller.

4.3.6 Thermal Insulation

(1) Fibreglass of 32 kg/m^3 with thermal conductivity of not greater than 0.05 W/mK at 20°C mean temperature.

Max. service Temperature : 300°C.

(2) All ductwork shall be external insulation of 25mm fibreglass thickness, including aluminium sheet 0.5mm. Insulation shall be continuous.

4.3.7 Flexible Duct

- Description : High quality insulated aluminium foil flexible air duct using aluminium foil inner core. Thick blanket of fibre glass insulation for energy efficiency. Tough reinforced outer jacket for resistance to tear and puncture.
- Construction : Outer vapour barrier is constructed from 2 layers of tough polyester and one outer layer of foil laminated with fire retardant adhesive with spiral fibreglass strand reinforcement.
- Working pressure :

  ϕ100 - ϕ250 : 1.5 kPa (pos.), 0.19 kPa (neg.)

  ϕ300 - ϕ500 : 1.0 kPa (pos.), 0.19 kPa (neg.)
- Air velocity : Max. 25 m/s .
- Thermal Value (R) : 0.74 (m2 – C/W) at 24°C mean temperature.

4.3.8 Diffusers/Grilles

- Diffusers to be used in factory will be of wall type with horizontal and vertical blades.
- Diffusers/grilles shall have face sections consisting of a peripheral border, individually adjustable horizontal aerofoil blades or shall have face sections consisting of a peripheral border, individually adjustable horizontal and vertical aerofoil blades. Front border 30mm wide with visible screw fixing. Available on request with spring clip fixing or concealed fixing and sub frame.
- Blades and frames are made of extruded aluminium 1.2 to1.5mm thickness or Black steel sheet 0.8mm thickness.
- Power-coated on requirement of Architect.

In addition, square diffusers or wall type with horizontal and vertical blades will be used. In general, proposal from the Interior Designer will be considered.

4.3.9 Air Louvre

- Air louvre shall have face sections consisting of a peripheral, core made up with fixed air control blades. Front border 30mm wide with visible screw fixing. Available on request with spring clip fixing or concealed fixing and sub frame.
- Blades and frames are made of extruded aluminium 1.5 to 2.0mm thickness or Black steel sheet 1.2mm thickness.
- Power-coated on requirement of Architect.

4.4 AXIAL FAN AND WALL MOUNTED FAN

4.4.1 Axial Fan:

4.4.1.1 Impellers

- Blades :

  The blades have been designed with a special aerofoil section to give excellent performance and low noise characteristics. The materials used can be injection-moulded, chemically-coupled, glass-reinforced polypropylene.
- Hubs :

  The bush ensures ease of fitting and removal of the impeller from the motor shaft should adjustment of the pitch angle, cleaning or repair of the impeller prove necessary.
- Fixings :

  All impellers are assembled using high-tensile, zinc-plated set screws and self-locking nuts.
- Material :

  Polypropylene blades will be supplied for this fan.

4.4.1.2 Casing

Casing is rolled and flanged from heavy-gauge mild steel. The casing enclose the impeller and motor completely and weatherproof external terminal box is standard.

4.4.2 Wall mounted Fan:

Impeller & Casing : Plastic.

4.5 AIR COOLED SPLIT UNIT

4.5.1 General :

- The split air conditioning Units shall consist be of an external, exposed condensers and exposed fan coil units.
- The units shall be rated at the performance given in drawings. The units shall be rated in accordance with the relevant JIS standard.

4.5.2 Condensing Units :

- Condensing Units shall be assembled on heavy gauge steel frames. Units shall include a compressor, split fin condensing coil, fan and motors, controls and holding charge of refrigerant (R22). Operating range shall be between 50 deg C and 10 deg C.
- The unit casing shall be constructed of galvanized heavy gauge steel. Units shall have removable panels which allow access to all major components and controls.
- Compressors may be reciprocating or scroll type. Temperature and current overload protection shall be provided. Compressor shall be mounted on spring or rubber isolators, and sound mufflers as necessary to minimise vibrations transmission and noise.
- The condenser coil shall be internal finned or smooth bore copper tubes, mechanically boned to aluminium plate fin. Coils shall be factory pressure and leak tested to 2500 kPa. Coils shall be delivered with suitable protection from damage as would normally be expected during installation. This could be using rigid, corrugated plastic board.
- The condenser fan shall be a direct drive, statically and dynamically balanced propeller fans with aluminium blades and corrosion protected steel hubs. Condenser fan motors shall be of the totally enclosed type, with permanently lubricated ball bearings, and shall have build in thermal and current overload protection.

4.5.3 Fan coil Units :

(1) Fan coil units shall be completely factory assembled including evaporator coil, condensate drain pan, fan motors, filters and casing.

(2) The unit casing shall be constructed of moulded plastic. Units shall have removable panels which allow access to all major components and controls. Knockouts shall be provided for electrical and refrigeration connections.

(3) The evaporator coil shall be internally finned or smooth bore copper tubes, mechanically boned to aluminium plate fin. Coils shall be factory pressure and leak tested to 2500 kPa.

(4) The supply air fan shall be a forward curved, centrifugal type fan with direct drive. Three speed motors required.

(5) All necessary controls shall be factory installed and hardwired.

(6) The fan coil unit temperature controller shall be of the remote hardwired type allowing it to be fixed in position. As a minimum the controller shall include temperature adjustment, and an on/of switch.

4.6 ELECTRICAL

4.6.1 General

(1) Codes

Electrical materials, methods of construction and work quality must equal or exceed the requirements of this specification and the minimum requirements within the following :

All Municipal Codes enforced by the city or country where the equipment is to be installed.

All State Codes enforced by the state inspection department in the state where the equipment is to be installed.

Latest Edition of National Electric Code.

(2) Test and Inspections

All materials and workmanship is subject to inspection by an authorised representative of the purchaser's Engineering Division, Power and Control group, during and after fabrication.

The vendor shall notify the purchaser at least 2 weeks in advance of the date the equipment is ready for shipment.

4.6.2 Raceway and Fitting

(1) Rigid Conduit

Rigid steel conduit shall be standard weight, mild rigid steel, hot deep galvanised. Couplings, elbows and bends shall meet these same requirements. The minimum trade size shall be ¾ inch.

All conduit fittings and boxes shall be of the threaded hub with watertight gaskets. Conduit bodies shall be solid gaskets types with covers.

Conduit shall be cut smoothly and supported firmly. All sharp edges, burrs, rough surfaces, or threads which may come in contact with wire insulation shall be remove.

(2) Liquid-tight flexible Conduit

Liquid-tight flexible metal conduit shall be constructed of single strip, flexible, continuous, interlocked, and double wrapped steel, galvanised inside and outside and with liquid-tight jacket of flexible polyvinyl chloride (PVC). All liquid tight flexible metal conduit shall be coloured grey and be a minimum trade size of ½ inch.

Liquid tight flexible conduit shall be used for the final connection to isolate equipment vibration or to connect to movable components. Maximum length of a flexible connection shall be limited to 36 inches, the minimum length shall be 18 inches and should be considered the standard required length if flexible conduit is required.

The minimum size of the underground conduit shall be 25mm diameter.

4.6.3 Wire and Cable

4.6.3.1 General

Wires shall run continuously from one piece of apparatus to another with no slices in conduits or conducts.

Inside the control panel enclosure the vendor shall route the above three wiring groups away from each other and in separate group wireways.

Cable shall be handle with care.

Cable runs shall present a neat and tidy appearance.

The vendor shall provide all wiring between electrical components on packaged equipment.

4.6.3.2 Wire

All conductors shall be stranded copper with 600 volt minimum insulation rating.

Power cables shall be sized to meet the load and regulatory requirements along with the following considerations.

- Motor supply cables shall produce a maximum voltage drop of 20% on starting, at the motor terminals
- Feeder cable shall give a maximum voltage drop of 5% at the buss bar when the largest load is started with all other loads running.
- Steady state voltage drop stall not exceed 5% under any circumstances.

4.6.3.3 Labelling

Cables and all the cores of all control/data/signal/communication cables shall be numbered, on both ends, using approved type numbers to correspond to the relevant diagrams and equipment drawings.

Numbers shall read way from left to right or up to down.

Numbers shall be arranged so that they can be easily read without the need for twisting or moving of wires.

4.7 PAINTING, LABELLING AND FINISHING

4.7.1 Equipment

All items of equipment shall be given one finishing coat of full gloss enamel, except where the manufacturer's standard finish is approved.

4.7.2 Exposed Metalwork

All exposed metalwork shall be painted with one priming coat, one undercoat and one finishing coat of full gloss enamel.

The primer coat for exposed galvanised iron shall be an approved galvanised iron primer.

4.7.3 Pipework Identification

Circumferential bands of standards ground colours shall be not less than 100mm wide on pipes up to 50mm nominal diameter, and not less than 150mm wide on pipes greater than 50mm nominal diameter.

Supplementary colours shall be displayed as bands not less than 25mm wide in the centre of the ground colour bands.

Where lettering is required it shall be painted in contrasting colour in accordance with the standard, in block letters not less than 15mm high for pipes up to 50mm nominal diameter, and in block letter not less than 40mm high for larger pipes.

Identification bands shall be located where they are clearly visible in each room or compartment through which the pipe runs, and shall be placed at centres not exceeding 6m.

Direction of flow shall be indicated by an arrow painted on the pipe adjacent to each colour band. Arrows shall be 75mm long on pipes up to 50mm nominal diameter, and 150mm long on large pipes.

4.8 REGULATION OF QUALITY ASSURANCE

4.8.1 Conditions of Materials

All materials shall have to assure the following conditions :

- 100% brand-new.
- Technical data are correct and sufficient as stated in specification.
- All materials shall be approved by Owner.

4.8.2 Operating Manuals

The contractor shall prepare four (4) copies of an operating manual, therefore employer and one for Engineer describing the operation and maintenance of the whole system and including:

(1) Equipment and system description
(2) Operating Instruction for all equipment
(3) Manufacturer's pamphlets and catalogues for all equipment
(4) Schedule of recommended maintenance by contractor for each system and equipment item.
(5) Schedule of equipment including labelled valves if possible, indicating the design and commissioned duty points.
(6) Completed check list (commissioning and testing item)
(7) Completed testing and commissioning results
(8) As-built drawings

4.8.3 Completion

After all, the systems have been successfully tested and the As-built drawings and operating manuals submitted, the contractor shall request the Owner (or representative) in writing to request the issue of the certificate of completion. The maintenance period begins from the date that the Owner (or Representative) is certified as having reached completion.

4.8.4 Testing and commissioning

Before any of the systems in the contract are put into service, we shall be subjected to a commissioning and testing procedure

4.8.4.1 Procedure – General

Testing and commissioning procedures shall be so arranged to verify that the equipment on systems as installed fully comply with the specification and documents and result. In a permanent record of the test carried out. They include the followings:

(a) Visual check of all work for completion and against diagrams of all wiring.
(b) Check that all work complies with latest regulations, specifications, and performance criteria.
(c) Check that all equipment in safe to operate, and that overloads, safety devices and interlocks are all in working order.
(d) Check operating frequently, function of all devices and rotation of motors.
(e) Verification of performance under site conditions, under load and simulated “WORST CASE” condition.
(f) Insulation tests shall be made with 500V”Megaohmmeter”. No cable will be accepted with an insulation resistance, including termination, of less than 50 Megaohmmeter.
(g) Testing continuity and unique identification of all conductors in all cables.
(h) Measure resistance of main earth and test all earth continuity connections
(i) Check polarity and phase rotation of supply and at all outlets.

All tests shall be conducted in accordance with commissioning guides or handbooks

4.8.4.2 Procedure –Equipment, systems, controls and safety devices

(a) Check of all work for completeness and proper working order

(b) Test run all equipment for at least 24 hours

(c) Check calibration and operation of each device

4.8.4.3 Off-Site tests

The following items shall be tested at the manufacturer’s factory and then retested on site as necessary to verify the performance – where necessary detailed calculation will be carried out and submitted for review based on shop drawings and actual equipment to be used to verify fan, control panels, switchboards, variable volume boxes, fan coil units (indoor).

4.8.4.4 Procedure - Fans

(a) Check bearings for overheating

(b) Measure flow, pressure, current and power factor and adjust unit to reach design conditions. For supply fans, the design air flow are with air filters in a dirty condition with a maximum pressure drop of 125 Pa to simulate pressure rise due to dirty filters

4.8.4.5 Procedure – Outlets airflows

Measure airflow at each outlet and adjust to within 10% of design airflow as stated on the drawings.

Adjust outlet flow directions (using black painted sheet metal blanks for diffusers) to ensure that velocities at occupant level do not exceed 1m/s when achieving the correct air throw.

4.8.4.6 Procedure – Refrigerant Piping Guide Lines

All units are prepared at the factory. To ensure satisfactory operation and performance, the following points should be noted:

(a) Adhere to recommended piping sizes and lengths

(b) Liquid loops or oil traps must be provided according to standard piping guidelines.

Notes:

- Insulate all refrigerant suction piping and connections. Secure all piping to prevent vibration
- Do not connect a multi- circuit outdoor unit to a single circuit evaporating unit (Blower)

4.8.4.7 Procedure – Refrigerant piping procedure (outdoor units)

(1) Puncture seal caps to remove N2 and reduce pressure

(2) Heat and remove the seal caps

(3) Cut, fit and braze tubing, starting at the outdoor unit and work toward the indoor unit. All brazing should be done using a 14 to 55 kPa dry Nitrogen purge flowing through the pipe being brazed

(4) Shut off Nitrogen supply

(5) Shut off the manifold valve for the line that is connected to the suction line gauge port. Disconnect the line from the gauge port.

4.8.4.8 Procedure – Refrigerant piping procedure (indoor units)

One liquid and suction lines are complete on the indoor unit, puncture the seal caps on the indoor unit connection stubs.

(1) Remove both seal caps from the indoor unit connection stubs

(2) Turn nitrogen supply on, Nitrogen enters through the liquid line gas port

(3) Braze the liquid line connections

(4) Open the Schrader valve on the suction line and the braze suction line to the connection stub- Nitrogen will bleed out the open gauge port on the suction line.

(5) Shut off nitrogen supply and disconnect from the gauge manifold

(6) Connect an R 22 drum to the gauge manifold and purge nitrogen from the circuit with 83 to 104 kPa R 22 - place a leak detector at the open suction gauge port. When R 22 begins following from the gauge port, replace the gauge port cap.

(7) Allow system refrigerant pressure to build up to about 276 kPa

- ***Leaking testing:***

  Leak test the entire system – using proper procedures and caution, repair any leaks found and repeat the leak test.

- ***Evacuation procedure:***

  1. Connect vacuum pump to both the liquid and suction line Schrader valves.
  2. Evacuate the circuit to hold a 350 micron vacuum

- ***Refrigerant charging procedure:***

  Recommended refrigerant charges are given in table No.2, calculate any required additional refrigerant using table 3, and charge by weight through the gauge port on the liquid line. Once the charge enters. The system, disconnect the charging line.

Table 2. Refrigerant charge (R-22)

Model Number	Nominal Refrigerant charge
75	6.4 kg
100	8.6kg
150	6.4kg ea. ckt
200	8.6kg ea. ckt

Sufficient operating charge for outdoor unit and 7.6m of nominally sized refrigerant piping.

Table 3 Additional Required Refrigerant

Tubing size		Additional	Additional	See
Suction liquid	*Tubing length*	*Refrigerant*	*Note*	
28.6 mm	2.6mm	4.6 m	0.320 kg	(1)
28.6 mm	2.6mm	7.6 m	0.085 kg	(1)
28.6 mm	2.6mm	9.7 m	0.682 kg	(1)
28.6 mm	2.6mm	12.2 m	0.852 kg	(1)
34.9 mm	12.7mm	4.6 m	0.568 kg	(2)
34.9 mm	12.7mm	7.6 m	0.938 kg	(2)
34.9 mm	12.7mm	9.7 m	1.222 kg	(2)
34.9 mm	12.7mm	12.2 m	1.506 kg	(2)
41.3 mm	15.8mm	4.6 m	0.881 kg	(3)
41.3 mm	15.8mm	7.6 m	1.491 kg	(3)
41.3 mm	15.8mm	9.7 m	1.909 kg	(3)
41.3 mm	15.8mm	12.2 m	2.386 kg	(3)

(1) Amounts shown are based on 21 gram of refrigerant per foot of 28.6 mm and 2.6 mm lines

(2) Amounts shown are based on 38 gram of refrigerant per foot of 34.9 mm and 12.7 mm lines

(3) Amounts shown are based on 60 gram of refrigerant per foot of 41.3 mm and 15.9 mm lines

- For tubing over 12.2 m calculate the additional refrigerant needed, based on notes above.

4.8.4.9 Procedure – Insulating and Isolating Refrigerant Lines

Insulate the entire suction line with refrigerant piping insulation. Also insulate any portion of the liquid line exposed to temperature extremes. Insulate and Isolate liquid and suction lines from each other – Isolate refrigerant lines from the structure and any ductwork.

To prevent possible noise or vibration problems be certain to Isolate Refrigerant lines from the building.

4.8.4.10 Procedure – Gaseous charging

This Procedure is accomplished with the unit operating. Electrical connections must be complete do not proceed until the system is ready to operate.

(1) Connect R 22 with gauge manifold to the Schrader valves (Pressure taps) on the compressor discharge and suction lines.

(2) Turn on power to the unit. Allow the system to run for five to ten minutes to stabilize operating conditions.

(3) Measure airflow across the Indoor coil-compare the measurements with the fan performance Data in Data / Submittal or facts – once proper airflow is established, observe the suction and head pressure gauges on the gauge manifold.

Pressure reading should fall approximately at the points shown by the pressure airs in service facts. Add or remove refrigerant (gas only) as required to obtain correct head and suction pressures – check suction line superheat and condenser sub-cooling to ensure the unit is operating properly.

(4) Disconnect all power to the unit

(5) Remove the charging system from the unit and close the opening in the bottom of the control box, with the pivotal cover before attempting to replace access panel.

(6) Replace all panels

- ***Electrical wiring:***

  The wiring consists of providing power supply to the unit, installing the system indoor thermostat and providing low voltage system interconnecting Wiring – Access to Electrical connection locations is shown in the dimensional drawings.

- ***Unit Power Supply:***

  The installer must provide line Voltage Circuit(s) to the unit main power terminal as shown by the unit wiring diagrams in service facts or field wiring.

  Power supply must agree with electrical data specified on the unit nameplate. Power supply must include a disconnect switch in a location convenient to the unit. Ground the unit according to local codes and provide flexible conduit if codes require and/or if vibration transmission may cause noise problems.

  Determine proper wire sizes and unit protective fusing requirements by referring to the unit nameplate and/or the unit service facts. Filed wiring diagrams for accessories are shipped with the accessory.

- ***Low voltage Wiring:***

  Mount the indoor thermostat in accordance with the thermostat installation instructions

- ***Sequence of operation:***

  Generally, Operation of the system cooling cycles is controlled by the position of the system switch on the room thermostat – once system switch is placed in either the cool position, unit operation is automatic. The optional automatically cool with sufficient room temperature change.

- ***Evaporator Fan (Indoor Supply Air)***

  The evaporator fan is controlled by an ON/AUTO switch on the room thermostat – with the switch position at Auto and the system operating in the cooling made, fan operation coincides with the cooling ON, fan operation is continuous.

- ***Cooling Mode:***

  With the disconnect switch in the “ON” position, current is supplied to the compressor crank case heater(s) and control transformer. The crank case heater(s) supplies heat to the compressor(s) during the “OFF” cycle. With the room thermostat system switch position at cool and the fan switch at AUTO, the compressor contactor energized on a call for cooling. When the contracts of the compressor contactor close, operation of the compressor and condenser fan begins. The evaporator fan contactor also energizes on a call for cooling and initiates evaporator fan operation.

  Safety control: All of these controls may not be installed on your unit, check electrical schematic

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SECTION 5. STRUCTURAL STEELWORK

5.1 STANDARDS AND CODES OF PRACTICE

5.1.1 General

The steel work shall comply with the current Vietnamese Building and Construction Regulations and the relevant clauses of the following current British Standards, TCVN, JIS, JASS, ASTM and codes of Practice (of their current replacement) unless otherwise specified or approved by the Engineer.

5.1.2 British Standards and Codes of Practice.

BS	499	Welding terms and Symbols
BS	638	Arc welding plant, Equipment and Accessories
BS	639	Covered Electrodes
BS	648	Schedules of weights of Building Materials
BS	709	Methods of Testing Fusion Welded joints and Steel Articles.
BS	729	Hot Dip Galvanized Coating on Iron and Steel Articles
BS	916	Black Bolts, Screws and Nuts
BS	1449	Steel Plate , Sheet and Strip (parts 1 & 2)
BS	1580	Unified Screw threads
BS	2600	Methods for Radiographic Examination of Fusion (part I & II) Welded Butt joint in steel
BS	2910	Methods for Radiographic Examination of fusion welded Circumferential Butt joint steel pipes
BS	3100	Steel Castings for General Engineering Purposes
BS	3889	Methods for Non _Destructive Test of Pipes (part 1A,2A) and Tubes (2B,3A &4A)
BS	3923	Methods Ultrasonic Examination of Welds
BS	4165	Electrode 3 Wires and Fluxes for the Submerged Arc Welding of carbon Steel and Medium Tensile Steel
BS	4190	ISO Metric Black Hexagon Bolts , Screw and Nuts
BS	4232	Surface Finish of Blast Cleaned Steel for Painting
BS	4320	Metal Washers for General Engineering Purposes
BS	4360	Weldable Structural Steels
BS	4848	Hot Rolled Structural Steels (part 2 & 4) Sections
BS	4871	Approved Testing of Welders
BS	5135	Metal Arc Welding of Carbon and Manganese Steels
BS	5493	Protective Coating of Iron and Steel Against Corrosion
BS	5950	The Use of structural Steel in Building
BS	6323	Seamless and Welded Steel tube
BS	6399	Dead and Imposed loads (1 & 2)

5.1.3 Other Standards

Swedish Standard SIS 05 59 00

Pictorial Surface Preparation Standards for Painting Steel Surfaces.

5.2 INFORMATION REQUIRED FROM CONTRACTOR

(1) The Contractor shall submit a method statement accompanied by working drawings and calculations as applicable ,supplementing the present Specification where required and fully describing the following:

(a) Fabrication and assembly procedures and sequence in addition to those described in this Specification. Particular attention shall be given to the means of ensuring accurate fitting of members and the avoidance of excessive distortion Stresses in assembly.

(b) Temporary stresses where significant in the steel structure during storage, transport , assembly , lifting and other operations.

(c) Specification of materials, design calculations ,and arrangement and detail drawing of the connections supporting the steel structure.

(d) Lifting and control Procedures ,as listed under "method Statement-lifting" in this Specification.

(e) Quality control program

(f) Safety program

(g) Corrosion protection system

(h) Temporary and incidental works needed

(i) An outline program of the works which shall be satisfactorily elaborated within 2 weeks of the award of the contract

(2) Nothing contain in the contractor's proposals shall be inferior to or in any other way conflict with this Specification. In the event of any discrepancy between them, this Specification shall over-ride, unless otherwise approved by the Engineer in writing beforehand.

5.3 DRAWINGS & SCHEDULES

(1) The Engineer's drawings shall be read in conjunction with all related drawings issued by the Contractor or any other Specialist Contractor or Contractor or Consultant.

(2) The Contractor shall verify all dimensions and levels shown on the drawings and shall bring any errors , omissions or conflict of information to the notice of the Engineer before the work is put in hand .

(3) The Contractor shall not substitute any other sections for those shown on the Drawings without prior approval in writing from the Engineer .

(4) After fabrication detail have been submitted and approved, no alteration are permitted unless submitted for subsequent approved or other authorized by instruction from the Engineer.

(5) Alterations consequent upon changes or work necessary at site ,when approved , shall be added to the appropriate drawing and record copies made available ,without delay.

5.4 WORKSHOP AND ERECTION DRAWINGS & SCHEDULES

(1) The Contractor shall prepare all the necessary workshop and erection detail drawing and shall submit duplicate copies of the same to the engineers free of cost for approval at least fourteen days before approval is required .

(2) The Contractor ‘s workshop drawing shall given complete information necessary for the fabrication of joint and component parts of the structure, including the location ,type size and extent of bolts and welds. They shall clearly distinguish between

(a) Different qualities of steel.

(b) Grades of bolts.

(c) Types and positions of welds.

(d) Manual and automatic welding.

(e) Shop and site welds.

(3) The drawing shall shown weld preparation ,the process, filler metal and all joints design and detail .

(4) The contractor shall submit a planned procedure to be followed in the erection ,assembly and welding of the structural member .The erection Procedure proposals shall include a detailed sequence of operations together with all calculations for erection stresses, etc.

(5) The Contractor shall submit full details and drawings, diagrams and schedules of the proposed welding procedures and including edge preparations welding technique ,positions and sequences of all welds together with the details of the manufacture ,classification ,code (as defined in BS 639) and size of electrode to be used , to the Engineer for his approval .Tests shall be undertaken as may be required by the relevant British Standard or other Specified standard or by the Engineer.

(6) The contractor ‘s drawing for all welded work shall comply with BS 5135 “Metal-arc welding of carbon and carbon manganese steels”.

(7) On all working drawings welding procedure Sheets, etc., terms and symbols relating to the welding shall be in accordance with the relevant

(8) BS.

(9) Method of jointing other than those shown as typical on the drawing may be employed subject to the Engineer ‘s approval.

(10) The design and details of all joints and connection ,but and fillet welds and the permissible working stresses to be used there in shall comply with BS 5950 and BS 5135 except as may be otherwise specified or shown on the Contract drawings .

(11) Single bolt connections will not be allowed unless the Engineer’s agreement in writing is obtained .

(12) If two or more types of welds are combined in a single joint, the effective capacity of each type shall be separately computed with reference to the axis of the group in order to determine the allowable of the combination .

(13) All shop details and erection drawings shall have been approved in writing by the engineer before the work is put in hand . The contractor shall be solely responsible for the correctness of his shop details, notwithstanding approval by the Engineer .

(14) The approval of the welding schedules and procedures shall not relieve the Contractor of his sole responsibility for the correct welding and for minimizing distortion in the finished structure.

(15) The Engineer's approval shall not in any way the Contractor of responsibility for any errors subsequently discovered in the details.

5.5 AS-BUILT DRAWINGS

After the erection of the works, the Contractor shall revise and correct where needed the original approved shop and erection drawings to the correspond with the changes made in the field and shall submit all " As built " drawings in accordance with the requirements of Section1, General Specification.

5.6 SUBLETTING

The Contractor shall not sublet any fabrication or other work without prior approval in writing by the Engineer. The Contractor shall not Sub-Contract any work to any other firm who is tendering for the steelwork without prior agreement and approval in writing by the Engineer.

5.7 STRUCTURAL STEEL WORK PROGRAMME

(1) The Contractor shall draft his detailed fabrication, delivery, assembly and erection programme in consultation with the Engineer and such programme shall be subject to the agreement of the Engineer and particularly in so far as it relates to the commencement of assembly and erection of the structure steel work.

(2) Where fabrication is to be carried out in more than on workshop at different locations the appropriate information regarding the location of the works and the sub-divisions of fabrication shall be stated.

(3) An erection procedure shall be submitted to the Engineer before erection is commenced on the site. The schedule shall give full details of the erection loads to be lifted and imposed on the ground and the order in which erection is to take place. Erection shall not commence on the site until approval to the erection schedule and processes have been obtained in writing from the Engineer. Approval of this schedule shall not relieve the Contractor of hid responsibility for the stability and safety of the structure and plant during all stages of work.

5.8 PROGRESS REPORTS

The Contractor shall submit to the Engineer at weekly intervals in such from as may be required by him, detailed progress reports on the ordering and deliveries of materials, and the fabrication and the assembly of the steelwork for each section of the works in the contract, in relation to the time programme.

5.9 DELIVERIES TO SITE

(1) Deliveries of steelwork to the site shall not be made without the prior agreement of the Engineer and shall be planned so as to cause the minimum possible interference or inconvenience to others engaged on the site.

(2) Each delivery to the site shall be recorded on Advice Note giving the net calculated weight of each piece. Two copies of the Advice Note shall be supplied as directed by Engineer.

(3) The Contractor shall notify the engineer when each consignment of fabricated steelwork is received at the site so that he may insect the consignment.

5.10 MATERIALS

5.10.1 Quality of Steel

(1) Except where otherwise shown on the drawings, steel shall comply in all respects with JIS for all structural steel rolled sections, all plate welded box sections, and for all plated connections. Other grades used shall be approved by the Engineer.

(2) All steel shall be new and shall be well and cleanly rolled to the dimensions, sections and weights specified. It shall be sound and free from cracks, surface flaws, laminations and other defects and shall be finished in a workmanlike manner.

(3) The flanges of rolled steel or plates used for boxed sections shall, where indicated on the drawings or required by the Engineer, be checked to ensure that no laminations occur.

(4) Where tensile loads are transmitted through the thickness of a plate or tensile forces applied to the surface of a plate it shall be tested and shown to be from laminations unless otherwise agreed by the Engineer. The cost of any testing for compliance with the above shall be deemed to be included in the rates.

(5) The mechanical and chemical properties of each batch of steel supplied shall be submitted for the Engineer's approval with original certificates from the mills of origin permitting clear identification of the various steel clauses.

5.10.2 Steel Sections and Dimensions

5.10.2.1 Rolled Steel and Hollow Sections

All steel sections shall comply with BS 4848 Parts 2 and 4. The rolling or manufacturing tolerances shall be such that the actual weight of sections does not differ from the theoretical weight by more than –2.5% or +5%.

5.10.2.2 Bolts and Nuts

Unless otherwise noted, all bolts shall be comply with JIS. Dimensions tolerances and thread to comply with JIS.

5.10.2.3 Other Materials

Other Materials used in association with steelwork shall comply with the appropriate BS unless such material is covered by a relevant local by-law or regulation, which shall override such standards.

5.10.2.4 List of Suppliers

The Contractor shall supply to the Engineer a summary list of the rolling mills and manufacturers from which it is proposed to obtain the steel sections, plates, forgings and fixings.

5.10.3 Straightness of Members

(1) Member shall be free from twists and localised deviations from the true line. The deviation from straightness of members shall not exceed 1/1000 of the length of the member.

(2) When two or more such length are joined the deviation from straightness shall not exceed 1/1000 of the completed length unless otherwise agreed by the Engineer.

5.10.4 Out of round

Circular Hollow Sections (CHSs) shall be circular at any section within + 1% of the mean diameter, base on the differences between the maximum and minimum mean diameters at any section, and if necessary to meet this requirement, shall be set up so that the differences in dimensions are matched as evenly as possible.

5.10.5 Marking of Steel

Each piece of steel shall be legibly marked with the manufacturer's name or trade mark, and with cast number by which the steel can be traced to the cast from which it was made, and in addition with its British Standard Specification designation, and shall bear such other identification marks as will facilitate erection. Two copies of the marking drawings shall be supplied by the Contractor to the Engineer. A copy of all orders for materials shall be supplied to the Engineer by the Sub-Contractor at the time of ordering for identification purposes.

5.10.6 Storage and Handling

(1) All structural steel shall be stored and handled so that members and their coatings are not subjected to excessive stresses or damage. Stacking shall be such as not to interfere with the smooth progress of the works.

(2) Open ends of tubular members at all times shall be securely protected from the ingress of water or deleterious materials.

5.11 WORKMANSHIP

5.11.1 General

(1) All steelwork before and after fabrication shall be straight and free from twist. All component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged. Forcible connection to fit the members together shall not be used. All steelwork shall be cut and fabricated to a tolerance of + 1.5mm in its length unless otherwise agreed by the Engineer. End plates shall be truly at right angles to the longitudinal axis of the section.

(2) No work shall be painted, packed or dispatch from the manufacturer's works until it has been inspected, and complies with, or has been certified comply with, all the tests and requirements of the standard applicable to the materials specified, and pass by the Engineer.

(3) Where the length of welds required at connections is less than the length of edge of brackets etc., the edges shall be sealed with a sealing weld unless specified or approved by the Engineer.

(4) Load-bearing connections containing more than one type of fastening shall not be used unless specified or approved by the Engineer.

5.11.2 Fabrication

(1) The Contractor's workmen fabricating the steelwork shall be subject to prior approval by the Engineer. As much of the fabrication of the steelwork as it is reasonable shall completed in the fabrication yard.

(2) Construction and fabrication of the structural steelwork shall comply in all respects with the requirements of the relevant Codes of Practice and Standards listed in the Clause 4.1.

5.11.3 Fabrication of Steelwork on Site

When the steelwork is to be made up on the site, all test procedures and dimensional tolerances shall conform to the specification for the supply of steelwork. Adequate facilities shall be provided for supporting and aligning the members.

5.11.4 Gas Cutting

Use of a cutting torch will be allowed where the metal being cut is not tressed during the operation, and provided stresses will not be transmitted through a flame cut surface. Gas cuts shall be smooth and regular in contour. The effective width of members so cut shall be taken to be 3mm less at gas edge.

5.11.5 Joint tolerance

(1) Plates, shapes or CHSs which are to be jointed by butt-welding shall be accurately cut to size and, where forming is necessary, this shall be done by pressure and not by blows. A tapered transition having a length not less than ten times the offset between the adjacent surfaces of abutting section shall be provided at joints between sections that differ in thickness by more than 15% of a thickness of the thinner section or by 3mm whichever is less. The transition may be formed by any process that will provide a uniform taper.

(2) The Contractor shall take care, especially in the manufacture of welded steelwork, to ensure that flanges are accurately at right angles to webs and that completed parts and members are accurate both in section and in elevation so as to ensure correct registration in the members and in completed units when assembled and/ or erected. Allowances shall be made in dimensions wherever necessary for contraction caused by site welding. Members shall be set up so that the differences in dimensions are matched as evenly as possible at the joints.

5.11.6 Erection

(1) Before delivery the steelwork shall, if required by the Engineer, be temporarily erected at the manufacturer's works either wholly or in such portions to ensure that site erection can be carried out without major amendments. After the fabrication work has been completed and before it is dismantled, each part shall be careful mark for erection with distinguishing marks, and stamped with durable markings. Drawing shall be such as not to damage the material. No work shall be painted or packed for delivery to work site until it has been inspected and passed.

(2) The suitability of all plant and equipment used for erection shall be subject to the approval of the Engineer.

(3) Approval of any of the construction methods or plant shall not in any way relieve the Contractor from his responsibilities under the Contract.

(4) During erection the work shall be securely bolted or otherwise fastened, and if necessary temporally braced, so as to make adequate provision for all erection tresses and conditions including those due to the erection equipment and its operation. Neither permanent bolting nor field welding shall be done until the proper alignment has been obtained.

(5) The Contractor shall supply also necessary false-work and staging, labour, tools, erection plant, drifts, service bolts, nuts and washers and other materials necessary to carry out the work and shall remove them as progress of the erection permits.

(6) Any damage to materials on the site due to inadequate precautions being taken during the erection of the steelwork shall be made good to satisfaction of the Engineer at the Contractor's expense.

5.11.7 Safety during Assembly and Erection

(1) The Contractor shall pay due regard to the stability and safety of the structure temporary works and plant during all stages of the work of assemble and erection.

(2) Temporary bracing shall be provided whenever necessary to resist all erection loads and stresses, sides way, wind and other temporary loads during construction and under all other erection conditions.

(3) Final welding or other fixing of permanent connections shall not be done until proper alignment of the portion of the framework has been obtained. The contractor shall take particular care to ensure and shall be responsible for ensuring, that temporary bolts, jigs or other fixings and/or supports are adequate to provide safety for all erection conditions and are left in until after the final joints have been made and passed.

(4) The Contractor is to refer to the Particular Specification for further requirements.

5.11.8 Site Dimensions

The contractor shall check the site dimensions related to the building in which the steelwork is to be erected and he shall verify all dimensions given on the drawing and inform the Engineer of nay errors or omissions in them before the work is put in hand.

5.11.9 Positioning of Steelwork

(1) The Contractor shall be responsible for the positioning and levelling of all Steelwork and other parts of Works, the plumbing of stanchions and posts and the accurate placing of every part of the Works in accordance with the Engineer's working drawings and to the satisfaction of the Engineer.

(2) The Contractor shall be responsible for ensuring the final accuracy of the positions and levels of the steelwork on the completion and the Contractor shall be responsible for and ensure himself as to its accuracy before accepting it has completely erected.

5.11.10 Temporary Connections

Where connections are to be site-welded, temporary connections shall be used for positioning the Steelwork prior to welding. Before welding is carried out, as much of the Steelwork as will be rigidly fixed thereby shall by finally positioned, plumb and levelled, allowances being made for contractions due to cooling of the welds. Where temporary fastening for site connections have been welded to members they shall be removed preferably by grinding but may be burnt off to procedures including nay pre-heat agreed by the Engineer.

5.11.11 Joints and Connections

(1) No variation of the member, type or position of the joints or connections shown on the approved drawing shall be made without the consent of the Engineer. If such consent is desired the Contractor shall submit detailed drawings of the proposed joints for the approval of the Engineer and no extra cost incurred by reason of such additions or alterations will be allowed to the Contract.

(2) Members and sections shall be to accurate dimensions and positions, to enable proper connecting in the field.

(3) Drifting shall not be used to correct bad alignment. Burning equipment shall not be used for the rectification of misalign holes or lack of fit in members without the permission of the Engineer in each specific case.

5.11.12 Universal Plates or Flats

Where two or more universal plates or plats of the same nominal width are used in tiers the edges shall be machined straight and except only in case when the approval of the Engineer has been obtained to omit these operations and provided that in such cases all edges shall be clean and true, reasonably square and flush.

5.11.13 Holing

Holes through connection plates and plates of adjoining units shall be drill after the members are assembled and tightly clamped or bolted together. The plates which have been so drilled shall be separated after drilling and the burrs removed. The matching holes shall register with each other so that a gauge 2mm in diameter less than the diameter of the holes shall pass freely through them. Finished holes shall not be more than 2mm in diameter larger than the diameter of the bolt passing through them, unless otherwise agreed by the Engineer.

5.11.14 Punching, Drilling and Reaming

Finished holes shall be precisely located to ensure passage of bolts through the holes without drifting. Enlargement of holes necessary to receive bolts shall be done by reaming. Poor matching of holes shall be sufficient cause for rejection.

5.11.15 Bolts and Nuts.

(1) All nuts shall be adequately tightened appropriate power tool and where specified the required torque shall applied. All bolts shall be fitted with washers which shall be tapered wherever necessary to give the heads and nuts a true bearing.

(2) The washers shall be steel or wrought iron and fitted under the nuts. The length of the bolt shall be such that the threaded portion is clear of the parent hole in the steel members jointed. All bolts shanks shall project at least one thread and not more than three threads beyond the nuts. Nuts shall be tightened securely in the finished work.

5.11.16 Service Bolts and Drifts

(1) Where possible service bolts shall have the same clearance as permanent back bolts and in all cases where it is important that there should be no movement prior to final fixing, turned location bolts and drifts with a clearance as specified for turned bolts shake be used.

(2) All drifts that may be used in fabrication or erection shall be of such shape and dimensions as to locate the work accurately without causing any damage or deformation to the holes and parent metal.

(3) Bolts supporting members subject to dynamic loading shall, where so required by the Engineer, have their nuts locked or located in such a way as prevent loosing.

5.12 WELDING

5.12.1 General

(1) Welding of structural steelwork shall be by an electric arc process. The procedure to be followed, plant and equipment to be used and the testing and inspection to be applied shall all be to the satisfaction of the Engineer and shall conform generally with the relevant BS and with the further requirements contained in this Specification.

(2) All welding shall be carried out by fully trained and experience welders and should have passed “Welders qualification/tests under British Standard” or under equivalent qualification tests as approved by the Engineer. In addition to the general provisions of this Specification, the welding shall conform with BS 5135 or equivalent approved by the Engineer.

(3) The sizes and lengths of welds shall not be less than those shown on the drawings nor shall they be substantially in excess of those requirements without approval. The location of welds shall not change without approval by the Engineer.

(4) All welds shall be finished full and made with the correct number of runs, the welds being kept free from slag and other inclusions.

(5) Butt welds shall be at approved positions and may be welded by automatic or manual processes.

(6) Where manual welding is used, hollow sections shall be welded together, where possible, by using a stringer head technique. Where weaving is essential, as in the vertical-up technique, it shall be restricted to the minimum possible amount.

(7) No joints or welds shall be made in any position except where shown on the Drawings or as directed by the Engineer.

5.12.2 Welding Equipment

(1) All welding equipment shall conform to the requirements of the manufacturers of the electrodes used and shall be of adequate capacity and suitable for their purposes. They shall be fitted with instruments for accurately measuring the current and voltages. All welding cables, earth leads accessories and connections shall be suitable for the maximum current to be used. The plan shall be situated as closely as possible to the operator depositing the welds, so that he may have at hand the means of adjusting the current.

(2) The Contractor shall provide all necessary staging and screens for the welders, the supervisors and the Engineers and shall maintain all plant and equipment in an efficient condition. Suitable tong test ammeters shall be provided by the Contractor for measuring the current.

5.12.3 Protections of Welding Site

Welding shall not be done when surfaces are wet or exposed to rain or high wind not when welders are exposed to inclement weather conditions, and the Contractor shall take proper precautions to ensure that all welding sites are adequately protected against the deleterious effect of moisture and wind.

5.12.4 Electrodes

(1) Welding electrodes for manual operations shall comply with BS 639 and shall be of a type suitable for producing sound welds that have strength and toughness at least equal to the materials being welded and as recommended by the manufacturers for the location and the type of weld required.

(2) The classification and size of electrodes, are length, voltage and amperage shall be suited to the thickness of the material, type of groove, welding positions and other circumstances attending the work and shall be as for the welding procedures developed in conjunction with the Engineer.

(3) Electrodes shall be stored for approval in their original cartons or packets in a dry place adequately protected from weather effects. When special protection during storage is recommended by the manufacturer of the electrodes they shall be stored in accordance with the conditions detail by the manufacturer.

(4) All low hydrogen electrodes shall be in hermetically sealed containers or shall be dried for at least 2 hours between 230^0C and 260^0C just before they are used. Electrodes shall be drier prior to use if the hermetically sealed container shows signs of damage. Immediately after removal from hermetically sealed containers or from drying ovens, electrodes shall be stored in ovens at a temperature of least 120^0C. electrodes, which have been wet, shall not be used.

5.12.5 Welding Current

The strength of the current shall be within the range recommended by the manufacturer of the particular electrode being used and shall be towards the upper limit of the range rather than the lower.

5.12.6 Shop and Site Welding

(1) Shop welding shall be carried out under specified welding procedures and continuous supervision exercised. Machine welding will be allowed where approved machines are in used correctly and controlled by qualified operators.

(2) All welding shall where possible be carried out under cover in the workshop.

(3) Site welding shall be carried out on suitable platforms, adequately screened and protected from the weather and under specified and agreed welding procedures and continuous supervision exercised.

5.12.7 Welding Procedures

(1) The contractor shall develop welding procedures, which in conjunction with the overall fabrication methods will produce members and structures meeting the quality requirements of the specifications. These procedures and nay revisions necessary in the course of the work shall show full details of edge preparation, the number of runs, current size of electrode and all other relevant data and shall be submitted to the Engineer for his approval in principle.

(2) The Contractor shall obtain the Engineer's approval of his proposed welding procedures before commencing work.

(3) Welding procedures shall be such that distortion is rendered negligible in the final structure.

5.12.8 Preparation of Material

(1) The dimensions and shape of the edges to be joined by welding shall be such so to ensure thorough fusion and complete penetration at the root of the joint. Surfaces and edges to be welded shall accurate, smooth, uniform, and from fins, tears, cracks and other defects which may adversely affect the quality or strength of the weld. Surfaces to be welded for at least 500mm from the welding edge shall also be free from mill scale, slag, rust, grease, paint or other foreign matter that may prevent proper welding or produce objectionable fumes.

(2) When it is necessary to deposit metal over a previously welded surface, any scale or slag shall be removed to prevent the inclusion of impurities. If for any reason the welding is stopped, special care shall be taken in restarting to secure thorough fusion.

(3) Special care shall be taken to shape accurately the end of one member to fit the other. This shall be by machine flame cutting, machining, properly prepared templates or other approved methods. The correct fusion bevel shall be employed, using automatic bevelling machines wherever practicable.

(4) In the preparation of the fusion faces, shearing shall be limited to metal thickness greater than 9mm. All fusion faces shall be prepared by machining, machine flame cutting or other means approved by the Engineer. Faces shall be kept clean, dry and protected.

(5) Weld joints prepared by arc-air gouging shall require additional preparation by grinding or chipping and wire brushing prior to welding.

(6) Machining. Air-carbon-arc flame cutting or flame gouging, chopping or grinding may be used for joint preparation, back gouging, or the removal of the defective work or material.

(7) Preparation of edged by flame cutting shall wherever practicable be done by machine. Flame cut edges shall be left free of slag. Pre-heat temperatures for flame cutting shall be equivalent to those specified for welding.

(8) In all flame cutting, the cutting flame shall be so adjusted manipulated as to avoid cutting beyond or inside the prescribed lines as applicable. Cut surfaces shall be smooth and any roughness and occasional notches or gouges be more than 5mm deep, on otherwise satisfactory surfaces, shall be removed machining or grinding. Cut surfaces and edges shall be left free of slag. Correction of defects shall be faired to the flame cut edges with a slope not exceeding 1 in 10. Defects in flame cut edges shall not be repaired by welding, except with the approval of the Engineer for occasional notches or gouges less than 9mm deep. Such weld repairs shall be made by suitably preparing the defect, welding with electrodes not exceeding 8mm in diameter, and grinding the completed weld smooth and flush with the adjacent surface to produce a workmanlike finish.

(9) Re-entrant corners except for the corners of weld access cope holes adjacent to a flange, shall be filleted to a radius of not less than 12mm. The fillet and its contiguous cuts shall meet without offset of cutting past the point of tangency.

(10) In branch joints additional preparation at the crotch shall be provided where necessary to ensure full penetration welding.

(11) The throat areas of the web shall be drilled to form semi-circles of 35mm diameter open to the flanges to ensure a full penetration of the flanges using a root pass. The surfaces of the openings shall be ground down to remove any notches after the completion of the weld.

(12) The Engineer's approval shall be obtained if different edge preparation for welded tubes from that shown on the drawings is required for use with automatic welding machines or because of the method of rolling.

5.12.9 Assembly

(1) Structures shall be assembled in jigs or on suitable surface plates on which shall be drawn out the hole section of structure. Members shall be correctly aligned. When correctly aligned the structure shall be tack welded in accordance with BS 5135. Any wedges used to space root gaps shall be removed from the root gaps immediately after tacking and before making the root run.

(2) The Engineer shall be given facilities to inspect the assembled structure tack welded before the final welding is undertaken. Where bolted flanges for connections are welded to main chords, step shall be taken either by pre- or post-heat treatment, by grinding, or by other approved means to ensure that the flanges are rendered flat at the completion of the welding.

(3) The parts to be jointed by fillet welds shall be brought into close contact as practicable. The gap between parts shall not exceed 2mm. If the separation is 1mm or greater, the leg of the fillet weld shall be increased by the amount of the separation or the Contractor shall demonstrate to the Engineer's satisfaction that the required throat thickness has been obtained. The separation between contract surface of lap joints and of butt welds landing on the backing shall not exceed 2mm. Fillers shall not be used except as shown on the drawings.

(4) The spacing between plates forming T joints shall not exceed 2mm. Member to be welded shall be brought into correct alignment and the correct gap and alignment maintained by bolts, clamps, wedges, guy lines, struts, other suitable devices or by tack welds until welding has been completed. Jigs and fixtures shall be used where practicable. Suitable allowances shall be made for warpage and shrinkage.

(5) Any offset from the theoretical alignment shall not exceed 15 percent of the thickness of the thinner part jointed, or 3mm, whichever is the lesser. In correcting misalignment in the such cases, the parts shall not be drawn into a greater slope than 1 in 20. Measurement of offset shall be based upon centre line of parts unless otherwise shown on the drawings.

(6) Strongbacks or other appliances used for alignment shall be so arranged as to allow for expansion and contraction during production welding. The removal of such items shall be carried out to the satisfaction of the Engineer.

(7) Longitudinal seam welds of tubes shall whenever possible be evenly staggered, but in any case by at least 100mm.

(8) All means adopted for correcting improper fitting shall be to the satisfaction of the Engineer. Where excessive root openings are encountered, for butt weld connections weld built up off the plate edges may be allowed at the discretion of the Engineer subject to his approval of the welding procedures before welding the plates together. Such build up of each plate edge, where permitted shall not exceed ½T or 6mm whichever is lesser, where T is the thickness of the thinner plate being welded.

5.12.10 Butt Welded Joints

(1) Plates shall be prepared for welding by bevelling the edges of both plates from one or both sides to form a single-Vee or double-Vee but joint with an included angle of 60^0. The root faces shall not exceed 2mm in depth and the root opening or rap between the plates shall not be less than 2mm nor more than 5mm, except where shown on the drawings.

(2) Butt welds shall be terminated at the end of a joint using extension bar pr run-off plates to ensure sound welds. Such bars or plates shall be removed after the welds have cooled.

(3) Butt welds made with the use of backing shall have the weld metal thoroughly fused with the backing. The backing shall be fitted so that a minimum space exits between the backing and the plates to be jointed. Splices in backing shall be welded with full-penetration welds. Butt welds made without the use of backing shall have the root of the initial weld gouged, chipped or otherwise removed to sound metal and sealed with root passes. Where arc-air gouging is employed, an approved technique which minimizes carbon build up and burning of the weld or base metal shall be used.

(4) The ends of the welds shall be ground smooth and flush with edges of the abutting parts.

(5) Butt welds shall be ground down flat before any spice plates are placed in position.

(6) Butt welds in flange plates and/or web plates shall be completed before the flanges and web are welded together.

5.12.11 Welds Tubes

(1) Tubular steelwork shall be continuously welded and the interior of all tubes shall be clean, dry and free from loose scale, etc., and shall be completely sealed, other than blow holes where required for the galvanising.

(2) All welds shall be full penetration but welds and with the exception of continuous tube-making processes, longitudinal welds shall be made with extension plates at the staring and finishing points if each seam.

(3) End to end connections and flanged joints shall be fitted with backing rings.

(4) The thickness of backing rings shall be no greater than is required by the appropriate welding procedure. They shall be well fitted to provide continuous backing to the parts to be jointed.

(5) Backing rings for circular hollow sections shall be cut on the scarf to ensure ease and accuracy of fit while for rectangular hollow sections the backing ring may be in more than one piece subject to the Engineer's approval.

5.12.12 Rolled Steel

(1) All main welds shall be complete penetration and shall be welded from both sides, the back of the first run being suitably gouged out.

(2) The end of the welds shall have full throat thickness. This shall be obtained on all main welds by use of extension pieces adequately secured on either side. The extension pieces shall be removed by machining or by other means approved by the Engineer and the ends of surfaces of the welds shall be smoothly finished.

5.12.13 Fillet Welds

Preheat and low hydrogen electrodes shall be used where small fillets are used for attachment to thick plates or tubes.

5.12.14 Intermittent Welds

Intermittent welds shall not be used unless approved by the Engineer.

5.12.15 Tack Welds

Tack welds shall be subject to the same procedure and quality required for the final welds and shall be deposited in such a manner as not to interfere with the completion of the final welds. Multiple pass tack welds shall have cascaded ends.

5.12.16 Temporary Welds

(1) Temporary welds shall be subject to the same welding procedure and quality required for the final welds. They shall be removed unless otherwise permitted by the Engineer. When they are removed, the surface shall be made flush with the original surface.

(2) There shall be no temporary weld in tension zones except at locations more than 1/6 of the depth of the web at other locations shall be shown on shop drawings.

5.12.17 Arc Strikes

Arc strikes outside the area of permanent welds are prohibited. Cracks or blemishes resulting from arc strikes shall be ground to a smooth contour and checked to ensure soundness.

5.12.18 Removal of slag

All slag, scale and other inclusions shall be removed and the adjacent metal brushed clean not only from the edges to be welded but also from each pas or layer before the deposition of subsequent passes or layers. This requirement shall apply not only to successive layers but also to successive beads and to the crater area when welding is resumed after any interruption. The steelwork at welded joints shall not be painted, slag, patter, rust, scale, oil and dirt have been removed, the surface, and the joint has been inspected and approved by the Engineer.

5.12.19 Preheat and Interpass Temperatures

(1) Parts to be welded shall be preheated by means of gas flames, induction heating or other means to bring to the specified preheat temperature the full thickness of the part being welded, but not less than 75mm from the point of welding. The specified preheat temperature shall be maintained as a minimum interpass temperature as welding progresses.

(2) Welding preheat temperatures shall be in accordance with BS 5135 and Table 1 unless otherwise modified with the Engineer's approval following the welding procedure tests.

Table 1

Welding Preheat Temperatures

Thickness of Thickest Part at Point of Welding	Welding with other than low Hydrogen Electrodes	Welding with Low Hydrogen electrodes
≤ 19mm	None	None
19mm < 38mm	≤ 70^0C	None
38 < 60mm	Not Permitted	≤ 70^0C
60mm <	Not Permitted	≤ 100^0C

(3) The measurement of temperature shall be by means of temperature indicating crayons or pellets that melt at the specified temperature. Each welder engaged on the work shall be provided with the appropriate temperature indicating device.

(4) Where local condensation is like due to temperature changes, such as at early morning recommencement of work, localised gentle preheat of parts shall be applied before welding.

5.12.20 Post-weld Heat Treatment

(1) Except where otherwise specified, all welded support components and welded parts thicker than 19mm shall be given a post-weld heat treatment after all welds are in place. A post-weld heat treatment of 600^0C shall be held for a minimum of one hour per 25mm of thickness, but not less than ¼hour. When it is impractical to post-weld heat-treat at the temperature specified it is permissible to heat-treat at lower temperatures for longer periods as specified in Table 2.

Table 2

Post-weld Heat Treatment Temperature

Lower Minimum Temperature (^{0}C)	Minimum Holding Time at Decreased Temperature (Hours/25mm)
566	2
538	3
510	5
428	10

(2) For welded tube attachments for which post-weld heat treatment is required, shall be locally post-weld heat-treat by heating a circumferential band around the entire pipe with the welded connection located at the middle of the band. The width of the band shall be uniformly heated to the temperature and held for the time specified for post-weld heat treatment.

(3) The portion of the structure outside of the circumferential band shall be protected so that the temperature gradient is not harmful.

(4) In the case of the weld pipe connections requiring post weld heat treatment the adjacent pipes or fittings shall be heated in a circumferential band at least 3 times the width of the widest part of the welding groove but not less than twice the width of the weld reinforcement.

5.12.21 Control of Distortion and Shrinkage Stresses

(1) In assembling joining parts of structure or of built-up members and in welding reinforcing parts to members, the procedure and sequence shall be such as will minimize distortion and shrinkage.

(2) In so far as practicable, all welds shall be deposited in symmetrical sequence so that shrinkage on both sides of the structure will be equalized.

(3) Welding of members shall progress from relatively fixed points towards where parts have greater relative freedom of movement.

(4) Joints expected to have significant shrinkage shall be welded before joints expected to have lesser shrinkage and with as little restraint as possible.

(5) All shop splices in each component part of a coverplated beam or built-up members shall be made before such component part is welded to other component parts of the member.

(6) All welding shall be carried out continuously to completion or to a point that will ensure freedom from cracking before the joint is allowed to cool below the minimum specified preheat and interpass temperature.

5.12.22 Dimensional Tolerances

(1) The dimensions of welded structural members shall be within the following specified tolerances:

(a) Deviation from straightness of welded members where there is no specified camber or sweep:

(b) 1mm X No. of metres of total length but not over 9mm.

- 1mm x No. of metres of total length/3 or
- 6mm *whichever* is greater

5.12.23 Weld Profiles

(1) The faces of welds may be slightly convex, flat or slightly concave. Except at outside corners, the convexity shall not exceed the value 0.1S + 1mm where S is the actual size of the fillet weld in mm.

(2) Butt welds shall be made with a slight or minimum reinforcement, except 3mm in height and shall have a gradual transition to the plane of the base metal surface.

(3) Surface of butt joints required to be flush shall be finished so as not to reduce the thickness of the thinner base metal or weld metal by more than 0.7 mm or 5% of the thickness, whichever is the smaller, or leave reinforcement that exceeds 0.7mm. All reinforcement shall be removed where the weld forms part of a contact surface. All reinforcement shall blend smoothly into the plate surface with transition areas free from edge weld undercuts. Chipping may be used provided it is followed by grinding.

5.12.24 End Returns

Fillet welds terminating at the ends or sides or parts of members shall be returned continuously around the corners for a distance of not less than twice the size of the weld.

5.12.25 Quality of Welds

(1) Welds shall be uniform and of the specified sizes. They shall fuse thoroughly with the base metal and with successive layers of weld metal, and shall be free from overlaps of weld metal or abrupt edges or grooves and from incomplete penetration, slag inclusions, undercutting, burn troughs, voids, cracks, porosity and other defects.

(2) The surfaces of welds shall be visually inspected and shall be regular and uniform with a minimum amount of reinforcement and reasonably free from overlap.

(3) All craters shall be filled to the full cross section of the welds.

(4) In general, sections of weld those are shown by radiography or other tests to have any of the following types of imperfections shall be considered unacceptable and shall be repaired:

(a) Undercut

Under cut more than 0.2mm deep when its direction is transverse to the primary stress in the part that is undercut. Undercut more than 0.7mm deep when its direction is parallel to the primary stress in the part that is undercut.

(b) Incomplete Fusion or Penetration

Any type of crack or zone of incomplete fusion or penetration.

(c) Elongated Slag Inclusion or Cavities

Any elongated slag inclusion or cavity, which has a length greater than 6mm or 1/3T whichever is smaller, where T is the thickness of the thinner plate being welded.

(d) Slag Inclusion in Line

And group of slag inclusions in line that have an aggregate length greater than T in a length of 12T, where T is the thickness of the thinner plate being welded.

(e) Porosity

The sum of diameters of piping porosity shall not exceed 9mm in any linear 25mm of weld and shall not exceed 19mm in any 300mm length of weld. Regardless of the method of testing, welds shall have no cracks and shall be rejected if they have porosity or fusion type defects.

(5) Alternatively, if approved by the Engineer, the criteria for acceptance or rejection of welds shall follow provisions of applicable British Standards.

5.12.26 Corrections

(1) A piece or member containing welding which is unsatisfactory or which indicates inferior workmanship shall be rejected or corrected by measures approved by the Engineer.

(2) Defective or unsound welds or base metal shall be corrected as directed, either by removing and replacing the entire weld, or as follows:

(a) Overlap or excessive convexity: reduce by removal of excess weld metal by grinding.

(b) Excessive concavity of weld or crate, undersize welds, undercutting: clean and deposit additional weld metal to its full cross section.

(c) Weld porosity, slag inclusions, incomplete fusion: remove defective portions and reweld.

(d) Cracks in weld or base metal: ascertain the extent of the crack by use acid etching, magnetic particle inspection or other equally positive means, remove the crack and sound metal 50, beyond end of the crack and reweld.

(3) The removal of weld metal or portions of the base metal may be done by machining, grinding, chipping, oxygen gouging, or air carbon-arc gouging and in such a manner that the remaining weld metal or base metal is not nicked or undercut. Defective portions of the weld shall be removed without substantial removal of the base metal.

(4) Additional weld metal to compensate for deficiency in size shall be deposited using an electrode smaller than that used for making the original weld, and in and case not more than 4mm in diameter. The surface shall be cleaned thoroughly before welding.

(5) Improperly fitted parts shall be cut apart and rewelded as directed. Members distorted by welding shall be straightened by mechanical means or by application of a limited amount of localized heat in the presence of the Engineer. The temperature of heated areas as measured by approved methods shall not exceed 600^0C (a dull red colour). Parts to be heated for straightening shall be substantially free of stress and from external forces except those stresses resulting from mechanical means used in conjunction with the application of heat.

(6) Both preheat and low hydrogen electrodes shall be used when repairing welds. Fairing by heating or flame shrinking and other methods of correcting distortion or defective workmanship in fabrication of main members shall be carried out only with the express approval and at the absolute discretion of the Engineer. These corrective measures shall be kept to an absolute minimum.

(7) Prior approval shall be obtained for repairs to the base metals, major or delayed cracks, or for a redesign to compensate for deficiencies.

(8) The Engineer shall be advised prior to cutting apart improperly fitted and welded members.

5.13 INSPECTION AND QUALITY CONTROL

5.13.1 Quality Control Program

(1) The Contract is to appoint an inspection agency (Engineer) approved by the Engineer who shall carry out all NDT, shop and site inspections, required under this specification, all to the Contractor's cost.

(2) The inspections carried out by the Engineer are for the sole purpose of independent quality control checks required by the Engineer.

(3) These inspection shall not relieve the Contractor of his sole responsibility to produce works in accordance with this specification, or substitute the Contractor's own quality control program.

(4) The Contractor shall implement his own quality control program to ensure the quality of his materials and workmanship and shall submit to the Engineer his proposals in this respect.

(5) The cost of carrying out material tests, providing material/mill certificates and implementing the Contractor's own quality control programme and procedures shall be deemed to be included in the contract rates for materials/workmanship.

(6) The Contractor shall also allow in his rates and prices for the steelwork for the cost of the testing of his operators, for the provision of all additional labour, material and apparatus and for the preparation and destructive testing of the test specimens, all as specified under clause 4.13.10 to clause 4.13.15.

5.13.2 Testing and Inspection

(1) The fit up, preparation, welding procedures and all welds shall be subject to their development and inspection by a nominated inspection agency (Engineer) under the direction of the Engineer, as defined above.

(2) Before undertaking the welding of any steelwork the Contractor shall have obtained the Engineer's approval of the electrodes and welding process, and his welders shall have been duly qualified for the work intended, all as specified.

(3) Electrodes shall be subject to tests conducted at an approved laboratory and certified as to the grade, operating characteristics and limits of application. Test assemblies shall be prepared in the presence of the Engineer and tests shall be carried out in his presence and to his satisfaction.

(4) Welding tests using procedures and materials similar to those intended for production welding shall be carried out by the Contractor as directed by the Engineer and in the presence of the Engineer and to their satisfaction. Each finished joint shall be subjected to a radiographic test in addition to two reduced section tension and guided bend tests, as specified in BS 709. The welded test pieces shall be heat treated in the same manner as for the joints in the works they represent.

(5) The Contractor shall, at his own expense, provide all test pieces for the development of welding procedures and for the testing of welders under clause 4.13.10 and shall include for the dressing and surface preparation of welds necessary for the appropriate weld inspection and testing.

(6) The Engineer will carry out NDT and inspection of such procedures and welders, as instructed by and under the direction of the Engineer to fulfil the requirements of this specification.

5.13.3 Test Certificates

(1) The Contractor shall supply manufacturer's test certificates, analyses and mill sheets for all structural steel to the Engineer.

(2) The certificates shall include a test sheet signed by the manufacturer giving the results of the mechanical tests applied to the steel purchased and its chemical composition. Should the Engineer require structural steel to be tested, samples shall be tested at an independent testing station for compliance with BS 4360.

(3) Should the results of either test be unsatisfactory the whole consignment of steel which the sample represents shall be rejected and shall be replaced by other materials of specified quality.

5.13.4 Other Tests

Tests on other materials and parts, bolts and other prefabricated fixings shall be carried out or arranged by the Contractor whenever required by and under the direction of the Engineer.

5.13.5 Cost of Test, etc.

The contractor shall be deemed to have included in his rates and prices appropriate allowance for the cost of supplying copies of material lists and orders and for the carrying out of material tests and supplying Test Certificates, as defined under Clause 4.13.

5.13.6 Inspection and Testing Generally

(1) The Contractor shall have all the welding inspection and testing required by this specification carried out by an approved independent laboratory, referred to herein as the Engineer, and shall submit all signed test certificates to the Engineer, all at the Contractor’s expense.

(2) Representatives of the Engineer shall have the right to inspect and/or test at any stage the manufacturing and other processes, and shall at all reasonable times be given free access to the Contractor’s workshop and to the site. The Contractor shall provide such attendance, samples and other facilities as may be necessary for inspection and quality control during any stage of the fabrication and other operations and for witnessing the required tests. The Contractor shall supply of charge all labour and tools required in connection with the inspection and testing of the steelwork.

(3) All materials, sections and fixings may be subject to inspection and witnessed testing at the manufacture’s works as directed by the Engineer. Inspection as aforesaid, will be carried out as far as possible at the manufacturer’s works but the Engineer may at his discretion defer inspection of or re-inspect any parts until after delivery to the site.

(4) All parts of the works done on the site will be subject to inspection and testing and shall be completed to the satisfaction of the Engineer.

The Contractor shall have all site welding tested in accordance with this specification and shall submit results to the Engineer.

5.13.7 Rejection

(1) Any steelwork which, in the opinion of the Engineer and/or the Engineer, is not in accordance with this Specification shall be rejected either before or after delivery to the site, and if delivered shall be removed from the site at the Contractor's expense. Any delay caused by such rejection shall not in any way relieve the Contractor from his responsibilities with regard to the provisions of the Contract.

(2) In the event of and materials proving defective subsequent to delivery, such material shall be rejected notwithstanding any previous certificate of satisfactory testing.

(3) Rejected material or workmanship shall be remedied or replaced by the Contractor without extra cost and without affecting the time of completion of the Contract.

(4) Inspection and acceptance of material, sections and fixings, etc., by the Engineer shall not in any way relieve the Contractor of any of his own responsibilities for ensuring that the materials, parts and fixings are sound and of requisite quality.

(5) Where the Engineer considers that an excessive number of welds fail to meet the specification, the frequency and number of tests will be increased to that directed by the Engineer. The cost of all such extra testing shall be borne by the Contractor.

(6) Where there is an excessive number of weld test failures as 4.13.7 (5) above, the Contractor shall submit proposals to the Engineer of how he will amend his welding procedures and/or personnel to avoid further weld test failures. Such agreed amendments shall be made before proceeding with further welding.

5.13.8 Supervision by Contractor

(1) The Contractor shall be responsible for ensuring that all materials and workmanship comply with this Specification and shall provide all the supervision necessary to fulfil this requirement.

(2) The works shall be supervised throughout by qualified representatives of the Contractor who have had a thorough experience of the management, fabrication and erection of large works and special welded steel structures. The appointment of the representative in charge of the work on site shall be subject to approval by the Engineer.

(3) The supervision as aforesaid shall be under the charge of competent Technical personnel nominated for the purpose by the Contractor and working full time on the site during the progress of the site work.

(4) For welded work the Contractor shall appoint sufficient supervisors who shall be responsible for seeing that all welding plant and equipment is maintained in proper working order and that all welding is carried out in accordance with this specification. He shall provide approved means of identification by means of an identification mark to enable all welds to be traced to the welding operators responsible for the work.

(5) The steelwork shall be erected and fixed in accordance with the agreed programme under the direct supervision of competent staff fully experienced in this class of work.

5.13.9 Welders Qualification

(1) The Contractor shall be responsible for ensuring that every welding operator employed on the fabrication and/or site work is a competent welder. The competence shall be first assessed by testing to procedures laid down in this Specification or as stipulated in relevant British Standards.

(2) Every welding operator before he carries out any welding for this sub-contract shall pass or shall have passed, qualifying tests in accordance with BS 4871 to verify his competence for the type or types of welds that the he will be called upon to make. The tests shall be as specified or such other equivalent tests as the Engineer may at his discretion specify from time to time.

(3) The Contractor shall provide, free of cost, all material and facilities for the tests on each and every welder and for each procedure employing different welding methods.

(4) The name of all operators qualified as aforesaid and particulars of the tests shall be recorded by the Contractor and agreed by the Engineer and shall subsequently be made available as and when required. The Engineer shall have the right to require the immediate suspension by the Contractor of any operator whose standard of workmanship is unsatisfactory regardless of his having previously passed the agreed tests but the Contractor may submit the operator for re-test if he has received further instructions.

(5) All welders shall be tested and qualified for each type of process on which he is to be engaged.

(6) All welders shall qualify for filler and butt weld tests on approved specimens.

5.13.10 Test Fillet Welds

(1) Test fillet welds shall be 25mm fillet welds on 25mm thick plates lapping by 200mm x 200mm, both plates in vertical plane, centre lines of plates horizontal, weld all round.

(2) Two test welds shall be made with the maximum size single-pass fillet weld and one with minimum size multipass fillet that will be used in construction.

5.13.11 Test Butt Welds

(1) Test Butt Welds shall be single V on 25mm thick plates with backing strip, one test weld of each type, as follows:

(a) Horizontal weld from top in T joint, butting plate vertical on top.

(b) Vertical weld in T joint, both plates vertical

(c) Horizontal overhead weld in T joint, butting plate vertical at underside.

(2) All welders engaged in the welding of tubes shall in addition qualify in the following butt weld tests on tubes.

5.13.12 Test Tube Junction Butt Welds.

100mm chord tube horizontal, 100mm butting tube at 40^0C to horizontal at underside.

5.13.13 Test Joint

If joint details different from those shown on the tender drawings are proposed by the Contractor, all welders engaged in the welding of such joints shall be subject to additional qualification tests prescribed by the Inspector, at the Contractor's expense.

5.13.14 Test Full Sized Bending/Curving

For curved members, full sized bending/curving tests shall be performed to the satisfaction of the Engineer.

5.13.15 Test Radiographic, Ultrasonic and Penetrant Dye

(1) Radiographic, ultrasonic and penetrant dye tests shall be applicable to the test welds, as required by the Engineer. The test specimen shall then be subjected to destructive testing of test sample shall be deemed to be included in the Contract.

The destructive tests shall be carried out in an approved laboratory and paid for by the Contractor. Any NDT on test samples shall be done by the Engineer, employed y the Contractor but under the direction of the Engineer.

5.14 NON-DESTRUCTIVE EXAMINATION OF WELDS

(1) The Contractor shall ensure that all production welding is of sound quality. During production of welded tubes at least one radiograph approximately 300mm long shall be required on a circumferential and a longitudinal weld respectively in each completed length as a spot check on quality. If the results of any weld test do not conform to the specified requirements, two additional tests on the same member shall be carried out at the Contractor's expense.

(2) In addition the Inspector shall carry out radiographic tests on butt/filet welds in the structure on both shop and site welds in accordance with the relevant specification except that the number of tests shall be as specified herein or as directed by the Engineer.

(3) The Inspector may carry out dye penetrant tests on all or selected welds in members of the primary steel structure and such other welds as the Engineer may require, using the standard methods set out in BS 3889.

(4) The Inspector shall also carry out the following random (or where noted 100%) tests to check the quality of welds:

(a) Magnetic Particle test on 20% of all Fillet and Partial Penetration Welds.

(b) 100% Radiographic tests on all Splice Butt Welds (Full Penetration).

(c) Ultrasonic tests on 20% of Full-Penetration Butt Welds other than 14.4.2 above.

(5) Radiographic or ultrasonic inspection or both shall be when the overall soundness of the weld cross section is to be evaluated. Magnetic-particle or dye-penetrant inspection or both shall be used when investigating the outer surface of welds or as a check of intermediate weld passes such as root passes and of chipped, ground or gouged joints prior to depositing subsequent passes.

(6) The final non-destructive testing shall be delayed to accommodate occurrence and detection of delayed cracking. Weld run-on or run-off tabs may be used where practical and be sectioned for examination. The practice of taking weld plugs or samples by machining or cutting from the welded structure shall be used only in the absence of other suitable inspection methods. When such weld plugs or samples are removed from the welded structure, the holes or cavities thus formed shall be properly prepared and welded, using a suitable welding procedure as established for the original joint.

(7) Where welds do not meet a standard to the satisfaction of the Engineer, the defective portion with the Engineer's permission may be removed and then re-welded and submitted for approval.

(8) The results of all tests shall be submitted to the Engineer for his inspection.

(9) A single welded circumferential but joint with backing strip may be radiographed without removing the backing strip, provided it is not to be removed subsequently and provided the image of the backing strip does not interfere with the interpretation of the resultant radiographs.

(10) Principal welds in bedplates shall be examined radiographically or ultrasonically.

(11) An alternative approved method of test may be used in lieu of the radiographic inspection of pipe joints, where the latter cannot be applied.

5.15 CORROSION PROTECTION

5.15.1 General

(1) of moisture, windborne dirt, dust sea spray or other pollutants. Such surfaces shall be further cleaned and prepared before additional coatings are applied or where sea spray, dust or other pollutants are contaminating the surface.

(2) Any relevant requirements not covered by this Specification shall be in accordance with the manufacturer's data sheets and instructions. All painting shall comply with statutory requirements as to health, environment and safety.

(3) All steelwork shall be handled, transported, stacked and erected in such a way as to avoid damage to the applied paintwork and due precautions taken to ensure that erection tackle, equipment and methods minimize the risk of such damage. Where damage occurs the Contractor shall take appropriate remedial action to provide a surface preparation and painter finish conforming with the requirements of this Specification.

(4) Steelwork surfaces shall be protected from corrosion by means of galvanizing and/or and approved painting system from an approved manufacturer. For galvanized steelwork, refer Clause 4.16 of this Specification and for the extent of galvanizing and painting, refer to the drawings.

5.15.2 Surface Preparation

(1) After inspection and approval and before leaving the workshop, all steelwork shall be thoroughly cleaned of all loose mill scale, rust, spatter, slag, or flux deposit, oil, dirt and other foreign matter by abrasive blast cleaning to BS 4232nd quality (equivalent Swedish Standard SIS 05 59 00).

(2) Any surface laminations, shelling, cracks, crevices, inclusions, surface flaws, burrs or sharp edges shall be removed before coating.

(3) Contact surface shall be cleaned by effective means, before assembly and painted.

(4) Coating system shall be applied within 2 hours of blast cleaning. If rusting occurs after the completion of the surface preparation, the surface shall again be blast cleaned as specified. Blast cleaned surfaces shall not be left overnight before painting.

5.15.3 Coating System

(1) The coating system shall be as specified on the drawings.

All paints shall be to BS 5493 and applied in accordance with the manufacture's instructions.

(2) Each coat shall applied as recommended by the manufacturer at an interval that ensures the proper hardening or curing of the previous coat and provide the specified dry film thickness without detriment to surface finish.

(3) Generally various surfaces shall be primed and painted as follows:

(a) Surfaces to be encased in concrete shall not be painted.

(b) All other structural steel except where encased (see above) shall be primed and painted or galvanized if so specified on the drawings.

Finishing coat colours are to be specified by the Engineer.

5.15.4 Welded Work and Other Surfaces in Contact

(1) The surface after preparation within 200mm of site welds to steelwork and other steel surfaces to be in contact with each other shall be masked for temporary protection prior to assembly. Alternatively after the specified surface preparation has been carried out, approved primer coatings which have been proved to have no deleterious effects on the production of satisfactory welds and the subsequent paintwork may be used in lieu of masking.

(2) Surface in contact but inaccessible after assembly shall receive their specified protection treatment before assembly.

5.15.5 Internal Surfaces of Sealed Tubes

The internal surfaces of hermetically sealed steel tubes shall be exempt from the specified requirements for corrosion protection, except where galvanised, but shall be protected against ingress of water or other corrosive substances prior to sealing and at all other time.

5.15.6 Painting on Site

(1) Before assembly of the steelwork at the site, the Contractor shall clean, prepare and prime all components or connections not otherwise treated and paint all areas in accordance to this specification of previously primed members damaged during delivery.

(2) After assembly of the steelwork, all exposed bolt heads shall be cleaned and painted as specified. The paintwork wherever damaged, deteriorated or affected by site welding shall be repainted and made good by the Contractor in accordance to this specification.

(3) Painting of site welded galvanised members is to be carried out in accordance with clause 4.16 of this Specification.

5.15.7 Acceptability and Inspection of Coatings

(1) The finished coating shall be generally smooth, of a dense and uniform texture and free from sharp protuberances, voids, bubbles, pin holes, sags, dimpling or curtaining.

(2) Any coat damaged by subsequent processes or which has deteriorated to an extent such that proper adhesion of the coating may not be obtained or maintained shall be recleaned to the original standard and recoated with the specified sequence of coats.

(3) The complete coating shall be checked for continuity by the Engineer.

5.16 HOT DIP GALVANIZING

(1) Where noted “Galvanized” on the drawings, steelwork may be chemically decaled and cleaned, so that all rust, mill scale, oil, grease and other foreign matter be removed leaving a clean surface of metal or a tightly adhering coating of zinc or iron phosphate.

(2) Steel shall then be immersed in a bath of molten zinc so that when withdraw, the zinc coating solidifies to a dry film thickness of 100 microns. Allow a 48 hour curing period before transporting steelwork. Galvanizing is to comply with the requirements of BS 729, except as modified herein.

(3) All hollow sections to be galvanized shall have adequate blow holes in end plates to allow complete galvanizing without air pockets.

(4) All transport and erection abrasions, site welds etc. are to be reinstated by thoroughly wire brushing all affected areas to achieve a clean sound substrate and patch coating with “cold-galv” or an inorganic zinc silicate primer equivalent in quality to Dimetcote 6 to a dry film thickness of 110 microns, followed by any finishing coats specified for that part of the steelwork by the Engineer.

5.17 MARKING FOR ERECTION

(1) Every separate member shall be plainly and permanently with paint to show position and direction as necessary for easy identification and correct placing.

(2) Loose pieces of connections shall attached to their respective members.

(3) Bolts, where not in holes, shall be metal tagged each type and size in a separate container.

(4) The extent and size of all fillet welds which are to be made in the field shall be clearly marked.

(5) Where welds are to be made between distinctive steels they shall be given a distinctive colour.

(6) Where priming coats will not receive a finishing coat of decorative paint, members shall be marked in a position that will not be visible after erection is completed and cladding-if any-attached. Where this is possible members shall be marked using a metal tag wired to the member.

5.18 ERECTION

5.18.1 General

(1) Safety requirements, erection cranes, equipment, scaffolding and staging, shall meet the requirements of the relevant controlling Local Authorities.

(2) The Contractor shall adopt an erection procedure such that all members can be placed and fixed in position without distortion.

(3) The Contractor shall take full responsibility for the Safety and Stability of the steelwork during erection and until such time as it is finally completed and handed over, must take all precautions including temporary bracing necessary to ensure stability of the partially assembled structure against wind forces, and those stresses exerted due to erection equipment and its operation tending to distort or deform the framework.

(4) The Contractor shall allow for the cost of temporary erection bracing required and any professional advice required in connection with such bracing.

(5) As each section of steel is erected, all members shall be lined, levelled and plumbed before final bolting up commences. The ties, jacks braces etc. used in lining, levelling and plumbing the steelwork shall be left in position until all bolts have been finally tightened.

(6) The Contractor shall submit detailed proposals and Method Statement for assembly, erection, fixing of the steel structure for the approval of the Engineer.

5.19 TOLERANCES

5.19.1 General

The Contractor shall erect, fix, adjust and maintain all members in their intended vertical and lateral alignment and level. Members who do not meet the specified tolerances shall be liable to rejection. Where no specified tolerances are specified herein, these shall comply with applicable British Standards, AS or AISC, whichever is the more stringent. Refer to the Particular Specifications for further requirements on tolerances.

5.19.2 Position

Unless otherwise noted on the Particular Specifications, variations from the intended position shall be:

(1) For beams and trusses –
3mm when measured at the support in horizontal direction

(2) For columns
at the column base 1.5mm

at the top of the column or at points of connection with other members---1/100 of the distance between the point considered and the base of the column.

(3) Other compression members
at ends of the member---3mm
at points of connection with other member---1/500 of the distance between the point considered and the nearer end, with a maximum of 3mnm.

5.19.3 Straightness

(1) Deviation from straight-line, unless cambered shall not exceed 1/100 between Points of Supports.

(2) Struts (columns, compression members). The maximum deviation from a straight line between points of lateral support, between alternate points of lateral support, between the ends of the member, shall be 1/1000 of the distance between the respective point to a maximum 3mm.

5.19.4 End Bearing Splices

(1) In contact over portion of the area.

(2) The maximum tolerances shall be 1/500 of the least dimension of the section at the splice or 600 micro metres whichever is the lesser. Permanence bolting or welding shall not be carried out until correct alignment, and camber if any, has been obtained in each member of the structure.

(3) Additional members used to facilitate erection shall be affixed in a manner which does not weaken or deface permanent steelwork.

5.19.5 Holding Down Bolts

(1) Holding down bolts including prestressing bars shall be set in position be the Main Contractor and confirmed and agreed by the Contractor before pouring.

(2) The bolts shall be preset in their correct position using templates in a true vertical line and firmly held by an approved method before concrete encasing the H.D. bolts.

(3) Refer to Particular Specifications on notes on inter-facing.

5.19.6 Bedding and Grouting

(1) Where steelwork is supported by concrete, masonry or like material, it shall be set up on packing or wedges to facilitate alignment and permit subsequent grouting. Such packs, if permanent, shall be of grout of similar strength to the permanent grout. All other packs shall be removed before completion of grouting.

(2) All grouting shall conform with methods in BS 5950 Part 2 Clause 2.6 and this Clause unless shown otherwise on the drawings.

(3) Permanent grout shall be of non-shrink type and of approved quality with a minimum strength of 40 N/mm^2 at 28 days. The Contractor shall obtain approval from the Engineer for the type of non-shrink grout to use.

(4) The Contractor shall be responsible for the grouting of all base plates, bearing plates and for end connections where shown on drawings. Grout shall be neatly finished and tapered at the edges by steel towelling.

5.19.7 Site Cutting, Drilling and Welding

During erection steel members shall not be cut burnt welded or drilled without approval. Drifting may only be used for bringing parts into position, not to match unfair holes, or enlarge holes, or distort metal.