The Contractor shall provide a sufficient number of vibrators with mechanical means of handling if necessary, to properly compact fresh concrete immediately after it is placed in the forms and shall maintain at least one spare vibrator at the form.

In concrete having a placing rate greater than 20 cu.m per hour, compaction shall be accomplished using vibrators of 100 mm or greater in diameter.

Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures, and into corners and angles of the forms. Vibration shall be applied at the point of placement and in the area of freshly placed concrete. The vibrators shall be inserted into and withdrawn from the concrete slowly. The vibration shall be of a sufficient duration and intensity to thoroughly compact the concrete, but shall not be continued at any one point of the extent that excess water or grout appears. Application of vibrators shall be at points uniformly spaced and not further apart than twice the radius over which the vibration is visibly effective.

Vibration shall not be applied directly or through the reinforcement to sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibration. Vibrators shall not be used to transport concrete in the forms.

Concrete shall be placed in horizontal layers not more than 450 mm thick except as hereinafter provided. When less than a complete horizontal layer is placed in one operation, it shall be terminated using a vertical bulkhead. Each layer shall be placed and compacted before the preceding batch has taken initial set to prevent injury to the green concrete and to avoid surface separation between the batches. The provision for bonding successive courses of concrete shall all times be subjected to the Employer's approval.

3013 GREEN-CUTTING

When successive lifts of concrete are to be placed, laitance shall be removed from the surface of the concrete of the previous lift by means of approved manners prior to pouring the subsequent lift. The timing of this operation shall be such that individual pieces of concrete aggregate are exposed but their bond with the underlying concrete will not be affected. If required by the Employer, the surface shall be cleaned by surface chipping or wire brushing.

3014 JOINTS IN CONCRETE

(1) General

Construction joints, expansion joints and contraction joints shall be located in the positions shown on the Drawings or as required by the Employer. The Contractor shall not be permitted to form any additional joints or deviate from the joints indicated in the Drawings either in design or location, without the written approval of the Employer. Joints at exposed surfaces of concrete shall be straight and continuous as shown in the Drawings or otherwise specified.

To prevent feather-edges, the construction joints at the tops of horizontal lifts near sloping exposed concrete surfaces shall be inclined near the exposed surface so that the angle between such inclined surface and the exposed concrete surface will not be less than 50 degrees.

Disturbance of the new surface at a joint during the early stages of hardening except as specified for green cutting is prohibited and no work or traffic on the new concrete will be permitted until the concrete has hardened sufficiently to withstand such treatment without injury.

All surfaces upon which, or against which, concrete is to be placed shall be in a saturated surface-dry condition prior to being covered by fresh concrete.

(2) Preparation

Prior to placement of new concrete, all surfaces upon which, or against which, concrete is to be placed, including surfaces of construction joints between successive concrete placements, shall be thoroughly cleaned of all loose particles, dried mortar or grout or other deleterious matter. Cleaning shall include through-washing using water and brush. Where directed by the Employer, all laitance and loose or defective concrete not removed by green cutting operation, shall be removed by surface chipping or wire brushing. The aggregate of formed surfaces of construction joints shall be exposed. On formed expansion and contraction joint concrete surfaces, the aggregate shall remain unexposed.

(3) Cold Joints

Cold joints shall be avoided. In the event of equipment breakdown, or if for any other reason continuous placing is interrupted, the Contractor shall thoroughly consolidate the

concrete to a reasonably uniform and stable slope while it is plastic and if concreting is not resumed within 1 hour it shall be discontinued and not resumed until permitted by the Employer. When concreting operations are resumed, the usual construction joint treatment shall be applied on the surface of the concrete at the joint, before being covered with fresh mortar and concrete.

3015 CURING OF CONCRETE

All concrete shall be cured by maintaining its surface in a constantly moist condition for a period of at least 7 days after placing or until the surface is covered with fresh concrete. All surfaces shall be protected from the sun's rays for at least 5 days after placing.

(1) The surface of concrete, shall be moistened by covering with water-saturated materials or by employing other effective means approved by the Employer which will keep the surfaces to be cured continuously wet as soon as the concrete has hardened sufficiently to prevent damage.

Equipment for curing shall be available at the site before concrete placement is started and the water used for curing shall meet the requirements for water used for mixing concrete.

Steel reinforcement projecting from any placement shall be positively tied to prevent movement and possible debonding during placement and shall be protected from all disturbance for at least 24 hours after completion of such placement.

3016 TEMPERATURE CONTROL OF CONCRETE IN HOT WEATHER

The Contractor shall apply any or all of the recommendations contained in ACI 305, "Hot Weather Concreting", to control the temperature of concrete as directed by the Employer, in order to avoid the detrimental effects of high temperatures to the concrete which becomes hard or is already hardened.

(1) When the shade air temperature is 35 degrees C and rising, the coarse aggregate shall be sprayed with water or cooled by appropriate means. Special precautions shall be taken during the entire concreting process so that the temperature of the concrete does not exceed 33 degrees C when it is placed.

Fresh concrete placed at these temperatures shall be carefully shaded from the sun's rays and wind to the satisfaction of the Employer.

(2) No concrete shall be mixed or placed when the shade air temperature reaches 40 degrees C or more unless proper measures are taken for cooling aggregates and mixing water.

All costs of provision for hot weather concreting shall be included in the unit price of the appropriate concrete works.

3017 TOLERANCES FOR CONCRETE CONSTRUCTION

Permissible surface irregularities for the various concrete surface finishes are specified in the section 3018 "Finishing", and are to be distinguished from tolerances as specified hereunder. The intent of this section is to establish tolerances that are consistent with modern construction practice, but which are governed by the effect that permissible deviation will have upon the structural action or operational function of the structure.

(1) Subject to the requirements of section 3018 "Finishing" and except as otherwise shown on the Drawings or required by the Employer, deviation of concrete from the lines, grades and dimensions shown on the Drawings will be permitted within the following limits:

a) Variation in location from specified position in plan.

± 25 mm

b) Variation from centerline specified in plan for each structure.

For overall length	± 25 mm
For any span less than 9 m	± 10 mm

c) Variation from pump, specified batter, or specified curved profile for lines and surfaces of columns, walls, beams, buttresses, piers and similar members:

For any two successive intermediate points on the lines or surfaces separated by:

3 m	6 mm
6 m or more	20 mm

d) As (b) above, but for surfaces to be in contact with backfill:

twice the above dimensions

e) Variation from the level or from the elevations specified in plan:

±6 mm

f) As (d) above, but for surfaces to be in contact with backfill:

twice the above dimensions

g) Variations in cross-sectional dimensions from those specified for columns, walls, beams, buttresses, piers and similar members:

-6 mm, + 12 mm

h) Variation in thickness of slabs, walls and similar members from that specified:

-6 mm, + 12 mm

(2) The Contractor shall be responsible for setting and maintaining concrete forms sufficiently within the specified tolerance limited and shall ensure that the concrete is completed within these limits. Concrete work that exceeds the specified tolerance limits shall be remedied or removed as required by the Employer.

3018 FINISHING

(1) General

Allowable deviations of concrete from the established lines, grades and dimensions shown on the Drawings or specified in section 3017 "Tolerances for Concrete Construction", are defined as tolerances and are to be distinguished from surface irregularities as defined hereunder.

The finished surfaces of concrete shall be true, sound, smooth and free from fins, offsets, pits, depressions, voids, blemishes and other defective concrete, and shall be in accordance with the requirements for the corresponding class of finish specified herein.

Finishing of concrete surfaces shall be performed only by skilled workmen.

Surface irregularities are classified as "abrupt" or "gradual". Offsets caused by displaced or misplaced from sheathing, lining or form sections, by loose knots in forms, or otherwise defective form lumber will be considered as abrupt irregularities and will be measured directly. All other irregularities will be considered as gradual irregularities and will be measured with a template consisting of a straightedge for plane surface or its equivalent for curved surfaces. The length of the template will be 1.50 m for testing formed surfaces and 3 m for testing unformed surfaces.

(2) Formed Surface Finishes

The classes of finish for formed concrete surfaces are designated by the use of the symbols F1, F2 and F3, and shall be as follows:

a) Finish F1

The finish applies to surfaces upon or against which fill material or concrete is to be placed. The surfaces require no treatment after form removal except for repair of defective concrete and the specified curing. Surfaces to be submerged or below ground water level shall have all form-tie holes filled as directed by the Employer.

b) Finish F2

This finish is required on all formed surfaces not permanently concealed by fill materials or concrete and for which no other finishes are specified. This finish shall present a uniform appearance and no special surface treatment will be required other than the repair of defective concrete, the filling of fastener holes, the removal of abrupt irregularities in excess of 6 mm and the reduction of gradual irregularities so that they shall not exceed 12 mm for the length designated.

c) Finish F3

The finish is designated for surfaces prominently exposed to public view where appearance is of special importance. On completion of the repair of defective concrete and filling of fastener holes, this finish shall present a surface of uniform appearance and texture. Surface irregularities shall not exceed 6 mm for gradual irregularities and abrupt irregularities exceeding 3 mm will not

be permitted. In addition to the repair of defective concrete and the removal of fins, offsets and other irregularities, the surface shall, if the Employer considers it necessary, be sack-rubbed to fill pits and air holes. Sack-rubbing shall be done as soon as the forms have been stripped and after any required patching and correction of major imperfections have been completed. The mortar to be used shall consist of 1 part cement to 2 parts by volume of sand passing a No. 16 US. Sieve and shall be mixed with water to a creamy consistency. If required by the Employer, the Contractor shall add white cement to the mix in order to obtain a color and texture that will match the surrounding concrete surfaces. After surface treatment is completed, the specified curing shall continue for not less than 14 days.

(3) Architectural Finishes

Formed surfaces which are subsequently to be rendered, plastered or tiled shall be adequately dressed down, as soon as the forms have been removed, so that surface irregularities are not deeper than half the thickness of the rendering ,plaster or mortar for tiles. Surfaces shall be roughened to allow adequate bond with the mortar or plaster finish.

(4) Unformed Surface Finishes

The classes of finish for unformed concrete surfaces are designated by the use of the symbols U1, U2 and U3, except those for topping, and shall be as follows:

a) Finish U1 (Screeded Finish)

This is a screeded finish used on surfaces that will be covered by fill materials or concrete. Finishing operations shall consist of sufficient leveling and screeding to produce even, uniform surfaces. Surface irregularities shall not exceed 10 mm.

Finish U1 is also used as the first stages of finishes U2 and U3.

b) Finish U2 (Floated Finish)

This is a floated finish used on surfaces not permanently concealed by fill materials or concrete. Finishing operations shall consist of sufficient leveling and screeding to produce even surfaces in which the surface irregularities shall not exceed 6 mm. Floating with hand or power-driven equipment shall be started as soon as the screeded surface has stiffened sufficiently, and shall be the minimum necessary to produce a surface that is free from screed marks and is uniform in color and texture.

c) Finish U3 (Troweled Finish)

This is a troweled finish used on surfaces where accurate alignment and evenness of surface are required for prevention of destructive effects of water action or as specified on the Drawings. Finish U3 shall be screeded and floated as indicated for finishes U1 and U2, and shall consist of steel troweling the floated surface as soon as it has hardened sufficiently to prevent excess of fine material being drawn to the surface. Steel troweling shall be performed with firm pressure, such as will flatten the sandy texture of the floated surface and produce a dense, uniform surface, free from blemishes and trowel marks. Abrupt irregularities will not be permitted.

d) Finish for Slabs to Receive Topping

This finish applies to structural slabs on which a separate topping will be placed. The finish shall be equal to finish U1 except that before the concrete has fully hardened, the surface shall be broomed so that the aggregate at the surface shall become exposed. Alternatively, these slabs may receive Finish U1 and subsequently roughened by chipping or scarifying if approved by the Employer.

Unless otherwise shown on the Drawings or directed by the Employer, all surfaces which would normally be horizontal and exposed to the weather, shall be sloped for drainage approximately 10 mm per one meter of width.

3019 REPAIR OF DAMAGED OR DEFECTIVE CONCRETE

(1) General

Repair of damage or defective concrete shall be performed by skilled workmen only. No repair work shall be carried out until the Employer has inspected the location of the proposed repair and has directed the method of repair.

The Contractor shall correct all imperfections on the concrete surface as necessary to produce surfaces that conform to the requirements specified in section 3018 "Finishing".

Unless otherwise approved by the Employer, repair of imperfections in formed concrete shall be completed within 24 hours after removal of forms. Concrete that is honeycombed, fractured, or otherwise defective, and concrete which, because of excessive surface depressions, shall be cut out and built up to bring the surface to the prescribed lines, shall be removed and replaced with drypack mortar or concrete.

The Contractor shall correct abrupt or gradual irregularities which lie outside specified tolerances by rubbing with a carborundum stone or grinding where directed.

Materials and procedures specified to suit individual types of repair and to reinstate structural capacity of members may include use, as approved by the Employer, of a proprietary non-ferrous non-shrink grout, epoxy or latex-based bonding agent, epoxy compound and cementitious grout, mortar and concrete. The Contractor shall, whenever possible, perform repair of defects while the concrete is still green. Curing interruptions shall be limited to the minimum time and area practicable.

The holes left by removal of pipes, tie-rods or other accessories shall be reamed with suitable toothed reamers before being cleaned and filled with drypack as specified. All bulges or other projections on exposed surfaces shall be chipped and ground until a true smooth surface of matching color and texture is obtained.

(2) Drypack

Drypack material shall be placed and packed in thin layers. Each layer shall be solidly compacted.

Drypack shall be used for filling holes having at least one surface dimension less than the hole depth, for narrow slots cut for repair of cracks, for grout pipe recesses, and for tie-rod fastener recesses. Drypack shall not be used for filling behind reinforcement or for filling holes that extend completely through a concrete section.

(3) Mortar

Mortar filling shall be placed under impact by use of a mortar gun, and may be used for repairing defects on surfaces designated to receive F1 and F2 finishes where the defects are too wide for drypack filling and too shallow for concrete filing and no deeper than the far side of the reinforcement that is nearest the surface.

(4) Concrete Placement

Concrete filling shall be used for holes extending entirely through concrete sections, for holes in which no reinforcement is encountered and which are greater in area than 0.1 square meters and deeper than 100 mm, and for holes in reinforced concrete which are greater in area than 0.15 square meters and which extend beyond reinforcement. Holes less than 0.15 square meters in reinforced concrete which extend beyond the reinforcement shall be enlarged to permit satisfactory filling of the hole with concrete.

Defective concrete shall be cut out to a depth of not less than 25 mm in sound concrete in all directions so that the edges of each hole are sharp-edged and undercut to provide a key, and the hole shall be cleaned, brushed and soaked 12 hours before being refilled. The fillings shall be tightly packed and completely bonded to the surface of the holes. The mix proportions of the filling materials shall be such to provide a strong, dense repair which will avoid color variations in surfaces exposed to view. Where required by the Employer, the Contractor shall supply white cement in sufficient amount, as determined by trial in the presence of the Employer, which, when blended with normal cement, will produce a finish of similar appearance to the adjacent concrete. Non-shrink additives shall be used where a watertight joint is required. The surface of patches shall be smooth and flush with the surrounding concrete.

3020 EMBEDDED ITEMS IN CONCRETE

All items which are to be embedded in either primary or secondary concrete, shall be accurately set in place to conform to the required tolerance. All embedded items shall be thoroughly cleaned of rush, grease, paint, splashed mortar or other coatings that reduce bond. Prior to concreting, the Contractor shall satisfy himself that the parts are rigidly held and set to the required tolerance, and where so required by the Employer, s hall take formal delivery of the parts.

The methods of placement of concrete around the embedded parts shall be approved by the Employer. The responsibility for maintaining the required tolerance shall lie with the Contractor.

During concrete placing adjacent to embedded parts, vibrators shall not be allowed to touch any metal parts embedded in the concrete, and the concrete shall be placed in such a manner as not to disturb the embedded parts.

3021 MEASUREMENT AND PAYMENT

(1) Measurement for payment of concrete cast in situ shall be made by volume in cubic meters of respective classes of concrete placed as computed from the dimensions shown on the Drawings.

Payment for concrete will be made at the unit price per cubic meter, which unit price shall include the cost for supply and storage of all necessary materials including cement, coarse and fine aggregates, water, admixtures and additives, and for testing all necessary materials, all measures necessary for batching and mixing of all materials, transportation of concrete, site preparation prior to pouring and casting, provision of joints, finishing, protection, curing and temperature control of concrete, supply and transportation of the specimens, and incidentals in order to complete the production and placement of concrete.

Measurement and payment for formwork, reinforcing bars and other miscellaneous materials to be embedded in or installed on the concrete cast in situ shall be separately made as described in Section 3100 "Formwork", Section 3200 "Reinforcing Bar" and Section 3300 "Waterstop, Contraction Joint, Expansion Joint Filler and Dowel Bar", respectively.

SECTION 3100 FORMWORK

3101 GENERAL

The fabrication, erection and removal of all the formworks shall be carried out in order to construct the required concrete structures.

This Section covers the requirements for the design, materials, fabrication, erection and removal of formwork for concrete.

The following standards are referred to in this section:

ACI SP-4	Formwork for Concrete
ACI 347	Recommended Practice for Concrete Formwork

3102 LUMBER

All materials used in the fabrication and erection of forms shall be of adequate strength and quality for their intended purpose, to meet the approval of the Employer. Suitable local timbers shall be used.

Forms shall be of straight lumber, shiplap, tongue and groove lumber, or plywood. Steel forms may be used only with the approval of the Employer. All materials used in formwork shall be of a type and strength sufficient to withstand the pressures due to the concreting, and deflection shall be within the tolerances specified.

Where finishes F2 or F3 specified, forms may be of plywood sheathing or lining, or tongue and groove lumber, and shall be approved by the Employer.

3103 FORM TIES

Internal ties shall be bolts and rods and they shall be straight and so arranged that when the forms are removed, no metal shall be left closer than 50 mm to any exposed surface for all finishes. Form ties shall not be fastened to reinforcing steel or embedded parts. Wire ties will not be permitted.

3104 FORM OIL COATING

All form surfaces shall be thoroughly cleaned before erection and shall be coated with a non-staining mineral oil or lacquer. All excess oil shall be wiped off prior to concreting and no oil shall be permitted on the reinforcing steel or other embedded items. The use of all form coatings or lacquers shall be subject to the approval of the Employer, and the Contractor shall be required to provide proof of compatibility between the product to be employed, the concrete itself, and any subsequent treatment that the formed surface is to receive. All form coatings shall prevent ingress of wood resins into the concrete surface.

3105 DESIGN OF FORMS

The Contractor shall design all formworks and falsework. Notwithstanding any approval given to the Contractor by the Employer, the Contractor shall remain responsible for the safety and structural soundness of all formwork and falsework.

The Contractor shall submit the designs of all formwork and falsework to the Employer for his approval. The Shop Drawings submitted for approval shall clearly indicate the dead and live loads assumed for the design, the maximum permissible speed of rise of concrete in the form, the dimensions of all structural members and the capacity of all ties, anchors and hangers.

3106 CONSTRUCTION OF FORMS

The construction of forms shall adhere to the Contractor's approved design and shall conform to the shapes, lines and dimensions of the structure as shown on the Shop Drawings. Failure or misalignment of the forms and any damage caused thereby shall be corrected by the Contractor.

At all unformed construction joints, wooden strips of a minimum size of 50 mm by 50 mm shall be secured to the inside of the forms at the location of each joint to ensure a uniform finish to the outside edges of any lift of concrete. The upper layer of concrete shall be worked up to and under these strips so as to provide smooth edges.

Unless otherwise shown on the Drawings, exterior external arises shall be chamfered 40 mm and interior external arises shall be chamfered 30 mm.

3107 INSPECTION OF FORMS

Temporary openings shall be provided at the base of forms as necessary to facilitate cleaning and inspection. After inspection, these openings shall be closed in such manner that leakage during concreting is prevented and that the concrete surface finish is not impaired.

3108 RE-USE OF FORMS

Forms shall be thoroughly cleaned and repaired to the satisfaction of the Employer prior to re-use. Except where F1 finish is specified, metal patches shall not be allowed in the repair of forms.

3109 REMOVAL OF FORMWORK AND FALSEWORK

Forms shall be removed as soon as practicable and the recommendations contained in ACI 347 shall be used as a general guide for determining the time for stripping. In all cases, forms shall not be removed until such removal is authorized by the Employer.

Notwithstanding the recommendations of ACI 347, forms or sections containing waterstops shall not be removed within 24 hours after the placing of concrete.

The minimum period which shall elapse between the completion of concreting and the removal of forms shall be as follows:

Forms for:	Minimum Period
Vertical or near vertical faces of mass concrete	24 hours
Beam sides, walls and pier	2 days
Beam soffits (props left under)	6 days
Slabs (props left under)	3 days
Props under beams and slabs	14 days

3110 MEASUREMENT AND PAYMENT

Measurement for payment for formwork for concrete cast in situ shall be the area shown on the Drawings, measured in square meters, of concrete surfaces formed. Payment for formwork will be made at the unit price per square meters, which shall include the supply and storage of all materials and for all measures necessary for preparation, fabrication, transportation, placing and erection, supporting, scaffolding, removal, cleaning and incidentals.

Separate payment shall not be made for respective kinds of formwork to complete the relevant finishing as specified in Section 3018 "Finishing".

SECTION 3200 REINFORCING BAR

3201 GENERAL

The furnishing, cutting, bending and erection of all the reinforcing bars shall be carried out in order to construct the required concrete structures.

This section covers the material requirements, bending and erection of the reinforcing bars to be used in the concrete.

The following standards are referred to in this section:

ACI 318	Building Code Requirements for Reinforced Concrete
ASTM A 497	Specification for Welded Deformed Steel Wire Fabric for Concrete Reinforcement
TIS 20	Standard for Steel Bars for Reinforced Concrete : Round Bars
TIS 24	Standard for Steel Bars for Reinforced Concrete : Deformed Bars

3202 BAR-PLACING DRAWINGS AND BAR-BENDING DIAGRAMS

The size and spacing of the reinforcing bar shall be as shown on the Shop Drawings. The Contractor shall prepare and submit to the Employer, for approval, reinforcement detail drawings for all structures, including bar-placing drawings, bar bending diagrams and bar lists before bar cutting and bending commences.

Bar-placing drawings and bar-bending diagrams to be prepared by the Contractor shall conform in general to the concrete lifts shown on the Drawings. In the event that the Contractor requests changes in lift heights and the Employer approves such changes, the Contractor shall revise or replace bar-placing drawings and bar-bending diagrams to suit the changed lift.

Such bar-bending diagrams and bar-placing drawings revised by the Contractor shall be submitted to the Employer for his approval prior to concreting at the portion of the changed lift.

3203 MATERIALS

Reinforcement shall be of deformed bars and shall conform to TIS 24, Designation SD 30. For bars smaller than 10 mm in diameter, round bars conforming to TIS 24, Designation SR 24, may be used.

Tie wire shall be heavy black annealed iron wire. Preformed clips or attachments shall be of proper design and strength so that reinforcing bars are rigidly supported in position.

3204 PROTECTION

Reinforcing bars shall be stacked for storage purposes clear of the ground such that it will not become submerged in standing water.

Reinforcing bar shall be protected at all times from damage. When placing in the works, it shall be free from dirt, detrimental scale, paint, laitance, mortar, oil or other foreign substance.

Reinforcing bar embedded or partially embedded in the concrete shall remain completely undisturbed for a minimum period of 24 hours or longer if the Employer so directs, after the concrete placement has been completed.

3205 FABRICATION

Reinforcing bar shall be cut and bent cold, unless otherwise permitted by the Employer, to the dimensions and shapes as shown on the approved Shop Drawings with equipment and methods approved by the Employer. The reinforcing bar partially embedded in the concrete shall not be field bent.

All bars shall be cut from stock length. Bends and hooks shall be made in accordance with the requirements of ACI 318. The reinforcing bar having cracks or splits on the bends shall be rejected.

Reinforcing bar shall not be straightened or bent again once having been bent, except otherwise approved by the Employer.

Fabricated reinforcements shall be properly tagged for easy identification.

3206 ERECTION

Reinforcements shall be accurately erected in accordance with the approved Shop Drawings and shall be securely wire-tied at each intersection. Metal or concrete chairs and metal spreaders of approved types shall be used where necessary for support or spacing of bars. The reinforcements shall be erected within the limit of the following tolerances:

Concrete cover	:	-3 mm to +6 mm
Longitudinal location of bends	:	±25 mm
End of bar	:	±25 mm

All reinforcing bars shall be furnished in the full lengths shown on the approved Shop Drawings. Splicing of bars will not be permitted without the prior written consent of the Employer. The splicing shall be by overlapping, as indicated on the Drawings. Splices may also be made by the use of approved couplings or by special welding techniques as approved by the Employer.

Welded wire fabric shall be placed and tied as indicated on the approved Shop Drawings with minimum lap at joints of 150 mm.

Concrete protection for reinforcement shall conform to the requirements of ACI 318, unless otherwise shown on the Drawings.

3207 MEASUREMENT AND PAYMENT

Measurement, for payment, of reinforcing bars will be based on the weight of reinforcing bars placed in the concrete in accordance with the approved reinforcement detail drawings. No measurement for payment will be made for reinforcement used in precast concrete products and reinforcements used in chairs, hangers, spacers and other support for reinforcement.

Payment for reinforcing bar will be made at the unit price per metric ton, which shall include the cost for supply, bending, cutting and erection of reinforcing bar, provision and using of tie wire, metal and concrete support, spacers and other fixing devices, coupling or welding, and other incidentals.

SECTION 3300 WATERSTOP, CONTRACTION JOINT, EXPANSION JOINT FILLER AND DOWEL BAR

3301 GENERAL

This section covers the requirement for materials and installation of waterstop, contraction joint, expansion joint filler and dowel bars.

3302 WATERSTOP

(1) Waterstop shall be of central hollow bulb type conforming to JIS K6733, and shall be extruded from a high grade compound with no reclaimed material. The main constituent shall be dense, homogeneous and free from porosity or other imperfections.

At least 60 days prior to installing any waterstop, the Contractor shall submit drawings and data to the Employer for approval.

The drawings shall show details of the waterstops, including dimensions, shapes, and details of intersections and splices between waterstops of the same sizes and of different sizes.

The Contractor shall submit detailed laboratory test reports on the physical properties of the compound which will be used in the waterstops to be furnished.

(2) Measurement, for payment, for furnishing and installing the various sizes of waterstops will be made of the number of linear meter of waterstops in place measured along the centerline of the waterstop with no allowance for lap at splices and intersections.

Payment for furnishing and installing the various sizes of waterstops will be made at the unit price per linear meter, which unit price shall include the cost of furnishing all materials, preparing and submitting drawings and data, making field splices and intersections, and installing the waterstops; and of furnishing and installing coverings for protecting waterstops from damage.

3303 CONTRACTION JOINT

(1) Contraction joints, where specified, shall be formed as deliberate planes of discontinuity in the concrete structure. To form such a joint the face of concrete slab or block first formed shall be painted with two coats of approved rubber bitumen paint or oil paint before the adjoining slab or block is concreted.

(2) Measurement, for payment, of contraction joint will be based on the area of contraction joint shown on the approved Shop Drawings. Payment for forming contraction joint will be made at the unit price per square meter, which unit price shall include the cost of furnishing rubber bitumen paint or oil paint and of painting.

3304 EXPANSION JOINT FILLER

(1) Expansion joints shall be formed in the same way as contraction joints but, in addition, an approved compressible sheet or filler shall be supplied and placed in the joint to provide freedom for two adjacent concrete slabs or blocks to expand. In certain situations a highly compressible joint filler of foam rubber or other approved material shall be used. The exposed edges of the joints shall be sealed with an approved synthetic rubber or similar resilient sealing compound.

(2) Measurement, for payment, of expansion joint filler will be made of the area of material in place. Payment for furnishing and placing joint filler will be made at the unit price per square meter, which unit price shall include the cost of furnishing and placing joint sealer, joint filler and other materials required to complete the expansion joint.

3305 DOWEL BAR

(1) Dowel bar will be D19 mm reinforcing bar of one meter long in which half length of the bar is inserted into ø25 mm PVC pipe with a cap. Dowel bar shall be installed as shown on the Drawings or directed by the Employer.

(2) Measurement, for payment, of dowel bar will be made of the number of dowel bars in place. Payment for furnishing and installing the dowel bar will be made at the unit price per number, which unit price shall include the cost of furnishing all materials and installing the dowel bars, and of protecting the dowel bars from damage.

DIVISION 4 PILING WORKS

SECTION 4000 PILING WORKS

4001 GENERAL

This section covers the materials, workmanship, equipment and methods to be adopted for the piling which shall be driven into the foundations of diversion dam and other structures as shown on the drawings.

The Contractor shall propose for approval of the Employer the nominated manufacturers who shall supply the prestressed spun concrete (P.C.) piles in accordance with TIS 398, the reinforced concrete (R.C.) piles conforming to TIS 395 and the steel pipe (S.P.) pile conforming to JIS A 5528.

4002 SITE PREPARATION

The Contractor shall be responsible for construction of any temporary site access and site grading required for installation of the piles. Construction of temporary access road, site grading, drainage, excavation and other site work shall follow the requirements of Division 2 "Earth and Stone Works".

The Contractor shall submit a schedule indicating the location of all temporary access roads, temporary grading plans, and drainage for approval by the Employer at least two weeks prior to the anticipated start of the works. The Employer may limit the amount of temporary fill placed beneath structures in order to avoid surface settlement which could induce drag loads on the pile foundations.

4003 MANUFACTURING AND SUPPLY OF PRESTRESSED SPUN CONCRETE PILE

The prestressed spun concrete pile shall be manufactured by an established pile manufacturer, and the Employer shall be advised six weeks in advance of commencement of manufacturing.

Casting beds of concrete or other suitable, rigid construction shall be used. Forms shall be constructed of heavy gauge steel or other rigid and smooth materials; shall be adequately braced; and shall be free from dents, gauges or other irregularities.

Casting beds for fabrication of prestressed members shall have jacking equipment at one end and a rigid reaction frame or block at the other end. Equipment for measuring stress and elongation of the prestressing reinforcements shall be approved.

The use of steel forms on concrete founded casting beds is required unless otherwise approved in advance. Outer forms shall enclose all except the top horizontal surface. The side forms may have a maximum draft on each side not exceeding 20 mm per meter.

Prestressed piles longer than 20 m shall be designed for a two point pick up. Design bending moments shall be increased by a minimum of 40 percent to allow for impact during handling.

Aggregates and cement shall be as specified in Division 3 "Concrete Work." Maximum size of aggregate shall be 25 cm, and the type of cement for the pile shall be TIS 15 Type V.

The minimum concrete compressive strengths shall be 500 kg/sq.cm at the time of delivery.

Prestressing reinforcement shall conform to JIS G 3536 "Uncoated Stress Relieved Wire and Strand" or ASTM A 416 "Uncoated Seven Wire Stress - Relieving Strand for Prestressed Concrete".

Concrete shall have attained a compressive strength of at least 350 kg/cm^2 before the pretensioning stress on the prestressing wires or strand is released. Compressive strength shall be determined first by examining the rate of increase of strength as disclosed by the crushing of the test cylinders made in connection with the establishment of the design mix. In addition to this advance determination, a running check shall be made throughout the period of casting the prestressed members.

All precast concrete piles furnished shall be new, undamaged members which have not been previously rejected for any reason and shall be manufactured especially for the Works. Members which are damaged or which do not meet the requirements of this section shall be rejected.

Piles shall in all cases be stored and handled in accordance with the recommendations of the pile manufacturer. Particular care shall be taken to avoid dropping or severe jarring while in a horizontal position. If for any reason the pile is damaged or the reinforcement is exposed, its use shall not be allowed.

Concrete piles shall be so proportioned, cast, cured, handled and driven as to resist without cracking the stresses induced by handling and driving as well as by the design loads as shown on the drawings. The piles shall have a uniform cross section, the length of which is embedded in the bearing soil.

Each pile shall be stamped or marked with the date of its manufacturer, identification of dimensions and identification of manufacturer. Lifting hooks or points, shall be plainly marked on each pile.

The top of the pile must be perpendicular to the longitudinal axis of the pile, and the ends of any prestressing or reinforcing steel shall be cut flush with the top of the pile to prevent direct impact on the steel during driving. Pile top ends shall be planed surfaces which shall be perpendicular to the long axis of the pile within a tolerance of 10 mm per meter. Pile tips shall be tapered and include a cast ironcone shaped shoe.

The maximum sweep (deviation from straightness measured along two perpendicular faces of the pile while not subject to bend forces) shall not exceed 3 mm in any 3 m of its length. All corners shall be chamfered to 40 mm or rounded to 50 mm radius. A smaller chamfer or radius, not less than 19 mm may be used if approved by the Employer. Forms for piles shall be such as to avoid the formation of fins at intersection of surfaces.

The unformed top surface of each pile shall be given a uniformly smooth finish to match the finished surface of the formed surfaces.

The lateral reinforcement at both ends of the pile shall be spaced sufficiently close to resist impact stresses due to driving and in no case more than 7.5 cm on centers. A minimum covering of 5 cm of concrete shall be provided over all reinforcements.

Piles shall be provided at the top with longitudinal reinforcing steel required to resist uplift load and for unsupported lengths of piles. In the case of reinforcing steel to resist uplift loads on the piles the bar design shall be subject to the approval of the Employer for the required tension load.

Following driving, the concrete at the top of the pile shall be broken away to expose the reinforcing steel which is to be incorporated in the structural concrete foundation of the structure. The reinforcing steel in the top of the piling shall not be installed in drill holes in the piling nor shall the reinforcing steel be extended by weldings. The reinforcing steel may be bent over in the pile concrete to reduce the amount of concrete to be broken away.

4004 SUPPLY OF SHEET PILE, AND STEEL PIPE PILE

All steel sheet pile, and steel pipe (S.P.) pile shall be obtained from sources approved by the Employer. Before the dispatch of any consignment of steel sheet pile and steel pipe pile, the Contractor shall hand to the Employer a certificate from the manufacturer that the consignment complies with the approved specifications. Steel sheet piles and steel pipe pile shall be manufactured to JIS A 5525 and JIS A 5528 respectively.

4005 JOINTING OF PILES

The root edges or root faces of lengths of piles that are to be butt welded shall not differ by more than 3 mm. Longitudinal seam welds in lengths of tubular piles forming a complete pile shall be evenly staggered. Welding shall be in accordance with JIS G 3443 or equivalent.

Prior to any welding of piles the Contractor shall carry out procedural trials as agreed with the Employer. The accepted trial welds shall be retained and used as a standard for all subsequent welds.

4006 PILE DRIVING

(1) Lines and Grandes

The datum elevation and grid system are shown on the drawings. Piles shall be located and staked out by the Contractor and the Contractor shall maintain all location stakes and shall establish all elevations required, including the elevation of the top of the pile prior to cutting off any length of pile. All location and survey stakes shall be checked on a regular basis to insure that pile driving operations have not caused movement of the stakes. Each pile is to be identified by number on Shop Drawings.

Within one working day after all of the piles in a cluster have been driven, the Contractor shall provide the Employer with a written tabulation indicating the following information for piles driven in that cluster:

a) Pile cluster designation
b) Pile number
c) Elevation of top of pile prior to cutting (measured to nearest 0.02 m)

Within two weeks after the completion of driving of all piles, or within two weeks of the completion of excavation required to expose the piles at the cutoff grade, the Contractor shall provide the Employer with a certified plan showing the as-driven location of all piles driven within the structures.

As-driven pile locations shall be surveyed and shown on the drawing to the nearest 0.01 m.

(2) Determination of Pile Length and Pile Load Capacity

Design pile dimensions or design loads for piling are shown on the drawings. Design dimensions include design pile cutoff grade and required pile tip elevation. The required pile tip elevation shall be continued by load test as specified.

Pile lengths shall be determined as the length from the pile tip elevation (confirmed by load test) to the design pile cutoff grade plus a length allowance required for reinforcing steel for uplift load.

Where pile loads are indicated, the required pile embedment shall be computed from static formula as directed by the Employer.

Under certain structures, piles may be required to resist both compression loads and tension loads. The required pile tip elevation for both compression and tension loadings shall be confirmed by load testing. Only one pile shop shall be used for each design load condition. Pile length may be increased or decreased from the lengths shown on the drawings, as a result of load test. The final determination of pile length shall be approved by the Employer upon review of the pile load test.

Orderings, manufacturing and delivery of piles shall be planned in such a manner that changes in length of piles for piles not yet manufactured may be made if driving experience, as the work progresses, indicates to the Employer the need for such changes.

(3) Installation of Piles

Piles shall be driven with approved equipment. The leads of the pile driving rig shall be fixed at two points; the points shall be at least half the length of the leads apart in order to maintain the pile and hammer in axial alignment at the correct plan location during the entire operation. The leads shall extend down to the lowest point at which the hammer must operate.

Driving shall be accomplished using equipment that will hold the pile in the design alignment (vertical or battered) during the installation of the pile. The alignment of vertical piles shall be carefully checked by means of a carpenters level 9a bubble level with a minimum length of 1.2 m, a transit, by sighting the axis of the pile against a string supporting a plumb bob. Alignment of batter piles shall be checked by transit or other methods approved by the Employer.

The method of driving shall be such as not to impair the strength of the pile and shall meet with the approval of the Employer. The Contractor shall submit a written statement describing the proposed equipment and shall obtain from the Employer approval of the same before driving any piles.

The Contractor shall employ cushioning devices as are required to protect the pile from damage during driving.

Production piling shall be installed using the same equipment used to install the test piles including hammer size, drop, cushion block material and driving cap.

(4) Driving Criteria

As part of the preparation for pile driving, the Contractor shall mark each pile at 30 cm intervals along its entire length. In addition, the footage shall be marked and designated at 1.50 m intervals, starting from the pile tips.

When driving precast concrete piles through soft clay soil or in predrilled or jetted holes, the ram velocity and stroke for the given hammer size shall be reduced to avoid critical tensile stresses in the pile.

Shattered, crumpled or otherwise damaged pile heads shall be cut back to sound material before continuing the driving.

Driving of all piles shall be continuous without intermission until the pile has been driven to its final elevation. The tops of piles shall be cut off true and level at the elevations indicated on the drawings. All portions battered, split, warped damaged or imperfect in any way shall be removed or repaired to the satisfaction of the Employer.

Piles shall be driven to the required tip elevation shown on the drawings and as confirmed by load test. Piles shall be driven into the same soil stratum as the test pile.

Where piles are driven as bearing piles into the sand stratum found below a depth of 20 meters the driving resistance of the test pile shall be used to establish the final driving resistance of the piles. The final driving resistance (number of hammer blows required to drive the pile in the final 15 cm) shall not be less than the final driving resistance of the test pile.

(5) Tolerances and Criteria for Acceptance

Piles shall be cutoff at the required cutoff elevation. Piles previously driven shall be protected from damage during construction in the immediate area and any damage to piles that cannot be repaired to the satisfaction of the Employer shall be cause for rejection of the pile.

A pile shall be placed not more than 3 percent of its length out of plumb from vertical. The measurement shall be made on that portion of the pile projecting above the cutoff grade. At least three measurements shall be made to confirm the alignment.

After completion of excavation the plan location of each pile shall be determined at the design cutoff elevation.

A maximum lateral deviation from the correct location at cutoff elevation equal to 7.5 cm will be permitted for piles which have been driven without a follower or for piles which have been driven with a follower not exceeding 3 m in length. The lateral deviation will be increased in proportion to the length of the follower up to a maximum permissible lateral deviation of 15 cm for piles driven with a follower 5 cm in length.

Where piles as installed exceed the specified tolerances, the Employer shall then verify the total loads on individual piles, based on the calculations and survey information. If

the load on any pile exceeds the specified load capacity, corrections shall be made in accordance with an approved design provided by the Contractor to the Employer.

The installation of replacement piles and other corrective measures shall in all cases be in accordance with the approved designs provided by the Contractor and approved by the Employer.

(6) Piling Records

The record of all piles installed shall be kept by the Contractor and a copy of the record of work made each day shall be given to the Employer.

On completion of the piling of any particular section, the Contractor shall deliver to the Employer a drawing recording the final founding levels of all piles, together with any results of measurements carried out by the Contractor to prove the bearing capacity of any piles tested.

4007 MEASUREMENT AND PAYMENT

(1) Measurement, for payment, of steel sheet piling will be made of the piling remaining in place. Payment for supply and driving of steel sheet piles will be made at the unit price per metric ton, which unit price shall include the cost for supplying and driving the piles. The unit price shall also include the costs of welding of field connections, cutting of tops, and pulling and replacing unsatisfactory piling.

(2) Measurement, for payment, for supply and driving of R.C. piles, P.C. piles and S.P. piles will be made for the length of the piles actually installed in locations as shown on the approved drawings. No measurement shall be made for the piles cut off or pulled out. Payment for supply of piles will be made at the unit price per meter, which unit price shall include the cost of supplying, transporting and handling the piles and all other costs required for the complete installation of the piles. Payment for driving of piles will be made at the unit price per meter, which unit prise shall include the cost of driving the piles, welding for pile jointing, capping the pile to provide a tie between pile and concrete foundation, pulling and replacing unsatisfactory piling, and all other costs required for the complete installation of the piles.

SECTION 4100 SAND MAT AND SAND COMPACTION PILE

4101 GENERAL

The section covers the sand mat and sand compaction pile works including sand drain in the closure dam except the earth and stone works such as excavation, embankment, riprap, and sand and gravel bedding.

4102 PREPARATION WORKS BEFORE CONSTRUCTION

Following data shall be prepared and submitted by the Contractor to the Employer at least three weeks (21 days) prior to the time of construction starting for approval.

- Topographic map of closure dam site and river profiles
  a) Surveying area Sta. 0 + 870 to Sta. 1 + 250 with 100 meter widths in upper & downstream from station center.
  b) Size of drawing is A-1 size and 100 g/sq.m tracing paper.
  c) Temporary benchmarks and 50 cm contour line shall be shown on the map.
  d) Records of sounding by echo-sounder and distance meter.

- Construction method & material analyzing data
  a) Construction method and schedule, list of equipment to be used for the sand mat construction and installation of sand compaction piles.
  b) Data of grain size analysis of sand materials to be used.

4103 SAND MAT

(1) Material

Materials for sand mat shall consist of sand, silty sand, sandy gravel or gravel and containing not more than 2% of organic matter. The materials shall have particle size gradings within the following limits and shall be non-plastic.

Sieve Size	Percentage Passing (by weight)
10 mm	100
5 mm	60 - 90
2 mm	40 - 80
1 mm	20 - 60
0.3 mm	10 - 30
0.074 mm	20

(2) Placing

The materials for sand mat shall be placed in such a manner as will result in reasonably uniform layers of sand mat of the specified thickness.

(3) Measurement of Payment

Measurement, for payment, of sand mat will be made of the outline of the sand mat in place and on the basis of the nominal thickness shown on the drawings or prescribed by the Employer.

No allowance will be made in measurement for payment for settlement, shrinkage and consolidation of the foundation or of the material in the sand mat.

Payment for sand mat will be made at the unit price per cubic meter, which unit price shall include all the expenses for labor, equipment, machinery, right or royalty of materials acquisition in quarry or borrow area, extracting, hauling, loading and unloading of materials, transporting and placing of materials by barges or other approved machinery, and cleaning and treatment of quarry or borrow area after worked out and incidental works necessary for the completion of the work.

4104 SAND COMPACTION PILE

(1) Material

Material for sand compaction pile and sand drain shall have particle size grading within the following limits and shall be non plastic.

Sieve Size	Percentage Passing (by weight)
5 mm	70 - 100
2 mm	35 - 90
1 mm	20 - 70
0.5 mm	10 - 50
0.3 mm	5 - 30
0.074 mm	10

(2) Installation of Sand Compaction Pile and Sand Drain

Unless otherwise approved by the Employer, the installation process of sand compaction pile and sand drain shall be as follows.

INSTALLATION PROCESS OF SAND COMPACTION PILE AND SAND DRAIN

(Penetration of Casing Pipe)

a) Install the casing pipe of 400 mm dia. at the specified site on the working ground of pile-driving equipment.

b) Excite the vibrator and penetrate the casing pipe to the specified lower limit elevation (EL. B in the following figure) of the sand compaction pile as shown on the drawings or prescribed by the Employer.

When there is a hard layer which makes it difficult to penetrate the casing pipe, water jet or air jet is co-used to force penetration.

(Installation of Sand Compaction Pile)

c) A certain quantity of sand is thrown into the casing pipe from upper hopper and while drawing up the casing pipe up to the height specified (about 3 m) by the Employer, sand in the casing pipe is forced out into the bored hole by compressed air.

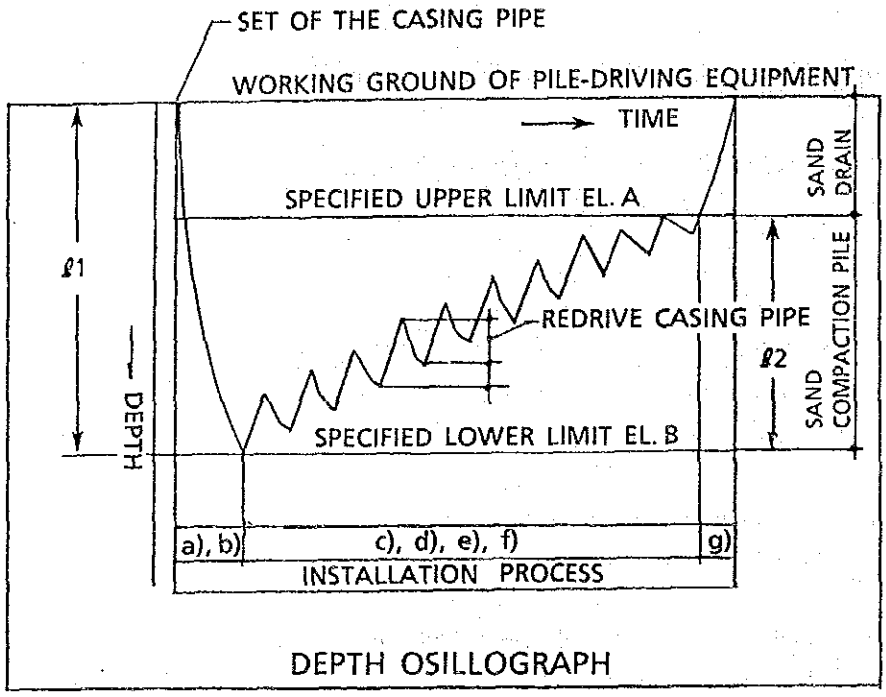
d) The casing pipe is redriven into the hole to the depth specified (about 2 m) by the Employer and sand is compacted by vibration. Sand is compressed into the surrounding subsoil layer.

e) Again feed sand into the casing pipe and draw up the casing pipe to the height specified by the Employer.

f) By repeating the above steps (c), d) and e)), complete the sand compaction pile up to the specified upper limit elevation (EL. A in the following figure) of the sand compaction pile.

(Installation of Sand Drain)

g) Feed sand into the casing pipe and drawing up the casing pipe to the working ground of pile-driving equipment whiie forcing out the sand into the bored hole by compressed air.



(3) Record

The Contractor shall submit the following data to the Employer.

a) Piling depth of each pile ..... GL meter
b) Quantity of sand fed into each pile ..... SL meter (Sand level meter)
c) Other date requested by the Employer

Oscilographs of GL meter and SL meter shall be attached in the above data.

(4) Allowable Accuracy in Piling

a) The bottom of sand compaction pile installed shall be lower than the specified lower limit elevation of the pile.

b) The top of sand compaction pile installed shall be higher than the specified upper limit elevation of the pile.

c) The location of sand compaction pile installed shall be within 20 cm of the specified location of the pile.

4105 MEASUREMENT AND PAYMENT

The cost required to complete the steps a), b) and g) in the installation process of sand compaction pile and sand drain indicated in section 4104 (2), but not including the cost of sand material, shall be included in the unit price per meter for the pay item No. 3207 in the Bill of Quantities (Part-1 Main Works), and the cost required to complete the remaining steps c), d), e) and f) shall be included in the unit price per meter for the pay item No. 3208.

The cost of sand material shall be included in the unit price per cubic meter for the pay item No. 3209.

All other costs necessary to complete the sand compaction pile and sand drain shall be included in the unit prices for the pay item Nos. 3207 and 3208. Embankment on the closure dam will be necessary to prepare the working ground of pile-driving equipment. The cost of construction and removal of the embankment and other required facilities shall be included in the price for the pay item No. 3101 "Temporary works".

Measurement, for payment, of the work included in the pay item No. 3207 done by the Contractor will be made on the actual depth, up to the specified lower limit elevation, of casing pipe penetrated into the foundation, that shall be "$\ell 1$" shown on the figure in section 4104 (2).

Measurement, for payment, of the work included in the pay item No. 3208 done by the Contractor will be made on the actual length of sand compaction pile installed between the specified upper limit elevation and the specified lower limit elevation of the sand compaction pile, that shall be "$\ell 2$" shown on the figure in section 4104 (2).

Measurement, for payment, of sand material will be made of the number of cubic meter of sand compaction pile and sand drain computed based on the records of GL meter and SL meter.

DIVISION - 5 MISCELLANEOUS WORKS

SECTION 5000 PRESTRESSED CONCRETE GIRDER FOR BRIDGE

5001 GENERAL

Pre-stressed concrete girder for bridge shall be installed in the O/M Bridge and Road Bridge. The girders shall be designed, fabricated and installed as prestressed concrete girder of the post-tensioning method and shall conform to the provision of this section in addition to all application provisions of other sections in the Specifications.

5002 DESIGN

The Contractor shall, prior to the fabrication of girders, submit detailed structural calculations, shop drawings and explanations of the method of prestressing in accordance with the conditions indicated below for approval of the Employer. The design load shall be TL-20 designated in the Japanese Design Standard for Road Bridge or approved equivalent. The girders shall be designed to be safe against loads which may occur during transportation and installation. Depth of girder and number and location of girders shall be as shown on the drawings.

5003 SHOP DRAWINGS

It should be noted that the Specifications and the drawings show only the general type of the superstructure members and the governing dimensions and are not intended to define the exact details of the superstructure members to be furnished. Before commencement of manufacturing the superstructure members, the Contractor shall prepare and submit the design criteria, calculations, detailed dimensional shop drawings for the superstructure members including arrangements of camber, asphalt concrete surfacing, bearing shoes, expansion joints, hardrails and embedded steel works at the edges of top surfaces of the abutments. The Contractor shall be responsible for the adequacy of location of all embedded components where installed by him.

All shop drawings shall be checked by the Contractor before being submitted for approval of the Employer. The Contractor shall be responsible for the correctness and

completeness of the shop drawings and for shop assembly and field connections, although the shop drawings have been approved by the Employer.

5004 MATERIALS

(1) Concrete

The quality of concrete as tested in accordance with ASTM C 172 and C 31 shall indicate compressive strengths at 28 days of not less than 400 kg/cm^2. The minimum quantity of cement shall be 400 kg/m^3 of concrete, slump shall be 5.0 cm and water-cement ratio 0.35 to 0.50 by weight.

(2) Prestressing Tendon

The steel wires used for the prestressing tendons shall conform to the requirements designated in the Thailand Industrial Standard or the equivalent.

Prestressing tendons shall be of the quality indicated below and shall be free of objectionable defects and bends.

Tensile strength	not less than 17,500 kg/cm^2
Yield strength (strength at residual strain of 0.2%)	not less than 15,000 kg/cm^2
Elongation (measurement length 100 mm)	not less than 3.5%

(3) Anchor Bolt and Base Plate

Anchor bolts and base plates shall be galvanized. Parts to be embedded in concrete, however, shall not be galvanized.

(4) Elastomeric Bearing Pad

The Contractor shall furnish and install the elastomeric bearing pads in bridges as shown on the drawings or as directed by the Employer.

After accelerated aging in accordance with ASTM Designation: D 573 for 70 hours at 212°F the elastomers shall not show deterioration changes in excess of the following amounts:

Tensile strength, percent	± 15
Elongation at Break, percent	- 40 (but not less than 300% total elongation of the material)
Hardness, points	+ 10

The Contractor shall furnish to the Employer a certification by the manufacturer that the elastomer, in the elastomeric bearing pads to be furnished, conforms to all of the above requirements. The certification shall be supported by a certified copy of the results of tests, performed by the manufacturer upon samples of elastomer to be used in the pads, covering all of the above mentioned requirements.

O/M Bridge

Amount of movement	25.81 mm
Maximum reaction forth at bearing shoe	60 tf
Minimum reaction forth at bearing shoe	48 tf

Road Bridge

Amount of movement	20.5 mm
Maximum reaction forth at bearing shoe	46 tf
Minimum reaction forth at bearing	36tf

(5) Expansion Joint

The elastometric expansion joint shall be constructed in the specified position after assembling the superstructure members of the bridges as shown on the drawings.

(6) Sheaths and Extractable Cores

All sheaths and cores shall be maintained in their correct positions during the placing of the concrete. Where members are made up of units stressed together, the ducts in the joints between the units shall be in alignment. Where sheaths are used, the number of joints shall be kept to a practicable minimum and each joint adequately sealed against the ingress of any material. Joints in adjacent sheaths shall be staggered by at least 300 mm. Sheaths shall be kept free of any matter detrimental to the bond between the sheath and the grout and, except for material sealing a sheath joint, between the sheath and the concrete.

Extractable cores shall be coated with a release agent only with the approval of the Employer. Cores shall not be extracted until the concrete has hardened sufficiently to prevent it being damaged. The ends of all ducts and tendons shall be respectively sealed and protected until the tendon is threaded through and the stressing operations are commenced.

5005 FABRICATION

(1) Fabrication Plant

Shop drawings shall be submitted for approval of the Employer prior to fabrication of member fabricating beds, forms and supports. The fabricating bed shall be sufficiently firm to prevent misalignment due to concrete placement and vibration.

(2) Prestressing Tendon

Prestressing tendons shall be processed as necessary for sure anchorage and saws shall be used for cutting excess and portions. Transportation and storage shall be in such manner as to prevent bending, thermal changes, loose rusting and damage occurring to the steel.

(3) Placement of Steel

Steel shall be positioned securely at its designated locations by reinforcement, stirrups, spacers and hangers in order to prevent movement during placing of concrete.

(4) Tensioning of Prestressing Tendon

Tensioning calculations and tensioning schedule shall be submitted to the Employer prior to prestressing. Compressive strength of concrete shall not be less than 340 kg/cm^2 at tensioning of prestressing tendon. The tensile forces on tensioned steel shall be measured by both readings on the pressure gauge of tensioning jack and elongation of the tensioned steel. Tensioning shall be performed as a rule by jacking from both ends. The sequence of tensioning shall be according to the tensioning calculations and tensioning schedule approved by the Employer. Care shall be exercised to prevent uneven tension in tendons within a single sheath.

In carrying out the work, the following shall be recorded and submitted to the Employer.

a) Compressive strength of concrete
b) Reading of pressure gauge of tensioning jack and elongation of prestressing tendon
c) Slip of tendon when anchored
d) Camber and other deformation of beam

(5) Allowable Tolerance

Beam length	± 10 cm
Depth, flange width	-5 to + 10 mm
Flange and web thicknesses	-5 to + 10 mm
Cross-sectional position of sheath (in every direction)	±5 mm

5006 GENERAL FOR POST TENSIONING

Post-tensioning operations shall be carried out only under the direction of an experienced and competent supervisor and all personnel operating the stressing equipment shall have been properly trained in its use. In addition to the normal precautions against accident which should be taken at all times for the whole of the Works, special precautions shall be taken when working with or near tendons which have been tensioned or are in the process of being tensioned.

5007 JACKS FOR PRESTRESSING

All jacks used for prestressing shall be of the type applicable to the system adopted. The accuracy of all load measuring equipment shall be checked to the satisfaction of the Employer at the start of work each day it is to be used and whenever the equipment is moved to a different jack.

5008 POST-TENSIONING PROCEDURE

Tensioning shall be carried out only in the presence of the Employer or his Representative unless permission has been obtained to the contrary.

Immediately before tensioning, the Contractor shall prove that all tendons are free to move between jacking points and that members are free to accommodate the horizontal and vertical movements due to the application of prestress.

Unless otherwise described in the Contract, concrete shall not be stressed until it has reached at least the age at which two test cubes taken from it attain the specified transfer strength. The test cubes shall be made and tested in accordance with prescribed specifications but shall be cured in similar conditions to the concrete to which they relate. The Contractor shall cast sufficient cubes to demonstrate that the required strength of the concrete at transfer has been reached.

Where members consist of jointed elements, the strength at transfer of the jointing material shall be at least equivalent to the specified transfer strength of the member.

The Contractor shall establish the datum point for measuring extension and jack pressure to the satisfaction of the Employer. The Contractor shall add to the forces described in the Contract an allowance for anchorage friction, wedge pull-in, jack losses and friction due to duct alignment and curvature. The total forces and calculated extensions shall be agreed with the Engineer before stressing is commenced.

Immediately after anchoring, the stresses in the pre-stressing tendons shall not exceed 70 percent of their ultimate tensile strength. During stressing the value shall not exceed 90 percent.

The tendons shall be stressed at a gradual and steady rate. The force in the tendons shall be obtained from readings on two load cells or pressure gauges incorporated in the equipment. The extension of the tendons under agreed total forces shall be within 5 percent of the agreed calculated extension.

Stressing shall be from both ends unless otherwise required in the Contract or agreed by the Employer. When stressing from one end only, the pull-in at the end remote from the jack shall be accurately measured and the appropriate allowance made in the measured extension at the jacking end.

When the prestressing has been applied to the satisfaction of the Employer, the tendons shall be anchored. The jack pressure shall then be released in such a way as to avoid shock to the anchorage or tendons.

If the pull-in of the tendons at completion of anchoring is greater than that agreed by the Employer, the load shall be released at a gradual and steady rate and tensioning carried out afresh.

If it is necessary to cut the tendons to enable the ducts to be grouted, this shall be delayed as long as practicable up to the time of grouting. In all other cases, unless agreed otherwise by the Employer, the tendons shall not be cropped less than 3 days after grouting. The Contractor shall keep full records of all tensioning operations including the measured extensions, pressure gauge or load cell readings and the amount of pull-in at each anchorage. Copies of these records shall be supplied to the Employer within 24 hours of each tensioning operation.

5009 GROUTING OF DUCTS

Grouting trials shall be undertaken when required by the Employer. All ducts shall be thoroughly cleaned by means of compressed air. Ducts formed without sheathing shall be filled with water at least one hour before grouting. Sheathed ducts shall not be filled with water unless required by the Employer. Where ducts have been filled with water it shall be blown out by compressed air. All anchorages shall be sealed before grouting.

Ducts shall be grouted as soon as practicable after the tendons in them have been stressed and the Employer's permission to commence has been obtained. Grout shall be injected in one continuous operation and allowed to flow from the vents until the consistency is equivalent to that being injected. The ducts shall be completely filled with grout.

Vents shall be sealed consecutively in the direction of flow and the injection tube sealed under pressure until the grout has set. The filled ducts shall be protected to the satisfaction of the Employer to ensure that they are not subjected to shock or vibration for 1 day. 2 days after grouting, the level of grout in the injection and vent tubes shall be inspected and made good if necessary.

The Contractor shall keep full records of grouting including the date each duct was grouted, the proportions of the grout and any admixtures used, the pressure, details of any interruptions and topping up required. Copies of these records shall be supplied to the Engineer within 3 days of grouting. Where required by the Employer, the Contractor shall provide facilities and attendance for the radiographic testing of ducts.

5010 PLANT FOR GROUTING OF DUCTS

The grout mixer shall produce a grout of colloidal consistency. The grout injector shall be capable of continuous operation with a sensibly constant pressure up to 6.9 kgf/cm^2 and shall include a system of circulating or agitating the grout whilst actual grouting is not in progress. All baffles to the pump shall be fitted with sieve strainers of 1.0 mm nominal aperture size.

The equipment shall be capable of maintaining pressure on completely grouted ducts and shall be fitted with a nozzle which can be locked off without loss of pressure in the duct. The pressure gauges shall be calibrated before they are first used in the Works and thereafter as required by the Employer. All equipment shall be thoroughly washed with clean water at least once every 3 hours during the grouting operations and at the end of use for each day.

5011 GROUT FOR DUCTS

Unless otherwise directed or agreed as a result of grouting trials, the grout shall:

(i) consist only of ordinary Portland cement and water.

(ii) have a water: cement ratio as low as possible consistent with the necessary workability, and under no circumstances shall the water: cement ratio exceed 0.45.

(iii) not be subject to bleeding in excess of 2 percent after 3 hours or 4 percent maximum when measured at 18°C in a covered glass cylinder approximately 100 mm diameter with a height of grout of approximately 100 mm, and the water shall be re-absorbed after 24 hours.

Admixtures containing chlorides or nitrates shall not be used; other admixtures may be used only with the written permission of the Employer and shall be applied strictly in accordance with the manufacturr's instructions. The grout shall be mixed for a minimum of 2 minutes and until a uniform consistency is obtained.

5012 STORAGE POST-TENSIONED MEMBERS

When members are stored, they shall be firmly supported at such bearing positions as will ensure that the stresses induced in them are always less than the permissible design stresses.

5013 TRANSPORTATION AND INSTALLATION OF GIRDER

In transporting the girder, care shall be exercised as to the method of support to prevent inclination and twisting. The girders shall be transported in such a manner as to prevent vibration and development of cracks.

Prior to installation of girders, installation schedule giving details of erection, sequence of installation and method, together with name, capacity and structural diagram of installation equipment shall be submitted to the Employer for approval.

Bearing points or lifting points during fabrication, transportation, stockpiling and installation shall, as a rule, be at both ends. In the event intermediate supporting points are required, structural calculations shall be made, and shall be approved by the Employer.

5014 MEASUREMENT AND PAYMENT

The bridge work shall consist of designing, manufacturing, supplying, finishing, painting, packing for transport, delivery to the site, storing and handling at the site, erection of superstructure members of the bridge including expansion joint, bearing shoes, handrails and steel conduits or cable pits and covers made of checkered plate for electrical wiring, asphalt concrete surfacing, side walks and rail bases construction, and installation and removal of temporary facilities. All works shall be done in strict accordance with the drawings, applicable provisions stipulated in this section hereof and as directed by the Employer.

Construction of the substructure such as abutments and piers shall be made in accordance with the other applicable provisions stipulated in the Specifications.

Payment for the bridge work will be made after completion of the superstructure in the location shown on the drawings or directed by the Employer. The application of pay item to the bridge work shall be as follows.

Pay Item Application to Bridge Work

Construction Work	Pay Item No.
O/M Bridge (W = 6.6 m, L = 170 m)	2232
Road Bridge (W = 13 m, L = 227 m)	4228

The prices for the pay item Nos. 2232 and 4228 shall constitute full compensation for the cost of all labor, tools, equipment and materials required for designing, furnishing, manufacturing, transporting, installing, painting and maintaining the superstructures and all other costs necessary to complete the bridge work.

SECTION 5100 PAVING WORK

5101 GENERAL

The Contractor shall carry out, as shown on the drawings or as directed by the Employer, the construction of permanent roads.

Items of work pertaining to road construction such as sub-base, base and surface courses, guard railing, etc., shall be in accordance with the provisions stipulated in this section as well as the other applicable sections of the Specifications. Gravel pavement shall be constructed in accordance with section 5103 "Base Course" of the Specifications.

The Contractor shall stake out the work and secure the Employer's approval of the stake-out before proceeding with construction. If, in the opinion of the Employer, any modification of the line or grade is advisable, either before or after stake-out, the Employer will issue detailed instructions to the Contractor for such modification and the Contractor shall revise the stake-out for further approval. These requirements shall be met without additional payment.

Sufficient templates and straightedges shall be furnished by the Contractor for use in checking the finished surface of the pavement structure. These templates and straightedges shall be submitted to the Employer for his approval and shall be maintained by the Contractor at all times in a condition to produce the correct cross-sectional profile. They shall be checked at intervals and, if necessary, repaired or adjusted as directed by the Employer. The furnishing and maintenance of the templates and straightedges will not be paid for directly, but all costs therefor shall be included in the applicable unit prices and prices entered in Division 4 of the Bill of Quantities (Part-1 Main Works).

The gradation, moisture control, density, placing, compaction and asphalt application requirements for the construction of sub-base course, base course and surface course shall be as stipulated herein; however, the Employer reserves the right to adjust these requirements as he deems best, and in such case no change will be allowed in the unit prices for such work as entered in the Bill of Quantities.

5102 SUB-BASE

After completion of the subgrade, the Contractor shall place the laterite sub-base over the full width of roadway.

(1) Material

Material for subbase shall consist of selected laterite with one of the following properties:

Sieve Size		Percentage Passing (by weight)			
		Type C	Type D	Type E	Type F
2"	(50 mm)	100	100	-	-
1"	(25 mm)	95 - 100	95 - 100	100	100
3/8"	(10 mm)	50 - 85	60 - 100	-	-
No. 4	(4.76 mm)	35 - 65	50 - 85	55 - 100	70 - 100
No. 10	(2.00 mm)	25 - 50	40 - 70	40 - 100	55 - 100
No. 40	(0.420 mm)	15 - 30	25 - 45	20 - 50	30 - 70
No. 200	(0.074 mm)	5 - 20	8 - 25	6 - 20	8 - 25

a) The fraction passing No. 40 screen shall have a liquid Limit (L.L.) not exceeding 35%.

b) Plasticity index (P.I) shall be between 3% and 10%.

c) The fraction passing through screen No.200 shall not exceed 2/3 of the fraction passing through screen No. 40.

d) Regarding the particle hardness - the loss must not exceed 50 percent when tested by the Los Angeles Abrasion Test (ASTM C131).

e) The material shall be free from impurities such as roots, grass, organic matter or clay lumps.

(2) Placing and Compaction

a) Placing of Sub-base

The Contractor shall carry out the work so as to obtain the true grades, minimize degradation, control the moisture content, and ensure a satisfactory sub-base course. The material, from approved sources, shall be spread in uniform layers of such loose thicknesses that the finished layer will conform to the specified grading and designate thickness. The materials shall be spread uniformly from spreader boxes, dump boards, moving vehicle, or by

other approved methods. The material shall be mixed with blade graders, or other approved equipment in such manner as not to disturb or mix material from the lower subgrade. The sub-base material shall then be leveled to the required contour and graded with blade graders. Unsuitable material shall be removed and replaced as directed by the Employer.

b) Layer Thickness

The compacted thickness of the sub-base course shall be as indicated on the drawings. When a compacted layer of 30 cm or less is prescribed the material may be placed in a single layer; when a compacted thickness of more than 30 cm is required, no layer shall exceed 15 cm but shall exceed 10 cm when compacted.

c) Compaction

Each layer of the sub-base course shall be compacted by an approved roller. Water content shall be maintained during the compacting procedure at optimum value or at the percentage specified by the Employer. In all places not accessible to rollers, the mixture shall be compacted with mechanical tampers. Compaction shall continue until each layer is compacted through the full depth to at least 95% of the maximum dry density determined by JIS A 1210 (Standard). Compaction shall be carried out from the edges towards the center of the layer being compacted.

The Contractor shall make such adjustments in rolling or finishing procedures as may be directed by the Employer to obtain true grade to minimize segregation and degradation, to reduce or accelerate loss or gain of water, and to insure a satisfactory sub-base course. Any materials found to be unsatisfactory shall be removed and replaced with satisfactory material or reworked to produce a satisfactory material.

(3) Measurement and Payment

Measurement, for payment, of the sub-base course will be made on the basis of actual compacted volume in cubic meter to the design lines, grades and thicknesses as shown on the drawings or as directed by the Employer.

Payment for the sub-base course will be made at the unit price per cubic meter, which unit price shall include the cost of all labor, equipment and materials required for obtaining the materials, hauling to the site, placing, spreading, wetting or drying as required, compacting, shaping, finishing and testing, and all other costs necessary to complete the works.

5103 BASE COURSE

After completion of sub-base, the Contractor shall place the base course over the full width of roadway.

(1) Material

Material for base course shall consist of a natural or artificial mixture of hard, durable gravel or crushed stone and binder, free from soft particles and excess clay and shall have the following grade:

Sieve Size (ASTM-E11		Percentage Passing (by weight)
1"	(25 mm)	100
3/8"	(10 mm)	50 - 85
No. 10	(2.00 mm)	25 - 50
No. 40	(0.42 mm)	15 - 30
No. 200	(0.074 mm)	5 - 15

a) Lab. C.B.R. value shall not be less than specified in the drawing.

b) Minimum dry density shall be 95% of the maximum dry density.

c) Liquid limit shall not be greater than 25 (or otherwise specified in the drawing).

d) Plasticity index shall not be greater than 6 (or otherwise specified in the drawing).

e) Percentage abrasion of coarse size aggregate shall not be greater than 40.

(2) Placing

a) Preparation of the Laterite Sub-base

Prior to constructing the base course, the previously constructed sub-base of all foreign substances shall be cleaned. The surface of the sub-base will be inspected by the Employer for adequate compaction and accuracy. Ruts or soft, yielding spots that may appear in sub-base areas having inadequate compaction, and deviations of the surface from the requirements set forth therein shall be corrected to line and grade and to all specification requirements.

b) Placement of Base Course

The coarse aggregates and binder materials shall be spread in layers of uniform thickness from spreader boxes or moving vehicles. Aggregates shall be placed in a layer of uniform thickness on the sub-base course without segregation of sizes, followed by placing therein uniform layers of the other material to such loose thickness and proportions that, when mixed together and compacted, the finished layer will conform to the specified gradation, liquid limit, plasticity index, and designated thickness. Alternate placement of aggregates and binder materials in windows shall also be permitted. The material shall then be spread in a layer of uniform thickness. The material shall be mixed with mechanical mixers, blade graders, harrows, disks, or other approved equipment, in such manner as not to disturb or mix material from the underlying sub-base course into the overlying layer. Initial mixing shall continue until the mixture is uniform throughout, adding water to the extent necessary to prevent segregation during mixing by the sprinkling equipment specified above. Mixing shall continue until the water is uniformly distributed throughout, as determined by the Employer. Following this mixing procedure the approved mixture shall be leveled to the required contour and grades with blade graders. Unsatisfactory areas shall be removed and replaced with satisfactory material, or the material shall be remixed in the area, as directed.

d) Compaction

Each layer of the base course shall be compacted as specified in the section 5102, (2), c).

(3) Measurement and Payment

Measurement, for payment, of the base course and gravel pavement will be made on the basis of actual placed volume in cubic meters to the design lines, grades and thickness shown on the drawings or as directed by the Employer.

Payment for the base course and gravel pavement will be made at the unit price per cubic meter, which unit price shall include the cost of all labor, equipment and material required for procuring the processed material from commercial quarries or other approved areas, hauling to the site, placing, spreading, wetting or drying as required, compacting, finishing and testing,and all other costs necessary to complete the works.

5104 ASPHALT SURFACE COURSE FOR PAVEMENT (HOT MIXTURE METHOD)

(1) General

This work shall consist of constructing asphaltic concrete of one or multiple layers on a previously prime-coated base course as well as providing a bituminous leveling course where necessary as directed by the Employer.

Prime coat shall be applied at a time when the surface of base course to be treated is dry at the ambient temperature. Asphaltic material for the prime coat shall be applied by means of a distributor at the rate or rates directed by the Employer, at a temperature within the range shown in the Table below.

Spraying Temperature for Asphaltic Prime Coat

Type and Grade of Asphalt	Distributor Spraying Temperature, Degrees C
MC-30	30 - 90
MC-70	50 - 110
CSS-1	20 - 70
CSS-1 h	20 - 70

(2) General Composition of the Mixture

The design of asphalt concrete mixtures shall be undertaken by the Contractor in accordance with paragraph 4.1.1.3 of the Standard Specifications of ROYAL IRRIGATION DEPARTMENT for Highway Construction. The design of mixtures shall be carried out in a materials testing laboratory approved by and under the supervision of the Employer.

The mixture shall consist of mineral aggregate, filler (1-2% of lime or 2-4% of cement if necessary according to the Employer) and the asphaltic cement. The total mineral aggregate shall have a job mix grading within the limits shown in Table 4.6-1 of the Standard Specification for Highway Construction. Gradations outside the limit specified shall have the approval of the Employer. The ratio of total material passing the No.200 sieve to asphalt by weight shall not exceed 1.5 : 1 nor be less than 1 : 1.

In addition to meeting the job mix formula in section 4.1 of the Standard Specifications for Highway Construction, laboratory samples shall be prepared according to the Marshall method (AASHTO T245-78) using 75 blows to compact the sample. The samples shall be of approved material to the gradation and asphalt content stated and shall have the following characteristics. The Strength Index shall be determined according to the Ontario Vacuum Immersion Marshall Test or the U.S. Army Corps of Engineers-Asphalt Institute Immersion Marshall Test.

i) Marshall Stability (lbs) not less than 1,500 lb. (680 kg)
ii) Marshall Flow (0.01 ins) not less than 8 nor greater than 18. (2 mm - 4.5 mm)
iii) Ratio Marshall Stability (lbs) to Marshall Flow (0.01 ins) shall not be less than 125.
iv) Air voids in Mix: Wearing 3 - 5%; Binder 4 - 7%
v) Voids in mineral aggregate: 14 to 20 percent
vi) Voids filled with asphalt: Wearing 70 - 80%; Binder 65 - 80%
vii) Strength Index: minimum 75%

The selected job mix shall conform to the guidelines outlined in Table 4.6-1 of the Standard Specifications for Highway Construction. Asphaltic concrete for leveling course shall follow the same mix requirements of the lowest layer of asphaltic concrete pavement or overlay (usually binder course) as shown on the drawings or directed by the Employer.

(4) Asphaltic Material

Bituminous materials for asphaltic concrete shall be asphalt cement with penetration grades of 60 - 70% or 80 - 100%, unless otherwise directed by the Employer.

(5) Construction Method

(a) The temperature of the aggregates shall be so controlled that the temperature of the mixture on being discharged from the mixing plant is between 135° and 175°C. The Contractor shall select the minimum temperature which will ensure the aggregates are properly dried, and which enables him to deliver the mixture to the paver at or slightly above the required temperature.

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

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

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

(e) The average thickness of the compacted pavement laid in any one day shall not be less than the thickness shown on the drawings. The minimum thickness at any one point shall be no more than 5 mm below the specified thickness.

(f) The surface of the finished pavement shall be tested for evenness by using a 3.5 meter straightedge. The surface will be considered acceptable providing the deviation from the straightedge, placed either longitudinally or transversely, does not exceed 3 millimeters between two contact points. Pavement surfaces not conforming to this tolerance may be rejected by the Employer. Rejected areas shall be removed and repaved at the Contractor's own expense.

(6) Measurement and Payment

Asphaltic concrete to be used as a surface course, of thicknesses specified in the drawings, shall be measured on a square meter basis, the dimensions of which shall comprise the thickness and width specified on the typical cross section and the length of completed and accepted construction. Side road intersections, curve widenings, fillets and other smaller areas required to be paved shall also be measured on a square meter basis. Pavement thickness shall be within the limit specified in paragraph (5) (e). Additional payment will not be considered for thicknesses greater than those specified.

Payment for asphaltic concrete surface shall be made at the unit price per square meter, which unit price shall include the cost of all material, labor, equipment and tools required for constructing and maintaining the asphalt concrete surface. The unit price shall also include the cost of prime coat and all other materials and operation necessary to complete the work.

5105 GUARD RAILING

The Contractor shall furnish and install guard railing, including concrete foundations for the steel post as shown on the drawings or as directed by the Employer.

Material to be used for the steel guard railing shall conform to the requirements of JIS G 3101 (Structural Rolled Steel for General Use) or approved equivalent. Steel pipe used for the posts shall conform to the requirements of JIS G 3452 (Steel Gas Pipes), or approved equivalent. Materials for concrete shall conform to the requirements of Division 3 "Concrete Works" of the Specifications.

The guard railing shall be constructed to the lines and grades, and at the locations as shown on the drawings or as directed by the Employer. Posts shall be set plumb in the concrete footings. Rail elements shall be erected in a manner resulting in a smooth, and continuous installation. All bolts, except adjustment bolts, shall be drawn tight. Bolts shall be of sufficient length to extend beyond the post at least 0.6 cm but not more than 1.2 cm. Painting of all components of the guard railing which has been erected shall be made in accordance with the applicable provisions stipulated in Division 6 of the Specifications.

Measurement, for payment, of furnishing and installing the guard railing and posts will be made for the length along the centerline of the railing.

Payment for furnishing and installing the guard railing and posts will be made at the unit price per linear meter, which unit price shall include the cost of all labor, equipment and material required for installing the guard railing and posts including earth work for the posts, concrete footings, painting and all other necessary work.

5106 CONCRETE CURB

(1) Description

Concrete curb shown on the drawings shall be constructed as detailed on the drawings or directed by the Employer. Concrete type shall be class C and shall be either precast or cast-in-place with the prior approval of the Employer.

This work shall also include curb marking of white and yellow paint where shown on the drawings or designated by the Employer.

(2) Materials

Bedding material, shall consist of sand, gravel, crushed stone or other approved pervious materials of 1 cm maximum size.

Base concrete shall be class E and shall conform to the requirements of Division 3.

(3) Measurement and Payment

The quantity measured for payment shall be the number of linear meters of concrete curbs of the several types, completed in place and accepted. No deduction shall be made for flattening of curbs for entrances.

Payment for concrete curb will be made at the respective unit prices per linear meter, which unit prices shall include the costs of furnishing and installing the concrete curbs. The unit prices shall also include all the costs of excavation, backfilling, tamping, bedding materials, base concrete, formwork, equipment, tools, labor, curb marking and all incidentals necessary to proper completion of the work.

5107 ROAD MARKINGS

(1) Description

The marking shall be white or yellow continuous or intermittent lines, letters, figures, arrows or symbols.

(2) Materials

(i) Hot Applied Thermoplastic Materials (Super Imposed Type)

The laid material shall be one of the three types (a), (b) or (c) detailed below as directed by the Employer.

a) Non-reflectorized Thermoplastic

The thermoplastic material shall be factory mixed, from an approved manufacturer and shall be suitable for the type and location of application. The material shall possess

adequate thermoplastic properties over the range of climatic conditions of the location viz. resistance to spreading under traffic at the highest road temperatures and retention of plasticity at the lowest road temperatures and shall give a marking which is effective for at least eighteen months under normal traffic conditions. The composition of the material with minimum and maximum proportions and grading of the constituents, the acid value of the binder, the temperature range of mixing and application, the setting time, the softening point (°C) and the open flash point (°C) shall all be stated.

The material shall be supplied in containers which do not contaminate the contents and which protect the contents from contamination and shall be stored in accordance with the manufacturer's instructions.

b) Reflectorized Thermoplastic

The material shall be in accordance with (a) above except that ballotini (glass beads) shall be incorporated in the mixture during the manufacture of the thermoplastic material. The quantity of ballotini included shall be between 13 % and 22 % by weight of the total mix and shall be counted as part of the aggregate. The whole of the ballotini shall pass a No. 12 U.S. sieve and not more than 10 % shall pass a No. 40 U. S. sieve. The ballotini shall be free of sharp angular particles and not less than 80 % shall be of transparent glass, reasonably spherical and free from flaws.

c) Reflectorized Thermoplastic with Ballotini Surface

The material shall be in accordance with (b) above except that a layer of ballotini shall be superimposed in the surface of the hot thermoplastic immediately after laying to give immediate reflectivity. The superimposed ballotini shall be of the same quality as that incorporated in the reflectorized thermoplastic but may be smaller in size ; not more than 20 % shall pass a No. 70 U. S. Sieve. Ballotini shall be applied at a rate of 250-450 grams per square meter (0.8-1.5 ounces per square foot) such that the combined total of ballotini incorporated in and superimposed on the thermoplastic shall be between 20 % and 26 % by weight of the material.

(ii) Road Marking Paint (Hot-applied and Cold-applied)

The paint shall be either hot or cold-applied, and shall be one of the three types (a), (b), or (c) detailed below as directed by the Employer. Cold applied paints shall be suitable for

applying by brush or mechanical means. The following particulars of the paint shall be supplied :

(i) Composition (analysis by weight),

(ii) Application (hot-applied or cold-applied)

(iii) Type and maximum amount of reducer (thinner)

(iv) Drying time (to touch)

(v) Setting time (to recoat)

(vi) Recommended coverage (liters or gallons per lineal kilometer of 10 centimeters stripe)

(vii) Heat resistance i. e. maximum road temperature

(viii) Details of any primer, undercoat or tack coat require. For hot-applied paints the following additional information shall be supplied :

(ix) The temperature rage of heating and application

(x) The open flash point

The paint shall be supplied fresh and ready for use in sealed containers which shall be stored in accordance with the manufacturer's instructions.

a) Non-Reflectorized Road Paint

The paint shall be a brand approved by the Employer, specifically made for road marking, suitable for the type and location of application, factory mixed, and shall be suitable for applying to cement concrete or asphalt pavement to give a chemically stable, non-bleeding film of uniform thickness with a flat (non-glossy) finish.

b) Reflectorized Road Paint

The paint shall be in accordance with (a) above except that ballotini shall be incorporated in the paint during manufacture. The quantity of ballotini included shall be 330 to 500 grams per liter (4 to 6 pounds per U. S. gallon of paint), the whole of the ballotini shall pass a No. 20 U. S. sieve and not more than 5 % shall pass the No. 100 U. S. sieve. The ballotini shall be free of sharp angular fragments and not less than 75 % shall be of transparent glass, reasonably spherical and free from flaws.

c) Reflectorized Road Paint with Ballotini Surface

The paint shall be in accordance with (b) above except that 50% to 70% of the ballotini shall be incorporated in the paint and 30% to 50% of the ballotini shall be superimposed on the surface of the freshly applied paint to give immediate reflectivity.

(3) Construction Methods

(i) Thermoplastic Materials

a) Preparation of Road Surface

The material shall be applied only on a surface which is clean and dry. It shall not be laid over loose detritus, mud or similar extraneous matter, or over an old paint marking, or over an old thermoplastic marking which is faulty. In the case of smooth polished surfaces e. g. smooth concrete, old asphalt surfacings with smooth polished surface stones, and/or where the method of application requires or the Employer directs, a tack coat shall be applied to the surface prior to the application of the material. The tack coat and the rate of application shall be as the manufacturer of thermoplastic material shall recommend, with the approval of the Employer.

b) Preparation of Thermoplastic Material

The material shall be melted in accordance with the manufacturer's instructions in a heater fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic such that local overheating shall be avoided. The temperature of the mass shall be within the range specified by the manufacturer and shall on no account be allowed to exceed the maximum temperature stated by the manufacturer. The molten material shall be used as expeditiously as possible and for thermoplastics which have natural rosin binders or are otherwise sensitive to prolonged heating the material shall not be maintained in a molten condition for more than 4 hours.

c) Laying

Center lines, lane lines and edge lines shall be applied by approved mechanical means and shall be laid to a regular alignment. Other markings may be applied by hand-screed, hand-propelled machine or by self-propelled machine as approved or directed by the Employer. After transfer to the laying apparatus the material shall be maintained within the

temperature range specified by the manufacturer and stirred to maintain the right consistency for laying.

In the case of screeded application the material shall be laid to a thickness of not less than 3 mm (approx. 1/8 inch) or more than 6 mm (approx. 1/4 inch) unless specifically authorized by the Employer when laid over an existing marking. In the case of sprayed application the material shall be laid to a thickness of not less than 1.5 mm unless specifically authorized by the Employer. In all cases the surface produced shall be uniform and appreciably free from bubbles and streaks. Where the Employer directs, that ballotini shall be applied to the surface of the markings, these shall be applied uniformly to the surface of the hot thermoplastic immediately after laying such that the quantity of ballotini firmly embedded and retained in the surface.

Road markings of a repetitive nature, other than center lines, lane lines, etc. shall unless otherwise directed by the Employer be set out with stencils which comply with the size and spacing requirements of the Employer.

d) Re-Use of Thermoplastic Material

At the end of the day's work as much as possible of the material remaining in the heater and/or laying apparatus shall be removed. This may be broken and used again provided that the maximum heating temperature has not been exceeded and that the total time during which it is in a molten condition does not exceed the requirements (3). (i). (b).

(ii) Road Marking Paint

a) Preparation of Road Surface

The paint shall be applied only on a surface which is clean and dry. It shall not be laid over loose detritus, mud or similar extraneous matter or over a thermoplastic marking or over an old paint marking which is faulty or incompatible with the paint being applied. If a primer or undercoat is necessary to ensure proper adhesion of the marking paint to the road surface without bleeding or other discoloration the primer or undercoat shall be fully compatible with the marking paint and the road surface and shall be applied only if, and at the rate of application, approved by the Employer.

b) Preparation of Paint

A cold-applied paint shall be thoroughly field mixed before applying in order to keep the pigments in uniform suspension. Hot-applied paints shall be heated in a properly designed heater, preferably thermostatically controlled, to the correct laying temperature at which it shall be maintained as required for the method of application. The paint shall on no account be allowed to exceed the maximum temperature specified by the paint manufacturer. The use of thinners or other additives shall not be permitted unless otherwise agreed to by the Employer.

c) Laying

Center lines, lane lines and edge lines shall be applied by approved mechanical means and shall be laid to a regular alignment. Other markings shall be applied by brush, spray, screed, hand-propelled or self propelled machine according to the marking configuration and the type of paint approved for use or as directed by the Employer. The rate of application of the paint for each coat shall be that recommended by the manufacturer unless otherwise directed by the Employer. When more than one coat is used the succeeding coat shall not be applied until the previous coat has fully set.

Road markings of a repetitive nature, other than center lines, lane lines etc. shall, unless otherwise directed by the Employer, be set out with stencils which comply with the size and spacing requirements of the Employer.

d) Protection of Markings

All markings shall be protected from traffic until they have dried sufficiently to show no pick up of type marks of traffic dirt.

(iii) Defective Materials or Workmanship

Materials which are defective or have been applied in an unsatisfactory manner or to incorrect dimensions or in a wrong location shall be removed, the road pavement made good and the materials replaced, reconstructed and/or properly located. all at the Contractor's expense and to the satisfaction of the Employer.

(iv) Protection of Traffic

The Contractor shall protect pedestrian, vehicular and other traffic adjacent to the working area against damage or disfigurement by construction equipment, tools and materials

or by spatters, splashes and smirches of paint or other construction materials and shall during the course of the work provide and maintain adequate signs and signals for the warning and guidance of traffic.

(4) Measurement and Payment

Road marking shall be measured by the area in square meters completed in place and to the lines shown on the drawings or prescribed by the Employer.

Payment for road marking will be made at the unit price per square meter, which unit price shall include the costs of road marking materials, labor, equipment, tools and all other materials and operation necessary to complete the road marking.

SECTION 5200 HOUSING WORKS

5201 GENERAL

(1) This section covers the construction of the houses, as classified into Main Works in the Bill of Quantities, in the area of the diversion dam, pumping station, Bang Sang water level gauging station and Nakhon Nayok water level gauging station.

The Contractor shall supply materials, equipment, and labor to complete the housing works as shown on the drawings or as directed by the Employer.

The Contractor shall submit to the Employer for his approval catalogs, data, samples, and/or operation manual of the materials and equipment to be used for the housing works prior to commencement of the works in accordance with the provision as specified on the drawings or as directed by the Employer.

(2) Housing works in each area consist of the following.

a) Diversion Dam Area
One (1) Control house
Six (6) Hoist houses
One (1) Electric house
Four (4) Observation houses

b) Pumping Station
One (1) Pump house
Two (2) Observation houses

c) Bang Sang Water Level Gauging Station
One (1) Observation house

d) Nakhon Nayok Water Level Gauging Station
One (1) Observation house

5202 SCOPE OF WORKS

The scope of the housing works in this section consist of the following and/or as specified in the drawings.

(1) Control House

Unless otherwise specified in the Specifications (Part-2 Building Works), the scope of housing works of the control house is as follow.

i) Earth and stone works and concrete works for the house works.

ii) Foot slabs, columns and beams.

iii) Floor, walls, windows, doors, shutter, ceiling, roofing, fittings, toilet, electrical work, water supply system, sewage system, drainage system, etc. as specified on the drawings.

iv) Lighting facilities, ventilator fans, lightning apparatus, and other facilities as shown on the drawings.

v) Outdoor water supply pipe works up to 10 m for the external wall of the house

vi) Cable pits as shown on the drawings or prescribed by the Employer.

vii) All other materials, facilities and works to complete the control house.

(2) Hoist Houses

i) Concrete works for the house works

ii) Columns and beans.

iii) Cinder concrete floor of 20 cm thick, Floor, walls, windows, doors, ceiling, roofing, electrical work, etc. as specified on the drawings.

iv) Lighting facilities, lightning apparatus, staircases shown on Dwg. No. DDM-1058 and other facilities as shown on the drawings

v) Cable pits including checkered plates, structural steel, etc. as shown on the drawings or prescribed by the Employer.

vi) All other materials, facilities and works to complete the hoist houses

(3) Electric House

i) Earth and stone works and concrete works for the house works.

ii) Foot slabs, columns and beams.

iii) Floor, cinder concrete floor of 40 cm thick, walls, windows, doors, shutter, ceiling, roofing, electrical work, etc. as specified on the drawings.

iv) Lighting facilities, ventilator fans, lightning apparatus, and other facilities as shown on the drawings.

v) Cable pits including checkered plates, structural steel, etc. as shown on the drawings or prescribed by the Employer.

vi) All other materials, facilities and works to complete the electric house.

(4) Observation Houses

The observation houses at the sites of diversion dam and pumping station shall be constructed as shown on the drawings.

i) Earth and stone works and concrete works for the house works.

ii) Foot slabs, columns and beams.

iii) Floor, walls, stairs, windows, doors, handdrails, ceiling, roofing, electrical work, etc. as specified on the drawings.

iv) Lighting facilities and other facilities as shown on the drawings.

v) All other materials, facilities and works to complete the observation houses.

(5) Pumping House

The pump house shall be constructed on the suction sump and the ground as shown in the drawings.

i) Earth and stone works and concrete works for the house works including piling for the foundation of septic tank.

ii) Foot slabs, columns, R.C. beams and truss-beams.

iii) Floor, walls, windows, doors, shutters, ceiling, roofing, fittings, toilets, electrical work, water supply system, sewage system including septic tank, drainage system, etc. as specified on the drawings.

iv) Lighting facilities except outdoor lighting faciltities, air conditions, ventilator fans, lightning apparatus, handrails, crane girders and other facilities as shown on the drawings.

v) Outdoor water supply and sewage pipe works.

vi) Cable pits including checkered plates, structural steel, etc. as shown on the drawings or prescribed by the Employer.

vii) All other materials, facilities and works to complete the pump house

(6) Bang Sang and Nakong Nayok Water Level Gauging Stations

i) Earth and stone works, piling works and concrete works

ii) Foot slabs, columns and beams.

iii) Floor, walls, windows, doors, ceiling, roofing, electrical work, etc. as specified on the drawings.

iv) Lighting facilities, lightning apparatus, handrails and other facilities as shown on the drawings.

v) Approach roads and yards, and miscellaneous works.

vi) All other materials, facilities and works to complete the water level gauging stations.

5203 Measurement and Payment

All the costs of each housing work specified in section 5202 of the Specifications shall be included in the following pay item.

Description of Work	Pay Item No.
1) Diversion Dam Area	
Control House	2237
Hoist Houses	2236
Electric House	2238
Observation Houses	6205
2) Pumping Station Area	
Pump House	5239
Observation Houses	6205
3) Bang Sang Water Level Gauging Station	
Observation House	6201
4) Nakhon Nayok Water Level Gauging Station	
Observation House	6202

SECTION 5300 REINFORCED CONCRETE PIPES

5301 MATERIALS

This section covers the supply and installation of reinforced concrete pipe for the pipe culvert. The reinforced concrete pipe shall be fabricated by a manufacturer approved by the Employer and shall correspond to TIS 128, Class 3.

Joints for reinforced concrete pipe shall be the tongue and groove type. The pipes shall be joined with wire mesh and mortar as shown on the drawings or prescribed by the Employer.

5302 INSTALLATION OF PIPE

The pipe shall be furnished, stored, handled in such a way as to prevent any damage to the ends. Any pipe with a broken tongue shall not be used in the work.

All concrete pipe delivered to the site shall be inspected by the Employer and any pieces rejected shall promptly be removed from the site.

Field cutting of reinforced concrete pipe end shall be done with a carborundum saw or similar device approved by the Employer. Cutting of special pipe lengths with only a chisel or similar tool is prohibited.

Pipe shall be installed as soon as the excavation is completed to the normal grade of the bottom of the trench. The Contractor shall immediately place granular material in the trench and the pipe shall be firmly bedded in this material to conform accurately to the line and grade shown on the drawings. No blocking under pipe will be permitted. Sand bedding is indicated on the drawings.

Before the pipe is lowered into the trench, the tongue and groove must be cleaned and free from dirt. All joints shall be grouted in the following manner:

For 600 mm diameter and larger pipe, the interior joints shall be filled with mortar after the backfilling is completed. The mortar shall consist of one part by volume of cement and

2 parts by volume of well-graded coarse sand. The mixture shall have a dry, crumbly consistency and shall be pounded into place and troweled to make a smooth joint.

5303 MEASUREMENT AND PAYMENT

(1) Measurement, for payment, for supply and installation of reinforced concrete pipe will be made from end to end of the reinforced concrete pipe installed, and no allowance will be made for lap at joints.

Payment for supply and installation of reinforced concrete pipe will be made at the unit price per meter, which unit price shall include the cost of furnishing, transporting, handling, installing and jointing the pipes and all other costs necessary to complete the pipeline.

(2) Measurement, for payment, of pipe bedding with a granular material will be made only for the quantities actually placed within the limits of the pay lines shown on the drawings or established by the Employer.

Payment for pipe bedding with a granular material shall be made at the unit price per cubic meter for the pay item No. 4216 or No. 5231 in the Bill of Quantities (Part -1 Main Works), which unit price shall include all the costs of labor, equipment, machinery, right or royalty of material acquisition in borrow area, extracting, hauling, loading, unloading, spreading and compacting of materials, shaping and trimming, and cleaning and treatment of borrow area after worked out and incidental works necessary for the completion of pipe bedding with a granular material.

SECTION 5400 MISCELLANEOUS

5401 CONCRETE BLOCK RIVERBED PROTECTION

The concrete block riverbed protection shall be provided on the riverbeds both up and downstream of the diversion dam so that the riverbeds can be protected from scouring by river discharge. The concrete block riverbed protection consists of precast concrete block and rock material filling in the voids between the concrete blocks. Shape and thickness of the concrete block shall be as shown on the drawings, and the concrete shall be class E specified in section 3007 of the Specifications. Thickness of the rock material filling shall not be less than 60 cm and the rock material shall conform to the gradation requirement specified in section 2302 of the Specifications.

The Contractor shall submit explanations of the method of manufacturing, transporting and installing the concrete block riverbed protection for approval of the Employer.

Measurement, for payment, of concrete block riverbed protection will be made of the areas actually installed as directed. Payment for concrete block riverbed protection will be made at the unit price per square meter, which unit price shall include the cost of all labor, tools, equipment and materials required for furnishing, manufacturing, transporting, installing and maintaining the concrete blocks. The unit price shall also include the cost of furnishing, delivery, handling, placing and compacting the rock materials filling and all other costs necessary to complete the work.

5402 POLYVINYL CHLORIDE PIPE (PVC PIPE)

The pipe shall be fabricated by a manufacturer approved by the Employer and shall be in compliance with TIS 17 Class PVC 13.5 or JIS K 6741 "Unplasticized Polyvinyl Chloride (PVC) Pipes".

Measurement, for payment, for supply and installation of PVC pipes will be made from end to the end of the PVC pipes actually installed, and no allowance will be made for lap at joints. Payment for supply and installation of PVC pipes will be made at the unit price per meter, which unit price shall include the cost of furnishing, transporting, handling, installing and jointing the pipes and all other costs necessary to complete the pipeline.

5403 TRAFFIC SIGN

Traffic sign shall be created with approved fittings on posts as shown on the drawings and shall comply with the requirements of the regulation of the Highway Department of Thailand. The posts shall be installed at the locations as directed by the Employer.

Measurement, for payment, of traffic sign will be made of the number of the traffic signs actually installed as directed. Payment for traffic sign will be made at the unit price per number of the pay item No. 4225 in the Bill of Quantities (Part - 1 Main Works), which unit price shall include the cost of furnishing, handling, electing and installing the traffic sign, post and necessary accessories; the cost of earth and stone works, and concrete works required for installation of the post and all other costs necessary to complete the work.

5404 MANHOLE COVER

Manhole covers and frames shall be installed at the designated locations in the intake and suction sump of the pumping station, as shown on the drawings.

Measurement, for payment, of manhole covers will be made of the number of manhole covers installed as directed. Payment for furnishing and installing manhole covers will be made at the unit prices per number, which unit prices shall include the cost of all labor, tools, equipment and materials required for furnishing, handling, installing, painting and maintaining the manhole covers and flames and all other costs necessary to complete the work.

5405 MISCELLANEOUS METALWORKS

Steel handrail, steel floor grating, steel ladder and step, steel weir and steel gas pipe are classified into miscellaneous metalwork for payment.

Measurement, for payment, of miscellaneous metalwork will be made only for the weight of the miscellaneous metalwork installed as directed. Payment for miscellaneous metalwork will be made at the unit price per kilogram, which unit price shall include the cost of furnishing, handling, installing, painting or galvanizing and maintaining the miscellaneous metalwork and all other costs necessary to complete the work. Payment will be made under the following pay items in the Bill of Quantities (Part - 1 Main Works).

Bang Pakong Diversion Dam & Diversion Canal ..... Pay Item No. 2239
Pumping Station ..... Pay Item No. 5224

Steel structures assembled by using structural steel, steel gas pipes, fitting , etc. and installed in accordance with the written instruction of the Employer will be paid under the above pay item. No measurement shall be made for the miscellaneous metalwork included in the works of other pay items.

5406 JETTY CONSTRUCTION

The Contractor shall construct jetties at both up and downstream of the closure dam. The Contractor shall submit shop drawings for jetty prepared based on the contract drawings for approval of the Employer.

Measurement, for payment, of jetty construction will be made of the number of jetties constructed at the locations shown on the drawings or directed by the Employer. Payment for jetty construction will be made at the unit price per number for the pay item No. 3210, which unit price shall include the cost of all labor, tools, equipment and materials required for designing, furnishing, manufacturing, transporting, installing, painting and maintaining the jetty. The unit price shall also include the cost of earth and stone works, concrete works, pilling works and all other works necessary to complete the jetty.

5407 LIGHTING POST

The Contractor shall supply the lighting posts and install them on the concrete foundation as shown on the drawings.

Measurement, for payment, of lighting posts will be made of lighting post with lamp actually installed. Payment for lighting post will be made at the unit prices for the following pay items.

Lighting posts for road lighting : Pay Item No. 4227
Lighting posts for outdoor lighting system in the pumping station : Pay Item No. 5236

The unit prices for the pay item Nos. 4227 and 5236 shall include the cost of furnishing, handling, painting and installing the lighting post with lamp and accessories

necessary to complete the lighting post. The unit prices shall also include the cost of earth and stone works, concrete works and other works required for the construction of the lighting post foundation.

The Contractor shall supply and install the cables and all other materials necessary to complete the road lighting and the outdoor lighting system in the pumping station. These costs shall be included in the prices for the following pay items.

For road lighting	:	Pay Item No. 6701
For outdoor lighting system in the pumping station	:	Pay Item No. 6401

DIVISION 6 METAL WORKS

SECTION 6000 METAL WORKS

6001 GENERAL

This section covers the metal works for trashrack, handrails, steel ladder, steel step, staff gauge on concrete surface, and other miscellaneous metal works.

The Contractor shall prepare the Shop Drawing showing the size, welding details, thickness and gauge of all materials and installation details.

The Contractor shall take all precautions to not damage or alter strength or other characteristics of adjoining works.

6002 MATERIAL

The metal materials to be used in the works shall be free from harmful defects and rust, and cut to the correct shapes. The metal materials shall conform to the following specifications:

Structural steel bars and shape	ASTM A36 "Structural Steel"	JIS G3101 "Rolled Steel for General Structure"
Mild steel for railing, posts, flanges and sleeves	ASTM A35 "Welded and Seamless Steel Pipe"	JIS G3454 "Carbon Steel Pipes for Pressure Service" TIS 276 Class 2 "Standard for Steel Pipes"
Steel pipe (medium weight)	BS 1387 "Steel Tubes and Tubulars Suitable for Screwing to BS 21 Pipe Threads"	JIS G3452 "Carbon Steel Pipes for Ordinary Piping" TIS 276 Class 2 "Standard for Steel Pipe"
Cast iron	ASTM A48 (Class 30) "Gray Iron Castings"	JIS G5501, "Gray Iron Casing"

Bolts and nuts	ASTM A307 "Low Carbon Steel Externally and Internally Treaded Standard Fasteners"	TIS 171, TIS 291 "Standard for Bolt, Screw, Nut and Stud", and "Standard for Hexagon Head Bolts"
Cast steel	ASTM A27 "Mild-to-Medium-Strength Carbon-Steel Castings for General Application"	JIS G5101, "Carbon Steel Castings"
Stainless steel pipe	ASTM A269, type 304 "Seamless and Welded"	JIS G3463 "Stainless Steel Boiler and Head"
Steel pipe nuts	ASTM A269, type 304 "Seamless and Welded Austenitic Stainless Steel Tubing for General Service"	JIS 3459 "Symbol of Class SUS 304 TP" and "Stainless Steel Pipes"
Stainless steel plate and sheet	ASTM A480, type 340 "General Requirements for Delivery of Falt-rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip"	JIS G4305 Notation SUS 304 "Cold Rolled Stainless Steel Sheet and Plate"
Stainless and Shapes	ASTM A276, type 340 "Stainless and Heat-Resisting Steel Bars and Shapes"	
Aluminum for structural shapes	ASTM B221, alloy 6061, temper T6 "Aluminum-Alloy Extruded Bars, Rods, Shapes, and Tubes"	
Architectural aluminum	ASTM B221, alloy 6063, temper T5	
Road steel	ASTM A283 C "Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality"	JIS G3101 "Rolled Steel for General Structures"
Square steel columns	AISI C1015	JIS G4051, S 15C "Carbon Steel Machine Structure Use"

6003 WORKMANSHIP

Material shall be thoroughly straightened by methods that will not result in injury, except that sharp kinks or bends in members to be straightened will be cause for rejection. Finished members shall be free from kinks or bends. Shearing shall be accurately done, and all portions of the works neatly finished. Corners shall be square and true, unless otherwise shown on the drawings. Where re-entrant cuts cannot be made by shearing, a rectangular punch may be used. Re-entrant cuts shall be filled, unless otherwise approved by the Employer. Bends, except for minor details, shall be made by approved dies or bending rolls. Where heating is required, precautions shall be taken to avoid overheating the metal and it shall be allowed to cool in such a manner as not to destroy the original properties of the metal. Steel with welds will not be accepted, except where welding is definitely specified, called for on the drawings, or otherwise approved. All bolts, nuts, and screws shall be tight. The ends of pipes, except for handdrailing, shall be reamed.

6004 WELDING

Welding of parts shall be in accordance with the Standard Code for Arc and Gas Welding in Building Construction of the AWS and shall only be done where shown on the drawings, specified, or permitted by the Employer. All welding shall be done only by welders certified as to their ability to perform welding in accordance with locally accepted testing requirements. The AWS Code will be used as guide.

Welding of pressure vessels shall be in accordance with the ASME, "Boiler and Pressure Vessel Code" and/or JIS B8243 "Construction of Pressure Vessels".

Welding of steel water pipe shall be in accordance with AWWA C206, "Field Welding of Steel Water Pipe Joints".

Damage to galvanized areas shall be thoroughly cleaned by wire crushing and all traces of welding flux and loose or crocked zinc coating removed prior to painting. The cleaned area shall be painted with two coats of zinc oxide-zine dust paint. The paint shall be properly compounded with a suitable vehicle in the ratio of one part zinc oxide to four parts zinc dust by weight. As an alternate to the above, the Contractor may submit for approval the use of a galvanizing rod or galvanizing solder to repair damaged areas.

6005 FIELD ASSEMBLY

All parts to be installed shall be cleaned thoroughly; all packing compounds,rust, dirt, grit and other foreign matter removed; all holes and grooves for lubrication cleaned; and all enclosed chambers or passages examined to make sure that they are free from injurious materials. Where units or items are shipped as assemblies they will inspected by the Employer, prior to installation. Disassembly, cleaning and lubrication will not be required except where there is indication that such work is necessary to place the assembly in a clean and properly lubricated condition. The top of all steel floor plating and gratings, shall be installed flush with abutting curb surfaces. Stillson wrenches, cold chisels, or other tools, likely to cause injury to the surfaces of rods, nuts, or other parts, shall not be used for the work of assembling and tightening parts. Bolts and screws shall be tightened firmly and uniformly, but care shall be taken not to overstress the threads by using excessive force or wrenches of excessive length. When a half nut is used for the purpose of locking a full nut, the half nut shall be placed first and followed by the full nut. Threads of all bolts, nuts, and screws shall be lubricated by lead and oil before assembly. Driving and drifting bolts or keys will not be permitted.

6006 PAINTING

(1) Shop Priming

All structural steel, miscellaneous ferrous metal and metal castings, shall be shop primed before delivery to the site. This prime coat is to be applied after fabrication and before exposure to the weather.

(2) Field Priming

Any structural steel, miscellaneous metal and other metals which arrive at the site unpainted shall be cleaned and field primed. Surfaces that have been shop primed and have been damage in shipment and/or in installation or where shop prime has deteriorated shall be promptly cleaned and retouched before any successive painting is done in the field. Shop primed surfaces damaged by field welding shall be cleaned and field primed.

(3) Field painting

Successive cost of paint shall be tinted so as to make each coat easily distinguishable from each other with the final undercoat tinted to the appropriate shade of the finished coat. Finish surfaces shall not show brush marks or other irregularities. Under coats of metal surfaces shall be sanded to remove defects and provide a smooth surface.

Painting shall be continuous and shall be accomplished in an orderly manner so as to facilitate inspection. Surfaces of exposed members that will be inaccessible after erection shall be cleaned painted before erection. Any defective paint changes in color or incompatible paint with undercoat shall be scraped off and repainted.

Any pipe or other metal surfaces to be painted a color other than black that have a coating of tar or asphalt-compound shall be painted with a paint specifically designed to isolate the finish paint from the tar surface.

6007 STEEL HANDRAIL

The Contractor shall furnish all square metal tubing, flat bars, fittings, bolts, and other accessories required for the steel handrails. Steel handrails shall be installed by the Contractor in the manner and at the locations shown on the drawings. Fixed and removable handrails and safety chains shall be furnished and installed in the locations indicated on the drawings.

All shop and field connections shall be welded unless otherwise indicated on the drawings. All welds shall be ground smooth. All handrails shall be galvanized or painted as indicated on the drawings after fabrication. Galvanized coatings damaged in the field shall be repaired or replaced as directed by the Employer.

Handrails shall be carefully adjusted prior to fixing in place to insure proper matching at abutting joints and correct alignment and camber throughout their length. Handrails to be set in concrete shall be assembled and installed when concrete is placed, or recesses shall be left or holes shall be drilled in the concrete for anchorage, and the handrails shall be assembled and grouted in position at some later time.

6008 STEEL LADDER AND STEP

Steel ladders and steps shall be installed as shown on the drawings or as directed by the Employer. Steel ladders and steps shall be welded assemblies of the structural steel and round steel bars, and of the dimensions shown on the drawings. Safety cages shall be provided if directed by the Employer. Ladders shall be galvanized or painted after fabrication and fastened to walls in accordance with the details indicated on the drawings.

Steel ladders and steps shall be completely fabricated in sections convenient for handling and transporting. Field anchors and anchor bolts shall be assembled by bolting or welding. Anchors and anchor bolts shall be embedded in the concrete at the proper positions while the concrete is placed, or recesses shall be left in the concrete and the anchors and anchor bolts shall be thoroughly grouted or concreted in place.

Anchor bolts, fasteners, washers and all parts of devices necessary for proper installation, whether or not fully detailed on the drawings, shall be furnished and installed by the Contractor. All nuts, screw and other fastening devices shall be tight.

6009 STAFF GAUGE

(1) General

The Contractor shall supply and install staff gauges as shown on the drawings or as directed by the Employer. The location and elevation of staff gauges shall be fixed to the requirements of the drawings or as directed by the Employer.

(2) Materials

Staff gauge plates shall be made of steel sheet having a minimum thickness of 2 millimeters and surfaces shall be finished by enamel process. Graduation of the plate shall conform to the details on the drawings. Color shall be white for both faces and all numerals and graduations shall be black.

Enamel faces shall consist of one undercoat and one top coat, applied and stoves, 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 Employer, staff gauges shall be mounted. All mounting holes shall be accurately located and fixed as detailed on the drawings. The gauge shall present an even surface free from twist, cracks, faults or other blemishes after complete installation.

6010 ENTRANCE GATE & BARBED WIRE FENCE

(1) Entrance Gate

(i) General

The Contractor shall construct entrance gates which are located at the entrance of premises for No. 1 substation on the left abutment of diversion dam and pumping station as shown on the drawing or prescribed by the Employer.

The gate door shall be fabricated of light gauge steel, steel bars and steel wire mesh as shown on the drawings.

Anchors for the gate hinges and gate rails shall be installed at the time of concrete placing. The gate rails shall be made level and care shall be taken to avoid occurrence of water pockets.

Name plate shall be provided on the gate wall as shown on the drawings or directed by the Employer.

The Contractor shall submit shop drawing showing gate door details and form arrangement of the gate columns and walls for approval of the Employer.

(ii) Measurement and Payment

Measurement, for payment, of construction of the entrance gates will be made of the number of the entrance gates installed and accepted.

Payment for the entrance gate will be made at the unit price per number, which unit price shall include the cost of all labor, tools, equipment and materials required for furnishing, fabricating, transporting, installing, painting and maintaining the entrance gate. The unit price shall also include the cost of excavation, backfill and concrete works for the construction of the gate columns, walls and slabs, and all other costs necessary to complete the work.

(2) Barbed Wire Fences

(i) General

The Contractor shall construct the barbed wire fences as shown on the drawings or as directed by Employer. Barbed wire fence shall consists of barbed wires and reinforced concrete fence posts. The fence posts shall be set at intervals specified on the drawings and backfilled and compacted sufficiently.

(ii) Measurement and Payment

Measurement, for payment, of construction of the barbed wire fence will be made of the actual length of barbed wire fence installed in accordance with the drawings or as directed by the Employer.

Payment for construction of the barbed wire fence will be made at the unit price per linear meter, which unit price shall include the cost of furnishing and installing the barbed wire fences and reinforced concrete fence posts, and all other costs necessary to complete the work.

6011 LOG BOOM

(1) General

A log boom shall be provided in front of the diversion dam and pumping station to prevent encroachment of drift wood, trash, water hyacinth, etc. as shown on the drawings or prescribed by the Employer.

The Contractor shall submit to the Employer for his approval the catalogues and shop drawings showing complete details, sections and plans of all parts of the log boom and anchorages, assemblies material lists, etc.

(2) Materials

All materials to be furnished by the Contractor shall be new and shall have the best quality of their respective kinds. All materials for the log boom shall principally be of anti-corrosive type. The log boom shall consist of the following components.

- Main wire rope covered with resin or equivalent
- Float including band and ballast
- Link chain
- Guy wire
- Anchor float
- Anchor block with hook
- Anchor piles
- Other related connections and accessories to complete the work

Main wire shall be of resin-covered wire rope which shall have the minimum factor of safety not less than 4.0 against its maximum tensile force. The design load of the wire shall be 40 kg/m at the minimum in consideration of wind load, trash load, etc., which will act perpendicular to the line on the anchorage at both end of the wire.

Guy wire shall have the sufficient strength of the same safety factor as the main wire for any tensile load from the two main wires and anchor float shall have a sufficient buoyancy to lift the end of the guy wire on the reservoir.

(3) Measurement and Payment

Payment for log boom will be made after completion of the log boom in the location shown on the drawings or directed by the Employer. The application of pay item to the construction of log boom shall be as follows.

Pay Item Application to Construction of Log Boom

Construction Work	Pay Item No.
Bang Pakong Diversion Dam & Diversion Canal	2235
Pumping Station	5237

The prices for the pay item No. 2235 and 5237 shall include the cost of all labor, tools, equipment and materials required for furnishing, transporting, assembling, installing and maintaining the log boom. The prices shall also include the cost of piling, earth and stone works, concrete works and all other works necessary to complete the log boom.

6012 TRASHRACK

Four (4) sets of trashracks made of rolled steel (JIS G3101 SS-400 or equivalent) shall be provided at the intake of the pumping station with necessary accessories as shown on the drawings.

Height of intake	:	5.50 m
Effective width of intake	:	4.05 m
Pitch of screen (net opening)	:	50 mm
Inclination of screen	:	Approx. 70 degrees

The trashrack shall be provided with sufficient strength to withstand the water level difference of 1.0 m across the trashrack with a deflection not more than 1/800 of respective spans. The thickness of bar shall be as shown on the drawings.

Payment will be made at the price for pay item No. 5238 after installtion of the transhrack. The price shall include the cost of furnishing, transporting, assembling, installing and maintaing the trashrack, and all other costs necessary to complete the transhrack.