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MAE TUEN HYDROPOWER PROJECT

CHIANGMAI PROVINCE

CONTRACT C1

CIVIL WORKS AND TRANSMISSION LINE

VOLUME 2

TECHNICAL SPECIFICATIONS

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MAE TUEN HYDROPOWER PROJECT

CONTRACT C1

CIVIL WORKS AND TRANSMISSION LINE

VOLUME 2 : TECHNICAL SPECIFICATIONS

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SECTION 1- GENERAL REQUIREMENT

SECTION 1 - GENERAL REQUIREMENT

S1.01 REQUIREMENT

The Specifications shall be read in conjunction with the Conditions of Contract, the Drawings and the Schedule of Quantities, Rates and Prices (hereinafter called "the Schedule") , and the Contractor shall comply with all the provisions contained within the Contract Documents and the Engineer's instruction.

The Specifications describe the minimum required standards or criteria to be applied to the Works.

The Contractor shall fully understand the site conditions and the detail extent of the Works and carry out the Works in accordance with the Specifications and Drawings as well as the instruction of the Engineer.

The Contractor shall furnish all labor, materials, equipment, tools, and incidentals to construct and make completely ready the Works in accordance with the Specifications.

The Contractor shall fulfill all the requirements and obligations of all provisions contained in the Conditions of Contract and Specifications. Where there is no specific item in the Schedule and where no statement is made in the Specifications to the contrary, the cost of requirement or obligation such as mobilization of construction equipment, overhead, profit, etc., shall be included in each appropriate pay item in the Schedule.

S1.02 SCOPE OF WORKS

The Works to be carried out under this Contract include, but are not limited to, site investigation, testing, supply, construction, manufacture or fabrication, shipping, erection, tests commissioning and handover to the Owner of the following principal items of work as shown on the Drawings and detailed in this Specification:

(1) Mae Tuen Weir

(a) Concrete cover on weir crest. The weir crest is approximately 23.88 m long and the crest is approximately 7.0 m high.

(b) Intake

(i) Construct the inlet of headrace and sand sluice. Inlet is approximately 1.10 x 1.10 m (W x H)

(ii) Supply and install vertical gate and gate lift 3 tons with gear motor

(2) Headrace

(a) Access road, the access road is approximately 3,462 m long and 5.0 m wide and appurtenant works of access road.

(b) Concrete conduit pipe

(i) Construct the concrete conduit pipe of headrace is 1.00 m. dia. and is approximately 3,462 m long

(ii) Laying steel conduit pipe of headrace is 1.00 m. dia. and is approximately 43 m long.

(c) Drain culverts are 17 units. Each drain culverts are 1.20 m. dia.

(3) Forebay

(a) Forbay is reinforcing concrete structure. Forbay is approximately 30.0 m long, 3.0 m wide and 9.0 m high.

(b) Valve chamber and outlet are appurtenant of forebay.

(4) Penstock

(a) Steel conduit pipe

(i) Construction of a steel pipe conduit supported on anchor block. Steel conduit pipe of penstock is 0.90 m. dia. and 118 m long.

(ii) Supply and installation of valve and joint for transfer water demands.

(5) Powerhouse and tailrace

(i) Construction of a powerhouse for installing turbine and the control equipment.

(ii) Supply facilities and equipment for rooms in powerhouse.

(iii) Construct the concrete box culvert of tailrace is 1.00 x 1.20 m. and 2 rows

(6) Access road 2 lines

(a) The access road for first line is approximately 804 m long and 4.0 m wide and appurtenant works of access road and traffic surface is concrete pavement.

(b) The access road for second line is approximately 990 m long and 4.0 m wide and appurtenant works of access road and traffic surface is concrete pavement

(c) Supply and installation of guard posts, guard rails and concrete barrier

(d) Construction of prestressed concrete bridges for vehicle traffic

(e) Construction of ditches and pipe culverts for drainage facilities

S1.03 STANDARD

(1) Except as otherwise specified in this Specification, all materials and workmanship shall comply in all respects with the requirements of the appropriate standards and codes issued by:

TIS	Thai Industrial Standard
NEC	National Electric Code of Thailand
BS	British Standard
ASTM	American Society for Testing and Materials
ACI	American Concrete Institute
ASME	American Society for Mechanical Engineers
ANSI	American National Standards Institute
AWS	American Welding Society
USBR	U.S. Bureau of Reclamation
AASHTO	American Association of State Highway and transportation Offices
AISC	American Institute of Steel Construction
SSPC	Steel Structures Painting Council

Or such other approved standard current at the date of Invitation to tender as may be applicable to any parts of the Permanent Works. If, after the date of Invitation to Tender, there is an amendment to a standard or code relevant to the Contract, the Engineer will direct whether the amendment is to apply.

(2) The Contractor shall have available in his site office at all times at least one copy of every standard or code referred to in this Specification, any additional standard or code which may be referred to therein, and shall make these available for reference by the Engineer upon request.

S1.04 CONSTRUCTION MATERIALS AND WORKMANSHIP

Principal construction materials to be supplied for the Works shall be subjected to the Engineer's approval.

(1) The Contractor shall submit samples of construction materials and list of their supply sources and/or manufacturers to the Engineer for his approval within two (2) months after the date of signing of the Contract. Principal construction materials being subjected to the Engineer's approval include cement, admixtures, aggregate, sand, water for concrete mixing, materials for riprap, reinforcing bar, steel, etc.

(2) All soil, turf, gravel, stone, timber and other materials obtained from the excavation, clearing of the Site and soil stripping, shall belong to the Administration and shall not be removed from the Site without the consent of the Engineer. The Contractor, however, may use for the construction of the Works, timber fallen on the Site and any of the materials excavated under the Contract upon approval and directions of the Engineer.

(3) When no item is provided in the Schedule for the furnishing of any materials required to be furnished by the Contractor, the cost of furnishing, hauling,

storing and handling shall be included in the rate of the work for which the materials are required.

(4) All workmanship shall be of the best quality in each respective category of the Works. Except where otherwise stated, or approved by the Engineer, all materials used in the Works shall be of the best quality, of the respective kinds specified or described in the Specifications, Drawings and the Schedule and shall comply wherever possible with the current issue of the reference standards or other equivalent approved national standards, subject to the approval of the Engineer.

S1.05 SUB-CONTRACTORS

When and in case the Contractor intends to employ sub-contractor(s) for a major part of civil works, such sub-contractor(s) shall be nominated by the Contractor and accepted by the Owner at the time of executing the Contract.

S1.06 SETTING OUT

It shall be the Contractor's responsibility before commencing the Works to confirm with the Engineer the coordinates and elevations of permanent benchmarks and control points to be used. All levels and coordinates referring to the Works shall be based on the following:

(1) Benchmarks and reference survey stations have been established at certain points on the Site as shown on the Drawings No.MT-WE-01 and as listed herein. Horizontal and Vertical Control Benchmark

STA.	LEVELS (M.S.L.)	COORDINATES (M)
Weir Crest	+958.00	N 1,967,202 m E 423,937 m

(2) Prior to commencing the Works, the Contractor shall undertake the survey check of the reference benchmarks and satisfy himself as to their accuracy. The Contractor shall carry out all other survey work necessary to extend the survey network to the area of the Works and shall establish, maintain and preserve permanent monuments, temporary benchmarks, and reference stations.

(3) Permanent benchmarks for setting out will be as shown on the Drawing and as given in (1) above. Setting out the elevations and coordinates of all temporary benchmarks shall be performed by the Contractor. The Contractor shall carry out the survey of profile and cross section required for setting out of structures.

These survey results shall be submitted to the Engineer for his approval.

S1.07 SANITARY AND HEALTH SERVICES

(1) Sanitary

(a) The Contractor shall arrange for a high standard of sanitation to be maintained throughout the Sites. He shall construct and maintain, at his own cost, a system of surface drainage and waste disposal, to be approved by the Engineer before any work commences. Sanitary conveniences shall be provided and maintained by the Contractor in accordance with the appropriate regulations to the extent and in such manner, and at such places as may be approved by the Engineer, and all persons connected with the Works shall be obliged to use them.

(b) The Contractor shall arrange throughout the duration of the Contract for the off site disposal of sewage effluent arising from toilets, Contractor's and Engineer's offices, canteen and the like. Such arrangements shall be subject to the Engineer's approval. The Contractor is reminded that a connection from the Site into an existing public sewer will not be available.

(2) Health Services

(a) The Contractor shall make satisfactory arrangements with a doctor or a hospital in the vicinity for the provision of all medical, and health services for all persons employed by him and by any sub-contractors employed by him on the Works including the dependents of such persons (providing such dependents are residents on Site).

(b) The Contractor shall construct the clinic building for the first aid and services which shall be available at all times when work is in progress on Site for all persons employed by the Contractor or by any sub-contractors employed by him on the Works, for the staff of the Owner and of the Engineer or any other person authorized the Owner or the Engineer to be on Site.

(c) The Contractor shall submit to the Owner within one month after "Notice to Proceed" the layout plan of clinic building, detail of medical equipment and medicine, qualified nurse and assistant nurse with them qualification and agreement with them and service method of clinic. In addition, the Contractor shall submit the plan to provide ambulance under the agreement with the first class hospital in Nan Province.

S1.08 SAFETY MEASURES

(1) General

In the performance of the Works, the Contractor shall exercise every reasonable precaution to protect persons or property from injury. He shall erect and maintain all necessary temporary fencing, barricades, barriers,

multilingual signs, and lights and provide fire alarm, fire extinguishing and fire fighting services at strategic points on the site. The Contractor shall adopt and enforce such rules and regulations as may be necessary, desirable or proper to safeguard the public, all persons engaged in the works and its supervision and all traffic adjacent to thorough areas. The Contractor shall appoint a safety officer and hold regularly scheduled safety meetings with the Engineer and with his own supervisors and foremen.

(2) Road Safety and Maintenance of Traffic

The Contractor shall install convey mirrors at road intersections, junctions and bends of poor visibility as well as priority signs at proper locations of his temporary access roads.

The Contractor shall provide substitute passes and bridges to give access to the existing villages, houses, etc. to the satisfaction of the Owner and authorities concerned whenever and in whatever manner the Contractor disturbs such existing way during the execution of the Works.

Where the works will be carried out at the site on or near the existing road, the Contractor shall maintain vehicular and pedestrian traffic at all times. If the Contractor's operations cause traffic hazards, he shall repair the road surface, provide temporary way, erect wheel guards or fences or take other measures for safety satisfactory to the Engineer. For the construction at the location of heavy traffic or at road junctions, and for structure lying across the road, the Contractor shall submit a work program showing number of labor and equipment, the expected amount of work to be done, detours and another necessary details to the Engineer for approval fifteen (15) days in advance of the starting of the works.

Detours around construction site will be subject to the approval of the relative authorities. Where detours are permitted, the Contractor shall provide all necessary barricades and signs as required to divert the flow of traffic. While traffic is detoured, the Contractor shall expedite construction operation and the period be strictly controlled by the Engineer.

For road crossings or in heavy traffic locations, the Contractor shall carry out the works at the time and within the working hours directed by the Engineer. After completion of the works, the Contractor shall immediately replace backfill and pavement at the crossings.
Should the Contractor intend to occupy the land of the Owner of Highways and/or disturb the traffic of the highways for his construction purpose, the Contractor shall submit the details of occupation and schedule to the Owner for his approval after getting all necessary approvals by authorities concerned and carry out the Works under the instructions of the Owner of Highways and other authorities concerned.
The Contractor shall have full responsibility for the safety at the Site crossing highways and the Contractor shall submit his weekly activities schedule and the

locations of the works crossing the highways to the Owner of Highways through the Owner, and obtain all necessary approvals from the Owner of Highways, prior to commencement of the respective works.

(3) Temporary Fencing

The Contractor shall erect, maintain and remove suitable and approved temporary fencing to enclose such areas of the works within the site as may be necessary to the satisfaction of the Engineer. Where any temporary fence has to be erected alongside a public road, foot path, etc., it shall be of the type required by and shall be erected to the satisfaction of the authorities concerned.

(4) Lighting

The Contractor shall provide sufficient lighting to ensure that, in all places where the work is done at night.

(a) Safe working conditions are provided both for the Contractor's personnel and for personnel of the Engineer.

(b) The works can be constructed in complete compliance with the instruction of the Engineer.

(c) A complete inspection of all works in progress can be made by the staff of the Engineer.

Unless otherwise directed by the Engineer the minimum intensity of illumination on ground or working surfaces to be provided for the various operations or work areas shall be as tabulated below:

Operation or Area	Minimum Intensity of Illumination in Foot-candles
Earthworks and excavation	2
Bridges	2
Access and haul roads where cross traffic or other hazardous conditions exist	2
Concrete batching plant	4
Concrete placing	4
Maintenance shops and auxiliary buildings	5
Explosives storage area	2
Tunnel working place	4

Illumination for areas or operations not listed in the above table shall conform to the specified requirements for similar listed areas or operations.
All moving equipment or plant used during night operations shall be equipped with sufficient lights and reflectors to ensure safe working conditions.

Not less than 14 days before he proposes to start 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 submission to or approval by the Engineer for lighting shall not relieve the Contractor of any of his liabilities or obligations under the Contract.

(5) Explosives

In the use, handling, transporting and storage of explosives, the Contractor shall comply with the guidelines given in the Thai regulation. The handling or use of explosives shall be discontinued during the approach and progress of a thunderstorm. All persons shall be removed from danger areas to a place of safety during such periods.

The explosives storage shall be located as directed by the Engineer and shall be protected with an earth bunker surround and enclosed with security fencing and provided with lighting to the approval of the authorities concerned. The Contractor shall store all explosives in a secure manner marked clearly in English "Danger Explosives"

(6) Signposts and Notice Board

The Contractor shall provide signposts and notice boards at the places indicated by the Engineer.

The signposts shall show the direction to the working site and the names of the work site, the Engineer and the Contractor. The notice board shall describe the outline of project and illustrate the general plan of project.

The signposts for traffic control shall be required according to the regulations of the relative authorities in case a part of existing road will be occupied by the works and detours will be provided

(7) Materials and Equipment Supply

The Contract shall provide following listed materials to the Engineer within one month after "Notice to Proceed"

Description	Quantity
- Safety helmets (White color)	100
- Boots and rain coats (Orange yellow)	50
- 3 m long packet measure (Steel)	25
- Flashlight (Pocket torch)	25
- Cotton gloves	250
- Illuminance measuring equipment	2

The qualities of these materials and equipment shall be subjected to approval of the Engineer.

S1.09 MAINTENANCE AND REPAIR OF EXISTING ROADS

In case the Contractor uses regularly any existing public or private road for construction, the Contractor shall provide the maintenance services to such existing road to the satisfaction of the Engineer.

In case the Contractor made damage to the existing road including damages to laterite or any other surface pavements, the Contractor shall repair such damages to the satisfaction of the Owner or other authorities concerned.

Maintenance and repair of existing road shall include supply and compaction of laterite material, grading, dust control by Spraying water, removal of hazardous materials and repairing of asphalt pavement, etc.

S1.10 PROTECTION OF MATERIALS AND WORKS

The Contractor shall at all time take care to protect and preserve all materials, supplies and equipment of any description and all works performed. All requests of the Engineer to enclose or satisfactorily protect such property shall be complied with accordingly.

(1) Materials shall be stored so as to ensure preservation of their specified quality and fitness for the Works. When so directed they shall be placed on wooden platforms or other hard and clean surfaces and not on the ground. When so required they shall be placed under cover. The suitability of the said materials for the purposes of the Contract at the time of installation remains the responsibility of the Contractor. Stored materials shall be located so as to facilitate prompt inspection and control.

(2) Concreting, grouting and other works shall not be started if they are to be exposed to inclement weather, except under conditions whereby the Engineer may specifically direct or permit such work.

(3) If suspension of the works is on the account of inclement weather or from any other cause, the Contractor shall, at his own expense, protect carefully his materials and Works against any damage or injury and the site shall be cleaned up and left in good order during the period of such suspension. If, in the opinion of the Engineer, any works or materials have been damaged or injured, by failure on the part of the Contractor (or any of his sub-contractors) to protect the Works, such works and materials shall be removed and replaced at the expense of the Contractor.

(4) The Contractor shall at all time comply with all laws, ordinances, rules and regulations relating to the performance of Work, the protection of adjacent

property and the maintenance of passageways, guard fences, lights or other protective facilities.

(5) The Contractor shall at all time safely guard the Owner property from injury or damage. He shall at all time also safely guard and protect his own work and that of adjacent property from damage. Such damage or injury that occurs shall be replaced or made good at the expense of the Contractor.

(6) The Contractor shall store all explosives in a secure manner marked clearly in English "Danger Explosives"

S1.11 ASSISTANTS FOR ENGINEER

The Contractor shall provide competent assistants and laborers for the Engineer to help him in carrying out the checking of survey works and the testing of concrete and soil at the laboratory, etc. Qualifications of the assistants and laborers shall be submitted to the Engineer for approved and the cost of their provision shall be borne by the Contractor.

The Contractor shall provide the Geologist, the technician and skill labor as follows:

- Expert for geologist for investigation property of materials	1	person
- Laboratory technician for concrete works	1	person
- Laboratory technician for roller compacted concrete works	2	persons
- Laboratory technician for earth works	1	person
- Skill labor for concrete works	2	persons
- Skill labor for roller compacted concrete works	2	persons
- Skill labor for earth works	2	persons

S1.12 TESTING OF MATERIALS AND EQUIPMENT AND INSPECTION

Materials and equipment furnished by the Contractor, which will be incorporated in the Permanent Works, shall be subject to inspection and testing as provided in the Contract. To allow sufficient time to provide for inspection 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 and testing of materials and equipment or the waiving of inspection 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 costs relating to the inspection and testing of materials and equipment shall be borne by the Contractor.

S1.13 TEMPORARY WORKS

(1) General

The Contractor shall submit to the Engineer for his approval, the drawings and full particulars of the temporary works. The submission to or approval by the Engineer for any such proposals by the Contractor shall not relieve the Contractor of any of his responsibility for the sufficiency of the temporary works for their intended purpose.

The Contractor shall also obtain any necessary approval from the local, statutory or other authorities concerned before temporary works are elected. No house, office, store, workshop or other habitable buildings will be permitted to be established underneath or within 10 meters of the nearest point in plans of any contractor of an overhead power line.

Unless otherwise specified, all temporary works shall be removed or otherwise disposed of to the satisfaction of the Owner by the end of the Period of Maintenance. The site of temporary works shall be cleaned up, reinstated or arranged by the end of the Maintenance Period to the approval of the Engineer.

(2) Site Preparation

The area of Works nominated in the Contract and handed over to the Contractor (hereinafter called "the Site") is shown in the Contract Drawings. The Contractor shall keep the Site free from any damage after it has been handed over to him.

The land for quarries, borrow areas, spoil areas, the Contractor's camp facilities, workshops, stores, and other temporary works and facilities, etc., will be provided by the Administration. When the Contractor intends to use additional lands which are not provided by the Administration, the Contractor shall obtain such land at his own effort and expenses, obtaining the approval of the Engineer.

When it is necessary to compensate for existing houses, walls, fences, trees, crops, other artificial obstacles, etc., in the area not handed over by the Administration, such compensation shall be made at the Contractor's own expense after obtaining the approval of the Engineer.

The Contractor shall clear the Site in accordance with the Specifications and the instructions of the Engineer.

All usable materials such as trees recovered during the clearing of the land handed over by the Administration belong to the Administration. If the Administration orders storage of such materials, the Contractor shall store them in a place designated by the Engineer.

The destruction of vegetation by fire may not be carried out without the Engineer's prior approval. The Contractor shall be however, entirely responsible for consequences of such destruction by fire even though it may

have been approved by the Engineer.

Upon completion of the Work, the Contractor shall remove all temporary facilities and clear away waste materials or rubbish of whatever kind remaining on the Site. Such refuse material shall be deposited at a place assigned or approved by the Engineer.

(3) Constructional Plant and Equipment

The Contractor shall use construction plant and equipment which will be efficient and appropriate to ensure a satisfactory quality of the Works and a rate of progress which will ensure the completion of the Works within the time stipulated in the Contract. If at any time such plant and equipment should appear to the Engineer to be inefficient, inappropriate or insufficient for securing the required quality of the Works or for producing the satisfactory rate of progress, then the Engineer may order the Contractor to increase the efficiency, change the character or increase the number of plant and equipment and the Contractor shall comply with such order. The Contractor shall not be entitled to any extra payment or any other claims in complying with the Engineer's order.

(a) The Contractor shall prepare and submit to the Engineer an original and five (5) copies of an itemized statement showing the quantities, production rates and specifications for all items of equipment or supplies required under the Contract. The description of each item shall be sufficiently accurate to determine easily its classification, as to type, durability and capacity.

(b) The Contractor shall complete mobilization for staff, machinery and equipment within a period of thirty (30) days from the Date of Commencement. All equipment and staff; Mobilization is paid to be included in the rates and lump sums bid in the Schedules for the various items of the Contract.

(4) Temporary Access Roads

The Contractor shall construct and maintain temporary access roads to, in and around the various working sites, borrow areas and spoil banks with his own expenses. No particular land is provided, other than the alignment of main and lateral canals, for temporary access roads by the Engineer. The Contractor shall prepare the land area to be occupied by the access road by his own effort and his own expenses in accordance with the consent of the landowner. After completion of works, the Contractor shall restore the area occupied by access roads to the original state without any claim of the landowner.

The Contractor shall maintain his temporary access roads. Maintenance of temporary access roads shall include measures to control dust such as regular spraying of road surface with water during dry periods and removal of

hazardous mud during wet periods.

All costs for temporary access roads covering the cost for land compensation, design, construction, maintenance and removal shall be included in the unit price of the items in the relevant works in the Schedules. No separate payment shall be made.

(5) Contractor's Camp, Offices, Stores and Workshops

(a) Contractor's Camp

The Contractor shall construct staff quarters and labor camps at the location proposed by the Contractor and approved by the Engineer.

The Contractor shall provide and maintain temporary accommodation and living facilities including all necessary services for water supply, drainage, lighting, roads, paths, parking places, sanitation and refuse disposal, fire protection, commercial and recreation facilities for his staffs and labor force and for the employees of his sub-contractors.

The Contractor shall ensure that the site is at all times kept in a clean and sanitary condition, and shall provide and maintain sanitary conveniences for the use of persons employed on the works to the extent and in the manner and at such places as shall be approved by the Engineer, by the medical officer and by any local or other authorities concerned, and all persons connected with the works shall be obliged to use these conveniences. Any employee found violating this requirement shall be liable to immediate discharge and to refusal of further employment on the works.

All such facilities shall be designed and submitted to the Engineer for approval prior to construction.

(b) Contractor's Offices, Stores and Workshops

The Contractor shall provide and maintain such temporary buildings, offices, workshops and adequately fenced stores and delivery compounds as are necessary for the execution or the works.

All such facilities shall be designed and submitted to the Engineer for approval prior to construction.

(6) Power Supply for Construction

The Contractor shall secure and supply sufficient electricity to meet all requirements relating to the works under the Contract including the demands of laboratories, requirements for testing and test operations, etc. and on a twenty-four hour per day basis throughout the construction period. There is no facility provided for supply of electricity for construction purpose by the Engineer.

The Contractor shall prepare his own electric generating facilities and distribution systems of sufficient capacity and adequate reliability to meet all his power needs for construction of the Works.

Should the Contractor intend to use electric power from public transmission lines for constructional works, the Contractor shall get the approval of the Electric Authority of Myanmar.

The installation and maintenance of transformers, distribution lines and switches provided by the Contractor shall be in accordance with regulation of the Electric Authority of Myanmar.

A rare occurrence of electric power interruption by the Electric Authority of Myanmar shall be expected. The Contractor shall prepare his own electric generation facilities for power requirements of his works for construction in order to cope with such interruptions of power supply. The interruption of power supply from the Electric Authority of Myanmar during the construction period shall not be subject to claim any additional payment to the Contractor. The Contractor shall submit to the Engineer for his approval the electrical system for construction, power output at each working site and expected consumptive power output in accordance with the detail work schedule within one month after "Notice to Proceed".

Cost for power supply for construction shall not be made separately in the Schedules. All cost shall be included in the unit price and lump sum for the relevant works in the Schedules.

(7) Water Supply for Construction

The Contractor shall secure and supply a sufficient amount of water of acceptable quality to meet all the requirements relating to the works under the Contract including the demands of laboratories, testing and test operations etc., on a twenty-four hour per day basis throughout the construction period.

The Contractor shall prepare his own water supply facilities and distribution systems or transportation means of sufficient capacity and adequate reliability to meet all his water needs for construction if of Works.

The Contractor shall submit to the Engineer for his approval the layout plan of water supply system to the Contractor's camp, and each working place including the facilities and capacity for pump, pipeline, water lorry, etc., within one month after "Notice to proceed".
All cost for water supply of construction shall be included in the unit price and lump sum of the relevant works in the Schedules. No separate payment shall be made.

(8) Garbage Collection and Disposal

The Contractor shall maintain work areas, camp amenities and surroundings in a clean, sanitary and tidy condition.

An adequate number of garbage bins and skips shall be provided in appropriate locations. Garbage incinerators shall be located at the places proposed by the Contractor and approved by the Engineer.

Rubbish, garbage, and construction debris shall be collected in locations designated by the Employer and shall be disposed of daily.

At the disposal area, exposed garbage shall be kept to a minimum and adequate vermin control and stray dog control measures shall be taken.

All cost for garbage collection and disposal shall be included in the unit price and lump sum of each work in the Schedules. No separate payment shall be made.

(9) Field Laboratory and Equipment for Testing

(a) Field laboratory

The Contractor shall provide the Field Laboratory for use of the Owner, the Engineer and the Contractor. The Field Laboratory shall be maintained throughout the construction period.

The field laboratory shall have a total area of not less than sixty (60) sq.m. and shall be designed and constructed by the Contractor after approval by the Engineer. The Contractor shall supply and equip the field laboratory with the following listed new furniture and equipment:

Description	Quantities
- Metal desk, 1.50 m x 0.75 m top, 6 side drawers and 1 center drawer	1
- Straight chair	2
- Table	1
- Wastebasket, large, solid sides, no wire	1
- Wall board, 2.50 m x 1.50 m	1
- Cupboard with shelves and locks	1
file cabinet, 4 drawers, lock type, legal size with metal clip hanging files (30 files per drawer)	
- Air conditioner, 12,000 BTU	1
- Set of shelves for the concrete curing room	2

The Contractor shall furnish the necessary equipment and apparatus for the purpose of carrying out the required concrete and soil tests.
The laboratory equipment and apparatus shall be of approved type and shall be adequate to carry out all the tests as listed in the Specifications to the approval of the Engineer.

The following listed equipment and apparatus shall be the minimum furnished to the laboratory by the Contractor.

(b) Laboratory equipment

Description	Quantities
1. Quality Control Test for Backfill (Soil Test)	
a. Compaction Test, ASTM D698, AASHTO T99, JIS A1210	
- Mold, 101.6 mm dia x 116.43 mm high	1
- Detachable collar assembly, 101.6 mm dia x 50.8 mm high	1
- Base plate	1
- Rammer, 2.5 kg, 305 mm drop	1
- Sample extruder	1
b. Compaction test, ASTM D1557, AASHTO T180 or JIS A1210	
- Mold, 152.4 mm dia x 116.43 mm high	1
- Detachable collar assembly, 152.4 mm dia x 50.8 mm high	1
- Base plate	1
- Hammer, 4.54 kg, 457 mm drop	1
- Sample extruder	1
c. California Bearing Ratio Test, ASTM D1883-67 AASHTO T193	
- Mold, 152.4 mm dia x 177.8 mm high, and base plate	1
- Spacer Dise, 63.5 mm high	1
- Hammer, 4.54 kg	1
- Swelling plate	1
- Tripod	1
- Surcharged weight, 2.27 kg/plate	1
- Dial indicator, capacity 25.4 mm sensitivity 0.025 mm	1
- Penetration piston, 19.35 mm square	1
- Loading device, type hydraulic jack or screw jack	1
- Tank	1
- Sieve No.4 and No.19 mm	1
- Balance, tray, straight edge, cylindrical can	1

Description	Quantities
d. Filed Density Test, ASTM D1556, AASHTO T191or JIS A1214	
- Plastic Jug	1

- Sand cone	1
- Base plate, 304.8 mm square	1
- Digging pools and paint brush	1
- Glass plate, 5 mm thickness, 200 mm x 200 mm	1
- Cylindrical can for calibration of sand, 2.5 liters	1
- Multi-purpose field scale capacity 16 kg sensitive	1
- Ottawa sand or clean air dry uniform sand passing no. 20 sieve and retained on the no. 30 sieved.	1 bags
e. Moisture Content Determination	
- Drying oven, 100 x 75 x 60 cm internal size thermostatically controlled capable of maintaining a temperature of 110 ± 5 ^{o}C	1
f. Sample Splitter	1
g. Sieve-analysis	
- Hydrometer	1
- 8″ dia, coarse series, 150 mm to No.1	1 sets
- 8″ dia, fine series, Sieve No.4, 8, 10, 16, 18, 20, 30, 35, 40, 50, 100, 200, pan and cover	1 sets
- Sieve No.200 for wet washing	1 sets
- Motorized sieve shaker 220 v, 50 Hz	1
h. Atterberg's Limit Test	
- Liquid Limit	1
- Plastic Limit	1
i. Balance and Scale	
- Heavy duty solution balance capacity 20 kg sensitivity 1 g.	1
- Even arm solution balance 5,000 gm sensitivity 0.5 gm.	1
- Triple beam scale 2610 gm	1
- Triple beam balance capacity 311 gm sensitivity 0.01 gm.	1

Description	Quantities
2. Concrete Test	
a. Slump Test, ASTM C143 or JIS A1101	
- Slump cone, 102 mm dia top, 203 mm	1

dia bottom x 305 mm height	
- Iron Plate	1
- Tamping rod, 16 mm dia x 500 mm length	1
- Steel ruler	1
b. Making of Specimen ASTM C31 or JIS A1132	
- Cylindrical mold, 150 mm dia x 300 mm height	10
- Capping set	1
- Concrete curing bath	1
c. Compressive Strength, ASTM C39 or JIS A1108	
- Compressive testing machine with electric pump capacity 100-120 tons	1
d. Abrasion Test ASTM C131 or AASHTO T96	
- Los Angeles machine	1
e. Specific Gravity and Absorption Fine Aggregate, ASTM C128	
- Sand cone	1
- Tamping rod	1
f. Specific Gravity and Absorption Coarse Aggregate, ASTM C127	
- Standard wire mesh bucket	1
g. Organic Impurities Test, ASTM C40 or AASHTO T21	1
h. Sieve Analysis	
- 8" dia coarse series sieve No.2", 1 ½", 1 ¾", 3/8"	1
3. Miscellaneous	
- Straight edge, 300 mm long	1
- Beaker, 500 cc	1
- Small hand scoop	1
- Large hand scoop	1
- Venire calipers, measuring length 300 mm	1
- Steel ruler, 3.0 m log	1
- Tray, 400 mm x 300 mm	2
- Wire brush	2
- Sampling spoon	1
- Moisture content sample container, with lid	10

At the end of the Contract, the field laboratory, all equipment, apparatus and furniture of the field laboratory shall remain the property of the Contractor and shall be removed from the Site.
The Contractor shall maintain the field laboratory and any assistance to the Engineer for operation of the laboratory.

Power, water, and gas shall be supplied to the field laboratory by the Contractor. The daily laboratory supplies including additional Ottawa sand and cylindrical concrete molds shall also be supplied by the Contractor.

The Contractor shall provide the technician and skill labor as follows:

- Laboratory technician for concrete works	1	person
- Laboratory technician for earth works	1	person

(10) Clearing of the reservoir

The Contractor shall clear reservoir area, and surroundings to smooth. The removal of trees will have to be moved and new planted in the suitable area. All cost for clearing of the reservoir shall be lump sum as shown in the Schedule.

S1.14 FIELD OFFICES AND PERMANENT HOUSING

(1) Field Offices

(a) The Contractor shall provide, furnish, equip, maintain and clean two offices, one for the sole use of the Owner, and another for the sole use of the Engineer, and provide all provide all related services as hereunder specified. The buildings shall be the property of the Owner.

The buildings and services shall be available in full working order within three (3) months after the commencement of the Works and shall continue to be so during progress of the Works until the Certificate of Final Acceptance has been issued.

The Contractor shall be responsible for the Site as shown on the Drawings, and shall have a total area of not less than one hundred and twenty (120) sqm for each building. These offices shall be designed and constructed by the Contractor and submitted to the Engineer for approval of materials and design prior to construction.

(b) The field offices shall be located at the Site as shown on the Drawings, and shall have a total area of not less than one hundred and twenty (120) sqm for each building. These offices shall be designed and constructed by the Contractor and submitted to the Engineer for approval of materials and design prior to construction

The laboratory shall have a tiled or concrete roof, gypsum board ceiling, brick or concrete block walls, well ventilated and well lighted. The floor of the office and working area shall be concrete with polished surface. A connecting toilet shall be furnished with quality appliances and materials. The above mentioned and other materials, furnishing and appliances shall be submitted for the approval of the Engineer before the final design of the Contractor if carried out.

(c) The temporary field office of the Owner and the Engineer shall be

maintained at the expense of the Contractor through out the period of construction and each field office shall be furnished by the Contractor.

(2) Permanent Housing

(a) The Contractor shall construct, maintain and clean the permanent housing for the sole use of the Owner's staff and Engineer's staff as shown on the Drawing.

(b) The buildings shall be the property of the Owner.

(c) All housing in Clause S1.14 and related services shall be available in full working order within three (3) months after receiving the instruction from the Owner to commence these works and shall continue to be so available during progress of the Work until the Certificate of Final Acceptance has been issued.

(d) The Contractor shall be responsible for the security of the buildings and their contents at all times and shall employ watchmen for this purpose.

(e) The permanent housing shall be located at the Site as shown on the Drawings.

(f) The buildings shall be constructed according to the details and requirements shown on the Drawings.

(g) The buildings shall be designed and constructed by the Contractor and submitted to the Engineer for approval of material and design prior to construction or as directed by the Engineer.

(3) The building shall be equipped with furniture and facilities basing on necessity of Engineer's approval.

S1.15 MEASUREMENT AND PAYMENT

(1) Mobilization and Erection of Construction Plants and Equipment

No separate payment will be made for mobilization and erection of constructional plant and equipment and all costs shall be deemed to be included in the rates and lump sums bid in the Schedule.

(2) Survey Equipment, Laboratory Equipment and Building for the Laboratory
No separate payment will be made for survey equipment, laboratory equipment and building for the laboratory and all costs shall be deemed to be included in the rates and lamp sums bid in the Schedule.

(3) Field Offices and Permanent Housing

Payment for the supply of materials, equipment and labor for the preparation of the area, for the construction, supplies and services of the facilities including electricity and water supply as described in Clause S1.13 will be made at the applicable rate (s) bid stated in the Schedule. The payment will cover all the temporary facilities the Contractor shall establish to carry out his obligation. This rate (s) if fixed and shall not be subject to change.

(a) Field Offices
- Equal monthly installments from the completion of the buildings to the Completion Date of the Total Contract.

(b) Permanent Housings

- Completion of foundations and ground beams	20 %
- Completion of upper floors and roofs	25 %
- Completion of all doors and windows	25 %
- Completion of all works	30 %

(4) Contractor's Office, Camp, Stores and Workshop

No separate payment will be made for Contractor's offices, camps, stores and workshops and all costs shall be included in the other rates and lump sums bid in the Schedules.

(5) Advance Payment

Before advance payment will made, the contractor shall provide two sets of surveying equipment and two sets of computer equipment, after obtaining the approval of the Engineer.

(6) Water Supply

No separate payment for water supply for the construction as described in Clause S1.13, and all costs shall be deemed to be included in the rates and lamp sums bid in the Schedule.

(7) Clearing of the Reservoir

Payment for removal tree, bushes, shrubs, rubbish and weeding for clearing of the reservoir for water storage in reservoir as described in Clause S1.13 will be made at the applicable rate (s) bid stated in the Schedule. The payment will be paid as lump sum follow in the Schedule.

SECTION 2 - WATER CONTROL AND DEWATERING

SECTION 2 - WATER CONTROL AND DEWATERING

S2.01 DIVERSION AND CONTROL OF WATER DURING CONSTRUCTION

(1) General

(a) The Contractor shall design, construct and maintain all temporary diversion and all protective works which are necessary for the prevention of surface drainage and groundwater entering the various parts of the Works.

(b) Diversion and protective works shall comprise, but are not necessarily limited to tunnels, cofferdams, channels, conduits, drains, pumps and settling ponds. The location of these works shall be such that there is no encroachment on any area required for construction of the Works.

(c) On completion of the Works all diversion and protective works shall be removed and disposed of or shall be leveled in a manner to give a slightly appearance, and so as not to interfere in any way with the operation or usefulness of the Works.

(2) Dewatering

The Contractor shall design dewatering systems and shall furnish, install, maintain and operate all necessary pumping, piping and other equipment and temporary structures for dewatering and maintaining the various parts of the Works free from water during construction and, as required, for inspection, safety and installations by other contractors or the Owner or, if directed, after any part of the Works is completed.

(3) Pollution

(a) The Contractor shall design, construct, maintain and operate suitable pollution control facilities necessary to prevent discharge of water containing polluting matter or visible suspended materials into rivers, streams or existing drainage systems. These facilities are in addition to any control measures shown on the Drawings.

(b) All diverted and pumped water shall be discharged at locations on the surface from which it cannot re-enter the Works and in a manner which does not cause erosion, pollution or nuisance to landholders, other contractors employed by the Owner or other persons within or adjacent to the Site.

(c) Disposal of waste oil from workshops and other areas shall not cause pollution of rivers and streams and shall be in accordance with the method approved in the Acceptance of Bid.

(4) Interference with Rivers and Streams

The Contractor shall not interfere with the natural flow of rivers or streams on the Site for any purpose without prior approval.

(5) Responsibility of the Contractor

(a) The Contractor shall be fully responsible for any damage or delay to the Works caused by failure of the diversion and protective works and/or dewatering installations constructed by him and shall indemnify the Employer against claims by other contractors employed by the Employer working on the Site or by landholders or other persons, arising out of any such failure.

(b) The Contractor shall be responsible for, and shall repair or reinstate at his expense, any damage to foundations, excavated slopes or any other parts of the Works caused by the failure of the diversion and protective works and/or dewatering installations.

S2.02 DIVERSION AND CONTROL OF RIVER DURING CONSTRUCTION

(1) Water Control Plan

(a) At least thirty (30) days before commencing any work on the diversion the Contractor shall submit to the Engineer a detailed Water Control Plan describing the proposed sequence of work.

(b) The Water Control Plan shall include proposals for placing second stage concrete in the plug after diversion is completed. A suitable means of venting shall be provided to ensure that the blockout for plug is solidly and completely field with second stage concrete.

(2) Data Supplied to Contractor

The reservoir capacity curve and the calculated discharge curves for the diversion tunnel as shown on the Drawings. The administration does not guarantee the reliability or accuracy of these data and will not be responsible for any deductions, conclusions or interpretations which may be made by the Contractor from these data.

(3) Diversion and Protection Works

To divert river and dewatering of surface during construction, the Contractor shall:

(a) Design and construct the diversion and protection works in accordance with the Contractor’s approved proposals.

(b) Construct the diversion culvert to the line and grade shown on the Drawings.

(c) Construct and maintain cofferdams, where and as shown on the Drawings.

(d) Design, furnish, install and remove bulkhead gate in the diversion culvert intake structure.

(e) Design, construct and maintain all other diversion works proposed in the Water Control Plan and any other diversion and protective works which are necessary to prevent surface drainage and groundwater from entering the various parts of the Works and, where necessary, settling ponds to prevent pollution in accordance with the relevant requirements of this Specification.

(4) Cofferdams

(a) Cofferdams shall be constructed across the river upstream and downstream of the dam in the locations and to the lines and levels shown on the Drawings.

(b) The cofferdam upstream of the dam will be permitted to remain but shall be breached. The downstream cofferdam shall be removed by the Contractor and the area cleaned up when and as directed by the Engineer.

(5) Diversion Box Culvert and Commencement of Reservoir Filling (Not Applicable)

(a) The Contractor shall close the bulkhead gate by the date stipulated at intake structure.

(b) After closing the bulkhead gate the Contractor shall place the concrete plug in box culvert as shown on the Drawings.

(c) Diversion of river through the diversion culvert shall continue until the commencement of the last dry season of construction and all requirement of diversion work has been completed.

(d) Before beginning to fill the reservoir, the Contractor shall remove all constructional plant, materials and facilities in the reservoir area and construct the dams, spillway and bridge so that such structures will be completed as stipulated.

S2.03 TRASH BOOM (Not Applicable)

(1) General

(a) The Contractor shall furnish and install a trash boom upstream of the diversion tunnel intake structure before diverting through the diversion tunnel.

(b) The trash boom shall be constructed as shown on the Drawings and installed at a location and to a length directed by the Engineer. The Contractor shall keep the trash boom in a serviceable condition and shall clear trash from it from time to time, or when directed, while water is being diverted through the diversion tunnel.

(2) Removal of Trash Boom

When directed, after commencement of storage, the Contractor shall remove the trash boom. All components of the trash boom shall remain the property of the Contractor and shall be removed from Site.

S2.04 INSTALLING BULKHEAD GATE INTAKE STRUCTURES

(1) General

The Contractor shall design, furnish, install and commission the bulkhead gate, embedded frames, anchor bolts, hoist and control cubicles in intake structure in accordance with the relevant requirements of this Specification.

(2) Handling of Bulkhead Gate, Installation and Commissioning

(a) The Contractor shall be responsible for the handling of the bulkhead gate and associated equipment as specified.

(b) The Contractor shall install and commission the bulkhead gate and associated equipment as specified and in accordance with the Water Control Plan.

(c) Commissioning shall be complete to allow for commencement of storage by the specified date.

(3) Operation of Bulkhead Gate

(a) After the bulkhead gate has been installed by the Contractor, the Contractor shall operate this

(i) After completion of the dam embankment spillway, and intake structure, the Contractor shall close the bulkhead gate against the flow then install the valve in accordance with the relevant requirements of this Specification.

(ii) After the power house is in operation the Contractor shall remove the hanger beams, close the diversion bulkhead gate.

(4) Provision of Erection Supervision

The Engineer will provide the services of an erection supervisor who will advise on the proper assembly and erection during final closure. The handing of the bulkhead gate and associated equipment and closure of the diversion conduit shall be the responsibility of the Contractor.

(5) Date for Installation

The Contractor shall install the bulkhead gate in the diversion box culvert as soon as the diversion is finished and start to fill the river. The date of bulkhead gate installation is established in the Special Condition (not later than April, of second dry season).

S2.05 DEWATERING OF SURFACE CONSTRUCTION SITES

(1) General

(a) The Contractor shall perform all works necessary to drain the surface construction sites of rain, groundwater and service water.

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

(i) Design and construction of drainage, ditches, pits, and pump sumps.

(ii) Design, furnishing, operation and maintenance of dewatering equipment.

(iii) Relocation of dewatering facilities required for the performance of other works.

(iv) All auxiliary works required for safe and continuous dewatering of the construction sites.

(2) Requirements and Design

(a) The Contractor shall install complete dewatering facilities at the lower weir construction site including powerhouse site.

(b) The surface water dewatering systems shall be designed to accommodate, without undue disruption to the work climatological information for the project area given in Drawing No. MT-GN-02. The peak capacities of the systems shall be selected to satisfy the above criterion, taking account of the extent of the sites to be dewatered and the dewatering arrangements proposed.

(c) Claims for extension of time due to delays caused by unfavorable weather conditions will not be considered unless caused by rainfall exceeding the design conditions stated above. Such claims must be substantiated by validated records from the automatic or manual rain gauges to be installed at the Site by the Contractor.

(d) In order to keep the excavated areas free from water, the dewatering systems must be able to operate at any time during the whole construction period in any part of the Works at the approved design capacity. All components of the systems shall always be maintained in ready-for-service condition and access to pumps and other important equipment shall be kept in good condition under the most adverse weather conditions.

(e) A standby power supply shall be provided in the event of failure of the main power source. The standby power supply shall undergo weekly trial runs lasting at least 30 minutes. An adequate number of standby pumping units shall also be providing.

(f) The Contractor shall ensure the all drainage water will be disposed of with be disposed of without causing interference to his own or other contractors operations elsewhere on Site and that no drainage water runs into adjacent Works.

(g) The dewatering systems shall be designed and installed in such a way that modifications and extensions to the systems are possible while they are in full operation.

(h) The approval by the Engineer of the dewatering system shall not relieve the Contractor form being fully responsible for the design and operation of the dewatering systems and he shall be liable for any damage or delays caused by its failure. The Contractor shall indemnify the Administration against claims arising out of any such failure, made by other contractors, land holders or other persons.

(3) Diversion of Creeks

(a) Creeks in the stockpile, spoil, and quarry areas or where required by the construction of any temporary structure shall be diverted into ditches either concrete lined or paved with rock in mortar, in accordance with Contractor's proposal, and to the approval of the Engineer.

(b) Creek diversions shall be designed to accommodate any rain fall event whose intensity duration lies below the 1 in 25 year's rainfall intensity duration curve for the project area.

(c) The peak capacities of the systems shall be selected to satisfy the above criterion, taking account of the extent of the sites to be dewatered and the diversion arrangements proposed.

(4) Materials and Execution

(a) All the components of the dewatering systems shall be installed and operated in accordance with the agreed method and time schedule or approved modification thereof.

(b) Drainage ditches shall be excavated along the top of excavated slopes and on the berms. Such ditches shall be kept well back from the excavation edges in order to prevent saturating the upper part of the slopes. The ditches shall be regularly cleaned out of all accumulated silt and other matter so that water may flow freely at all times.

(c) Where excavation is to be made below the groundwater table, the Contractor shall lower the water table sufficiently below any working surface by means of properly screened wells and/or ditches to ensure that the foundation surfaces remain free of standing water and undamaged by the passage of construction traffic. All ditched shall be outside the foundation areas. The water shall be collected and removed by pumping if no outflow by gravity is possible.

(d) Where concrete will be placed, the water table shall be maintained below the lowest part of the finished excavation for minimum one day following.

The raising of structure above the natural groundwater table, and for such additional time as may be necessary to preclude damages to structure foundation.

(e) In cut off trenches and embankment foundations the dewatering shall at all times enable to carry out the excavation work in dry, and in a manner that will prevent loss of fines from the foundation.

(f) During the placing and compacting of the embankment material in the cutoff trench the water level shall be maintained below the bottom of the excavations until the compacted embankment has reached the height at that point at least 3 m. Subsequently, the water level shall be maintained at least 1.50 m below the top of the compacted embankment.

(g) Upon completion of dewatering, temporary pipes and pumps sumps beneath permanent structures shall be close off and completely filled with grout, mortar of concrete as required by the Engineer.

S2.06 MEASUREMENT AND PAYMENT

(1) Diversion and Control of River during Construction

(a) Payment for the river diversion will be made as the lump sum price bid therefore in the Schedule.

The lump sum price shall include, but not limited, to the following:

(i) Design, construct and maintain the temporary upstream and downstream cofferdams.

(ii) Protective works for the cofferdams on the water side.

(iii) Auxiliary work required for safe and continuous diversion of the river during the flood season.

(b) The lump sum price for the river diversion mentioned will be submitted with the breakdown outlined in (a) for the approval of the Engineer.

(c) Permanent upstream and downstream cofferdam incorporated in the Weir will be measured and paid for in the applicable rate (s) in this clause.

(2) Trash Booms (Not Applicable)

(a) Measurement, for payment, of the trash booms will be made of the length installed as directed by the Engineer.

(b) Payment for furnishing and installing trash booms will be made at the rate per linear meter bid therefore in the Schedules. Such rate shall include the cost of all labor and materials required to perform the work specified in this Clause including galvanized drums and reinforcing fabric, wire rope, anchor bars, excavating and placing concrete, where required, for anchorage and maintenance cost for trash booms.

(3) Diversion Culvert Bulkhead Gate

Payment for fabricating, furnishing, and installing the diversion culvert bulkhead gate will be made at the lump sum price bid therefore in the Schedule.

(4) Dewatering of Surface Construction Sites

Payment for the dewatering of surface construction sites will be made as lump sums bid therefore in the Schedule, for the following construction sites:

Dewatering of foundation work and associated works, including powerhouse site.

These lump sum prices shall include:

(a) Design of all dewatering system.

(b) All cost and labor for excavation, construction and protection of drainage ditches, wills, pits, and pump sumps.

(c) Capturing and conveying the water into the drainage system.

(d) All costs of supply, installation, operation, maintenance and removal of pumps, pipes and equipment for pumping water, regardless of the amount of water.

(e) Grouting of pipes and pump sumps if required.

(f) All auxiliary work required.

SECTION 3 - SURFACE EXCAVATION

SECTION 3 - SURFACE EXCAVATION

S3.01 CLEARING, GRUBBING AND STRIPPING

(1) Clearing and Grubbing

(a) Clearing

(i) Within areas where structures, excavation or filling is to be carried out, the ground shall be cleared of all vegetable growth such as trees, limbs, bushes, shrubs, rubbish vegetation, grass and other objectionable material including existing fences to the satisfaction of the Engineer. All vegetable growth shall be cut to a maximum height of 0.5 m from the ground surface or as shown on the Drawings

(ii) All or part of the materials from clearing operations shall be the property of the Owner if considered utilizable by the Engineer and shall be stored where instructed.

(iii) Materials from clearing operations shall be hauled from the job site areas to designated waste areas and shall be burned, buried or otherwise disposed of, as approved by the Engineer. Trees outside the areas designated shall not be cut down or damaged by Contractor's operations.

(iv) All materials to be burned shall be piled, cut and split, if necessary, and then in a suitable condition shall be burned and reduced to ashes. Piling for burning shall be done in such a manner and in such locations as to cause the least fire risk. The Contractor shall take special precautions to prevent fire from spreading and shall have available at all times suitable equipment and supplies for use in preventing and suppressing fires.

(v) Roots of trees and stumps shall not be grubbed up unless ordered or approved by the Engineer unless otherwise specified.

(vi) All branches or trees extending into the aerial limits shall be trimmed carefully to give a clear height as required over the site.

(b) Grubbing

(i) Grubbing shall consist of removing and satisfactorily disposing of buried logs, stumps and large root mats and all the unsuitable materials as to a depth under the original ground surface as shown in the Drawings or as directed by the Engineer, but in no case less than thirty (30) centimeters.

(ii) With the exception of areas to be excavated, all depressions made below the ground surface by the removal of stumps and roots shall be refilled with suitable material and compacted to the satisfaction of the Engineer.

(c) Limits and Work Sequence

The limits and extent of areas to be cleared or cleared and grubbed shall be as shown in the Drawings or instructed by the Engineer. Clearing and grubbing shall extend to approximately fifteen (15) meters beyond the limits of excavation and toes of fills. Clearing and grubbing shall be performed in advance of excavation operations, unless otherwise approved by the Engineer.

(2) Stripping

(a) Immediately after clearing operations and before excavation commences, the Contractor shall strip from the surface of all required excavations and borrow areas the surface layer of soil including herbaceous vegetation, overlying grass and organic matter. Stripping shall extend for 2 m outside the limits of required excavation and the surface shall not be disturbed beyond these limits. Stripping shall be limited to a depth of 30 cm, or within a depth as shown on the Drawing.

(b) All materials removed by stripping operations shall be disposed of in approved disposal areas.

S3.02 SURFACE EXCAVATION

(1) General

(a) Suitable material from surface excavations shall be used in the Works. The Contractor's blasting and other operations in the excavations shall be such that the materials excavated will yield as much required suitable material as practicable. Where practicable, materials suitable for use in the Works shall be excavated separately from materials to be wasted. Suitable material shall be segregated by loads during the excavation and shall be placed in the designated final locations or shall be placed in stockpiles and later placed, or processed and placed, in the designated final locations, in accordance with the provisions of this Specification.

(b) The suitability of material obtained from the required excavations for use in the Works will be determined by the requirements of Section 3 and the Engineer.

(c) Any and all over-excavation performed by the Contractor for any purpose or reason, except as may be directed, and whether or not due to the fault of the Contractor, shall be at the expense of the Contractor. All such over-excavation shall be backfilled with approved material from required excavations or concrete, as directed, and the cost of furnishing and placing this backfill shall be at the expense of the Contractor.

(d) Excavated materials to be wasted from all surface excavations shall be disposed of in accordance with the provisions of this Specification.

(2) Shape of Excavation

(a) All surface excavations shall be made to the lines, grades and dimensions shown on the Drawings or directed by the Engineer.

(b) The Engineer may direct core drilling to determine the depth of excavation required.

(c) The Engineer may direct the excavation to be performed in successive stages until a suitable foundation or surface, as determined by the Engineer, is reached.

(d) All temporary shoring including, planking, strutting and supports necessary to retain the sides of the excavations shall be designed provided, erected and maintained in a safe condition by the Contractor.

(3) Seams, Cavities and Other Defects in Rock

(a) The exploratory investigations of the foundations, slopes and other areas to be excavated are not sufficiently complete to disclose all seams, cavities and other defects that may exist in the rock. It is anticipated that there may be depressions, fissures, faults, seams and bands of soft disintegrating rock running in various directions in the materials to be excavated and in the foundations, slopes and other areas. The assumed lines of excavation shown on the Drawings shall therefore not be interpreted as indicating with any degree of accuracy the final or actual excavation lines or that no defects exist.

(b) Where such seams, cavities or defects occur they shall be corrected by local surface excavations, below the general surface of excavation, to the lines, depths and dimensions directed by the engineer. These local surface excavations shall be solidly backfilled with approved materials from the required excavations, concrete or covered by shotcrete as directed the Engineers; except that seams and other defects below the general level of the foundations for the dam shall be treated as specified in the relevant sections of this Specification.

(c) The Engineer may direct that certain surfaces be protected and/or supported in accordance with the relevant sections of this Specification.

(4) Excavation Precautions

(a) All necessary precautions shall be taken to preserve, in the soundest possible condition, the material below and beyond the lines of all excavation. Any damage done to the Works by blasting, including the shattering or loosening of the material beyond the required excavation lines, shall be repaired by and at the expense of the Contractor as specified.

(b) The Contractor shall exercise special care to avoid damage to concrete, shotcrete or pressure grouting already completed. Delay-blasting shall be used to reduce shock waves. Unless otherwise approved, the Contractor shall not fire any charges within 60 m of concrete or shotcrete already placed.

(c) The Contractor shall periodically remove loose material from excavated batters to maintain them in a safe condition. All berms shall be maintained with the clear width of passageway shown on the Drawings.

(d) All planking, strutting and supports necessary to retain the sides of the excavations shall be provided, erected and maintained in a safe condition by the Contractor.

(5) Classification of Excavation Types

Classification of excavation types for purposes of payment, the terms “rock excavation” and “common excavation” are defined as follows:

(a) Rock Excavation

Rock excavation includes weathered rock and sound rock.

(i) Sound rock is in defined as rock of such hardness and texture that it can not be effectively loosened or broken down by ripping in a single pass with a late model tractor-mounted hydraulic ripper, equipped with one digging point of standard manufacturer’s design adequately sized for use with and propelled by a crawler-type tractor rated 230 flywheel horsepower operating in low gear. In the case where criteria is not convincing, rock excavation is defined as sound material with a seismic velocity greater than 1,800 m/s. Sound rock includes all boulders or detached pieces of solid rock, more than 1 cubic meter in volume, shall be loosened by blasting before removal.

(ii) Weathered rocks is defined as rock, having the blow count value from the Standard Penetration Test greater than 30 (N>30), which can be loosened or broken down by ripping in a single pass with a late model tractor-mounted hydraulic ripper, equiped with one digging point of standard manufacturer' design adequately sized for use with and propelled by a crawler-type tractor rated flywheel horsepower operating in low gear and single pan. In the event of a dispute as to classification of a material, the decision of the Engineer shall be final.

(b) Common Excavation

Common excavation includes all materials other than rock excavation. All boulders or detached pieces of solid rock less than 1 cubic meter in volume will be classed with common excavation.

(6) Drilling and Blasting

(a) General

(i) The Contractor shall submit to the Engineer at least 30 days before the commencement of excavation; the description of his proposed methods and sequence of excavations. The work shall be programmed so as to minimize blasting adjacent to previously constructed Clauses of the works. Unless otherwise approved, the Contractor shall not fire charge within 20 m of concrete.

(ii) To preserve the structural integrity of the excavated openings, the Contractor's excavation methods shall be such as to product smooth and sound rock surface with a minimum of fracturing of the in-situ rock mass. For that purpose the Contractor shall develop the most suitable drilling and blasting techniques.

(iii) The Contractor will optimize the drilling and blasting pattern to optimize the excavation profile and minimize the over breaks.

(iv) All open excavations shall be made to lines, grades and dimension shown on the approved construction drawings and/or the approved site design change drawings.

(v) The Engineer may amend the drawings in this respect as necessitated by foundation conditions revealed as excavation proceeds.

(vi) Unless otherwise detailed on the Drawings or directed by the Engineer, all blasting works shall be carried out using controlled blasting techniques to minimize damage to the final profile. These techniques are mainly presplitting and smooth blasting.

(b) Presplitting

It comprise drilling a line of closely spaced parallel holes of appropriate diameter (not less than 50 mm), spaced not more than ten times the hole diameter and forming a surface along the line of drill holes.

The first line of production holes next to the presplit face shall be lightly charged to ensure that the presplit face is not damaged when the charges in the production holes are detonated.

Presplitting shall be used for subvertical faces of excavations

(c) Smooth Blasting

Smooth blasting shall be used at the bottom of horizontal or subhorizontal excavations: it involves (above the final excavations line) drilling holes at a reduced interval (initial mesh of about 4 m^2 which can be adapted according to the site condition and subject to the Engineer's approval); loading the holes lightly with a uniform continuous charge of small diameter explosive. Special care shall be taken to ensure that the bottom of the holes is not more than 20 cm from its design location.

(d) Safety Precautions

(i) The Contractor's attention is drawn to the fact due to the topography of the valley, special care is required in blasting operations to safeguard personnel and plant, and to avoid damage to the remaining rock.

(ii) The Contractor shall provide suitable magazines at approved locations for the storage of all explosives. Storage, transportation, handling, charging, etc., shall be performed by experienced personnel using approved equipment in accordance with the relevant local statutory regulations.

(iii) The Contractor shall use explosives for blasting in connection with the work only at such times and places and in such manner as described in the submitted work method or as the engineer may approve.

(iv) A standard blasting warning signal shall be used in connection with all blasting.

(v) Detonators with protected bridging or other acceptable precautions shall be used in all blasting operations done by electric firing. The maximum permissible voltage shall not exceed that recommended by the manufacturer.

(vi) Control of the power circuit shall be by means of a locked switch with one key there to.

(vii) No charging operations shall be carried on during thunderstorms or other electrical disturbances.

(viii) The Contractor shall regularly inspect excavated faces of all works and shall forthwith scale, remove and dispose of and material which is loose, unsound or disintegrated or in way unsafe.

(ix) The Contractor shall perform all remedial work required in excavation to ensure that all excavated surfaces are maintained in stable and safe conditions.

S3.03 EXCAVATION FOR FOUNDATIONS OF DAM (Not Applicable)

(1) General

(a) Excavation for foundations of dam after clearing, grubbing, and stripping have been completed includes:

(i) The removal of partially and completely weathered material from the foundation area, the removal of materials which might interfere with the proper bonding of the dam with the foundation or the proper compacting of the dam and the removal of materials of inadequate strength. The extent and depth of the excavation to reach a suitable foundation shall be as directed by the Engineer.

(b) The Engineer may direct that the excavation be performed in successive stages until suitable foundation conditions are reached in accordance with the requirements

(2) Required Quality of Foundation

(a) Excavation for the foundations of the dam shall be made to sufficient depth to secure a foundation on generally moderately to highly weathered rock essentially free from weathered materials, open seams or other objectionable defects.

(b) The alignment and cross-sectional dimensions of the foundations will be subject to changes considered necessary to adapt the foundation to the conditions disclosed by the excavation.

(c) Steep or overhanging rock faces shall be cut back to a short continuous face, or a series of stepped faces, to provide satisfactory abutment contact slopes of the dam. Such rock faces shall, in general, be cut back to slopes of 0.75 horizontal to 1 vertical or as shown on the drawing. Where it is not possible or desirable to meet these

requirements the rock shall be solidly faced with backfill concrete to provide abutment contact slopes not steeper than 0.75 horizontal to 1 vertical or as shown on the drawing.

(d) Seams or other defects below the general level of the foundation shall be excavated to the lines and levels directed and backfilled solidly with concrete or shotcrete or directed by the Engineer.

S3.04 EXCAVATION FOR CONCRETE STRUCTURES

The bottom and side slopes of excavations upon, or against which, concrete is to be placed shall be excavated to the lines, grades and dimensions shown on the Drawings or as directed by the Engineer. Material will not be permitted to extend within the neat lines of the structure. If, at any point in rock excavation, material is excavated, at the direction of the Engineer, beyond the lines shown on the Drawings, the additional excavation shall be filled solidly with concrete. If, at any point in rock excavation, material is excavated beyond the lines shown on the Drawings or directed, or foundation materials are needlessly damaged by blasting or other operations by the Contractor, the over-excavation shall be filled solidly with concrete and the cost of all such work shall be at the expense of the Contractor.

S3.05 EXCAVATION FOR TRENCHES, PITS AND FOOTINGS

(1) Excavation shall be performed by the use of hand tools and mechanical plant, in such a manner as to prevent shattering of the sides and bottom of the excavation. The Engineer may approve the use of line drilled holes and light blasting in appropriate locations.

(2) All temporary shoring including planking, strutting and supports necessary to retain the sides of the excavation shall be designed, provided, erected and maintained by the Contractor.

S3.06 DRILLING HOLES

(1) General

Drilling holes shall be drilled during the prepared foundation of structure or surface of existing structure in locations and at inclinations and directions on the Drawing or determined by the Engineer.

(2) Drilling

(a) Drilling holes shall be drilled by rotary or rotary percussion drilling. The minimum diameter at the bottom of each drilling hole shall be 76 mm and anticipated minimum depth shall be 0.5 m as shown on the drawing or directed by the Engineer.

(b) Each drilling hole shall be protected from becoming obstructed until all work in the vicinity has been completed.

S3.07 CLEAN-OFF OF FOUNDATIONS FOR INSPECTION

(1) The Contractor shall clean-off foundations for inspection with an air and/or and water jet under high pressure, where and when directed by the engineer.

(2) The Engineer may direct clean-off of foundations for inspection after each successive stage of excavation for foundations to determine whether any unsound or unsuitable material is present in the foundation.

(3) Clean-off of foundations for inspection is separate and distinct from clean up before placement of any embankment materials and concrete, as required elsewhere in this Specification.

S3.08 DISPOSAL AND STOCKPILING OF MATERIALS FROM EXCAVATION

(1) General

(a) The Contractor shall dispose of excavated materials which are unsuitable for or which are not required for construction in the disposal areas shown on the Drawings and elsewhere as approved or directed.

(b) Such excavated materials shall be disposed of so as not to interfere with the operation of any facilities, and disposal areas shall generally be leveled and trimmed to reasonably regular lines to the approval of the Engineer.

(c) Unless otherwise approved, the finished outer slopes of the disposal areas shall not be steeper than 1 vertical to 3 horizontal.

(d) Excavated materials suitable for use in construction which cannot be used immediately shall be stockpiled within the stockpile areas shown on the Drawings and elsewhere as approved by the Engineer.

(2) Composition of Disposed Material

Material placed in compulsory disposal areas shall be dumped, spread in layers and compacted by the controlled passage of haulage equipment over the surface of each layer.

(3) Treatment of Surfaces

(a) The Contractor shall grade the top surfaces of all material placed within disposal and stockpile areas and shall construct permanent drains and other protective works, sufficient to ensure that surface run-off will not erode the surfaces of stockpiles and/or disposal areas or the material placed therein.

(b) Unless otherwise directed, the finished surfaces of disposal areas shall be covered with 100 mm of topsoil and grassed in accordance with the provisions of this Specification.

S3.09 MEASUREMENT AND PAYMENT

(1) General

(a) Materials excavated will be measured for payment in excavation, to the lines shown on the Drawings or established by the Engineer.

(b) Before commencing and immediately after completion of excavation for which payment is to be made by quantities measured by survey methods, the Contractor shall take survey measurements sufficient to define the dimensions and elevations of the original and final surfaces.

(c) Not less than 7 days before commencing such survey measurements, the Contractor shall submit to the Engineer for approval, a plan showing the proposed layout of reference lines, cross-sections and method of survey.

(d) Reference lines and points are to be set out on the ground and related to permanent marks. At least 24 hours before commencing this work the Engineer shall be notified. Original field notes of the setting out of these reference lines are to be submitted to the Engineer with the notes on actual quantity observations.

(e) Measurements which are to be the basis of quantities for claim for payment shall be taken only in the presence of the Engineer. The Contractor shall notify the Engineer of his intention to take such measurements not less than 24 hours beforehand.

(f) Payment for excavation shall include the entire cost of excavating and transporting the materials from the excavation to the point of final use or to disposal, and where stockpiles are used shall include the entire cost of transporting the material to the stockpiles; of re-handling and of transporting such material to the point of final use; and the entire cost of cleaning up excavated surfaces.

(2) Clearing and Grubbing

(a) Measurement will be horizontal projection of areas specified to be cleared. The payment will be made at the rate per square meter.

(b) Clearing and grubbing of top soil, and disposal of material for the camps storage of material and temporary facilities which the Contractor may need for his purposes, shall not be measured for payment but shall be regarded as subsidiary obligation of the Contractor and considered to be included in other items of the works.

(c) The rate shall include the cost of all labor, materials, tools, construction equipment, hauling clearing, burning and all other work necessary for doing the works as specified in this clause, shown on the Drawing or directed by the Engineer.

(3) Stripping

(a) Measurement will be based on the area calculated on horizontal projection of areas specified to be stripped and multiply by depth as shown on the Drawing or as directed by the Engineer.

(b) Stripping and disposal of top soil at quarries, borrow areas, trenches, pits and footing for foundation of structure shall not be measured for payment and shall be included in the rates in items of surface excavation as appropriate.

(c) Payment for stripping will be made at the applicable rate per square meter. This rate shall include the cost of all labor, materials, tools, construction equipment, stripping, disposal hauling, stockpiling and all other work necessary for doing the works as specified in this clause, shown on the Drawing or directed by the Engineer.

(4) Common Excavation

(a) Measurement, for payment of common excavation will be of the volume of material excavated to the lines, grades and dimensions shown on the Drawings or directed by the Engineer.

(b) Payment for the various items of common excavation will be made at the applicable rates per cubic meter under the pay items set forth in the Schedules. These rates shall include the cost of all labor, materials, tools, construction equipment and incidentals for excavation, loading stockpiling and rehandling, hauling to the point of final use or disposal area, and disposal of excavated waste and surplus materials, all works necessary to maintain the excavation in good order during construction and all other necessary works as specified in this clause, shown on the Drawing or directed by the Engineer.

(5) Rock Excavation

(a) Measurement for payment of rock excavation will be of the in situ solid volume of the rock material removed between the surveyed rock surface and the lines and grades shown on the Drawings or directed by the Engineer.

(b) Payment for the items of rock excavation will be made at the applicable rates per cubic meter under the pay items set forth in the Schedule. These rates shall include the cost of all labor, materials, tools, construction equipment, drilling holes for blasting, performance of blasting methods, blasting test, and any cost associated with establishing satisfactory blasting techniques, and all other works necessary to maintain the excavations in good order during construction and hauling materials from the excavation to the point of final use or disposal area. Following rates are provided in the Schedule:

(i) Weathered rock excavation
(ii) Sound rock excavation

(6) Drainage holes

(a) Measurement for payment, for drilling holes will be of the length of drilled holes and length of reinforcing bar installed.

(b) Payment for drilling holes will be made at the rate bid in the Schedule

This rate shall include the cost of all labor, materials, plant and operations required for drilling and cleaning the holes.

(7) Cleaning of Foundation for Inspection

No measurement for payment will be made for cleaning of foundation, the cost thereof will be deemed to be included in the rates bid in the Schedule for the excavation.

(8) Disposal and Stockpiling of Materials from Excavation

The cost of hauling and the cost of disposal of materials removed from excavation, including stockpiling separately materials for use as concrete aggregate, embankment materials, roadway materials, and the other works, shall be included in the rates bid in the Schedule for the various items of excavation

(9) Demolish Existing Structure from Remedial Work

The cost of demolish existing structure and the cost of hauling and disposal of materials removed from the existing structure, measurement for payment will be of the in situ solid volume of the concrete material removed between the surveyed dimension of existing structure as demolished and shown on the

Drawings or directed by the Engineer.

Payment for demolish existing structure will be made at the rate bid in the Schedule. This rate shall include the cost of all labor, hauling, disposal and operations required for this works.

SECTION 4 - FILL AND BACKFILL

SECTION 4: FILL AND BACKFILL

S4.01 EARTH FILL

(1) General

(a) The Contractor shall place earth fill to the lines, grades and dimensions and in the locations shown on the Drawings or directed by the Engineer.

(b) Material shall be obtained and comply with the provisions of this Specification for aggregates from approved sources.

(2) Placement

Earth fill shall be deposited in horizontal layers not more than 150 mm thick after being compacted, and shall be brought to the moisture content required for the purpose of compaction, and the moisture content shall be uniform throughout each layer. The density of compacted earth fill shall not be less than 95 percent of the maximum dry density obtained by compaction in accordance with ASTM D698 or, where the fill is a cohesionless, granular material, each layer shall be compacted by the number of passes of the vibrating roller and thickness specified in test section as approved by the Engineer.

S4.02 RANDOM BACKFILL

(1) General

(a) The Contractor shall furnish, place and compact random backfill to the lines, grades and dimensions and in the locations shown on the Drawings or directed by the Engineer.

(b) Random backfill shall be obtained from required excavation and other approved sources. Random backfill shall be free from stumps, roots, rubbish, topsoil and other objectionable matter. Random backfill placed within 1 m of structures shall be selected material containing rocks not larger than 75 mm in maximum dimension and shall be placed carefully so as not to damage the structure.

(2) Placement

Random backfill shall be deposited in horizontal layers not more than 150 mm thick after being compacted, and shall be brought to the moisture content required for the purpose of compaction, and the moisture content shall be uniform throughout each layer. The density of compacted random backfill shall not be less than 95 percent of the maximum dry density obtained by compaction in accordance with ASTM D698 or, where the

backfill is a cohesionless, granular material, each layer shall be compacted by the number of passes of the vibrating roller and thickness specified in test section as approved by the Engineer.

S4.03 FREE-DRAINING BACKFILL

(1) General

(a) The Contractor shall furnish, place and compact free-draining backfill to the lines, grades and dimensions and in the locations shown on the Drawings or directed by the Engineer.

(b) Free-draining backfill shall be obtained from required excavation and other approved sources. Free-draining backfill shall be well graded with a maximum dimension of 75 mm, and not more than 5 percent smaller than 0.075 mm. Free-draining backfill placed within 1 m of concrete structures shall not contain rocks larger than 75 mm in maximum dimension and shall be placed carefully so as not to damage the structure.

(2) Placement

Free draining backfill shall be placed in accordance with the following requirements:

(a) Free-draining backfill shall be deposited in horizontal layers not more than 500 mm thick after being compacted, and shall be thoroughly wetted for the purpose of compaction, as determined by the Engineer and the moisture content shall be uniform throughout the layer.

(b) Free-draining backfill shall be compacted by the number of passes of the vibrating roller and thickness specified in test section as approved by the Engineer.

S4.04 IMPERVIOUS BACKFILL

(1) General

(a) The Contractor shall furnish, place and compact impervious backfill to the lines, grades and dimensions and in the locations shown on the Drawings or directed by the Engineer.

(b) Impervious backfill shall be obtained from required excavation or other approved sources. Rocks which cannot be encompassed in a 150 mm layer shall not be incorporated in impervious backfill. Impervious backfill placed within 1 m of structures shall not contain rocks larger than 75 mm in maximum dimension.

(2) Placement

(a) Impervious backfill shall be deposited in horizontal layers, not more than 150 mm thick after compaction.

(b) Before and during compacting operations, impervious backfill shall have the moisture content required for the purpose of compaction, as directed, and the moisture content shall be uniform throughout each layer. So far as practicable, moistening of the impervious backfill shall be performed at the site of excavation and/or stockpiles but such moistening shall be supplemented, if necessary, by sprinkling at the site of compaction.

(c) When each layer of impervious backfill has been brought to the specified moisture content, it shall be compacted to not less than 95 percent of the maximum dry density, measured in accordance with ASTM D698.

(d) Impervious backfill shall be placed carefully in the vicinity of any structure so as not to damage the structure.

(e) Where impervious backfill is placed against walls with weepholes, a gravel filter, having a grading as directed, shall be formed at each weephole to prevent clogging.

S4.05 SAND AND GRAVEL FILL

(1) General

(a) The Contractor shall place sand and gravel fill to the lines, grades and dimensions and in the locations shown on the Drawings or directed by the Engineer.

(b) Sand and gravel shall be obtained and comply with the provisions of this Specification for aggregates from approved sources.

(2) Placement

(a) Where concrete is to be placed on sand and gravel, materials shall be covered with either plastic sheet, polyethylene sheet, or a thin concrete screed.

(b) Where fill is to be placed on the gravel, materials shall be covered with either galvanized iron or polyethylene sheets.

S4.06 ROCKFILL

(1) General

(a) The Contractor shall furnish, place and compact rockfill to the lines,

grades and dimensions and in the locations shown on the Drawings or directed by the Engineer.

(b) Rockfill shall be obtained from required excavation and other approved sources. Rockfill shall be well graded with a maximum dimension of 200 mm. Rockfill placed within 1 m of structures shall be placed carefully so as not to damage the structure.

(2) Placement

Rockfill shall be placed in accordance with the following requirements, placing rockfill by dumping into chutes or by similar methods likely to cause segregation of the various sizes sill not be permitted. The desired distribution of the various sizes of stone throughout the mass shall be obtained by selective loading of the material at the quarry or other source, by controlled dumping of successive loads final placing, or by other methods of placement which will produce the specified results. Rearranging of individual stones by mechanical equipment or by hand will be required to the extent necessary to obtain a reasonably well graded distribution of stone sizes.

S4.07 MEASUREMENT AND PAYMENT

(1) Earth Fill

Measurement, for payment, of furnishing, placing and compacting earth fill will be made of the volume of material required to be placed. To the lines, grades and dimensions as shown on the Drawings or directed by the Engineer. Payment for earth fill will be made at the rate per cubic meter bid therefor in the Schedule.

(2) Random Backfill

Measurement, for payment, of furnishing, placing and compacting random backfill will be made of the volume of material in place to the lines, grades and dimensions shown on the Drawings or directed by the Engineer. Payment for random backfill will be made at the rate per cubic meter bid therefor in the Schedule. Material from required excavation used for random backfill will be paid for both as excavation when removed from required excavation and as backfill when place. Payment will not be made for excavating materials from stockpiles or other sources than required excavation.

(3) Free-Draining Backfill

Measurement, for payment, of furnishing, placing and compacting free-draining backfill will be made of the volume of material in place to the lines, grades and dimensions shown on the Drawings or directed by the Engineer. Payment for free-draining backfill will be made at the rate per cubic meter

bid therefor in the Schedule. Material from required excavation used for free-draining backfill will be paid for both as excavation when removed from required excavation and as backfill when place. Payment will not be made for excavating materials from stockpiles or other sources than required excavation.

(4) Impervious Backfill

Measurement, for payment, of furnishing, placing and compacting impervious backfill will be made of the volume of material in place to the lines, grades and dimensions shown on the Drawings or directed by the Engineer. Payment for impervious backfill will be made at the rate per cubic meter bid therefor in the Schedule. Material from required excavation used for impervious backfill will be paid for both as excavation when removed from required excavation and as backfill when place. Payment will not be made for excavating materials from stockpiles or other sources than required excavation.

(5) Sand and Gravel Fill

Measurement for payment, of sand and gravel fill will be made of the volume of material required to be placed. To the lines, grades and dimensions as shown on the Drawings. Payment for sand and gravel fill will be made at the rate per cubic meter bid therefor in the Schedule.

(6) Rockfill

Measurement for payment, of rockfill will be made of the volume of material required to be placed. To the lines, grades and dimensions as shown on the Drawings. Payment for rockfill will be made at the rate per cubic meter bid therefor in the Schedule.

SECTION 5 - DRAINAGE

SECTION 5 - DRAINAGE

S5.01 GENERAL

(1) Scope of Work

(a) The Works shall be drained by systems of drains as shown on the Drawings or elsewhere as directed by the Engineer. If any drain becomes clogged or obstructed from any cause before final acceptance of the Works, it shall be cleaned out or replaced by and at the expense of the Contractor.

(b) Drains to be constructed by the Contractor include, but are not limited to, the following:

(i) Unlined surface drain

(ii) Lined surface drains, gutter, drain ditch (plain concrete, RC concrete, stone masonry, grouted riprap) and catch drain

(iii) Drainage holes

(iv) Drainage below spillway chute slab

(v) Under drain with PVC weepholes

(vi) Drain pipe
- RC pipe culvert
- PVC pipe

(vii) Toe drain with perforated upper half PCV pipe.

(viii) Side drain

(c) Excavation for drainage work is covered in Section 3.

(2) Submittals

At least sixty (60) days before the commencement of drainage work and prior to the shipment of any materials to the Site, the contractor shall provide details of his proposed pipework materials for approval. All pipes supplied to the Site shall be provided with certificates from the manufacturer confirming compliance with the Standards specified herein.

S5.02 UNLINED SURFACE DRAIN

Excavation shall be made to along the cut section of the access road and other surface excavations for drainage purpose as may proposed by the Contractor of as directed.

S5.03 LINED SURFACE DRAIN

(1) Plain Concrete Lining

(a) The low slump of concrete Class A as specified in Section 9 will be used for the plain concrete lining.

(b) The concrete will be spread and compacted by mean of an appropriate straight edge resting on wooden guides that shall be removed before final setting of concrete.

(c) Concrete shall be placed starting from the bottom of the ditch and proceeding upwards.

(2) Reinforced Concrete Lining or R.C. Drain Ditch

(a) The class of concrete shall be the same as plain concrete lining.

(b) The reinforcement steel shall conform to the requirement of reinforcement of Section 9

(c) Placing of concrete will conform to article (1) (c) of this clause.

S5.04 STONE MASONRY, GROUTED RIPRAP, PLACE RIPRAP AND FILTERS

(1) General

(a) The Contractor shall furnish and install stone masonry, place riprap, grouted riprap and filter material to the prescribed lines and thicknesses as shown on the Drawings and elsewhere if required by the Engineer. The slope protection of the upstream and downstream slope of the dam embankment is not covered by this Section, but is stipulated in Section 4.

(b) All stone masonry, grouted riprap, placed riprap and filter material shall be durable stone, gravel and sand. Gypsum, anhydrite, chart, shale and soft or weathered rock will not be acceptable. The minimum weight per solid cubic meter, calculated from the bulk specific gravity (saturated surface dry) of the sample determined in accordance with the procedure in ASTM C127, shall be 2260 kilograms per m^3.

(c) Material

Rock shall be free from cracks, seams or defects that would tend to increase unduly its deterioration from natural causes. The inclusion of objectionable quantities of dirt, sand, clay and rock fines will not be permitted.

The size of stone masonry, grouted riprap and placed riprap will consist of stones having different sizes as specified here below:

Size of Fragments	Finished Riprap Thickness, T(m)		
	0.30	0.50	0.60
Over 50 cm	-	-	Over 30%
Over 30 cm	Not over 20%	Not over 50%	Over 50%
Over 15 cm	Over 60%	Over 70%	Over 70%
Over 7 cm	Over 80%	Over 90%	Over 90%
Under 3 cm	Under 5%	Under5%	-

(2) Stone Masonry

The Contractor shall construct stone masonry gutter, drainage channel and similar work where shown in the Drawings or as directed by the Engineer. Material for stone masonry shall be sound, durable rock split to true size with parallel, reasonably flat faces; the stones shall be accurately laid and bound by means of a3:1sand to cement mortar. The mortar bed shall be at least 1 cm thick in both vertical and horizontal joints, and all joints shall be struck, cleaned of surplus mortar and smoothed by steel trowel or other approved tool. Prior to laying, the stones shall be wetted and cleaned of surface dust.

(3) Grouted Riprap (grouted pitching)

Where shown on the Drawings or as directed by the Engineer, the Contractor shall place riprap of the required grading and thickness as specified in subclause (1) in which the stone fragments shall be bound by means of cement mortar.

The stones shall be laid to the prescribed lines and grades and all the interstices shall be filled with a 3:1 sand to cement mortar. The mortar shall be well tamped in to the interstices by means of trowels or other approved tool, and shall be smoothed to a level lower than the face of the riprap.

(4) Placed Riprap

(a) The placed riprap shall be constructed of sand and durable rock obtained from approved quarry areas. The maximum weight of any piece of rock shall not be over 120 kilograms and its maximum dimension shall not be larger than three times its minimum dimension.

(b) Placing

Riprap shall be placed in such manner as to produce a reasonably well-graded mass of rock with the minimum practicable percentage of void, and shall be constructed within the specified tolerance to the lines and grades shown on the Drawings. Stakes shall be set both ways at 10 m intervals, and at points at grade changes, before riprap is placed. A tolerance of plus 15 cm from the thickness shown on the Drawings will be allowed in the finished surface of the riprap. Where thickness of riprap exceeds the

allowable tolerance, excess riprap shall be redistributed or removed from the work. No minus tolerance will be permitted. Riprap shall be placed to its full course thickness in one operation and in such a manner to avoid displacing the underplaying material. The large stones shall be well distributed ad the entire mass of stones in their final position shall be roughly graded. The finished riprap shall be free from pockets of small stones and/or clusters of larger stones. Preparation of the subsurface will be done as prescribed for filters.

Placing riprap by dumping into chutes or by similar methods likely to cause segregation of the various sizes sill not be permitted. The desired distribution of the various sizes of stone throughout the mass shall be obtained by selective loading of the material at the quarry or other source, by controlled dumping of successive loads final placing, or by other methods of placement which will produce the specified results. Rearranging of individual stones by mechanical equipment or by hand will be required to the extent necessary to obtain a reasonably well graded distribution of stone sizes.

(5) Filter

(a) Material

Filter underneath riprap shall be a continuous layer of sand and gravel and shall be placed in separate layers. The gravel and sand shall be composed of tough durable particles, shall be reasonably free from thin, flat and elongated pieces, and shall contain no organic matter or soft, friable particles.

Gravel or crushed stone and sand shall be in accordance with the table below:

Filter Materials	Percent by Weight Passing Standard Sieve									
	No.200	No.100	No.50	No.30	No.16	No.8	No.4	3/8”	¾”	1-1/2”
Sand	0-3	3-7	15-25	30-26	55-85	95-100	-	-	-	-
Coarse Aggregate	-	-	-	-	0-5	10-25	20-40	40-60	65-80	100

(b) Subsurface Preparation

Areas on which filter layers are to be placed shall be trimmed and dressed to conform to cross sections shown on the drawings within an allowable tolerance of $\pm$ 5 cm from the theoretical lines and grades.

Areas that are below the allowable minus tolerance limit shall be brought to grade by filling with material similar to the adjacent material and well compacted and no additional payment will be made for any material thus required. Immediately prior to placing the filter material the prepared

subsurface will be inspected by the Engineer and no material shall be placed thereon without his approval. Material of the grading or in accordance with the above table may be produced by screening and recessing river gravel or by blending gravel with crushed rock.

(c) Placement

Filter material shall be spread uniformly on the base, to the lines and grades indicated on the Drawings or as directed. Placing of filter material by methods which tend to segregate particle sizes will not be permitted. Any damage to the subsurface caused during placing of the filter shall be repaired before proceeding with the work. Tamping of the filter layers will be required, but the top surface shall be finished free from mounds or windows. The filter underneath the riprap shall have a thickness as indicated on the Drawings.

S5.05 DRAINAGE HOLES

(1) General

Drainage holes shall be drilled during the excavation lining in locations and at inclinations and directions determined by the Engineer. In addition to use for drainage purposes, the holes may be used as groundwater observation wells or to determine groundwater pressures.

(2) Drilling

(a) Drainage holes shall be drilled by rotary or rotary percussion drilling. The minimum diameter at the bottom of each drainage hole shall be 76 mm and anticipated maximum depth shall be 75 m or as directed by the Engineer.

(b) Exact location, direction, order of drilling and depth of each hole shall be determined by the Engineer to intercept the zones of high seepage.

(c) Where required, drill holes shall be cased. Casing shall be withdraw after installation of drainage pipes.

(d) Each drainage hole shall be protected from becoming obstructed until all work in the vicinity has been completed. Any hole or liner which becomes obstructed before all work has been completed shall be cleared out or replaced by and at the expense of the Contractor.

(3) Perforated and pipe liner

(a) The pipe shall have a nominal size diameter of 35 mm and shall be installed where directed by the Engineer. The pipes shall conform to TIS 277-2532 or similar approved. Pipes shall be provided with couplings to achieve any

required length. The PVC pipe liner shall consist of a perforated part with blind end and imperforated with open end.

(b) The size, location and spacing of the perforations shall be as directed by the Engineer.

(4) Installation of perforated pipe liner

(a) Immediately after each hole has been drilled, the perforated pipe liner shall be inserted for the full length of the drilled hole. The end section of the pipe liner shall be pointed or shaped to assist in forcing the pipe through caved sections of hole and to prevent material entering the end of the pipe.

(b) Open ends of pipes shall be temporarily plugged or otherwise suitable closed until connected to the drainage system. If the pipes become clogged they shall be cleaned out or replaced by and at the expense of the Contractor.

S5.06 DRAINAGE BELOW SLAB AND BEHIND WALL

(1) General

The Contractor furnish and install the drainage following systems as shown on the Drawings.

(a) Under drain beneath the chute slab.

(b) Drain behind the side walls of structure.

(2) Material

The Contractor shall provide and install the following material to the drainage system.

(a) PVC perforated pipe ∅ 150 mm and ∅ 300 mm shall comply with TIS 17-2532 class 13.5.

(b) Gravel or crushed stone for filter surrounded of the perforated pipes complying with gradation 9.5 mm to 38 mm as shown on the Drawing.

(c) Geotextile underlying the gravel or crushed stone filters complying with Clause S14.05.

(d) Plastic sheet placed on the top of filter material complying with S5.07 (3).

S5.07 UNDERDRAIN WITH WEEPHOLES

(1) Scope of Work

(a) The Contractor shall provide the underdrain with PVC pipe weepholes in the walls of spillway as shown on the Drawing or as directed.

(b) Material

(i) Free drain material shall be composed of tough, durable particles, shall be reasonably free from thin, flat and elongated pieces, and shall contain no organic mater or soft, friable particles.

(ii) Gravel or crushed stone shall be in accordance with the table as shown on the drawing

(2) Placement

(a) Free drain material shall be spread uniformly on the prepared area and dressed to conform to cross- section shown on the drawing. Placing of filter material by methods which trend to segregate particle sizes will not be permitted.

(b) compaction of the free drain material will not be required, but the top surface shall be tamped and finished free from mounds.

(3) Weepholes and Plastic Sheet

(a) General

PVC pipe ∅ 25 mm as shown on the Drawings or when otherwise directed weepholes will be incorporated in the underdrains.

(b) The Contractor shall submit the sample of weepholes for the approval of Engineer at thirty (30) days before commence the works.

(c) Installation

(i) Weepholes; the Contractor shall provide open PVC weepholes and place accurately in position prior to placing of concrete.

(ii) Material for PVC weephole shall conform to standard of TIS 17-2532 class 8.5.

(iii) Plastic sheet shall conform to standard of TIS 1293-2537

S5.08 DRAIN PIPE

(1) Reinforced Concrete Pipe Culverts

(a) General

(i) The contractor shall construct reinforced concrete pipe culverts under roads and elsewhere as shown on the Drawings or as directed by the Engineer.

(ii) Concrete pipes for culverts shall conform to the requirements of ASTM C76 or TIS 128-2528 class 3.

(iii) All joints in concreter pipe culverts shall be sealed with mortar consisting of 2 parts fine aggregate to 1 part cement.

(b) Installation

(i) Pipes shall be laid in trenches in bedding of compacted layer. Bedding materials shall be compacted to provide a firm and uniform bed for approximately one third of the circumference of the pipe as directed by the Engineer. The reinforced culvert pipe shall be supported firmly through it entire length.

(ii) Unless otherwise shown on the Drawings or directed by the Engineer, all pipes for concrete pipe culverts shall be laid on a 150 mm thick layer of selected fine granular bedding material and properly jointed. The bedding material shall not contain stones or rock fragments having a maximum dimension greater than 10 mm and shall be obtained from sources approved by the Engineer.

(iii) Joints of pipes shall be aligned straight with end squared and the joint of pipe section shall be such as to produce watertight joints. Cement mortar used in jointing shall be 1 part of cement and 2 parts of sand.

(iv) After the pipes have been bedded, laid and jointed and approved by the Engineer, backfill material shall be placed around the pipes and compacted by tamping, or other approved methods, for a height of at least 300 mm above the top of the pipes, unless otherwise shown on the Drawings or directed by the Engineer. Backfill material placed within 300 mm of any pipe shall not contain stone or rock fragments having a maximum dimension greater than 80 mm. Insofar as it is practicable, backfill material shall be obtained from excavation in the vicinity of the pipe being backfilled and additional material which may be required shall be obtained from sources approved by the Engineer.

(c) Headwalls, Wingwalls and Apron

(i) For road construction and elsewhere as shown on the Drawings or directed by the Engineer, concrete headwalls and wingwalls shall be constructed at the end of pipe culverts, as directed by the Engineer.

(ii) Culvert headwalls, wingwalls and apron shall be constructed to the lines, grades and dimensions show on the Drawings or directed by the Engineer.

S5.09 SIDE DRAIN

(1) Scope of Works

(a) The Contractor shall provide Side drain with open pipe weephole at the side slopes of concrete slab and side wall as shown on the Drawings or as directed as follows:

(2) Material

(a) Gravel of crushed stone shall be in accordance with the table as shown on the drawing.

(b) PVC pipe with perforated end for open pipe weepholes shall be constructed to the shape and size as shown on the Drawings.

PVC pipe shall comply with TIS. 17-2532 Class 8.5.

(c) Geotextile underlying the gravel or crushed stone shall comply with the requirements of Clause S4.10.

(d) Plastic sheet shall conform to standard of TIS 1293-2537.

(3) Placement of Filter and Weepholes

(a) Filter material shall be spread uniformly on the prepared area and dressed to conform to cross-section shown on the Drawings. Placing of filter material by methods, which trend to segregate particle sizes will not be permitted.

(b) Compaction of the filter layers will not be required, but the top surface shall be tamped and finished free from mounds.

(c) Weepholes; the Contractor shall provide open PVC weepholes and place accurately in position prior to placing of concrete.

S5.10 MEASUREMENT AND PAYMENT

(1) Unlined surface drains and catch drain

(a) Measurement for payment for excavation of unlined surface drains will be of the volume of material excavated to the line shown on the Drawings or directed by the Engineer.

(b) Payment for excavation of unlined surface drains and catch drain will be at the applicable rate per cubic meter, under the provision of Clause S3.08, therefore in the Schedule.

(2) Lined surface drains

(a) Measurement for payment for excavation of lined surface drains or R.C. drain ditch will be of the volume of the lined material.

(b) Payment for lined surface drains will be made at the rate bid therefore in the Schedule as follows:

(i) Excavation for lined surface drains per cubic meter

(ii) Concrete lining; per cubic meter

(iii) Stone masonry lining; per cubic meter

(iv) Grouted riprap lining; per cubic meter

(v) Placed riprap lining; per cubic meter

(vi) Sand filter for riprap; per cubic meter

(vii) Gravel filter for riprap; per cubic meter.

(3) Drainage holes

(a) Measurement for payment, for drainage holes will be of the length of drilled holes and length of PVC pipe installed.

(b) Payment for drainage holes will be made at the rate bid in the Schedule as follows:

(i) Drilling of drainage holes per meter

(ii) Supply and install perforated PVC pipe liner per meter.

This rate shall include the cost of all labor, materials, plant and operations required for drilling the holes, installing the pipe liners and connection the pipe liners to the surface drainage system.

(4) Drainage below the spillway slab

(a) Measurement for payment for:

(i) PVC perforated pipe will be of the length of pipes and fittings installed.

(ii) Gravel or crushed stone will be of the volume of materials placed calculated from the Drawings excluding pipes volume.

(iii) Geotextile will be for area laid as shown on the Drawings.

(iv) Coated papers will be of area laid as shown on the Drawing.

(b) Payment for:

(i) PVC perforated pipe will be made at the rate bid per linear meter of pipe lain for each diameters in the Schedule.

(ii) Gravel of crushed stone for filter will be made at the rate bid per cubic meter in the Schedule.

(iii) Geotextile will be made at the rate bid per square mater in the Schedule.

(iv) Coated paper will be made at the rate bid per square meter in the Schedule.

(5) Underdrain and weepholes

(a) Measurement for, weephole will be of the volume for material placed in situ and the length of the weepholes pipe.

(b) Payment for underdrain with weepholes will be made at the rate bid in the Schedule as follows:-

(i) Free drain backfill material for cubic meter

(ii) PVC pipe for weepholes for meter

(6) Drain pipes

(a) Measurement for payment for reinforced concrete pipe culvert will be of length of pipe measured along the center line of the pipe placed with no allowance for lap at joint. Measurement for payment of the excavation and backfill for trench, bedding and the like for the installation of the pipes will be of the volume of material placed.

(b) Payment for furnishing and installing of the pipes culverts, excavation and backfill, bedding, and the like for the pipes culvert installation will be made at the raters bid in the Schedule as follow:

(i) Excavation and backfill for trench per cubic meter

(ii) Supply and install R.C. pipe culvert per meter

These rater shall include all cost of material, equipment, labor, and incidental for placing transporting, compacting, etc., necessary to completer the work.

(7) Headwall, wing wall and apron for culverts

(a) Measurement and payment for concrete and reinforcement will be made separately.
(i) Measurement for concrete in cubic meter

(ii) Measurement for the reinforcement in kilogram of reinforcement

(b) Payment for reinforcement and concrete will be made in kilogram and cubic meter respectively at the rates bid in the Schedule of Section 9.

(8) Side drain

(a) Measurement for side drain will be of the volume for material placed in situ, no. of set of the weepholes pipe and the area of the plastic sheet.

(b) Payment for side drain will be made at the rate bid in the Schedule as follows:

(i) PVC perforated pipe will be; per meter.

(ii) Open pipe PVC. weepholes will be; per set.

(iii) PVC flap valve weepholes will be; per set.

(iv) Filter material for side drain; per cubic meter.

(v) Geotextile for side drain; per square meter.

(vi) Plastic sheet or coated paper; per square meter.

(vii) PVC pipe of each diameter; per meter.

SECTION 6 - ROAD CONSTRUCTION

SECTION 6 - ROAD CONSTRUCTION

S6.01 GENERAL REQUIREMENT

(1) Temporary Access Roads

It shall be the sole responsibility of the Contractor to maintain and repair all temporary access and haul roads constructed by him and for his own use and in accordance with his proposals as approved by the Engineer.

(2) Maintenance

(a) The Contractor shall be wholly responsible for maintaining all drainage structures include bridge, box culverts, road culvert, etc., permanent access roads, haul roads parking area and all temporary access roads constructed by him.

(b) In maintaining these roads the Contractor shall:

(i) Keep clear and in good working order at all times all road structures, bridges, culverts, side ditches and other waterways;

(ii) Patch potholes with approved materials, keep the road surface in good repair and perform any grading and necessary resurfacing;

(iii) Maintain all guide posts, guard posts, guardrail, signs, signposts and other roadside structures;

(iv) Keep the road surface and shoulders free from all rocks, fallen timber, branches, limbs, leaves, rubbish and other debris and materials removed from drains and drainage structures;

(v) Maintain side slope and cross falls;

(vi) Maintain proper soil conservation measures.

(3) Use of Access Roads

(a) The roads provided with DBST surface shall not be used as haul roads or used by heavy construction equipment, unless otherwise approved.

(b) The permanent laterite surface roads may be used by the Contractor as haul roads during the execution of the Works, until such time as notified by the Engineer whereupon they shall be repaired and restored to the original conditions as constructed according to these Specifications.

(c) During the period of the Contract, the Administration and other contractors employed by the Administration will be engaged on other work in the vicinity of the Works and the Contractor shall allow the Administration and such other contractors full and unrestricted use of all roads described in this Section.

(4) Soil Conservation

The Contractor shall carry out soil conservation measures on all works for Permanent Access Roads, where and when directed, in accordance with Clause S4.11.

(5) Material Sources

Not less than thirty (30) days before use of any material for the construction of roads and appurtenant works, the Contractor shall submit for approved and the details of all other material sources including suppliers and manufacturers. He shall also at the same time submit the test results and certificates showing the appropriateness of incorporating material in the Works. This shall not relieve the contractor from the responsibility of supplying material meeting the requirements of these Specifications for any part and during any time of the construction.

S6.02 CLEARING, GRUBBING AND STRIPPING

(1) Clearing and Grubbing Requirement

The area to be cleared shall be confined to the areas occupied by roadway embankments and excavation. The ground shall be cleared of trees, brush, rubbish and other objectionable matters. The ground surface under all embankments shall be grubbed of all stumps and roots in accordance with Clause S3.01 (1). All cleared material shall be disposed of in accordance with Clause S3.01 (1).

(2) Stripping Requirement

Top soil in any layer of soil within a depth as specified in Clause S3.01(2) of the existing surface on the site which contain or is discolored by the roots of vegetation or any other organic material shall be stripped before any filling.

S6.03 DRAINAGE

(1) Side Ditches

Side ditches shall be required at the toe of excavation as indicated on the

Drawings or directed by the Engineer. The ditches shall be lined with plain concrete.

(2) RC Pipe Culverts

(a) The Contractor shall construct pipe culverts and headwalls as shown on the Drawings.

(b) RC pipes for culverts shall conform to TIS 128-2528 and shall have tongue and groove joints.

S6.04 EARTHWORKS

(1) Excavation

(a) All excavation shall be carried out to the lines, grades and dimensions shown on the Drawings in accordance with the prescription of Section 3, or as directed by the Engineer.

(b) For cuts in earth, the road subgrade shall be treated as road embankment and constructed according to all relevant provisions of Clause S6.04 (2).

(c) The extent of the cut section shall properly accommodate the requirements for side ditches described in Clause S6.02 (1).

(d) Unless otherwise directed by the Engineer the side slopes shall be:

(i) 1.0 vertical to 0.025 horizontal in fresh rock

(ii) 1.0 vertical to 1.0 horizontal in moderately weathered rock

(iii) 1.0 vertical to 1.50 horizontal in earth

(e) Benching of cut slopes whether in overburden or soft rock where required or direct to stabilize the surface of excavation shall be allowed. Where benching is directed by the Engineer, the width of cut shall be at least 2 meters and an inward cross slope not flatter than 1 vertical to 6 horizontal.

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

(2) Road Embankments

(a) Material

(i) Embankments shall be constructed of suitable material such as clay, soil aggregate, sand or rock, which are free of roots, or other deleterious materials obtained from excavations of cut-off channel approved by the Engineer.

(ii) Oversize rock fragments or gravel, in excess of 75 mm in effective diameter, shall not be incorporated in the road embankments.

(b) Where the height of embankment measured from the finished surface to the natural ground surface is at any point less than 1 m, all vegetable matter shall be removed, and the top 150 mm of the existing earth shall be stripped. The foundation shall be compacted to not less than 95 percent of the maximum dry density as determined by AASHTO test method T 99.

(c) If unsuitable materials occur in some area under the road embankment, such materials shall be removed by cut or excavated to levels as directed by the Engineer, the bottom of road embankment shall be backfilled and compacted with suitable material or fill material replacing as diverted by the Engineer.

(d) Approved material shall be placed in embankments in approximately equal layers for the full width of the embankment to a thickness of not more than 200 mm after compaction. Road embankments shall not be widened with loose material dumped from the top. Benching of embankment side slopes shall not be allowed, unless otherwise directed by the Engineer.

(e) Each layer of the embankment shall be compacted for its full width until the dry density, as determined by field density is not less than 95 percent of the maximum dry density obtained from the compaction test carried out in accordance with AASHTO test method T 99.

(f) The Contractor shall carry out field density test by AASHTO T 191 at a rate of not less than 1 test per compacted layer per 200 m length of embankment.

(3) Preparation of Subgrades or laterite Surface

(a) Immediately before constructing of subbase or laterite surface, the Contractor shall compact, or scarify and compact the entire surface of subgrade to the lines and grades to the density requirements as specified in Clause S6.04 (2).

(b) Spray watering or drying out by harrowing and respreading, as the case may be required improving the compaction characteristics of the subgrade.

(c) Soft and yielding material which will not dry out readily or compact satisfactorily shall be removed and replaced with approved material. Any holes or depressions shall also be filled with approved material.

(d) The subgrade surface before the construction of the subbase course shall be within 20 mm of the required levels.

(e) After compaction and leveling, the Contractor shall carry out such maintenance as is necessary to preserve and keep the surface of the subgrade in its approved condition until the subbase is placed.

S6.05 CONCRETE PAVEMENT

(1) The concrete pavement in this clause is designated for external area of powerhouse, access road and parking area or where otherwise directed by the Engineer.

(2) The Contractor shall construct access road at defined location, line and elevation as shown on the Drawings or as directed.

(3) Materials

Access road shall be reinforcing concrete in the shape and manner designated on the Drawings and the materials shall conform to the requirements of Section 8.

(4) Construction Methods

Construction of access road shall conform to method in the Section 9 and defined on the Drawings or as directed by Engineer.

(5) Painting

Traffic sign shall be painted by colors paint in Clause S6.09. This paint shall be the kind used by Department of Highways for same purpose and shall be subject to approval by the Engineer.

S6.06 GUARD RAIL

(1) Requirement

The Contractor shall furnish and install steel beam guard rail at the locations shown on the Drawings or as directed or approved by the Engineer.

(2) Materials

The details of the steel beam guardrail and concrete guide posts shall be as shown on the Drawings.

(a) Post

Steel posts shall conform to the requirement of AASHTO M 193.

(b) Guardrail

Steel guardrail shall be made from steel of thickness not less than 10 or 12 gage as shown on the Drawings, conforming to Specification of Department of Highway (1970).

(c) Bolts and Nuts

Bolts and nuts shall be galvanized in accordance with AASHTO Standard Specification M111 and all connection shall be able to withstand a side pull in any direction of 2,200 kilograms. If the contract documents indicate that galvanizing is required, all steel except reinforcement for reinforced concrete shall be galvanized.

(d) Paint

Paint shall be applied in the number of applications and of the type indicated in the manufacturer recommendation. Paint shall conform to the appropriate specification as follows:-

Red lead paint	AASHTO M 72
White and tinted paint	AASHTO M 70 Type 1 Class B
Aluminum paint	AASHTO M 69
Zinc chromate paint	AASHTO M 142

(3) Construction Methods

(a) Posts

Posts shall be set vertically in position and to the lines and levels shown on the Drawings. Post holes shall be back filled with approved material well tamped in layers of not more than 10 centimeters thickness. If driving of posts is permitted the tops of posts shall have substantially the same dimensions as the body of the posts. Damage to posts in driving will be cause for rejection.

(b) Steel Rails

Steel rails shall be supplied to be site fully fabricated requiring only bolting on site. Bolts shall be drawn tight except where otherwise required at expansion joints.

(c) Painting

All metal work not galvanized shall be given one shop coat of red lead or zinc chromate paint or a rust inhibiting primer of a type approved by the Engineer and two field coats of white or aluminum paint. Painting shall otherwise be in accordance with Section 20.

S6.07 GUIDE POSTS

(1) Requirement

The Contractor shall furnish and install guide posts, at the location and in accordance with the sizes and dimension shown on the Drawings or as directed.

(2) Materials

Guide post shall be pre-cast in the shape and manner designated on the Drawings and the materials shall conform to the requirements of Section 9 concrete class B. Reinforcement shall conform to the requirements of Section 9.

(3) Painting

Guide post shall be painted by emulsion paint (Exterior paint) with Black and White color and reflectorized white paint as shown on the Drawing. This paint shall be the kind used by Department of Highways for same purpose and shall be subject to approval by the Engineer.

(4) Construction Methods

Construction, fabrication and installation of guide posts shall be as shown on the Drawings or as directed by Engineer.

S6.08 STREET LIGHT FIXTURE

(1) Fixture

The fixture shall be mounted on post street lamp. The electrical unit shall be made of high pressure die-cast aluminum with non-contain ballast, capacitor and lamp holder. The reflection shall be of press stainless steel. The fixture shall be rainproof and insect-tight.

(2) Lamp

The lamp shall be high pressure mercury vapor or high pressure sodium vapor.

(3) Ballast

The ballast shall have a 90% power factor, 45 dB sound level. The ballast shall be electrical designed to ensure very low operating temperature, insulator not less than Class E and low wattage losses.

S6.09 ROAD SIGNS

(1) General

The Contractor shall furnish assembly and mount posts, signs, and sign frames in accordance with the details shown on the Drawings or as directed at the locations as directed by the Engineer.

The work shall include all necessary foundation, excavation, backfill, anchorages, fixtures and fastenings, brackets, lighting units and electrical installations where required, application of paints and finishes, testing and all the processes necessary to complete the work. The road sign shall include:

(a) Warning sign
(b) Regulating sign
(c) Destination sign
(d) Distance sign

(2) Sizes, Colors and Types

Unless otherwise shown on the Drawings or otherwise directed by the Engineer, signs and their supports shall be of the sizes, colors and types prescribed by, and sited in accordance with the recommendations of, the latest edition of the Department's Traffic Control Device Manual and subsequent supplements and amendments.

(3) Sign Plates

Sign plates and panels shall be manufactured from one of the following materials:

(a) Aluminum Alloy

Flat sheets and plates shall be one of the following alloys: either Alloy 5052-H34, 6061-T6 or 3003-H18 complying with ASTM Specification B209.

(b) Steel Plate, Sheet or Strip-The material shall comply with ASTM Specification A245, Grade B, or such other internationally recognized specification as is acceptable to the Engineer.

Screws, bolts, nuts and washers shall be of steel, aluminum alloy or of a high tensile non-corroding metal. Washers in contact with surfaces which may be damaged by over tightening of nuts or bolts shall be of a suitable soft and weather resisting material.

Steel fixings and fittings which are in contact with aluminum shall be coated with zinc or cadmium. All steel fittings shall be rustproofed. Rivets shall be made from copper, brass, aluminum alloy or pure aluminum. Brass, copper, lead or nickel shall not be used in contact with aluminum.

(4) Preservative, Paints and Finishes

All coatings, paints, varnishes and enamels used in the preparation and finish of the signs, posts and fittings shall be of the best quality, specially made for the purpose they shall serve, and of brands and types acceptable to the Engineer. To ensure compatibility, primers, undercoats and finishing costs shall, wherever possible, be of the same manufacture. All materials shall be stored, and used within such time limits, as specified or recommended by the manufacturers or in accordance with the directions of the Engineer.

Zinc coating (galvanizing) on steel parts shall comply with ASTM Specification A 123 or A153 as appropriate.

All paint used for steel parts, other than finishes on a sign face, shall be high zinc oxide content coating material of approved formulation containing a minimum of seven kilograms of zinc oxide (acicular type) per one hundred liters of coating material (sixty pounds per one hundred U.S. gallons). The color of the primer shall be different from succeeding coating.

Priming paints for aluminum alloys, when required, shall be pigmented with chromates or chromes (excluding lead chromes) except on sign faces where the specified finish is unsuitable for use with such primers.

Reflective sheeting shall be “Scotchlite” Engineer Grade or other approved colorfast reflective material applied in accordance with the manufacturer’s specifications or instructions.

(5) Materials

(a) Mounting Posts

Reinforced Concrete Posts-Materials shall conforms to the requirements of Section 10 of these Specifications. Concrete shall be Class B. Unless otherwise specified on the Drawings.

(b) Beads for reflectorization of signs shall be of good quality, optically clear, lead-free glass with not less than 90% reasonably spherical and free from flaws. The beads shall contain not more than on percent of sharp angular particles and not more than one half percent of foreign matter and shall be free flowing under normal atmospheric conditions.

(6) Installation

Wherever possible, signs shall be mounted on sign posts and shall be such that all sign plates, posts, fittings, can be assembled and erected without site modification.

S6.10 PAINTING AT BRIDGE APPROACHES

(1) General

The end of the parapets and sidewalk slabs on both approaches to the bridge shall be painted with alternate oblique strips of black and white, light reflecting paint to the pattern shown on the Drawings or as directed.

This paint shall be of the kind used by the Highway Department for the same purpose and shall be subject to approval by the Engineer. Concrete surfaces shall be completely dry and clean when paint is applied, and the surface preparation and application shall be in accordance with the paint manufacturer's instruction, to the satisfaction of the Engineer.

S6.11 INCIDENTALS

(1) Requirement

The Contractor shall furnish, install and construct such incidentals required for the proper functioning of the permanent access roads, miscellaneous material for bridge including PVC drain pipe, celotex with tar, mastic joint sealer, asphalt paper, dowels on pier, mastic joint material, painting at bridge end, etc., as shown on the Drawings approved by the Engineer or as directed.

Details of these incidentals shall be conforming to the current practice and specifications of the Department of Highways.

S6.12 MEASUREMENT AND PAYMENT

(1) Clearing, Grubbing and Stripping

(a) Measurement will be of the area covered by the embankment conforming to Section 3, Clause S3.01but the depth of stripping for the road embankment shall be limit to 15 cm or 30 cm depth as specified or directed by the Engineer.

(b) Payment will be made at the rate per unit bid therefor in the Schedule.

(2) Side Ditch

(a) Measurement and payment will be made for the excavation and concrete lining as stipulated in Clause S7.10 (2)

(3) Road Embankment

(a) Measurement will be of the volume of compacted fill measuring from the stripped ground surface to the finished subgrade elevation.

(b) Payment will be made at the rate per cubic meter bid therefor as in the Schedule.

(4) Subbase Course

(a) Measurement for payment of subbase material will be of the volume of material placed to the line, grades and dimensions shown on the Drawing or as directed.

(b) Payment for subbase and laterite surface will be made at the rate per cubic meter bid therefor in the Schedule which shall include the cost of hauling, watering and compacting the material as described in this Section.

(5) Aggregate Base Course

(a) Measurement for payment of aggregate base will be of the volume of material after placement to the lines, grades and dimensions shown on the Drawings or as directed.

(b) Payment for aggregate base will be made at the rate per cubic meter bid therefor in the Schedule which rate shall include the cost of hauling, placing, watering and compacting the materials as described in this Section.

(6) Shoulder

Measurement and payment for shoulder material will be in accordance with the measurement and payment for aggregate subbase in subclause (3). Payment will be made at the rate per cubic meter bid therefor in the Schedule.

(7) Concrete Surface

(a) Measurement for payment of concrete surface will be of the area in square meter constructed as shown on the Drawings or as directed.

(b) Payment for concrete surface will be made at the rate per square meter bid therefor in the Schedule, which rate shall include the preparation of the surface, testing of material, furnishing, placing and curing concrete and materials, and including all labor, equipment, tools and incidentals necessary to complete the Works.

(8) Guide Posts

(a) Measurement for payment for guide posts will be made of the actual number of guide posts furnished, placed, and accepted.

(b) Payment for furnishing and installing guide posts will be made at the applicable rate per post bid therefor in the Schedule. The rate shall be deemed full compensation for furnishing and installing of material, include labor, equipment, tools painting and incidentals necessary to complete the Works.

(9) Drain Pipes

(a) Measurement for payment for reinforced concrete pipe culvert will be of length of pipe in meter measured along the center line of the pipe place with no allowance for lap at joint Measurement for payment of the excavation and backfill for trench, bedding and the like for the installation of the pipes will be of the volume of material placed.

(b) Payment for furnishing and installing of the pipes culverts, excavation and backfill, bedding, and the like for the pipes culvert installation will be made at the rates bid in the Schedule as follows:

(i) Excavation and backfill for trench per cubic meter

(ii) Supply and install R.C. pipe culvert per meter

These rates shall include all cost of material, equipment, labor, and incidental for placing transporting, compacting, etc., necessary to complete the Works.

(10) Guardrails

(a) Measurement for payment of guardrail and steel post will be made of the length along the rail from center of end posts installed as shown on the Drawings or directed by the Engineer.

(b) Payment for furnishing and installing guardrail and posts will be made at the applicable rate per linear meter bid therefor in the Schedule. These rates shall include full compensation for furnishing and installing all materials, including labor, equipment, tool and incidentals necessary to complete the Works.

(11) Road Signs

(a) Measurement, for payment, of the road sign shall be the actual number of completed road signs of each type and size furnished including mounting post installed and accepted.

(b) Payment for road signs will be made at the rate bid therefore in the Schedule which shall be full compensation for furnishing and erecting, including all lab our tools, testing, painting and incidental necessary to complete the work. The item of payment in the Schedule will be :

(i) Traffic Regulating Signs
(ii) Traffic Warning Sign
(iii) Destination Sign
(iv) Distance Sign

(12) Incidentals

The Contractor shall include in the lump sum rate of incidentals, the cost of all the works as specified in this clause or shown on the relevant Drawings.

Payment for furnishing and installing incidentals as required in this subclause shall be deemed to be included in the rates and lump sums bid for the Works in this Section.

SECTION 7- PROTECTION AND SUPPORT EXCAVATION

SECTION 7 - PROTECTION AND SUPPORT EXCAVATION

S7.01 SLOPE PROTECTION

(1) Slope protection shall be classified into 2 types: soil and rock slopes protection.

(2) Soil slope shall mean any slope cut in loose material and completely weathered rocks as following to this section.

(3) Rock slope shall be any slope cut in the fresh to highly weathered rocks as following to section 5.

(4) Unstable soil slope shall be stabilized by sodding as specified in Clause S7.02.5 or shotcrete shown on the Drawing as directed and approved by the Engineer.

(5) The following clauses in this section shall particularly concern the rock slope support.

(a) Nothing contained in this Specification shall relieve the Contractor from sole responsibility for the safety of excavations or for liability for injuries to or deaths of persons or damage to property, nor of any of his obligations under the Contract.

(b) Nothing contained in this Specification shall prevent the Contractor from erecting, at his own expense, such amounts of protection or support as he may consider necessary or from using heavier supports than directed or approved.

S7.02 SUPPORT IN SOIL EXCAVATION

(1) Support excavation shall mean measures taken to prevent the deterioration of excavated surfaces through the action of water, wind, temperature and other surface and near surface effects. The methods of support to be used and for which payment will be made are:

(a) Placed and grouted riprap on bedding

(b) Stone masonry

(c) Gabions and mattresses

(d) Geotextile

(e) Sodding on topsoil

(2) The Contractor shall support excavation of surface excavations as shown on the Drawings or as directed by the Engineer.

S7.02.1 PLACED AND GROUTED RIPRAD

(1) Placed and grouted riprap

(a) Rock for placed and grouted riprap shall consist of rough uneven quarry rock as nearly rectangular in section as possible. The rock shall be sound, tough, durable, dense, resistant to the action of water and wind, and suitable in all respects for the purpose intended.

(b) Unless directed otherwise, the rock pieces shall range in weight from a minimum of 10 kg to a maximum of 50 kg with not less than 50 percent of the rock weighing more than 25 kg.

(2) Bedding

Bedding underneath riprap shall be a continuous layer of sand and gravel. The gravel and sand shall be composed of tough durable particles, reasonably free from thin, flat and elongated pieces, and shall contain no organic matter nor soft, friable particles and selected from required excavations or other approved sources. Gradation requirements of bedding should be specified such that filters criteria is met between protected material, bedding, and riprap.

(3) Cement mortar

Mortar for grouting the riprap shall be composed of 1 part of cement and 3 parts of sand by dry loose volume and sufficient water to make a mortar. Retempering of mortar that has not been used for period of 45 minutes or longer will not be permitted. Material for mortar shall conform to the requirements of Section 10.

(4) Placing

(a) Riprap shall be placed to the nominal thickness shown on the Drawings. The rock fragments in riprap shall not be compacted but shall be unloaded by crane or other approved equipment in such a manner to ensure that the larger rock fragments are uniformly distributed, that the smaller rock fragments fill the spaces between the large fragments, that displacement of underlying materials is avoided, and that compact uniform layers of riprap of the specified nominal thicknesses result.

(b) Grouted riprap shall be excavated at beds to the required depths and properly trimmed and shaped. Rock shall be placed by hand. It shall be laid with broken joints and shall be firmly bedded fitting the adjoining rocks as closely as practicable. The vertical joints in each course shall break joints with those in adjoining course by at least 15 cm.

The rock shall be thoroughly compacted as laying progresses and the finished surface shall present an even tight surface. Rock placed against slopes or ditch drains shall be laid with the largest rocks used in the lower courses, gradually, reducing in size as laying progressed upwards. Interstices between rocks shall be chinked with spill firmly rammed in place. Spaces between stones shall be filled up with mortar. Prior to filling the spaces of rocks with mortar, the rock shall be sufficiently

moistened with water as directed. All joints shall be filled with sufficient mortar to completely fill all voids. All surfaces or joints of grouted riprap shall be swept clean after mortar has initially set. After grout has sufficiently set, the surface shall be cured by spraying or covering the surface with sacks and constantly wetted for a period of at least 7 days.

(c) Bedding material shall be spread uniformly on the foundation, to the line and grades indicated on the Drawings or as directed by the Engineer. Any damage to the subsurface caused during placing of bedding shall be repaired before proceeding with the works. Bedding underneath the riprap shall have a thickness as indicated on the Drawings.

S7.02.2 STONE MASONRY

(1) General

The Contractor shall furnish and construct stone masonry in ditch drains or gutter and on surfaces of slopes and batters where shown on the Drawings or directed by the Engineer.

(2) Materials

Rock used for stone masonry shall be sound durable rock selected from the harder rock from the required excavations or other approved sources.

(3) Bedding and Placement

(a) The rock shall not be less than 150 mm thick and shall be properly bedded to a uniform surface on bedding material. The exposed surface of each stone shall be approximately flat and of an area not less than 0.03 m^2.

(b) The foundation surfaces on which stone masonry is to be placed shall be trimmed and shaped where necessary and the rocks set in a mortar consisting of 3 parts of clean fine aggregate to 1 part of cement by volume. Material for mortar shall conform to the requirements of Section 10.

(c) The mortar bed shall be at least 10 mm thick in both vertical and horizontal joints, and all joints shall be struck, cleaned of surplus mortar and smoothed by steel trowel or other approved tool. Prior to lying, the rocks shall be wetted and cleaned of surface dust.

S7.02.3 GABIONS BOXES AND MATTRESSES

(1) General

All mesh wire for gabion boxes and mattress shall be galvanized and coated with

a polyvinyl chloride compound (PVC). The sizes and locations of gabion boxes and mattresses filled with approved rock shall be as shown on the Drawings or as directed by the Engineer. Gabion boxes and mattresses shall be manufactured by the factory accredited under ISO 9002 and shall be assembled in accordance with the specification and the manufacture's instructions. Gabion and mattress shall be rectangular boxes formed from panels of mesh and framed by thicker selvedge wire. Where the sizes are larger than 1 m in length, diaphragms shall be required at the interval of not exceeding 1 m and shall be fully laced at all sides.

(2) Mesh

Gabion boxes and mattresses shall be fabricated from wire, triple twisted to from an hexagonal mesh. The mesh size for gabion boxes shall be 80 mm x 100 mm. The mesh size for gabion mattresses shall be 60 mm x 80 mm. The Contractor may propose another mesh size as alternative for the approval of the Engineer.

(3) Wire

The wire used to manufacture the mesh shall be conformed to BS 1052. 1980 "Specification for mild steel wire for general engineering purposes" with a tensile strength of between 38 to 50 kg/mm^2 and with a minimum elongation at failure of 12% an equal of higher quality than the above standard shall be allowed.
The minimum wire diameter, in millimeters, after galvanizing and before PVC coating shall be as follows:

	Wire Mesh	Selvedge Wire	Lacing Wire
Gabion	2.7	3.4	2.2
Mattresses	2.2	2.7	2.2

(4) Galvanizing

All wire used in the fabrication of the gabion boxes and mattresses and in the wiring operations during construction shall be zinc coated by hot dip galvanizing in accordance with BS 443 : 1980 "Specification for testing zinc coatings on steel wire and for quality requirements" prior to being PVC coated. An equal or higher quality than the above standard shall be allowed. The minimum zinc coating weights for various wire diameters shall be as follows:

Wire Diameter (mm)	Weight of Coating (gm/sq.m)
3.4	275
2.7	260
2.2	240

(5) PVC Coating

All galvanized wire shall be coated with PVC. The PVC coating shall has a minimum wall thickness of 0.5 mm and shall be capable of resisting the effects of exposure to ultraviolet light, immersion in neutral weather exposure without cracking, blistering, splitting or any make change in color.

(6) Tolerances

A manufacturing tolerance of ± 5% on the height and ± 3% on the length of gabion boxes and mattresses shall be allowed. A tolerance of ± 5% shall be allowed on the mesh size for gabion boxes and mattresses.

(7) Gabion Rock

The rock for gabion boxes and mattresses shall be hard, sound, durable with a minimum density of 2,400 kg/m^3 and free from cracks and other structural defects that would cause it to deteriorate. Rock shall be well graded with the following limits:

Mesh Size	Minimum Dimension (mm)	Maximum Dimension (mm)
60 x 80 mm mesh	70	180
80 x 100 mm mesh	90	240

(8) Sizes of Gabion Boxes and Mattresses

The sizes of gabion boxes and mattresses shall be rectangular shape (width x length x height). Various sizes shall be used as shown on the Drawing.

S7.02.4 GEOTEXTILE

(1) General

The Contractor shall furnish and install the non-woven geotextile underneath filter zone of dam embankment, riprap and at other locations as shown on the Drawings or as directed by the Engineer.

(2) Material

(a) The geotextile shall serve as filter or bedding material and shall have the following properties:
Tensile strength : not less than 8 kN/m
Tear strength : not less than 280 N
Pore size, D90 : not less than 100 micron

(b) The non-woven fabric bond shall have excellent mechanical characteristic, resistance to abrasion, imperviousness to rotting, and low creep character under long period stressing.

(c) The geotextile can be accepted on manufacturer's, testing certificate. If the results meet the requirement specified in the Drawing. Where the Engineer has reason to believe that testing is necessary he may order the geotextile to be sampled and tested at any time.

(3) Jointing Method

(a) The width and length of the geotextile shall be overlapping as shown on the Drawings or accordance with the manufacturer's instructions.

(b) The assembly technique to be used by the Contractor is stitching, and it shall be done parallel to the contours of the facing. If preliminary tests show that two layers have to be laid over each other to withstand tearing, the two layers will preferably be stitched together. Otherwise they may be stapled together.

(c) To protect the geotextile when it is laid against a material which might damage it, the Contractor shall place a layer of bedding material before laying the geotextile.

(d) Backfill material shall be placed in such a way that no damage, or movement of the membrane sufficient to leave the foundation unprotected, take place. The membrane shall be covered within 24 hours of unrolling to limit exposure to sunlight.

S7.02.5 SODDING ON TOPSOIL

(1) General

(a) This work shall consist of furnishing seed, sprigs or sods as required or permitted and planting them to give a healthy stable covering of sod which will maintain its growth in any weather and prevent erosion of the material in which it is planted.

(b) This work includes the providing of block sodding or strip sodding on the topsoil covered slopes of embankment, subbase and shoulder and on other areas subject to erosion as shown on the Drawings and where required by the Engineer.

(2) Materials

(a) Sod shall be species native to Thailand, harmless and inoffensive to people and animals and not of a kind recognized as a nuisance to agriculture. It shall be free of disease and noxious weeds, deep rooted and sufficiently rapid growing and spreading to give complete cover over the planted area within two years of planting.

(b) The term "sod" embraces sods, sprigs and seeds and, if the Engineer permits, may include plants of other types capable of giving effective protection.

(c) Fertilizer shall be approved lime or mixtures of plant nutrients or both.

(d) Sods and sprigs shall be planted with their root system substantially

undamaged and packed around with moist earth in which they have grown.

(3) Methods

Sodding shall be carried out in accordance with any of the following methods:

(a) By topsoil placement, which consists of distributing topsoil to depth of between 10 cm and 15 cm as directed in the Drawings.

(b) Sodding shall be done by planting sods to give continuous cover over the whole area.

(c) Strip sodding shall be done by planting strips of sods not less than 8 cm wide, not more than 45 cm apart (center to center) or as required by the Engineer.

(d) Strip sodding shall be planted with the strips lying along contours. All sods shall be planted with roots well buried in firm material.

(e) Sod shall be planted at such a time and the work shall be done in such a way that at the time of the final construction inspection all areas to be grassed are substantially covered with healthy, well established, firmly rooted sod and the planted area is free from erosion channels. In the case of strip sodding bare strips between the strips of sods will be permitted at the time of the construction inspection.

(f) Occasional small bare patches will not be cause for rejection. Any bare areas which, in the Engineer's opinion, may permit erosion shall be made good and replanted with sodding at no additional cost to the Department.

(g) Surfaces to be planted shall be trimmed in such a way that the ground surface after planting shall be as shown on the Drawings.

(h) Fertilizer shall be added at the time of planting if it is necessary to ensure good ground cover within the required time.

(i) Whenever a slope is completed, dressed and ready for sodding the Contractor shall proceed with block sodding or strip sodding as designated on the Drawings or instructed by the Engineer. The Contractor shall maintain the sod at his expense until the end of the Contract Period. Maintenance shall consist of preserving, protecting and replacing grass, and such other work as may be necessary to keep it in a satisfactory condition to prevent erosion and to present a dense and uniform appearance. The Contractor shall be responsible for satisfactory growth and shall water, fertilize and mow the sod at such intervals as will ensure good ground cover of live sod all through the Contract Period.

S7.03 SUPPORT IN ROCK EXCAVATION

(1) Scope

(a) Rock slope support shall mean measures taken to prevent the failure of rock surface excavation. The methods of support to be use are:

(i) Rock bolts

(ii) Anchor bars

(iii) Shotcrete

(b) The Contractor shall support rock surface excavations, where and when directed, and approved by the Engineer. Unless otherwise specified or directed, the Contractor shall not proceed with excavation more than 2 m below a point where support for the batters has been directed until the required support has been installed.

(2) Responsibility for Safety

(a) Nothing contained in this Specification shall relieve the Contractor from sole responsibility for the safety of excavations or for liability for injuries to or deaths of persons or damage to property, nor of any of his obligations under the Contract.

(b) Nothing contained in this Specification shall prevent the Contractor from erecting, at his own expense, such amounts of protection or support as he may consider necessary or from using heavier supports than directed or approved.

S7.03.1 ROCK BOLTS

(1) General

(a) For the purposes of this Specification a rock bolt is a length of steel reinforcing bar which has been installed in a drilled hole, anchored to the rock at the far end and tensioned by the application of an axial, tensile load through a nut and steel plate bearing against the surface of the rock or shotcrete. Such a rock bolt may be grouted.

(b) The Contractor shall furnish and install grouted rock bolts in surface excavations where or directed or approved by the Engineer.

(c) For the purposes of this Specification the term "grouted" includes full encapsulation of the rock bolt in the hole with either cement or resin grout.

(d) Where rock bolts are required for permanent support, the bearing plate, the nut, and the ball and machine washer shall be coated by hot-dip

galvanizing and the mass of coating shall be not less than 0.6 kg/m^2. After installation, any defects in the coating shall be thoroughly repaired as directed by the Engineer.

(2) Materials

Material used for rock bolt and accessories shall be in accordance with the applicable provision of Clause S7.03.2

(3) Patterns of Installation

The required patterns in which the rock bolts shall be installed and the anticipated maximum lengths of rock bolts shall be subject to changes according to the rock condition uncovered during excavation. The Contractor shall submit for approval drawings showing details of rock bolt and its patterns, which he intends to use; to the Engineer before beginning bolting work.

(4) Methods of Installation and Testing

The method of installation and testing of rock bolts is specified in Clause S7.03.2

S7.03.2 ANCHOR BARS

(1) General

(a) (i) For the purposes of this Specification a anchor bar is an untensioned length of steel reinforcing bar which has been grouted into a drilled hole.

(ii) Anchor bars are separate and distinct from grouted anchor bars used for anchoring concrete structures to foundations.

(b) The Contractor shall furnish and install anchor bars in surface excavations where directed or approved. For the purposes of this Specification anchor bars are untensioned, structural grade, deformed bars with not more than 2 m embedded in grout unless otherwise specified by the Engineer, and used to fix the wire mesh to the rock. The anchorage length may be subject to modification according to the form of slope after excavation and to the geological conditions uncovered during excavation.

(2) Material

(a) Anchor bars shall be 16 mm nominal diameter, deformed bar complying with grade SD40 embedded in mortar grout for the full length of the bar.

(b) Mortar grout shall consist of fine sand, cement and water thoroughly mixed. Unless otherwise specified by the Engineer, the weight ratio of cement to sand shall be 1.0 and the slump about 80 mm.

(c) Cement for grouting shall comply with the relevant provisions in Section 8.

(3) Pattern of Installation

The location, length and direction of anchor bar installation shall be directed or approved by the Engineer.

(a) The bored holes for the anchor bars should be about 2 times the nominal diameter of the bar. The holes shall be drilled, cleaned with compressed air and/or water under pressure immediately prior to placing the anchor bars and completely filled with the mortar.

(b) The anchor bar shall be forced into the hole before the mortar takes its initial set and contact intimately with the mortar over its full length. The Contractor shall provide a means of ensuring the anchor bars do not move in anyway at least 24 hours.

(4) Anchor in Rock

(a) Requirement

The Contractor shall drill holes and furnish, install and grout anchor bars for anchoring concrete structures or parts of structures to the foundations where shown on the Drawings or directed.

(b) Materials

(i) Anchor bars shall comply with the relevant requirements for reinforcing bars

(ii) Anchor bars shall be provided with a centering device to ensure that they are fully encompassed in grout.

(b) Installation

(i) The dimensions of the anchor bars and the locations, diameters and depths of the drilled holes shall be as shown on the Drawings or as directed.

(ii) The diameter of each drilled hole shall not be less than 1.5 times the diameter or greater cross-sectional dimensions of the anchor specified for that hole.

(iii) The hole shall be cleaned thoroughly and shall be completely filled with grout. If the hole cannot be kept dry during the filling operation, the grout shall be introduced into the bottom of the hole by means of a pipe which shall subsequently be withdrawn.

(iv) The anchor shall be forced into place before the grout takes its initial set and, where practicable, shall be vibrated or rapped. Thereafter, the Contractor shall ensure that movement of the placed anchor does not occur, and concrete shall not be placed around anchors until 24 hours after the anchors have been grouted.

(v) Anchor bars may be connected to the reinforcement steel of the concrete structure to be anchored. The depth of holes indicated on the Drawings or directed by the Engineer shall be measured from the effective excavation surface. Longer bars shall be provided by the Contractor in case of over excavation, to maintain the required position in the concrete structure. The difference between theoretical and effective length needed shall be at Contractor's cost.

(d) Testing

The Contractor shall carry out load tests, in the presence of the Engineer, on anchor bars selected by the Engineer. The required frequency of testing will not exceed one test for every 200 anchor bars installed. The testing method and equipment shall be capable of stressing the largest diameter anchor bar to the yield stress of the bar.

S7.03.3 SHOTCRETE AND WIREMESH

The Contractor shall construct reinforced shotcrete to the excavated surfaces of surface excavations where shown on the Drawings or directed by the Engineer, If the Contractor intends to apply shotcrete, it will be subject to prior approved by the Engineer. By no means the Contractor shall use shotcrete at existing or directed by the Engineer.

(1) General

(a) Shotcrete shall to be applied to all work in connection with strengthening rock surfaces of both surface and underground works as shown on the Drawings and/or as directed by the Engineer.

(b) Shotcrete used for rock support shall comply with American Concrete Institute "Recommended Practice for Shotcreting" (ACI 506). Where shown in the Drawings or required by the Engineer, the shotcrete shall be reinforced by wiremesh.

(c) Where shotcrete support is required, the Contractor shall apply shotcrete to give the minimum thickness specified on the Drawings or as directed by the Engineer.

(2) Materials

(a) Constituent material for the Shotcrete shall comply with the material required as specified for their use in concrete (see Section 10)

(b) Fine and coarse aggregates shall comply with ASTM C33

(c) Admixture for shotcrete shall be develop quick setting and high early strength, not contain water-soluble chlorides or materials corrosive to steel and shall not cause other detrimental effects, such as cracking and spalling of applied shotcrete.

(d) The proportion of admixture shall normally not exceed 5% of the weight of cement. However, a higher propor may be accepted where rapid treatment of weak rock or wet area is needed.

(e) Where admixtures are employed, the typical dosage and the detrimental effects, if any, of underdosage and overdosage with particular regard to long term durability shall be established in advance.

(f) Water shall conform to the requirements specified for its use in concrete.

(g) Wiremesh shall be a single layer of welded steel wire fabric of mild steel, Grade 40, meeting the requirements of ASTM A497, TIS 926-2533 or equivalent, with 4.0 mm diameter wires at 150 mm centers or an alternative approved by the Engineer.

(3) Mixing

(a) The contractor shall design mix proportion for shotcreting which is usually base on a specified compressive strength as follow:

- 100 kg/cm^2 at 24 hours
- 190 kg/cm^2 at 7 days
- 270 kg/cm^2 at 28 days

(b) Proportioning by volume may be allowed in the case of mobile mixers, provided that regular checking of mix proportions is carried out and approval is obtained from the Engineer.

(c) For dry mixes aggregate and cement shall be thoroughly mixed in the surface dry state before being deposited in the placing Equipment.

(d) The proportion of cement, aggregates and admixture shall be determined by
pre-construction test. The proportions of cement and dry aggregates shall be between 1:3 and 1:5 by weight.

(e) The moisture content of the fine aggregate at the time of mixing shall be in the range of 3% to 6% by weight of the oven-dry (100 $^{\circ}$C) aggregate.

(f) The contractor shall provided the procedure and control for mix proportioning of specified materials in sufficient quantity to maintain continuous placement to the Engineer.

(g) Admixture, if approved, shall not be added until immediately prior to depositing materials in the placing Equipment or, if in liquid form, may be accurately proportion into the water supply at the application nozzle.

(h) The Water/cement ratio will be conditioned by the aggregate used, the method placing and the need for good adhesion, good embedment of reinforcement and sagging.

(i) The Contractor shall achieve a sprayed concrete consistent with all the requirement of the Specification.

(4) Personnel, Placing Equipment and Application

(a) At least thirty (30) days prior shotcrete works, the contractor shall submit to the Engineer his detailed equipment and personal as following information:

- Type, number and specified of mixing and placing equipment
- Number and name of nozzlemans.

(b) Placing Equipment shall incorporate methods of cheeking:

- Water pressure at offtake from supply line at face.
- Water volume used.
- Air pressure at machine inlet.
- Rate of feed of dry mix.
- Rate of feed of admixtures.

(c) The Equipment shall have positive settings on the various control devices so that quantities can be easily and accurately controlled by the nozzleman or machine operator.

(d) The air and water supply system shall be capable of supplying the delivery machine and hose at the pressures and volumes recommended by the manufacturer of the machine. No air supply system shall be used that delivers air contaminated by oil.

(e) The feed conveyor shall be of a screw type or as otherwise approved by the Engineer and so arranged that admixture and dry material can be fed to the delivery machine at a regular rate. Admixture shall be introduced from an approved dispenser in a regulated flow to the tail of the feed conveyor so that complete mixing with the dry material is achieved before discharge into the delivery machine.

(f) The delivery machine shall be capable of introducing dry materials to the delivery hose at a uniform rate with ejection from the nozzle at velocities that will allow adherence of material to the treated surface with a minimum rebound and maximum adherence density.

(g) Placing Equipment capable of introducing wet materials shall incorporate a suitable metering device for liquid admixture and adequate in situ density shall be proven by site trials. The Equipment shall be capable of producing maximum adherence of the sprayed concrete to the treated surface with a minimum of rebound.

(h) Placing Equipment shall be so arranged that the nozzleman may use air and water in any combination to prepare raw surfaces or to clean completed work.

(i) Before the commencement of spraying, loose rock fragments shall be removed. All rock surfaces or the surface of previously applied shotcrete shall be thoroughly cleaned and wetted immediately before spraying is carried out in order to ensure the required bond. The surface shall be damp but without free water prior to the application of sprayed concrete.

(j) The Contractor shall take whatever action is necessary to control groundwater an prevent it adversely affecting the shotcrete. Water inflows which might cause deterioration of the shotcrete, or prevent adherence, shall be diverted by channels chases, pipes or other approved means to a drainage system as approved or directed by the Engineer. Alternatively the Contractor may opt, with the approval of the Engineer, to apply shotcrete to the general area affected by water inflow, carrying out subsequent remedial water control as necessary. The area thus remedied shall that be treated with additional layers of sprayed concrete which shall provide adequate support to the approval of the Engineer.

(k) Mixed material shall be used within 60 minutes after the addition of cement otherwise the material shall be discarded, except that this time limit may be extended by the Engineer to 90 minutes if job conditions are such that satisfactory results can be attained.

(l) Should the mix be too dry or too wet or of uneven quality, the spraying shall be stopped and the unsatisfactory shotcrete shall be removed.

(m) The Contractor shall provided appropriate methods of fixing wiremesh to approval of the Engineer. Wiremesh reinforcement shall overlap by one mesh in each direction or 150 mm at least.

(n) Spraying shall be carried out with the nozzle at right angles to the rock surface and a distance of about one meter. Care shall be taken that the wire fabric is with embedded.

(o) The spraying shall be made 2 layers for excavated surfaces of underground structures, the first layer shall be applied for rock surface with half of thickness as shown on the Drawings. The second layer shall be sprayed after completely of wiremesh fixing. For excavated surface of open excavation, the spraying shall be done 1 layer as approved by the Engineer.

The thickness and alignment of the sprayed materials shall be controlled by screed boards, stainless steel or plastic pins, guide wires of non-corrosive material or other means approved by the Engineer.

(p) Unsatisfactory shotcrete including voids, sag, rebound pocket or not specified compressive strength shall be removed or re-sprayed to appoved by the Engineer.

(q) Construction joints shall be tapered to a thin edge at approximately 30° or cut back square to the reinforcement and then tapered at 30°. The entire joint shall be thoroughly cleaned and wetted prior to the placement of adjacent shotcrete.

(r) Rebound shall be removed during the spraying and shall not be re-used.

(s) After completion of the spraying, shotcrete in the open shall be kept moist during at lest 7 days. For the curing of shotcrete underground, no special measures are required.

(t) The Contractor may be directed by the Engineer to execute a systematic drilling of drainage holes after shotcreting

(5) Testing of Compressive Strength

The following minimum cylinder compressive strength requirements reference is made to Clause (3) “Mixing”. These compressive strength requirements refer to test cylinders with length of 100 mm to 200 mm and diameter of 100 mm or length/diameter ratio L/D between 1.0 and 2.0 may be used.

(a) Pre-construction Tests

Pre-construction tests shall be carried out by spraying panels; these tests

conform to the applicable parts of ACI 506, and be to the approval of the Engineer.The pre-construction tests shall commence in due time before the commencement of the shotcreting. The engineer may approve an early start of the shotcreting Contractor can prove that the 28 days compressive strength in accordance with above is met. In order to facilitate the Engineer's decision regarding the use of accelerator Contractor shall perform tests using at least two different percentages of each the acceleration admixtures proposed by the Contractor; the percentages determined with due consideration of the recommendations given by the manufacture. The compressive strength shall be determined at 24 hours, 7 days and 28 days in such tests and, as a control measure, each series of specimen always contain an adequate number of samples without admixture.

The Engineer may, in the event of repeated failures quality control to adjust the mix to achieve the required strength and properties.

(b) Works Tests

The quality control of strength shall be carried cut by means of coring in the direction of spraying from test panels and from completed works. One series of four 100 mm diameter cores shall be extracted per 20 m^3 of applied of applied shotcrete in the early stages of execution of shotcreting work. The Engineer may approve less frequent testing, provide that test results are consistently satisfactory.

Three cylinders shall be tested for strength after 24 hours, 7 days and 28 days respectively and the this one shall be kept as spare. Notwithstanding the possible use of accelerating admixture, at least 95% of the cylinders shall meet the specified strength requirements. No single cylinder, however, shall have a strength of less than 80% of the specified strength

The Engineer may direct testing cylinders that coring from working faces if unsatisfactory of test result from panels.

(6) Weep Holes and Drain Holes

(a) Where water seepage could cause hydrostatic pressure between the rock and the shotcrete layer, the contractor shall drill drainage holes with a minimum diameter of 50 mm penetrating not less than 300 mm into the rock

(b) The pattern of these weep holes shall be approved by the Engineer.

(c) The perforated PVC pipe shall be embedded in the rock. The perforated PVC pipe installed in highly weathered rocks, or directed by the Engineer shall be wrapped with geotextile and plugged the end of pipe with the PVC cover as approved by the Engineer.

S7.04 MEASUREMENT AND PAYMENT

(1) Placed and grouted Riprap

(a) Measurement, for payment, for placed and grouted riprap will be of the volume in place to lines, grades and elevations shown on the Drawing or directed by the Engineer.

(b) Payment, for placed and grouted riprap will be made at the rate per cubic meter bid therefor in the Schedule, which shall include the cost of excavation, grading, trimming, and transporting, storing, placing and other incidentals to complete the works.

(2) Bedding

(a) Measurement, for payment, for bedding will be of the volume in place to the lines and grades as shown on the Drawings or directed by the Engineer.

(b) Payment, for bedding will be made at the rate per cubic meter bid therefor in the Schedule, which shall include the cost of excavating, crushing, screening, grading, transporting, placing and where necessary compacting.

(3) Stone Masonry

(a) Measurement, for payment, for stone masonry will be of the volume of material placed to the lines and grades as shown on the Drawings or directed by the Engineer.

(b) Payment, for stone masonry will be made at the rate per cubic meter bid therefor in the Schedule, which shall include of material, mortar, transporting, grading, placing and finishing of the stone masonry.

(4) Gabions and Mattresses

(a) Measurement, for payment, for gabions and mattresses will be of the set of gabions and mattresses actually placed to the lines, grades and elevations shown on the Drawings or directed by the Engineer. One set of gabion and mattresses shall be of the following dimension:

(i) Width (m) x Length (m) x Height (m)

(b) Payment, for gabions and mattresses will be made at the rate per set bid therefor in the Schedule, which shall include the cost of material (rock and gabion or mattress), excavation, grading, transporting, placing and finishing, and other the manufacturer’s instructions of the gabions and mattresses.

(5) Geotextile

(a) Measurement, for payment, of geotextile will be of the area actually placed at the rate per square meter bid therefor in the Schedules. No extra payment will be made for the overlapping.

(b) Payment, for geotextile will be made at the rate per square meter bid therefor in the Schedule, which shall include the cost of material, transporting, installing, overlap and other incidental to complete the works.

(6) Sodding on Topsoil

(a) The quantity measured for payment shall be sodding measured as the number of square meters of planted surface (whether horizontal or sloping) measured on the slope, of required and accepted grassing well established in place. Fertilizer will not be measured. In the case of sodding planted surface shall mean the whole area including that initially uncovered between the strips.

(b) Payment for sodding will be made at the rate per square meter bid therefor in the Schedule, complete and accepted in place, which shall include all materials, handling, storage, site preparation, placing, maintenance, equipment, tools, labor, incidentals and satisfactory disposal of all unsuitable or surplus materials.

(7) Rock bolts

(a) Measurement, for payment, of furnishing and installing rock bolts will be based on the length of the bolt installed as directed or approved by the Engineer. For bearing steel plates for rock blots will be made of the mass of steel installed as directed or approved by the Engineer.

(b) Payment for furnishing and installing grouted rock bolts will be made at the applicable rate per linear meter bid therefor in the Schedules, and bearing steel plates for rock bolts will be made at the rate per kilogram bid therefore in the Schedule.

(c) Separate payment will not be made for furnishing rock bolts for testing, for performing control tests or for drilling holes for the rock bolts. All such costs shall be deemed to be included in the rates bid in the Schedules for furnishing and installing grouted rock bolts.

(8) Anchor Bars

(a) Measurement, for payment, for anchor bars will be made of the length of hole drilled into rock as the directed and approved by the Engineer.

(b) Payment for anchor bars will be made at the rate per linear meter bid therefor in the Schedule. This rate shall include the cost of furnishing cement and aggregate for the grout, drill holes, and deformed bar.

(9) Shotcrete

(a) Measurement, for payment, of construction shotcrete to the excavated surface will be made of the area of shotcrete.

(b) Payment for shotcrete will be made at the rate per square meter bid therefore in the Schedule.

(10) Wiremesh

(a) Measurement, for payment, of steel mesh will be made of the mass of all steel mesh installed at the direction of the Engineer and shall include the cost of all surface anchors required for fastening the mesh.

(b) Payment for furnishing and installing steel mesh will be made at the rate per kilogram bid therefore in the Schedule. This rate shall include the cost of material, transporting, installing overlap and other incidentals to complete the works.

(11) Weep Hole and Drain Hole

(a) Measurement, for payment, of weep holes and drain holes will be made of the length of hole drilled into rock as directed by the Engineer.

(b) Payment for weep holes and drain holes will be made of the rate per linear meter bid therefor in the Schedule. This rate shall include the cost of material, installing and drill hole.

SECTION 8 - CONCRETE PRODUCTION

SECTION 8 - CONCRETE PRODUCTION

S8.01 CONTRACTOR'S PLANT, EQUIPMENT AND CONSTRUCTION FACILITIES

(1) General

The Contractor may manufacture concrete at the Site or obtain ready-mixed concrete.

(2) Concrete Manufactured at Site

(a) For manufacture of concrete at the Site the Contractor shall, not less than sixty (60) days before installing his plant and equipment, submit flow charts, drawings, and written descriptions of his proposals for the production of aggregates and the production and placing of concrete, mortar and shotcrete in the Works to the Engineer.

(b) All aggregate shall be produced using plant capable of supplying aggregate at a rate which is adequate to meet the requirements for the progress of the Works.

(c) The Contractor shall install, maintain and operate a communications system linking the points of placing concrete with the concrete batching and mixing plant, and such shall be available to the Engineer at all times.

(3) Ready-mixed Concrete

For ready-mixed concrete the Contractor shall, not less than thirty (30) days before placing any concrete, nominate the plant from which he proposes to obtain concrete and submit details of the equipment he proposes to use for transporting and placing concrete and mortar.

(4) Transporting and Handling Equipment

The use of transporting and handling equipment including buckets, chutes, hoppers, agitator trucks or pumps which cannot readily handle and place concrete of the slumps specified will not be permitted.

(5) Alternative Type of Equipment

Where this Specification requires specific types of equipment to be used or specific procedures to be followed, such requirements are not to be construed as prohibiting use by the Contractor of alternative types of equipment or procedures if it can be demonstrated that equal results will be obtained by the use of such alternatives.

S8.02 READY-MIXED CONCRETE

Ready-mixed concrete shall be produced in accordance with ASTM C94, TIS. 213-2520 and the requirements of this specification.

S8.03 COMPOSITION

(1) General

Concrete shall be composed of Portland cement, fine aggregate, coarse aggregate, water and admixtures as specified, all well mixed and brought to the proper consistency. All concrete and its constituent materials and all methods and procedures shall conform to applicable Standards of the American Society for the Testing of Materials unless otherwise specified.

(2) Maximum Size Aggregate

Unless otherwise shown on the Drawings or approved, the nominal maximum size aggregate used in concrete shall be as follows:

(a) 75 mm - for concrete in walls, slabs and sections more than 400 mm in thickness but not within 1 m from exposed surfaces.

(b) 38 mm - for concrete in walls, slabs and sections less than 400 mm in thickness.

(c) 20 mm - for heavily reinforced sections, precast concrete units and walls less than 250 mm thickness.

(3) Responsibility for Mix Design

(a) Contractor has full responsibility for the selection of the proportions of the concrete mix in order to meet the minimum 28-day compressive strength specified herein and all other concrete properties specified in this Section. Contractor shall prepare a separate mix design in accordance with ACI 211.1 for each concrete mix to be used in the work, and shall verify adequacy of each mix design by laboratory testing in accordance with Subsection 4.2.3 of ACI 301-96. No concrete shall be used on the work unless the Engineer has approved in writing the mix design for that class of concrete and maximum size aggregate.

(b) At least sixty (60) days before placing any concrete in the Works the Contractor shall submit to the Engineer details of proposed mixes for the various classes of concrete specified.

(c) The Contractor shall prepare, in the Engineer's presence, trial mixes of the proposed mixes and carry out tests in accordance with the provisions of this Specification to verify their compliance with the Specification.

(d) The class of concrete, minimum cement content and maximum water cement ratio applicable to the concrete in various structures shall be as specified in the following table:

TABLE 8.1 STANDARD CLASSES OF CONCRETE

Class of Concrete	Maximum Water-cement Ratio	Minimum Cement Content per Unit Volume of Concrete(kg/m^3)	Characteristic Strength (kg/cm^2) at 28 Days	
			Cylinder	Cube
A	0.75	200	140	180
B	0.65	280	175	210
C	0.55	300	210	240
D	0.50	350	300	350
E	0.40	420	350	400

* The minimum cement content shown in this table is the minimum amount necessary for durability requirements. No increase in the rates or prices for concrete of the various classes will be permitted on account of higher cement content required to satisfy other properties of concrete specified in the Section.

(e) The various classes of concrete shall be placed in the location specified below and elsewhere as directed.

TABLE 8.2 CLASS OF CONCRETE

Class of Concrete	Location
A	Finishing in surface drain and lean concrete
B	1. Backfill concrete, mass concrete and gravity wall 2. Office and building 3. Other reinforced concrete (small structure)
C	1. Concrete for slab in bridge 2. Water Conveyance Pipe, Control House 3. Box Culvert Diversion and Pipeline Works 4. Spillway, River Outlet and Intake Tower 5. Secondary Stage Concrete
D	Not applicable
E	Prestress concrete

(4) Required Properties of Concrete

(a) Concrete shall be liable to rejection if:

(i) The air content is not within the ranges specified in Clause S8.04 (2) (b)

(ii) After the concrete has been discharged at the placing point and before it has been consolidated, the slump exceeds 80 mm. The Engineer may direct the use of a lesser slump whenever concrete of such lesser slump can be consolidated into place by means of the vibration specified.

(b) Hardened concrete shall be liable to rejection if:

(i) The characteristic strength of the concrete for the particular class does not comply with Table 8.1.

(ii) The density of the concrete is less than 2,400 kg/m^3.

(iii) The chloride ion content of the concrete is not in compliance with ACI 318M.

(5) Regulation of Water Content

(a) During batching, the Contractor shall periodically measure the moisture content of the fine aggregate held in the batch bins.

(b) (i) The amount of water used in the concrete shall be regulated to adjust for any variation of the moisture content or grading of the aggregates as they enter the mixer.

(ii) Addition of water to overcome stiffening of the concrete before placing will not be permitted.

(iii) Concrete shall have uniform consistency from batch to batch.

(c) Aggregate shall not be batched for concrete or mortar when free water is dripping from the aggregate.

S8.04 MATERIALS

(1) Cement

(a) Type of Cement

Cement for concrete, mortar and shotcrete shall conform to ASTM C150. Type I cement or TIS 15-2532 of the latest edition. For surfaces exposed to public view, where color of the finished concrete is important, all cement shall be of the same type and color and from the one plant. Cement used in pressure and rockbolt grouting shall conform to ASTM C150. One hundred (100) percent of the cement shall pass a 0.150 mm sieve and not less than 98 percent shall pass a 0.075 mm sieve. The Engineer may direct the use of low heat cement complying with ASTM C150 for certain sections of the Works.

(b) Testing Cement

Cement shall be tested in accordance with the provisions of this Specification.

(c) Maximum Storage Period

Cement that has not been used within three (3) months from the date of initial sampling shall not be used in the Works unless it has been retested and is shown to conform to the specified requirements.

(d) Cement Containers

The Contractor may deliver cement to the Works in bulk or bags, except that cement for pressure and rockbolt grouting shall be delivered in bags.

(e) Delivery of Bulk Cement

Where cement is supplied in bulk containers, the following requirements shall apply:

(i) All containers shall be completely weatherproof and maintained in good order and condition.

(ii) All apertures in the containers shall be fitted with completely watertight closures and shall be sealed after filling.

(iii) All containers shall be filled as completely as possible.

(iv) All containers shall be completely cleaned out at each transfer or delivery point after each and every use and before being returned for refilling.

(v) Each and every container dispatched from the manufacturer's works or any intermediate transfer point shall be accompanied by a delivery docket signed by a responsible person which shall clearly show the brand and type of cement, identification number or numbers relating to the testing and certification of the cement, the date of filling the container and the net mass of the cement in the container. This docket shall be carried in a suitable fashion inside the sealed container and shall be handed over to the Engineer at any subsequent transfer or delivery point.

(vi) Cement supplied in bulk shall not be re-bagged for use in the Works.

(f) Delivery of Bagged Cement

Where cement is supplied in bags the following requirements shall apply:

(i) Cement shall be delivered in sound undamaged bags uncontaminated by moisture, oil or any other substance.

(ii) Individual bags which vary by more than 5 percent from the nominal mass shall be rejected. Where the average mass of 50 bags taken at random from any one consignment is less than the nominal mass, the whole consignment shall be rejected.

(iii) Every bag shall be marked with the manufacturer's brand, the type of cement, identification number or numbers relating to the testing and certification of the cement, and the date the bag was filled.

(iv) The contents of broken or damaged bags shall not be rebagged.

(g) Storage and Handling of Cement

The following requirements shall apply to the storage and handling of cement at site or at any intermediate transfer or storage point:

(i) All methods for transporting, handling and storing bulk and bagged cement shall be designed, constructed and arranged so as to ensure the use or transfer of cement in the approximate chronological order of manufacture.

(ii) All storage bins and cement handling equipment shall be completely weatherproof and substantially dust-free to the satisfaction of the Engineer and shall be designed and constructed so as to ensure that there will be no dead storage of cement.

(iii) The Contractor shall not set up cement handling facilities where cement dust may come in contact with electrical and mechanical equipment stored in the vicinity and to which cement dust will be deleterious.

(iv) All loading and unloading facilities for cement shall be under cover and weatherproof.

(v) Where cement is handled by pneumatic means which involve contact of compressed air with the cement, the temperature of air in contact with the cement shall not at any time exceed 38ºC. Where necessary, after-coolers or other means shall be provided to cool the compressed air. All compressed air supplies where the air may come in contact with the cement shall be fitted with filters for the removal of moisture, oil or any other contaminating substances. Such filters shall be regularly inspected and maintained by the Contractor.

(vi) All bagged cement shall be stored at all times, up to its use in the Works, in completely weatherproof structures, which shall include a raised floor and be adequately ventilated to prevent the accumulation of moisture.

(vii) All storage of bagged cement shall be arranged so as to permit easy access for inspection and definite identification of all cement in the storage.

(h) Cement Used in Ready-mixed Concrete

If ready-mixed concrete is used, the Contractor shall ensure that the supplier continuously maintains a record of the use of cement so related to the test certificates as to permit the immediate identification of cement in use at any time.

(i) Temperature of Cement

The temperature of the cement as delivered to the Site shall not exceed 60ºC.

(j) Rejection

Cement not conforming to the requirements of this Specification shall not be used in the Works.

(2) Admixtures

(a) General

Only approved admixtures shall be used in the concrete, shotcrete or mortar for the Works. When more than one admixture is to be used, each admixture shall be batched in its own batcher and added to the mixing water separately before discharge into the mixer. Admixtures shall be delivered in suitably labeled containers to enable identification. All admixtures shall be prevented from segregating before batching.

(b) Air-entraining Agent

(i) Where specified or when directed, the Contractor shall use an air-entraining agent. The Contractor shall demonstrate, to the satisfaction of the Engineer, it's the air-entraining agents compliance with ASTM C260, when tested with the cement, aggregates and admixtures used in the Works.

(ii) The amount of air-entraining agent used in each concrete mix shall be such as will effect the entrainment of the percentage of air specified in the concrete at the point of delivery shall not exceed the values in the following table:

Coarse Aggregate (Maximum size)	Total Air Content (% of volume by concrete)
75 mm	4.0 ±1
38 mm	5.0 ±1
20 mm	6.0 ±1

(iii) The air-entraining agent shall be supplied and batched as a solution with a solids content not exceeding 15 percent by mass.

(c) Expanding Agent

(i) The Contractor may be directed to use an expanding agent in a small amount of the second stage concrete and mortar used in the Works.

(ii) The expanding agent shall consist of an approved aluminum powder or other approved material.

(iii) To facilitate batching, the expanding agent shall be prevented with a portion of the cement in the proportions of one part of powder to 50 parts of cement before adding the mix.

(iv) The amount of expanding agent used in the concrete or mortar shall be as approved by the Engineer.

(d) Water-reducing, Set-retarding Agent

(i) The Contractor may use a water-reducing set-retarding admixture conforming to ASTM C494. The use of such an admixture will not

be permitted to overcome problems associated with inadequate concrete plant capacity or improperly planned placing operations and shall only be used as an aid to overcoming unusual circumstances and placing conditions.

(ii) The specified limits in respect of maximum slump, slump loss during transit and the time allowed for concrete to remain in the mixer may be changed by the Engineer when a water-reducing, set-retarding agent is used.

(3) Water

The mixing water used in concrete, grout, and mortar, shall be subject to approval and shall be free from objectionable quantities of suspended material, organic matter, acid, alkali, salts and other impurities deleterious to the concrete. In addition, water shall not contain more than 650 parts per million (ppm) of chlorides or more than 1,000 pmm of sulfates.

(4) Find and Coarse Aggregates

(a) General

(i) Fine and coarse aggregates shall conform to ASTM C33 except as modified herein.

(ii) Fine aggregate in which the maximum size of particles is 5 mm for concrete, mortar and grout shall be furnished by the Contractor and shall be natural sand, manufactured sand or a blend of natural and manufactured sands. For coarse aggregate in which the minimum nominal size is 5 mm and which is reasonably well graded from 5 mm to the largest size required in concrete work shall be furnished by the Contractor and shall consist of natural gravel, a mixture of natural and crushed oversize gravel or manufactured aggregate.

(iii) At least sixty (60) days before placing any concrete the Contractor shall submit to the Engineer test results from representative samples of the proposed aggregates.

(b) Tests

Aggregate shall be tested in accordance with the provisions of this Specification.

(c) Deleterious Substances

(i) Aggregates shall consist of hard, dense, durable, uncoated rock particles and shall be free from organic matter and the amounts of dust, clay lumps, soft or flaky particles, shale, alkali, loam and other substances considered deleterious by the Engineer shall not exceed the values in the following table:

MAXIMUM AMOUNTS OF DELETERIOUS SUBSTANCES

Item	Maximum Percentage by Mass	
	Fine Aggregate	Coarse Aggregate
Material passing 0.075 mm sieve	2.0	0.5
Lightweight material	2.0	2.0
Organic matter	Zero	Zero
Clay lumps	1.0	0.5
Other deleterious substances	2.0	1.0

(ii) The sum of the percentages of all deleterious substances in aggregates as delivered to the mixer shall not exceed 3 percent for fine aggregate and 2 percent for coarse aggregate.

(iii) Aggregate shall be non-reactive to alkalis in Portland cement, when tested in accordance with ASTM C277 or C1260. Aggregates that test reactive, is will be considered deleterious, and will be rejected.

(d) Particle Shape

The aggregates shall consist substantially of particles of satisfactory shape. A particle of satisfactory shape is defined as a particle having a maximum dimension not greater than three (3) times the minimum dimension.

(e) Grading of Fine Aggregate

(i) The fine aggregate as batched shall be well graded and when tested shall conform to the limits specified.

(ii) The grading of the fine aggregate shall be so controlled that at any time the fineness modulus of at least nine (9) out of ten (10) consecutive test samples of finished fine aggregate will not vary more than 0.20 from the average fineness modulus of the ten (10) test samples.

(iii) Where fine aggregates from different sources are being used at the one batching plant at the same time, they shall be so blended to ensure uniform grading and color in successive batches.

GRADING OF FINE AGGREGATE

Sieve size (mm)	Percentage of total mass Passing sieve
9.50	100
4.75	95 to 100
2.46	80 to 100
1.18	50 to 85
0.60	25 to 60
0.30	10 to 30
0.15	2 to 10
Pan	2 to 5

(f) Grading of Coarse Aggregate

(i) The coarse aggregate as batched shall be separated into nominal sizes and shall be well graded such that when tested by the sieves designated in the following table the minimum amounts of intermediate sizes are:

NOMINAL SIZE RANGES OF COARSE AGGREGATE

Designation of size (mm)	Nominal size range (mm)	Minimum percentage retained on sieve indicated
9.5	4.75 to 9.5	Not applicable
19.0	9.5 to 19.0	25 on 16.0 mm
38.0	19.0 to 38.0	25 to 31.8 mm
75.0	37.5 to 75.0	25 to 63.0 mm

(ii) Separation of the coarse aggregate into the specified sizes shall be such that when the aggregate, as batched, is tested by the sieve designated in the following tabulation, the materials passing the undersize test sieve shall not exceed 2 percent by mass, and all materials shall pass the oversize test sieve.

Designation of	Size of Square Opening in Sieve

	For undersize test	For oversize test
9.5	4.0	11.2
19.0	8.0	22.4
38	16.0	45.0
75.0	31.5	90.0

(g) Other Properties

Aggregate which does not comply with the following may be rejected.

Aggregate Properties	Fine Aggregate	Coarse Aggregate
Minimum specific gravity	2.56	2.56
Maximum weighted loss of a portion retained on an 0.300 mm sieve when subject to 5 cycles of sodium sulphate test	8% by mass	10% by mass
Maximum loss in Los Angeles abrasion test	N/A	40%
Maximum sum of flakiness and elongation indices	N/A	60%
Minimum fineness modulus	2.10	N/A
Natural sand	3.10	N/A
Manufactured sand	2.80	N/A

* For a mixture of natural sand and manufactured fine aggregate the maximum fineness modulus shall have a value between 3.10 and 2.80 in proportion to the constituent materials.

(5) Production of Coarse and Fine Aggregate

(a) Source

(i) Only aggregates from approved sources shall be used in the Works.

(ii) Should the Contractor elect to process aggregates from alluvial deposits, the material shall be removed in an approved manner, and the areas cleaned up or restored all in accordance with the provisions of this Specification.

(iii) Approval of the Contractor's use of any deposits shall not be construed as constituting approval of all materials taken from the deposit, and the Contractor will be held responsible for the specified quality of all such materials used in the Works.

(b) Clearing

(i) Before excavating materials for the production of concrete aggregate, the Contractor shall clear trees, roots, brush, sods, clay, unsuitable sand and gravel, weathered and unsound rock and other objectionable matter from all of those portions of the surface deposits from which aggregates are to be produced.

(ii) The areas from which aggregates are to be obtained shall be located and operated so as not to detract from the usefulness of the deposits or any other property and so as to preserve, insofar as is practicable, the future usefulness or value of the deposits. Materials, including stripping, removed from the deposits and not used in carrying out the Works shall be disposed of as specified.

(c) Processing

(i) Processing of the raw materials may include crushing, screening and washing, milling and blending, to produce fine and coarse aggregates meeting the requirements of this Specification.

(ii) Water used for washing aggregate shall comply with the provisions of this Specification.

(iii) After washing, fine aggregate shall be stored in stockpiles with a free draining base for at least 72 hours and shall be subsequently handled to ensure that sand delivered to the batching plant has uniform and stable moisture content.

(iv) Where the surface of stockpiles from which fine aggregate is being delivered directly to the batching plant is substantially drier or wetter than the bulk of fine aggregate in the pile, handling shall be such as to exclude this surface material from the batching plant.

S8.05 BATCHING AND MIXING

(1) Plant

(a) If the Contractor installs at the Site a plant for batching concrete ingredients, it shall be constructed and operated in accordance with ASTM C94 with the following modifications.

(b) The plant shall be an efficient and dependable, automatically or semi-automatically controlled batching plant capable of supplying concrete at a rate adequate to meet the requirements of the Contract.

(2) Measuring and Tolerances

(a) Cement shall be weighed separately on an individual scale. Water shall be weighed separately on an individual scale or may be measured by volume. All other ingredients shall be measured by mass except that liquid admixtures may be measured by mass or volume. If water is measured by volume, two (2) flowmeters shall be installed in parallel so that no delay shall result from faulty operation of the meters.

(b) The equipment shall be capable of controlling the delivery of each size of aggregate to the mixer within the tolerances specified in ASTM C94.

(3) Calibration

(a) The construction and accuracy of the weighing and measuring equipment will be such that the equipment will maintain accuracy within 0.4 percent of the scale capacity. The equipment will be capable of ready adjustment for compensating for the varying weight of any moisture contained in the aggregates and for effecting changes in concrete mix proportions. Batching equipment shall be maintained and operated so that the combined inaccuracies in feeding and measuring the materials will not exceed 1 percent for water or air-entraining agent and 3 percent for cement and each size of aggregate.

(b) The Contractor shall provide standard certified test weights and any other auxiliary equipment required for checking the accuracy of each measuring device.

(c) The Contractor shall calibrate each measuring device in the presence of the Engineer when and as directed. Such tests shall be made at least once every month in the case of equipment for measuring aggregates and at least once every two weeks in the case of equipment for measuring cement, water and admixtures.

(d) The Contractor shall furnish copies of the complete results of all calibrations to the Engineer and shall adjust, repair or replace any measuring device which does not meet the requirements for accuracy.

(4) Batching and Weighing Equipment

(a) The batching equipment shall be capable of handling a minimum of two (2) different sets of mix proportions without the necessity of resetting the scales manually and shall be capable of recording the batches of each mix separately.

(b) Materials shall be weighed individually and each weighing device shall be equipped with a visible springless dial which shall register the scale load at any stage of the weighing operation.

(c) The Contractor shall provide all necessary facilities for obtaining representative samples of aggregates and cement from the discharge

streams between the bins and weigh-hoppers or between weigh-hoppers and the mixers.

(d) All gates and closing devices shall be positive in action and shall prevent leakage of materials when in the closed position.

(e) Batching equipment shall be interlocked so that:

(i) A new weighing cycle cannot be started until all weigh-hoppers are completely emptied and the discharge gates closed.

(ii) The discharge-gates of the weigh-hoppers cannot be opened until the correct masses of materials are in and the scales in balance.

(iii) The discharge-gates cannot be closed until all materials are entirely discharged and the scales are back in balance.

(iv) The discharge-valve of the water-measuring device cannot be opened until the filling-valve is closed.

(v) Accidental overbatching of admixtures is prevented.

(f) The batch bins will be constructed so as to be self-cleaning during draw-down and the bins shall be drawn down until they are practically empty at least three times per week. Materials shall be deposited in the batch bins directly over the discharge gates. The coarse aggregate shall be deposited in the batch bins through effective rock ladders when the distance through which the aggregate would fall is greater than 1.0 m. Equipment for conveying batched materials from the batchers or hoppers to and into the mixer shall be so constructed, maintained and operated that there will be no spillage or contamination of the batched materials or overlap of batches. Equipment that fails to conform to this requirement shall be effectively repaired, modified or replaced to the satisfaction of the Engineer.

(g) When cement and aggregates are hauled from a central batching plant to the mixer, the cement for each batch shall be placed in an individual covered watertight compartment which, during transit, will prevent the cement from intermingling with the aggregates and will prevent loss or contamination of cement. Aggregates shall be covered to prevent changes in moisture content during transit. Each batch compartment shall be of sufficient capacity to prevent loss in transit and to prevent spilling and intermingling of batches as compartments are being emptied. Surface haulage of batched aggregates from a central batching plant to mixers will not be permitted, if when so hauled the changes in moisture content of the fine aggregate between batching plant and mixer exceeds 1%.

(5) Records

The batching equipment shall include an accurate recorder for making a continuous, visible record, combined on a single chart, of the measurement of each separate concrete ingredient, including all mixing water and admixtures. The recording equipment shall include facilities for automatically registering on the chart the time of day at intervals of not more than 15 minutes. All graphic records shall be furnished to the Engineer at the completion of each day's production. The records shall become the property of the Employer.

(6) Mixer

(a) The concrete ingredients shall be mixed thoroughly in batch-mixers which are so designed as to ensure uniform distribution of all of the component materials throughout the mass at the end of the mixing period.

(b) The Contractor shall not use any mixer which:

(i) From three (3) tests of any batch of concrete, a range in slump exceeding 25 mm or a range in air content exceeding 1 percent is given between representative samples taken at different portions of the mixer discharge.

(ii) For any batch of concrete, the difference between unit masses of air-free mortar in samples taken from the first and last portions of the batch as discharged from the mixer exceeds 1.6 percent of the mean value.

(iii) For any batch of concrete, the difference between the unit masses of coarse aggregate from samples from the first and last portions of the batch as discharged from the mixer exceeds 10 percent of the mean value.

(7) Testing

The approved laboratory shall test mixers to ensure compliance and the Contractor shall submit the results to the Engineer. Every mixer shall be tested not more than thirty (30) days before being used to manufacture of concrete required under this Specification. Additional tests during the progress of the work shall be carried out when directed by the Engineer.

(8) Truck-mounted Mixer and Agitation Units

Truck-mounted mixer and agitator units and the mixing and transporting of concrete in such units shall be in accordance with the requirements of BS 4251 or ASTM C94.

(9) Mixing Time

(a) The mixing of each batch shall continue for not less than the time recommended by the batch plant manufacturer.

(b) The minimum mixing periods recommended by the batch plant manufacturer are conditional on the materials being fed into the mixer in a manner which will facilitate efficient mixing and on operation of the mixer at its designed speed.

(10) Charging Sequence

(a) The Engineer reserves the right to vary the mixing time or to limit the batch size when the charging and mixing operations fail to produce a batch of concrete that conforms to the foregoing requirements with respect to adequacy of mixing.

(b) Water shall be added before, during and following the mixer-charging operations. Excessive over-mixing, requiring addition of water to preserve the required concrete consistency, will not be permitted.

(11) Discharging Period

Concrete shall be completely discharged into the forms from the mixers or agitator drums within 60 minutes after the mixing water has been added to the dry ingredients. If the air temperature is below 85° F or during weather not conducive to quick stiffening of concrete, this period may, if approved by the Engineer, be extended, but in no case shall the time limit exceed 90 minutes. Any concrete which requires additional water to be added to permit satisfactory discharge or placing will not be accepted regardless of the time which has elapsed since the mixing water has been added. Such rejected concrete shall be removed from the Works with the least possible delay.

(12) Delivery Docket

At the point of delivery or placing, the Contractor shall furnish the Engineer with a delivery docket stating the batch number, the time of batching, class of concrete and volume of concrete delivered.

S8.06 TEMPERATURE OF CONCRETE

(1) Placing Temperature

(a) The temperature of all concrete when it is being placed shall not exceed:

(i) 30ºC for structural concrete

(ii) 20ºC for mass concrete.

(b) The temperature of all concrete when it is being placed shall not fall below 7° C:

(2) Cooling Concrete

The Contractor shall, where necessary, employ effective means such as precooling the aggregates, refrigerating the mixing water, adding chipped or flaked ice to the mixing water, placing at night or a combination of these or other methods to ensure that the concrete does not exceed the temperatures specified.

(3) Heating Concrete

Whenever it is necessary to maintain the temperature of the concrete above the temperatures specified as it is placed, the Contractor shall heat concrete ingredients to a temperature not higher than that necessary to keep the temperature of the mixed concrete from falling below the specified temperature. In no case shall any ingredient be heated to a temperature higher than 60ºC. Methods of heating concrete ingredients shall be subject to approval.

(4) Cooling Hardened Concrete

In addition to the requirements of this Clause the Contractor will be required to control the temperature of mass concrete after placing.

(5) Temperature Differential

(a) In order to limit thermal cracking of massive reinforced placements, the internal temperature differential shall not exceed 20ºC, that is, the temperature of the hottest and coolest points in the concrete mass shall not differ by more than 20ºC. For the purposes of this Clause massive placements shall mean any concrete placements whose least dimensions are 0.5 m or greater.

(b) Not less than six weeks before the start of construction of any massive placement, the Contractor shall submit to the Employer's Representative for approval, his proposals for keeping the temperature differential within the allowable limits. These proposals may include:

(i) alteration to mix design, to keep the cement content to a minimum, consistent with other requirements of the Specification;
(ii) the use of cement having low heat of hydration;

(iii) reduction in the temperature at placement of the concrete by pre-cooling the aggregates and/or mixing water, or the concrete mix itself;

(iv) casting the unit in sections, the size, relative positions and time interval between which will ensure adequate surface area for cooling;

(v) the incorporation of special cooling arrangements, such as water circulation, by which the temperature of the mass may be controlled;

(vi) avoiding concreting in hot weather;

(vii) concreting at night;

(viii) a system of thermal curing which may included, but is not limited to: leaving formwork in place; pounding of water; placing sand and polythene sheets; sot board; qualiting; and testing.

(c) The Contractor shall monitor the internal temperature differential by an approved method from the time of placement until the temperature of the warmest point in the concrete mass is within 20ºC of the ambient air temperature. The time interval between sequential temperature readings shall not exceed two hours during the period before the concrete reaches its maximum temperature, and shall not exceed four hours thereafter. The temperature shall be monitored at least at the points in each pour as specified below, and at any additional points required by the Engineer.

(i) 25 mm from the most exposed face of the placement

(ii) mid-depth of the placement

(iii) 25 mm from excavated rock surfaces where concrete is placed against rock.

(iv) Each temperature measuring point shall be located in a position approved by the Engineer.

(d) The Contractor shall record all data pertaining to the temperature of the concrete and the operation of any cooling system. The following data shall be recorded, where applicable:

(i) Daily record of maximum and minimum ambient air temperature.

(ii) Location and date of concrete lifts placed and cooling procedures carried out.

(iii) Concrete placing temperature. The concrete placing temperature shall be taken as the temperature of the concrete when delivered to the point of placement.

(iv) Where artificial cooling by water circulation is used:

- A daily record of cooling water temperature at entry to and exit from the concrete.

- The date of disconnection of cooling coils from any lift, and any subsequent re-connection.
- A daily record of concrete temperature for eight (8) days after placing any lift, then at two (2) days intervals up to fourteen (14) days and thereafter at weekly intervals for a period of three months.

(e) All data pertaining to the temperature of the concrete and the operation of any cooling system shall be made available to the Engineer within 24 hours of temperature readings being taken.

S8.07 SAMPLING AND TESTING

(1) Testing Facilities

(a) The Contractor may nominate, for approval, an independent registered laboratory that he proposes to use for testing concrete materials and concrete in accordance with this Specification. Such laboratory shall in no way be associated with the Contractor or supplier or a subsidiary of the Contractor or supplier.

(b) At all batch and mixing plants the Contractor shall provide and maintain a lock-up, weatherproof, dustproof, soundproof room for use by the Engineer. The room shall have a minimum area of 7 m^2 with a 2.8 m high ceiling and shall be located immediately adjacent to and on the same level as the operations console of the plant. Each room shall be furnished with a bench 3 m long by 60 cm wide, fitted with a sink connected to drainage with a water supply over and electricity power points and fluorescent lights. The design layout and location of each room shall be submitted, for approval, and all costs associated with the provision of these rooms shall be included in the rates for concrete.

(2) Standards

(a) Unless otherwise specified, sampling and testing of concrete materials, plastic concrete and hardened concrete shall be in accordance with the testing methods and recommended practices of the American Society for Testing and Materials, hereinafter referred to as the ASTM.

(b) Tests on materials for concrete, plastic concrete and hardened concrete shall include, but not necessarily be restricted to, those listed in the following tables.

STANDARDS FOR TESTING CONCRETE

Test	Designation No.
Sampling	ASTM C172

Compressive strength	ASTM C39
Slump	ASTM C143
Air Content	ASTM C231
Chloride ion content	ACI 318M
Drying shrinkage	ASTM C157

STANDARDS FOR TESTING AGGREGATE

Test	Designation no.	Sampling/testing Frequency (m^3)
Sampling	D75	500
Particle shape	D3398	2,500
Material finer than 75 μm	C117	500
Light particles	C123	500
Friable particles	C142	500
Organic impurities	C40	500
Soundness	C88	2,500
Grading	C136	500
Los Angeles Abrasion	C131, C535	500
Unit weight	C29	2,500
Specific gravity and absorption	C127, C128	500
Alkali Reactivity	C227, C1260	2,500

(c) All sieve sizes referred to in this Section refer to the aperture dimensions in millimeters of sieves conforming to ASTM E11 and ASTM E323.

(d) In checking the grading of aggregate and other materials imperial size ASTM sieves shall be related to specified metric sizes.

(3) Testing Cement at Source

(a) Cement shall be sampled at the source and tested by the manufacturer and certified as conforming to the requirements of this Specification before being dispatched from the factory of the cement manufacturer. All costs associated with the sampling and testing shall be included in the rates for furnishing and handling cement.

(b) Bulk or bagged cement used for concrete, mortar or shotcrete shall be sampled by taking one grab sample representing not more than 300 tons of cement manufactured in an uninterrupted process and stored in one silo. The sample shall be tested for all the requirements given in ASTM C150 by the methods given in that Standard. Test results shall be forwarded to the Engineer, within a period following testing, as determined by the Engineer.

(c) Cement used for pressure grouting shall be additionally sampled by taking one grab sample (usually one integral bag), representing not more than 480 bags filled with cement manufactured in an uninterrupted process and delivered to the Site in one consignment. This additional sample shall be tested in accordance with ASTM C150 for specific surface and for the percentage of material retained on the 0.150 mm and 0.075 mm sieves.

(d) The Engineer may require the Contractor to take samples of cement from any bulk or bagged storage, transfer point or usage point and arrange for testing. Cement found not to comply with the requirements of this Specification shall be removed from the Site.

(4) Testing Aggregate

At least sixty (60) days before placing any concrete, the Contractor shall submit to the Engineer results of tests on representative samples of the proposed aggregates that have been tested by the approved laboratory for compliance with this Specification.

(5) Sampling and Testing Concrete

(a) The Contractor shall sample concrete, for testing, from the batching and mixing plant, delivery trucks, at the forms or elsewhere where concrete is being handled or placed. Samples shall be obtained at uniform intervals, as directed, throughout the production or delivery of concrete for a given placement. A placement shall be considered as an operation involving the continuous placing of concrete between adjacent construction joints.

(b) The frequency of sampling of a class/type of concrete in any one placement shall be in accordance with the following table:

FREQUENCY OF SAMPLING CONCRETE

Up to 10 m^3	1 sample
10 to 40 m^3	2 samples
40 to 80 m^3	3 samples

For each additional 50 m^3, one (1) additional sample shall be taken.

(c) Where the concrete is deposited in to the forms directly from the agitator truck chute, sampling shall be from the discharge and the sampling procedure will be as in ASTM C172.

(d) The Engineer has the right to be present at any sampling or testing conducted by the Contractor.

(6) Testing Cylinder or Cube

(a) In general the Engineer will require two (2) specimen cylinders or cube for testing at twenty-eight (28) days, plus as many specimens as required for other testing, be made from any sample.

(b) The compressive strength of the concrete will be determined by tests on 150 mm diameter 300 mm long cylinders and 150x150x150 mm cubes.

(7) Testing Hardened Concrete in Structures

(a) If approved by the Engineer on each specific occasion, hardened concrete liable to rejection may be tested for compressive strength in accordance with ASTM C42. Unless otherwise directed, core specimens shall be 150 mm in diameter and 300 mm in length. At least three (3) specimens shall be tested and the points from which the specimens are obtained shall be as directed.

(b) If the average compressive strength of the core specimens so obtained is equal to or greater than the specified characteristic strength for that section of the Works, then the concrete represented by the core specimens shall be considered to be structurally satisfactory.

(c) If the concrete is considered to be structurally satisfactory then the holes left by the removal of the test cores shall be repaired as directed.

(d) Unless otherwise directed, concrete which fails to meet the requirements of this Clause shall be removed and replaced in an acceptable manner.

S8.08 CONCRETE CONSTRUCTION

(1) General

All concrete construction shall conform to the requirements of this Section and the detailed requirements of Clause S8.08 to S8.21. All structures shall be built in a workmanlike manner to the lines, grades and dimensions shown on the Drawings or directed by the Engineer.

(2) Accessories

The Contractor shall place and attach to each structure all timber, metal or

other accessories necessary for its completion, as shown on the Drawings or directed by the Engineer. The cost of such work, for which specific Items are not provided in the Schedule, shall be deemed to be included in the rates bid in the Schedule for the work to which they are appurtenant.

(3) Changes to Dimensions

The dimensions of each structure shown on the Drawings will be subject to such changes as may be found necessary by the Engineer to adapt the structure to the conditions disclosed by the excavation.

(4) Changes in Color

Abrupt changes in color of external concrete surfaces exposed to public view will not be permitted. The Contractor shall ensure that as far as possible these surfaces shall be of uniform or well graded color.

(5) Application of Loads

Loads shall not be applied to concrete placed in the Permanent Works without the approval of the Engineer.

S8.09 CONCRETE JOINTS

(1) Construction Joints

(a) Concrete surfaces, upon or against which concrete is to be placed and to which new concrete is to adhere, that have become so rigid that the new concrete cannot be incorporated integrally with that previously placed, are defined as construction joints.

(b) The location of construction joints and sequence of concrete placements shall be nominated by the Contractor. At least ninety (90) days before commencing construction of a separate feature the Contractor shall submit drawings showing the location of all his proposed construction joints and sequence of concrete placements for that feature.

(c) Certain joints may be shown on the Drawings as compulsory construction joints these joints shall not be altered and no concrete shall be placed adjacent to the joint for at least seven (7) days for features up to 1 m in thickness and for ten (10) days where the thickness exceeds 1 m.

(d) Construction joints shall be approximately horizontal or vertical unless otherwise shown on the Drawings or directed and shall be given the prescribed shape by the use of forms, key wall will not be required at construction joints. All intersections of construction joints with concrete surfaces which will be exposed to view shall be made straight and level or plump.

(2) Perimetric Joints

Perimetric Joint are joints placed in concrete to minimize the compression forces transmitted by abutting concrete caused by differential movement or rotation of adjacent structural elements. These joints are designed to isolate structural elements from each other. The joints shall be the full depths of the element and of the widths shown on the Drawings. Preformed Joint Filler material, water stops and bitumen bond breaker materials shall be as shown on the Drawings and shall conform to the requirements in this Clause.

(3) Contraction Joints

Contraction joints shall be located and constructed as shown on the Drawings. The joints shall be made by forming the concrete on one side of the joint and allowing it to set before concrete is placed on the other side of the joint. The surface of the concrete first placed at contraction joints shall be coated with sealing compound to break the bond before the concrete on the other side of the joint is placed.

(4) Expansion Joints

Expansion joints shall be located and constructed as shown on the Drawings. The joints shall be made by forming the concrete on one side of the joint and allowing it to set before concrete is placed on the other side of the joint. The surface of the concrete on either side of the expansion joint shall be separated by approved joint filler as shown on the Drawings.

S8.10 WATERSTOPS

(1) General

(a) PVC waterstops shall be placed in joints of the concrete faced dam and concrete structures as shown on the Drawings or directed.

(b) The Contractor shall store the waterstops in such a way that the material does not deteriorate during storage.

(c) Adequate provision shall be made to support and protect the waterstops during the progress of the work.

(d) The Contractor shall replace or repair any punctured or damaged waterstops before final acceptance of the Work.

(e) Particular care shall be taken to ensure that concrete in the vicinity of waterstops is adequately compacted, while avoiding any damage or displacement of the waterstop.

(2) PVC Waterstops

(a) Size and Material

(i) PVC waterstops shall be of extruded polyvinyl chloride with the physical properties specified in the following table:

PROPERTIES OF PVC WATERSTOPS

Specific gravity	1.33 +/- 0.03 at 25 ºC ASTM D792
Tensile strength	140 kg/cm^2 to 160 kg/cm^2 at 25 ºC ASTM D412
Ultimate elongation	310% to 350% at 25 ºC ASTM D412
Span Stiffness in flexture, 6 mm	Not less than 28 kg/cm^2 ASTM D747

(ii) PVC waterstops shall be of sufficient stiffness so that they remain in their correct position during concreting. The type shall suit the particular location in the dam face in which the waterstop is to be placed and the pattern shall be such that concrete can be placed all around it with complete consolidation and no voids or crevices. PVC waterstops used in each location shall include at least one nailing strip so located that the efficiency of the waterstop is not impaired. The width of the waterstop shall be within a tolerance of 10 mm of the nominal width exclusive of the nailing strip, and have minimum thickness as shown on the table. The waterstops required shall be of the following types:

Type	Wide (mm)	Minimum Thickness (mm)	Central Bulb
A	230	4.5	Yes
B	150	4.5	Yes
C	150	4.5	No
D	90	2.8	Yes

(b) Joints

(i) The number of joints in PVC waterstops shall be of the minimum practicable. "Tee" and "Flat X" joints shall be factory produced.

(ii) All joints shall be made with a temperature controlled apparatus and in such a manner as to ensure that:

. the PVC is not damaged by heat, searing or by the application of cementing materials

. the splice has a tensile strength not less than 80 percent of that specified for the PVC

. the splice is watertight and free of air bubbles

. the ribs and central bulb, where applicable, match up exactly and are continuous.

S8.11 MATERIAL SEALS IN JOINTS

(1) Metal Seals

(a) The Contractor shall furnish and install sealing strips of corrosion resisting metal in joints in the structures where shown on the Drawings or directed. The shape and method of the placing of metal seals shall be as shown on the Drawings. Metal seals shall be joined carefully by welding or brazing so as to form continuous watertight diaphragms in the joints. Adequate provision shall be made to support and protect metal seals during the progress of the work. The Contractor shall replace or repair any metal seal punctured or damaged before final acceptance of the work.

(b) Materials

Metal seals shall be 0.8 mm thick, soft tempered copper complying with ASTM B370 and nails shall comply with BS 1202.

(2) Bituminous Seals for Contraction Joints

(a) The Contractor shall construct bituminous seals in contraction joints as shown on the Drawings or directed.

(b) Materials

(i) Bitumen shall comprise a resilient, adhesive compound which is capable of being brought to a uniform pouring consistency suitable for completely filling the formed holes without inclusion of large air holes or discontinuities and without damage to the material. The bitumen shall form a tight bond with the concrete and shall have the following properties:

. Softening point as determined in accordance with ASTM Designation D36: 80ºC maximum - 60ºC minimum.

. Penetration at 25ºC as determined in accordance with ASTM Designation D 5: 40 maximum - 20 minimum.

. Pour point as determined in accordance with the applicable provisions of ASTM Designation D 1191: 107ºC maximum - 82ºC minimum.

. Generally comply with the requirements of ASTM D994.

(c) Heating

(i) When, in the opinion of the Engineer, the ambient temperature is likely to fall below 0ºC the Contractor shall furnish and install heating wires comprising 2.50 mm diameter galvanized steel wire with a 0.6 mm thickness of PVC insulation.

(ii) The heating wires shall be installed to the bottom of the hole before the first bitumen is placed. The wires above the top of the hole shall be protected against damage during construction.

(iii) The bitumen shall be heated and placed in the hole to the top of each lift of concrete. After each bituminous seal has been completed to the top of the structure in which it is located, the bituminous seal shall be capped as shown on the Drawings.

(d) Construction

(i) The 125 mm diameter holes for the bituminous seals shall be formed at each contraction joint between blocks as shown on the Drawings, to provide a continuous uniform hole free from obstructions.

(ii) After each lift of concrete has been completed, the recesses for the bituminous seals shall be cleared of all aggregate and other foreign matter and the surfaces of the holes shall be thoroughly dried by air blasts or other acceptable means.

S8.12 JOINT FILLERS

(1) Joint fillers

(a) Joint filers shall be placed in joints where shown on the Drawings or as directed by the Engineer.

(b) The Contractor shall submit a sample of all proposed fillers and the details of the proposed method of application to the Engineer for

approval at least 60 days before their intended use.

(2) Polysulphide Mastic Joint Fillers

(a) The Contractor shall furnish and install mastic filler where shown on the Drawings or directed.

(b) Materials

(i) Mastic filler shall be a two-part polysulphide liquid polymer sealant complying with ASTM D1850.

(ii) At least sixty (60) days before its intended use, the Contractor shall submit a sample of the proposed mastic filler together with the manufacturer's technical data and the details of the recommended method of application.

(3) Bituminous Fiber Sheet

(a) The Contractor shall furnish and install bituminous fiber sheet in expansion joints where shown on the Drawing or directed.

(b) Materials

The bituminous fiber sheet shall be 12 mm thick and complying with ASTM D1751.

(c) Installation

(i) Exposed edges of the bituminous fiber sheet shall be installed flush with either the back of the recess formed by chamfers on the corners of the concrete or the finished concrete surface as shown on the Drawings or directed.

(ii) Joints in the bituminous fiber strips shall be scarred. The number of field joints shall be kept to a minimum and where possible joints shall be factory produced.

(4) Expanded Polystyrene

(a) The Contractor shall furnish and install expanded polystyrene filler in expansion joints where shown on the Drawings or directed. Expanded polystyrene shall comply with BS 3837 of density 24 kg/m^3. Expanded polystyrene shall be 25 mm thick and shall be installed in as large a size sheet as possible.

(b) Installation

(i) The Contractor shall cut the polystyrene filler to cover the required

surface of the concrete at expansion joints and to fit around all openings.

(ii) Where placed against vertical surfaces, polystyrene filler shall be held in place against the completed side of an expansion joint by a waterproof cement applied to the face of each piece of polystyrene filler as a marginal strip coating approximately 50 mm wide.

(iii) Joints in the polystyrene filler shall be scarred, made tight and filled so that mortar from the concrete will not seep through to the opposite concrete surface. The number of field joints shall be kept to a minimum.

(iv) Where shown on the Drawings or directed the polystyrene filler shall be raked out after the concrete has set.

(5) Joint Strips

(a) Joint strips for expansion joints shall be furnished and installed by the Contractor, where shown on the Drawings or directed. Where a pre-formed rubber or plastic joint strip is used, all joints in the joint strips shall be close fitting butt joints and the location of all joints shall be subject to approval.

(6) Annular Seal for Pipes

(a) The Contractor shall furnish and install an annular seal between the pipeshell and surrounding concrete as shown on the Drawings.

(b) Material

(i) The annular seal material shall:

. Consist of a silicone elastomer, similar to Rhodorsil Mastic 3b.

. Permit a relative movement of 25 mm between the pipeshell and the concrete without breaking its bond to the concrete or to the pipeshall.

. Be compatible with the pipe wrapping material.

(ii) At least sixty (60) days before its intended use, the Contractor shall submit a sample of the proposed mastic together with the manufacturer's technical data and details of the recommended method of application.

(7) Cork Board

(a) The Contractor shall furnish and install cork board as shown on the Drawings or directed.

(b) Material

Cork board shall be 12 mm thick, coated in the factory on both faces with bitumen, thick enough to cover all surface voids, but not thicker than 1.5 mm at high points.

(c) Installation

(i) The Contractor shall cut the cork board to cover the required surface of the concrete.

(ii) Where shown on the Drawings or directed the exposed edges of the cork board shall be given two (2) coats of a bituminous damp-proofing compound.

(8) Cork Mastic

(a) The Contractor shall furnish and apply cork mastic as shown on the Drawings or directed.

(b) Materials

(i) The cork mastic shall be a mixture of bituminous emulsion, granulated cork and Portland cement. The mixture shall contain at least 60 percent by volume of granulated cork and not more than 10 percent of cement.

(ii) The granulated cork shall be clean, dry cork in granules not larger than 3 mm and not smaller than 1.5 mm.

(c) Application

(i) The surfaces to be coated shall be clean and dry immediately before application of the cork mastic. All grease and dirt shall be cleaned from the surface by wiping with a clean rag soaked in mineral spirits. The surface shall then be primed with one or more coats of a bituminous primer.

(ii) The ingredients of the cork mastic shall be thoroughly mixed to ensure an even distribution of the cork granules and cement. Cork mastic shall be applied immediately after mixing, using a trowel, to a thickness of 12 mm on the steel surfaces to be coated, except the steel pipe liners where the thickness shall be 6 mm. The coverage shall be complete and uniform and shall terminate neatly. Cork mastic applied in excess of that required shall be completely removed.

(iii) Following application the cork mastic shall be allowed to set for a period of 24 hours, or such longer period as may be directed. The cork mastic shall then be covered or wrapped with a single

thickness of bituminous fiberglass fabric having 8 meshes/cm. The fabric shall be lapped at the edges and bonded to the cork mastic with a coat of a bituminous adhesive. The coating shall be allowed to set for a further period of 24 hours, or such longer period as may be directed, before being covered with concrete.

(iv) The Contractor shall protect the cork mastic from damage at all times and make good any damage.

S8.13 SECOND STAGE CONCRETE

(1) Concrete in Blockouts - The Contractor shall construct blockouts in concrete structures for installation of equipment and other metal works shown on the Drawings or as directed by the Engineer.

The blockouts shall be filled by the Contractor with concrete or mortar after the equipment has been installed.

Prior to filling concrete or mortar in blockouts, the concrete surface of large blockouts shall be roughened by chipping or other methods and shall be in such condition as to ensure a good bond between the existing and the second stage concrete or mortar. The roughened surface of concrete shall be cleaned and the surfaces shall be dampened after the cleaning before filling with concrete or mortar. Filling of blockouts shall proceed after approval by the Engineer.

Second stage concrete shall be placed, packed and compacted to ensure satisfactory bond with the installed equipment or metalwork and shall be free of voids. The exposed surfaces of concrete shall be smoothly finished. Concrete or mortar to be placed in blockouts shall be of the same strength as the concrete of the structure where the blockouts are located.

(2) Where the concrete could not be placed by one stage and require a second stage concrete to be placed to form a completed part of that structures, the Contractor shall propose a construction joint as hereafter specified.

S8.14 EPOXY MORTAR

(1) General

(a) The Contractor shall place non-shrink epoxy mortar in blockouts as shown on the Drawings or directed.

(b) The Contractor shall also construct blockouts and place epoxy mortar in the blockouts as shown on the Drawings or directed to permit installation of items of structural steelwork, metalwork and equipment.

(c) The Contractor shall place epoxy mortar under baseplates as shown on the Drawings or directed after baseplates have been leveled and aligned

correctly and the baseplates rigidly secured in place by the anchor bolts and nuts. All spaces under the baseplates shall be completely filled with epoxy mortar.

(2) Composition

(a) Epoxy mortar shall consist of an approved filled resin or an unfilled resin with sand or other approved fillers added on site.

(b) All sand must be thoroughly dry before being mixed with resin.

(3) Preparation and Placing

Epoxy mortar shall be prepared and placed in accordance with the applicable manufacturer's instructions.

S8.15 FORMWORK

(1) General

(a) Forms shall be used to confine the concrete and shape it to the required lines.

(b) Forms shall be designed and constructed by the Contractor in accordance with ACI 347 and shall have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete, and shall be maintained rigidly in position.

(c) Forms shall be sufficiently tight to prevent loss of mortar from the concrete.

(d) Moulding strips shall be placed in the corners of forms so as to produce beveled edges on permanently exposed concrete surfaces. Interior angles on such surfaces and edges at formed joints will not require beveling unless the requirement for beveling is shown on the Drawings.

(e) The Contractor shall remain fully responsible for the safety of structures from which he removes formwork. The Engineer shall be informed before the Contractor strips any formwork.

(2) Finishes from Forms

All forms for concrete surfaces shall comply with ACI 347.

(3) Materials for Formwork

The formwork materials shall be such as to give the concrete surfaces the appropriate finish, as specified in Clause 9.15 hereinafter.

(a) The lumber used in formwork shall be free from warp, the boards shall be of uniform thickness and width, free from loose knots, decay, or other defects.

(b) Steel formwork shall be defined as a steel plate of approved thickness supported by structure steel shapes. Steel lining shall be defined as thin steel sheets, supported by a backing of wood boards.

(4) Forms for Curved Surfaces

Form for curved surfaces and transition sections shall be constructed to conform accurately to the required curvatures. Dimensions from horizontal and vertical base lines will be given at several sections throughout the length of the curved or transition sections. The Contractor shall interpolate intermediate sections as necessary for the type of form construction being used, curvature will be continuous between sections. After the forms have been constructed, all surface imperfections shall be corrected, and any roughness and all angles on the surfaces of the forms caused by matching the form material shall be dressed to required curvatures.

(5) Form-ties

(a) Embedded ties for holding forms shall remain embedded not less than two diameters or twice the minimum dimension of the tie or 10 mm, whichever is the greater, in from the formed faces of the concrete.

(b) The ties shall be constructed so that the ends or end fasteners can be removed without causing appreciable spalling at the faces of the concrete.

(c) Recesses resulting from removal of form-ties shall be repaired in accordance the provisions of this Specification.

(6) Treatment of Forms

Before concrete is placed the surfaces of the forms shall be coated with a napthalinic form-oil that will effectively prevent sticking and will not stain the concrete surface. The Contractor shall submit to the Engineer at least two (2) liters of the proposed form-oil at least thirty (30) days before its use is required. When concrete is placed, the surfaces of the forms shall be free from encrustations of mortar, grout, or other foreign material.

(7) Removal of Forms

(a) Except as provided in ACI 347, or as directed or approved, forms shall be removed carefully as soon as the concrete has hardened sufficiently to prevent damage in order to facilitate satisfactory progress with the specified curing and enable the earliest practicable repair of imperfections in the surface of the concrete.

(b) Concrete shall be cured immediately the forms have been removed.

(c) Forms on upper sloping faces of concrete shall be removed as soon as the concrete has attained sufficient stiffness to prevent sagging. Any needed repairs or treatment required on such sloping surfaces shall be performed at once.

(d) In order to avoid excessive stresses in the concrete that might result from swelling of the forms, timber forms for wall openings shall be loosened as soon as this can be accomplished without damage to the concrete. Forms for the openings shall be constructed so as to facilitate such loosening.

(e) Subject to approval, forms on concrete surfaces close to excavated rock surfaces may be left in place, provided that the distance between the concrete surface and the rock is less than 500 mm and that the forms are not exposed to view after the completion of the Works.

S8.16 TOLERANCES FOR CONCRETE CONSTRUCTION

(1) General

(a) Allowable deviations from plumb or level and from the alignment, profile, grades and dimensions shown on the Drawings are defined as "tolerances". Deviations from the established lines, grades and dimensions will be permitted to the extent set forth in this Clause.

(b) Where tolerances are not stated in the Specification or shown on the Drawings for any individual structure or feature thereof, permissible deviations will be interpreted in conformity with the provisions of this Clause. Notations on the Drawings or included in this Specification of specific tolerances in connection with any dimensions, shall be considered as supplementary to the tolerances specified in this Clause.

(c) The Contractor shall be responsible for setting and maintaining concrete forms sufficiently within the tolerance limits and shall ensure that the work is completed within the tolerances specified. Concrete work that exceeds the tolerance limits specified shall be remedied or removed and replaced by and at the expense of the Contractor.

(2) Concrete

Tolerances for reinforced concrete structures shall be in accordance with the requirements of ACI 117, except where such tolerances are amended by this Specification or the Drawings.

(3) Reinforcement

(a) Tolerances for reinforcing steel:

(i) Length of splice -25 mm

(ii) Variation of protective cover +/-5 mm

(iii) Variation in indicated position of reinforcement:

. starter bars one bar diameter
. slabs and walls 0.25 the indicated spacing
. beams and columns +/-5 mm

(iv) Dimensions of bent bars:

. stirrups and ties +/-5 mm
. other bars +/-10 mm

Provided the number of bars required by the specified spacing is not varied.

(4) Embedded Metalwork

Tolerances for placing embedded metalwork +/-5 mm.

(5) Soleplates

Tolerances for placing soleplates:

. variation in level +/-3 mm
. maximum tilt along a diagonal 3 mm

(6) Precast Footbridge Slabs

Variation in level of underside of precast Footbridge slabs after installation in 3 m ..... +/-3 mm

S8.17 REINFORCEMENT

(1) General

The Contractor shall furnish and install all reinforcement required for execution of the Works where shown on the Drawings or directed by the Engineer.

(2) Material

(a) Reinforcement shall be steel deformed bars Grade SD30 and SD40 complying with TIS 24-2536, and steel round bars Grade SR 24 complying with TIS 20-2527. The minimum yield strengths of the reinforcing bar shall be:

(i) SR24 - 235 MPa (2,400 ksc.)
(ii) SD30 - 294 MPa (3,000 ksc.)

(iii) SD40 - 392 MPa (4,000 ksc.)

(b) Test certificates will be required for all reinforcement furnished by the Contractor to be used on the Works.

(3) Drawings

Steel reinforcing bars shall be placed in concrete where shown on the Drawings or directed by the Engineer.

(4) Bar Lists

(a) The Contractor shall prepare complete reinforcing bar lists, including bar bending details, for each reinforcement detail drawing in an approved form. All reinforcing bars shown on the reinforcement detail drawings shall be identified on the bar lists in accordance with the standard reinforcing bar shapes as shown on the Drawings. All bar lists shall be identified with the relevant reinforcement detail drawing and all bars scheduled on the bar lists shall be defined and dimensioned in an approved manner.

(b) At least thirty (30) days before placing reinforcement shown on any reinforcement detail drawing, the Contractor shall furnish to the Engineer two (2) copies and one (1) transparency of the reinforcing bar list for that drawing, together with two (2) copies and one (1) transparency of the reinforcement detail drawing marked up with each bar identified in accordance with the bar list.

(5) Placing Reinforcement

(a) The Contractor shall be responsible for the accuracy of the cutting, bending and placing of the reinforcement.

(b) Before the reinforcement is placed, the surfaces of the bars or fabric and the surfaces of any metal bar supports shall be cleaned of heavy rust, loose mill scale, dirt, grease and other objectionable foreign substances. Heavy flaky rust which can be removed by firm rubbing with hessian or equivalent treatment is considered objectionable. After being placed, the reinforcing bars or fabric shall be maintained in a clean condition until they are completely embedded in the concrete.

(c) Reinforcing bars or fabric shall be accurately placed and secured in position so that there will be a clear distance of at least 25 mm between the bars or fabric and any adjacent embedded metalwork and so that the bars and fabric will not be displaced during the placing of concrete, and the Contractor shall ensure that there is no disturbance of the reinforcing bars or fabric in concrete that has already been placed.

(d) Chairs, hangers, spacers and other metal, plastic or concrete supports may be furnished and used by the Contractor for supporting reinforcing

bars or fabric. Concrete supports where used shall conform to the concrete requirements of this Specification. Steel spacers which are liable to cause rust staining of finished surfaces shall not be used.

S8.18 PREPARATION FOR PLACING CONCRETE

(1) General

(a) Concrete shall not be placed in water unless the method of depositing the concrete has been approved. Concrete shall not be placed in running water and shall not be subject to the action of running water until after the concrete has hardened.

(b) All surfaces of forms and embedded materials that have become encrusted with dried mortar or grout from concrete previously placed, shall be cleaned of all such mortar or grout before the surrounding or adjacent concrete is placed.

(2) Cleaning Foundations

(a) Immediately before placing concrete, all surfaces of foundations upon or against which the concrete is to be placed shall be free from standing water, mud, debris, oil, objectionable coatings and loose, semi-detached or unsound fragments. Where directed surfaces of foundations shall be cleaned with air-water jets.

(b) The surfaces of absorptive foundations against which concrete are to be placed, shall be moistened thoroughly so that moisture will not be drawn from the freshly placed concrete. Where directed an approved water barrier such as 0.25 mm thick polyethylene sheet shall be used to cover absorbent foundations.

(3) Cleaning Previously Placed Concrete Surfaces

(a) The surfaces of construction joints shall be clean and damp when covered with fresh concrete or mortar. Cleaning shall consist of the removal of all laitance, loose or defective concrete, coatings, sand, curing compound if used, and other foreign material to the satisfaction of the Engineer.

(b) The surfaces of blockouts against which concrete is to be placed shall be roughened by scrabbling.

(c) The surfaces of all construction joints, including surfaces of blockouts, shall be washed thoroughly with air-water jets immediately before placing adjoining concrete. All pools of water shall be removed from the surfaces of construction joints before the new concrete is placed.

(d) The surfaces of all contraction joints shall be cleaned thoroughly of accretions of concrete or other foreign material.

(4) Placing

The Contractor shall place all concrete in structures as shown on the Drawings or directed by the Engineer in accordance with this Specification or as approved by the Engineer. The Contractor shall advise the Engineer when concrete will be placed and concrete shall only be placed in the presence of the Engineer.

(5) Concreting During Hot Weather

The Contractor's attention is drawn to the recommendations contained in Manual of Concrete Practice Part 2-1989, "Hot Weather Concreting-American Concrete Institute 305R-77". The Contractor shall adopt any or all of these recommendations as necessary, to manufacture and place concrete in accordance with this Specification.

(6) Concreting During Cold Weather

The Contractor's attention is drawn to the recommendations contained in Manual of Concrete Practice Part 2-1989, "Cold Weather Concreting - ACI 306 R-78". The Contractor shall adopt any or all of these recommendations as necessary, to manufacture and place concrete in accordance with this Specification.

(7) Slush Mortar

(a) Unless otherwise approved in each specific case, construction joints and highly fractured or irregular rock surfaces against which concrete is to be placed shall be covered with a layer of mortar approximately 10 mm thick.

(b) The mortar shall have the same proportions of water, air-entraining agent, cement, and sand as the regular concrete mixture, unless otherwise directed. The water-cement ratio of the mortar in place shall not exceed that of the concrete to be placed upon it, and the consistency of the mortar shall be suitable for placing and working in the manner hereinafter specified.

(c) The mortar shall be spread and shall be worked thoroughly into all irregularities of the surface.

(d) Concrete shall not be placed upon mortar which has dried out or become contaminated by water, debris or other deleterious material. Mortar which has been so contaminated shall be removed from the surface of the rock or construction joint, the surface shall be recleaned and a fresh layer of mortar deposited on the surface before concrete is placed against the surface.

(8) Depositing Concrete

(a) The Engineer may direct that structural concrete placements in formed work shall be started with an over sanded mix containing 20 mm maximum size aggregate, a maximum water-cement ratio of 0.47 by mass, and having a maximum slump of 100 mm.

(b) Where two different classes of concrete are shown on the Drawings adjacent to one another without an intervening movement joint, the two classes shall be placed at the same time. Where the surface of division between the two classes is vertical or inclined the two classes of concrete shall be placed together using a separator which shall be withdrawn as the concrete is placed.

(c) Whenever practicable, concrete shall be deposited directly in its final position and shall not be dropped, chuted or caused to flow in a manner to permit or cause segregation. Methods and equipment employed in depositing concrete in forms shall be such as will not result in clusters or groups of coarse aggregate being separated from the mass. The Contractor shall provide chutes and baffles to confine and control the falling concrete. The movement of concrete within the forms by use of vibrators will not be permitted.

(d) In the event of continuous placing being interrupted for any reason, the Contractor shall thoroughly consolidate the concrete at such joints to a reasonably uniform and stable slope while the concrete is plastic and any concrete which is unconsolidated and no longer plastic shall be removed by the Contractor at his own expense. The concrete at the surface of such cold joints shall be clean and damp when covered with fresh concrete.

(9) Concrete Placed in Horizontal Layers

Except as intercepted by joints and for concrete in tunnel linings, all formed concrete shall be placed in continuous approximately horizontal layers, the depths of which generally shall not exceed 500 mm. The Engineer may direct thinner layers where concrete in 500 mm layers cannot be placed in accordance with the requirements of this Specification.

(10) Placing Unformed Concrete on Slopes

In placing unformed concrete on slopes so steep as to make internal vibration of the concrete impracticable, the concrete shall be placed ahead of an unvibrated slip-form screed extending approximately 800 mm back from its leading edge. Concrete ahead of the slip-form screed shall be consolidated by internal vibrators so as to ensure complete filling under the slip-form screed.

(11) Placing Concrete Monolithically Around Openings

If concrete is placed monolithically around openings having vertical dimensions greater than 600 mm, or if concrete in decks, floor slabs, beams, girders or other similar parts of structures is placed monolithically with supporting concrete, the following instructions shall be strictly observed:

(a) Placing of concrete shall be delayed not less than 30 minutes nor more than 1 hour at the top of openings and at the bottom of bevels under decks, floor slabs, beams, girders or other similar parts of structures when bevels are specified and at the bottom of such structural members when bevels are not specified, but in no case shall the placing be delayed so long that the vibrating unit will not of its own weight readily penetrate the concrete placed before the delay. When consolidating concrete placed after the delay, the vibrating unit shall penetrate and revibrate the concrete placed before the delay.

(b) The last 600 mm or more of concrete placed immediately before the delay shall be placed with as low a slump as practicable, as determined by the Engineer and shall be thoroughly consolidated.

(c) The surfaces of concrete where delays occur shall be clean and free from loose and foreign material when concrete placing is started after the delay.

(d) Concrete placed over openings and in decks, floors, beams, girders and other similar parts of structures shall be placed with as low a slump as practicable and the Contractor shall ensure that thorough consolidation of the concrete is effected.

(12) Placing Mass Concrete

(a) In placing mass concrete, the Contractor shall maintain the exposed area of fresh concrete at the practical minimum, by first building up the concrete in successive approximately horizontal layers to the full width of the block and to full height of the lift over a restricted area at one end of the block and then continuing to the opposite end in similar progressive stages to the full area of the block.

(b) The lift heights and the period between successive lifts shall be controlled to prevent the maximum temperature exceeding the limits specified.

(c) Clusters of large aggregate shall be scattered before new concrete is placed over them. Each deposit of concrete shall be vibrated completely before another deposit of concrete is placed over it.

(d) Mass concrete shall not be placed during rains sufficiently heavy or prolonged to wash mortar from coarse aggregate on the forward slopes of the placement.

(e) Once placement of mass concrete has commenced in a block, placement shall not be interrupted by diverting the placing equipment to other uses.

(13) Consolidation

(a) Consolidate concrete in accordance with recommendations in ACI 309 R. Concrete shall be consolidated to the maximum practicable density in such a manner that it is precludes segregation and closes snugly against all surfaces of forms and embedded materials.

(b) (i) Whenever practicable concrete shall be consolidated by immersion type vibrators operated in accordance with the manufacturer's recommendations. Where the use of mechanical vibration is not possible or would be inadequate concrete shall be consolidated thoroughly by hand.

(ii) Consolidation of concrete in the side walls and arch of tunnel linings and in parts of other structures exposed to view shall be immersion-type vibrators supplemented by heavy-duty form vibrators. Form vibrators shall be firmly attached to the forms but the vibrator shall be capable of being moved up or down or laterally along the forms and shall operate at speeds of at least 8,000 revolutions per minute when vibrating concrete.

(iii) The concrete in the cutoff wall shall be tremied into place without any vibration.

(c) In consolidating each layer of concrete, the immersion type vibrator shall be operated in a near vertical position and the vibrating head shall be allowed to penetrate and revibrate the concrete in the upper portion of the underlying layer. In the area where newly placed concrete in each layer joins previously placed concrete in the same layer, more than usual vibration shall be performed, the vibrator penetrating deeply at close intervals over the areas of contact of these layers. Layers of concrete shall not be placed until layers previously placed have been vibrated thoroughly as specified. Contact of the vibrating head with surfaces of the forms shall be avoided. Direct vibration of the reinforcement will not be permitted.

(d) The total consolidating capacity in cubic meter of concrete per hour, of all vibrators in effective operating condition, and employed on concrete compaction in the Works, shall be based on a rated capacity of 70 percent of the manufacturer's recommendation of each type of vibrator in operation and the total compacting capacity so computed shall be not less than the maximum rate at which concrete is placed in the Works. For every three (3) vibrators in use on a concrete placement, the Contractor shall provide one (1) additional standby vibrator of similar compacting capacity in good working order.

S8.19 FINISHES, FINISHING AND REPAIRS

(1) General

The surface of the finished concrete shall be smooth, uniform in color and texture, free from projections, irregularities, holes, honeycomb and encrustations.

(2) Classification of Surface Finish

(a) General

Except for the construction tolerances, the surface of concrete, both formed and unformed, shall be smooth and shall not present abrupt or gradual irregularities outside the surface finish tolerances herein described. Abrupt irregularity is defined as a change in a surface that takes place without any transition whatsoever; gradual irregularity is defined as a change that taken place over a transition distance.

(b) Classification of Surface Finish

Surface finish shall be governed by the nature of formwork materials, by the finishing tools employed in unformed surfaces, and by the maximum allowable irregularities. Unless otherwise instructed by the Engineer the surface finish of concrete shall conform to the following Specifications.

(i) Finish for surfaces against which backfill or further concrete will be placed. The formwork shall be produced by sawn timber or finished by wood trowel with abrupt irregularities up to 2 cm and gradual irregularities up to 3 over 100.

(ii) Finish for surfaces permanently exposed to view e.g. wall and slab of building.

The formwork shall be produced by dressed timber or finished by wood trowel; with abrupt irregularities up to 1 cm and gradual irregularities up to 1 over 100.

(3) Approval of Finishes

The degree of surface finish of the concrete shall be inspected and approved by Engineer for each day's work or immediately after stripping the formwork. Any needed correction will be carried out immediately.

(4) Repair of Concrete

Immediately after the removal of the formwork, the Contractor shall inspect the concrete and shall report all defects to the Engineer.

(a) Any irregularity outside the specified tolerance, or any voids, honeycombs or other damage shall be repaired. All repairs of such defects shall be performed only by skilled workmen and at the expense of the Contractor. The Contractor will inform the Engineer before starting the repair work. Materials, procedures and operations used in the repair of concrete shall be done in accordance with the orders and instructions of the Engineer.

(b) All repairs shall be made immediately after removal of the forms and never longer than twenty-four (24) hours after exposure. Concrete damaged from any cause and concrete that is honeycombed, fractured or otherwise defective, and concrete which, because of excessive surface depressions must be cut back and rebuilt, shall be replaced with mortar or concrete as hereinafter specified or as otherwise directed by the Engineer.

The defective concrete shall be cut down to sound concrete, and at least down to a depth behind the reinforcement steel sufficient to provide complete bonding of the reinforcement steel to the concrete replacement. Voids to be filled shall be provided with anchors, keys, welded wire mesh, or dovetail slots, whenever necessary, to attach the new material securely in place. Cut out areas shall be thoroughly cleaned.

The holes left by the removal of tie rods and/or cones shall be thoroughly moistened and filled with dry pack mortar, thoroughly tamped into place. The color of replacement concrete and patching mortar shall match that of the surrounding concrete.

(c) Concrete and mortar used for patching and repairs, shall be cured in the same manner as specified for general concrete work. Where specifically authorized by the Engineer bulges may be removed by grinding procedures. Other methods to be used in such repair work shall be those detailed in Chapter VII of the Concrete Manual USBR, latest Edition.

Water-retaining concrete structures shall be watertight up to the full design head of water and the Contractor shall repair at his own expense all leaks that may develop prior to or during the Guarantee Period as defined in the General Conditions of Contract.

S8.20 CURING AND PROTECTION OF CONCRETE

(1) Curing of Concrete

(a) All concrete shall be cured using water in accordance with this Clause except that, for certain surfaces, membrane curing may be approved. Membrane curing will not be approved for surfaces exposed to public view or surfaces which are to be subsequently coated.

(b) The unformed top surfaces of walls and slabs shall be moistened by covering with water-saturated material or by other effective means as

soon as the concrete has hardened sufficiently to prevent damage by water. The surfaces shall be kept completely and continuously moist, before and during form removal.

(2) Equipment for Water Curing

(a) At least fourteen (14) days before placing concrete in any structure to be water cured, the Contractor shall submit to the Engineer details of the equipment and methods he proposes to use for water curing. After the initial placement of concrete in any structure, subsequent placements will not be permitted until equipment for curing has been satisfactorily installed and is operating on all previous placements in the structure.

(b) The equipment and method proposed shall provide for adequate control of the application of curing water to avoid interrupting other work.

(3) Water Curing Period

Concrete cured with water shall be kept continuously wet for at least seven (7) days immediately following placement of the concrete, or until covered with fresh concrete. Water used for curing shall meet the requirements of this Specification for water used in concrete, but with the additional requirement that the water shall not contain any chemicals or other substances that will cause staining of concrete surfaces.

(4) Membrane Curing

(a) At least thirty (30) days before using curing compound, the Contractor shall submit to the Engineer details of the proposed compound. Such details shall be accompanied by test certificates to show that the compound will give satisfactory results for the proposed application. Curing compounds shall comply with ASTM C309.

(b) Membrane curing, if approved, shall be by application of a type of curing compound which forms a water retaining membrane on the surface of the concrete. Curing compound shall be applied to the concrete surfaces in accordance with the manufacturer's instructions.

(c) When curing compound is to be used on unformed concrete surfaces, application of the compound shall commence immediately after the finishing operations are completed.

(d) When curing compound is to be used on formed concrete surfaces, the surface shall be moistened with a light spray of water immediately after the forms are removed, and shall be kept wet until the surface will not absorb more moisture. As soon as the surface film of moisture disappears but while the surface still has a damp appearance, the curing compound shall be applied. There shall be ample coverage with the compound at edges, corners and blow-holes of formed surfaces. After application of the curing compound has been completed and the coating is dry to touch,

any required repair of concrete surfaces shall be performed. Each repair, after being finished, shall be moistened and coated with curing compound in accordance with the foregoing requirements.

(e) Equipment for applying curing compound and the method of application shall comply with recommendations of the manufacture.

(f) Traffic and other operations by the Contractor shall be such as to avoid damage to coatings of curing compound for a period of not less than twenty-eight (28) days after application of the curing compound. Where it is impossible because of construction operations to avoid traffic over surfaces coated with curing compound, the membrane shall be protected by a covering of sand not less than 25 mm in thickness or by other effective means. The protective covering shall not be placed until the sealing membrane is completely dry. The Contractor shall remove all sand covering after completion of the curing period. Any sealing membrane that is damaged or that peels from concrete surfaces within twenty-eight (28) days after application, shall be repaired without delay.

(g) Curing compound shall be delivered to the Site in suitably labeled containers to enable identification of the batch number and date of manufacture.

(5) Protection of Concrete

(a) The Contractor shall protect all concrete against damage or disfigurement in accordance with ACI 318M and this Clause until final acceptance by the Engineer.

(b) High Temperatures

When the ambient temperature in the vicinity of the Works is likely to reach or exceed 32 ºC, the Contractor shall protect all concrete from drying winds or surface temperature rise for not less than 48 hours after it is placed. Such protection shall include method as recommended in ACI 305R-77.

(c) Freezing

(i) When the ambient temperature in the vicinity of the Works fall below 5 ºC for two or more successive days the concrete shall be protected against freezing for at least 72 hours after it is placed. Such protection shall include method as recommended in ACI 306R-78 and/or amended by this Specification.

(ii) At any time when the ambient temperature ie expected to fall below 5 ºC within 24 hours of the commencement of concrete placement, the concrete surface shall be protected against freezing for the first 48 hours after placing.

(iii) The minimum temperature of the concrete during the protection period shall be 7 ºC. At the end of the protection period the surface concrete temperature shall be allowed to cool gradually to the ambient temperature at a rate not exceeding 5 ºC in 24 hours.

(iv) The minimum temperature of the concrete as placed shall be not less than 7 ºC and not greater than 18 ºC.

(v) Concrete shall be prevented from drying during the required curing period including the protection period. Concrete cured by water curing shall be protected against freezing for four days following the protection period and shall be discontinued 24 hours before exposure of the concrete to freezing temperatures.

(6) Damage and Disfigurement

All surfaces for formwork is specified shall be protected from damage or disfigurement during placement of concrete in adjacent areas by covering such surfaces with polythene sheets or by other effective methods.

S8.21 PIPE WRAPPING MATERIAL

(1) Requirement

The Contractor shall furnish and install a pipe wrapping material where shown on the Drawings or directed.

(2) Material

(a) The wrapping material shall be closed-cell polyethylene foam 20 mm.

(b) The pipe wrapping material shall not absorb water to any appreciable extent, shall be chemically inert and shall be compatible with concrete, the material of the item being wrapped and its external coating.

(c) At least sixty (60) days before its proposed use the Contractor shall submit:

(i) A sample of the proposed pipe wrapping material.

(ii) Details of its composition.

(iii) Details of its proposed use, including the method of attachment to the item being wrapped.

(iv) A certificate from an approved independent laboratory that the proposed pipe wrapping material satisfies the requirements of this subclause.

(3) Pipe Wrapping for Embedded Pipe work

(a) The pipe wrapping material for use with embedded pipe work shall be capable of being deformed, without rupture, by the following longitudinal and radial movements of any point on the pipeshell relative to the surrounding concrete

(i) A 10 mm radially after being subjected to a pressure of 35 kPa (0.3 ksc).

(ii) A 25 mm longitudinally movement of the pipe.

(4) Application

The material to be used shall be applied in at least two equal layers with joints between sheets offset at least 200 mm from the joints of the adjoining layer. The joints between adjacent sheets shall be tightly sealed with a contact adhesive tape to prevent the ingress of concrete or mortar. An adhesive shall be used to fix the material to the pressure pipelines.

SECTION 9 - CONCRETE WORK

SECTION 9 - CONCRETE WORK

S9.01 CONTRACTOR PLACED AGAINST ROCK

(1) The requirements of this clause apply to all concrete placed against rock on the surface and underground.

(2) All spaces outside the minimum specified thickness of the concrete shall be filled completely and solidly with concrete and the Contractor shall ensure than concrete is forced into all irregularities in the excavated surfaces.

(3) Where an appreciable quantity of water flows from the excavated surface against which the concrete is to be placed, it shall be excluded from the space to be filled by concrete by caulking, diverting by pipes, pans and other means, and pumped from sumps, until the concrete has set sufficiently to be unaffected by water throng the action of percolation, hydrostatic pressure or abrasion.

(4) (a) The Contractor shall backfill grout all spaces between the rock remaining unfilled after placing of the concrete has been completed, provided that such grouting shall be performed after the concrete has attained sufficient strength, as determined by the Engineer, to resist the grouting pressures. The injection of the grout shall be done at a pressure determined by the Engineer, but in no case shall the pressure exceed 200kPa ($2kg/cm^2$).

(b) The backfill grout shall be injected through drilled holes or through pipes set in the concrete. The size and location of the holes and pipes shall be as shown on the Drawings or as directed.

(c) The installation of the pipes and fittings, grout materials, and grout placing operations for this grouting requirement shall be in accordance with the applicable provisions of Section 6.(Not Applicable)

S9.02 DIVERSION TUNNEL CONDUIT PLUG (Not Applicable)

(1) The Contractor shall furnish and install closure bulkhead gate in accordance with the provision of Clause S9.04. The second stage concrete in the diversion tunnel conduit plug shall be placed immediately after the bulkhead gate has been installed and all the work required by this Clause shall be completed as soon as is practicable thereafter.

(2) Concrete shall be placed in sections with drainage pipes to allow the removal of percolated water, air vents, grout stops, and grouting system.

(3) Grouting of joints between the first and second stage concrete in the conduit plug shall be in accordance with Clause 6.05(8), and shall not commence until the concrete has attained sufficient strength. Grout shall be forced through

previously installed longitudinal feeder pipes along the conduit axis and lateral riser pipes with grout outlets.

S9.03 MASS CONCRETE PLACING AT WEIR CREST, CHUTE AND STILLING BASIN

(1) The Contractor shall submit the concreting procedure and method of placing concrete for the mass concrete at structure for the Engineer's approval thirty (30) days prior to start the concrete placing.

(2) The Contractor proposal for the concreting shall be based on the following criterion:

(a) Time and rate of placement.

(b) Control of concrete temperatures.

(c) Treating of the construction joints.

(d) Proposed method for the uniform concrete consistency and control of concrete slump.

(3) The maximum size of coarse aggregate shall be 75 mm in accordance with Clause S8.02.

(4) The slump of concrete shall be kept as low as practicable for vibrator consolidation so as to reduce excessive mortar breeding on the surface. Concrete of relatively dry consistency 1 to 2 inch slump shall be used and adequately and thoroughly vibrated into place.

(5) Block diversion will be made to suit the capacity of concrete placing and production of concrete to avoid delay of placing which result in cold joints within a lift. Any imperfection and defective concrete shall be removed and replaced.

(6) Care shall be taken to vibrate and consolidate concrete in the area where a newly place layer of concrete joins previously placed concrete. Procedures for vibration shall be established to eliminate the possibility of incomplete consolidation.

(7) The concrete temperature shall be strictly control according to Clause S8.06.

S9.04 CONCRETE IN BLOCKOUTS AND UNDER BASEPLATES

(1) Requirement

(a) The Contractor shall place blockout concrete blockouts, constructed as shown on the Drawings or as directed, after the installation and adjustment of metalwork furnished and installed has been completed. Blockout concrete, excludes concrete designated on the Drawings are considered as second stage concrete.

(b) The Contractor shall also construct blockouts and place concrete in the blockouts to permit installation of items of structural steelwork, metalwork and hydromechanical equipment to be furnished and installed by the Contractor (or his subcontractor), and the cost of such work shall be included in the cost of the concrete in which the blockout is provided and the items installed respectively.

(2) Preparation and Placing Concrete in Blockouts

(a) Before concrete is placed in the blockouts, the concrete surfaces of the blockouts shall be roughened by chipping or other approved methods and in such a manner as not to loosen, crack or shatter any part of the concrete beyond the roughened surface.

(b) After being roughened, the surface of the concrete shall be cleaned in accordance with Clause S8.18 and shall be sound and hard and in such a condition as to ensure a good mechanical bond between the existing and the new concrete.

(c) All concrete which is not hard, dense and durable, as determined by the Engineer, shall be removed to the depth required to secure a surface satisfactory to the Engineer.

(d) The Contractor shall place the concrete in blockouts in such a way as to ensure satisfactory bond with the existing concrete, to secure complete contact with metalwork to be embedded in the blockout concrete and to avoid displacement of the metalwork being embedded. Where directed, concrete placed in blockouts shall contain an approved expanding agent in accordance with Clause S8.04(2) (C) or placing of mixed concrete shall be delayed to reduce subsequent shrinkage. The cost of preparing the surface of the concrete against which blockout concrete is to be placed, shall be included in the rate for concrete in the blockout.

S9.05 CONCRETE IN SURFACE WORK

(1) The Contractor shall place all required concrete for the following surface works:
. box culvert diversion

. conduit pipe
. river outlet
. intake tower

(2) Concrete Surround for Steel pipe Conduit

(i) The steel conduit shall be supported on steel or concrete cradles resting on the first stage concrete. The steel liners shall be braced internally to maintain their correct shape.

(ii) The Contractor shall provide all external bracing and ties necessary to maintain the conduit pipes in their correct position during placement of the surrounding concrete.

(iii) The Contractor shall not carry out any welding to the steel conduit except for the attachment by welding of steel reinforcing bars passing through the seep rings at the upstream end of the steel conduit. Welding of the reinforcing bars to the seep rings shall be carried out by qualified welders.

(iv) Prior to the concrete embedment of the steel conduit, the Contractor shall provide grout pipes and outlets below the invert of the conduit pipe to enable any void in the concrete placed beneath the pipe to be subsequently grouted. The Contractor shall not weld any grout pipe or fitting to any part of the steel conduit. After completion of the concrete embedment, backfill grouting of all voids between the steel conduit and the concrete surround shall be carried out by the Contractor in accordance with the applicable requirements of the Specification.

S9.06 CONCRETE IN TUNNELS (Not Appricable)

(1) The Contractor shall place all required concrete for the following tunnels as shown on the Drawings or directed:
. diversion tunnel and tunnel portals

(2) Placing Concrete in Tunnels

Concrete in tunnel linings shall be placed by a displacement type pump or by pneumatic placing equipment or by any other acceptable method. The equipment used in placing the concrete, and the method of its operation, shall be such as will permit introduction of the concrete into the forms without high-velocity discharge and resultant segregation. After the concrete has been built up over the arch of tunnel lining at the start of a placement, the end of the discharge line shall be kept adequately buried in the concrete during placement of the arch to ensure complete filling. The discharge line shall be marked so as to indicate the depth of burial at any time. Concrete shall be forced into all irregularities in the rock surface to fill completely the arch. Placing equipment

shall be operated by experienced operators only. Cold joints in tunnel linings shall be avoided where practicable. Where an appreciable quantity of water flows from the rock against which the concrete is to be placed, the water shall be excluded from the space to be filled with concrete by caulking, diverting by pipes, pans and other means, and the pumping from sumps, until the concrete has set sufficiently to be unaffected by action of the water through percolation, hydrostatic pressure or abrasion.

(3) Removal of Timber before Placing Concrete Lining

(a) Unreinforced lined sections of tunnels and shafts: In unreinforced concrete lined sections of tunnels and shafts supported by steel rib supports all loose timber shall be removed as completely as practicable before concrete lining is placed. All timber spreaders shall be removed prior to placement of concrete lining. The Contractor shall securely brace the supports with the minimum practicable amount of blocking and wedging. No timber support accessories will be permitted between the outer face of the steel rib support and the minimum excavation line.

(b) Circular lined sections of tunnels and shafts: No timber support accessories will be permitted in circular lined sections of tunnels and shafts supported by steel rib supports. Only steel support accessories shall be permitted to remain prior to connecting. All timber spreaders shall be removed prior to placement of concrete lining.

(4) Concreting Behind Steel Conduit Liners in Diversion Tunnel Plug

(a) Before concreting behind steel conduit liners all objectionable material shall be removed from the outside surface which shall be maintained clean until concrete is placed. Field welding of any joint shall be completed before concreting. All temporary timber struts, loose material and debris shall be removed from outside the conduit liner before concreting.

(b) The Contractor shall adequately support and anchor the steel conduit liners with effective steel or concrete cradles. Site welding of supports to the outside of the pipeshell will not be allowed. The temporary internal stiffeners of the tunnel liners shall not be removed for at least 24 hours after placing concrete backfill.

(5) Backfill Grouting

(a) The Contractor shall backfill grout all spaces between the concrete lining and rock and between the concrete and steel liners remaining unfilled after placement of the concrete has otherwise been completed provided that such grouting shall be performed after the concrete has cooled and obtained sufficient strength as determined by the Engineer to resist the grouting pressures. The injection of the grout shall be done at a pressure

as determined by the Engineer but in no case shall the pressure exceed 200 kPa (2 ksc).

(b) In unreinforced concrete lined sections the backfill grout shall be injected through holes drilled through the concrete or through pipes set in the concrete.

(c) In reinforced concrete lined sections the grout shall be injected through pipes set in the concrete lining.

(d) In steel lined sections, the grout shall be injected through holes drilled to rock at the location of the predrilled grout holes provided in the steel liners. At any point where inspection indicates that a cavity exists between the steel liner and the concrete, the Contractor shall drill and tap the liners to provide additional grouting points.

(e) The size and location of the holes or pipes shall be as shown on the Drawings or as directed by the Engineer.

(f) Composition of backfill grout

. cement and water
. cement, fine aggregate and water, or
. cement, filter and water.

The proportions of water to cement by weight shall be within the range 0.7 to 0.8. The proportion of fine aggregate to cement by weight shall be within the range 1.5 to 2.0. The fine aggregate for grout shall be clean 100 percent shall pass a 2.36 mm sieve and at least 30 percent shall pass at 0.30 mm sieve.

(g) Grout plugs

After completion of the backfill grouting, the grout holes shall be sealed off with threaded steel plugs and a sealing compound, as shown on the Drawings or directed by the Engineer.

(h) At any point where inspection indicates that a cavity exists between the steel liner and the concrete, the Contractor shall drill and tap the liners to provide additional grouting points. After completion of the backfill grouting, the grout holes shall be sealed off with threaded steel plugs and a sealing compound, as shown on the Drawings or directed by the Engineer.

(6) Exploratory Adits

(a) The Contractor shall place concrete in the existing exploratory adits as shown on the Drawings or as directed by the Engineer. The exploratory adits shall be cleared of all timber supports and loose rock, clay rubbish and other objectionable material removed to the satisfaction of the Engineer. The floor of the adits shall be free of standing water immediately prior to concreting. All the exploratory adits shall be filled completely and solidly with concrete and the Contractor shall ensure that concrete is forced into all irregularities in the rock surface.

(b) Backfill grouting

The Contractor shall backfill grout all spaces in the roofs and side walls of the adits remaining unfilled after placing of the concrete.

(7) Concrete in Tunnel Plugs

(a) The Contractor shall place all required concrete for the tunnel plugs as shown on the Drawings or directed by the Engineer.

(b) Placing Concrete in Tunnel Plugs

(i) The Contractor's proposal for cooling of the concrete in the tunnel plug shall be submitted to the Engineer at least sixty (60) days prior to commencement of concreting. The cooling system and thermometer pipes shall consist of black steel pipes embedded in the concrete. Cooling shall commence at the time of placing the concrete in the plug and shall continue until the concrete temperature has been reduced to that of the surrounding rock.

(ii) The Contractor shall supply, install and test thermometers.

(iii) Grouting between concrete and rock and between the plug placements shall be carried out after the concrete has cooled to the surrounding rock temperature.

(iv) After the cooling and thermometer pipes have served their purpose, the embedded pipes shall be filled with grout. The grout shall be forced into the pipes with only sufficient pressure to ensure that the pipes are completely and solidly filled. All holes left at the grout connections shall be filled immediately and completely with dry-pack.

(v) The Contractor shall furnish and install closure stop logs in accordance with the requirements for diversion. The second stage concrete in the diversion tunnel plug shall be placed immediately after the bulkheads have been installed and all the work required by this Clause shall be completed as soon as is practicable thereafter.

(vi) Grouting of the joints between the first and second stage concrete in the tunnel plug shall not commence until the concrete has cooled to 25ºC.

S9.07 CONCRETE IN POWERHOUSE

(a) The Contractor shall place all required concrete in the Power House as shown on the Drawings or directed by the Engineer.

(b) Tentative Features

The following features, as shown on the Drawings, are tentative only and the Contractor shall not be entitled to any additional compensation above the rates tendered in the priced Bill of Quantities for the items of concrete on account of changes to such features:

(i) Levels of floors.

(ii) Sizes of columns, girders and beams.

(iii) Thickness of walls and floors.

(iv) Location of walls, partitions, floors, columns, girders, beams and openings.

(v) Numbers, locations and sizes of blockouts, holes, pipes, pits, trenches, cables, anchor bolts and embedded metal work for plant.

(3) Details on Drawings

Blockouts, holes, pipes, pits, trenches, pedestals and embedded metalwork for machinery, pipes, cables, anchor bolts and other accessories are not fully detailed on the Drawings and may be changed in number, location or size when full details of the equipment and accessories become available. The Contractor will not be entitled to any increase in rates for such changes made before concrete placement around the relevant blockouts, holes, pipes, pits, trenches, pedestals or embedded metalwork commences.

(4) Openings

Openings in floors and walls shall be formed before the concrete is placed.

(5) Allowance for Floor Tiles

Concrete slabs to be covered with a floor finish or tiles shall be left at a sufficient depth below the finished floor elevations to permit placing of the required thickness of floor finish or tiles, and proper allowance shall be made for the finish when anchor bolts, pipes and other metalwork are placed. Concrete slabs forming floors shall be carefully screeded to the design levels shown on the Drawings. Scrabbling or grinding to bring the floor to the correct levels will not be permitted after installation of mechanical or electrical equipment has commenced.

S9.08 BACKFILL CONCRETE

The Contractor shall place backfill concrete in the following locations:

. filling seams and treating defects, below the general level of excavations
. modifying abutment contact slopes
. filling over excavations
. bedding below the lining of surface drains
. elsewhere as directed.

S9.09 MISCELLANEOUS CONCRETE

The Contractor shall place miscellaneous concrete in the following locations:

. concrete surround, anchor blocks and pits for water supply, drainage and sewerage pipes

. drainage junction sumps, manholes, cable pits and trenches valve boxes, hydrant boxes, septic tank and biological filter

. inlet sumps, head walls, retaining walls, wing walls, concrete surround for culverts

. terminal structures and instrument boxes

. kerb paths, kerb drains, channel drains, gutters footpaths in parking areas and drainage inverts

. backfill for drainage

. base and associated valve pit for the water supply tank

. foundations

. rock traps

. other miscellaneous concrete as shown on the Drawings or directed.

S9.10 MEASUREMENT AND PAYMENT

(1) General

(a) Measurement, for payment, of concrete required to be placed directly upon or against surfaces of excavation will be made to the lines for which payment for excavation is made.

(b) Measurement, for payment, of second stage concrete required as shown on the Drawings will be made of the actual volume of concrete directed to be placed.

(c) Measurement, for payment, of backfill concrete, concrete placed in the cutoff wall, concrete placed in cavities, concrete placed in exploratory adits and concrete placed at upstream toe of the dam will be made of the batch volume of concrete placed in these locations.

(d) Measurement, for payment, of all other concrete will be made to neat lines of the structures as shown on the Drawings unless otherwise prescribed in this Specification.

(e) In measuring concrete for payment, deductions will be made for the volume of all ducts, embedded pipes, surface conduits and drains, recesses for rails and gate guides in first stage concrete, embedded metalwork and other blockouts having a cross-sectional area larger than 0.10 square meters as measured at right angles to their longitudinal axis. Deductions will also be made for all openings, recesses and blockouts with cross-sectional area less than 0.10 square meters but which have an individual volume larger than 0.5 cubic meters.

(f) Measurement, for payment, of concrete required for treatment of defects outside the excavation pay lines other than in excavation for underground works, will be made of the actual volume of concrete directed to be placed in these locations.

(g) Payment for concrete in the various parts of the Works will be made at the applicable rate per cubic meter bid in the Schedule. These rates shall include the cost of all labor, constructional plant and materials including cement required in the construction, except that payment for furnishing and handling joint filler, waterstops and reinforcement bars and fabric will be made at the applicable rates bid in the Schedule.

(h) Except as provided in subcause (f) of this Clause, payment will not be made for concrete required to be placed outside specified or approved excavation pay lines due to over-breakage, excess excavation or wasted concrete, or for any other reason.

(2) Formwork

Measurement, for payment, of formwork, separate payment will not be made for formwork for concrete and all costs shall be included in the rates bid in the Schedule for the various items of concrete constructions.

(3) Reinforcing Bars

(a) Measurement, for payment, of placing reinforcing bars will be made only of the calculated mass of the bars placed in the concrete in accordance with the Drawings or as directed by the Engineer.

(b) Payment for placing grade SR 24 rounded reinforcing bars will be made at the rate per tonne bid therefor in the Schedule. Payment for placing grade SD30 and SD40 deformed reinforcing bars will be made at the rate per tonne bid therefor in the Schedule.

(c) All joints or splices shown on the Drawings or directed by the Engineer will be measured for payment as laps, Mechanical compression couplings, approved by the Engineer, will be measured for payment in terms of length of equivalent lap joint. Additional joints or splices will not be measured for payment.

(d) These rated shall include the cost of preparing reinforcement detail drawings, scheduling reinforcement and of furnishing and attaching wire ties and metal, concrete or other supports, of cutting, bending, cleaning, securing and maintaining in position all reinforcing bars. Payment will not be made for joints or splices nor for reinforcement used in miscellaneous precast and prestressed concrete units.

(4) Diversion Tunnel (Not Applicable)

(a) Payment for concrete in the diversion tunnel closure gate structure, inlet and outlet structures and the circular sections of diversion tunnel will be made at the rate per cubic meter bid there for in the Schedule.

(b) Payment for concrete in tunnel plug structure will be made at the rate per cubic meter bid therefor in the Schedule. This rate shall include the cost of the concrete cooling, thermometer pipes and thermometers and grouting of joint.

(5) Concrete Plug

In addition to works included as described in Clause S9.10(1), the entire cost of labor and material related to contact grouting between the plug concrete an the conduit walls shall be included in the rate bid in the Schedule for concrete plug in diversion conduit.

(6) Structure Concrete

(a) Payment for concrete in structure: floor slabs, cantilever walls and bridge pier will be made at the rate per cubic meter bid therefor in the Schedule.

(b) Payment for the precast prestressed beams for the bridge will be made in accordance with Clause S10.06.

(c) Payment for concrete and concrete non-shrink compound will be made at the rate per cubic meter bid therefor in the Schedule.

(d) Payment for concrete in the power house will be made at the rate per cubic meter bid therefor in the Schedule.

(7) Blockout and Second Stage Concrete

Payment for blockout and second stage concrete will be made at the rate per cubic meter bid therefor in the Schedule.

(8) Miscellaneous Concrete

Payment for miscellaneous concrete will be made at the rate per cubic meter bid therefor in the Schedule.

(9) Waterstops

(a) Measurement, for payment, of furnishing and placing waterstops will be of the lengths placed in accordance with the Drawings or as directed by the Engineer. Waterstops installed by the Contractor in construction joints in locations other than those shown on the Drawings or directed by the Engineer will not be measured for payment.

(b) Payment, of furnishing and placing waterstops will be made at the applicable rate per linear meter under the following types set forth in the Schedule.

(i) PVC waterstop type A, B and C

(10) Material Seals in Joints

Separate payment will not be made for material seals in joints and cost of materials shall be included in the rate bid in the Schedule for the various items of concrete joints.

(11) Joint Fillers and Sealer

(a) Polysulphide and Bitumen-Rubber mastic joint filler
Measurement, for payment, of furnishing and placing mastic joint filler

will be made of the dimensions shown on the Drawings Payment for furnishing and placing polysulphide and bitumen-rubber mastic joint filler will be made at the rate per square meter bid therefor in the Schedule. This rate shall include the cost of the protective synthetic rubber membrane.

(b) Bituminous fiber sheet and expanded polystyrene joint filler

Measurement, for payment, of furnishing and placing bituminous fiber sheet and expanded polystyrene joint filler will be made to the dimensions shown on the Drawing of the area required to be covered with joint filler and deductions will not be made for openings required to be made in the joint filler. Joint filler required to be placed beyond the excavation pay lines will not be measured for payment. Joint filler required to be raked out of the joint will be measured for payment as expanded polystyrene. Payment for furnishing and placing bituminous fiber sheet joint filler, and for furnishing and placing expanded polystyrene joint filler will be made at the applicable rate per square meter bid therefor in the Schedule.

(c) Joint strips

Measurement, for payment, of furnishing and installing joint strips will be made of the length of joint strips as shown on the Drawings or directed by the Engineer. Payment for furnishing and installing joint strips will be made at the rate per linear meter bid therefor in the Schedule.

(d) Annular seal for pipes

Measurement, for payment, of furnishing and placing annular seal for pipes will be made of the length of joint sealed as shown on the Drawings or as directed by the Engineer. Payment for furnishing and placing annular seal for pipes will be made at the rate per linear meter bid therefor in the Schedule.

(e) Cork board

Measurement, for payment, of furnishing and placing cork board will be made of the area of joint sealed as shown on the Drawings or as directed by the Engineer. Payment for furnishing and placing cork board will be made at the rate per square meter did therefor in the Schedule.

(f) Cork mastic

Measurement, for payment, of furnishing and placing cork mastic will be made of the volume of joint filled with mastic shown on the Drawings or directed by the Engineer. Payment for furnishing and placing cork mastic will be made at the rate per square meter bid therefor in the Schedule.

(g) Pipe wrapping material

Measurement, for payment, of furnishing and placing pipe wrapping material will be made of the area of pipe shall wrapped as shown on the Drawings. Payment for furnishing and placing pipe wrapping material will be made at the rate per square meter bid therefor in the Schedule.

(h) Epoxy mortar

Measurement, for payment, for epoxy mortar will be made of the actual volume of mortar placed in the blockout and under baseplates. Payment for furnishing and placing epoxy mortar will be made at the rate per cubic meter bid therefor in the Schedule.

SECTION 10 - PILING PRECAST AND PRESTRESSED CONCRETE

SECTION 10 - PILING PRECAST AND PRESTRESSED CONCRETE

S10.01 PILING WORK

(1) GENERAL

Piles shall be constructed, in accordance with the details shown on the Drawings, of concrete Class D, proportioned, mixed and placed in accordance with the provisions of Section 8 and this Section. Reinforcement shall comply with the provisions of Section 8. Main reinforcing bars shall be supplied in one complete length and should this prove impracticable separate lengths shall be effectively spliced by a method approved by the Engineer.

The pile shall be so straight 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.

(2) PREPARATION FOR DRIVING

(a) Abutments

Abutment piles shall be driven from a working surface which extends up to the underside of the pile cap and out to the finished slopes around the abutment. The working surface shall form part of the permanent embankment and shall be constructed to the relevant specifications. Under no circumstances will the Contractor be permitted to complete this part of the embankment after the piles have been driven.

(b) Pile Caps

The heads of all concrete piles shall be protected by caps of approved design, preferably having a rope or other suitable cushion next to the pile head and fitting into a casting which in turn supports a timber shock block.

(c) Splicing Piles

Full length piles shall be used where practicable. In exceptional circumstances splicing of piles may be permitted.

Splices shall be made as follows:

After the driving is completed, the concrete at the end of the pile shall be cut away, leaving the reinforcement steel exposed for a length of 40 diameters. The final cut of the concrete shall e perpendicular to the axis of the pile. Reinforcement similar to that used in the pile shall be securely fastened to the projecting steel and the necessary form work shall be placed, care being taken to prevent leakage along the pile. The concrete shall be of the same quality as that used in the pile, lust prior to placing concrete, the top of the pile shall be thoroughly wetted and covered with a thin coating of neat cement, retempered mortar or other suitable bonding material. The forms shall remain in place not less than seven days and shall then be carefully removed and the entire exposed surface of the pile

finished as previously specified.

(3) METHOD OF DRIVING

(a) General

Reinforced concrete piles may be driven using a drop hammer, single or double acting steam hammer, or a diesel hammer. Drop hammers shall weigh not less than 80 percent of the pile weight and the drop shall be not more than one meter. Steam and diesel hammers shall produce an equivalent energy per stroke.

In case the required penetration is not obtained by the use of a hammer complying with the above minimum requirements, the Contractor shall provide a heavier hammer or resort to jetting at this own expense.

(b) Leads

Pile driver leads shall be of approved design and constructed in such a manner as 1_0 afford freedom of movement of the hammer, and they shall be held in position by guys or stiff braces to insure support to the pile during driving. Except where piles are driven through water, the leads shall be of sufficient length so that the use of a follower will not be necessary.

Inclined leads shall be used in driving battered piles, and shall provide sufficient lateral support for the pile so that no undue stresses are induced in the pile during driving.

(c) Followers

The driving of piling with followers shall be avoided if practicable and shall be done only under written permission of the Engineer.

(d) Water Jets

When water jets are used, the number of jets and the volume and pressure of water at the jet nozzles shall be sufficient to freely erode the material adjacent to the pile. The plant shall have sufficient capacity to deliver at all times at least 7 kilograms per square centimeter pressure at 20 mm jet nozzles. Before the desired penetration is reached, the jets shall be withdrawn and the piles shall be driven with the hammer to secure the final penetration.

(e) Accuracy of Driving

Piles shall be driven with a deviation of not more than 1° from the vertical or from the batter shown on the plans. After driving, the positions of the pile heads shall not deviate by more than 80 mm from the positions shown on the Drawings. The center of gravity of any row of piles shall be within 50 mm from its theoretical position in any direction.

(f) Defective Piles

The procedure incident to the driving of piles shall not subject them to excessive and undue abuse producing crushing and spalling of the concrete. Manipulation of piles to force them into proper position, considered by the Engineer to be excessive, will not be permitted. Any pile damaged by reason of internal defects, or by improper driving or driven out of its proper location or driven below the elevation fixed by the Drawings or by the Engineer, shall be corrected at the contractor's expense by one of the following methods approved by the Engineer for the pile in question:

- The pile shall be withdrawn and replaced by a new and if necessary,

  a longer pile.

- A second pile shall be driven adjacent to the defective or low pile.

- The pile shall be spliced or build up as otherwise provided herein or a sufficient portion of the footing extended to properly embed the pile.

All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down again to their previous elevations.

(g) Cutting Off Piles

Piles shall be cut off at such elevation that they will extend into the cap or footing as indicated on the Drawings. Reinforced concrete piles may be cast the full length of the reinforcing bars, provided that the concrete is cut off to expose the steel as shown on the Drawings after the piles have been driven.

All cut off lengths of piling shall become the property of the Contractor. Cut-off lengths of piling may be incorporated in the work if approved in writing by the Engineer, otherwise pile cut-off lengths shall be disposed off to the satisfaction of the Engineer.

(4) DETERMINATION OF BEARING CAPACITY

(a) General

All piles shall be driven to such depths or sets as may be required to obtain the necessary allowable bearing value. The Engineer will decide on the criteria for when this value has been achieved, based on the criteria for when this value has been achieved, based on load tests or the driving records. He will choose a factor of safety dependent on the uniformity of the foundation conditions, but the required ultimate load will generally be two and a half times the working load for loading tests, or three times the working loading when determining the final set of the pile according to the specified driving formula.

(b) Test Piles

The lengths of piles shown on the Drawings are based on information which it has been possible to obtain from a site investigation prior to the driving of test piles.

Before the driving criteria are finally settled, the Contractor shall construct to the lengths specified by the Engineer such pilot piles as may be found necessary and these piles shall be driven · the positions and to the set specified by the Engineer, who shall be notified in advance of the driving. The Contractor shall furnish the Engineer daily with a detailed record of the driving of pilot piles throughout the full depth of driving, as specified in clause (c) below.

Based on the results of the pilot piles, the Engineer will choose one or more locations for pile loading tests which shall be carried out prior to driving production piles.

(c) Loading Tests

The Engineer may require one or more loading tests at each building location. At the start of the Project, the Contractor shall therefore submit to the Engineer detailed Drawings of the equipment and arrangement be intends to use for loading tests. The equipment shall be designed to apply loads in smooth increments. If the Contractor proposes to suspension piles for the load reaction, such tension piles shall be of the same type and size as the permanent piles and shall be driven in the location of permanent piles. Loads for the load test shall not be applied until 10 days or such times as directed by the Engineer have elapsed since the driving of the piles. Tension piles will require strengthening with extra steel to carry the tension loading. The Contractor shall submit Drawings to the Engineer showing the extra reinforcement and method of transferring the load between the piles and loading frame. A minimum of 3 pile diameters clear distance shall be allowed between the test pile and tension piles.

No particular payment will be made for any additional length supplied, cast or driven, or for any additional reinforcement of such piles that may be required for their use as tension piles, nor for any resumed driving that may be ordered by the Engineer, during or after the test, due to the piles having moved, or for repair of any damage caused during the test, such costs being considered incidental to load tests, and included in unit rate of Load Test.

Piles selected by the Engineer shall be tested as follows:

- The test load shall be applied by a method approved by the Engineer and shall be measured within the accuracy of 2 percent. Settlements shall be measured within an accuracy of 0.2 mm.
- The test load shall be applied in the increments of 25 percent of the working load of the pile.
- The load after each increment shall be kept constant until the rate of settlement does not exceed 0.2 mm per hour.

- The amount of settlement shall be recorded before the next increase of load.
- The load shall be reduced in stages equal to those in which it was applied.
- The amount of recovery shall be recorded before the next decrease of load.
- The Contractor shall, within 24 hours of the completion of the test, submit to the Engineer for each pile tested graphs showing load and settlement plotted above and below a common base line of time; settlement and recovery plotted vertically against a base line of load.

The ultimate bearing capacity of the pile shall be defined as the load where the gross settlement begins to exceed 1 mm per ton of additional load, or which cause a gross settlement of 25 mm, whichever occur first.

Other details of loading tests shall conform to method defined by the Engineer.

(d) Driving Records

A record of all piles installed shall be kept by the Contractor and a copy of the record of each day's work shall be given to the Engineer within 24 hours. The record shall contain the following information:

Date of driving
Date of casting and identification number Location of pile
Length of pile and cross section
Ground level before driving
Estimated tip elevation (as shown on the Drawings)
Actual tip elevation after driving
Number of blows for each 30 cm penetration from start of driving
Number of blows for each 10 cm penetration for last 100 cm
Hammer type, weight and rated energy
For drop hammer, the actual drop height
Details of interruptions to driving
Details of redriving
Details of condition of pile head.

On completion of piling, the Contractor shall deliver to the Engineer a drawing recording the final depths of all piles relative to project elevations.

(e) Driving Formula

To interpolate bearing capacities of piles between load test locations or at locations where load tests have not been earned out, the ultimate capacity of piles may be calculated from the following formula:

$$Q_{ult} = \frac{1000eWH}{S+0.5\sqrt{(eWHL/A)}}$$

Where Q_{ult} = Ultimate bearing capacity in t

W = weight of hammer in t

H = drop of hammer in m

L = length of pile in m

A = cross section of pile in sq.m

S = penetration per blow in mm, for the last 20 blows

e = efficiency factor:

1.0 for drop hammer with free fall

0.7 for drop hammer with wire drum hoist

0.9 for single or double acting hammer

For piles driven with a diesel hammer, the bearing value may be calculated according to the formula given by the manufacturer of the hammer, subject to the Engineer's approval.

S10.02 PRECAST CONCRETE

(1) General

(a) The Contractor shall construct and erect precast reinforced concrete units in accordance with this Clause where and as shown on the Drawings or directed by the Engineer.

(b) Except as otherwise provided in this Clause, all units shall be constructed and erected in accordance with the applicable requirements of the Specification and ACI 318M-83.

(c) The maximum size of the coarse aggregate for all precast concrete units shall be 20 mm.

(d) All precast concrete units shall be cast in individual forms and may be cured by steam curing.

(e) Where the use of immersion type vibrators is not practicable the Contractor shall consolidate thin precast concrete slabs and units on a vibrating table or by another effective method.

(f) Precast concrete units shall not be branded or marked in any position which can be seen in the finished work or against which any concrete is to be placed.

(g) The units may be supplied by a manufacturer or may be manufactured by the Contractor at an approved location. For units other than concrete blocks and precast units which are detailed on the Drawings, the Contractor shall also submit to the Engineer all details of the individual units, including proposed reinforcement, proposed concrete strength and location of lifting points as hereinafter specified.

(h) Repairing of damaged units will not be permitted except where such damage and repair will not impair the installation or the appearance of the units after installation.

(2) Submission of Proposed Methods

Thirty (30) days before commencing manufacture of all precast reinforced concrete units, the Contractor shall submit to the Engineer all details of the methods to be used in manufacture, handling, transport, storage and erection of the units.

(3) Handling

During transportation and storage, all precast reinforced concrete units shall be supported as in their final positions. Precast members shall be adequately braced and supported during erection to ensure proper alignment and safety. Such bracing or support shall be maintained until adequate permanent connections have been made.

(4) Tolerances

The dimensions of all finished precast reinforced concrete units shall be within the following limits at the time of placement of the units in the structure, unless otherwise shown on the Drawings:

(a)	Overall dimensions of units	+/- 5 mm
(b)	Cross-sectional dimensions	
	(i) sections less than 75 mm	+/- 1.5 mm
	(ii) sections over 75 mm	+/- 5 mm
(c)	Deviation from straight line in long section	Not more than 5 mm per 6 m
(d)	Deviation from specified camber	+/- 1.5 mm per 3 m of span
(e)	Maximum differential in camber between adjacent units in erected position	10 mm

S10.03 PRESTRESSED CONCRETE

(1) General

(a) The Contractor shall manufacture prestressed concrete units (or members) as shown on the Drawings or directed in accordance with this Clause and the applicable provisions of the Specification. The work shall be supervised either by specialist staff experienced in prestressing or shall be carried out by a specialist subcontractor and shall comply with ACI 318M or AS 1481 except as otherwise specified in this Clause.

(b) The Contractor shall construct and erect the prestressed concrete members to the lines, grades and dimensions shown on the Drawings or directed.

(2) Methods of Prestressing

(a) The method of prestressing shall be as shown on the Drawings unless otherwise approved.

(b) The Contractor may propose an alternative system to that specified herein and shown on the Drawings. The proposed alternative system shall provide means of:

(i) prestressing in stages, and destressing at any stage before grouting; and

(ii) measuring the load in the tendons.

(c) All members of the Contractor's alternative system shall be designed for the prestress forces and eccentricities shown on the Drawings. Reinforcement behind prestressing anchor plates shall be designed for the anchor plate sizes and prestressing forces shown on the Drawings.

(d) Any alternative prestressing systems proposed by the Contractor shall be such that the general arrangement, depth and outward shape of the members remain unaltered.

(e) The Contractor shall submit to the Engineer, at least thirty (30) days before constructing any members, full details of anchorages, anchorage reinforcement, sheathing and relevant particulars of the proposed tendons, together with complete drawings of those parts of the structure affected by the change and all appropriate design calculations.

(f) The Contractor shall precast the prestressed members at an approved location.

(g) The Contractor shall at least thirty (30) days before commencement of manufacture of the prestressed members:

(i) Submit, to the Engineer, full details of his method of forming, placing and curing of the members and of his handling, transporting, erection, stressing and grouting methods. The Contractor shall not vary his methods without resubmitting full details of the proposed changes.

(ii) Submit shop drawings and details of all metalwork, prestressing tendon anchorages to be embedded in the members, schedules of locations of material and marks by which individual items can be identified.

(3) Concrete Materials

Cement, admixtures, water and aggregates for prestressed concrete members shall comply with the applicable requirements of this Specification.

(4) Materials for Tendons

(a) High tensile steel wire and strand shall conform to ASTM A416 - A421 or AASHTO M204.

(b) High tensile alloy bars shall have the following physical properties:

(i) Minimum tensile strength – 1,080 MPa (11.0 tonnes/cm^2)

(ii) Proof stress at a non-proportional strain of 5 percent, not less than 85% of the minimum tensile strength.

(iii) Percentage elongation at fracture, not less than 6 percent.

(iv) Relaxation at 1,000 hours from initial stress of 70 percent ultimate tensile strength, not more than 4 percent.

(c) The Contractor shall state the secant modulus of the material proposed at the average tensioning stress shown on the Drawings together with the guaranteed limits of its variation. Values shall be substantiated by test results.

(d) High tensile steel bars will be individually inspected for superficial tears, nicks, roller marks or any other form of surface imperfection. A bar with surface imperfections that range from 0.15 mm to 0.40 mm deep may be accepted for use at the discretion of the Engineer, provided the imperfections whose depths range from 0.15 mm to 0.40 mm are filed smooth with a fine cut half round file. A bar with surface imperfections that exceed 0.40 mm in depth will not be acceptable for use. Notwithstanding the above conditions of acceptance, any bar which has an imperfection that the Engineer considers detrimental to the strength of the bar shall not be used.

(e) Three (3) test pieces selected by the Engineer shall be tested by the Contractor and manufacture of cables or placing of tendons shall not commence until satisfactory results have been received from these tests. Further test pieces, approximately one for each tonne of tendons used in the construction, will be taken during the progress of the work and shall be tested by the Contractor for conformity with the requirements of this Specification. The ratio of length to diameter of test pieces will exceed 100:1. Test pieces will not be taken from the end 1.5 m of a coil of wire or strand.

(f) All testing shall be carried out in an authorized and registered laboratory approved by the Engineer.

(5) Anchorage Devices and Couplings

(a) All anchorages for high tensile steel strand tendons shall generally be in accordance with ACI 318M. All anchorages shall be provided with a positive centering device so that the anchorage heads shall not move during tensioning operation.

(b) All high tensile steel bar tendons shall be anchored by means of rolled threads and nuts except that, for wholly embedded anchorages, tapped plates shall be used in conjunction with the rolled threads.

(c) Anchorages and coupling devices shall be capable of withstanding a force of not less than 95 percent of the specified minimum ultimate tensile strength of the tendon without damage or excessive deformation or draw-in.

(d) Swaging of strand and button-heading of wire shall be carried out only by approved methods and the swages/button-heads shall develop not less than 95 percent of the specified minimum ultimate tensile strength of the strand or wire.

(e) At least thirty (30) days before the start of concreting operations, the Contractor shall supply, to the Engineer, details and results of tests carried out on the following:

(i) Two (2) complete anchorages and couplings for each type of tendon to be used in the Works.

(ii) Two (2) sample lengths of tendon with ends treated for anchorages and couplings.

(f) Further anchorages and couplings shall be tested by the Contractor during the progress of the work at the rate of one anchorage of each size and one coupling for the strand prestress tendons and one complete high tensile steel bar tendon for each consignment delivered to the Works. Sufficient length of the appropriate made-up tendon shall be tested with

each anchorage or coupling for the strand prestressed tendons to suit testing arrangements.

(g) Anchorages and tendons shall not be installed until test results for the anchorages have shown that they meet the specified requirements.

(h) Should any anchorage or coupling fail to comply with paragraph d. of this subclause, the quantity of anchorages or couplings represented by that specimen shall be replaced.

(i) No damaged anchorage or coupling devices shall be used. All steel in the anchorages shall be protected from corrosion at all times. All threaded parts shall be protected by greased wrapping and all tapped holes shall be protected by suitable plugs until used. The devices shall be kept free from mortar, loose rust, grease, tar, paint, oil, mud or any other coating. The Engineer may direct the use of a suitable coating to protect the exposed faces of anchorages and anchorage plates after embedment in the precast girder segments but all such coating shall be removed immediately before the tendons are installed.

(6) Ducts

(a) Ducts for the insertion of prestressing tendons shall be formed in the concrete members by means of light-gauge steel conduits, flexible steel sheathing or by other acceptable means except that bars may be cast in place after wrapping with a tape coating to prevent bonding with the concrete.

(b) The ducts shall be strong enough to withstand the placing and the vibration of the concrete without suffering any damage or deformation. Internal and external diameters of the ducts shall be within the limits shown on the Drawings.

(c) The ducts and any joints shall be mortar tight and the ducts shall be in one piece between the ends of each segment or placement. Curved pieces of duct shall be pre-bent to the dimensions shown on the Drawings and shall be checked with lengths of tendon for flattening and other distortions which might obstruct the free movement of the tendons.

(d) Before the ducts are embedded in the concrete, they shall be accurately aligned and securely fixed in position by means of rigid supports spaced at intervals of not more than 1 m. Bar tendons to be cast in place shall be similarly aligned and fixed, but shall not be welded to the supports.

(e) Grout holes shall be provided at both ends of ducts and shall be at least 10 mm in diameter. The grout holes shall be equipped with a plug, valve or similar device capable of withstanding a grout pressure of 700 kPa without loss of water or air. For ducts with high points along their length, additional vents with plug valves of similar diameter shall be provided at

the high points to bleed air and water and to ensure that the duct is completely filled with grout after grouting.

(7) Handling and Storage of Tendons and Accessories

(a) The Contractor shall receive all materials at the Site and store the materials under cover on suitable supports above the ground. High-tensile steel wire and strand shall be supplied in coils, which shall be supported so that they are free to rotate before lengths of tendons are drawn from them. Materials shall be kept free from loose or thick rust, oil, grease, tar, paint, mud, or any other deleterious substance but shall not be brought to a smooth polished condition. A slight film of rust will not be regarded as harmful, but the steel shall not be visibly pitted by rust.

(b) The Contractor shall be responsible for checking that all dimensions and quantities shown on the manufacturers' schedules are correct and shall obtain copies of these schedules from the manufacturers for this purpose.

(c) Before being assembled or worked in any way, the prestressing materials shall be clean and free from kinks or damage. All damaged materials shall be removed from the Site and replaced.

(8) Marking of Precast Prestressed Members

(a) The date of casting, length of member and the identification number directed by the Engineer shall be marked on every precast prestressed member in an approved position which cannot be seen in the finished work. When directed the word "TOP" and/or lifting positions shall also be marked on the member.

(b) Temporary identification and date of casting marking shall be scratched into the top surface of the member near an end immediately after screeding off.

(c) The final marking shall be made by indelible marking material using letters approximately 75 mm high.

(9) Lifting, Handling and Stacking of Precast Prestressed Members

(a) Post-tensioned members shall be fully stressed or stressed to the extent shown on the Drawings and all stressed tendons shall have been grouted for seven (7) days before lifting or handling of the member unless the moving of post-tensioned members off their casting beds before grouting stressed tendons is approved. If such approval is given each ungrouted tendon shall be adequately marked for possible slip and should any slip or damage occur, the tendon shall be replaced and/or restressed as directed.

(b) At all times, during handling, members shall be secured in an upright position by means of suitable packing pieces and braces. Members shall

not be braced against each other but shall be provided with independent bracing. Special care shall be exercised not to damage the flanges of members.

(c) Members shall not be stacked on top of each other and no superimposed load shall be placed on a member.

(d) Members shall be handled, lifted and supported carefully at the positions and in the manner shown on the Drawings. Where no method of lifting is shown on the Drawings, the Contractor shall submit details of his proposal for lifting the members.

(e) No member which is manufactured away from the Site shall be delivered to the Site without prior approval.

(10) Dimensions and Tolerances

(a) The dimensions and shape of prestressed concrete members stated on the Drawings shall be taken to apply to the members and structure at the time of their completion when under self weight alone.

(b) Except where stated otherwise on the Drawings or approved by the Engineer, the dimensions and profile of the forms shall compensate for deformations caused by prestressing so that the dimensions and profile of the completed members shall conform to the Drawings. The Contractor shall submit, prior to construction of the forms, details of the magnitude of these deformations and how he proposes to allow for them.

(c) Variation in the overall length and length centre to centre of bearings shall be accurate to within 5 mm or +/-0.06 percent of the length, whichever is the greater.

(d) Deviation from profile in a vertical plane:

Sagging profiles will generally not be accepted but upward deviation (hog) from the required profile of up to 0.1 percent of the span length will be permitted.

(e) The deviation of a member from the required profile in a horizontal plane shall not exceed 5 mm or +/-0.06 percent of the length of the member, whichever is greater.

(f) Variation in location ducts and sheathing: +/-4 mm.

(g) Cover to ducts and sheathing shall be not less than 50 mm.

S10.04 MANUFACTURE OF PRESTRESSED CONCRETE MEMBERS

(1) General

(a) The Contractor shall manufacture precast prestressed concrete members to the dimensions shown on the Drawings or directed.

(b) Care shall be taken during tensioning to ensure the safety of all personnel engaged on the work and of other persons in the vicinity.

(c) Jacks shall be secured in such a manner that they will be restrained should they lose their grip on the tendons. No person shall be allowed to stand behind the jacks or close to the line of action in front while tensioning is in progress. The operation of the jacks, the measurement of the elongation and associated operations shall be carried out in such a manner and from such positions that the safety of all concerned is ensured.

(d) Heavy stoppers made either of hardwood or sheet metal shall be provided and placed in such a manner as to prevent any tendon, which might become loose, recoiling unchecked. During actual stressing operations, warning signs in adequately large letters shall be displayed at both ends of the post-tensioned member.

(e) Sheathing for all ducts shall be placed accurately in the formwork in the position shown on the Drawings and shall be adequately tied and held against movement during concreting. The sheathing shall be fixed so as to ensure the alignment as well as the position of ducts at joints is accurate. The joint between the sheathing and anchorage plates shall be mortar tight. Ducts shall be stiffened during concreting by means of an internal strand of diameter equal to or greater than the final strand tendons. Immediately after the whole of the concrete has been placed in a precast member, all duct internal stiffeners shall be pulled back and forth for about 300 mm to ensure they are perfectly free inside the ducting.

(f) High tensile steel bar tendons shall be located as shown on the Drawings and suitable devices shall be provided to ensure that the tendons are maintained in their correct position, both laterally and vertically, during casting. When bar tendons are being placed, particular care shall be taken that the tendons shall not come into contact with the oiled surface of the forms or be otherwise contaminated. Any oil or other contamination which might collect on the tendons shall be removed by cleaning the affected tendons with clean rags soaked in mineral spirit or by other approved methods. Welding of high tensile steel bar or plate will not be permitted. High tensile steel bars or plates splashed by weld splatter shall be removed and replaced at the expense of the Contractor. After installation of the bar tendons in the forms, the exposed parts of the rolled threads on the bars shall be protected and such protection shall be kept over the threads until just before tensioning the tendon.

(g) All anchorage plates for prestressing tendons shall be accurately positioned square to the line of action of the tendons and held firmly during concreting. Any mortar adhering to the exposed faces of the anchorages shall be removed.

(h) Placing of concrete shall be performed only in the presence of the Engineer.

(2) Tensioning Equipment

(a) All tensioning equipment shall be preferably power driven. The power unit shall be adjusted so that the rate of extension of the tendon is within recommended limits or as directed by the Engineer.

(b) Dynamometers and each set of equipment comprising pump, jack and pressure gauges shall be calibrated immediately prior to delivery to the site and every six months thereafter unless otherwise directed and the true force determined from the calibration curve. Calibration certificates shall be submitted to the Engineer prior to the equipment being delivered to the Site. Dynamometers and scales shall permit force and elongation respectively, to be determined within an accuracy of 2 percent.

(c) Pressure gauges shall be concentric scale gauges accurate to within 1 per cent of their full capacity. They shall be selected so as to be used between 50 and 90 percent of their full capacity. Where pressure gauges are used, a snubber, or similar device, shall be fitted so as to protect the gauge against sudden release of pressure. Provision shall also be made, by such means as a Tee connection, for the attachment of a second gauge to be used as a check whenever so requested by the Engineer.

(3) Required Strength and Age of Concrete for Prestressing

(a) The prestressing force shall not be applied to a member until all the concrete in the member has attained the compressive strength stated on the Drawings, nor shall it be applied at an earlier age than 60 hours after casting (or repair) or 36 hours after casting (or repair) when steam cured, provided that when steam cured the temperature of the concrete has returned to the ambient temperature. The use of excess cement to obtain high early strength will not be permitted.

(b) The age at which the prestressing force is to be applied shall take into consideration the modulus of elasticity of the concrete. Variations in atmospheric temperature and humidity may make it desirable to vary the age at which members are prestressed so that the modulus of elasticity, and hence the resulting deformations, are as alike as possible.

(4) Tensioning Force Required

(a) The tensioning force applied to any tendon shall be measured both directly by measurement of the force or jacking pressure and indirectly by measurement of the elongation of the tendon. Where not stated on the Drawings, the Engineer will direct which of these methods is to be regarded as determining the tensioning force and which is to be regarded as checking it.

(b) The Contractor shall measure tensioning force required for the elongation and for the force in the tendon at the jack. Allowance shall be made for the anticipated draw-in at the anchorage devices on release of the jacks. Any difference in the force determination from each measurement greater than 5 percent shall be ascertained and corrected.

(c) Determination of the tensioning force by means of elongation will only be accepted when the limits of variation of the secant modulus, at the tensioning stress guaranteed by the Contractor, are approved. Should the secant modulus of batches of tendons differ by more than 3 percent, the required elongation shall be adjusted accordingly.

(d) Every endeavor shall be made to obtain the force shown on the Drawings or directed. A tolerance of 5 percent will be permitted for individual tendons provided that the total prestress load being applied at that time is within 2 percent of the required value.

(e) If, on completion of tensioning of a tendon, the requirements of this Clause and ACI 318M are not satisfied, the Engineer may direct the Contractor to adopt special methods overcoming friction loss, such as lubricating the tendon with a water soluble oil, and may direct the tendon to be stressed simultaneously from both ends in the restressing operation if this is physically possible.

(5) Placing and Tensioning of Tendons

(a) Strand prestressing tendons shall be placed in the sheathing in accordance with the recommendations of the prestressing system supplier and this Clause.

(b) The method of placement shall be such as to ensure that neither the tendon nor the sheathing shall be damaged during the operation.

(c) Immediately before placing each tendon, the Contractor shall ensure that all water is driven out of the duct and that the strand tendon, once placed, shall be completely protected against weather, in the period between placing in the duct and grouting, by covering and sealing openings in the duct. In the period between placing in the duct and grouting of the tendon, ends exposed to weather shall be provided with weatherproof coverings. The Engineer may direct the Contractor to dry any tendon in a duct or to fill the duct with a saturated lime solution before fitting the weatherproof covers and seals.

(d) The tensioning procedure for all tendons shall be in accordance with ACI 318M. Tensioning shall be performed only in the presence of the Engineer and only by technicians trained for and experienced in this type of work. Special care shall be taken to apply the tensioning force smoothly and at an even rate and to release the jack smoothly. Members shall be prestressed in accordance with the best practice applicable to the particular prestressing method.

(e) The process of prestressing shall be continuous, the tendons being stressed in the sequence and to the loads shown on the Drawings and the operation completed without interruption in as short a time as possible, unless otherwise specified or directed by the Engineer.

(f) The protruding ends of tendons shall be cleaned of any contamination which may have accumulated since placing. Tendons shall be checked before tensioning to ensure that they are free to move inside the duct, and anchorages shall be thoroughly cleaned before commencement of tensioning. Special care shall be taken to set the jack or jacks accurately in the line of the tendon. The force which is applied initially to take up the slack of the tendon shall be chosen so as to seat the jack firmly but shall not exceed the force normally associated with the particular method of prestressing. During the tensioning of each tendon, after taking up the slack, the jack force (or pressure) shall be read and an elongation reading made. Subsequent similar readings of force and elongation shall be made at intervals directed by the Engineer and plotted to determine the total tendon elongation. The draw-in on anchoring shall also be measured.

(g) In the case of slipping of one or more components or tendons of a group tensioned together, the Engineer may approve a compensating increase in the elongation of the remaining tendons of the group provided that the jacking force does not exceed 85 percent of the minimum ultimate strength of each of the tendons. If a tendon breaks or slips during or after tensioning, so that the allowable tolerances are exceeded, the tendon shall be released, replaced if necessary and prestressed.

(h) Unless otherwise shown on the Drawings or directed, strand tendons shall be stressed from one end only. When stressing a tendon from both ends is directed, the jacking forces shall not differ by more than 10 percent throughout the tensioning operation. The tensioning operation shall continue until the required force in the tendon at each jack is reached. Where tendons are shown on the Drawings to be stressed simultaneously, the force shall be increased in each tendon so that the maximum jacking force for each tendon is reached and tendons are anchored at approximately the same time.

(6) Data to be recorded

(a) The following data, where applicable, shall be recorded by the Contractor:

(i) Identification number of dynamometers, gauges, pumps and jacks.

(ii) Identification particulars of tendons.

(iii) Initial force (or pressure) when tendons are marked for measurement of elongation.

(iv) Final force (or pressure) and elongation obtained on completion of tensioning.

(v) Elongations remaining after release of jacks.

(vi) Ramming pressures.

(vii) Elongation obtained at suitable intervals during tensioning together with corresponding force (or pressure).

(b) All forms shall be forwarded to the Engineer on completion.

(7) Grouting of Prestress Tendons

(a) The Contractor shall completely fill with grout each prestressed tendon duct in accordance with ACI 318M and this Clause.

(b) Tendons shall be grouted within 24 hours of tensioning unless otherwise directed by the Engineer.

(c) The ratio of water to cement by weight in the cement grout shall not be more than 0.45 and the compressive strength on 150 mm by 75 mm diameter cylinders of cement grout, cured for twenty eight (28) days at 20°C +/-2°C and 97 to 100 percent relative humidity, shall be at least 27.5 Mpa (280 ksc.). Before injection, the grout mixture shall be mixed for a minimum of three minutes by means of a high speed mechanical stirrer and sieved through a 1.4 mm sieve and, unless otherwise directed, the flow time through a standard flow cone shall be not greater than 30 seconds.

(d) The grout shall be prepared using a mixture and additives which prevent shrinkage and bleeding. Neither aluminum powder nor chloride compounds shall be used as an additive. A methyl cellulose additive may be used to improve fluidity and control bleeding. Water used in the grout mixture shall be substantially free of either chloride or sulphate compounds.

(e) At least sixty (60) days before grouting any prestressing tendons, the Contractor shall prepare in the presence of the Engineer a trial mix of his proposed grout mixture including admixtures which shall then be sampled and tested by the Contractor to verify its compliance with this Clause.

(f) As the work progresses, the Contractor shall take further samples for testing when directed. The Engineer may direct that grout mixtures to be varied so as to achieve the specified properties.

(g) The grout shall be used within one hour of commencing to mix the ingredients.

(h) The grouting equipment shall be arranged to provide a supply line and a return line from the grout pump to the grout connection. Provision shall be made to permit accurate control of grouting pressures and of grout flow at the grout connection, and continuous circulation of grout within the grouting system.

(i) The duct to be grouted shall first be filled with water under pressure of 700 kPa (7 ksc.) for at least one hour before grouting. All ducts shall be flushed with clean water followed by compressed air immediately before grouting until all loose particles are removed. Grout shall then be injected by means of a grout pump of either the piston displacement type or screw or impeller type. An even, slow, continuous flow of grout shall be maintained until the duct is completely filled and pure grout of the consistency being injected issues from all vents and until all entrapped air has been expelled. The vents shall be progressively closed until the duct is completely filled. The grout shall then be held at 700 kPa (7 ksc.) pressure for at least one minute after which the grouting end shall be plugged. All care shall be taken to prevent loss of grout immediately after grouting. The grouting tubes shall be topped up with grout if a wastage or subsidence of grout occurs when disconnecting the pump. Unless otherwise directed, all vents and other openings shall be kept closed until regrouting commences.

(j) Sufficient grout shall be available for immediate use to enable the grouting of a whole duct without interruption, refilling of the grout tank or the necessity of mixing further quantities.

(k) Regrouting of prestress tendons, in accordance with this subclause, shall be carried out by the Contractor during the second hour after the first grouting of the tendon has been completed but in any case before the grout begins to set. Grout shall be injected in such a way as to prevent air being introduced into the duct with the grout. The Engineer will direct the locations at which grout is to be injected into any duct. The Engineer may direct the use of a mineral pigment in the grout to help determine when grout from the second grouting operation is beginning to flow through vent openings.

(8) Cutting and Protection of Anchorages

(a) After the grout in any tendon duct has set, the wire or strand ends shall be cut to the prestressing system supplier's requirements with a cutting disc.

(b) All anchor heads for strand tendons shall be protected by grout or concrete with a minimum clear cover of 25 mm.

S10.05 PRESTRESSED BEAMS FOR BRIDGE

The Contractor shall manufacture and erect the precast prestressed concrete beams for the bridge shown on the Drawings or directed by the Engineer.

S10.06 MISCELLANEOUS PRECAST CONCRETE

The Contractor shall furnish and install miscellaneous precast concrete not specifically included elsewhere, including but not limited to:

(1) Precast covers for the sewerage stilling chambers and miscellaneous manhole covers.

(2) R.C. pile and R.C. box beam for bridge.

(3) R.C. pipe and guard post for access roads.

S10.07 MEASUREMENT AND PAYMENT

(1) Piling Works

(a) Measurement of piling works

When concrete piles are extended, the length of the extension from the cut-off to the top of the extension shall be considered as concrete piling and will be added to the original length for measurement.

The cut-off elevation will be considered to extend five centimeters into the pile cap and no deduction of concrete volume of the pile cap will be made.

If after driving of test piles or completing the pile tests for a particular structure the Contractor desires for his own convenience of pile rig utilization to drive the other piles of the particular structure, before their tip elevations have been calculated and agreed upon, he may apply in writing to the Engineer to do so. The Engineer may approve this application provided tot the Contractor agrees to redrive the piles so driven at a later date if the calculated pile tip elevations fall lower than the elevations to which the piles were driven or, if the piles were over driven to a lower elevation than those calculated from the pile load test, to accept payment to the pile tip elevation established by .the pile load tests.

In the case of extending the pile bent above the lateral braced beam, the cut-

off elevation will be considered to be at the bottom elevation of the braced team if the Contractor chooses the option to cut-off piles at this level. The concrete and reinforcing steel in the braced beam as well as in the extended piles will in this case be measured and paid for under the respective unit rates of concrete.

The quantities of bar reinforcing steel required in concrete piling, including the length extending into caps or footings, will not be paid for as a separate item and full compensation therefore will be considered as included in the unit rate price said per lineal meter for concrete piling, unless otherwise specified by the Engineer.

(b) Payment

It not otherwise specified as lump sum contract, reinforced concrete or prestressed concrete pile of specified cross-section shall be paid for at the respective unit rate per linear meter complete in place and accepted.

The price shall include all materials, labor, equipment including reinforcement, hardware, furnishings, formwork. driving, casting, cutting-off. splicing, welding, tools and incident" necessary for the completion of works.

Pay items shall be as follows:

Item No.	Description	Unit
-	Provide and Drive R.C. Pile, Size	Linear meter
-	Provide and Drive R.C. Pile, Size	Linear meter
-	Load Test R.C. Pile, Size.....	Each

(2) Prestressed Beams for Bridge

(a) Measurement, for payment, of prestressed beams for bridge will be made of the set of prestressed concrete in the bridge beam installed.

(b) Payment for furnishing and installing prestressed beams for the spillway bridge will be made at the rate per set bid therefor in the Bill of Quantities. This rate shall include the cost of all labor, equipment and materials to perform the work specified including the supply and installation of the prestressing cables or bars except that payment for in situ concrete, reinforcing steel, jointing materials, bearings and metalwork placed in situ concrete bridge decks will be made at the applicable rates bid in the Schedule.

(3) Miscellaneous Precast Concrete

(a) Measurement, for payment, for furnishing and installing miscellaneous precast concrete will be made of the quantities of concrete in the precast units.

(b) Payment for furnishing and installing miscellaneous precast concrete will be made at the rate per unit bid therefor in the Schedule.

SECTION 11 - BUILDING CONSTRUCTION

SECTION 11 - BUILDING CONSTRUCTION

S11.01 GENERAL

(1) Requirement

(a) The Contractor shall perform the whole of the buildings construction work in accordance with this section.

(b) All building constructions and finishing works shall be performed by skilled workmen or specialists approved by the Engineer. The Engineer may direct the Contractor to supply proof of competency of any workman employed.

(2) Scope of Works

(a) The works include, under this section shall be executed at following locations:

(i) Power house

(ii) Component structure

(iii) Owner's residences and Engineer's residences

(iv) Housing in resettlement area

(b) All materials shall be supplied, placed and attached to the structure by the Contractor. All timber metal or other accessories necessary for proper completion of the Works shall be as shown on the Drawings or as specified or directed and those costs of such material shall be included in the rates bid therefor in the Schedule.

(c) If the Contractor considers that the working space of the control house is not enough for operation the Contractor shall design new lay-out and buildings submit to the Owner for approval. The additional payment shall be paid in the same unit rate as shown in the Schedule.

(3) Submittals

The Contractor shall submit, for approval, samples of all materials with specimens of workmanship, colour and finish for all items specified in this section at least thirty (30) days before the date of procuring such materials.

(4) Nominal Sizes

The Contractor shall allow for variations between nominal sizes and actual sizes where such variation is within the required tolerances or is a normal trade practice.

(5) Finishing Work

Finishing work shall not commence until each or all of the following conditions have been met to the satisfaction of the Engineer:

(a) The area concerned and such adjacent areas which may affect the finishing work have been weatherproofed.

(b) Unless otherwise directed, all construction, including installation of permanent plant, fittings and equipment has been completed.

(c) Concrete or other materials have dried out sufficiently. The Engineer may apply a test for dryness, which he may consider applicable.

(d) In all wall and ceiling finishings, the Contractor shall make necessary provision, to the satisfaction of the Engineer, for the installation of pipes, metal frames, electrical conduit, electrical wiring, lighting fittings, and other fixtures, and shall neatly finish the surfaces around them to conform to the surrounding wall or ceiling finishes.

(6) Tiles

All required floor and wall tiles and roofing sheets of a particular colour or type shall be procured by the Contractor from one source.

(7) Dissimilar Metals

The Contractor shall take all precautions to prevent contact between dissimilar metals in the finished structure and shall provide approved, permanent, separating material. The following precautions shall also apply:

(a) All aluminium abutting steel or copper shall be protected by a 0.20 mm thickness of black polythene fixed with an approved adhesive. Alternatively, zinc chromate primer may be used, taking care not to mark exposed aluminium faces.

(b) Where aluminium abuts onto concrete, the aluminium shall be protected by coating with bituminous paint; taking care not to mark exposed aluminium surfaces.

(8) Painting

Painting of the Works described in this section shall be carried out in accordance with Section 17.

(9) Manufacturer's Recommendations

Unless otherwise specified, approved or directed, all works specified in this section shall be performed in accordance with the written recommendations of the manufacturer from whom the Contractor purchases the specified materials.

Throughout this section the word 'recommended' shall mean 'recommended by the manufacturer of the material'.

(10) Thermal Expansion

Allowance shall be made for thermal expansion where necessary, to the satisfaction of the Engineer.

S11.02 CONCRETE AND REINFORCEMENT

(1) All concrete referred to in this section shall comply with the requirements of Section 8. The minimum compressive strength of concrete shall be as indicated on the Drawings or as directed.

(2) Reinforcing steel shall comply with the prescription of Clause S8.10.

S11.03 BRICK MASONRY

(1) General

This clause covers all works in connection with the construction of walls, partitions and screen block for ventilation as shown on the Drawings or as directed.

(2) Material

(a) Common Brick

Common brick shall be sound, durable, properly burned, free from defects that will affect service ability or strength, and shall be of the best local manufacture conforming to the requirement of TIS. 77-2517.

(b) Cement, Water and Fine Aggregate

Cement, water and fine aggregate for plaster, mortar and grout shall conform to Section 9 except that the grading of fine aggregate shall conform to the following limits:

Sieve Size	Percentage by Mass Passing Sieve
2.36 mm	100
1.18 mm	70-100
0.60 mm	40-80
0.30 mm	5-40
0.15 mm	0.10

(c) Mortar

Mortar shall consist of a homogeneous mixture of ingredients and shall be mixed in the following proportions:

Cement 1 part, hydrated lime 0.10 part and Fine Aggregate 5 parts of the mix volume.

All joints shall be struck flush.

(d) Admixture

Mortar shall be mixed with admixture, which is available in Thailand, to prevent crack and to obtain sufficient adhesive strength. The quantity of admixture shall be controlled so as not to considerably influence the strength and other properties of mortar and the quantity to be mixed shall be approved by the Engineer.

(3) Placing

(a) Common bricks shall be laid in horizontal courses true to line and plumb, and vertical joints shall be staggered with respect to those in the courses next above and below.

(b) All walls shall be raised up uniformly and as regularly as possible. No part is to be raised more than 100 cm above any other part at any time. The mortar in the horizontal and vertical joints shall range from 8 mm to 15 mm thick.

For bed joints a thick bed of mortar shall be spread and only slightly furrowed so that the joint will be completely filled with mortar. Spreading of the bed mortar shall extend only so far ahead that the mortar will be plastic when the blocks are laid. The ends of the blocks shall be buttered with an ample quantity of mortar and thebrick pushed into place so that the vertical joint is completely filled with mortar. In making closures ample mortar shall be spread in the closure space, the

closure brick buttered on both end and end joints are completely filled with mortar.

(c) Where an adjustment must be made after the mortar has lost its plasticity, the mortar shall be removed and fresh mortar shall be used to reset the Works.

(d) The Contractor shall install at every third course of bricks, two 6 mm diameter bars embedded in mortar that will run horizontally for the whole length of the wall. Brick masonry shall be tied to adjoining columns with anchors sufficiently long to extend into the masonry not less than 20 cm and spaced at 35 cm interval or at every sixth coarse which is the lesser.

(e) Screen Blocks for Ventilation

These blocks shall be placed of the wall of the generator house as indicated in the related Drawings. Opening of blocks shall be square and made of concrete of 39x19x7 cm.

(f) Lintels

The Contractor shall construct and install concrete lintels for doors, windows and other openings left in the brick walls and partitions. The size of the lintels shall be of the thickness of the wall and in accordance with the span of the opening, as shown on the Drawings or directed. Each lintel shall be composed of two 9 mm diameter bars.

S11.04 FLOOR FINISHES

(1) General

(a) The Contractor shall furnish and install the floor finishes, as specified in this clause, in areas as shown on the Drawings or as directed.

(b) The Contractor shall be responsible for ensuring that the background or subbase to which the specified finished is to be applied, has properly cured, has the correct moisture content, is properly finished and is completely adequate to receive the specified finish. Any faulty work resulting from non-compliance with the above shall be replaced at the Contractor's expense and such replacement may be extended at the Engineer's discretion to include the whole of the rooms or area affected.

(2) Preparation of Surface

(a) The surfaces of all concrete floors specified to receive a finish shall be constructed as shown on the Drawings.

(b) The Contractor shall maintain the prepared surface in a satisfactory condition until the time of application of the specified finish, and shall ensure that:

(i) All materials likely to reduce adhesion of the finish, including curing compounds and surface retarders, shall be removed before application of the specified finish and the surface left dust free and clean. The surface shall be protected from contamination until the time of laying finish.

(ii) Surfaces that are to receive cement mortar shall be roughened and dampened before application of the mortar.

(iii) All traffic and loads shall be kept off completed work at least until bonding has set. If possible, areas shall be locked upon completion of finishing work.

(iv) The finished floors shall be protected by taping down building paper over finished surfaces, lifting and relaying as required for cleaning, sealing and polishing and removing immediately before handing over.

(3) Asbestos Vinyl Tile/Ceramic Tile Finish

(a) The subbase of surfaces with asbestos vinyl tile and ceramic tile finishes shall be prepared in accordance with subclause (2) above.

(b) Materials

(i) Asbestos vinyl tiles of size as shown on the Drawing

(ii) Glazed ceramic tiles of size as shown on the Drawing in accordance with TIS 38-2531

(iii) Cement mortar bedding shall be composed of 4 parts sand to 1 part cement with 25 percent approved bonding agent. Grout shall be composed of a mixture of 4 parts sand to 1 part white Portland cement.

(c) Tiles shall be set out to the approval of the Engineer, and shall commence at expansion and control joints in the concrete slab. No tile shall bridge a concrete slab expansion joint.

(d) Ceramic tiles shall be laid on the mortar bed and tamped into place. Closure tiles shall be neatly cut and set in. Joints shall be 2 mm wide and shall be slightly dished. After 24 hours, all joints shall be pointed up with cement grout and all surplus grout removed. No walking over the floor shall be allowed during the first 24 hours after laying.

(e) Asbestos vinyl tile shall be laid on the floor, using adhesive of either emulsion or cut-back type. Adhesive for baseboards shall be a water resistant product recommended by the baseboard manufacturer.

(f) Baseboards for vinyl tile/ceramic tile shall be rubber core type, 3 mm thick and 10 cm height. Molded external and internal corners and end pieces shall be used. Baseboard, exclusive for corners, shall be furnished in length not less than 1.20 m each using of corners shall not be less than 5 cm long.

(g) Warranty

The Contractor shall obtain from the firms supplying the materials warrantees against defective materials of the same type, quality and colour, equal to 2 percent of the quantity of each type laid. These materials shall be suitably packed and labelled for storage.

(4) Acid Resistant Flooring

Where specified, as shown on the Drawings or directed by the Engineer, acid resistant flooring shall epoxy resin as approved by the Engineer. Each coat of epoxy resin shall have a minimum dry film thickness of 0.40 mm, and shall be applied in accordance with the manufactures's instruction.

S11.05 WALL FINISHES

(1) General

(a) The Contractor shall furnish and install the wall finishes, as specified in this clause, in areas as shown on the Drawings or as directed. The wall finishes in these Specifications shall be:

(i) Cement plaster finish
(ii) Ceramic wall tile
(iii) Glass block
(iv) Wire mesh

(b) The Contractor shall be responsible for ensuring that the background or subbase to which the specified finish is to be applied has properly cured, has the correct moisture content, is properly finished and is completely adequate to receive the specified finish. Any faulty work resulting from non-compliance with the above shall be replaced at the Contractor's expense and such replacement may be extended at the Engineer's discretion to include the whole of the wall or area affected.

(2) Preparation of Surfaces

(a) Surface which are to receive finishes shall be cleaned free from loose materials, fins, encrustations, oil, paints, dirt and any other material that might prevent satisfactory bond. Surfaces to receive mortar shall be kept thoroughly and continuously damp for at least 24 hours and then allowed to stand until the surface film of moisture has disappeared. All faces of concrete work shall be roughened need to the satisfaction of the Engineer prior to applying mortar.

(b) All conduits, boxes, switches and services shall be fixed and properly cased. Where necessary, adequate keying shall be provided for render. Galvanized metal mesh shall be provided over pipes and fixed with galvanized fasteners.

(c) Surfaces to receive adhesives or fixatives shall be thoroughly dry.

(d) Surfaces shall be left dust free and clean and shall be protected from contamination until time of laying the finish.

(e) Masking tape shall be provided where necessary to prevent staining of adjoining work such as aluminium windows and door frames.

(3) Plaster Finish

(a) The Contractor shall apply one coat plaster wall finish where shown on the Drawings or directed by the Engineer.

(b) One coat cement render 15 mm thick shall be applied to all internal and external walls required to be rendered. Grounds or screeds shall be placed at all points where required for rendering.

(c) For external and internal plastering with smooth finish, the mix shall be 1 part of cement to 3 parts of sand by volume. Cement shall be as specified in Section 8. Sand grading shall be in accordance with Clause S8.03 (b).

(d) All plaster shall be machine mixed for a period of not less than 2 minutes until it is uniform in colour and in composition. Remixing of plaster with addition of water will not be permitted. Plaster shall be used within 2 hours of mixing and all remainings after this period shall be discarded.

(e) The plastering shall be applied with a wooden float, finished with a sponge, levelling up any unevenness on the surfaces and shall not exceed 15 mm in thickness. Each surface to be rendered shall be finished in one operation to avoid joining marks except that day to day breaks shall be made to coincide with architectural breaks in order to avoid joining marks. Particular attention shall be given to this matter

by careful planning of the work site. Particular care shall be taken to ensure that the rendering is strong and sound at the corners.

(f) The Contractor shall prepare samples of the rendering as directed by the Engineer until the quality, texture and finish required is obtained and approved by the Engineer, after which all rendering executed shall conform to the respective approved samples. The quality and mixing of the materials shall be constant throughout so that there is no variation in colour.

(g) The finished render shall be cured by 4 applications of a water-spray at 12 hours intervals, the first application commencing 12 hours after completion of rendering. During and after the curing period, the render surfaces shall be protected against rapid drying.

(h) The Contractor shall protect all rendered work from damage. Damaged, dummy or otherwise defective render shall be replaced at the Contractor's expense, and in such a manner that on completion of the Contract the render shall be sound and the general appearance of the work shall not be marred.

(4) Ceramic Wall Tiles

(a) Ceramic wall tiles shall be glazed ceramic tile of size as shown on the Drawing conforming to TIS. 613-2529.

(b) The Contractor shall submit, for approval, loose samples of each type of tile. Samples shall be sufficient in number to illustrate the extremes and average of the ranges of colour, size and texture.

(c) The Contractor shall prepare sample panels, not less than 2 sq.m in area, of each type of finish specified. Examples of specified junction details and trim shall be included. Each panel shall be preserved until all works of its type is complete. Approved panels may form a part of the completed work.

(d) Tiles shall be set out to use only whole tiles where practicable or to give equal margins of cut tiles larger than half a tile.

(e) Cemented mortar shall be of 1 part of cement and 3 parts of fine sand. Grout shall be mixed in the proportions of 1 part white cement to 4 parts sand or proprietary grout, and colored to the approval of the Engineer.

(f) Joints in all tiled wall panels shall be 2 mm wide in both directions. All joints and edges shall be grouted not less than 24 hours after tiles have been fixed. When it is necessary to cut tiles, cutting shall be done with a saw. Holes shall be drilled for cocks, spouts, etc., large enough for

the body of the cock to be unscrewed if required, but smaller than the cover plate of the cock.

(g) Cemented mortar shall be cleaned off tiles during laying. Grout shall not be cleaned off tile faces before 24 hours after last application.

(h) Where structural joints occur in the base material, the joints shall be continued through the tiles in the form of control joints filled with an approved material. Joints shall be 5 mm minimum width and shall go right through tiles and bed. The joints shall be partly filled with polyurethane foam and sealed off flush with approved silicone rubber or polysulphide based sealant.

(i) Warranty: The Contractor shall obtain from the firms supplying the materials warranties, against defective materials and workmanship of the finishes specified in this clause for a period of 2 years after the issuance of the certificate of final acceptance.

(j) Spare Materials: The Contractor shall furnish additional spare materials of the same type, quality and colour equal to 2 percent of quantity of each type laid. These materials shall be suitably packed and labeled for storage.

S11.06 CEILING WORKS

The Contractor shall furnish and install the ceilings and frames as shown on the Drawings or as directed.

(1) Gypsum Board Ceiling

(a) Material

Gypsum board shall be of panel type with dimension 0.60 m x 0.60 m and 9 mm thick and square edge type or as directed by the Engineer. The gypsum board of waterproof type shall be used for the toilet room. Gypsum board shall be conformed to TIS 219-2524.

(b) Ceiling Frames

Frame shall be gavanized steel T-bar of natural white surface and of minimum thickness 0.25 mm.

The main frame shall be fastened to the roof frames by suspension tied rods hanging from the steel purlin every 2.00 m center to center.

The suspended frame will be required to support only the lighting fixture, the other mechanical equipment unit will have separate supporting.

The frames shall be installed true to level and plumb to make an even surface when laying the units.

(2) Installation

(a) Installation shall not be started until all wet work, including concrete placing and plastering have been completed and dried out to a degree acceptable to Engineer.

(b) Joints between two boards of tapered edge shall be filled jointing tape according to the instruction of the manufacturer to make a neat and smooth joint. On completion, all joints shall be sanded flush and smooth with fine paper before receiving the finish paint.

(c) Where the ceiling panel meets wall, column or beam, wooden trims shall be installed at the edges. Wooden trims shall be made of dry and sound in quality of hardwood and painting according to Section 20 after finishing the installation.

On completion, the ceiling board shall be in true level and plumb to an even, smooth surface.

The gypsum board shall be painted with 2 coats of acrylic emulsion paint as specified in Section 17.

S11.07 STRUCTURAL STEELWORKS FOR ROOF TRUSS

(1) Requirement

The structural steelworks specified in this clause includes all rolled, cold formed and fabricated sections as shown on the Drawings or as directed in the following structures:

(a) Power House

(2) Standards for Fabrication

Except as otherwise provided in these Specifications, the fabrication, and erection of structural steel shall be carried out in accordance with AISC, Specification for the Design Fabrication and Erection of Structural Steel for Buildings. All welding shall conform to the requirements of AWS D1.1. All welding rods shall be furnished by the Contractor and shall conform to AWS A5.17 and AWS A5.1. These operations shall be performed by approved experienced specialized personnel.

(3) Protective Coating

When fabrication has been approved all structural steelworks shall be cleaned and coated in accordance with Section 17.

(a) The Contractor shall furnish all necessary equipment and shall erect the structural steel in accordance with these Specifications and the Drawings.

(b) Not less than thirty (30) days before starting erection, the Contractor shall submit for approval drawings showing the method of erection proposed and the amount and type of equipment to be used. The Works shall not be commenced until such approval has been obtained.

(c) Structural steel members to be stored shall be placed on blocks so that no part of the members will touch the ground or be over-stressed and shall be kept clean and properly protected.

(d) Proper allowance shall be made to compensation for shrinkage of field welds so that the structure will not be unduly stressed or correct alignment affected.

S11.08 ASBESTOS CEMENT ROOFING TILES

(1) General

The Contractor shall furnish and install:

(a) All roofing tiles, capping, flashing, ridge cover and other necessary accessories to perform the Works as shown on the Drawings or as directed.

(b) The system shall be designed and fabricated by the Contractor to suit the building as shown on the Drawing and shall be installed under the supervision of the manufacturer and in accordance with his recommendation.

(2) Materials

Unless otherwise specified, materials including accessories and trim shall be as follows:

(a) Roofing shall be asbestos cement roofing tile, Romantile of dimension 50x120 cm and white colour. The roofing tile shall conform to TIS 79-2529.

(b) Fasteners shall be either 12 inches bolts or 16 inches bolts to fit the dimensions of purlins.

(c) Capping, flashings, ridge cover, corrugation closers and other accessories necessary for installation shall be as indicated on the Drawings or as recommended to match the roofing.

(3) Installation and Fabrication

(a) Flashing, capping, ridge cover, fasteners and other accessories shall be used in accordance with the manufacturer's recommendations.

(b) Roofing tile angle shall be cut before installation. Overlapping of end tiles shall be not less than 150 mm to protect from the wind and rain.

(c) After finishing the installation, roofing tiles shall be cleaned of dirt, mortar and other debris.

Steel roof members, such as truss, purlins and tie rods shall comply with Section 12. All steel surfaces shall be primed and painted before installation.

S11.09 STEEL ROLLING SHUTTER DOORS

(1) The Contractor shall furnish and install galvanized steel rolling shutter doors where shown on the Drawings or directed by the Engineer.

(2) The rolling shutter doors shall be double corrugated profile doors as approved by the Engineer.

(3) The Contractor shall submit shop drawings of the typical shutter curtain and details of guides, brackets and operating mechanism to the Engineer for approval.

(4) Rolling shutter doors shall have curtains constructed of interlocking roll-formed galvanized steel slats secured with malleable metal clips and wearing pads. The doors shall be fitted with wind lock lugs. Guides shall be steel sections of sufficient depth to retain the curtain with fittings as required. The brackets and drum shall be capable of supporting the full weight of the door without undue deflection and fixed so as to allow the smooth operation of the doors. Rolling shutter doors shall be installed in accordance with the manufacturer's written instructions to the approval of the Engineer.

(5) Rolling shutter doors shall be fitted with wicket doors and shall be operated by means of an endless rust proofed chain to a cast reduction gear of ratios as recommended by the manufacturer to allow smooth efficient operation.

S11.10 DOORS AND WINDOWS

(1) General

(a) The Contractor shall furnish and install aluminum and wooden doors and windows including all glazing, flashing, fixings, hardware and other accessories as specified in this clause, as shown on the Drawings or as directed. The furnishing and installation of frames with necessary incidentals are included.

(b) The Contractor shall obtain from the manufacturer written warranties in favor of the Owner. The warranties shall state that the fabrication of all doors and windows complied with this Specification and any defects that may arise during a period of two (2) years after issuance of the certificate of Final Acceptance shall be made good at the expense of the manufacturer.

(c) Not less than ninety (90) days before commencing fabrication the Contractor shall submit, for approval, shop drawings of doors and windows showing sections, dimensions, fixing, provision for doors and windows accessories and other information as may be required by the Engineer.

(d) Before ordering the fabrication of the doors and windows, the Contractor shall check the actual dimensions and shape of existing concrete openings.

(2) Glazing

(a) The Contractor shall furnish the materials, labour and all necessary incidentals and equipment for the installation of the glazing. All glass for glazed door and window shall be 5 mm thick clear float glass, Grade A quality and equal to TIS. 54-2516.

(b) The method of glazing shall be such that building movements due to wind and thermal effects are not transferred to the glass. Before glazing, rebates and fixing surfaces shall be cleaned, any temporary protective film shall be removed and glass edges shall be checked to ensure that glass is undamaged.

(c) After installation glass shall be marked with soap or marking compound, not with advertising stickers.

(d) During the progress of the Works, the Contractor shall kept the glass clean by promptly removing foreign matter, particularly cement deposits. Immediately before handing over all glass shall be cleaned twice internally and externally, removing any remaining protective coatings, cleaning off any excess sealant or other mark and checking to ensure the correct smooth operation of all doors and hardware. Any damaged or broken glass shall be replaced, and the whole of the works left in good condition.

(e) Glass cleaning agent shall be clean water, with or without detergents, or approved glass cleaning agent. Agents such as paraffin, kerosene, acid or abrasive cleaners or cleaners, which contain felspar, shall not be used for glass cleaning.

(f) All glass shall be supplied and installed by the specialist. All glass shall have clean cut edges without shells or damage and shall be secured in position with colour fast neoprene extruded snap in type glazing beads or colour to match the frame sections. The glazing beads shall be fixed internally and glazing shall be carried out complete with all necessary sealant as approved by the Engineer.

(3) Door and Window Accessories

(a) Door and window accessories including latches, locks, handles, bolts, plates, closers and hooks shall be installed to doors and windows as required. Locks shall be equivalent to TIS 756-2535 and suitable for use of interchangeable stumbler cylinders.

(b) All door accessories shall be fixed as recommended by the manufacture, and to the satisfaction of the Engineer.

(4) Aluminum Doors and Windows

(a) Material for aluminum doors and windows shall conform to ASTM. B209 or the equivalent. They shall be true shapes and free from any defect.

The outside surface of the aluminum material shall be anodized brown finish with more than 6.2 mg/cm^2 of anodized coating.

Anodized aluminum shall be finished so that it is of uniform appearance and free from all marks and blemishes. Aluminum for frames shall be not less than 2 mm thick and shall be not less than 1.5 mm for blade of louvers.

All assemblies for these items shall be first class local products used as standard material for multi-storey building.

(b) Fabrication shall be performed true to the shapes and dimensions as shown on the approved shop drawings, to make them weather-tight, well-fitting, sturdy in construction and easy in operation.

(c) All works shall be installed plumb, level, square and in proper alignment. Possible wrappings shall be adjusted before glazing is begun. Installation shall be executed by highly skilled workmen in accordance with the highest standards of quality for work of this type.

Aluminium to be placed in contact with concrete, mortar, plaster or similar metals shall be given a heavy coat of alkali-resistant bituminous paint applied to the contact surfaces.
The units shall be fastened firmly to the structure by galvanized bolts, screws and other approved means and all such fixing shall be concealed type.

After installation, all works shall be cleaned of protective materials and surface blemishes and left in a condition satisfactory to the Engineer.

(5) Wooden Doors and Windows

(a) Materials for wooden door and window shall be Dang wood or Takean wood which shall be dry and sound in quality without any defects. Plywood for panel shall be made of Teak more than 6 mm thick, and shall be of the waterproof type. The thickness of the doors shall range from 40 mm to 45 mm.

(b) Fabrication shall be performed true to the shapes and dimensions shown on the approved shop drawings to make them well-fitting, sturdy in construction and easy in operation.

(c) Doors and windows shall be installed accurately and true to the dimensions. All the frames of doors fixed in walls shall be installed before the plastering of walls. All door frames shall be secured in position by mean of heavy and approved steel fittings.

The lower ends of the door frames shall be blocked in the floor to the extent of 5 cm when the sill is omitted.

The Contractor shall protect all doors and windows against dampness during delivery and after installation before it will be painted by approved method.

After installation, all woodworks shall be finished with lacquer coating and painting in accordance with the prescription of Section 17.

S11.11 WATER SUPPLY AND SANITARY SERVICES

(1) Water Supply

(a) The Contractor shall install the water the water supply for all buildings as shown on the Drawings or as directed by the Engineer.

(b) The Contractor shall include in his lump sum price for the water supply, the cost of water distribution as well as the connecting line for the incoming water line as shown on the Drawings.

(c) Excavation and backfill of the trench as well as coating and wrapping with coal tar felts shall be included in the lump sum.

(2) Sanitary Services

The Contractor shall install the following for the toilet rooms of all buildings:

(a) Septic tank

(b) One shower cold water
(c) One washes basin (lavatory) / mirror
(d) W.C. service
(e) Drain and vent pipe
(f) Toilet paper holder
(g) Sanitaryware as directed on the Drawings.

The sanitary installation described above will be drained through 100 mm ∅ PVC pipe Class 8.5 to a septic tank. The septic tank and seepage tank shall be as shown on the Drawings.

S11.12 NAMEBOARD, FLAG POLE, GUARD SHED, FENCING ENTRACE GATE AND ELEVATED TANK WITH ELECTRICAL PUMP

(1) Concrete for all foundations, curb and concrete post shall comply with concrete described in Section 9 and shall be concrete 175 ksc compressive strength (Class "B").

(2) Reinforcement for all foundations, post, and board shall be as shown on the Drawings and comply with the requirement of Section 8.

(3) Logo and lettering of the panel board shall comply with notes and as shown on the Drawings.

(4) Shrub for decoration in front of the nameplate shall be as species approved by the Engineer.

(5) Flag pole and its foundation shall comply with notes and as shown on the Drawings.

(6) Type of fence shall comply with notes and as shown on the Drawing.

(7) Entrance gate shall comply with the notes and as shown on the Drawing.

(8) Elevated tank with capacity in accordance with notes and as shown on the Drawings.

(9) Electrical pump shall be provided to submersible pump water from the natural stream and store in the elevated tank. The pump capacity and head shall be as specified on the Drawings unless otherwise shall have a minimum capacity of 25 litres/ minute and minimum total dynamic head of 10 m. The pumping system shall consist of automatic water level control (float switches at the elevated tank and pump control panel, etc.) and any piece of equipment required for satisfactory pump operation.

S11.13 LIGHTNING PROTECTION SYSTEM

The lighting protection system shall be installed in the building or elsewhere as shown on the Drawings or as directed. The Contractor shall prepare the Shop Drawings and submit to the Engineer for approval before commencement of the work.

S11.14 MEASUREMENT AND PAYMENT

(1) Concrete and Reinforcement for the Power House, Housing, Office and Component structure.

Payment will be made per cubic meter at the rate bid therefor in the Schedule as stipulated in Section 9.

(2) Brick Walls

(a) Measurement for payment for the brick wall will be of the area obtained from the Drawings and/or the instruction given by the Engineer. Openings less than 0.25 m in cross section will not be deducted.

(b) Payment will be made at the rate per square meter bid therefor in the Schedule, which shall include full compensation for furnishing all labour, materials, tools, construction equipment and incidentals for mortar, scaffolding and any other cost necessary for doing the work as specified.

(3) Cement Plastering Brick Walls

(a) Measurement for payment for cement plastering brick will be of the area obtained from the Drawings or/and the instructions given by the Engineer. Openings less than 0.25 sq.m in cross section will not be deducted.

(b) Payment will be made at the rate per square meter bid therefor in the Schedule, which shall include full compensation for furnishing all labour, materials, tools, construction equipment and incidentals for mortar, scaffolding and any other cost necessary for doing the work as specified.

(4) Doors and Windows

Payment for furnishing and installing doors and windows as specified will be made at the rate bid therefor in the Schedule per each unit. The payment will include the cost of supply and installation of the doors and windows, cost of all labour and materials required to perform the work, accessories, glazing, lacquer coating, painting and all other incidental works. The following pay items are provided in the Schedule:

(a) Aluminium opening door
(b) Wooden opening door w/fanlight

(c) Aluminium sliding window
(d) Aluminium fixed glass window
(e) Double opening window
(f) Adjustable glass louver window
(g) Fixed glass louver window

(5) Steel Rolling Shutter Doors

Payment for furnishing and installing roller shutter doors will be made as the lump sum bid therefor in the Schedule. This lump sum shall include the cost of all labour and materials required to perform the work, including the testing and commissioning.

(6) Partition Plywood Wall with Hardwood Frame

Payment for furnishing and installing partition plywood wall will be made as the lump sum bid therefor in the Schedule. This lump sum shall include the cost of all labour, material, protective coating and incidental required to perform the Works.

(7) Floor Finishes

(a) Measurement, for payment, for furnishing and installing floor tiles and base boards will be of the exposed surface of tiled area and of the length of base board.

(b) Payment

(i) Payment for furnishing and installing asbestos vinyl and ceramic floor tiles will be made at the rate per square meter bid therefor in the Schedule.

(ii) Payment for furnishing and installation of terrazzo block and ceramic floor tiles will be made at the rate per square meter bid therefor in the Schedule.

(iii) Payment for furnishing and installing PVC strip will be made at the rate per linear meter bid therefor in the Schedule.

(iv) Payment for furhishing and installing oil and resistant flooring will be made at the rate per square meter bid therefore in the Schedule.

(v) These rates shall include the cost of all labour and materials required to perform the work specified.

(8) Wall Finish

(a) Measurement, for payment, for furnishing and installing or applying the following wall finishes will be made of the exposed surface areas of ceramic wall tile, glass block wall and wire mesh.

(b) Payment for furnishing and applying cement plaster and furnishing and installing ceramic wall tiles glass block wall and wire mesh will be made at the rate per square meter bid therefor in the Schedule. These rates shall include the cost of all labour and materials required to perform the Works specified.

(9) Ceiling Works

(a) Measurement, for payment, for furnishing and installing of ceiling will be of the area of ceiling installed.

(b) Payment for furnishing and installing gypsum board ceiling will be made at the rate per square meter bid therefor in the Schedule.

These rates shall include the cost of the suspended T-bar frames, the gypsum boards, wooden trims and all labour and materials to perform the Works specified.

(c) Payment for painting of gypsum board ceiling will be made separately as stipulated in Section 17.

(10) Asbestos Cement Roofing Tiles

(a) Measurement, for payment, for furnishing and installing the roofing will be of the net area, i.e., included of the roof installed.

(b) Payment for furnishing and installing of the roofing sheet including accessories, flashings, and insulation will be made at the rate per square meter bid therefor in the Schedule.

(c) Measurement for payment of steel roof frames will be made separately as stipulated in the Section 12.

(11) Nameboard and Entrance Gate

Payment for nameboard and entrance gate will be made at lump sum bid therefor in the Schedule. The lump sum shall include supply and construct of all concretes, logo, shrub, letting and all the works required to complete the nameplate and entrance gate.

(12) Flag Pole and its Foundation

Payment for the flag pole and its foundation will be made as the rate bid therefor in the Schedule.

(13) Guard Shed

Payment for guard shed will be made as lump sum bid therefore in the Schedule.

(14) Water Supply and Sanitary Services

Payment for the water supply and sanitary service will be made at the lump sum price, which includes the work described in Clause S11.11.

(15) Elevated Tank with Electrical Pump

(a) Measurement and payment for construction, furnishing and installing of concrete works, pipe and valve, storage tank with electrical pump and control will be made of completed as shown in the Drawings or as directed.

(b) Payment for water elevated tank with electrical water pump will be made at the lump sum bid therefor in the Schedule.

The term of payment for elevated tank with electrical water pump mentioned above will be scheduled as the followings:

- Completion of foundation and concrete works 30%
- Completion of furnishing and installing elevated tank 30%
- Completion of furnishing and installing eletrical pump and control 25%
- Completion of furnishing and installing pipes and valves, railing stall pipes and remaining works 15%

(16) Fence

Measurement and payment for the fence will be made in unit rates bid therefor in the Schedule (type of fence refer to Clause S11.12 (6)).

(17) Lightning Protection System

(a) Measurement for payment for supplying and installing the approved lightning protection system will be the lump sum bid therefor in the Schedule.

(b) Payment for supplying and installing lightning protection system will be made at the lump sum price as specified in the Schedule. This lump sum shall include the cost of all labors, materials, equipments and others related with the Works.

(18) Paving Block and Concrete Curb

Measurement for payment of paving block and concrete curb including sand layer 0.10 m under the block will be made at the rate per square meter as shown on the Drawings.

(19) Roof Drain

Measurement and payment for roof drain will be made in unit rates bid therefor in the Schedule (type of PVC pipe refer to Clause S11.11).

SECTION 12 - PERMANENT EQUIPMENT AND MISCELLANEOUS METAL WORKS

SECTION 12 - PERMANENT EQUIPMENT AND MISCELLANEOUS METAL WORKS

S12.01 FABRICATION AND DELIVERY OF PERMANENT EQUIPMENT

(1) General

The work covered by this section shall include but shall not be limited to, the supply of materials, fabrication transportation, painting and delivery of the following permanent equipment and miscellaneous metalwork to be provided under the Contract:

Vertical gates (slide gate at Headrace and sluice gate at Sand Sluice), Gate valve, trashrack, Bulkhead gate, lifting system, embedded frames, staff gauges and miscellaneous metal works.

(2) Materials

The materials used under this Contract shall be such as to insure an efficient service life for each part of the equipment. In particular, material shall not be of inferior quality to that specified below.

All materials shall be new and without defects and comply with the specifications of the ASTM Standard or equivalent as listed below:

Material and Products	Standard Designation
Structural steel (bars, shapes, plates)	ASTM-A36/A36M, TIS 107-2533 or TIS 1227-2539
Corrosion resistant steel plates	ASTM-A240 Type 504 or 410
Cast iron	ASTM-A48 Class 35 or Class 30
Cast alloy steel	ASTM-A148 Grade 80-40
Forged steel for gears	ASTM-A291 Class 1
Forged steel for stems, trunnions, etc.	ASTM-A293 Class 2 or ASTM-A235 Class 6
Forged alloy steel for general use	ASTM-A237

Material and Products	Standard Designation
Steel bolts and nuts (not submerged)	ASTM-A307
High strength bolts and nuts	ASTM-A325
Welding electrodes for:	
- corrosion resistant steel	AWS-A5.9 or ASTM-A371
- cast iron	AWS-A5.15 or ASTM-A398 AWS-A5.1-69 or ASTM-A233
Steel piping black or galvanized	ASTM-A120 or TIS 277-2532
Galvanization for:	
- Steel piping	ASTM-A120
- Section and plates	ASTM-A123
- Bolts and nuts	ASTM-A153
Cast bronze	ASTM-B143 Alloy 1B or 2B
Bronze for bearing, bushes, etc.	ASTM-B144 Alloy 3A
White metal for bearings	ASTM-B23 Alloy No.3
Brass for bolts and nuts	ASTM-B21 Alloy 485

Other materials not expressly specified in the list above shall conform to the most recently published ASTM standards regarding the class or type of those materials.

In case materials adopted are classified according to other material specifications, the Contractor shall submit the list of equivalence of adopted materials to ASTM standards.

(3) Tests on Materials

All materials used for the Contract shall be tested in accordance with the standards. The tests which must be executed and those which must be

witnessed by the Engineer, in order to verify the compliance of the material characteristics with those established in these specifications.

At tests shall be carried out in accordance with the relevant ASTM Standards. In particular, forged or cast pieces shall be provided with test billets for the execution of tests.

All equipment, services and costs for such tests will be the responsibility of the Contractor.

(4) Fabrication

(a) General: The fabrication of the permanent equipment shall be carried out in accordance with the highest current technical standards. In particular, identical parts shall be interchangeable.

(b) Plates and steel sections: Plates and steel sections must be perfectly straight with smooth surfaces. If straightening is necessary, hammering must be avoided. After the cutting of sheets and steel sections, the edges must be left sharp, clean and without burr.

High thickness plates may be flame-cut, provided that the material is not damaged and that the cut edges are ground clean or machined.

All tests shall be performed before the start of fabrication and the results submitted for approval to the Engineer or his authorized representative.

(c) Welding

(i) General: Welding shall be carried out with electric arc. The welding procedures shall be such as to ensure full penetration joints, free of internal and external defects. The edges to be welded must be prepared accurately and have smooth clean surfaces.

In the construction, welding procedures and welders qualification shall be accordance with the ASME Code for unfired pressure vessels.

Test procedure and result interpretation shall be in accordance with the ASME standards (American Society of Mechanical Engineers).

(ii) Examination of welds: In general all welds subject to pressure shall be radiographically examined if ordered or deemed necessary in the opinion of the Engineer.

Ultrasonic, magnetoscopic or dye penetrant inspection may apply wherever radiography is not possible.

All welds examined will be counter marked with identification marks appearing in the radiographic film and the marks shall not be removed before the approval of the Engineer for the relevant weld has been given.

The Contractor shall submit to the Engineer the radiographic film of all welds to be approved together with a location plan of the relevant identification marks.

All radiographic records will remain in the Contractor's file and they shall be made available to the Engineer upon request.

Should any of the welds prove to be defective, then the number of the same group of welds to be tested shall be twice that originally required. Should any weld of the second increment prove to be defective, then all welds shall be examined.

Welds performed on automatic resistance butt-welding machine shall undergo an indirect control providing sampling pieces. For each piece mechanical tests and other tests according to Contractor's practice shall be performed on the welding. In case one welding proves to be defective, the adjacent welds shall be cut out and tested.

All defects detected by inspection shall be fully corrected and inspected again until the correction has been approved by the Engineer.

(iii) Welding equipment at Site: The welding equipment at Site include all devices necessary to avoid arc extinguishing and to ensure a steady supply voltage within $\pm$ 5%. Voltage shall not be higher than 80 V.

The electrodes shall be shipped suitably packed and kept inside their packing up to the time of use. Should any package become damaged, the electrodes contained shall be rejected.

(iv) Stress relieving: For all structures and equipment welding that create high stresses the welds shall be stress relieved.

In all other cases, stress relieving shall be made when required by ASME code for unfired pressure vessels.

Stress relieving methods shall comply with ASME standards.

(v) Lubrication: All components in movement shall be properly lubricated.

Greasing or lubrication points shall be located in easily accessible positions.

The Contractor shall supply a lubrication schedule for the equipment, showing the recommended frequency of application and types and grades of required lubricants. The recommended lubricants shall be approved by the Engineer before ordering their supply.

Lubricant types shall be reduced to a minimum to facilitate maintenance.

After the Engineer's approval the Contractor shall supply all first application of lubricants, additional lubricant shall be applied at regular interval to maintain the Permanent Equipment is satisfactory condition until accepted.

(vi) Shop preassembly: The Contractor shall preassemble in his shop, unless otherwise specified, those assemblies, sub-assemblies and piece of equipment which require a precise fit for field erection. Shop assembly shall be done after all shop welding and machining has been completed.

The Contractor shall make all assemblies available for checking by the Engineer. All interferences, errors in dimensions and inaccuracies in workmanship discovered during the shop assembly shall be corrected. Before dismantling, each item to be shipped separately shall be match-marked and identified in conformity with the erection drawings. Marking shall be done in such a manner as to retain its legibility until field erection is completed.

(vii) Handling devices: All pieces heavier than 25 kg shall be equipped with hooks, eyebolts or lugs suitable for lifting, and in case the pieces are of such a shape as to make the above devices uneven or unaesthetic, handling belts and brackets shall be supplied.

Particular care shall be taken in making as easy as possible the handling and lifting of equipment which requires routine maintenance at Site.

(5) Tropicalization and Corrosive Protection

(a) General

All materials and equipment supplied under these specifications shall be suitable for being delivered, stored and operated under tropical conditions of high temperature, high humidity, heavy rainfall and environment favorable to mildew and fungus growth.

Process for tropicalization shall be in accordance with the best commercial and industrial practices.

(b) Metals

Iron and steel shall generally be painted or galvanized or metal sprayed as appropriate. When it is necessary to use dissimilar metals in contact, these shall be so selected that the potential difference between them in the electro-chemical series is not such as to cause galvanic corrosion. If this is not possible, the contact surface of one or both of the metals shall be electro-plated or otherwise finished in such a manner that the potential difference is reduced within the required limits or, alternatively, the two metals shall be insulated from each other by a suitable insulating material.

(c) Bolts, Screws, Nuts

Steel bolts, screws and nuts, when used, shall be zinc, cadmium or chromium plated or, where plating is not possible owing to tolerance limitations, corrosion-resistant steel shall be used. All wood screws shall be brass or nickel-plated with other suitable finish. Corrosion-resistant steel, copper-nickel alloy or bronze shall also be used for bolts and nuts when either or both are subject to frequent adjustment or removal, and for bolts projecting from concrete with nuts subject to removal.

(6) Anchor Bolts

The Contractor shall supply all necessary anchor bolts to be embedded in the first stage concrete as shown on the Drawings.

(7) Lateral Guides and Sealing Surfaces

The lateral guides and sealing surfaces to be mounted on the structures shall be smooth, true to form and free from twists, warps and kinks.

The frames and guides shall be supplied complete with stiffening bars and other accessories including the welding pads to be embedded in the first stage concrete.

Hook bolts to be embedded in the first stage one concrete shall be provided with double nuts and washers for the precise alignment of the guides.

(8) Stems and Bearings

The stems shall be made of high tensile rolled steel.

The bearings of the operating stems shall be provided with bushing of antifriction metal.

(9) Gears

The tooth profile for all types of gears shall be carefully machined.

All gears having an outer diameter less than 500 mm shall be made of forged steel, with exception made for the work-wheel helicoidally gear, that shall have a replaceable outer crown made of high strength bronze. The worm-wheel shall not allow self-reversing motion.

According to their operating requirements, the bearings shall be made of bronze or antifriction metal, easily replaceable.

(10) Tolerances

In addition to tolerances stated in the standards and in the Drawings the following tolerances shall be taken into account:

- Maximum flatness tolerance of the gate leaf shall be $\pm$1.0 mm
- The bottom of the gates shall be straight within $\pm$ 3 mm per meter of length.
- The faces of side guides and sealing surfaces shall not depart from vertical planes by more than $\pm$ 1.5 mm.

(11) Test

(a) Test at Laboratory

(i) Tests on Materials

- Hardness and tensile stress tests, according to ASTM E 8 the method on sample of steel plates and steel sections for structural members (one sample for each delivery);
- Magnetic particles tests (Magnaflux inspection) on all major steel forgings.

(ii) Test on Welding

Welds shall be tested according to the specified standard AWS A 5.1-9.

(iii) Pre-assembly

The pre-assembly and checking in the workshop shall be such as to allow the direct measure of all the gate dimensions in order to have the guarantee that no major adjustment will be required at Site during final erection.

(b) Tests at Site

The Contractor shall be responsible for the tests at Site and shall supply all the necessary equipment that shall remain the Contractor's property. All defects discovered shall be promptly corrected by the Contractor at his own expense.

Tests to be performed shall include, but not limited to, the following:

- Operation of all lifting system.
- Measurement of the gate leakage.

The gate leakage shall be measured during the test at the Site, the maximum limit of water leakages to be accepted will be not greater than the following: (not applicable)

(i) large gate width of opening of 1.00 meter or more — 1 liter/sec

(ii) small gate width less than 1.00 m — 0.5 liter/sec

The leakage that occurred through the contact of steel guide from and concrete shall not be accepted,

(12) Transportation of Gate Supplied by the Contractor

Transportation to the Site is included in the supply; the Contractor is assumed to be conversant with the conditions of the ways of communication to the site, and with any and all existing limitations on transportation, such as load limits, width and height of bridges and the like.

(13) Painting for Permanent Equipment

All exterior surfaces of permanent equipment for this contract, except finished or bearing surfaces, shall be coated with non-bleeding type coal tar epoxy. The coal tar epoxy to be used shall be dark gray in color or other colors that shall be subject to approval by the Engineer. The coating system shall provide a total dry film thickness not less than 200 microns.

(14) Spare Parts (Not applicable)

The Contractor shall supply the spare parts listed hereinafter, which are to be considered as the minimum requirement, for all the gates supplied under this Contract:

- ten (10) percent of each type of stem used for the gates, with a minimum of one (1) of spare parts and shall be as follow :

Item	Gate Stem	Gate Lift	Gate Leaf
Vertical Turnout Gate ; Dia (m)			
- 0.3, 0.4, 0.5, 0.6	Supply	Supply	Supply
- 0.8, 1.0	Supply	Supply	Not
Overflow Rectangular Gates and Slide Gate, Bgx C (mxm)			
- Bg < 2.0 and C < 1.75	Supply	Supply	Not
- Bg > 2.0 and C < 1.75	Not	Supply	Not

S12.02 INSTALLATION OF PERMANENT EQUIPMENT

(1) General

The work includes the assembly, erection, installation, testing and commissioning of the permanent equipment supplied by the Contractor.

(2) Storage at Site

(a) All materials and equipment to be installed shall be stored at Site at the care and expense of the Contractor.

All boxes and crates containing equipment, spare parts and small materials such as bolts, nuts, gaskets and accessories shall be stored under cover.

All equipment to be installed in open air may be stored out but the Engineer will have the right to request that some particular equipment be covered with tarpaulins in order to protect it.

The storage of the equipment both under cover and in the open air shall be done in an orderly manner, taking into account the safety regulations, leaving the required space for the maneuver of cranes and following as much as possible the erection sequence so to minimize the movement of the materials.

The custody of all materials and equipments shall be the care of the Contractor store houses shall be locked and areas for storage in open air shall be fenced, even if located inside the Contractor's camp.

(b) Following the arrival of each set of materials and equipment the Contractor and the Engineer shall jointly perform the following checks:

- Correspondence of the contents to what is indicated in the "Packing List";
- Visual inspection of the condition of the crating;
- Partial or total opening of the crates to check that the contents have not been tampered with or damaged during transportation;
- Visual inspection of the surface;
- Inspection of unpacked steel structures for damage.

An inspection report shall be prepared, and signed by both parties.

All packing materials, unless otherwise indicated, shall be the Department's property, and, if requested, shall be delivered in good condition. The unpacking shall be done so to avoid any unnecessary damages to the packing materials.

All packing materials not requested by the Department shall be removed from the Site at the cost of the Contractor.

(3) Erection Equipment

All equipment necessary for the movement, lifting, operation, blocking and testing of all materials to be erected and commissioned shall be supplied by the Contractor. Special tools that may be needed for erection of the permanent equipment shall be supplied by its manufacturer.

(4) Positioning of Equipment

The installation of any equipment shall start only with the approval of the Engineer.

The blocking out of any important part to be embedded in the concrete shall be done only after the Engineer has ascertained the correct positioning of the parts. In the case that after the blockout some parts are not correctly positional the Contractor shall be expense of the Contractor and include remove and reinstall the said parts.

(5) Finishing of Metal Surfaces at Site

All metal surfaces shall be accurately finished. The Contractor at the end of the erection shall carry out all necessary operations to finish the surfaces, subject to the approval of the Engineer.

On arrival at Site all metal surfaces shall be in one of the following conditions:

(a) Completely painted with primer and finish;
(b) Painted with two coats of primer;
(c) Galvanized;
(d) Untreated;
(e) Covered with protective layers to be removed.

After erection, or before, if requested by the Engineer, the Contractor shall perform the following operations:

In case (a) accurate cleaning of the surfaces with clothes first damp and then dried and final touch-up painting where required.

In case (b) accurate cleaning of the surface using, where the prime paint is damaged, emery-paper or sand-blast, then touching-up of the antirust paint and final painting.

In case (c) cleaning of the damaged parts and touching-up with cold zinc-plating.

In case (d) preparation of the surface and painting

In case (e) removal of the protective layer and preparation of the surface for the use it is allotted.

No surface treatment is required for all non-ferrous metals, stainless steel, and chrome plated steel and for the parts to be wholly embedded in the concrete.

(6) Safety Precautions

In addition to the existing regulation of the Kingdom of Thailand the Contractor shall comply with the following prescriptions:

(a) Railings

All platforms and gangways that are set at a height of more than four (4) m from the ground shall be provided with railings and toe boards on all sides. Railing height shall be at least 1 m.

(b) Lighting

All transit and open areas during night work shall be sufficiently lit. To satisfy this condition a lighting system shall be provided. In the working areas lighting shall not be less than 35 lux and in other areas shall not be less than 5 lux.

(7) Erection of the Permanent Equipment

(a) Embedded Parts

After the first stage concreting is completed the Contractor shall position all parts to be embedded in the second stage concrete. Said parts shall be temporarily fixed by u-braces, tie rods and struts and in the case of heavy pieces shall be supported by jacks.

Particular precautions shall be taken to avoid even minimal movements during second stage concreting.

The correct positioning shall be checked with a precision theodolite in respect to the fixed datum points. In the case of large parts controls shall be made on several points, possibly on machined surfaces.

Horizontality or verticality of the different parts or of the relative axis shall be checked with precision optical instruments.

The Contractor shall comply with the tolerances as stated in this Section. During concreting machined surfaces and threads shall be accurately protected to avoid damage.

(b) Mechanical Equipment

Before starting installation of the mechanical equipment, the Contractor shall inspect and clean all parts with particular care to the machined parts and to the nuts and bolts. The erection shall be carried out following the match marks made during shop assembly; with particular care to the matching of the reamed bolts and of similar elements.

The tightening of the nuts shall be done with appropriate wrenches. The Contractor shall tighten nuts and bolts applying the torque prescribed by the manufacturers.

Before the erection of any part the dimensions and tolerances shall be checked according to the drawings. No modification of tolerances shall be allowed without written approval of the Engineer.

(8) Tests

The Contractor shall perform all site tests as specified in Clause S12.01 (11).

S12.03 TRAVELING CRANE AND ASSOCIATED WORKS

(1) Installation and Operation

A traveling crane and associated work shall be installed at the powerhouse for installation and removal of turbine or motor using their respective monorail I-beam during the maintenance period.

(2) Design Data

The design and operation shall satisfy the following requirements:

Type	:	Traveling crane with manually operated hoisting unit and manually operated travel.
Service	:	Installation and removal of the pump or motor at pump station.
Number	:	one set
Capacity	:	As shown on the Drawings.
Length of Travel	:	The traveling crane beam shall be of sufficient length to give adequate hoist hook coverage of the areas to be served by the hoist.

Hook Lift : The traveling crane shall have a hook lift capable of lifting the pump or motor from their respective operating positions to maintenance positions.

(3) Design Loads

(a) The capacity of the traveling crane shall be sufficient for lifting and lowering one pump or motor complete with monorail I-beam during erection and maintenance. In establishing the capacity, the dead load plus any possible friction or lifting forces occurring in combination with the dead load shall be considered.

(b) The manual chain operated travel shall be grooved to give full control of the hoist during the travelling motion when carrying the maximum load. The effort on the load chain required to move the hoist under maximum load as shown on the Drawings.

(4) Traveling Crane Assembly

(a) The hoisting motion shall be by manual chain operation. The longitudinal travel shall be by manual chain operation also.

(b) The hoist design shall ensure closely controlled hoisting and lowering operation together with easy and accurate travel movements under all conditions of loading.

(5) Monorail

The monorail shall consist of a single rail designed to carry the hoist lifting a maximum load. The monorail shall be supplied with stainless hanging bolts, fittings and removable end stops.

(6) Maintenance Equipment and Special Tools

(a) The Contractor shall supply a complete set of high quality tools and accessories for carrying out all adjustments and maintenance operations. The set shall include all necessary single-ended spanners, ring spanners, socket wrenches, special tools, and lubricating equipment for the hoist.

(b) The tool shall be marked as to size and purpose and shall be supplied in a sheet steel cabinet of approved design. The cabinet shall be equipped with shelves, drawers, racks, fittings, lock and dyes for the secure and orderly storage of the tools, the cabinet shall be waterproof and shall be located as directed by the Engineer.

S12.04 STAFF GAUGES

(1) General

The Contractor shall supply and install staff gauges. The location and elevation of staff gauges shall be fixed to the requirements of the Drawings or as directed by the Engineer.

(2) Material

Staff gauge plates shall be made of steel sheet having a minimum thickness of 2 mm and surfaces shall be finished by enamel process. Graduation of the plate shall conform to the details as designated by the Contractor and approved by the Engineer Color shall be white for both faces and all numerals and graduations shall be black.

Enamel faces shall consist of two undercoats and one top coat, applied and stoved, of uniform thickness, homogeneous and uniform in color with an egg-shell flat finish. All holes shall be drilled before enamel processing.

(3) Fixing

Where indicated on the Drawings or otherwise directed by the Engineer, staff gauges shall be mounted. All mounting holes shall be accurately located and fixed as detailed by the Contractor and approved by the Engineer. The gauge shall present an even surface free from twist, cracks, faults or other blemishes after complete installation.

S12.05 TRASHRACKS, LIFTING BEAMS AND EMBEDDED FRAMES

(1) Installation and Operation

The trashrack shall be provided at the pump station in set, as shown on the Drawings, to prevent debris from entering the sand sluice. Each element of the trashrack shall be removed or reinstalled by means of a gantry crane with lifting beam provided under the contract.

(2) Design Data

(a) Design Data

Number	:	Number of sets equal to the pump sets.
Size of Opening	:	as shown on the Drawings
Design Head Loss	:	0.20 m.
Sill Level	:	as shown on the drawings
Ancillary Equipment	:	Lifting Beam

(b) The design shall ensure that no adverse vibrations will occur under any operating conditions and that head losses across the trashracks are kept to a minimum.

(c) The leading edges of the trashrack bars shall be rounded to reduce head loss.

(d) The trashracks are capable of withstand and water head (i.e., completely blocked with debris and trash).

(3) Trashrack Assemble

(a) The trashracks shall be fabricated From welded steel construction and shall completely fill the opening. Each trashrack panel shall consist of vertical trash bars supported on the load framework. The framework shall be formed of horizontal structural members suitable braced and vertical side members which shall carry the load. The load shall be transferred to the embedded frame via vertical bearing plates bolted to the trashrack framework.

(b) The trash bars shall be hot-dip galvanized bound with stainless steel binding bolts and bar spacers. The framework shall be painted in accordance with Section 10.

(c) The clear spacing between the trash bars shall not exceed 20 mm. The trashrack panels shall be provided with locating pins and matching holes for proper alignment of upper and lower panels.

(d) Guide rollers and associated guide bars on the embedded frames, panel springs shall be provided to guide the trashracks onto its groove.

(e) Lifting lugs and others necessary shall also be provided to facilitate handling of the trashracks or temporary storing on the deck of relating structure.

(4) Lilting Beam

(a) The lifting beam shall be of fabricated steel construction designed to carry the maximum load due to the dead weight of trashrack, and any other related loads. Only 1 trashrack will be required to be lifted at any one time.

(b) The lifting beam shall be fitted with lifting pins for connection to the gantry crane and with self-latching and unlatching counter-weighted lifting hooks which automatically engage or disengage with each trashrack when preselected to do so. Locating holes shall be provided on the lifting beam to engage with the locating pins on each trashrack to ensure positive alignment of the lifting beam with each trashrack. The lifting beam shall be guided in the guides and grooves provided for the trashracks and Bulkhead gates.

(5) Embedded Frames and Anchors

(a) Frame

(i) The embedded frames shall be designed to serve for trashracks and Bulkhead gates. The frames shall consist of vertical members forming the guides and seal seats on the upstream and downstream sides respectively of the grooves and horizontal members forming the top and bottom seal seats. The guides shall be commonly used for trashracks or Bulkhead gates, the seal seats shall be used for Bulkhead gates only.

(ii) The Frames shall be capable of being assembled in blockouts on anchor bolts embedded in first stage concrete, accurately located and aligned and then embedded in second stage concrete. All working surfaces shall be machined and free of twists and warps.

(iii) All surfaces not covered by concrete shall be of solid stainless steel or clad with stainless steel of minimum thickness of 4 mm after machining.

(iv) All frame joints shall be machine finished and bolted and dowelled and when assembled the joints shall be flush and shall butt firmly together with gaps at the joints not exceeding 0.03 mm.

(v) The contractor shall provide:
- all the anchor bolts to be embedded in the first stage concrete, and
- the anchor bolt extension, extension nuts and standard nuts to be embedded in second stage concrete.

(vi) Embedded frames and anchors, and their attachment points shall be of rigid design such that they will not suffer distortion or damage during installation and embedment.

(b) Tolerances

(i) The following manufacturing and installation tolerances shall apply. The manufacture of the various parts shall be such that the anchor bolts without additional jacking, straightening, correcting or grinding during erection and installation by the Contractor.

(ii) Parts embedded in first stage concrete, anchor bolts and other parts embedded in first stage concrete shall be to location and level within $\pm$ 5 mm.

(iii) Top and Side Seal Seats : Seating faces of top and side seal seats shall be in a common vertical plane perpendicular to the centerline, within $\pm$ 5 mm. overall.

(iv) Bottom Seal Seat: The sealing face of the bottom seal shall be horizontal within $\pm$ 5 mm overall.

(v) Guides: Faces of guides shall be plumb within mm. without gaps or offsets at joints.

S12.06 GANTRY CRANE AND ASSOCIATED WORKS (NOT APPLICABLE)

(1) Installation and Operation

A gantry crane and associated work shall be installed at powerhouse for installation and removal of trashracks or Bulkhead gates using their respective lifting beams during the maintenance period of trashracks.

(2) Design Data

The design and operation shall satisfy the following requirements:

Type	:	Gantry crane with manually operated hoisting unit and manually operated travel.
Service	:	Installation and removal of the trashracks or Bulkhead gates
Number	:	one set
Capacity	:	As shown on the Drawings.
Length of Travel	:	The gantry crane beam shall be of sufficient length to give adequate hoisthook coverage of the areas to be served by the hoist.
Hook Lift	:	The gantry crane shall have a hook lift capable of lifting the trashracks or Bulkhead gates From their respective operating positions to maintenance positions or storage above the intake service deck.

(3) Design Loads

(a) The capacity of the gantry crane shall be sufficient for lifting and lowering one trashrack panel or Bulkhead gates complete with lifting beam during erection and maintenance. In establishing the capacity, the dead load plus any possible friction or lifting forces occurring in combination with the dead load shall be considered.

(b) The manual chain operated travel shall be grooved to give full control of the hoist during the travelling motion when carrying the maximum load. The effort on the load chain required to move the hoist under maximum load shall not exceed load as specified from the manufacturer.

(4) Gantry Crane Assembly

(a) The hoisting motion shall be by manual chain operation. The longitudinal travel shall be by manual chain operation also.

(b) The hoist design shell ensure closely controlled hoisting and lowering operation together with easy and accurate travel movements under all conditions of loading.

(5) Monorail

The monorail shall consist of a single rail designed to carry the hoist lifting a

maximum load. The monorail shall be supplied with stainless hanging bolts, fittings and removable end stops.

(6) Maintenance Equipment and Special Tools

(a) The Contractor shall supply a complete set of high quality tools and accessories for carrying out all adjustments and maintenance operations. The set shall include all necessary single-ended spanners, ring spanners, socket wrenches, special tools, and lubricating equipment for the hoist.

(b) The tool shall be marked as to size and purpose and shall be supplied in a sheet steel cabinet of approved design. The cabinet shall be equipped with shelves, drawers, racks, fittings, lock and dyes for the secure and orderly storage of the tools, the cabinet shall be waterproof and shall be located as directed by the Engineer.

S12.07 BULKHEAD GATE AND EMBEDDED FRAMES

(1) Installation and Operation

(a) The Bulkhead gate and associated metalwork shall be furnished and installed by the contractor, generally as shown on the Drawings.

(b) The Bulkhead gate shall function as a bulkhead gate to close the inlet of the headrace for maintenance purposes.

(c) To close the inlet the Bulkhead gate shall be placed in the Bulkhead gate groove and slide down to its position.

(d) The Bulkhead gate shall be installed and removed only under balanced hydrostatic conditions.

(2) Design Data

The design and operation shell satisfy the following requirements.

Lift Fences	:	Gantry Crane Operation
Gate Type	:	Vertical lift, bulkhead gate with automatic balance valve
Service	:	Isolation of the pump pit for maintenance purpose.
Number	:	One (1).
Size of Opening	:	As shown on the Drawings.
Design Head	:	N.W.L- Sill Level
Sill Level	:	As shown on the Drawings.
Top Water Level	:	N.W.L.
Seals, Type and Orientation	:	Sides and top synthetic rubber, solid music note. Bottom flat synthetic rubber strip downstream sealing.

(3) Design Loads

The design of the Bulkhead gate and embedded parts shall be based on the most severe combination of the following loads:

(a) The full Hydrostatic pressure corresponding to N.W.L.
(b) The dead load of the Bulkhead gate.

(c) All possible lifting and friction forces occurring separately and in combination with the dead load stated above. The Bulkhead gate shall be designed to operate safety and smoothly under all conditions of operation. Under overload conditions caused by possible sticking or jamming during the lifting operation, the stresses induced shall not exceed 75 percent of the yield strength of the component material.

(4) Bulkhead gate Assembly

(a) Gate Leaf: the gate leaf shall be of fabricated steel construction consisting of a downstream skin plate, seals and a supporting framework. The supporting framework shall be formed of horizontal structural members suitable braced and vertical side members which shall carry the hydrostatic Load. The hydrostatic load shall be transferred to the embedded frame via vertical bearing bars bolted to the skin plate.

(b) Seals

(i) The Bulkhead gate shall be sealed at the bottom with a flat synthetic rubber strip attached to the Bulkhead gate so that the bottom edge of the strip seals tightly against the seating face of the bottom seal seat. The side and top seals shall be continuous and shall be of the synthetic rubber music note type.

(ii) All seals shall be made of high-grade synthetic or natural rubber and shall be moulded. The upper seal corners shall be moulded pieces.

(iii) The seals shall be fastened by stainless steel clamp strips to machined faces on the downstream side of the skin plate and shall be effective over their full length. Fixing screws for the clamps shall be of stainless steel.

(c) Resting Devices
The Contractor shell provide the resting devices located in the blockout of dogging device pit below deck level as shown on the Drawings.

(5) Embedded Frames and Anchors

(a) Frames and Anchors
The embedded frames shall consist of vertical member forming the seal on the downstream side of the Bulkhead gate groove and horizontal members forming the top and bottom seal seats. The Frames shall be capable of being assembled in blockouts on anchor bolts embedded in first stage concrete, accurately located and aligned and then embedded in second stage concrete. All working surfaces shall be machined and free of twists and warps.

(b) Tolerances

As same as trashrack.

S12.08 VERTICAL GATES

(1) General

The work covered the assembly, erection, installation, testing and commissioning of vertical gates supplied by the Contractor.

(2) Materials

The steel to be used for fabrication of vertical gate shall meet the requirements as follows;

(a) Steel plate in accordance with ASTM A283 Grade C or D or JIS G3101 SS400
(b) Steel sheet of coil in accordance with ASTM A570 Grade 36
(c) Steel conforming to JIS G3457 and TIS 427-2531

The thickness of vertical gate shall not less than the thickness of steel pipe. Tolerance on thickness of vertical gate shall be $\pm$ 0.25 millimeter, except otherwise as shown on the drawings.

(3) Erection

All equipment necessary for the movement, operation fitting and testing of all materials to be erected shall be supplied by the contractor

(4) Metal Surface

All metal surfaces shall be accurately finished. The Contractor at the end of the erection shall carry out all necessary operations to finish the surfaces, subject to the approval of the Engineer.

(5) Gate Lift and Gear Motor

(a) Installation and Operation

A gate lift and gear motor and associated work shall be installed at the inlet of headrace and sand sluice installation and operation of vertical gates using their during the maintenance period.

(b) Materials

The steel and metal to be used for fabrication of gate lift shall meet the requirements as shown on the Drawing. The gear motor shall be the products of manufacturer holding an ISO 9002 certificate. The capacity and specification of gear motor shall also be submitted to the Engineer.

(6) Gate Assembly

(a) Gate Leaf: the gate leaf shall be of fabricated steel construction consisting of a skin plate, seals and a supporting framework as shown on the Drawing.

(b) Seals

(i) The vertical gate shall be sealed at the bottom with a flat synthetic rubber strip attached to the gate so that the bottom edge of the strip seals tightly against the seating face of the bottom seal seat. The side and top seals shall be continuous and shall be materials as shown on the Drawing.

(ii) All seals shall be made of high-grade synthetic or natural rubber and shall be moulded. The upper seal corners shall be moulded pieces.

(iii) The seals shall be fastened by stainless steel clamp strips to machined faces on the downstream side of the skin plate and shall be effective over their full length. Fixing screws for the clamps shall be of stainless steel.

(7) Embedded Frames and Anchors

The embedded frames shall consist of vertical member forming the seal on the side of the gate groove and horizontal members forming the top and bottom seal seats. The Frames shall be capable of being assembled in blockouts on anchor bolts embedded in first stage concrete, accurately located and aligned and then embedded in second stage concrete. All working surfaces shall be machined and free of twists and warps.

(8) Tolerances

As recommended by the manufacturer.

S12.09 GATE VALVE

(1) General

The work covered the assembly, erection, installation, testing and commissioning of gate valve supplied by the Contractor. The gate valve shall conform to TIS 256 or AWWA C500. The gate valve shall be cast-iron bodies with non-rising stems and solid wedge. The minimum design working pressure shall be not less than 10 bars.

(2) Installation and Operation

A gate valve and associated work shall be installed at the penstock at near surge tank. The gate valve for aboveground service shall be furnished with hand wheel. The direction of opening for gate valve shall be counterclockwise as viewed from the top.

(3) Markings

Markings shall be cast on the bonnet or body of valve and shall show the following:

- Manufacturer's name
- Year of manufacture
- Nominal diameter
- Designation of working pressure
- Lot number
- Number of turn to open
- Owner

The letter or markings specified above shall be at least 15 mm. in height and shall be 3 mm. raised from the surface.

On the wrench nut or hand wheel, the arrows showing the direction of opening or closing shall be cast on.

(4) Accessories for gate valve

(a) Rubber gaskets for flanged joint shall be furnished for gate valve delivered. The rubber gasket shall be full face and their dimensions as shown on the Drawing. The rubber gaskets shall conform to BS 2494, Hardness range 56-65 or JIS K 6353, class III, Hardness Hs 55-65

(b) Bolts and nuts for flanges joint shall also be furnished for gate valve delivered. Bolts and nuts shall be made of steel conforming to ASTM A 307, grade B, or TIS 171, class 4.6 and shall be hot-dipped galvanized. The dimension of bolts and nuts shall be as shown on the Drawing.

S12.10 JOINT FOR STEEL PIPE

Joints for steel pipe shall be mechanical coupling, dismantling joint, and restrained joint or as shown on the Drawing and as specified in the Section 13.

S12.11 MISCELLANEOUS METAL WORKS

(1) General

The work covered by this Clause shall include, but shall not be limited to, the supply of material, fabrication, installation and painting or hot-dip galvanizing of items of miscellaneous metal work such as:

- Galvanized steel pipe, steel plate
- Steel grating cover, ladder rung, Handrail,
- Miscellaneous metal work for the other works as shown on the Drawings

(2) Materials

Materials shall conform to the following Specifications

Material and Products	ASTM Designation or Equivalent
Steel shapes	A 283, A 306 and A 36 or TIS 107-2533 and 1227-2539
Steel plate and section	A 36
Steel tube and pipe	A 53
Cast iron pipe	A377
Metal steel black bolts and nuts	A 36, A307
Galvanized bolt and nuts	A153
High strength bolts and nuts	A 325
Steel pipes, black or galvanized	A 120 or TIS-277-2532
Hot-rolled steel bars	A 575 and A 576 or TIS-55-2516
Cold finished steel bars	A 108
Galvanizing	A 123 or A 153
Anchor bolts	A 307
Welding	D1.1
Welding rod for carbon steel	A5.17

(3) Fabrication

(a) General

Fabrication of metal work shall be in accordance with the best modern practice in the manufacture and fabrication of materials of the type covered by these Specifications, and in accordance with the Drawings. Built-up metal work shall be completely assembled in the shop and matched for correct field erection. All frames shall be suitably braced as required, to maintain alignment during shipment and erection. All joints shall be filed, milled or machined as necessary to secure close and perfect connection.

All exposed bolts, projecting beyond the nut, shall be preened.

(b) Welding of Steel

Welded work shall be in accordance with the requirements of "Welding in Building Construction" as formulated by AWS.

(4) Painting

Miscellaneous metal work to be painted shall be treated as indicated in Section 10 hereafter.

(5) Hot-dip Galvanizing

Metal work to be galvanized shall receive an adherent, smooth and continuous zinc coating, free from bubbles, porosities or other irregularities that may affect the soundness of the protective layer. The thickness of the zinc layer shall be such that the rate of deposited metal corresponds to a minimum of 600 gm/m^2.

(6) Installation and Erection

(a) General

The work shall include all cutting, fitting and drilling required for proper installation, and to make all the required connection with adjoining work. All anchors, sockets, pipe sleeves and expansion bolts required for securing the metal work to the construction shall be furnished by the Contractor, except where specifically stated otherwise.

(b) Embedded Metal

(i) All embedded metal shall be accurately set in place before the concrete is poured or, subject to the approval of the Engineer, recesses may be left in the concrete and the metal work placed, anchored and blocked in place after the concrete of the structure has set.

(ii) Where it is impracticable to place anchors or anchor bolts required for the installation of ladders or other miscellaneous metal work before concrete is built, holes shall be drilled in the structures and expansion bolts shall be installed.

(c) Ladder Rungs

Ladders shall be fabricated, painted and installed in accordance with the Drawings and the provisions of these specifications. The components shall be cut, punched, drilled and welded as required for installation, which shall follow the completion of concrete work as closely as possible.

(d) Galvanized Steel Pipe Handrail

The Contractor shall furnish and install all pipe handrail and posts as shown on the Drawings in accordance with these Specifications. The

Contractor shall furnish and install all brackets, nuts, bolts and expansion anchors required for installation. Handrail sections shall be installed to true line and level to the satisfaction of the Engineer.

The galvanized pipe for handrail and posts shall be standard 37.5 millimeter (1 1/2 inch) nominal size steel pipe, intermediate grade.

(e) Anchor Bolts

Anchor bolts to be embedded in concrete shall be positioned with a template before concrete is placed and the Contractor shall ensure that the anchor bolts are maintained in the correct position as shown on the Drawings, during the placing of concrete.

(f) Galvanized Steel Pipe

(i) The dimension and/or size of galvanized steel pipe shall be fabricated to the dimensions and size as shown on the drawings.

(ii) The galvanized steel pipe for the blow-off valve pits shall be set to the correct alignment and profile and anchored in concrete as shown on the Drawings.

(g) Skin Plates

The skin plates shall be as shown on the Drawing and as approved by the Engineer and shall be delivered match marked for assembly and installed strictly in accordance the manufacturer's instructions.

(h) Miscellaneous Metal Works

The Contractor shall furnish and install miscellaneous metal works, including metal works listed in this subclause and miscellaneous metal works elsewhere as shown on the Drawings or directed.

- Embedded metal works
- Non-embedded metal works
- Embedded steel plate with bar anchorage
- Steel roof frame
- Galvanized steel
- Stiffener ring
- Steel strap
- Steel plate pipe collar

S12.10 MEASUREMENT AND PAYMENT

(1) Permanent Equipment

(a) The Contractor shall supply and install the following permanent equipment as shown on the Drawings, and/or proposed by the contractor and the Engineer approval.

The scope of work shall include the design manufacture, supply, delivery, erection, commissioning, production of operation and maintenance manuals and defect liability as described hereunder.

(b) The design, manufacture, supply, delivery to the Site, erection and commissioning, production of operation and maintenance manuals and defect liability shall be in accordance with Section 12 to the Specification. Section 12 covers the design, manufacture, supply and delivery to the Site, erection and commissioning and defect liability.

(c) The bidder shall submit drawings showing the general arrangement and important details of each item, a description of the construction, operation and materials to be used.

(d) Within ninety (90) days of the Acceptance of Bid, the Contractor shall submit detailed information including a complete set of design calculations and drawings as required in Clause 4.04 of Volume I, necessary for the manufacture, erection, commissioning, operation and maintenance of each item to the Engineer for approval. The Contractor shall be fully responsible for the correctness of these drawings. The Contractor may be required by the Engineer to supply such additional drawings, data and design calculations and to make such changes in the design as may be necessary to ensure that the plant conforms to the requirements of the Contract. When the Engineer has approved the drawings they shall become the Drawings and shall not be modified or departed from without the approval of the Engineer.

(e) The Engineer may inspect and/or test during design, manufacture, installation and commissioning, the various portions of the plant at all reasonable times and shall have the power to reject all components and/or assemblies that are not in accordance with the Drawings or that otherwise do not meet the requirements of this Specification.

(f) The Contractor shall be responsible for liaison with the permanent equipment manufacturer to determine final dimensions, blockout locations and sizes, other details such as embedded metalwork and compliance with the requirements of the Specification.

Payment for the installation of permanent equipment will be made at the rate bid, which shall be included all cost, for the completion of the work as specified in this Section and the Drawings, except second stage concrete in blockouts, which will be paid and included in payment for concrete for different classes provided in Section 9.

Payment for the Spare Parts will be made at the Lump Sum rate stated in the Schedule. The Lump Sum payment will cover all material and labor for the preparation of the spare parts as well as the transport to locations to be indicated by the Engineer.

Should all or part of the Permanent Equipment supplied by the Contractor be imported into Thailand, the Contractor shall be responsible for all the necessary arrangements for Custom clearance, and shall pay all applicable Custom duties and taxes. The duties and taxes shall be included in the local currency portion of the Schedule.

For Installation and grouting pipe in intake, the Contractor shall propose method of construction for the Engineer approval before proceeding.

(2) Traveling Crane

Traveling crane will be measured and paid at the rate per set therefor in the Schedule, and shall include accessories and incidental necessary to complete the work.

(3) Staff Gauge

Staff gauge will be measured by number of pieces installed and the payment will be made at the rate per set bid therefor in the Schedule.

(4) Trashracks

Trashracks will be measured by number of pieces installed and the payment will be made at the rate per set bid therefor in the Schedule.

(5) Bulkhead gates

Bulkhead gates will be measured by number of pieces installed and the payment will be made at the rate per set bid therefor in the Schedule.

(6) Lifting Beams

Lifting beams will be measured by number of pieces installed and the payment will be made at the rate per set bid therefor in the Schedule.

(7) Gantry Crane and Associated Works (Not Applicable)

Gantry Crane and associated works will be measured by set and the payment will be made at the rate per set bid therefor in the Schedule.

(8) Vertical Gates

Vertical gate will be measured by set and the payment will be made at the rate per set bid therefor in the Schedule, which shall included all costs of material, labor, welding, painting, installing, gate lift with gear motor and including all necessary works required to complete the Works as specified.

(9) Miscellaneous Metalwork

(a) Measurement for payment for the miscellaneous metalwork will be of the weight of finished material installed.

Measurement will be based on the calculated weight of the metalwork before installation. The Contractor shall supply the calculated weight of metalwork.

(b) Payment will be made at the rate per kilogram bid therefor in the Schedule, and shall include the complete costs for painting or galvanizing.

(c) Payment for furnishing and installing galvanized steel pipe handrail will be made at the rate per linear meter, which shall include all costs of material, labor, installing and, where required, excavation, backfilling, concreting for footing and including all necessary works required to complete the Works as specified.

(d) Payment for furnishing and installing ladder rungs will be made at the rate per kilogram bid therefor in the Schedule.

(e) The cost of anchor bolts shall be included in the rate bid in the Schedule for the various item of the metal works for which anchor bolts are used, except for the anchor bolts.

(f) The cost of galvanized steel pipe shall be made at the rate per linear meter. The cost will include full compensation for furnishing all labor, materials, test, construction equipment and incidentals for supply fabrication and any cost necessary for execution of the Works.

(g) Payment for furnishing and installing skin plates and frames will be made at the rate per kilogram.

(h) Payment for furnishing and installing miscellaneous metal work of the other works will be made at the rate bid therefor in the Schedule.

The price will include full compensation, for furnishing all labor, materials, tools, construction equipment and incidentals for supply, fabrication and any other costs necessary for execution of the Works.

(i) Payment for furnishing, erecting and installing of structural steelwork will be made at the rate per ton bid therefor in the Schedule. These rates shall include all required structural steelwork.
(i) Furnishing and installing roof members.

(ii) Furnishing and installing miscellaneous structural steelwork.

The price shall include the entire cost of furnishing all labor, materials, tools, construction equipment and incidentals for supply, transport, cutting, bending and welding of structural steelwork, and any other cost necessary for doing the work as indicated in this Section, shown on the Drawings and/or directed by the Engineer.

(i) The cost of miscellaneous metals works shall be made at the rate per kilogram for various item of metal work which metal works are used.

(10) Spare Parts (Not Applicable)

Spare parts of each type of stem used for permanent equipments will be measured by set and the payment will be made at the lump sum bid therefor in the Schedule.

The Lump Sum payment will cover all material and labor for the preparation of the spare parts as well as the transport to locations to be indicated by the Engineer.

SECTION 13 - STEEL LINERS AND STEEL CONDUIT PIPES

SECTION 13 - STEEL LINERS AND STEEL CONDUIT PIPES

S13.01 REQUIREMENTS

(1) General

The Contractor shall fabricate, deliver and install steel liners, and steel conduit pipes at the locations shown on the Drawings or directed.

(2) Work to be carried out

The Contractor shall:

(a) Supply all necessary materials.

(b) Develop and test suitable weld procedures.

(c) Prepare all workshop drawings necessary for fabrication and installation of steel liners and steel conduit pipes.

(d) Fabricate steel liners and steel conduit pipes as shown on the Drawings, including the inspection and repair at the place of manufacture.

(e) Furnish and install bracing and supports to prevent damage or distortion to steel liners and steel conduit pipes during manufacture, transport, storage and installation.

(f) Deliver steel liners and steel conduit pipes to the site of the Works.

(g) Supply and apply corrosion protection coatings to the internal and external surfaces of steel liners and steel conduit pipes.

(h) Install steel liners and steel conduit pipes in the location and to the lines and grades shown on the Drawings.

(i) Carry out non-destructive inspection of welds.

(j) Complete the application of internal and external protective coating.

(k) Inspect and repair all defects in the welds or coating and any damage to the coating.

(3) Submission to the Engineer

(a) The Contractor shall submit one transparency and two prints of the working drawings to the Engineer at least ninety (90) calendar days prior to performing any fabrication or installation required for the work. The

Contractor shall certify that these drawings have been checked before submission.

(b) Submission of the working drawings will not waive or modify this Specification, nor will it relieve the Contractor of any part of his responsibility under the Contract or for the correctness of all his drawings.

(c) The Engineer may require the Contractor to make changes to the Contractor's drawings necessary to ensure that the Works conform to the requirements of the Contract and the Contractor shall make such alterations when directed.

(4) Terms Used

(a) The terms "upstream" and "downstream" are considered, for the purpose of this Specification, to correspond with the direction of flow in the steel pipe.

(b) The term "components" includes all flanges, rings, backing strips and other parts of the steel liners and pressure pipeline required to complete the Works as shown on the Drawings.

(5) As-executed Drawing

Prior to the completion of the Contract, the Contractor shall forward to the Engineer one transparency of all his drawings showing "As Executed" work.

S13.02 MATERIALS

(1) Steel Plate

(a) Steel plate for steel liners, steel conduit pipes and welded attachments shall comply with JIS G3101 SS 55, ASTM 537 or equivalent.

(b) In accordance with ASTM A6, the following information forms part of the Specification:

(i) Purchaser steel works inspection is required.

(ii) Test certificates are required and the Contractor shall make copies available to the Engineer before steel covered by the Certificates is accepted.

(iii) Heat analysis is required in accordance with Clause 3 of ASTM A6.

(iv) Product analysis is required in accordance with Clause 4 of ASTM A6.

(v) Test reports are required in accordance with Clause 14 of ASTM A6.

(vi) The material shall be impact tests carried out at a temperature of $0^{\circ}C$ in accordance with ASTM E23, shall give an energy not less than 27 Nm.

(c) The Contractor shall transport steel plate to his place of manufacture and shall stockpile it in an acceptable manner. Plates shall be marked with paint to maintain their identity and shall have the heat number recorded.

(d) The Contractor shall submit copies of his steel orders and the steelworks test certificates to the Engineer for information within seven (7) days of receipt of steel at his manufacturing site.

(e) All materials stored prior to fabrication and all fabricated items stored prior to application of corrosion protection or transport shall be supported above the ground in a manner which will not cause damage, distortion or high stresses, shall be prevented from rusting and shall be kept free from dirt, grease, oil and other foreign matter.

(2) Welding Electrodes, Fluxes and Wires

(a) All welding consumables used for the Works shall be of the highest quality and shall be capable, with the welding processes and procedures used for the Works, of producing weldments to the requirements of this Specification.

(b) (i) Submerged arc consumables shall comply with AWS A5.17 Grade F80.

(ii) Gas shielded or self-shielded consumables shall comply with AWSA5.20.

(iii) Manual metal arc electrodes shall be low hydrogen electrodes complying with AWS 5.1.

(c) The characteristics of welding electrodes shall be superior to the base metal in ultimate tensile strength, yield point, and elongation.

(d) (i) Welding consumables supplied for the Works shall be equal in all respects to those used for the weld procedure tests and shall be certified to this effect by the material manufacturers.

(ii) The Contractor shall supply to the Engineer the manufacturer's certificates certifying that each batch of electrodes and each batch of flux complies with the specification listed in the developed welding procedure, before they are used in production.

(iii) The Contractor shall supply to the Engineer the manufacturer's certificates certifying that each batch of welding wire complies with the specification listed in the developed welding procedure. The certificates shall list the check chemical analyses of the wire.

(iv) The Contractor shall weld a production test plate to confirm that new batches of consumables provide welds with mechanical properties and soundness in accordance with this Specification and shall submit to the Engineer the results of the tests at least one (1) week before use of the new batch of consumables in production.

(e) (i) All electrodes shall be baked at a temperature as recommended by the electrode manufacturer but not less than 250°C for 4 hours prior to use. After baking, electrodes shall be stored in an oven at a temperature of at least 100°C and shall be withdrawn singly from this oven and if not used immediately shall be rebuked or rejected, as determined by the Engineer.

(ii) Flux for submerged arc welding shall be dried and stored as recommended by the manufacturer. Storage of flux overnight in supply lines and hoppers of welding machines will not be permitted. The flux shall be clean and dry at all times. Re-use of fused flux will not be permitted. Mixing of fluxes or batches of fluxes will not be permitted.

(iii) Wire for submerged arc welding shall be clean and dry to the satisfaction of the Engineer.

(3) Miscellaneous Materials

(a) Bolts, nuts and washers shall comply with ASTM A325 Type 1.

(b) Materials for internal and external corrosion protection shall be subject to approval and shall be sampled and tested in accordance with Section 20.

S13.03 GENERAL REQUIREMENTS FOR MANUFACTURE

(1) Supervision

(a) The Contractor shall ensure that all Work is carried out under the direction of qualified and experienced engineering personnel and is supervised by persons whose training and experience in the construction of large welded plate steel structures is acceptable to the Engineer.

(b) The Contractor shall employ or retain a qualified metallurgist or welding engineer, who is acceptable to the Engineer, and who shall be available to advise on problems associated with materials and welding.

(2) Quality Control

(a) The Contractor shall be responsible for quality control, supervision and testing during manufacture and installation and shall ensure that all checking of materials, dimensions, tolerances and all inspection of fabrication, welding and transport is carried out. As part of the quality control supervision, the Contractor shall make regular checks of the operation of all cutting and welding equipment and instruments, of the fit-up, pre-heat and interpass heat actually achieved, and of the compliance of welding operators with the details of automatic and manual welding procedure.

(b) The Contractor shall maintain quality control records of his operations and these shall be available for inspection by the Engineer. The Contractor shall nominate a quality control supervisor to liaise with the Engineer on matters of quality.

(c) If any part of the manufacture is not in accordance with the detailed workshop drawings or this Specification, the Contractor shall immediately advise the Engineer of the deficiency and the proposed method of rectification. The Engineer shall determine whether rectification is required and the extent and method of rectification. The Contractor shall effect the rectification to the satisfaction of the Engineer.

(3) Inspection

(a) The Contractor shall ensure that all welding or inspection of fabrication work which forms part of or is attached to steel liners and steel conduit pipes is carried out by personnel individually qualified for the work they perform.

(b) The Contractor shall maintain a current list of qualified personnel employed on the Works which shall be available at all times to the Engineer.

S13.04 PLATE PREPARATION

(1) General

(a) All plates shall be accurately prepared and trimmed so that the specified tolerances of fit-up at welded joints and of all fabrication are obtained.

(b) Cutting and trimming of plates shall be performed by machining or machine flame cutting.

(c) Hand flame cutting shall be limited to those locations where machining or machine flame cutting are not practicable.

(d) (i) The finish of edge surfaces which will not form part of a welded joint shall equal Class 2 as defined in Australian Welding Research Association (AWRA) Technical Note No. 5, Flame cutting of Steels, 1975.

(ii) The finish of edge surfaces which form part of a welded joint shall equal Class 3 as defined in the abovementioned Note.

(e) All notches whether rounded or sharp, shall be removed from flame cut surfaces by grinding to merge smoothly with adjacent plate surfaces. All burnt metal, slag and scale shall be removed by grinding except that removal by grit blasting will be permitted provided the specified finish is obtained. Slight discoloration of machine flame cut surfaces will be accepted. Repair of flame cut surfaces by welding shall be subject to prior approval.

(f) (i) All burring of edges shall be removed. All exposed edges shall be rounded or chamfered.

(ii) The edge surfaces shall not contain flaws, cracks, laminations, slag inclusions or other defects.

(g) All lugs, brackets, and reinforcements around openings and other members shall conform to the shape of the surface to which they are attached. This shall be accomplished by machining, grinding, gas cutting and grinding, or by pressing the attachment, but not by hammering.

(h) Rings shall be fabricated into not more than two segments prior to attachment to the pipe shell. The inside surfaces of the ring halves shall be machined or ground to fit the pipe shell to which they will be attached. The final preparation of the closing butt joints for the rings shall be performed after matching the inside surfaces with the pipe shell.

(2) Tapers

Where a butt weld is required between plates of different thickness, the thicker plate shall be trimmed to a smooth taper for a distance not less than four times the offset, including the width of the weld, or as shown on the Drawings.

S13.05 FABRICATION TOLERANCES

(1) Tolerance on Weld Preparations for Butt Joints

(a) Weld preparations whose cross-sectional dimensions vary from those shown on the workshop drawings by more than the following tolerances shall be corrected before welding:

Size of root face	+/-1.5 mm

Location of root face	+/-2.0 mm
Root gap	+/-1.5 mm
Groove angle	+10.0, -5.0 degree
Radius of J and U grooves	+3.0, -0.0 mm

(b) (i) If the gap exceeds 1.5 mm but is less than 5 mm the size of the fillet weld will be increased by the amount of the gap.

(ii) Gaps greater than 5 mm will be corrected by machining the ring.

(c) The maximum separation between the surfaces of butt welded material and permanent backing material shall not exceed 1.5 mm.

(d) The maximum offset between abutting external surfaces at any position along a butt joint shall not exceed 2 mm for longitudinal joints and 3 mm for circumferential joints.

(2) Match-marks

(a) The fabricated parts shall be adequately match-marked as shown on the Drawings. Each part shall be identified with a number and a mark indicating the direction of flow and its top and bottom vertical centerline. The location of the plane of the bend shall be marked on all miter sections as well as the top and bottom match points. The marked vertical plane through the centerlines of all components and the marked planes of bends shall be within 3 mm of the true position of the plane.

(b) Marking shall be performed with paint wherever practicable. Punch or die marks, if essential, shall be light so as to not damage the plate and shall not be located on or immediately adjacent to edge preparations. Marking may be performed during or after fabrication and shall be completed before delivery from the factory.

S13.06 WELDED ATTACHMENTS

(1) Definition of Attachments

(a) Permanent attachments are defined as those which are essential for the operation or maintenance of the steel liners and steel conduit pipes. Permanent attachments shall be as shown on the Drawings.

(b) Temporary attachments are those attachments required for erection, handling and joint alignments. The Contractor shall show all required temporary attachments on his workshop drawings before submitting these drawings to the Engineer. Temporary attachments shall be welded to the steel pipes in the workshop.

(2) (a) Welding of all attachments shall be done in accordance with the developed welding procedures. Temporary attachments shall not be welded all round in connecting them to the pipe shell.

(b) All temporary attachments required for erection shall be cut off and ground flush as soon as they have fulfilled their function. Flush shall mean level with the adjacent plate surface within a tolerance of +/-1 mm, this tolerance to be achieved by a smooth transition with a maximum angular deflection not exceeding 10 degree between tangents to the cross-section at adjacent points.

S13.07 WELDING

(1) General

(a) All welding including tack welds and welds for temporary attachments shall be carried out strictly in accordance with the developed welding procedures. All welders and welding machine operators shall be individually qualified. The Technician of the Contractor shall be certified from the CWI.

(2) Welding Equipment and Procedures

(a) The welding process, welding consumables, weld procedure and weld preparation shall be selected by the Contractor subject to the requirements that the weldment performance is in accordance with this Specification.

(b) All welding shall be performed by the electric arc method and automatic welding equipment shall be used wherever practicable.

(3) Cleaning

All surfaces to be welded and the adjacent plate surfaces shall be thoroughly cleaned of scale, rust, oil or other foreign matter down to a clean surface for a distance of at least 15 mm from the welding edge. Each run of weld metal shall be thoroughly cleaned and all slag removed before the next run is deposited.

(4) Tack Welds

Items to be welded shall be assembled and retained in position for welding by any suitable methods. Tack welds, where used, shall be laid in accordance with the developed weld procedures. Where tack welds are not removed and form part of the completed weld, then the specified test welds required shall include tack welds as proposed for production. Provided the test weld meets the requirements of this Specification, the tack welds will be permitted to remain in the weldment.

(5) Correction of Fit-up

Correction of major irregularities in fit-up shall not be carried out by hammering but minor adjustments are permissible provided care is taken to avoid damaging the plate.

(6) Root Gap

Where a root gap is specified the edges of butt welds shall be held so that the correct gap is maintained within permitted tolerances during welding.

(7) Preheating

(a) When preheating is part of the weld procedure, it shall be performed before and during tack welding and shall be maintained as a minimum temperature during welding.

(b) Pre-heating of joints shall be carried out using fixed gas burners or electric blankets wherever possible.

(c) The Contractor shall provide any temperature indicators necessary to satisfy the Engineer that minimum pre-heat is being maintained over a width of six times the plate thickness.

(d) The necessity for pre-heat and control of interpass temperature will be nominated by the Contractor with the weld procedures on the basis of the run size, joint thickness, steel composition and type, the welding process and the type of electrode. Notwithstanding satisfactory results in weld procedure tests, the Engineer may direct, for some welds, a higher pre-heat to compensate for lack of accurate fit-up, for variations in plate composition and for additional restraint.

(8) Sequence of Welding

(a) The sequence of welding and tack welding shall be selected by the Contractor to reduce distortion and minimize shrinkage stresses and shall be marked on the Contractor's drawings before submission.

(b) In general, all welds shall be deposited in a sequence that balances the applied heat of welding on various sides as much as possible while the welding progresses. The direction of the general progression in welding on a member shall be from points where the parts are relatively fixed in position with respect to each other towards points where they have a greater relative freedom of movement, and points expected to have lesser shrinkage and with as little restraint as possible. After commencement of the welding of any restrained joint, welding shall be continued to completion or to a point that will ensure freedom from cracking before the joint is allowed to cool below the minimum pre-heat and interpass temperature.

(9) Welding Practice

(a) Butt welds shall be welded from both sides of the plate, except where a permanent backing strip is used.

(b) The metal at the bottom of the first side welded shall be removed so as to provide clean sound metal on which to deposit the subsequent welds. When arc-air gouging is used, the gouging head shall be mechanically driven. Any welder or welding machine operator to be used for manual back gouging of welds shall demonstrate his gouging ability to the Engineer by completing the appropriate gouging test from BS 4820 or directed by the Engineer. Demonstrations shall be carried out at the Contractor's expense.

(c) The welding procedure for a butt weld welded from one side of the plate against a backing strip shall provide complete fusion. Special care shall be taken to ensure that the root is properly fixed and that distortion due to contraction of the weld metal is minimized.

(d) Welding shall, wherever practicable, be carried out in the down hand position.

(e) After welding has been stopped for any reason, care shall be taken in restarting to ensure proper fusion and penetration between the plates, the weld metal and the previously deposited weld metal, which shall be thoroughly clean and free from slag.

(f) Where applicable, run-on and run-off plates shall be provided for butt welds.

(g) Suitable allowances shall be made for distortion and shrinkage.

(h) Fillet welds shall be made so as to ensure proper fusion and penetration of the weld metal at the root of the fillet.

(i) Plates which will form part of a T-weld shall be ultrasonically checked for laminations before welding.

(j) The arc shall be struck only on those parts of parent metal or of the weld metal where metal is to be applied. Accidental arc strikes on surfaces where weld metal is not to be applied shall be repaired as directed.

(10) Surface Imperfections

Unacceptable surface imperfections in the pipe shell shall be removed by grinding, provided that the ground surface merges smoothly with the plate surface and that the final plate thickness meets the requirements of ASTM A6 Table 1. Larger imperfections shall not be repaired without prior approval.

(11) Weld Finish

(a) (i) Butt welds which have a smooth even weld crown not exceeding 2.5 mm in height will not require grinding of the weld crown.

(ii) Local areas of the weld shall be smoothed by grinding to eliminate excess crown height or uneven weld profile if the surface is not suitable for non-destructive inspection and application of corrosion protection.

(iii) In the case of misaligned plates the height of the weld crown shall be measured from the lower surface of the plates welded.

(b) Fillet or T-welds with a smooth even profile will not require grinding. Local grinding of areas of uneven profile shall be carried out by the Contractor as directed.

S13.08 WELDING PROCEDURES

(1) Submission of Procedures

(a) The Contractor shall develop the welding procedures for the Works for all welded joints in or attached to the steel liners and steel conduit pipelines. The developed procedures shall be described in detail in a written submission of all welding procedures which shall be submitted at least ninety (90) days before initial welding on any permanent steelwork. The Engineer may require the Contractor to carry out additional development work or provide additional details of welding procedures, if the submitted information is incomplete or the development work does not define the working limits of the procedure.

(b) At least the following information shall be provided for all welding procedures:

(i) Welding process (e.g. manual metal arc welding, automatic submerged arc welding, etc).

(ii) Material specification and the range of thickness to which the procedure specification applies.

(iii) Joint design (angle of bevel and size of root face, root opening, backing strips or bars if used, etc) and tolerance limits on fit-up.

(iv) The makes and brands of electrodes and fluxes, and the nominal composition of filler metal and shielding gases.

(v) Conditioning procedure for manual metal arc electrodes and submerged arc flux.

(vi) Size and type of electrodes, approximate number of runs, size of electrodes used for each run, sequence of runs and arc energy limits for each run.

(vii) Electrical characteristics (current and polarity, and the range of voltage, current and welding speed).

(viii) Welding position.

(ix) Pre-welding and post-welding heat treatment (method of heating, temperature range and methods of control).

(2) Weld Procedure Test Plates

(a) The Contractor shall weld in the presence of the Engineer the weld procedure test plates nominated in this Clause. The test plates shall be of identical material to the plate used for manufacture of the steel liners and steel conduit pipelines and shall be set with the worst fit-up conditions permitted by the Contractor's welding procedures.

(b) The test plates shall be subjected to the pre-heat and post-heat treatments specified in the welding procedures.

(c) The test plates shall be visually inspected and radio graphically examined over the full length and butt welds shall be submitted to mechanical testing only if the extent of rectification required from any cause is less than 5 percent of the length. Test plates which require repair to more than 5 percent of the length shall be rejected.

(d) The test plates shall be sectioned for mechanical tests without regard to the location of known discontinuities in the weld.

(e) Test plates for butt welds shall be 900 mm long with the weld centrally located in a strip 450 mm wide. The test plates shall be subject to the same restraints as will apply to production welds and test plates which are excessively distorted after welding will be rejected.

(f) Test plates for fillet welds shall be 1 m long.

(g) Test plates shall be identified by steel stamps with details of the test procedure number and the welding procedure, to the satisfaction of the Engineer.

(3) Test Plates for Steel Liners and Steel Conduit Pipelines

The Contractor shall weld at least the following test plates for steel liners and steel conduit pipelines:

(a) Longitudinal automatic double-sided butt weld, 16 mm plate thickness, in the down hand position.

(b) Circumferential automatic double-sided butt welds, 16 mm plate thickness, in the down hand position.

(c) Circumferential, semi-automatic or manual, double-sided butt welds, 16 mm plate thickness, consisting of three plates in down hand, overhead and vertical position.

(d) Circumferential, semi-automatic or manual, single-sided butt weld against backing strip, 16 mm plate thickness, consisting of three plates in down hand, overhead and vertical position.

(e) Circumferential fillet weld for backing strip and seep ring consisting of one plate 50 percent down hand and 50 percent vertical position.

(f) Manual weld repair for longitudinal and circumferential butt welds.

(4) Mechanical Tests on Weld Procedure Test Plates

(a) Mechanical tests on weld procedure test plates shall be made in accordance with Article II Section IX of the ASME Boiler Code or directed by the Engineer.

(b) The following test specimens shall be prepared from each double-sided butt weld test plate:

(i) Macro sections for soundness examination and hardness traverse, two off. No portion of the weld or heat affected zone shall show a hardness greater than 300 HV 10.

(ii) Side bends tests over a former radius of three times the specimen thickness, two off. Metal separation shall not occur.

(iii) Transverse joint tensile specimens - two off. Both shall achieve an ultimate tensile strength not less than the ultimate tensile strength of the parent plate.

(c) Mechanical tests for single-sided butt welds against a backing strip shall consist of macro sections and transverse joint tensile test in accordance with paragraph b. above. Two specimens are required for each test plate.

(d) On the completion of the test, no crack or other defect at the outer surface of the test piece shall have a dimension greater than 1.5 mm measured across the test piece or 3 mm measured along the length of the test piece. Premature failure at the corners of the test piece shall not be considered cause for rejection.

(e) Mechanical test on the weld procedure test plate for manual weld repairs are not required.

(5) Responsibility for Testing

The Contractor shall be responsible for carrying out all mechanical tests on procedure test weld plates and shall retain for this purpose an approved laboratory.

S13.09 PRODUCTION WELDING TESTS

(1) General

(a) During fabrication and installation, the Contractor shall, when directed, carry out production tests on welded joints in accordance with the developed weld procedure to:

(i) monitor the soundness and properties of welds on a routine basis

(ii) verify that the standard set from the welding procedure test is being maintained, and shall be carried out when directed

(iii) confirm that new batches of welding consumables produce welds with mechanical properties and soundness in accordance with the Specification.

(b) The test welds may be run-on or run-off tabs or separate test plates which simulate as closely as practicable the production weld being checked. Production test plates shall be of sufficient size to accommodate the test specimens listed in Clause S13.08 (4). All production test plates shall be welded in the presence of the Engineer.

(2) Frequency of Testing

(a) Production test weld plates shall be welded at approximately the following frequency:

(i) one test weld per 100 m of longitudinal welds in pipe shells welded by automatic processes

(ii) one test weld per 300 m of circumferential welds in pipe shells welded by automatic processes

(iii) one test weld per 100 m of butt welds welded by manual or semi-automatic processes.

(b) Installation test weld plates shall be welded at a frequency of one test weld per five circumferential welds.

(c) In general the frequency shall be greater than average at the commencement of each welding procedure and shall be arranged to test new supplies of consumables, electrodes, welding wire and flux, as their use is commenced in production welding.

(3) Radiographic and Mechanical Testing

(a) The production and installation test weld plates shall be radio graphically examined to ensure that the standard of welding is at least equal to that required in production. The test plate shall be rejected if rectification is required for more than 5 percent of the weld length.

(b) (i) Production and installation weld test plates shall be sectioned for mechanical testing in the same manner as procedure weld test plates and shall provide a minimum of 900 mm effective weld test length with the weld centrally placed in a 450 mm wide plate.

(ii) The Contractor shall be responsible for carrying out mechanical tests on production and installation test welds in accordance with the provisions of this Specification.

(4) Disqualification of Welding Procedures

If the mechanical tests or radiographic examination of a production test weld shows that the weld does not comply with the minimum standard required for a procedure weld, then that welding procedure shall be disqualified and further welding with that procedure shall not be permitted. The procedure shall be resubmitted when the cause of the failure of the production weld has been determined by the Contractor. The failure of the test weld to comply shall not in itself be grounds for the rejection of production welds performed in accordance with the weld procedure before the failure of the test weld. However the Engineer may request additional non-destructive testing to confirm the quality of the production welds completed since the previous production test weld plate.

S13.10 WELDER AND OPERATOR PERFORMANCE QUALIFICATION TESTS

(1) General

(a) The Contractor shall ensure that all welding or inspection on work is carried out by personnel individually qualified for the work they perform.

(b) All welders and welding machine operators engaged on welding in accordance with this Section of the Specification shall pass the welder performance tests which are designed to demonstrate their competence to make sound welds of the types on which each is to be employed.

(2) Qualification of Welders

(a) Welder performance tests shall be performed in accordance with the developed weld procedure. A welder who welds successfully all the test plates required for a welding procedure test will be considered as qualified for the particular welding process, welding position, and type of steel.

(b) The details of the welder performance test shall be recorded by the Contractor, and shall be included with the test results. Welders who successfully weld test plates in the flat, vertical and overhead positions shall be qualified for all positions.

(3) Requirements for Requalification

(a) Changes in the procedure which require requalification shall require new welder performance tests. A change in the make of electrodes, fluxes or filler material shall not be a cause for requalification providing that there is no significant change in welding and running characteristics.

(b) The Engineer may direct a qualified welder to repass the whole or part of the qualification test if there is any reason to doubt the welder's ability to make satisfactory production welds or if the welder, after qualification, has not been engaged on erection using the process and equipment appropriate to the procedure for a period of three months.

(4) Failure to Qualify

If one or more tests fail to meet the requirements, the welder may make two further test welds of each type rejected, both of which shall pass all test requirements. If any of the retests fail, the welder shall undergo further training before resubmission of further test welds.

(5) Welder Performance Test Plates

The welder performance test plates shall comprise at least 300 mm of welding for manual welds and 600 mm for automatic welds. All test plates shall be welded in the presence of the Engineer and shall demonstrate the welder's ability to follow the procedure. After welding, test plates shall be visually examined and radio graphed to ensure that the standard of quality is at least equal to the minimum required in production. If the requisite standard has been attained, the test plate will then be sectioned without regard to any indication on the radiographs. The specimens shall be prepared and tested in accordance with the specified requirements.

(6) Radiography, Macro and Bend Tests

The following tests shall be performed on the test weld and shall constitute a test series for the particular weld, welding process and position being considered. The results shall be assessed in accordance with Clause S13.08 (4).

TESTS FOR WELDER PERFORMANCE TEST PLATES

Test Type	Number of Tests	Method of Testing and Requirement
Macro Test	1	Article II Section IX and Section UW 51 or equivalent
Bend Test	2	Section VIII (1) of ASME Boiler Code or equivalent
Radiography	100%	In accordance with the specification

(7) Qualification for Various Types of Welds

(a) Manual welders qualifying for circumferential joints steel will be required to perform two test series of double sided welds, one test in which the both sides of the joint have been welded in the vertical position and one test in which one side of the joint has been welded in the overhead position and the other in the down hand position. Manual welders qualified in accordance with this paragraph shall be deemed to be qualified for butt welds welded from a single side against a backing strip.

(b) Welding machine operators qualifying for longitudinal and circumferential automatic welds steel will be required to perform one test series.

(c) Welding machine operators qualifying for semi-automatic welds steel will be required to perform one test series.

(d) Welders qualifying for repairs to automatic or semi-automatic welds will be required to perform one test series and comply with ASTM A573 or directed by the Engineer.

(8) Responsibility of Contractor

The Contractor shall provide all materials and equipment required for welder and operator performance qualification test and shall perform all work, fabrication and machining necessary to prepare the test specimens.

S13.11 WELDING INSPECTION

(1) General

(a) Production Welds

Circumferential and longitudinal production butt welds shall be radio graphically examined for 100 percent of their length.

(b) Field Welds

(i) Circumferential field butt welds for bifurcates and steel conduit pipeline components shall be radio graphically examined for 100 percent of their length.

(ii) Circumferential field butt welds for steel liners shall be ultrasonically tested on a spot basis. The extent of spot testing shall be 10 percent of the length of the circumferential butt welds. The Engineer will direct the location and position of welds to be ultrasonically tested.

(2) Repaired Welds

All areas of welds on which repairs have been made shall be radio graphically or ultrasonically examined, as directed by the Engineer, after repairs have been carried out. This examination shall be at the Contractor's expense.

(3) Radiographic Examination

(a) At least thirty (30) days before commencing radiographic examination, the Contractor shall submit details of all radiographic equipment, materials, processes and procedures. These details shall comply with the requirements for certification by an appropriate accreditation agency.

(b) Radiographic techniques shall employ X-rays only and shall comply with techniques 1 or 2 of BS 2600 for longitudinal welds and techniques 1, 2, 7 or 8 of BS 2910 for circumferential welds or directed by the Engineer.

(4) Repair of Defects

Defects which are greater than those permitted in Section UW 51 Section VIII (1) of ASME code are unacceptable and will require repair.

(5) Gouging and Re-welding

If any weld has been examined over the full length and rectification is required over more than 25 percent of the weld length, the entire weld length shall be rejected and the weld shall be cut out and re-welded to the satisfaction to the Engineer. The entire weld shall be re-examined after re-welding.

(6) Ultrasonic Examination

(a) Ultrasonic examination for Penstock or directed by the Engineer may be used to check that welds and heat affected zones of pipes are free from cracks and crack-like defects and to locate radiographic indications for repair.

(b) The Contractor shall make available a technician and equipment for ultrasonic examination of the welds. The Engineer will direct which welds are to be examined. Ultrasonic techniques shall comply with BS 3923 Part 1 or directed by the Engineer.

(c) (i) At least ninety (90) days before commencing ultrasonic testing the Contractor shall provide details of personnel with their qualifications, details of equipment and a clear specification of methods to be used.

(ii) All ultrasonic testing shall be carried out at Level 2 Standard. Where defects are to be sized, all such sizing shall be carried out at Level 1 Standard using the 20 Db drop method.

(iii) The roughness of the surface shall not be more than 3.2 micron Ra and shall permit uniform probe contact throughout the test.

(iv) Calibration of equipment, techniques, and procedures shall be in accordance with BS 3923 or directed by the Engineer.

(d) Defects which have been detected by ultrasonic examination shall be repaired as directed. Any defect which produces an ultrasonic echo that fails to reveal the nature of the defect shall be radio graphically examined, if possible, when so directed.

(7) Coating Examination

(a) Coat underground steel pipe for Headrace and aluminum bolts, nuts, anchors, fasteners, couplings, adapters, and miscellaneous metal not epoxy coated or not coated and/or wrapped or directed by the Engineer.

(i) Thoroughly clean surfaces to be coated and wash with solvent in accordance with the coating manufacturer's instructions. Solvent shall be entirely volatile so as to leave no trace of oil or grease.

(ii) Treat galvanized surfaces with metal conditioner as recommended by the coating manufacturer.

(iii) Apply at least two coats of mastic coating. Coating thickness shall be at least 40 mil (1mm). Apply in accordance with the coating manufacturer's instructions

(b) Field quality control

(i) Perform an electrical holiday-detection inspection on coated and/or wrapped underground piping systems.

(ii) The inspection shall be made by a skilled operator using an electrical holiday detector. Low-voltage, wet-sponge type detectors are not acceptable. Operate the detector unit at the voltage between the electrode and the coated pipe that is recommended by the coating manufacturer, or approximately 100V/mil (4kV/mm) of coating thickness.

(iii) Make the voltage measurement between the electrode and the coated metal pipe when the detector is in its normal operating position with the electrode resting on coating.

(iv) Minimize the electrical resistance in the holiday detector's ground-return system, which consists of the ground wire and the coated metal pipe. Where possible, direct electrical connection should be made between the detector and the metal structure.

(c) Repairs to underground pipe coating and wrappings

(i) Repair holidays to the satisfaction of the University.

(ii) Repair coating and/or wrappings on underground piping damaged by the Subcontractor during excavation or installation. Do not cover repairs until they are inspected and tested by the University.

(iii) Prepare damaged areas by cutting away loose, unadhered, or damaged wrapping and/or coating back to sound wrapping and and/or coating. Clean prepared surfaces and the area on the wrapping and/or coating at least 4 inches (100 mm) back from the prepared surfaces with solvent that does not leave film or residue.

(iv) Coat the damaged area within 2 hours of completion of the surface preparation.

(v) Cover prepared surfaces with mastic up to the level of the original pipe wrapping and/or coating

(vi) Cover the mastic and areas on the wrapping and/or coating at least 4 inches (100 mm) back from the filled area with 4 or 6 inch wide (100 or 150 mm wide) pipeline tape. The tape shall be half-lapped to provide the equivalent of at least two thicknesses of tape.

(vii) Upon completion of holiday detection and repair work, certify in writing that shop and field wrapped and/or coated piping, fittings, and like items, have undergone a complete electrical holiday-detection test and are free from holidays

(8) Additional Examination

The Engineer may direct the use of visual, dye-penetrant and magnetic particle to supplement radiographic and ultrasonic methods of examination. These additional methods will be used to ensure that welds do not contain unacceptable defects.

S13.12 HANDLING

(1) Precautions

The lifting and loading equipment and procedures, the transport equipment and the unloading equipment and procedures shall be designed and, if necessary, constructed by the Contractor to carry safely the loads to be supported and to ensure that the components are not overstressed, distorted or damaged. The Contractor's drawings and proposals for the equipment and procedures shall be submitted at least thirty (30) days before any of the components are to be handled. In the event of any damage occurring to the components, the Contractor shall at his expense, repair the damage to the satisfaction of the Engineer.

(2) Supports and Bracing

(a) All slings used in lifting or holding any component shall be padded with or constructed from suitable materials and all supports for pipes shall be curved and constructed of wood and rubber sheeting or other suitable materials to ensure that distortion or damage does not occur.
(b) Bracing shall be used to prevent distortion and shall not be welded to the metalwork of the steel liners and pipes.

S13.13 INSTALLATION

(1) General

The steel liners and steel conduit pipeline components shall be installed in the position and to the lines and levels shown on the Drawings in accordance with the match and flow marks positioned during fabrication.

(2) Precautions

All steel lining components stored before installation shall be supported above the ground in a manner which will not cause damage, distortion or high stresses, shall be prevented from rusting and shall be kept free from dirt, grease, oil and other foreign matter.

(3) Procedures

(a) Liners and pipe components erected on staging shall be supported on suitable packing to ensure they will be at the correct elevation and alignment when completed. Field joints shall be securely held in position to ensure accurate alignment, curvature and elevation before welding is commenced.

(b) The Contractor shall ensure that the steel liners and pipeline components are erected so that the longitudinal joints on either side of a field circumferential weld are staggered as shown on the Drawings.

(4) Field Welding

(a) Field welding shall be performed under suitable portable shelters to ensure protection from draughts and moisture.

(b) Positioning of steel conduit pipe components and tack welding shall be performed at times when the temperature difference between pipe components or between each side of a pipe component is small.

(c) Completion of welding at each joint shall follow the tack welding as closely as possible.

(5) Correction of Errors

The liners and pipe components shall not be over-stressed. Any error in the work which prevents proper assembling and fitting of the components shall be reported immediately to the Engineer. Correction of any error shall not commence until the method of correction has been approved.

(6) Tolerances

The following tolerances shall apply to the installation of the steel liners and steel conduit pipelines.

(a) The maximum offset between abutting external surfaces at any position along a butt joint shall not exceed 3 mm for circumferential joints.

(b) The difference between the maximum and minimum internal diameters of the pipe shell measured at any one cross-section shall not exceed 0.4 percent of the mean diameter of the pipe shell.

(c) The profile, measured on the outside or inside of the pipe shell by means of a gauge of the designed form of the pipe shell and having a length equal to 0.25 of the internal diameter, shall not depart from the designed form by more than 0.2 percent of the mean diameter of the pipe shell.

(d) The maximum deviation from a straight line parallel to the axis of the pipe shell as measured by a straight edge along the inside of the pipe shall not exceed the following:

. 5 mm in 6 m length
. 10 mm in 12 m length.

(e) The centerline of each component shall not deviate by more than 12 mm from the theoretical pipe centerline shown on the Drawings.

(f) The tolerances listed in this sub-clause may be supplemented by additional tolerances shown on the Drawings.

(7) Grout Plugs

Grout plugs in steel liner sections shall be coated with bond breaking deoxaluminate grease and screwed home before concrete placement. After concrete placement, the grout plugs shall be removed and grouting carried out in accordance with this Specification. After completion of grouting, the grout holes and grout plugs shall be degreased and cleaned then the plug threads shall be wrapped with tape, and the plug screwed tightly into position. The circumference of the plug shall be welded to the pipe as shown on the Drawings.

(8) Protective Coating

The Contractor shall complete the application of the protective coating to the surfaces of steel liners and steel conduit pipes and shall repair all damaged areas of the coating in accordance with this Specification.

S13.14 MEASUREMENT AND PAYMENT

(1) Method of Measurement

(a) Where payment is by mass, the mass of metalwork shall be determined by multiplying the volume of metalwork, calculated from the dimensions shown on the Drawings, by 7,850 kg per cubic meter.

(b) In calculating the volume of steel plates, the nominal thickness of plates will be adopted and all fillet welds and weld reinforcements will be disregarded; butt and Tee joints will be considered as the same thickness as the nominal thickness of the adjacent plate; covers and flanges will be considered as the nominal thickness prior to machining. In calculating

volumes there will be no deductions made for the holes cut for off-takes or other purposes.

(c) Notwithstanding other sub-clauses of this Clause, the mass of nuts, bolts and washers will be determined on the basis of nominal mass supplied by the manufacturer. Mass of nuts, bolts and washers not incorporated in the steel liners and pipelines will not be measured for payment.

(d) All backing strips will be deemed to be included in the measurement of the attached steel liner.

(e) For the purpose of measurement for payment, steel liners will be considered to include all liner sections installed as shown on the Drawings.

(2) Steel liners, and Steel Conduit Pipes

(a) Payment for fabrication, delivery and installation of steel liners and steel conduit pipes including transition, reducer and stiffener steel plate will be made at the rates per ton bid therefor in the Schedules.

(b) These rates shall include all costs associated with fabrication, delivery and installation to the storage area including the cost of designing and furnishing all plant, equipment, staging, haulage and storage facilities and service, welding of all joints in the pipe shell which make up the individual liners and pipes, bends and closing pieces, all field welding of all joints between the individual liners and pipes corrosion protection of all surfaces, design and fabrication and hydrostatic testing delivery. These rates shall also include the cost of all materials, construction facilities, professional and technical services, transport, equipment, labor and other necessary charges.

(3) Attachments

Payment for approved attachments welded to the steel liners and steel conduit pipes, for which provision for payment has not been included in the Schedules, will be made at the rate applicable to the steel liners and steel conduit pipes to which the attachments have been welded.

(4) Corrosion Protection

Payment for corrosion protection of the internal surfaces of the steel liners and steel conduit pipes will be made in accordance with Section 17.

(5) Welding

(a) Payment for the development of welding procedures will be made at the lump sum bid therefor in the Schedule for steel liners and steel conduit pipes.

(b) Payment for production welding tests on butt welds will be made at the rate per test series bid therefor in the Schedule. A test series is defined as comprising the tests listed in sub-clause S13.09 (2) for the particular welding process, type of weld and particular welding position being considered.

(d) Payment for welding and testing of welder and operator performance qualification test plates will be made at lump sum bid therefor in the Schedules for steel liners and steel conduit pipes.

(6) Concrete

Concrete required for anchor blocks and concrete encasing the steel conduit pipes will be paid for in accordance with Section 9.

(7) When work is required to be performed under any Clause of this Specification and provision is not made for direct payment of the work, the entire cost of such work shall be deemed to be included in the unit and lump sum prices in Schedule.

(8) The unit and lump sum prices in the Schedule shall include the costs for all materials, construction facilities, professional and technical services, transport, equipment, labor, delivery to site, and other necessary charges.

SECTION 14 - MISCELLANEOUS WORKS

SECTION 14 – MISCELLANEOUS WORKS

S14.01 HIGH STRENGTH CONCRETE

High strength concrete is a special concrete used at the control equipment alternative structure (see Section 8).

S14.02 REINFORCED CONCRETE BRIDGE

Reinforced concrete Bridge as shown on the Drawings are the responsibility of the Contractor to make shop drawings and type of materials and submit to the Engineer for approval.

(a) Dead weight of the bridges shall be as follows:
(b) Live load:
- AASHTO standard truck HS 20-44,
- 10-Wheel truck of 36-ton gross weight
- Mobile Crane of 45-ton Lifting capacity

(c) Impact of live load
(d) Wind load, 150 kg/sq.m

S14.03 POLYMORPHIC RESIN LINING (NOT APPLICABLE)

(1) General

(a) The work covers the requirement for furnishing materials, equipment and services necessary and incidental to provide, install and apply protective lining on concrete surface at the Barrage crest as shown on the Drawing or as directed.

(b) The approved material shall be subject to additional test if required by the Engineer, the Contractor through his supply shall submit proof or competency of the material to the satisfaction of the Engineer.

(c) All applications and installations shall be made under the supervision of the manufacturer expert.

(2) Material

Material shall be QTT – Polymorphic Resin by Repcon Co., Ltd. or Derakane 470 by Dow Chemical Co., Ltd. or Ceilcoat 658 by Master Builder Co., Ltd. or equivalent.

(3) Application

(a) Surface Preparation

Surface preparation of concrete shall conform to the manufacturer's recommendations. In general, concrete surface shall be free of deteriorated concrete and contamination such as oil, grease, etc. All application work shall be in accordance with manufacturer's recommendation.

(b) Method Statement

Prime Coat : Silicone Modified Epoxy Based Vinylester Resin

Base Coat 1 : Polymorphic Resin + Fiberglass 300 gm/sq.m

Base Coat 2 : Polymorphic Resin + Fiberglass 300 gm/sq.m

Top Coat 1 : Polymorphic Resin + Pigment Paste

Top Coat 2 : Polymorphic Resin + Wax + U.V.Absorber

Total Thickness : 2.0 mm (approx.)

(c) Typical properties

Type : Polymorphic Resin – Vinylester Base

Tensile Strength (PSI) (ASTM D638)	10,000
Flexural Strength (PSI) (ASTM D790)	17,000
Elongation % (ASTM D638)	5 - 8
Barcol Hardness (ASTM D2583)	40
Heat Distortion Temp (^{o}C) (ASTM D648)	100

S14.04 EXAMINATION THE BEARING CAPACITY OF FOUNDATION

Examination the bearing capacity of foundation by drilling as noted on the Drawings or as directed by the Engineer used for examining the bearing capacity of doundation is the responsibility of the Contractor. The Contractor shall submit Details of drilling to the Engineer not later than thirty (30) days prior to the commencement of the drilling work. The drilling details shall include, but not be limited to the following:

(a) The locations of drilling holes.

(b) The drilling, Dampling and field and laboratory testing methods

(c) The drilling programs (the mumber of holes, Samples and testings)

(d) The method of foundation analysis

The Contractor shall submit the results of drilling and the foundation analysis to the Engineer not lates than fifteen (15) days prior to the commencement of the foundation works.

S14.05 PVC PIPE DRAIN

(1) General

The work covers the requirement for furnishing materials, equipment and services necessary and incidental to provide, install and supply PVC pipe drain on at the Power house as shown on the Drawing or as directed.

The following standards are referred to:
- AWWA C900 Polyvinyl Chloride (PVC) Pressure Pipe, 4-Inches through 12-Inches, for Water
- TIS 17 Polyvinyl Choride Pipes for Drinking water Services

(2) Materials

(a) Pipe and Fittings

Polyvinyl chloride pipe, unless otherwise specified, or shown on the drawsings, shall conform to the provisions of AWWA V900 for Class 150 Dimension Ratio (DR) 18 or TIS 17, subject to the exceptions and supplemental Requirements contained in this section. Unless otherwise specified, fitting shall be made of cast iron, in general, conform to TIS 918.

(b) Pipe Rating and Dimensions

The pipe shall conform to the following dimensions and limiting values :

Nominal Size (mm)	Outside Diameter (mm)	Minimum Wall Thickness (mm)
80	89	4.1
100	114	5.2
150	165	7.5
200	216	8.8
250	267	10.9
300	318	12.9
350	370	15.0

400	420	17.0

(c) Tolerances

The tolerances for the outside diameters and wall thickness shall be in accordance with Clauses 4.1, 4.2, 4.3 and 4.4 of TIS 17-2532 respective. Measurement of dimensions shall be in accordance with TIS 17-2532.

(d) Joints

All pipe and fittings shall be designed for the rubber ring push-on type of joint, unless otherwise specified. Rubber ring gaskets shall provide a watertight seal for the assembled joint for all vertical and horizontal angular deflections of the pipe up to and including the maximum deflection recommended by the manufacturer, and at all pressures up to and including the test pressure of the pipe.

All materials used for jointing shall be compatible with one another and with the polyvinyl chloride pipe. The shall-neither support the growth of bacteria nor affect the portability of the water.

Solvent-cement couplings will not be allowed.

(e) Manufacturer's Mark
Pipe shall be clearly mark on the outside surface at the interval not exceeding 1.5 meters. The mark shall show the following information :

- raw material (PVC)
- nominal size and pressure rating
- name or trade mark of the manufacturer
- year of manufacture
- Owner's mark
- reference standard

(3) Shop Testing

Inspection and testing of pipe and fittings shall be carried out by the manufacturer in accordance with TIS 17-2532.

S14.06 MEASUREMENT AND PAYMENT

(1) High Strength Concrete
Measurement and payment for high strength concrete fc' = 350 ksc.strength concrete will be made at the rate per cubic meter as stated in the Schedule.

(2) Reinforced Concrete Bridge
Measurement and payment for Reinforced Concrete Bridge will be made at the rate per linear meter as stated in the Schedule which shall include the

cost of concrete topping.

(3) Polymorphic Resin

Measurement for payment for furnishing and lining the polymorphic resin will be of the area actually applied.

Payment for protective lining on concrete surface will be made at the rate per square meter therefor in the Schedule, such rate constituting full compersation for all materials, labor, equipment, tools and incidentals needed to complete the work.

(4) Drilling

Payment for the drilling will be made at the rate per linear meter there for in the Schedule which shall include the cost off all materials, preparation of the drilling equipment and all other relevant services that mcessary for the Work described in this Clause.

(5) PVC Pipe Drain

Measurement and payment for PVC pipe drain will be made at the rate per linear meter as stated in the Schedule which shall include the cost of supply and install, joint and fitting for this work.

SECTION 15 - ILLUMINATION EQUIPMENT

SECTION 15 - ILLUMINATION EQUIPMENT

S15.01 GENERAL

Illumination equipment shall be furnished and installed by the Contractor in accordance with this Specification and as shown on the Drawings. Within ninety (90) days prior to the executing of the Work, the Contractor shall prepare and submit shop drawings to the Engineer for approval.

(1) Scope of Works

Illumination equipment both indoor and outdoor shall consist of following work.

(a) Indoor Illumination Equipment

Item	Nature of Works
Lighting fixtures	Furnishing and installation various types of lighting fixtures. Lighting fixtures shall be furnished complete with lamps, ballasts, suspending members and accessories, including accessories necessary for installation at specified positions.
Wiring fixtures	Furnishing and installing circuit breaker boards, switches and receptacles. Installation of fixtures shall include furnishing of accessories necessary for installation at specified positions.
Conduit piping	Furnishing and installing conduits pipes beyond secondary terminals of circuit breaker board to be supplied under this work up to all boxes of indoor lighting fixtures and indoor wiring devices including conduit accessories (boxes, couplings, bushings, supports, normal bends, elbows, etc.) necessary for installation.
Wiring	Installing electric wires beyond secondary terminals of circuit breaker board to be supplied under this Wire up to all lighting and wiring fixtures. Connections to lighting and wiring fixtures are included under this work.

(b) Outdoor Illumination Equipment

Item	Nature of Works
Lighting fixtures	Lighting fixtures shall be furnished complete with lamps, ballasts, poles and accessories, including concrete foundation work and excavation and back-filling therefore, and accessories necessary for installation at specified positions.
Wiring fixtures	Furnishing and installing circuit breaker boards and photoelectric switches. Installation of equipment shall include the furnishing of accessories necessary for installation and specified positions.
Conduit piping	Furnishing and installing conduits pipes beyond secondary terminals of circuit breaker board to be supplied under this work up to all outdoor lighting fixtures and wiring devices including conduit accessories (boxes, couplings, bushings, supports, normal bends, elbows, etc.) necessary for installation.
wiring	Furnishing and installing electric wires beyond secondary terminals of circuit breaker board to be all outdoor wiring fixtures. Connections to lighting and wiring fixtures are to be performed under this work. Unless otherwise stipulated, electric wires shall be NYY cable, and shall be laid in conduit on dam crest as shown on the Drawing and Conduit pipes. Cable accessories, cable laying and earthling of cable shall be executed under this work.

(2) Instruction Book

The Contractor shall within two (2) months prior to start installation furnish ten (10) copies of instruction books the operation and maintenance of principal equipment furnished and installed by him under this clause.

S15.02 MATERIALS

(1) General

All fixtures and materials shall be furnished by the contractor and shall conform to applicable provision of TIS, ASTM or JIS and shall be approved by the Engineer prior to installation.

Lighting fixtures shall be finished products, complete with socket, ballast, power factor improvement condensers, installation hardware and other technically required accessories and parts.

Appliances shall be of the highest performance, shall not deteriorate in their function under prolonged use, shall be of construction easy to dismantle and to inspect, and shall be completely interchangeable as to common parts, including spare parts. Those items which are to be assembled at site shall be accompanied by all bolts, nuts and accessories necessary for assembly.

(2) Lighting Fixtures

Fixtures shall be of sturdy construction, easy to maintain and inspect. In particular, installation and connection leads shall be of sufficient strength. Fixtures shall be free of light leakage, shall admit no dust, insects and other objectionable matter so far as possible, and shall be so constructed as to sufficiently withstand surrounding temperatures. Consideration shall be given so that any heat generated within the appliances shall be diffused completely. No defects of electrical parts, insulating materials shall occur by overheating, and there shall be no deterioration, deformation, dis-coloring, peeling of paint due to overheating, poor material, and workmanship after many years of use.

For wiring within fixtures, different colored vinyl insulated electric wires shall be used, and a wiring diagram for each terminal shall be attached to each appliance.

Prior to installation at the site, dielectric strength of 1 or 2 fixtures of each type shall be tested at 1,500 V for 10 minutes in the presence of the Engineer.

Insulation resistance of the fixtures tested shall be more than 5 meg-ohms.

(a) Power Source
Mercury vapor lamp for normal use: AC single phase 220 V 50 Hz.

(b) Lamp
Mercury vapor lamp 250 W: total flux 19,000 luminal or more. The lamp shall be of the following manufactures, Philips or Sylvania or G.E. or as approved by the Engineer.

(c) Ballast
Mercury vapor lamp: high power factor, constant wattage.

(d) Lamp Post
Posts for outdoor illumination shall be of galvanized steel, and of the shape and type as shown on the Drawings or of similar shape and type approved by the Engineer.

(3) Tumbler Switches and Receptacles

The types and rating of tumbler switches and receptacles shall be in accordance with the descriptions on the Drawings. The standards are set as below.

Item	Description

Monopole tumbler switch:	250 V, 10 A, surface mounted type monopole tumbler switch with plate.
Receptacle:	250 V, 10 A, 2 poles with ground, surface mounted type, Single or duplex receptacle with plate.
Power receptacle:	400 V, 30 A, surface mounted type, 4 poles with ground, 5 wires, with plate.

(a) Tumbler Switches

Tumbler switches shall of the totally enclosed tumbler type and shall be thoroughly tested and inspected according to the Underwriters' Laboratories VDE, IEC or JIS standards for control of incandescent and fluorescent lamps to the full rated capacity. The terminals shall be of the side connecting screw type. The switch housing and operating lever shall be constructed of phenolic compound or high grade plastic. Switches with porcelain bases are not acceptable.

(b) Receptacles

Receptacles shall be of 2-pole, 2-wire, ground and round prong and straight blade type. The receptacle body shall be brown phenolic or high grade plastic and shall have screw terminals for side and back wiring Copper or copper alloy shall be used for all current carry and for wire binding screws. All other metal parts shall be on-ferrous finished to prevent corrosion.

(c) Power Receptacles

Power receptacles shall be as specified in the above table. Plugs of same rating as receptacle shall be furnished for each receptacle.

(d) Device Plates

The plates shall be stainless steel alloy.

(4) Lighting Panel Board

Lighting panel board shall be of steel construction, of the types (electric system, wiring circuit breaker) and construction (outdoor, self standing type) as shown on the Drawings and shall conform to the following:

(a) Casing shall be fabricated of steel frames and steel plates not less than 1.6 mm thick.

(b) Metal surfaces shall be cleaned of all rust and then coated with anti-corrosive lead base paint. Finish color scheme shall be as directed by the Engineer.

(c) Front of cases shall be so constructed as to be easily removable for inspection, and repair of equipment mounted inside, and shall be equipped with a door to facilitate operation of the distribution circuit breaker. Surface of the board shall be painted in a color directed by the Engineer.

(d) Panels shall be made of steel plate of 3.2 mm thick, and provide with the required distribution circuit breakers, magnetic contactors and shall be connected with copper strips of adequate size.

(5) Circuit Breaker Boards

Circuit breaker boards shall be of steel construction, of the types (electric system, wiring circuit breaker) and construction (surface mounted type) shall conform to the following. Casing shall be fabricated of steel frames and steel plates not less than 1.6 mm thick. Metal surfaces shall be cleaned of all rust and then coated with anti-corrosive lead base paint. Finish color scheme shall be as directed by the Engineer.

Front of cases shall be so constructed as to be easily removable of r inspection, and repair of equipment mounted inside and shall be equipped with a door to facilitate operation of the distribution circuit breaker. Surface of the board shall be painted in a color directed by the Engineer.

Power panels shall be made of steel plate of 2 mm thick and provided with the required distribution circuit breakers and shall be connected with copper strips of adequate size.

The circuit breakers shall be of the thermal type with quick-make and quick-break toggle mechanism for both manual and automatic operation. The design shall be such that the moving contacts shall be now welding and full contact assured up to the time of opening whether opened automatically or manually. The bimetallic element shall be such as to insure constant calibration, long life and shall be capable of withstanding short circuits or over load conditions without injury. In case of abnormal overload or short circuit on a branch circuit, the breaker shall open automatically. Automatic tripping shall be indicated by the handle assuming a position distinctive from the manual “ON” and “OFF” positions. The “ON” and “OFF” positions shall be indicated plainly by mean of the operating handle positions and marking.

Prior to installation at the site, tests as stated below shall be executed in the presence of the Engineer.

(a) Outside appearance, dimension, and structure
(b) Dielectric strength: 1,500 V for 10 minutes
(c) Insulation resistance: 1 meg-ohm or more

(6) Photo-electric Switch

Photo-electric switch shall be installed to control electric current by daylight. Switch shall have contract of sufficient rating to handle large currents without failure and to break and connect lamp circuits at specified daylight intensities.

Power source	AC 220 V, 50 Hz
Load current	10 A
Operation intensity	
Switch – on	5 to 25 lux
Switch – off	25 to 125 lux

(7) Conduit Pipes

Unless otherwise specified, all conduits shall be PVC in accordance with TIS 216-2524.

Conduit accessories shall be galvanized and shall conform to the respective publications and other requirements of Underwriter's Laboratories standards, NEMA, USAS or other equivalent standards.

Suitable conduit pipe accessories shall be selected. Outlet boxes for lighting fixtures, receptacles, local switches, etc., shall be made of metal. Wooden base, wooden box or the like shall not be substituted for metal products. Where 2 or more tumbler switches, receptacles or others are to be installed at the same place, a common box shall be provided together with proper common cover and plate. At the places where heavy lighting fixtures are installed, stud bolts adequate to support the fixtures shall be provided in structures supporting such boxes.

(8) Electric Conductors

Electric wires and cables shall be of 750 V thermoplastic insulated conductors NYY type fabricated according to Table 2, 4, 6, 11of TIS 11-2531.

Insulations shall be satisfactory for installation in wet or dry locations on AC and DC circuits and shall be suitable for use on a copper conductor with maximum operating temperature of not less than 70°C wet or dry.

The size of conductors of wires and cables shall be as indicated on the Drawings and shall be not less than 2.5 mm^2 for lighting and power.

S15.03 PERFORMANCE OF WORK

(1) Installation of Fixtures

Wiring connection shall be made in outlet boxes. In case of installing on wooden structures, the attached box or flange for pendant shall be screwed on directly to such structure. In case of installing on reinforced concrete structure, the outlet box shall be screwed on concrete for exposed piping, or shall be placed in concrete for embedded piping. In case of installing a built-in type fixture on ceiling, steel or timber furring shall be provided parallel with the longitudinal direction of the fixture, and the fringe of the reflecting shade or body shall be either supported by, or screwed on to, such steel or timber furring support. Concrete foundations shall be provided as shown on the Drawings for post type outdoor lighting and the poles shall be firmly installed on such foundations by bolts or other fasteners, or embedded in concrete foundation.

(2) Conduit Work

Conduit pipes and accessories of lighting fixtures, other than those which are laid in control building shall, unless other wise specified, be exposed. Exposed conduits shall be laid out in such an orderly manner as to match with the condition of surface for support.

Except for rising of pipes, other wall surface piping shall be generally supported along or suspended from the ceiling surface. Pull-boxes shall be generally suspended from the ceiling or attached to walls. All radii of conduit bends shall be 9 times or more than the inside diameter of conduit. The tube shall not have more than 4 rectangular bends or similar curves between any 2 fixtures or between any 2 boxes.

Conduits shall be sufficiently protected so that no water, dust, or other objectionable matter shall enter the pipes. During the period from the laying of tubes up to installing conductors, adequate measures shall be taken to prevent entry of moisture, dust or other materials into conduits, and the inside of the tube shall be cleaned by adequate means immediately prior to installing conductors.

(3) Wiring Work

In installing conductors, substance harmful to conductor, such as oil, grease shall not be used. Splicing of conductors within the conduit tube shall be strictly prohibited. No soldering shall be applied to the conductor joints.

Insulation resistance against round of each circuit shall be more than 1 meg-ohm.

S15.04 AIR-CONDITIONING SYSTEM

The Contractor shall supply and install air conditioner rotary split type in the buildings of capacity as shown on the Drawing.

S15.05 MEASUREMENT AND PAYMENT

Payment shall be made at the lump sum price bid therefore in the Schedule and shall include all costs for materials, fabrication, transportation, installation, tests and all other incidentals works.

The lighting system shall be maintained and protected by the Contractor in a satisfactory condition unit final acceptance by the Owner. Defective materials, including spare items and equipment damaged in the course of installation or tests, shall be replaced or repaired by and at the expense of the Contractor in a manner meeting the approval of the Engineer.

(1) Indoor illuminating Equipment at Power House

The Works shall consist of all illuminating equipment work including the furnishing and installation of indoor lighting fixtures, indoor wiring fixtures, indoor conduit piping, indoor wiring panel board or control box and painting.

The equipment to be furnished and installed by the Contractor under this item shall be as shown on the Drawing.

Payment for indoor illuminating equipment shall be made at the time of completion of installation the lump sum bid therefore in the Schedule.

(2) Outdoor illuminating Equipment and main low power cable

The Works shall consist of and include all the illuminating equipment Works including the furnishing and installation of outdoor lighting fixtures, outdoor wiring fixtures, control box, outdoor conduit pipes, outdoor wiring and painting and main low power line, 3 phases 4 wires, NYY, THW for all buildings, offices and others.

The equipment to be furnished and installed by the Contractor under this item shall be as shown on the Drawing.

Payment of outdoor illuminating equipment and main low power cable shall be made at the time of completion of installation and at the lump sum bid therefore in the Schedule.

(3) Payment for air-conditioner will be made to rate bid therefore in the schedule.

(4) Payment for ventilator will be made to rate bid therefore in the schedule

(5) Payment for miscellaneous equipment will be made to rate bid therefore in the schedule

SECTION 16 - 22KV TRANSMISSION LINE AND LOW TENSION CABLE

SECTION 16 - 22 KV TRANSMISSION LINE AND LOW TENSION CABLE

S16.01 SCOPE OF WORKS

(1) The Contractor shall, with his own expense, survey and design the 22 kV transmission line route for the Project by connecting the high-power line from the nearest PEA pole to the transformer and camp service transformer, and provide the low-power line NYY from the station transformer to the main distribution panel board of the station in the control house and main low tension cable for residence and outdoor lighting.

(2) The Contractor shall be responsible for the clearing of 22 kV transmission line route with the right of way 10 meters from its center line on both sides. The clearing shall include cutting and trimming of all trees higher than 1.5 meter and all trees that might damage, disturb and interfere the transmission line.

(3) The Contractor shall supply and install 22 kV transmission line for the service of the Project as shown on the Drawings or as directed by the Engineer. The scope of works shall include the supply and install the following equipment and materials:

(a) Prestressed concrete poles 12 m in height and stay
(b) Cross arm, insulator for main transformer
(c) Line material, conductor PIC

Poles and transmission shall conform to applicable PEA Standard Specifications and as described in these Specifications.

(4) The Contractor shall design and make the construction drawing in A-1 transparency sheet (with blue-print) with calculation sheets and submit to the Engineer for approval before commencement of the Works.

(5) All equipment to be used for construction of the transmission line must be submitted to the Engineer for approval before construction.

S16.02 PRESTRESSED CONCRETE POLES

(1) Requirements

The Contractor shall design prestressed concrete poles conforming to the requirements specified below:

(a) For 12.0 m Pole

Dimension of tip end	15x18	cm
Dimension of bottom end	24x27	cm
Minimum bending moment at point 2 m from the lower pole tip end:		
- Design	2,550	kg-m
- Ultimate	5,100	kg-m
Weight (Approximate)	1,265	kg

(b) Safety Factor = 2

(2) Design Approval

The Contractor shall submit to the Engineer for approval the detailed design of the poles. It shall include:

(a) Calculation sheets of the working bending moment and the ultimate bending capacity of pole. Factor of safety at each section shall be clearly shown.

(b) Arrangement of prestressing steel and reinforcing bar.

(c) Detailed design of concrete mixture for the designed strength of concrete.

(d) Test report of concrete test pieces.

(e) Test report of prestressed steel or steel wire for prestressing and reinforcing bar.

Prestressed concrete poles shall conform to applicable PEA Standard Specifications.

S16.03 CROSS ARMS

The cross arm shall be prestressed concrete cross arm and conform to the following requirements:

(1) Dimension and Bending Moment

The concrete cross arm shall have dimensions as following:

(a) The concrete cross arm, 100x100x2,500 mm. shall be used for line angle not exceeding 30 degrees. Working bending moment shall be not less than 265 kg-m Weight shall be between 60-65 kg per piece.

(b) The concrete cross arm, 120x120x2, 000 mm. shall be used for line angle exceeding 30 degrees and dead end. Working bending moment shall be not less than 450 kg.-m Weight shall be between 70-75 kg. per piece.

(2) Hole in Concrete Cross Arm

Concrete cross arm of 2,500 mm shall have hole of diameter 18 mm for 5 holes and of 22 mm for 4 holes. The holes shall be vertical and crossing the center line of the concrete cross arm. Inside surface of the hole shall be smooth enough for installation of machine bolts.

(3) Details and Drawing Required

The Contractor shall submit to the Engineer, the calculation details and drawings used in manufacturing of concrete cross arm 7 sets. The calculation details and drawing shall be as follows:

- Drawings showing dimensions, hole position and arrangement of reinforcement steel.

- Detail of tensile strength test results of reinforcing steel.

- Calculation details.

These details and drawings shall be the property of the Department and shall be used as reference documents to inspect and accept manufacture process.

(4) Earthing

(a) Material

Earth wire shall be ∅ 4 mm galvanized steel wire and comply with the provision of TIS 71-2517.

(b) Assembly

Every pin of insulator pin type shall be connected to ground. The earth wire ∅ 4 mm galvanized steel wire shall be lined under the concrete cross arm and shall be attached with washer square curved 60x60x5 mm. and connected to 25 sq.mm steel ground wire (buried in concrete pole) at the top of the pole with clamp single U-bolt M.8.

(5) Cross Arm Hardware for Concrete Pole

(a) Steel material for cross arm hardware for concrete poles shall have a yield point strength of 35 kg/sq.mm and shall be smooth surface and free from defects, cracks, etc.

(b) Galvanizing

Cross arm hardware and hardware for stay wires shall be galvanized. All ferrous materials shall be galvanized in accordance with ASTM A 235.

(6) Test Records

Records of the above mentioned tests and inspections shall be prepared immediately after completing the tests and inspections. These records, after obtaining approval of the Engineer shall be submitted in necessary copies to the Engineer.

S16.04 LINE MATERIAL

(a) The Contractor shall provide transmission line material conform to the appropriate PEA Specification.

(b) Test for the component steel gates, pumping and completed cable shall be conducted as specified in the relative provisions of TIS 86-2517.

S16.05 POWER CABLE

(a) 3.3 kV: Cross-Linked, Polyethylene shield conform to the appropriate JIS C3606 or IEC 502

(b) 380 V: NYY-N/THW, 750 V, 70°C, 2 PVC shield conform to the appropriate JIS standard or TIS 11-2531

(c) Illumination equipment: THW, 750V, 70°C, PVC shield or VAF, 300 V, 70°C PVC shield.

(d) Control system: CVV, 600 V, 70°C enclosure Binding Tap and PVC.

(e) Instrument system: CVV-S, 600 V, 70°C, Insulated and Sheathed Control Cable with shield.

S16.06 TRANSFORMER

The Contractor shall supply and install 1x400 kVA three-phase transformer with concrete foundation and wire mesh fence at Powerhouse or as shown on the drawing and including drop out fuse, PT, CT, lightning arrester, kWh meter and accessories for each pump station.

(1) Specifications of transformer

(a) The transformer shall be three-phase transformer, oil-immersed, natural self cooled, suitable for outdoor installation on foundation or on platform 22 kV 50 Hz system and shall be manufactured and tested in accordance with TIS 384-2525 or IEC.76 or equivalent: unless otherwise specified in these specifications.

H.T. and L.T. bushing shall be in accordance with the latest DIN 42531 & DIN 42530 respectively or equivalent.

(b) The transformer supplies under this Contract shall not be used for construction power and lighting in Contractor's work or accommodation.

(c) The Contractor shall provide the electric power supply adequate for use by his own expense.

(2) Principal Requirement

(a) Service Condition and Rating

The transformer shall be designed and constructed for outdoor installation and operation under the following conditions:

Attitude : up to 1,000 m. above sea level

Ambient air : 45°C maximum

temperature : 35°C average on one day

The transformer cores shall be according to manufacturer's standard.
H.T. and L.T. windings of transformers shall be made of copper.
Rating of transformers to be shown on drawings

(b) Taps

The primary windings of transformers shall be provided with full capacity of externally - operated off-circuit tap changers.

Tap voltage: ± 2x2.5 % of rated primary voltage. The externally-operated off-circuit tap changer shall be designed for de-energized operation with the operating handle brought out through the cover of the tank. The operating handle shall have provision for locking and shall give visual indication of the tap position without unlocking.

Vector group: Dyn 11

(c) Losses, Impedance Voltage and Insulation Level

The specified or guarantee losses plus positive tolerance shall not more than the PEA standard value.

Impedance voltage of the offered transformer shall be 4-6 percent impedance voltage at 75°C

Limits of temperature-rise, above 45°C ambient

Temperature of top oil : not exceeding 55°C
Temperature of winding : not exceeding 65°C

The insulation level of H.T. windings and connected parts of transformers shall be as follow:

Nominal System Voltage (kV-rms)	Insulation Level	
	Impulse Test Power Voltage Fullwave (kV Peak)	Frequency Test Voltage 1-min (kV-rms)
22	150	50

(d) Bushing

(i) Number and Location

Each transformer shall have three high-voltage bushings and four low-voltage bushing located on the cover of the tank. Secondary neutral point of transformer shall be brought out by separate-insulated bushing and loaded with rated current.

(ii) Material

Transformer bushings shall be made of good commercial grade wet-process porcelain. The entire porcelain surface of the bushings that will be exposed after assembly shall be glazed. The color of the glaze shall be brown.

(iii) Electrical Characteristics

Transformer bushings shall be capable of withstanding the impulse and low-frequency voltage listed below:

Bushing	Impulse Full wave (kV Peak)	Low Frequency, 50 Hz (kV-rms)	
		Dry 1-minute	Wet 10-second
High-voltage bushings for 22 kV system	150	50	50
Low-voltage bushing	30	10	10

(e) Terminal Connectors

H.T. bushings shall be equipped with solderless clamp type connectors for aluminum conductor diameter range from 7.5 mm. to 12.6 mm. (Sizes 35-95 mm^2).

L.T. bushings shall be equipped with solderless clamp type connectors for aluminum and copper conductor diameter range from 6.9 mm. to 12.6 mm. (Size 35-95 mm^2). Eye-bolt type connectors are referable.

The connector shall be provided with mounting hardware (bolts, nuts, washers and lock washers) of stainless steel or better. The connectors on L.T. bushings shall be of high conductivity bronze and tin plated.

(f) Tank Finish

Interior surface shall be finished with oil resistant paint.
Exterior surface shall be painted with a primer coat and not less than two finish weather-resistant coats of grey.

(g) Accessories

The transformers shall be furnished and equipped with the following accessories:

(i) H.T. and L.T. bushings, with terminal connectors

(ii) Arcing horns, corrosion proved

(iii) Tap changer

(iv) Thermometer pocket

(v) Name plate with connection diagram

(vi) Oil drain valve with plug or cap, installed at the lower part of the tank

(vii) Sludge drain plug, installed at the bottom of the tank

(viii) Earthing terminal, with solderless clamp type connector suitable for steel stranded conductor diameter of 9.0 mm. (Size 50 mm^2); complete with lock washer of stainless steel or better

(ix) Lifting lugs

(x) Lifting eyes on the cover

(xi) Supporting lugs for hanging the transformer tank to pole by using two M16 machine bolts; the lugs are 500 mm.apart (hanging type)

(xii) Oil level marking inside the tank
(xiii) Other necessary accessories according to manufacturer's design

(h) Initial Oil Filling

The transformers shall be supplied with initial oil filling. The oil shall be high-quality, clean and dry.

(i) Minimum Name plate Information

(i) Manufacturer's name
(ii) Manufacturer's serial number
(iii) Year of manufacture
(iv) Number of phases
(v) Rated frequency in Hz

(vi) Rated output in kVA
(vii) Rate voltage in V
(viii) Rated current in A
(ix) Tap voltages in V
(x) Vector group
(xi) Impedance voltage in %
(xii) Connection diagram
(xiii) Type of cooling
(xiv) Oil quantity in liter
(xv) Total weight in kg

(j) Packing

For transformers manufactured outside the territories of Thailand, each transformer shall be seaworthy packed in individual export crate or wooden case which will not be returned.

For transformers manufactured within the territories of Thailand, each transformer shall be packed in individual crate or wooden case which will not be returned.

(k) Tests and Test Reports

(i) Routine Test

Each transformer shall pass the manufacturer's standard routine test, and also pass the following tests in accordance with the relevant standard:

- Measurement of winding resistance
- Measurement of voltage ratio, and check of voltage vector relationship
- Measurement of impedance voltage
- Measurement of load loss
- Measurement of no-load loss
- Induced overvoltage withstand test
- Oil dielectric strength test

(ii) Type Test

The following type of tests shall be in accordance with the relevant standards:

- Temperature-rise test
- Impulse withstand voltage test

The costs of all tests and test reports shall be borne by the Contractor.

S16.07 LIGHTNING ARRESTER, DROP OUT FUSE, CT, PT AND kWh METER

(a) Lightning arrester and switch for H.T. and L.T. voltage shall be suitable for 22 kV and 400/230 V and comply with PEA standard. L.T. conductor shall be 70°C, THW. or NYY type installed in Rigid Steel Conduit (RSC) or others.

(b) Drop out fuse and fuse link completed with mounting accessories shall be 22 kV, 1-phase type.

(c) Lightning arrester completed with mounting accessories shall be 22 kV, 1-phase type.

(d) The current transformer (CT), and potential transformer (PT) and kWh meter for the power transformer shall conform to the following conditions:

(i) High tension metering types shall be used for transformers with as shown on the Drawing.

(ii) Low tension metering type shall be used for transformers as shown on the drawing.

kWh meter, CT, PT, DF and LA shall be in conformity with applicable PEA Standard Specifications and subject to the approval of the Department.

S16.08 EARTH RESISTANCE

For installation the transformer, the earth electrode resistance of H.T. lightning arrester and transformer tank, secondary neutral grounding and L.T. lightning arrester shall be not exceed 5 ohms.

S16.09 MAIN DISTRIBUTION PANEL BOARD (MDB)

(1) General

The low voltage section shall terminate the outgoing feeder cables and contain the circuit protective devices, metering equipment, and auxiliary components described herein and on the Drawings.
All low voltage bussing and connections shall be braced to withstand the maximum short circuit current available from the system and/or as specified herein.

(2) Technical Data

The main distribution board shall have the electrical rating as follows:-

- System wiring 3-phase, 4-wire with ground
- Rated voltage 400 V/230 V.
- System voltage 380 V/220 V.
- Rated frequency 50 Hz.

– Insulation class	600 V. (minimum)
– Rated continuous current	As indicated on the Drawing
– Short circuit current	50 kA (minimum) at 415 V. or as indicated on the Drawing

(3) Enclosure Construction

The main distribution board framework shall be fabricated on a die formed steel base assembly consisting of formed steel and commercial channel welder or bolted together to rigidly support the entire unit for floor mounting. The framework is to be formed in 3 mm thick code gauge steel, rigidly welded and bolted together to support all cover plates, basing, and component devices during installation.

Each section shall have an open bottom and individual removable top plate for installation and termination of conduit. The top and bottom conduit area is to be clearly shown and dimensioned on the Shop Drawings. All front plates use for mounting meters, selector switches or other front mounted devices shall be hinged with all wiring installed and laced with flexibility at the hinged side. The back closure plate shall also be hinged type and other closure plates shall be screw removable and small enough for easy handling by one man.

The enclosure shall be constructed as to prevent the entry of all files and rodents (protection degree IP54).

The structure shall consist of "three basic compartments" from front to rear as follows:-

a) Front, circuit breaker compartment.
b) Centre, bus bars compartment.
c) Rear, cable compartment.

Adequate ventilation shall be provided for the equipment enclosed.

The fabricated sheet steel panel shall not be less than 2.0 mm thick and applied with non rusting primer and finish with color code selected by the Department.

Name of main and distribution board manufacturer shall be submitted in the bid for consideration.

(4) Low voltage bus

The bus shall be bare copper and of sufficient cross sectional area to continuously conduct rated full load current with a maximum average temperature rise of $25^{\circ}C$ above an ambient temperature of $40^{\circ}C$. The current carrying capacity of bus bar shall be of the bare bus bar rating.

The phase and neutral main horizontal bus shall consist of a single continuous solid 98% copper conductor per phase and neutral.

The bus bars shall be rigidly braced to comply with the rated short circuit current of the main distribution board.

The main horizontal bus bars between sections shall be located to permit maximum of available conduit area. The end section is to have bus bar provisions for future addition of a section. The provisions shall include the bus bars installed and extended to the extreme side of the section and be fabricated in such a fashion that the addition of a future section would require only the installation of standard bolted splice plates. The horizontal main bus bar supports, connections and joints shall be bolted to be free of required periodic maintenance.

(5) Main Circuit Breaker

Circuit breakers shall be provided as shown on the Drawings. The circuit breakers shall be rated at 415 V. and certified by type tests to 50 kA. short circuit breaking current or the rating as indicated on the Drawing.

The design shall be such the main contact pressure increases with heavy through-fault currents. Auxiliary arcing contacts shall be provided to protect the main contacts from burning during the switching operation. All contact parts shall be readily replaceable.

A mechanically operated visual on/off/isolated indicating device shall be provided to indicate the circuit breaker position. A local push-button shall be provided for manual closing and tripping of the circuit breaker.

(6) Feeder Circuit Breakers

Circuit breakers shall be equipped with individually insulated, braced and protected connectors. The front faces of all circuit breakers shall be flush with each other. Large permanent, individual circuit numbers shall be affixed to each breaker in a uniform position (or equip. each breaker with a circuit card holder and neatly printed card identifying the circuit). Tripped indication shall be clearly shown be the breaker handle taking a position between “On” and “Off”

(7) Other Switchboard Instrument

(a) Metering

Metering such as ammeters, voltmeters or power factor meters etc. shall be of the panel flush mounted type, 1.5 accuracy class. The size of meter shall not smaller than 96 x 96 mm.

(b) Current Transformer (CT)

The current transformer shall be primary rated as indicated on the drawings and secondary rated 5A, accuracy class 1 or better and tropical proof.

(c) Indicating Lamps

Lamps shall conform to DIN for NEMA or other equivalent standards with color caps, suitable for the voltage supplied. Lamp element shall be LED type. All lamp bulbs shall be interchangeable, and shall be replaceable from the front of the panels.

(8) Control Wiring

Wiring shall be run in plastic trough or wire ways and connected through terminal blocks. Current test boxes for current transformer circuits shall be provided.

(9) Mimic Bus

Mimic bus shall be provided on the main distribution board to form a single line diagram which will simulate actual electrical connections. Color of mimic bus shall be selected by the Engineer.

(10) Nameplate

The nameplates shall be of laminated plastic material, black on the surface with a white internal layer. Lettering shall be machine engraved into the nameplate to form white letters against a black background. A sample nameplate shall be submitted for approval.

(11) Drawings

Upon award of the contract, the Contractor shall furnish for approval sets of Drawings showing the general arrangement and schematic diagrams. These Drawings shall indicate all installations and coordination data required by the Contractor for the preparation of electrical and mechanical details necessary for the installation of the main distribution board assembly.

(12) Test

The entire switchboard fabrication and installation shall be tested and approved by the Engineer and the Electricity Authority.

S16.10 MEASUREMENT AND PAYMENT

(1) Clearing

Payment for the clearing of 22 kV transmission line will be measured for payment in square meter and payment will be made at the rate per square meter in the schedule.

(2) Furnishing and Installing of 22 kV Transmission Line

Payment for the supply and installation of the 22 kV transmission line and pole including pole assembling will be made as the applicable rate per linear

kilometer bid therefor in the Schedule. These rates shall include the cost of all labors and materials required to perform the Works specified.

(3) Furnishing and Installing of Main Low Tension Cable

Payment for the furnishing and installing main low tension cable NYY, THW, 750 V, 4 wires from each transformer to the control board of the Project will be made as the applicable rate per set bid therefor in the Schedule. These rates shall include the cost of all labors and materials required to perform the Works specified.

(4) Transformer

Payment for supply and installation of transformer shall include PT, CT, LA, DF, protection, metering and all accessories complete with concrete pole assembly and will be made as the applicable rate per set bid therefor in the Schedule. These rates shall include the cost of all accessories, labors and materials required to perform the Works specified.

(5) Main distribution Panel Board (MDB)

Payment for supply and installation of Main distribution Panel Board (MDB) will be made as the applicable rate per set bid therefor in the schedule.

(6) Equipment of Switchyard

Payment for furnishing and installing the equipment of switchyard at power house of the Project will be made as the lump sum bid therefor in the Schedule. These rates shall include the cost of all labors and materials required to perform the Works specified.

(7) Emergency Generator

Payment for supply and installation of emergency generator will be made as the applicable rate per set bid therefor in the schedule.

SECTION 17 - CLEANING, CORROSION PROTECTION AND PAINTING

SECTION 17 - CLEANING, CORROSION PROTECTION AND PAINTING

S17.01 SCOPE OF WORK

The Contractor shall furnish, prepare and apply all material for cleaning, corrosion protection and painting of all surfaces as hereinafter specified. All painting shall be done strictly in accordance with the manufacturer's recommendation. The corrosion protection and painting of the hydromechanical equipment is excluded from this section, and is specified separately in Section 16.

(1) Surface Not Required Painting

The following surfaces are not to be painted unless specifically designated:

(a) Concrete surfaces except where required to be painted for architectural reasons or for protection from chemicals as specified herein.

(b) Hot-dip galvanized steel components except where required as part of total protection system or for decorative reasons as specified herein.

(c) Stainless steel, copper, PVC, glass, vinyl and aluminum surfaces.

(d) Steel surfaces to be covered by insulation and lagging.

(e) Machined surfaces.

(f) Prefinished panels for ceilings, walls and fixtures.

(g) Steel surfaces subject to temperatures above 100°C.

(2) Surface Required Corrosion Protection and Painting

It is the intent of this Section to require corrosion protection and painting of all exposed and submerged metal, piping, and all other surfaces obviously required to be painted unless otherwise specified.

(3) Surfaces of metalwork completely embedded in concrete unless otherwise specified or shown on the Drawings shall be treated as follows:

Metalwork	Surface Preparation	Treatment
External surfaces of ungalvanized embedded pipework equal to or Greater than 300 mm diameter	In accordance with Clause S17.04	In accordance with Clause S17.06
All other completely embedded metalwork	SSPC Specification SP6	None required

(4) Except as otherwise specified, surfaces of metalwork that will be in contact with other metalwork or concrete shall receive 3 coats of priming paint. The type of priming paint and the method of surface preparation shall be consistent with the requirement for other surfaces of the same metalwork.

(5) All machined surfaces shall be protected against corrosion by the application of 1 coat of suitable corrosion inhibitor to the satisfaction of the Engineer.

(6) Field weld preparations and the adjacent blast-cleaned surfaces shall be protected with 1 coat of an approved paint as a corrosion inhibitor. This paint shall be of a type which will not adversely affect the welded joint and which is readily removable for the restoration of the specified coatings to the satisfaction of the Engineer.

(7) Surfaces that have been coated shall be handled with care so as to preserve the coating in the best practicable condition and shall be protected as approved by the Engineer from the harmful effects of heat and weather conditions.

S17.02 COATING SYSTEMS

(1) Category 1 Metalwork (Not applicable)

(2) Category 2 Metalwork (Not applicable)

(3) Category 3 Metalwork

(a) Category 3 metalwork is the metalwork which will be exposed to sunlight and condensation. It shall be coated with one of the following systems, to be approved by the Engineer:

(i) polyester resin/mica filed coating, or

(ii) inorganic zinc silicate/PVC vinyl resin coating, or

(iii) inorganic zinc silicate/epoxy micaceous iron oxide coating.

(b) Category 3 metalwork will be applied for the foot bridge at spillway, and movable steel barricade.

(c) Surface preparation shall be abrasive blast-cleaning to SSPC-SP10 in accordance with Clause S17.04.

(d) The coating shall consist of:

(i) one coat of polyester resin/mica filled material with a total minimum dry film thickness of 0.750 mm. The coating shall be applied in not less than five passes, or

(ii) one coat of inorganic zinc silicate to give a minimum dry film thickness of 0.075 mm followed by two coats of PVC vinyl resin, each coat to give a minimum dry film thickness of 0.075 mm, or

(iii) one coat of inorganic zinc silicate to give a minimum dry film thickness of 0.075 mm followed by two coats of epoxy micaceous iron oxide, each coat to give a minimum dry film thickness of 0.050 mm.

(e) The blast profile shall be as recommended by the coating supplier.

(4) Category 4 Metalwork (Not applicable)

(5) Category 5 Metalwork

(a) Category 5 metalwork is the metalwork that will be exposed to normal atmospheric conditions. In shall be coated with an aluminum paint system as specified in this subclause.

(b) Category 5 metalwork includes miscellaneous metalwork exposed to the atmosphere, such as sign plates and road sign.

(c) Surface preparation shall be abrasive blast-cleaning to SSPC-SP5 in accordance with Clause S17.04.

(d) Zinc metalizing to give a minimum coating thickness of 0.050 mm.

(e) Aluminum metalizing to give a minimum coating thickness of 0.050 mm.

(f) Primer-One coat of a two-pack, zinc chromate wash, etch type, vinyl resin based, i.e., phosphoric acid modified, primer using spray application to a thickness of 0.015 mm.

(g) Finishing Coat-Two coats of an aluminum phenolic based paint, the first coat shall be applied at the rate of 2.5 sqm/l and the second coat at the rate of 5.0 sqm/l. The paint shall consist of 250 g of aluminum paste litre of phenolic resins par varnish freshly mixed before application.

(6) Category 6 Metalwork

(a) Category 6 metalwork is the metalwork that will be galvanized and painted such as trashrack of intake structure, gratings, cover of valve chamber.

(b) Surface preparation and galvanizing shall be in accordance with Clauses S17.04 and Clause S17.06.

(c) Primer-One coat of wash primer as specified in subclause (6) (f) of this Clause.

(d) Finishing coat shall consist of either:

(i) 2 coats of aluminum phenolic based paint as specified in subclause (5) (g) of this Clause, each applied at the rate of 5.0 sqm/l, or

(ii) full gloss alkyd resin enamel finishing paint consisting of an exterior grade full gloss alkyd resin enamel. It shall contain suitable pigments and shall dry to give a hard high gloss film. The paint as manufactured shall contain at least 68 percent by mass of nonvolatile film-forming solids. The system shall have not less than 2 finishing coasts and the progressive dry film thickness of the finished system shall be less than 0.080 mm.

(7) Category 7 Metalwork

(a) Category 7 metalwork is the metalwork to be hot-dip galvanized and shall include:

(i) mild steel anchor bolts;

(ii) steel pipes and fittings for dam instrumentation.

(iii) miscellaneous metalwork including metalwork partially embedded in concrete;

(iv) weir, baffle of the flow meter;

(v) handrails;

(vi) steel ladders, ladder rung;

(vii) conduit fittings;

(viii) grouted rockbolt accessories including associated flat plates and rolled sections, and

(b) Surface preparation shall be in accordance with Clause S17.04.

(c) Galvanizing shall be in accordance with Clause S17.06.

(8) Concrete

(a) Concrete post, such as guide post, shall be coated with a three-coat acrylic emulsion coating system, or a three-coat chlorinated rubber or a two-coat epoxy coating system.

(b) Surface preparation shall be cleaning, and if required, grinding and acid etching in accordance with Clause S17.04.

(c) Acrylic System:

(i) Undercoat-Water-borne acrylic alkali-resistant sealer-undercoat suitable for cement-based surfaces and gypsum plaster and compatible with the finishing coat.

(ii) Finishing Coat-High quality water-borne acrylic paint which is non-toxic, lead-free, with good resistance to abrasives, alkalis, chemicals and solvents. There shall be at least 2 finishing coats and the progressive dry film thickness of the finished system shall not be shall be flat or satin as directed by the engineer.

(d) Chlorinated Rubber System:

Finishing coat-High quality unmodified opaque pigmented chlorinated rubber enamel. There shall be at least three finishing coats and the progressive dry film thickness of the finished film shall not be less than 0.121 mm.

(9) Coatings for Surfaces not specified

Coatings for surfaces not specified herein will be chosen by the Engineer from the above systems. The surfaces shall be cleaned and coated as directed by the Engineer.

S17.03 APPROVAL AND SUPPLY OF COATING MATERIALS

(1) All paints constituting one paint system shall be supplied by one manufacturer.

(2) Representative samples of all coating materials to be incorporated in the coating system shall be submitted to the Engineer for approval not less than ninety (90) days prior to the proposed date of commencement of the coating operations with the system.

(3) Samples of two-pack type materials shall be supplied in sets of companion packs, each set containing enough of each component to make not less than 2.5 liters of the mixed paint. The number of sets shall not be less than the number of individual costs in the system. For all other coating materials a sample shall consist of not less than 1.0 liter.

(4) Samples shall be taken from a production run of the manufacture's plant and shall be identified by batch or lot numbers.

(5) The Contractor shall supply, with each sample, the following information:

(a) A certified copy of the manufacturer's statement of the physical and performance characteristics. These characteristics shall include:

(i) paint system;

(ii) components of paint system;

(iii) batch number;

(iv) surface of 'touch dry' time;

(v) hard dry time;

(vi) minimum and maximum recoat time; and

(vii) coat and system curing time.

(b) The manufacturer's recommended procedures for the surface preparation, application, handling instructions, equipment including nozzle sizes and minimum paint application pressures, ambient conditions including maximum and minimum temperatures and humidity, mixing instructions, safety an storage instructions. The procedures shall specifically detail requirements for transport and storage including storage temperatures, time for storage and conditions o storage so as to avoid increases in viscosity or any other deleterious effect on the coating materials. Procedures may include requirements for controlled temperature and/or humidity storage and transport facilities in which case the Contractor shall provide verification to the Engineer that the materials have been maintained within the temperature and/or humidity ranges recommended by the manufacturer. The procedures shall include any special requirements for factory application, for field repairs to the damaged coating and for the coating of field welded joints. These procedures shall be approved by the Engineer prior to the application of any coating materials.

(6) The Contractor shall supply, with each sample of coal tar epoxy coating material the following particular information.

(a) The supplier, country of origin and nature of quality control for the coal tar pitch, and the supplier and description of epoxy resin material.

(b) The coal tar pitches to epoxy resin ration.

(c) Mixing ratio of the two components.

(d) Percentage non-volatile by volume-formula basis.

(e) Percentage coal tar pitch by volume.

(7) The Contractor shall supply with each sample of polyester resin/mica filled coating material the following additional information:

(a) A description of the resin base material.

(b) Percentage of mica filling in the coating material.

(c) Mixing ratio of the two components.

(d) Percentage of total solids in the coating material.

(e) Type of solvent used in the coating material.

(8) The Contractor shall supply with each sample of inorganic zinc silicate coating material information regarding the minimum mass of zinc per square metre of coating.

(9) The Contractor shall supply with each sample of PVC vinyl resin coating material the following additional information:

(a) A description of the resin base material.

(b) Percentage of total solids in the coating material.

(10) Each batch of the coating materials supplied for the Works shall be accompanied by a certificate from the manufacture certifying that the coating material has been manufactured in accordance with the standard formulation and that it conforms in all respects to the manufacture's quality control tests. This certificate shall also accompany all samples of coating materials submitted in accordance with this Clause.

S17.04 SURFACE PREPARATION

(1) Steel Surface

(a) All cleaning and surface preparation of steel surface shall be performed by skilled personnel under the supervision of staff experienced in the surface preparation of steel work.

(b) Weld spatter, burrs and any other objectionable surface irregularities on metalwork shall be carefully removed or repaired before cleaning.

(c) Surface preparation for steel shall be in accordance with various degrees of Steel Structure Painting Council Standard (SSPC) as following:

SSPC – SP1	Solvent Cleaning
SSPC – SP2	Hard Total Cleaning
SSPC – SP3	Power Tool Cleaning
SSPC – SP4	White Metal Blast Cleaning
SSPC – SP5	Commercial Blast Cleaning
SSPC – SP6	Brush off Blast Cleaning

SSPC – SP7 Pickling
SSPC – SP8 Weathering followed by Blast Cleaning
SSPC – SP9 Near White Blast Cleaning

(d) Steel surfaces to be coated shall be cleaned of all detrimental foreign matter such as oil, grease, soil or other contaminants in accordance with SSPC-SP1.

(e) Unless otherwise specified, cleaning and surface preparation of all steel surfaces to be coated shall be in accordance with SSPC-SP10.

(f) The contractor shall use a steel grit or other abrasive approved by the Engineer to obtain the required surface preparation and the produce the surface profile specified for the particular coating. The abrasive shall be hard sharp and free from dust.

(g) Blast cleaned surface with SSPC-SP10 showing plate surface defects such as slivers, scabs or sharp gouges shall be repaired as directed by the Engineer prior to the application of the coating systems. The surface profile shall not be less than 0.05 mm and not greater than 0.100 mm.

(h) Before being coated, the blast-cleaned surface shall be fiber-brushed and vacuum-cleaned to remove all blast products and abrasives from the entire surface including pockets and corners. Final blast-cleaning operations shall not be conducted on surfaces that will become wetted after blasting and before paining, or on surfaces the temperature of which is less than $3^{o}C$ above the dew point of the surrounding air, or when the relative humidity of the surrounding air is greater than 85 percent.

(i) Cleaned surface shall be kept free from any contamination and shall not be touched by bare hands. The operators shall wear fabric gloves of an approved type whilst carrying out cleaning and coating, and any areas inadvertently touched by hands or bare parts of the body shall be solvent cleaned immediately.

(2) Concrete Surface

New concrete surfaces of guard post, sign post or surfaces where directed by Engineer shall be prepared by removing all dirt, dust, effervescence, oil and grease stains, or other foreign substances by wire or fiber brushing scrapers, light sand blasting and/or other approved means and by surface roughening, when necessary to provide good adhesion of paint. New concrete surfaces received paint shall be allowed to cure for a minimum of thirty (30) days before being painted. Cracks, holes and those pock marks exceeding 2 mm in dimension of the surface shall be repaired with approved patching material properly keyed to the existing surfaces and prepared smooth by sand paper. Unless otherwise specified or directed by the Engineer, surfaces to receive base paints shall be brush treated with solution consisting of two percent (2%) zinc chloride and three percent (3%) phosphoric acid in water and the surface

permitted to dry thoroughly. After drying, the residue shall be removed by light brushing prior to application of paint.

(3) Cost of Surface Preparation

The Cost of surface preparation prior to the application of a coating system shall be included in the cost of the application of the coating.

S17.05 APPLICATION OF COATING MATERIALS

(1) The application of all coating materials shall be carried out in a neat, workmanlike manner by skilled personnel under the supervision of staff experienced in the application of the particular system and in accordance with the manufacture's application instructions, as approved by the Engineer, and in accordance with these Specifications.

(2) All equipment use in the application of coating materials shall be as recommended by the manufacturer and approved by the Engineer. The equipment shall be in first class order and where power driven equipment is used, deliver the coating materials at the rate specified in the application specification.

(3) Where warming of the coating materials is required, the temperature and the method of heating shall be in accordance with the manufacturer's instruction. Coatings shall not be applied to surface upon which there is any moisture, or during rain or misty weather without suitable protection. Application shall not be carried out when the temperature at the time of application or the temperature anticipated during the subsequent 4 hours is less than 3°C above the dew point. Each coat shall be protected during the initial curing period against possibility of moisture condensation or contamination with foreign matter.

(4) Cleaned surfaces shall be treated as specified for the appropriate coating system as soon as practicable and in any case within 8 hours after cleaning. Blast-cleaned surfaces must not be allowed to stand overnight without having received the first coat of paint. Should rust form or the surface become otherwise contaminated in the interval between cleaning and coating, re-cleaning shall be performed.

(5) When the coating material is applied by spraying, suitable means shall be provided to prevent segregation during the coating operation. Free oil and moisture shall be removed from the air supply lines of all spraying equipment. Each coat shall be uniform and free from runs, sage and other imperfections. The time between successive coats shall be not less than the minimum nor more than the maximum re-coating time specified by the manufacturer.

(6) (a) The paint shall be applied so that the thickness at any point is not less

than that required for the particular coating material. Unless otherwise specified, the thickness shall not exceed this required value:

(i) 50 percent for coats up to 0.100 mm required thickness;
(ii) 0.050 mm for coats exceeding 0.100 mm in required thickness.

(b) These requirements apply both to each additional coat and to the complete system of coats.

(7) Surfaces that will be inaccessible after installation shall be completely coated as required prior to installation.

(8) Surfaces not required to be coated, but adjacent to surfaces which are to be cleaned and coated, shall be adequately protected during cleaning and coating.

(9) Unless otherwise approved by the Engineer, the application of a prime coat in the shop followed by the application of the finishing coats in the field will not be accepted.

(10) Surfaces that have been coated shall be handled with care to preserve the coating in the best practicable condition and be protected from mechanical damage and the harmful effects of heat and weather conditions.

(11) All coated areas which are defective or damaged, shall be cleaned and repaired in accordance with the field application instruction. Coatings that are loose, weakly bonded, blistered, injured or otherwise defective shall be removed and the surface relearned in accordance with the method prescribed for the specified coating at the Contractor's expense. The surface shall then be recoated in accordance with the appropriate clause in this Specification.

S17.06 GALVANIZING

(1) Galvanizing shall be applied by the hot-dip process conforming to ASTM A385, and shall comply with the following.

(a) Parts shall be treated in accordance with SSPC-SP8 before being galvanized. In addition, materials such as welding slag, paint and grease likely to resist attack by the pickling liquid shall be removed prior to pickling, and where specified, surfaces shall be grit blasted, which shall be carried out in accordance with the relevant requirements of Clause S17.04.

(b) The surface after galvanizing shall carry an unbroken covering 0.3 kg of zinc per square meter, uniform in appearance and thickness not less than 0.090 mm at any point.

(c) The erection marks shall be legible after galvanizing.
(d) Where possible, welding drilling and other working required for fabrication of the material shall be completed and all burrs and other

defects removed before the galvanizing process commences. All joints shall be seal welded prior to galvanizing.

(e) Where the galvanized coat has been broken during fabrication or damaged in handling, the exposed surface shall be painted as soon as possible in accordance with the following procedure and as directed by the Engineer.

(i) clean back to bright steel;

(ii) feather the edges of the surrounding galvanized coating;

(iii) degrease in accordance with SSPC-SP1;

(iv) apply 2 coats of zinc rich primer giving a total dry film thickness of not less than 0.075 mm.

(f) Zinc rich primer shall consist of fine zinc powder, epoxy resin base and polyamide accelerator, which when mixed in the correct proportions, produce paint suitable for brush or spray application with or without thinning as recommended by the manufacturer. The dry paint film shall contain at least 92 percent fine zinc powder.

(g) Metalwork that would be distorted or otherwise damaged by hot-dip galvanizing or from which runs and sage resulting from hot-dipping could not easily be removed or metalwork which cannot be accommodated by the available not-dip galvanizing plant and elsewhere as approved by the Engineer, may be coated with an approved coating system.

(2) The cost of galvanizing shall be included in the rates bid in the Schedule for furnishing and installing the various items of metalwork.

S17.07 PAINTING OF CONCRETE

(1) Where shown on the Drawing or elsewhere as directed by the Engineer, concrete shall be painted. Unless otherwise specified the color of all paints and the time at which painting is carried out shall be as directed by the Engineer.

(2) The surface preparation and painting system to be used shall be as specified in Clauses S17.04 (2) and S17.02 (8).

S17.08 INSPECTION

(1) All work shall be subject to inspection by the Engineer. Full and uninterrupted access to the Contractor’s and any of his subcontractor’s works shall be

provided. The working area shall posses illumination which, in the opinion of the Engineer, is adequate for the application and inspection of protective coatings.

(2) Thickness of coatings will be determined by the Engineer by methods set out below, at as many places as deemed by him sufficient, to prove the thickness overall to be to the specified minimum thickness. Either magnetic or electromagnetic thickness meters will be used, which meters will be calibrated against soft brass shims of known thickness free from burrs, in contact with plates of the same type of steel prepared by the same blasting processes as that used for the base metal, and of he same initial thickness as that of the base metal. When required, brass shims, free from burrs and of predetermine thickness and placed in contact with the prepared base metal, prior to applying the coating, shall be used as a check on thickness of coating and calibration of meters. In addition, coating thickness may be checked by any direct method of measurement deemed suitable by the Engineer.

(3) For the purpose of measuring the continuity of coatings, the Engineer shall use a low voltage 'Holiday' detector. High voltage 'Holiday' detectors shall not be used.

(4) For the purpose of measuring adhesion of thickness directly, the Engineer may remove a small section of the coating. Such areas shall be repaired by the contractor at his own expense.

(5) The Engineer may use test methods other than those listed above to determine the coating's compliance with this Specification.

S17.09 MEASUREMENT AND PAYMENT

(1) Painting of Concrete

(a) Measurement, for payment, of painting concrete where directed by the Engineer with acrylic paint, chlorinated rubber enamel and will be of the area painted.

(b) Payment for painting of concrete surface will be made at the applicable rater per square meter under the following Items set forth in the Schedule.

- Painting concrete with acrylic paint.
- Painting concrete with chlorinated rubber enamel.
- Painting concrete pavement of access road for traffic sign

(2) Note to be included that other painting and galvanizing will not be paid separately but will be deemed to be included in the rates bid in the Schedule for the corresponding equipment.