12.13 APPURTENANCE FOR OUTLET WORKS

12.13.1 Air Vent for Bellmouth

a. An applicable diameter air vent pipe shall be furnished and installed in the concrete of intake structures as shown on the Drawings. The bottom part shall be flanged connected to stub pipe provided at the upper part of the bellmouth of the conduit. The top port of the air vent shall be opened at an elevation higher than EL.152.800.

b. The individual air vent pipe lengths shall be flange and be connected with galvanised bolts and nuts. Joints shall be sealed with gaskets. No welding shall be permitted on the air vent pipe after fabrication and additional brackets should be provided as required by the Contractor for securing the pipe in the correct position during concrete embedded and for attaching to the steel support structure for the bulkhead gate guide frame or concrete above EL.152.800. The Contractor shall provide all necessary fixings and anchors for this work. Exposed fixings and anchors shall be galvanised.

c. Pipe length shall be designed so that flange connections shall not be nearer than 0.50 m from any finished concrete surface parallel to the flange.

d. The upper part of the air vent shall be suitably screened.

12.13.2 Air Valve for Guard Gate Operation

a. The emergency closure of the guard gate may result in substantial sub-atmospheric pressure in the pipe downstream of the gate leaf.

b. An air valve and air pipe shall be provided at the downstream side of the guard gate to supply air into the steel conduit during gate operation. The air valve shall be of coil spring balanced float type with a dash-pot.

c. The air valve pipe shall be connected by bolts and nuts to the flange stub connection piece provided on the outlet pipe shell. The flanged joint shall be sealed with gaskets. Flanges not embedded in concrete shall be connected by bolts and nuts of corrosion resistant steel.

12.13.3 By - Pass Device for Emergency Outlet Works

a. The guard gate shall be raised under balanced pressure conditions. For filling water in the pipe section between the guard gate and control gate, a by - pass device shall be furnished. The by - pass device shall consist of 150 mm diameter steel pipe, two 150 mm gate valves and a dismantling sleeve joint. These gate valves shall be of cast steel and operated manually. The dismantling sleeve joint shall be located just downstream of the downstream valve.

b. The by - pass device shall be made with flanged connections for field erection. Bolts and nuts at exposed locations shall be made of corrosion resistant steel. All flanged joints shall be sealed with gaskets.

c. The by - pass device shall be arrange so that the operating handles of the gate valves are parallel to and above the operation stand floor level in the control gate house.

12.13.4 Overhead Travelling Crane

a. The Contractor shall furnish and install a complete manually-operated overhead travelling crane in the location shown in the Drawings for disassembling the hoist (Valve control), bonnet covers, gate leave and seals of control gate and guard gates. The crane shall have sufficient capacity for handling these components but not less than 3 tonne safe working load.

b. The crane shall be of the single girder type. The girder shall be structurally braced to mobile blocks that travel along rails.

c. The crane shall be provided with a manually operated drive unit mounted on a gear box which shall be flange mounted and spigotted to the end carriage. The output shaft of the gear box shall have high tensile pinion meshing with the spur teeth on the driven crane wheel.

d. The hoist unit shall comprise a manually operated chain block and a travelling trolley. Both shall be provided by an established, long-standing specialist supplier of lifting equipment and are subject to the Engineer's approval.

12.13.5 Operating Stand

a. The Contractor shall furnish and install an Operating Stand as shown on the Drawings for the purposes of access to enable the easy operation and maintenance of control gates, guard gates, by-pass valves and maintenance air valve as shown on the Drawings.

b. Operating stand shall be steel made and shall include handrails and ladders with safety guards, and steps as necessary.

12.13.6 Supersonic Flow Meter

a. Two set of supersonic flow meter shall be furnished to the outlet pipe for measuring the discharge flow. These supersonic flow meters shall be capable of measuring the discharge quantity up to 3.0 m^3/s and 1.0 m^3/s within tolerance of 1% of full scale. To improve the measurement error, double range changeable type shall be adopted.

b. The discharge measured by the supersonic flow meter shall be displayed in the dam control office and shall be able to be used for automatic regulation and setting of the control gate operation. The Contractor shall provide the necessary terminals for this display and operation.

12.14 TAILRACE GATE

12.14.1 General

a. This Clause specifies the detailed technical requirements for the design and manufacture of the tailrace gate for the tailrace to be furnished in accordance with this Section. These requirements shall supplement and/or modify the applicable requirements of other relevant clauses of the Specification.

b. The tailrace gate shall include the following major items:

(i) one gate leaf

(ii) one set guide frames

(iii) single spindle with hand-operated hoist

12.14.2 Function and Operation

a. The function of the tailrace gate is to close the tailrace to prevent back-flow from the river to the turbine during maintenance or periods of high river level.

The tailrace gate shall be lowered and raised by a manually operated hoisting unit. The hoist shall be designed such the maximum force required to operate the hoist shall be 100 N.

12.14.3 Design Requirements

Type of Gate	:	Fabricated steel slide type
Clear Span	:	2.000 m
Clear Height	:	2.000 m
Design Water Level	:	EL. 84.8 m
Operating Water Level	:	Pressure balance
Water Seal	:	Rubber seals on all sides of the downstream face of gate leaf

12.14.4 Gate Leaf Construction

a. Sectionalising

The gate leaf shall not be sectionalised.

b. Skin Plate

The skin plate shall be on the upstream face of the gate leaf.

c. Main Girders

Main girders shall be arranged in such a manner that each main girder, except top and bottom girders, shall sustain almost the same amount of design load within the range of ± 10 percent.

12.14.5 Guide Frame for Tailrace Gate

a. Lower Seal Plate

The Contractor shall set the sill elevation of the tailrace gate at EL. 82.300 m. The lower seal plate shall be firmly embedded in concrete. Anchor bolts shall be provided in the structural concrete for erection, alignment and restraint of the embedded seal plate.

b. Guide Frame

The guide frame for the tailrace gate shall be embedded firmly in concrete. Anchor bolts shall be provided in the structural concrete around the blockout for erection, alignment and restraint of the embedded guide frame.

c. Upper Seal Plate

The upper seal plate shall be set at the level shown on the Drawings. The upper seal plate shall be embedded in concrete and anchor bolts shall be provided in the structural concrete for erection, alignment and restraint of the embedded frame.

d. Seal Plates

Seal plates shall be of corrosion-resistant steel. Side seal, sill seal and upper seal shall be continuous to ensure water-tightness.

12.14.6 Tolerances

The gate leaf and the guide frames shall be accurately manufactured and installed within the following tolerances:

a. Gate Leaf

Points to be Measured	Tolerances (mm)
Gate leaf width	± 4
Gate leaf weight	± 8
Gate leaf depth	± 4
Diagonal length difference	± 8
Distance between side seal rubbers	± 5/m
Distance from side seal rubber to centre of bearing plate	+2, -0

b. Guide Frame

Points to be Measured	Tolerances (mm)
Distance centre to centre of bearing plate	± 6
Flatness of side sealing plane	± 0.5/m
Straightness of side sealing plane	± 2
Flatness of bearing plate	± 0.5/m
Straightness of bearing plate	± 2
Flatness of sill sealing plane	± 1.5/m
Straightness of sill sealing plane	± 1.5
Flatness of lintel sealing plane	± 0.5/m
Straightness of lintel sealing plane	± 1.5

c. Other Tolerances

Tolerances not specified herein shall be defined by the Contractor subject to the Engineer's approval.

12.14.7 Leakage

Leakage from the seals of closure gate shall be less than 0.2 litre/s per one metre sealing length.

12.15 FLAP GATE

12.15.1 General

This Clause specifies the detailed technical requirements for the design and manufacture of the equipment for preventing high water levels in the river flowing back into the surface water drainage system and shall be furnished in accordance with this Section of the Specification. These requirements supplement or modify the applicable requirements of the relevant Clauses in this Section of the Specification.

The flap gate shall comprise one set of flap gate including frame.

12.15.2 Design Conditions

Type of gate	: Cast steel or fabricated steel
Nominal diameter	: 0.60 m dia.
Design water level	: EL. 85.0 (downstream)
Elevation of centre	: EL. 83.000

12.15.3 Requirements

a. The flap gate shall be provided with a complete circular frame to be embedded in first stage concrete. The frame shall be provided with suitable anchorage for this purpose.

b. The frame shall be provided with a continuous rubber seal that can be removed and replaced.

c. The flap gate shall be provided with a corrosion-resistant seal plate on the upstream face to seal against the rubber seal on the frame when the downstream water pressure is greater than the upstream water pressure.

d. The flap gate shall be hinged to the embedded frame so that minimum upstream pressure shall open it. The hinge parts shall be of corrosion-resistant steel.

12.16 CLOSURE GATE FOR DIVERSION TUNNEL

12.16.1 General

a. This Clause specifies the detailed technical requirements for the design and manufacture of the closure gate for the diversion tunnel to be furnished in accordance with this Section. These requirements shall supplement and/or modify the applicable requirements of other relevant clauses of the Specification.

b. The closure gate shall include the following major items:

- one closure gate leaf
- one set guide frame for closure gate

12.16.2 Function and Operation

a. The function of the gate is to close the diversion tunnel and to initiate the filling of the reservoir.

b. The closure gate shall be lowered by truck cranes or other construction equipment and shall be raised, as required, if commissioning tests indicate leakage past the gate greater than the design requirement specified in Sub-Clause 12.16.7.

A temporary cofferdam shall be used to block river flow during the lowering of the gate and in situ inspection and testing to confirm the condition and soundness of the gate and frame.

12.16.3 Design Requirements

Type of Gate	:	Fabricated steel slide type
Clear Span	:	5.60 m
Clear Height	:	5.60 m
Design Water Level	:	EL. 125.000 m
Operating Water Level	:	Pressure balance
Water Seal	:	Rubber seals on all sides of the downstream face of gate leaf

12.16.4 Gate Leaf Construction

a. Sectionalising

The gate leaf shall not be sectionalised.

b. Skin Plate

The skin plate shall be on the downstream face of the gate leaf.

c. Main Girders

Main girders shall be arranged in such a manner that each main girder, except top and bottom girders, shall sustain almost the same amount of design load within the range of ± 10 percent.

d. Lifting Lugs

The gate leaf shall be provided with filling lugs sufficient for handling the leaf.

12.16.5 Guide Frame for Closure Gate

a. Sill Beam

The Contractor shall set the sill elevation of the closure gate at EL. 98.500 m. The sill beam shall be firmly embedded in concrete. Anchor bolts shall be provided in the structural concrete for erection, alignment and restraint of the embedded sill beam.

b. Side Frame

Side frame for closure gate shall be embedded firmly in concrete. Anchor bolts shall be provided in the structural concrete around the blockout for erection, alignment and restraint of the embedded side frame.

c. Lintel Frame

The lintel frame shall be set at the level shown on the Drawings. The lintel seal elevation will be 104.150 m. The lintel beam shall be embedded in concrete and anchor bolts shall be provided in the structural concrete for erection, alignment and restraint of the embedded frame. Sufficient stiffeners shall be provided in the lintel frame to withstand impact loads from submerged logs during river diversion.

d. Seal Plates

Seal plates shall be of corrosion-resistant steel. Side seal, sill seal and lintel seal shall be continuous to ensure water-tightness. Protective steel plates for the seal plates shall be provided by fastening the protective plates to the concrete by means of embedded bolts into the blockout concrete as shown on the Drawings.

12.16.6 Tolerances

The gate leaf and the guide frames shall be accurately manufactured and installed within the following tolerances:

a. Gate Leaf

Points to be Measured	Tolerances (mm)
Gate leaf width	± 4
Gate leaf weight	± 8
Gate leaf depth	± 4
Diagonal length difference	± 8
Distance between side seal rubbers	± 5/m
Distance from side seal rubber to centre of bearing plate	+2, -0

b. Guide Frame

Points to be Measured	Tolerances (mm)
Distance centre to centre of bearing plate	± 6
Flatness of side sealing plane	± 0.5/m
Straightness of side sealing plane	± 2
Flatness of bearing plate	± 0.5/m
Straightness of bearing plate	± 2
Flatness of sill sealing plane	± 1.5/m
Straightness of sill sealing plane	± 1.5
Flatness of lintel sealing plane	± 0.5/m
Straightness of lintel sealing plane	± 1.5

c. Other Tolerances

Tolerances not specified herein shall be defined by the Contractor subject to the Engineer's approval.

12.16.7 Leakage

Leakage from the seals of closure gate shall be less than 0.2 litre/s per one metre sealing length.

12.17 DRAINAGE PIPE VALVE

12.17.1 General

a. This Clause specifies the detailed technical requirements for the drainage pipe valve to be furnished in accordance with this Section. These requirements shall supplement and/or modify the applicable requirements of other relevant clauses of the Specification.

b. The drainage pipe valve may be a ready-made standard commercially-available type complete with flanges, studs, washers, nuts and gaskets.

12.17.2 Function and Operation

The function of the drainage pipe valve is to allow the drainage of water from the outlet pipe through the stainless steel drainage pipe whenever it required to remove all water from the outlet pipe.

The drainage valve shall be hand-operated requiring a force not greater than 100 N.

12.17.3 Requirements

The drainage valve shall be of stainless steel construction of a type approved by the Engineer.

The valve and flanged connections shall be designed to withstand the same internal pressures as the outlet pipe.

12.18 MATERIALS

12.18.1 General

a. Materials shall be new and of first-class quality, suitable for the purpose, free from defect and imperfections, and of the classifications and grades listed herein, or their equivalents.

b. Defective material shall not be repaired and used in the equipment without the prior approval of the Engineer. No peening, caulking, or filling shall be permitted in repairing cracks, pinholes, or blowholes. Defects in welds shall be repaired by grinding out to sound metal and re-welding. For defects in casting, the method of repair shall be mutually agreed upon by both the contractor and the Engineer.

c. The used of cast iron shall be limited to sheaves, plumber block cases, gear cases, brake wheels equipment and parts and other parts of a non structural nature.

d. The Contractor shall not make any changes to the materials from that specified or implied by the Specifications without the written approval of the Engineer. Such changes or alterations shall in no way be detrimental to the interests of the Employer and shall not result in any increase to the Contract Price.

12.18.2 Structural Steel Plates, Bars, etc.

a. Steel plates shall be in accordance with ASTM A 36, A 242, A 441, or JIS 3101, SS 400, JIS G 3106, SM 400, SM 490, or approved equivalent.

b. Steel shapes shall be in accordance with ASTM A 6 or JIS G 3192

12.18.3 Corrosion Resistant Steel Plates, Bars, etc.

a. Corrosion resistant steel plate shall be in accordance with ASTM A 167, A 176, or JIS G 4304, 4305, 4306, 4307.

b. Corrosion resistant steel bolts, nuts and washers shall be in accordance with ASTM 167, A 176, or JIS G 4303.

c. Corrosion resistant clad steel plates shall be in accordance with ASTM A264, Type 304, or JIS G 3601, single clad.

12.18.4 Forged Steel

Forged steel shall be in accordance with ASTM A 668 class C, or JIS G 3201, SF 45, OR approved equivalent.

12.18.5 Cast Steel

Cast steel shall be fully annealed and shall be in accordance with ASTM A 27 Grade 60-30, A 148, A 216, A 216 M-84b, or JIS G 5101, SC 360, SC410, SC450, SC480, G 5102, G 5111, SCMnCr3B, or approved equivalent.

12.18.6 Spring Steel

Spring steel shall be in accordance with AISI 6150, or JIS G 4801, or approved equivalent.

12.18.7 Cast Iron

Cast iron shall be in accordance with ASTM A 48, class 30, or JIS G 5501, FC200, FC250, or approved equivalent.

12.18.8 Bronze

a. Bronze Castings

Bronze castings shall be in accordance with ASTM B 584, C 903, or JIS H 5111, BC2, BC3, BC6, orb approved equivalent.

b. Phosphor bronze castings shall be in accordance with ASTM B 427, C 907, or JIS H 5113, PBC2, PBC2B, PBC3B, or approved equivalent.

c. Aluminium bronze castings

Aluminium bronze castings shall be in accordance with ASTM B 148, C 952, or JIS H 5114, ALBC 2, ALBC3, or approved equivalent.

d. Leaded tin bronze castings

Leaded tin bronze castings shall be in accordance with ASTM B 584, C 937, or JIS H 5115, LBC2, LBC3, or approved equivalent.

12.18.9 Pipes

Steel pipes in small diameter shall be in accordance with ASTM A 120, A 53, A 213, or JIS G 3542 SGP, G 3454, STPG, G 3459 SUS-TP, or approved equivalent.

12.18.10 Wire Ropes

a. Standard wire ropes shall be in accordance with ASTM A 603, or JIS G 3525, and galvanised.

b. Wire rope fittings shall be the manufacture's standard fittings for the type of wire rope used.

12.18.11 Self-Lubricating Bushing

Self-Lubricating bushings shall be in accordance with ASTM B 22, Alloy E, with lubricant, or approved equivalent.

12.18.12 Other Steel Materials

"Carbon steel for machine structural use" JIS G 4051, S35C, S45C, or AISI 1035, 1045, or better.

"Chromium molybdenum steels" JIS G 4105, SCM432, ASTM A 668, Class L, or better, or JIS G 4105, SCM440, SCM435, or AISI 4135, 4140, or JIS G 4051.

"Solid rolled carbon steel wheels for railway rolling stock" JIS E 5402, SSW-R1, or approved equivalent.

12.18.13 Rubber Seals

Rubber seals shall be mould from a high grade, thread type compound. The basic polymer of butadiene and styrene, or a blend or both. The compound shall contain not less than 70 per cent by volume of the basic polymer, and the remainder shall consist of reinforcing carbon block, zinc-oxide accelerations, anti-oxidants, vulcanising agents and/or plasticity. The compound shall have the following physical properties:

Property	Limits
Tensile Strength	150 kgf/cm^2 minimum
Ultimate elongation	300 per cent minimum
Durometer Hardness (Shore, Type A)	40 to 75
Specific Gravity	1.1 to 1.6
Water Absorption (for 48 hours at 70)	5 per cent maximum by weight
Compression Set (as a per cent of total original deflection)	30 per cent maximum
Tensile Strength after oxygen bomb ageing for 48 hours at 70	80 per cent minimum of tensile strength before ageing

12.19 TESTS OF MATERIALS

a. All materials or parts for structural use, intended for use in the work, shall be tested, unless otherwise directed, according to the best commercial method for the particular type and class of work. If the manufacturer desires to use materials from his own stock, which are not manufactured specifically for the equipment to be furnished, satisfactory evidence that such materials conform to the requirement herein stated shall be furnished, in which case tests on these materials may be waived. Certified mill test reports of plates and sections will be acceptable.

b. Witness tests and inspection of material may be made at the place of manufacture by the Engineer or an inspection agency appointed by the Engineer. Such witnessing and inspecting will be conducted so as to interfere as little as possible with manufacturing operation. The Contractor shall, however, comply with any and all reasonable requests made by the Engineer or inspection agency concerning the method of test or correction of defective workmanship.

c. The Contractor shall furnish, free of charge, all test pieces, cut and machined to the size, shape and dimensions as prescribed by ASTM, JIS or other approved standards. The testing of the specimens will be carried out by the Contractor at his own expense and shall be performed as directed by the Engineer.

d. All tests pieces including those which represent rejected material shall be retained, delivered to the Engineer and reports shall be sent to the Engineer by registered mail or be hand delivered.

e. Waiving of inspection by the Engineer shall not relive the Contractor of the responsibility for supplying material and workmanship in accordance with The Contract.

12.20 WORKMANSHIP

12.20.1 General

a. Al the work shall be performed and completed in a through workmanlike manner and shall follow the best modern practices in the design and manufacture of all equipment. All work shall be done by personnel skilled in the related professions and trades. All parts shall be made accurately to standard gauges so as to facilitate replacement and repairs. All bolts, nuts, screws, threads, pipes, gauges, gears and measurements or dimensions shown on the drawings shall conform to metric standards.

b. Like parts and spare parts shall be interchangeable wherever possible. Machining of fits or renewable parts shall be accurate and to specified dimensions so that replacements manufactured to the size shown on the Contractor's drawings may be readily installed.

12.20.2 Welding

a. General

All welding shall be performed by the electric- arc method by a process that excludes the atmosphere from the molten metal, and where practicable, by automatic or semi-automatic machines. Machined surfaces of parts affected by welding shall be machined to final dimensions after welding. Machined surface of parts requiring stress relief shall be machined to final dimensions after the parts have been stress relieved.

b. Minimum Weld Requirements

All welds shall be made continuous and watertight. The minimum size of fillet welds shall be 5 mm measured on the leg when the base material thickness is 9 mm or more and 4 mm when the base material thickness is less than 9 mm. All butt welds shall be full penetration, welded from both sides.

c. Preparation of Base Material

Members to be joined by welding shall be cut to shape and size by mechanical means such as shearing, machining, grinding, or by gas or arc cutting, to suit the conditions. The design of welded joints and the selection of weld filler metal shall allow through penetration and good fusion of the weld with the base metal. The edges of surfaces to be welded shall be sound metal free of visible defects, such as laminations or defects caused by cutting operations, and free from rust, oil, grease and other foreign matter.

d. Qualification of Welding Procedure

The technique of welding employed, the appearance and quality of the welds made and the methods used in correcting work, shall conform to American Welding Society (AWS) Standard D.1.1, Japan Road Association Specifications for Highway Bridge (JRA), or other approved equivalent standards.

e. Qualification of Welders and Welding Operators

(i) All welders or welding operators assigned to the Work shall be qualified in accordance with AWS Standard C.1.1, or JIS Z 3801, Z 3821, Z 3841, or other approve equivalent standards.

(ii) The Contractor shall submit certificates of welders qualifications to the Engineer before starting any Work.

f. Weld Finish

All welds shall have a smooth even profile and a surface suitable for painting. Structural welds shall be ground and blended to avoid stress raisers. All welds which require non-destructive examinations shall be dressed by chipping and grinding as required for good interpretation by the selected weld examination methods.

12.20.3 Forging

The ingots from which the forging are made shall be cast in metal moulds, the workmanship shall be first class in every respect and the forging shall be free from all defects affecting their strength and durability, including seams, pipe flaws, cracks, scales, fins, porosity, hard spots, excessive non-metallic

inclusions and segregation. Large fillets compatible with the design shall be incorporated whenever a charge in section occurs. All finished surfaces of forging shall be smooth and free from tool marks.

12.20.4 Steel Castings

a. General

(i) Casting shall be free from injurious defects and shall be satisfactorily cleaned for their intended use. Surfaces of castings which do not undergo machining shall be dressed for good appearance and for painting. The location of existing defects shall be determined and all defects which impair the strength or utility of the casting shall be removed to sound metal. The structure of the castings shall be homogeneous and free from excessive non-metallic inclusions.

(ii) An excessive concentration of impurities or separation of alloying elements at critical points in a casting will be a cause for its rejection.

b. Repair Welding

Minor defects that will not impair the strength or serviceability of the castings may be repaired by welding in accordance with accepted foundry practice without review by the Engineer. Defects shall be considered minor when the depth of cavity properly prepared for welding is not greater than 25% of the actual wall thickness but in no case greater than 20 mm and when the area to be welded is smaller than 50 cm^2. However, an accumulation of minor defects which in the opinion of the Engineer casts doubt as to the general quality of the casting shall be considered as a major defect. A complete descriptive report of major defects, supplemented with sketches, photographs, and metallurgical test reports, as the case may warrant, and the proposed repair procedure, shall be submitted for review prior to any repair of major defects. If removal of defects reduces the stress-resisting cross-section of the casting by more than 30 percent, the casting may be rejected. All casting which require welding repairs of major defects after heat treatment shall be heat treated again.

12.20.5 Non-destructive Tests Welds

a. General

Unless otherwise indicated, all non-destructive tests shall be in accordance with the applicable sections of AWS standards, ASTM standards, or JIS standards or other approved equivalent standards. The Contractor's Drawings submitted for review shall define the areas, extent, and type of non-destructive examination to be employed.

b. Examination of Welds

(i) All shop welding shall be subject to non-destructive examination by radiographic, ultrasonic, dye penetrate, or magnetic particle method as proposed by the Contractor and approved by the Engineer.

(ii) All butt welds on skin-plate and steel conduit shell and bifurcation structure shall be tested by radiographic examination for 100% of their length including the intersection point of 2 welding lines.

Where radiographic examination is not practicable ultrasonic testing shall be carried out in the presence of the Engineer.

(iii) For important butt and fillet welds on structural members of gate units 20% of all such welds shall be tested by radiographic examination. When radiographic testing shall be carried out in the presence of the Engineer.

(iv) Important field fillet welds, as determined by the Engineer shall be tested by methods proposed by the Contractor and approved by the Engineer.

(v) All non-destructive examination shall be carried out in the presence of the Engineer.

(vi) The Contractor shall use only experienced personnel to carry out non-destructive examinations and qualification certificates of such persons shall be submitted to the Engineer for approval prior to commencing such work.

(vii) The Contractor shall submit judgement criteria of examination results in compliance with the applicable approved standards and repair methods to the Engineer for approval before commencing these examinations.

(viii) The Contractor shall submit a report on each examination with 24 hours of completing the examination, together with the radiographs in the case of radiographic examination. The radiographs shall remain the property of the Employer.

(ix) The Contractor shall repair the welds in compliance with approved criteria and directed by the Engineer. All repairs shall be subject to non-destructive examination as directed by the Engineer.

12.21 PAINTING AND SURFACE PREPARATION

12.21.1 Cleaning and Preparation of Surface

a. Cleaning and preparation of surfaces shall be as specified in Sub-clause 4 . of this Clause.

(i) Surfaces to be painted shall be cleaned before the application of paint or surface treatment. All oil, grease, dirt, rust, loose mill scale, weld spatter, slag or flux deposit, oil weathered paint, and other foreign substances shall be removed. The removal of oil and grease shall be accomplished before mechanical cleaning is started. Clean cloths and cleaning fluids shall be used to avoid leaving a thin film of greasy residue on the surface being cleaned. Cleaning and painting shall be programmed that dust or spray from the cleaning process will not fall on wet, newly painted surface. Where required, imperfections and holes in surfaces and open joints between matching surfaces shall be filled or removed in an approved manner. Any required wash treatment shall be carried out in accordance with the paint manufacturer's instructions.

(ii) Extreme care shall be exercised when blast cleaning is applied on structures to prevent blasting materials from entering or damaging machined surface and other precision parts.

b. All cleaning, preparation and paint application shall be carried out after the parts are completely finished and checked in the shop assembly. The parts shall be disassembled to the extent necessary to enable cleaning and painting those surfaces which are inaccessible when assembled. After the finishing coats have been applied and the paint surface has dried, parts shall be reassembled as required for shipment. Those bolts and other connections which will not be removed in erection shall be coated with the shop primer and finishing coats.

12.21.2 Paint Application

a. Workmanship

All work shall be done in a workmanlike manner so that the finished surface will be free from runs, drops, ridges, waves, laps, pinholes, and unnecessary brush marks. All coats shall be applied in such manner as to produce an even film of uniform thickness completely coating all corners and crevices. All painting shall be done by thoroughly experienced and skilled workmen. Care shall be exercised during spraying to hold the nozzle sufficiently close to the surface being painted to avoid excessive evaporation of the air, or the bridging of crevices and corners. All surface preparation and paint application in the shop and field shall be supervised by a supervisor, approved by the Engineer, from the paint manufacturer, provided by the Contractor. The supervisor shall certify that all preparations and applications are in accordance with this Specification and the paint manufacturer's recommendations and specifications.

b. Equipment

All paint shall be applied using airless spray equipment unless otherwise approved. Spray equipment shall be equipped with a mechanical agitator, a pressure gauge, and a pressure regulator. Nozzles shall be of the proper size as recommended by the paint manufacturer.

c. Paint Properties, Mixing and Thinning

(i) The Contractor shall submit the specification of each type of paint to be used in each system for the works for the Engineer's approval prior to the executing any painting work.

(ii) Test certificates from the paint manufacturer shall be provided for each batch of each type of paint used in the works.

(iii) All paint, when applied, shall provide a satisfactory film and a smooth even surface. Paint shall be thoroughly stirred, strained and kept at a uniform consistency during application. Paints may be thinned in accordance with the paint manufacturer's recommendations. Paint furnished for field touch-up work shall be delivered in containers which shall show the designated name, formula or specification number, colour, special directions, manufacturer, and data of manufacture.

d. Atmospheric Conditions

Paint shall be applied only to surface that are thoroughly dry and only under such combination of humidity and temperature of the atmosphere and surfaces to be painted as will cause evaporation rather than condensation. In no case shall any paint be applied to surface upon which there is moisture condensation. The temperature of the surface to be painted shall be at least 3 above dew point. Painting shall not be

carried out when the relative humidity of the surrounding air exceeds 85 percent.

e. Protection of Paint Surface

Where protection is provided for painted surface, such protection shall be kept in place until the paint film has properly dried. Items which have been painted shall not be handle, worked on, or otherwise disturbed until the paint coat is completely dry and hard.

f. Time between Surface Preparation and Painting

Surface which have been cleaned, pre-treated and/or otherwise prepared for painting shall be primed as soon as practicable after such preparation has been completed prior to deterioration of the prepared surface in accordance with the paint manufacturer's recommendations.

g. Coating Progress

Where painting on any type of surface has been commenced for any portion of the work, the completed as soon as practicable and without delays.

12.21.3 Colours

The finish colour of all structures shall be as approved by the Engineer but the Contractor shall propose a colour scheme for the work and shall submit colour strips or paint samples. A colour strip shall be included with the approved colour schedule for each type of finish to be applied at the Site shop or site.

12.21.4 Paint System

a. The paint systems for the Water Control Plant shall be in accordance with Table 12.17.

b. Where the paint system is applied to a structure that is party embedded in concrete, the surface preparation and paint system applied to the exposed material shall extend 100 mm beyond the edge of the concrete surround or embedded.

12.21.5 Painting Schedule for Systems Application

The following items of the Water Control Plant shall be painted according to the indicated paint system except as otherwise specified;

a. Paint System 1

- Trash rack for intake structure of outlet work;
- Trash rack for emergency gate of outlet work:
- Trash rack for inspection room of intake structure:
- Inner surface of outlet pipe including bellmouth (guide cover of bulkhead gate), transition pipe, branch, and reducer for outlet works;
- Outer surface of outlet pipe in control gate operating house;
- Control gate leaf ,bonnet, and bonnet cover;
- Guard gate leaf, bonnet, and bonnet cover;
- Bulkhead gate guide below NWL;
- Emergency gate guide below NWL;
- Other ferrous metal subject to continuous, frequent or repeated

lengthy immersion in water such as interior of filling devices.

b. Paint System 2

- Bulkhead gate leaf, guide frame above NWL and inspection room;
- Emergency gate leaf, guide frame above NWL and inspection room;
- Other ferrous metal subject to intermittent immersion, splash or humid environment.

c. Paint System 3

- Bulkhead gate hoist, emergency gate hoist, control gate hoist and guard gate hoist, except for application of Paint System 5;
- Operation stand for control gate and guard gate include handrail and ladders;
- Other ferrous metal subject to atmospheric exposure for which another paint system is not specified.

d. Paint System 4

- Other equipment to be used temporarily only.

e. Paint System 5

- Corrosion resistant steel items or parts of items.

f. Paint System 6

- Interior of local operating cabinet for control gate and guard gate hoists.

g. Paint System 7

- Small sized steel pipe for air vent.

h. Paint System 8

- Ferrous metal embedded in concrete except in accordance with Sub-clause .

12.21.6 Surface Not to be Painted

Wire ropes, gear teeth, corrosion resistant metal seals and other machined surfaces shall not be painted.

12.21.7 Paint Testing

All paint applications shall be tested in according to the following:

a. The dry film thickness of each shop primer coat and total thickness of all coats shall be measured by the Contractor and supervisor from the paint manufacture in the presence of the Engineer.

b. The edge, corners and the areas within 5 mm distance from them, and the surface of castings and steels forging shall be excluded unless the Engineer has reason to doubt the thickness of the application.

c. Two (2) portions shall be selected per 10 m^2 by the Engineer and more than four (4) arbitrary points shall be measures per portion.

d. An electronic thickness measuring gauge shall be used and shall be calibrated in accordance with an approved standard.

e. The mean value of each portion shall be more than the average thickness specified and the minimum thickness in all eight(8) or more points measured per 10 m^2 shall be more than the minimum thickness specified.

f. The details of testing shall be as approved by the Engineer following the submission of the Contractor's proposal.

TABLE 12.17 PAINT SYSTEMS

Paint System No.	Location	Site	Process	General Name	No. of Coats	Coating Interval (at 20)	Dry Film Thickness (micron/coat)	
							Ave.	Min
1	Ferrous Metal Continuous Immersion in water	Shop	Surface Preparation	Commercial Blast Cleaning (SSPC-SP6)				
			Primer Coat	Epoxy Zinc Rich Paint	1	3 days 6 months	20	15
			1st Coat	Coal Tar Epoxy Resin Paint	1	24 hours 7 days	280	200
			2nd Coat	Coal Tar Epoxy Resin Paint	1		280	200
		Field	Surface Preparation	Power Tool Cleaning (SSPC-SP3)		Note : Damage area and welded areas only		
			Touch-up Primer Coat	Epoxy Zinc Rich Paint	1	3 days 6 months	20	15
			Touch-up	Coal Tar Epoxy Resin Paint	2	24 hours 7 days	280	200
2	Ferrous Metal Intermittent Immersion and Splash	Shop	Surface Preparation	Commercial Blast Cleaning (SSPC-SP6)				
			Primer Coat	Epoxy Zinc Rich Paint	1	3 days 6 months	20	15
			1st Coat	Epoxy Resin Paint	1	24 hours 7 days	110	80
			2nd Coat	Epoxy Micaceous Iron Oxide Paint	1	24 hours 18 months	50	35
		Field	Surface Preparation	Power Tool Cleaning (SSPC-SP3)		Note : Damage area and welded areas only		
			Touch-up Primer Coat	Epoxy Resin Paint	1	3 days 6 months	20	15
			Touch-up	- ditto -	2	24 hours 7 days	110	80
			3rd. Coat	- ditto -	1	- ditto -	40	20
			4th. Coat	Coal Tar Epoxy Resin Paint	1		40	20

TABLE 12.17 continued

3	Ferrous Metal Atmospheric Exposure	Shop	Surface Preparation	Commercial Blast Cleaning (SSPC-SP6)				
			1st Coat	Lead Suboxide Anti-Corrosive Paint	1	24 hours 6 months	35	25
			2nd Coat	- ditto -	1	- ditto -	35	25
			3rd Coat	Phenol Micaceous Iron Oxide Paint	1	24 hours 18 months	50	35
		Field	Surface Preparation	Power Tool Cleaning (SSPC-SP3)		Note : Damage area and welded areas only		
			Touch-up Primer Coat	Lead Suboxide Anti-Corrosive Paint	2	24 hours 6 months	35	25
			Touch-up	Phenol Micaceous Iron Oxide Paint	1	24 hours 18 months	50	35
			3rd Coat	Long Oil Alkyd Resin Paint	1	24 hours 1 months	25	20
			4th Coat	- ditto -	1		25	20
4	Equipment for Temporary use	Shop	Surface Preparation	Commercial Blast Cleaning (SSPC-SP6)				
			1st Coat	Zinc Chromate Primer	1	8 hours 6 months	35	25
			2nd Coat	- ditto -	1		35	25
		Field	Surface Preparation	Power Tool Cleaning (SSPC-SP3)		Note : Damage area and welded areas only		
			Touch-up	Zinc Chromate Primer	2	8 hours(Note; 6 months(-ditto-)	35	25
5	Small Sizes Steel Pipe	Shop	Surface Preparation	Solvent Wash (SSPC-SP1)				
			Coating	Hard-Drying Anti-Corrosive Oil	1	Over 4 hours	50	
6	Ferrous Metal Embedded in Soil	Shop	Surface Preparation	Blast Cleaning (SSPC-SP10)				
			1st Coat	Zinc Chromate Primer	1	8 hours 6 months	35	25
			2nd Coat	- ditto -	1	8 hours 6 months	35	25
			3rd Coat	Alkyd Resin Paint	1	5 hours 6 months	20	15
			4th Coat	- ditto -	1			
7	Small Sizes Steel Pipe	Shop	Surface Preparation	Hand Tool Cleaning (SSPC-SP2)				
				Zinc Hot Dip Galvanising	1		86	50
8	Ferrous Metal Embedded in Concrete			Clean				

TABLE 12.17 continued

9	Ferrous Metal Embedded in Soil	Shop	Surface Preparation	Commercial Blast Cleaning (SSPC-SP6)				
			1st Coat	Coal Tar Primer	1	24 hours 5 days		
			2nd Coat	Coal Tar Enamel		Note: 2nd + 3rd Coat simultaneous		3000
			3rd Coat	Glass Cloth		Application		

12.22 SHOP ASSEMBLY AND TEST

12.22.1 General

a. All shop assemblies and tests specified below for the various items of the Water Control Plant will be witnessed by the Engineer or his inspection agency and the completed shop inspection forms shall be signed by him. Copies of all shop inspection records shall be furnished to the Engineer. No component shall be shipped from the Contractor's fabrication shop or place of manufacture until it has been inspected and approved. Prior to major shop assemblies and tests, the Contractor shall submit an outline of the procedures and tests he plants to perform to demonstrate fulfilment of the requirements of the Specification.

b. While being assembled, each items of structure shall be checked for dimensions, tolerances and accuracy of alignment. Any error and misalignment discovered shall be corrected. All parts of the structure which are separate from the assemble unit shall also be checked for dimensions, tolerances, accuracy and quantities.

c. Before disassembling and after installation of dowels and fitted bolts between bolted subassemblies, all parts shall be clearly matchmaking. Matchmaking diagrams shall be prepared for shop inspection and submitted to the Engineer or his inspection agency for approval.

12.22.2 Tests

After assembling, the structures shall be checked as to their alignment, dimensions and order of assembly. Any defect or damage shall be rectified.

a. Bulkhead Gate, Emergency Gate and Trash Rack

Each finished gate and trash racks panel, including seals, guiding devices, wheels, filling valves, and all other applicable accessories shall be as much as completely shop assembled as far as possible. All field splices shall be assembled and welded field splices shall temporarily bolted for shop assembly.

b. Control Gate, Guard Gate and valves

Each gate and valve shall be shop assembled into a unit with gate leaf, bonnet. Bonnet cover or casing and hoist. As a rule this shall be done in a vertical position.

c. Transition Pipe, Bend pipe and Bifurcation

Transition pipe, bend pipe and bifurcation, including all required accessories shall also be shop assembled.

d. Guide Frames

Each sealing frame shall be completely shop assembled, including sill beam, lintel beam and side frame members up to the first field connection (if any) outside of the frame section. This may be done in either the vertical or horizontal position as selected by the Contractor.

e. Hoist

Hoist for bulkhead gate unit, emergency gate unit control gate unit and guard gate unit shall be assembled in the shop and tests. The shop test shall be examined in the unloaded condition. The Contractor shall submit to the Engineer for approval the instruction shop test procedures. These procedures shall include at least the following items: temperature rise of motor, reducer and bearing, rated current of motor, operational check for brake and limit switches, backlash of open gears and checks for abnormal noise and vibration.

f. Pressure Test for Control Gate Unit and Guard Gate Unit

Control gate unit and guard gate unit shall be examined by pressure test under following conditions.

(i) 7.1 kgf/cm^2 water pressure shall be kept for 10 minutes. The leakage from seals shall be less than 100 cm^3/minute. Any leakage from the bolted joint portion of bonnet is not allowed.

(ii) 11.5 kgf/cm^2 water pressure shall be kept for 10 minutes. Any leakage from the bolted joint portion of bonnet is not allowed.

12.23 FIELD ERECTION

12.23.1 General

All equipment and structures shall be erected and/or installed by utilising conventional techniques and practices. The Contractor shall submit a field erection instruction manual to the Engineer for approval including the planned equipment and temporary facilities for the work.

12.23.2 Embedded Parts or Items

a. All guide frames, supporting frames, outlet pipes and other items to embedded in first or second stage concrete shall be adequately fixed and restrained in position such that all parts or items are within the specified tolerances both before and after concrete embedded. The Contractor will arrange his concrete placing rates and techniques and take all necessary measure to ensure such parts or items are not damaged or dislodged from the correct position in any way.

b. After concrete embedded and checking tolerances, the Contractor shall check for cavities behind the outlet pipes and report the finding to the Engineer. In locations where cavities occur and grout holes have not been provided, the Contractor shall drill and tap suitable holes and plug by welding on completion, to the approval of the Engineer. Alternatively the Contractor may submit for a approval an external grouting system for the work such that the requirement for providing grout holes in the conduit is avoided.

12.23.3 Grouting

Cavity grouting between concrete and the embedded steel conduit shall be carried out. Grouting pressure shall be 2.0 kgf/cm^2 using a grout mix to the Engineer's approval. Grouting shall be carried out in accordance with Section 5 of the Specification.

12.23.4 Groundings

All electrical equipment shall be substantially grounded to the earth electrode with copper wires. The location of the grounding system which will be prepared by Contract Package No.4 will be near the distribution panels shown on the Drawings.

12.23.5 Permanent Electricity Supplies

The power for permanent plant shall be as follows;

a. Power source

3-phase, 4-wire, 50 Hz

Voltage between phase	: 380 volts
Voltage between phase and neutral	: 220 volts
Voltage variation	: +10%
Frequency variation	: +5%
Neutral point	: Solidly grounded

b. Control source

1-phase, 2-wire, 50 Hz

Voltage between phase	: 110 volts
Voltage variation	: +10%
Frequency variation	: +5%

c. Distribution panel

The above mentioned power shall be supplied to the distribution panels furnished for the respective items of Water Control Plant.

12.24 FIELD TESTS AND COMMISSIONING

12.24.1 General

After installation and prior to the equipment's use, each equipment system will be tests and commissioned in the presence of the Contractor's representative and the Employer's representative and the Engineer. Each item of equipment will be initially tested under dry conditions. Each gate and hoist will be operated several times under each control mode to ensure proper operation. Each item of Water Control Plant shall be fully commissioned under flow conditions when water levels permit. Minimum commissioning conditions shall be with the water level at EL.148.900.

12.24.2 Commissioning

a. At least 90 days before completion of installation of each item of Water Control Plant, the Contractor shall submit a detailed commissioning

procedure for that item to ensure that all modes of operation are thoroughly tested under normal water level condition. The commissioning manual shall be to the approval of the Engineer. When approved, the Contractor shall submit ten (10) copies of each commissioning manual to the Engineer and Employer.

b. Final commissioning of the Water Control Plant will be dependent on the filling of the reservoir and the Contractor shall make due allowance in his programme and lump sum prices for sufficient commissioning personal to return to the Site when the water level permits commissioning to start, and for any consequential results of such delayed commissioning.

12.25 DESIGN CRITERIA

12.25.1 Scope

a. This Clause specifies the design criteria to be applied for all equipment to be furnished in accordance with this Section of the Specification. All requirements specified in this Clause shall apply to all equipment covered by this Section of Specification except where otherwise particularly modified elsewhere in the Specification or as approved by the Engineer.

b. Arrangement, components, or other features described in this Clause shall be considered non-applicable whenever subsequent Clauses limit the Contractor's selection to other arrangements, components, or features.

c. All aspects that are not specified in the Specification shall be in accordance with the recommendations of applicable industry design standards, and with modern conservative design practice.

d. The Contractor shall provide suitable holes and plugs for grouting and ventilation in all locations where the steel conduit is to be embedded in concrete and where it will be difficult to ensure no cavities remain after concreting. The number of such holes shall be minimised. Alternatively the Contractor may propose an external grouting system to be installed prior to concrete embedment which will be to the Engineer's approval.

e. All equipment covered by this Section of the Specification shall be suitable for performing safely its intended functions as described in the Contract Documents.

12.25.2 Design Loading on Structures

a. General

(i) Each gate, and each part of the equipment covered by the Specification having structural functions, shall be designed to comply with the specified structural requirements when subjected to each one of the loading conditions listed in this Sub-Clause and in subsequent Clauses.

(ii) The Contractor may limit his calculation to the critical loading case or cases, if it is evident or can be demonstrated that only these case(s) are critical.

(iii) In a similar manner, the Contractor may select the critical conditions such as gate leaf position or water level, with a loading case.

(iv) The magnitude of loading effects shall be calculated as specified in these Specifications, or in accordance with good engineering practice if not specified. Where maximum and minimum values are given, the selection of maximum or minimum shall be made so that it affects the result most unfavourably, to provide the greatest factor of safety in design.

b. Force Components

(i) Hydrostatic loads shall be calculated with a specific weight of 1000 kg/m^3 for fresh water.

(ii) Gravity acceleration shall be 9.8 m/s^2.

(iii) Wind load for all structures shall be 100 kg/m^2 over the entire exposed area.

(iv) Earthquake effect shall be calculated by applying horizontal coefficient of 0.12.

(v) Walkways, stairs and platforms shall have a 200 kg/m^2 load.

(vi) Horizontal loading on handrails shall be 50 kg/m.

(vii) Concrete placing pressure shall be calculated with a specific gravity of 2500 kg/m^3 for unhardened concrete.

(viii) Soil pressure shall be calculated with a specific weight of 2000 kg/m^3 for soil. This pressure acts as an external pressure load on buried pipes.

c. Loading Conditions for Gates

Effects of the following loads shall be combined so as to make the most unfavourable loading combination.

(i) Water load corresponding to the specified water level acting on the specified side(s) or parts of the gate.

(ii) Dead weight of the gate.

(iii) Hydrodynamic loads (if any) corresponding to flow conditions.

(iv) All force components caused by friction and other effects.

(v) Buoyancy.

d. Loading Conditions for Screen

Differential pressure head specified below shall be considered for over the entire gross area through which flow passes.

(i) Screen for intake structure of outlet works :

Differential pressure head of 2.0 m.

Differential pressure head of 0.5 m.

e. Loading Conditions for Steel Conduit

In designing the strength of the steel conduit, it shall be calculated without taking into consideration any additional strength given by the surrounding concrete.

(i) Internal pressure

Pressure head corresponding to the difference in height between specified water level and the centre of conduit. The water level shall include the water hammer pressure as specified in the Specification.

(ii) External pressure

Pressure head corresponding to the difference in height between specified water level and the bottom of conduit.

(iii) Grouting pressure

2.0 kgf/cm^2 joint grouting pressure shall be considered for the inlet and outlet pipe portions and bellmouth of the conduit embedded in concrete. These above mentioned pressures may be considered to act uniformly on the conduit shell or other items that may require grouting.

(iv) Effect of temperature change of 15 shall be considered.

(v) For the strength check of the conduit, the effect of the inclination of 1 vertically to 100 horizontally may be neglected.

12.25.3 Friction Forces

a. Rubber Seal

(i) Friction force due to rubber seal shall be calculated by summing the hydrostatic pressure acting on the seal and the seal pre-compression force. Pre-compression forces shall be used as given by the manufacturer's standard.

(ii) Friction coefficients for rubber seals shall be as follows :

- Rubber on corrosion-resistant steel in wet condition :
  - maximum : 0.70
  - minimum : 0.50.
- Rubber on corrosion-resistant steel in dry condition :
  - maximum : 1.20
  - minimum : 0.90.
- Fluoro-carbon on corrosion-resistant steel :
  - maximum : 0.15
  - minimum : 0.10.

b. Metal Seal

(i) Friction coefficients for sliding contact shall be as follows :

Bronze on corrosion-resistant steel, and bronze on carbon steel, and bronze on bronze :

maximum : 0.60
minimum : 0.30.

Self-lubricating bushing on corrosion-resistant steel, and self-lubricating bushing on carbon steel :

maximum : 0.20
minimum : 0.10.

(ii) When bronze or self lubricating bushing is used on corrosive steel axle or shaft, axle or shaft in the area in contact with the bushing is to be plated by hard chromium more than 0.05 mm thick.

(iii) Sleeve bearings (bushings) and sliding bearing plates shall be as a rule, lubricated with proper oil or grease for safe and smooth operation.

c. Other Friction Coefficients

(i) Roller bearings

Friction coefficients of maximum 0.02 and minimum 0.01 shall be used. These friction coefficients shall refer to the bearing bore.

(ii) Wheel rolling friction

Lever arm between load and reaction for nominal value shall be considered as 0.8 mm. Maximum and minimum values shall be calculated by increasing or decreasing the nominal value by 20%.

12.25.4 Allowable Stresses

a. Allowable Stress in Steel Members

Except for the steel conduit and mechanical parts of hoists, the allowable stresses shall be as follows :

(i) Tension, Bending Tension, Bending Compression, Shear and Bearing

Tension, bending tension: $C \times \sigma y$

Bending Compression : $C \times C1 \times \sigma y$

Shear : $C \times \frac{\sigma y}{\sqrt{3}}$

Bearing : $0.9 \times \sigma y$

where

σy : Yield strength of the respective material;

C : 0.5 for regulating gates, control gate, guard gate and screens;
0.6 for bulkhead gate and other appurtenances;

C1 = 1, when L/bf < 10/K

C1 = 1.1 - 0.01KL/bf, when 10/K < L/bf < 30 Not acceptable, when 30 < L/bf;

L : Laterally supported length of the compression flange;

bf : Width of the compression flange;

$K = \sqrt{3 + \frac{Aw}{2Ac}}$ when Aw / Ac > 2 ;

K = 2 when Aw / Ac < 2 ;

Aw : Area of web plate ;

Ac : Area of compression flange plate.

When the member is closed box or pipe sections, the allowable bending compression stress can be taken as :

$C \times \sigma y$

(ii) Compression

The allowable compressive stress shall be :

C x σy or I/C x (critical buckling stress) whichever value is smaller.

For calculating the critical buckling stress, the Contractor may select an applicable formulae from an authorised steel design standard.

(iii) Allowable Stress for Skin Plates

Skin plates which are subject to bending stress from water pressure shall be designed as plates in accordance with the theory of elasticity. The boundary conditions of skin plate panel shall be considered as built-in support on all edges. The Contractor may apply DIN 19704 (Hydraulic Steel Structures) clause 6.5.2.2, but the allowable bending stress of skin plate shall be taken as :

$C \times \sigma y$

b. Allowable Stresses for Steel Conduit

(i) Tension, Compression, Bending : $C \times \sigma y$

Shear : $C \times \frac{\sigma y}{\sqrt{3}}$

Bearing : $0.9 \times \sigma y$

where : C = 0.54.

(ii) When the local bending stress of pipe shell is taken into account, the above coefficient C can be multiplied by 1.35. This local bending stress occurs when the stiffener rings prevent the pipe shell from bulging elastically.

(iii) The safety factor for buckling of pipe shell, and stiffener rings shall be taken as 1.5.

c. Mechanical Components

(i) General

All mechanical components including shafts, sheaves, drums, pins and gears subjected to rated capacity loading condition shall be designed based on the following safety factors applied to the ultimate strength of the materials used :

Material	Safety factor for Tensile Stress	Safety factor for Compres-sive Stress	Safety factor for Shearing Stress
Rolled steel for general or welded structure	5	5	8.7
Carbon steel forgings	5	5	8.7
Carbon steel for machines structural use	5	5	8.7
Corrosion-resistant steel	5	5	8.7
Carbon steel castings	5	5	8.7
Grey iron castings	10	3.5	10
Bronze castings	8	8	10

(ii) Unit stress shall not exceed 90% of the yield strength of the material under the loading resulting from the maximum torque of the hoist motor.

(iii) The Contractor may propose to use materials other than those listed above but the safety factors in the table shall be applied similarly.

(iv) Wire rope

Safety factor to ultimate strength of the wire rope, calculated from hoisting load and from maximum motor torque shall be 8 and 1.7 respectively.

(v) Hydraulic cylinder piston rod

Hydraulic cylinder piston rod shall be designed based on the safety factor of buckling.

The safety factor used shall be :

At maximum working pressure	: 3.0
At rated oil pressure	: 1.1.

d. Bearings and Bushings

(i) Average bearing pressure shall be calculated by dividing the bearing load by the effective projected area of the bearing.

(ii) Bronze and other non-ferrous bushings :

Allowable bearing pressure shall be 200 kg/cm^2.

(iii) Self-lubricating bushings :

Allowable bearing pressure shall be :

When rotating	: 250 kg/cm^2
When not rotating	: 500 kg/cm^2.

(iv) Bearing plates

The allowable bearing pressure of bearing plates used for sliding type gates shall be :

When sliding	: 70 kg/cm^2
When not sliding	: 200 kg/cm^2.

e. Concrete

(i) General

Embedded parts and blockouts in the concrete works shall be designed considering the resulting shear stresses and bearing pressures in the concrete.

(ii) Allowable stress

Strength of concrete of 28 days age	: 210 kgf/cm^2
Compression stress	: 70 kgf/cm^2
Bearing stress	: 63 kgf/cm^2
Shear stress	: 4.25 kgf/cm^2

f. Seismic Load

For seismic loading cases the allowable stresses for metals can be multiplied 1.5, but shall not be larger than 90% of yield strength of the materials.

12.25.5 Sealing System

a. General

Each gate unit shall be provided with a suitable sealing system to ensure the sealing function required for each gate unit.

b. Rubber Sealing System

The rubber sealing system shall consist of rubber seals mounted on the gate leaf and seal plates attached to guide frames. Seal plates shall be of corrosion-resistant steel.

c. Seals

Seals shall have the following profiles :

(i) Bar type seals shall be used for sill seals or between adjacent blocks of sectionalised gate leaves.

(ii) L-shape seals shall be provided for side seals of the regulating gate leaf.

(iii) P-shape seals (music note type), with solid bulb shall be used for the bulkhead gate.

d. Clamp Bars and Clamp Bolts

(i) Clamp bars, clamp bolts and nuts shall be corrosion-resistant steel.

(ii) Thickness of clamp bars shall be at least 10 mm, and clamp bolts shall be arranged at 100 mm intervals.

(iii) Clamp bars shall provide adequate freedom of movement for seal rubber deflection and shall be designed to prevent seal rubbers from breaking or being damaged due to deflection of seals.

(iv) Clamp bars shall be fastened to the gate leaf by through-clamp bolts and nuts with packings. Tapped holes in the gate leaf shall not be acceptable.

e. Metal Touch Sealing System

(i) Metal touch sealing system shall apply to control gate, guard gate and other appurtenant valves. Two sealing contact metals shall be adequately machine finished to provide satisfactory sealing.

(ii) The sealing system, which consists of corrosion-resistant steel contacting to corrosion-resistant steel, shall be prohibited.

12.25.6 Structural Requirements

a. General

This Clause specifies the details of structures required for performing its intended functions as described in these Specifications and Contract Documents.

b. Minimum Thickness of Steel Plates

Except for appurtenances, all significant parts or components of structures shall be constructed by using at least 6 mm thick steel plates. The minimum thickness of rolled shapes shall be not less than 5 mm thick.

These minimum thickness shall include the corrosion allowance specified in subsequent paragraphs.

c. Corrosion Allowances

(i) Corrosion allowance may not be provided for the corrosion-resistant metals and ferrous metals embedded in concrete.

(ii) Gate leaves, guide frames, conduit and other parts which contact with water shall take the corrosion allowance into consideration. The corrosion allowance shall be decided in consideration of the significance of equipment and the frequency of being in water.

Steel conduit shell	: 1.5 mm
Regulating gate, control gate, guard gate, screens, and all guides frames including guides frames of bulkhead gate	: 1.0 mm
Bulkhead gate excluding guide frame	: 0.5 mm.

d. Deflection Limits

The main girders of gate leaves, supporting beams of the skin plate, supporting structures of screen and other major beams shall be designed to ensure maximum deflection less than specified below :

Regulating gate and bulkhead gate	: 1/800 of supporting span
Control gate leaf	: 1/3000 of supporting span
Guard gate leaf	: 1/2000 of supporting span
Supporting structures of screen panels	: 1/600 member length shall apply
Other major beams	: 1/600 of member length.

e. Plate in Compound Sections

For the plates in compound cross-sections serving as a flange, the full jointly bearing width with bending shall be calculated by graphical data given by DIN 19704, Clause 6.5.2.1.

f. Evaluation of Biaxial Stresses

Biaxial stresses shall be evaluated by replicating the equivalent monoaxial stress as follows :

$$\sigma_e = \sqrt{\sigma_1^2 + \sigma_2^2 - \sigma_1 \times \sigma_2 + 3 \times \tau^2}$$

Where

σ_e : Equivalent stress

σ_1 : Direct stress (tension Is considered as positive)

σ_2 : Direct stress acting perpendicular to axis of$_1$ (tension is considered as positive)

τ : Shearing stress.

The allowable equivalent stress shall be 1.1 times of allowable monoaxial stress specified In Sub-Clause 12.21.4. of this Clause. This multiplication shall not be permitted for the steel conduit.

g. Slenderness Ratio Limit

The slenderness ratio of major compression members shall be less than 120 and the secondary members shall be less than 150. The slenderness ration of major tension members shall be less than 200 and the secondary members shall be less than 240.

12.25.7 Wire Rope Hoist

a. General

Drums, sheaves, gears, reducers, shafts, bearings, couplings, manual operating devices, and other machinery parts for wire rope hoists shall be designed as specified in this Sub-Clause and other relevant Clauses in this Section of the Specification.

b. Drums

(i) The drums shall be of cast or welded steel construction, grooved to receive the full length of rope corresponding to the required lift plus three dead wraps on each drum, in addition to the length required for attachment to the drum.

(ii) The minimum pitch diameter of the drums shall not be less than 19 times the diameter of the wire rope.

(iii) Three or more layers of winding shall be prohibited. The fleet angle shall be less than 4for single layer winding and 2for double layer winding.

c. Sheaves

The sheaves shall be of cast steel or cast iron construction and shall have a minimum diameter of 17 times that of the wire rope.

d. Gears and Pinions

(i) All open gears and pinions shall be high strength alloyed steel and have machine cut spur teeth of pressure angle of 20. The number of pinion teeth shall be 17 or more and the reducing ratio of one set of spur gear and pinion shall be not more than 1:8. The breadth of spur gear shall be 10 times module, and the breadth of pinion shall be at least 10 mm wider than that of spur gear.

(ii) All open gears and pinions shall be provided with steel made covers for safe operation.

e. Reducers

(i) Except for manual operating devices, the worm gear reducer shall not be applied to gate leaf operation. Gears shall be enclosed in a gear case with easily accessible provision for lubrication. Gear shafts shall be mounted on ball or roller bearings.

f. Shafts

(i) The torsional rigidity of the drive shaft shall be commensurate with the functional requirements of hoists.

(ii) A solid bar or hollow tube shall be used for shafts. Abrupt diameter changes and other design features which cause stress concentrations shall be avoided.

g. Bearings

Bearings for high-speed, low torque shafts shall be roller or ball bearings. The low-speed, high torque shafts shall be mounted on plane (sleeve) bearings provided with bronze bushings.

h. Couplings

All couplings shall be torsionally rigid. A chain type or a gear type coupling shall be provided between individual mechanical units or parts necessary to transmit rotation and torque. These couplings shall ensure compensation for misalignment to some extent.

i. Manual Operating Devices

Each wire rope hoist shall be provided with a manual operating device which can operate the hoist within the handling force of 10 kg. The device shall be provided with a self-locking type worm gear. While the device is being operated, the electric motor shall be electrically disengaged.

j. Brakes

Each wire rope hoist shall be provided with two brakes including the one furnished in the motor enclosure. These brakes shall be automatically applied when the motor power supply is cut off and released automatically when the motor is energised. The rated braking capacity shall be not less than 150% of the rated torque of the motor.

k. Motors

(i) The motors shall be of horizontal shaft, 6 poles, squirrel cage, induction type, designed for full voltage starting, weatherproof and totally enclosed.

(ii) The motors shall have proper insulation and continuous rating at 40 degrees centigrade ambient temperature. Motor lead insulation shall be Class E or B depending on motor output and cable terminal boxes shall be provided preferably with stud-type connectors.

(iii) The capacity of the motor shall be more than 100% against the value calculated from the most adverse combination of loads. The starting and maximum torque of motor shall be more than 200% and less than 300% of its rated torque respectively.

l. Mechanical Position Indicators

(i) A mechanical gate position indicator shall be mounted on each hoist base. The indicator shall be an easily readable dial type having single or double pointers.

(ii) The dial plate shall be of corrosion-resistant steel or brass with engraved markings and the size shall be not less than 250 mm in diameter. The dial and pointers shall be mounted in a dust-tight and weather-proof enclosure, and shall have scale graduations in 1.0 cm increments.

m. Rope Adjuster

Rope adjuster shall be of spindle type furnished at the end of each wire rope for the purpose of adjusting the proper rope length.

n. Rope Slack and Overload Detector

If required in subsequent Clauses, rope slack and overload detectors shall be provided for safety of operation.

o. Lubricator

Hand operated grease pump, piping, distributors, grease nipples and other accessories shall be provided for ease of lubrication.

12.25.8 Local Control Cabinet

a. General

(i) The Contractor shall design, manufacture, deliver and furnish the following local control cabinets :

- Two local control cabinets for two (2) regulating gate units.
- One local control cabinet for bulkhead gate unit.
- One local control cabinet for both control gate and guard gate units.

(ii) The local control cabinet shall contain all relays, motor starters, disconnecting switches, control and lighting transformers, and any additional electrical equipment required to provide proper and safe operation of the hoists or hydraulic hoists. All electrical control components shall be mounted inside the control cabinet.

(iii) A local control panel shall be mounted on the door of local control cabinet.

b. Enclosure

(i) The enclosure of the electrical control cabinet shall be weatherproof cabinet constructed of heavy gauge steel not less than 2 mm thick.

(ii) This cabinet shall be provided with hinged and gasketed doors on the front and on all other sides required for full access to the equipment. All indicating equipment shall be visible with the door in the closed position ; all controls shall be behind the doors.

(iii) The doors shall be furnished with cylinder type locks and shall be keyed alike (master key). The door which should be opened for operation of the local control panel, but which shall not offer access to any other electrical equipment, shall have a different key not suitable to unlock other doors of the cabinet, (operator's key). Six keys of each type shall be furnished.

(iv) The cabinet shall be provided with holes for conduits entering from the rear, from below or from either side, as practicable.

(v) For control cabinets installed exposed to the weather, a rain protective canopy shall be provided above the door which is to be opened to operate the controls.

c. Indicators

All indicators such as voltmeter, ampere meter, gate position indicator, indicating lights, and other required indicating equipment shall be mounted on the door of local control cabinet, with hard glass window. All indicators shall be arranged functionally and clearly visible.

d. Push Button Controls and Switches

All push button controls and switches required for gate operation shall be arranged and mounted on the local control panel with lockable steel door. Any local operation shall not be possible without opening the door of local control panel.

e. Door Switch

(i) The control mode (local or remote) of gate unit shall be selected by the door switch furnished inside the door of the local control panel.

(ii) When the door of the local control panel is closed, the control mode shall become automatically remote mode.

(iii) When the door of the local control cabinet is opened, the control mode shall change automatically to local mode.

(iv) The bulkhead gate unit shall have only the local mode.

f. Heaters

The local control cabinet shall be equipped with electric heaters for moisture control. The construction of the enclosure and the placement of the heaters shall assure effective circulation of air and prevent damage to equipment by overheating. The heaters shall be designed to provide adequate heat to keep the cabinet dry when energised at their nominal operating voltage. Controls shall be of the automatic differential thermostat type to limit temperature rise when the heater circuits are energised.

g. Terminals

Terminals required for all indicating information and gate control operation shall be furnished for ensuring the remote control at the dam control office.

12.26 PAYMENT

a. Payment for the Water Control Plant will be made at the applicable lump sum prices tendered therefor in the Bill of Quantities (Items L.1.1, L.1.2, L.1.3, L.1.4, L.1.5, L.1.6, L.1.7, L.1.8, L.2.1, L.2.2, L.2.3, L.3 and L.4) which prices shall include the cost of all labour, materials equipment and incidentals for designing, manufacturing, supplying, testing, finishing, painting, packing, insuring, shipping, receiving and custom's clearance, storing, inland transportation, installing, erecting, providing temporary power for testing if necessary, site testing and commissioning of the Water Control Plant ; for preparing and submitting schedule, drawings, instructions, manuals, reports and photographs, for instructing Employer's personnel and for any other necessary works connected therewith.

b.

(i) For each lump sum item in the Bill of Quantities, the Employer shall pay 65 percent of foreign and local currency portions on completion of manufacture and fabrication and delivery to store at the Site of each item provided that all parts of the lump sum item are delivered and inspected by the Engineer and all inspection certificates have been received and approved by the Engineer.

(ii) For each lump sum item in the Bill of Quantities, the Employer shall pay 25 percent of the foreign and local currency portions on completion of installation, erection, concrete embedment, grouting, painting, testing and all other works associated therewith except final operational commissioning of each item to the approval of the Engineer.

(iii) For each lump sum item in the Bill of Quantities, the Employer shall pay the remaining 10 per cent of the foreign and local currency portions on satisfactory completion of each item including operational commissioning, supply of O & M manuals and undertaking all training for that item.

(iv) The payments to be made in accordance with paragraphs b.(i), b.(ii), and b.(iii) of this Sub-Clause shall be subject to deductions in accordance with Clause 60 of the Conditions of Contract.

CONSTRUCTION OF THE JATIBARANG MULTIPURPOSE DAM

PACKAGE 1: JATIBARANG MULTIPURPOSE DAM INCLUDING APPURTENANT STRUCTURES

SPECIFICATION

SECTION 13. INSTRUMENTATION OF STRUCTURES

TABLE OF CONTENTS

SECTION 13. INSTRUMENTATION OF STRUCTURES

13.1 GENERAL

13.1.1 Scope of Work

The Contractor shall supply, install, test and survey in the dam embankment, its foundation, and other locations, the instruments described in Sub-Clause 13.1.2, as shown on the Drawings, as described in this Section and as directed or approved by the Engineer.

13.1.2 Instruments and Ancillary Items

The instrumentation to be supplied, installed, tested and surveyed in the dam embankment, foundations, gallery and adjacent areas is as shown on the Drawings or directed comprises the following:

a. Electrical piezometers installed in the impervious zone and in boreholes in the foundation of the impervious zone;

b. Foundation deformation meters installed in boreholes in the foundation of the impervious zone;

c. Electrical tri-axial joint meters installed on connection joints of the internal gallery;

d. Probe extensometer installed in the impervious zone;

e. Strong motion accelerographs installed in the internal gallery and on the crest of the dam;

f. Surface movement markers installed along the crest of the dam and on the upstream and downstream slopes;

g. Terminal boxes in the internal gallery;

h. Digital readout units for recording data from items (a), (b) and (c);

i. Standpipe piezometers, of Casagrande type, installed at various locations outside the limits of the dam embankment;

j. Seepage measuring devices in the internal gallery under the downstream toe of the semi-pervious zone;

k. Thermometers for control of concrete curing of plug in diversion tunnel.

13.1.3 Tropicalisation and Power Rating

a. All instruments and associated equipment shall be suitable for operation in tropical areas.

b. All electrical equipment shall operate on portable power packs and battery supply.

13.1.4 Extent of instrumentation, Testing and Storage on Delivery

The Contract Documents give only the numbers, positions and general type of the instruments to be supplied by the Contractor.

All instrumentation operating on electrical or hydraulic systems shall be accompanied by certified test certificates for each such instrument. These instruments shall also be tested in the presence of the Engineer before

installation in the dam embankments or foundation, or concrete. All instrumentation shall be stored on site, before installation, in a secure, weatherproof and lockable building and fitted with facilities for testing and partial assembling of the instrumentation.

13.1.5 Approval of Instrumentation and Construction Procedures

a. The Contractor shall, not later than 120 days after Commencement Date, submit to the Engineer details of the instruments proposed including:

   (i) A detailed description of the instrumentation including the ancillary measuring equipment he proposes to install.

   (i) If the Contractor proposes to install brands or types of instruments other than those specified, he shall submit to the Engineer evidence that such brands or types have been installed and operated satisfactorily for a period of at least 5 years in other dam embankments.

   (ii) Procedures prepared by the manufacturers and/or suppliers of the instrumentation for the installation, testing and operation of the instruments.

   (iii) Details of portable and battery power supply units and the layout of all equipment and accessories to be installed in terminal boxes.

   (iv) The experience of the supervisor and technicians who will install the instruments.

b. During the execution of the Works, the Contractor shall submit to the Engineer for approval any further details regarding the instrumentation that the Engineer may require.

c. Not less than 60 days before the anticipated date of installing any instrumentation, the Contractor shall submit details of his proposed construction procedures detailing dam embankment placing operations in the vicinity of the instrument installation and the programmed sequence of events for this work including details of all labour, Equipment and materials to be used to the Engineer for approval. Within 30 days after receiving the construction procedures, the Engineer will approve the construction procedures with such modification as may be deemed necessary.

13.1.6 Skilled Personnel

For the installation of each instrument the Contractor shall employ approved technicians well experienced and skilled in the installation of embedded instruments in dams and who have a sufficient knowledge of the purpose and function of the particular instruments being installed. The whole of the instrumentation work shall be under the direct supervision of an approved supervisor, employed by the Contractor, and who is well experienced in all types of instrumentation and installation work, understands the purpose and function of all instrumentation being installed, has a sound knowledge of soil and rock mechanics, field and laboratory testing, construction techniques and construction control, the anticipated behaviour of the structure and who is approved by the Engineer.

13.1.7 Installation

a. The Contractor shall :

(i) install instrumentation in the presence of the Engineer;

(ii) where the Engineer considers it desirable, install instruments only during daylight hours;

(iii) provide lighting in accordance with Sub-Clause 1.10.2.4 when working at night or underground;

(iv) where necessary expose all temporary buried instruments to continue their installation;

(v) carry out all survey work required to locate such instruments;

(vi) tag all cables and movement gauges with identification tags approved by the Engineer at intervals of approximately 15 m horizontally or at such closer intervals as necessary to provide continuous identification;

(vii) install cables without joints, in the maximum lengths practicable, as determined by the Engineer;

(viii) where permitted, splice and couple cables in accordance with the manufacturer's recommendations as approved by the Engineer;

(ix) at all times during installation keep the insides of casing free from foreign matter.

b. The Engineer will take, for testing, samples from the dam embankment in the vicinity of instruments whenever he considers it necessary, and the Contractor shall allow in his construction procedures for such samples to be taken.

13.1.8 Care of Instrumentation

Unless otherwise specified or approved by the Engineer, no traffic or equipment shall be allowed to pass over any part of any instrument or connections until they are covered with compacted fill to a depth of not less than 0.5 m or such other depth as directed by the Engineer. The Contractor shall protect all instruments and connections from damage and displacement during the progress of the work. If, as determined by the Engineer, there has been any damage to, or displacement of the instruments and connections during the progress of the work, they shall be repaired or the instrument replaced immediately to the satisfaction of the Engineer by and at the expense of the Contractor.

13.1.9 Reading Instruments

During construction of the dam embankment, the Engineer will read the instruments at regular intervals. All instruments installed at any particular elevation will be read immediately after the Contractor has completed his installation, and the Contractor shall not place fill over the instruments or cables at these location until these readings have been taken. All required equipment shall be installed in each terminal box in the internal gallery and commissioned by the time connections are to be made from the lowest level of instruments connected to that structure. The Contractor shall allow the Engineer complete and unrestricted access to the terminal boxes and other necessary locations at all times, for the purpose of reading instruments.

13.1.10 Fittings and Cables

a. All instrument cables and fittings shall be of the heavy duty insulated type suitable for direct placing in saturated earth fill materials, and shall be as manufactured or supplied by Kyowa Dengyo (Tokyo, Japan) or approved equivalent.

b. Not later than 120 days after the Commencement Date the Contractor shall supply samples of all fittings and cables to be embedded for approval.

c. Separate payment will not be made for supplying and installing fittings and cables, including samples submitted for approval, and all such costs shall be included in the rates for the appropriate items of instrumentation.

13.1.11 Trenches and Protective Surrounds

13.1.11.1 General

The Contractor shall excavate trenches and construct as required, during the installation of instruments and cables in the dam embankment, protective surrounds to the dimensions and at the elevations shown on the Drawings and in accordance with the approved procedures. Such protective surrounds shall be placed and compacted as directed by the Engineer in trenches excavated for the purpose in the impervious zone.

13.1.11.2 Protective Surround in Impervious Zone

The protective surround through impervious Zone shall comprise 200 mm of loose selected rock-free impervious material, placed in a trench excavated to the lines and grades shown on the Drawings. The loose impervious material shall after laying tubes and cables be covered with a further 200 mm of selected impervious material, which shall be compacted by mechanical tamper, or other approved device and the degree of compaction shall be equivalent to that specified for impervious zone of the dam embankment. After compaction of the protective surround, the remaining depth of the trench shall be backfilled with selected rock-free impervious material compacted by mechanical tampers or other approved device in layers 150 mm thick after compaction to that specified for impervious Zone of the dam embankment.

13.1.11.3 Conduits for Cables

Where cables and measuring instruments are required to be embedded in concrete they shall be installed in PVC conduits filled with bentonite and sealed with epoxy at the ends. The Contractor shall exercise special care in placing concrete in the vicinity of the instruments, tubes and cables.

13.1.11.4 Payment

Separate payment will not be made for excavating trenches or for constructing protective surrounds , and all such costs shall be included in the rates for the appropriate items of instrumentation.