

SECTION 20300 CONCRETE

20301 General

20301.1 Standards

The materials and workmanship used in the manufacture of concrete shall be in accordance with JIS A 1101, JIS A 1108, JIS A 1105, JIS A 1132, ASTM C-1077, ASTM C-94, ASTM C-143, ASTM C-39, ASTM C-150, ASTM C-31 and ASTM C-33 or approved equivalent international standards as appropriate for maritime works, and as modified by this Specification.

20301.2 Materials to be Used

The Contractor shall advise the Engineer, within 30 days of the Award of Contract, of the source of all materials to be used in concrete for the works. In the event that the Contractor later proposes to obtain materials from a different source he shall notify the Engineer at least 30 days before such materials are to be used.

20301.3

The Contractor shall submit shop drawings at least six weeks prior to the start of any construction for the Engineer's approval.

20302 Aggregates

20302.1 Quality

The quality of aggregates shall comply with the requirements stipulated in Section 20200 of this Specification.

20302.2 Grading

After trial concrete mixes have been satisfactorily completed the Contractor shall check the gradings of the aggregate regularly and for this purpose shall take samples from the stockpiles under the supervision of the Engineer. Gradings shall be checked at least once for every 50 ton of each type of aggregate delivered.

20302.3 Changes of Quality of Grading

Should the Engineer consider that the quality or grading of the aggregates supplied is different from that of the aggregates used in approved trial mixes, he may direct the Contractor to take 50 kg samples in his presence and consign them to an approved laboratory for full testing at the Contractor's expense.

20302.4 Approvals of the Engineer

No aggregates shall be incorporated within the works without the approval of the Engineer.

20302.5 All in Aggregate

All-in aggregates shall not be permitted in the concrete Works.

20302.6 Changes in Source of Supply or Grading

Sample loads of aggregates of approximately 300 kg for each aggregate type shall be submitted to the Engineer for his preliminary approval for each and every change in source of supply or grading. From each load the Contractor shall take two representative samples, each of 50 kg and subject them to grading analysis and all those tests required by this specification and such other tests as the Engineer may direct. The sample loads shall be retained for use in the concrete trial mixes to be carried out by the Contractor as required by Section 20710

20302.7 Handling and Storage of Aggregates

The fine and coarse aggregates shall be handled and stored separately in such a manner that segregation of the various sized particles shall not occur. The dumping of aggregates down sloping stockpiles will not be permitted. The stockpiles shall be formed on a free-draining platform of impervious concrete or similar approved hard-standing and shall be kept free from foreign substances. Care shall be taken to avoid the crushing of aggregates by stockpiling equipment.

**20303
Water**

The quality of mixing water shall also be checked not less frequently than once per week by the testing of three concrete cubes, made with distilled water, alongside three additional cubes to normal test requirements. The time for concrete to attain initial set should not differ by more than 30 minutes and the strength at 3 days shall not be less than 90% of that obtained with distilled water.

**20304
Cement**

20304.1 Quality

The quality of Cement shall comply with the requirements stipulated in SECTION 20207 of this Specification

The Contractor shall not change or modify any arrangement for the sources of supply, transport, storage and certification without the approval of the Engineer.

20304.2 Storage of Cement

Except as may be approved by the Engineer for grades or qualities of cement not available in the Country, cement shall be obtained direct from the manufacturer and delivered direct to the site whether in bulk by approved purpose-built vehicles or in sealed bags. It shall be stored in silos or in approved containers or in bags, and shall be protected against any ingress of moisture, dust or other contamination. Bags shall be stored in stacks not more than 1.5 m high in well ventilated waterproof buildings having a raised dry floor. Cement shall be delivered in quantities sufficient to ensure that there is no suspension or interruption of concreting at any time and shall be used in the order of delivery. No lumpy or partially hydrated cement shall be used. Different types of bagged cement or from different manufacturers shall be stored separate and distinct. When cement is delivered in bulk it shall immediately be placed in the silos or in approved containers.

20304.3 Storage in Silos

Bulk cements of different types, or from different manufacturers, shall be stored in separate silos and distinctly marked. Precautions shall be taken during unloading, handling, storage and use of cement to prevent the emission of dust and to provide adequate protection from the weather when mean daily ambient temperatures exceed 25°C. All sheds, silos and purpose built delivery vehicles shall be painted white.

20304.4 Storage Keeper

The Contractor shall employ competent store keepers who shall have charge of the cement stores and keep suitable records of the delivery and use of all cement. Copies of these records shall be furnished to the Engineer as requested, showing in such detail as he may require, the quantity of cement used during the day in each part of the Works.

20304.5 Manufacturer's Certificates

The Contractor shall promptly provide the Engineer with manufacturer's certificates for each consignment or as otherwise agreed certifying that the cement complies with the requirements of the relevant Standard. These certificates shall record the results of the standard tests on samples, taken and tested from each consignment. In addition, routine test certificates are to be supplied by the manufacturer showing the average results of sample tests made on batches of cement produced at his factory.

20304.6 Test

The Engineer may also make any further tests which he may consider necessary to satisfy himself that any cement on site complies with the specification and has not suffered any deterioration in any manner during transit or storage. Any cement which has not been used within two months from the date of manufacture shall be tested for compliance with the relevant ASTM C-150. No cement shall be used in the Works until it has been approved by the Engineer.

20304.7 Usages According to Delivery

Cement of each type shall be used in order of delivery.

20304.8 Testing of Cement if more than 90 days since Manufacture

Cement held for more than 90 days since manufacture shall be tested, prior to use, for "loss on ignition".

20304.9 Different Brands

Cement of different brands shall not be used in the same part of the Works.

20304.10 Imported Cement

Imported cements shall be tested as may be required by the Engineer prior to their incorporation in the Works notwithstanding that the cement may have been tested prior to delivery to the site.

20304.11 Rejection of Cement

The Engineer may reject any cement not meeting this specification. Cement rejected by the Engineer shall be immediately removed from the Site.

20304.12 Cement Temperature

Cements shall not be placed in the mix at temperatures in excess of the ambient temperature.

20305

Admixtures and Additives

20305.1 Admixture

Admixture and additives shall only be used in specified circumstances, on specified occasions and then only with the approval of the Engineer in each case. Admixtures and additives used at the direction of the Engineer shall conform with and be used in accordance with this specification and as may be determined by the Engineer.

20305.2 Engineers Approval to use Admixtures

The Contractor shall apply in writing to the Engineer requesting approval to use admixtures or additives not later than two months before he proposes to incorporate the same into a concrete mix and then only:

- a) To improve the workability of concrete mixes when mean ambient daily temperatures exceed 25°C to underwater

20305.3 Test

Such application shall include full documentation and test information as may be required or recommended by JIS A 6204, or other internationally recognized standards as may be applicable to the admixture or additive. The Contractor shall also provide a full method statement for his proposals.

20305.4 Engineers Reject

The Engineer reserves the right to reject any such application without reason being given and the Contractor shall not in consequence be entitled to any claim on any grounds whatsoever.

20305.5 Specifications for Admixture Additives

Admixtures and additives approved in specific terms by the Engineer shall conform to and be used in accordance with the manufacturer's instructions, ASTM or such relevant internationally recognised standard or as may be specified by the Engineer.

20305.6 Chlorides

Admixtures or additives containing chlorides will not be approved for incorporation in concrete.

20306

Steel Reinforcement Bar to Concrete

20306.1 Quality

The quality of steel reinforcement bars shall comply with SECTION 20203 of this Specification.

20306.2 Bending Schedule

The Contractor shall prepare bending schedules stating shapes, diameters, lengths and quantity of steel reinforcement bars. The bending schedules shall be submitted in duplicate to the Engineer for approval and no reinforcement shall be bent until such approval has been received. In general the bending schedules shall be submitted to the Engineer six weeks before production is to commence and in general the Engineer will reply within four weeks of the schedules being submitted. Upon request these periods may be reduced, within reason, for particular schedules required urgently. Permission to use the bending schedules by the Engineer shall not in any way relieve the Contractor of the responsibility of providing the steel reinforcement bars shown on the Drawings.

20306.3 Steel Fabric

Steel fabric for the reinforcement bars of structural concrete shall be in accordance with the requirements of ASTM A-185 or equivalent and shall be supplied in flat sheets not rolls.

20306.4 Carbon Content

All steel reinforcement bars shall be weldable with a carbon equivalent not greater than 0.51%.

20306.5 Lifting

Reinforcement steel bars shall not be used for lifting purposes.

20306.6 Re-Rolled Bar

Re-rolled bars shall not be used in the Works.

20306.7 Tying Wire

Wire used for tying reinforcement shall be 1.6 mm diameter soft annealed iron tying wire to ASTM A-82 or approved equivalent.

20306.8 Bond Strength

The bond strength of deformed bars; as defined in ASTM A-615 shall exceed that of plain round bar by 40% or more when tested in accordance with ASTM A-944.

20306.9 Handling of Reinforcement

All reinforcement bars shall be bundled by size with separation of casts and each bundle shall be identified by durable tags bearing the manufacturer's name or mark, the reinforcement bars size or designation, the cast mark and the appropriate certificate reference. All reinforcement bars shipped by sea shall be stored below deck whether in containers or not.

20306.10 Test of Reinforcement Bars

After delivery to the Site, the Engineer may require the Contractor to carry out confirmatory tests on further samples at an approved nominated laboratory. Any reinforcement bars which, as a result of such confirmatory tests, does not comply with the Specification will be rejected and shall be removed from Site without delay.

20306.11 Bending and Works with Reinforcement Bars

Bends, cranks and other working of reinforcement bars shall be performed by competent artisans in accordance with ASTM A615 and ASTM A944. Reinforcement bars shall be bent cold in an approved bending machine.

20306.12 Bending Hot

Bending hot at cherry red heat i.e. not exceeding 850°C may be allowed except for bars which depend on cold working for their strength. Bars bent hot shall not be cooled by quenching.

20306.13 Laps and Splices

Unless otherwise approved by the Engineer all laps and splices shall be located as

shown on the Drawings.

20306.14 Welding

Mild steel reinforcement in structural concrete shall be welded only with the approval of the Engineer.

20306.15 Spacer Blocks

Concrete cover blocks required for ensuring that the reinforcement bars is correctly positioned shall be as small as possible consistent with their purpose, of a shape acceptable to the Engineer and designed so that they will not overturn when the concrete is placed. They shall be made of concrete complying in all respects with the requirements of this Specification. They shall be securely wired in position to the second layer of reinforcement bars from the concrete surface using 1.6 mm diameter soft annealed iron tying wire which shall not be embedded in the spacer block more than 15 mm. The spacer blocks shall be thoroughly soaked in fresh water immediately prior to pouring concrete.

20306.16 Arrangement of Reinforcement Bars

The number, size, form and position of all steel reinforcement bars, ties, links, stirrups, and other reinforcement shall be in exact accordance with the drawings and they shall be kept in the correct position and with the required cover, without displacement during the process of pouring and compacting the concrete in place, in a manner approved by the Engineer. The Contractor shall provide all necessary distance pieces and spacers to maintain the reinforcement bars in the correct position. The type of distance pieces shall be subject to the approval of the Engineer. Temporary supports within the concrete to keep reinforcement in place will not be allowed. Any ties, links, or stirrups connecting the bars shall be taut so that the bars are properly braced, and the inside of hooks and bends shall be in contact with the bars around which they are intended to fit.

20306.17 Store of Reinforcement Bars

All reinforcement bars shall be stored under a waterproof shelter and supported above the surface of the ground and any water lying on the ground, and shall be protected from damage and corrosion.

20306.18 Cleaning of Reinforcement Bars

Before any steel reinforcement bars are embedded in the concrete any loose mill scale, loose rust and any oil, grease or other deleterious matter shall be removed. The reinforcement steel bars shall be cleaned to SIS Standard 05 5900, ASTM D2200-67 (1980). Mechanical cleaning equipment for the removal of millscale or rust etc. of an approved design shall be provided by the Contractor on Site for this purpose.

20306.19 Cleaning of Exposed Reinforcement Bars

Partially set concrete which may adhere to exposed reinforcement bars during concreting operations shall also be removed.

20306.20 Concrete Cover to Ferrous Metal

Concrete cover to ferrous metal being used as or for the placement of reinforcement shall be neither less than 75 mm nor more than 80 mm either as noted or within ± 2.5 mm of the dimensions noted or shown on the Drawings.

20306.21 Supporting of Reinforcement Bars

Where sections of the work are carried out in lifts, the reinforcement projecting above the lift being cast shall be adequately supported so as to prevent movement of the bars during the casting and setting of the concrete.

20306.22 Care to Reinforcement Left Projecting

Reinforcement temporarily left projecting from the concrete at construction or other

joints shall not be bent out of position except with the approval of the Engineer.

20307
Formwork

20307.1 General

All formwork, shuttering, supporting falsework, struts and staging shall be of suitable quality, either metal, timber or other approved material and of such strength with ample scantlings as to ensure that the shuttering remains rigid and without distortion throughout the placing, ramming, compacting and setting of the concrete. The design of the formwork shall be such as to enable it to be struck and removed without damage to the concrete. No shutter fixings or supports, other than certain approved internal ties, will be allowed to be incorporated in the finished concrete. The Contractor shall submit his designs, in duplicate, for consideration not less than 14 days before the proposed commencement of each part of the work and work shall not start until the Engineer's approval has been received. Details of all proposed formwork and lining appropriate to the class of finish shall be submitted for approval by the Engineer before any materials are brought onto the Site. Where required by the Engineer, samples of formwork shall be constructed and concrete placed so that the proposed methods and finish can be demonstrated.

20307.2 Joints

All joints in shuttering or moulds shall be in either horizontal or vertical planes, and shall be of such a design as to ensure that there is no loss of fine materials or cement during the placing or consolidation of the concrete.

20307.3 Face of Exposed Concrete

All shuttering or moulds used for forming the face of exposed concrete, where specified to be "wrought", shall be of especially smooth planed or lined construction. Where "wrought" shuttering is not specified, sawn timber shuttering may be used which shall be designated as finish class F1. All wrought shuttering shall be provided with 25 mm by 25 mm splays on internal and external angles unless otherwise directed by the Engineer. Wrought shuttering is to be aligned to a tolerance of ± 3 mm except where a closer tolerance is required.

Wrought shuttering shall be divided into three classes as shown in Table 20300.1 and described as follows:

Class F1

Class F1 finish is for surfaces against which back-fill or further concrete will be placed. Formwork shall consist of sawn boards, sheet metal or any other material which will prevent the loss of grout when the concrete is vibrated.

Class F2

The irregularities in the finish shall be no greater than those obtained from the use of wrought thickness square edged boards arranged in a uniform pattern. The finish is intended to be left as struck but imperfections such as fins and surface discolouration shall, if required, be made good by methods approved by the Engineer.

Class F3

The formwork shall be lined with a material approved by the Engineer to provide a smooth finish to uniform texture and appearance. This material shall leave no stain on the concrete and shall be so joined and fixed to its backing that it imparts no blemishes. It shall be of the same type and obtained from only one source throughout any one structure. The Contractor shall make good any imperfections in the finish as required by the Engineer.

TABLE 20300.1 SURFACE FINISH TO CONCRETE

Class	Location
F1	Buried footings and foundations,
F2	Buried faces of land side, interior of wharf,
F3	Exposed faces of wharf, all exposed structural concrete in buildings, interior of all pits and drainage structures.

20307.4 Protection

Permanently exposed concrete surfaces shall be protected from rust marks and stains of all kinds.

20307.5 Formwork Joints

Unless otherwise described in the Contract all formwork joints for exposed surfaces of concrete to Class F2 and F3 finish shall form a regular pattern with horizontal and vertical lines continuous throughout each structure and all construction joints shall coincide with these horizontal or vertical lines.

20307.6 Inside Surface

The inside surfaces of forms shall, except for permanent formwork, or unless otherwise agreed by the Engineer, be coated with a release agent approved by the Engineer. Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not come into contact with the reinforcement or prestressing tendons and anchorages. Different release agents shall not be used in formwork to concrete which will be visible in the finished works.

20307.7 Ties

All internal metal ties where permitted or parts thereof shall be extracted without damage to the concrete and any resulting holes shall be filled with a permanently impermeable filler to the satisfaction of the Engineer. No permanently embedded metal part shall be less than the specified cover to the reinforcement from the finished surface.

20307.8 Shutter

The shuttering shall be cleaned out prior to concreting and thoroughly freed from sawdust, shavings, rust, dirt, mud or other debris, and special removable sections of shuttering shall be provided to facilitate this, all to the approval of the Engineer. After concreting, the exposed surfaces of the shuttering shall be cleaned of all adhering concrete before depositing fresh concrete.

20307.9 Void Formers

Void formers shall be sufficiently robust to resist damage during concreting operations. They shall be adequately supported and anchored in such a way as to prevent flotation or displacement during concreting. Where void formers are of hollow construction, drain holes shall be provided of a size and in positions to be agreed by the Engineer.

20307.10 Setting and Fixing of Accesories

All fixing blocks, brackets, built in bolts, holes, chases, inserts, and the like shall be accurately set and firmly fixed in position prior to the placing of concrete. No cutting away of concrete for any of these items shall be carried out.

20307.11 Fixing of Bolts and Inserts

Bolts and other inserts to be cast into the concrete shall be securely fixed to the formwork in such a way that they are neither displaced nor shall there be any loss of grout through holes in formwork during concreting. Continuous inserts of the channel or dovetail slot type and all fittings to which bolts or other fixings will later be attached shall be sealed and rendered grout-tight prior to commencement of concreting.

20307.12 Removal of Filler Materials and Obstructions

Immediately upon striking the formwork all filler materials and obstructions shall be removed from all inserts, etc., over their entire length. Construction joints shall not be formed within 100 mm of any insert or channel. External ferrous fixings shall be fixed such that the specified cover is maintained between such fixings and any reinforcement.

20307.13 Inspection before Concrete Placement

All formwork shall be inspected and approved by the Engineer before concrete is placed and the Contractor shall allow adequate time in his concreting programme for such inspection and for carrying out any remedial action or correction required by the Engineer.

20307.14 Shuttering

Except as may be approved by the Engineer, shuttering below or between tides shall be so fitted and caulked that the ingress of water is prevented. The shuttering is to be so restrained and the rate of placing of concrete so arranged as to prevent uplift and consequent deflection of the shutters due to buoyancy.

20307.15 Striking of Formwork

The Engineer shall be informed in advance when the Contractor intends to strike any formwork.

20307.16 Removal of Formwork

The removal of formwork and shuttering for ordinary structural concrete shall be carried out in such a manner as will ensure that no shock, vibration or damage to the concrete occurs. No formwork shall be removed before the concrete has attained sufficient strength, so that the concrete shall at no time be subjected to loading, including that from its own weight, which will induce a compressive stress in it exceeding one third of its compressive strength at the time of loading or of the specified 28-day strength. For the purpose of this section, the assessment of the strength of the concrete and the stresses produced by the loads shall be subject to the agreement of the Engineer. For special structural concrete, formwork shall only be removed after such time and/or strength has been determined and specified by the Engineer.

20307.17 Stripping Time

The minimum periods which shall elapse between the placing and compacting of ordinary structural concrete and the removal of the shuttering for various types of faces are given in Table 20300.2 but this will not relieve the Contractor from his obligation to delay removal of the shuttering until the concrete has attained sufficient strength, and the Contractor will be held responsible for and shall make good at his own expense all injury and damage arising from premature removal of the shuttering. A small portion of the shuttering shall be removed to ascertain that the concrete has set sufficiently hard before the whole area of the shuttering is removed.

TABLE 30400.2 Formworks Stripping Times

Type of Formwork	Percent of Specified 28-Day Strength	Minimum Stripping Time
Vertical faces of foundation plinths and precast items	50	1 day
Vertical faces of columns, beams and walls	50	5 days
Undersides of suspended slabs, beams, etc. Slabs Beams	70	10 days 14 days
Props to suspended slabs, beams, etc	70	15 days

20307.18 Protection and Loads of Newly Constructed Work

The periods indicated above assume that the structure is carrying normal dead loads only. The Contractor shall ensure that no loads of such an intensity that will cause damage are applied to newly constructed work. Any damage caused by such overloading shall be made good by the Contractor at his own expense to the satisfaction of the Engineer.

20307.19 Surface Finish

The finished surface of all concrete work shall be sound, solid and free from honeycombing, protuberances and blemishes and shall, if defective in any way, be brought to the attention of the Engineer and made good in a manner directed by him immediately after his instruction is given. No plastering, touching up or making good defective concrete will be allowed without prior agreement of the Engineer.

20307.20 Shuttering

Shuttering shall be provided for all slopes exceeding 15° to the horizontal to enable the concrete to be properly compacted. Where concrete has to be poured against a hard face in lieu of shuttering, the thickness of concrete shall be increased by not less than 100 mm on that face to provide additional cover. Before any concrete is poured against a hard face, all leakage or percolation of water which, in the opinion of the Engineer could cause damage to wet concrete, shall be effectively sealed. In addition, fissures or openings in the hard face which would cause loss of concrete whilst it is wet shall also be effectively sealed. Structural concrete shall not be poured against vertical or inclined rubble fill or earth surfaces in lieu of shuttering.

20307.21 Concrete Bedding Layer

For concrete placed against soil or fill, the bedding layer shall be either 75 mm thick non-structural building concrete or 75 mm thick compacted fine crushed rock covered by an approved impervious PVC membrane, of minimum thickness 0.15 mm.

20307.22 Removal of Forms and Falsework

After the completion of the structure all forms and falsework shall be completely removed but no forms or falsework shall be removed without the consent of the Engineer.

**20308
 Left-in-place
 Formwork**

20308.1 Type and Shape of Formwork

Where it is intended to leave formwork in place after the concrete it supports has been cast, that formwork shall, unless otherwise directed by the Engineer, be of glass reinforced cement. The shape shall be such that no re-entrant angles are presented to concrete being poured and no hindrance shall be offered by the formwork to the compaction of the concrete.

20308.2 Sectional Properties

The sectional properties of the formwork shall be such that the full deadweight represented by the wet concrete can be carried without the permanent deflection of the formwork exceeding one ninetieth of its free span. Where such deflection exceeds 10 mm the formwork shall be provided with a camber sufficient to offset the expected deflection.

20308.3 Materials

The materials used in manufacture of such formwork shall not be aggressive either to concrete or to reinforcement and shall not present a health hazard when cut or worked.

20309 Unformed Surface Finish of Concrete

20309.1 Surface Finish

For finishing of top surfaces on unformed concrete, the following types of finishes will be required.

[Type U.1 Screeded Finish]

Type U. 1 is a screeded finish for surfaces of foundations, beds and slabs to be covered by backfill and subsequent stages of construction. It is also the first stage for finishes U.2 and U.3.

The finishing operation shall consist of levelling and screeding the concrete to produce a uniform, plain or surface, surplus concrete being struck off by a straight edge immediately after compaction. Screed lines shall run in the direction of falls to assist drainage.

[Type U.2 Wood Trowel Finish]

Type U.2 is a trowelled finish for surfaces of beds and slabs where a hard smooth steel-trowelled surface is not required. Trowelling shall be done only after the concrete has hardened sufficiently, and may be by hand. Care shall be taken that the concrete is worked no more than is necessary to produce a uniform surface free from screed marks.

[Type U.3 Trowel Finish]

Type U.3 is a hard smooth steel-trowelled finish for surfaces of tops of walls, copings and other members exposed to weathering, seatings for bearing plates and the like, where the metal is in direct contact with the concrete. Trowelling shall not commence until the moisture film has disappeared and the concrete has hardened sufficiently to prevent excess laitance from being worked to the surface.

The surface shall be trowelled under firm pressure and left free from trowel marks.

20309.2 Tolerance

The permissible tolerances in unformed surfaces for the various classes of finish specified above shall not generally exceed the following limits.

Type U.1 Screeded finish	+15 mm, -10 mm
Type U.2 Wood float finish	+ 6 mm, -3 mm
Type U.3 Steel trowel finish	+ 3 mm, -3 mm

20310 Concrete Mix Design

20310.1 General

The design of concrete mixes shall be the responsibility of the Contractor in accordance with this Specification.

20310.2 Term Concrete

The term concrete shall include all concrete except dry-lean concrete wherever it is incorporated in the Works.

20310.3 Concrete Design

Concrete shall be designed to be dense, impermeable and durable.

20310.4 Grade

The various grades of concrete required for the works are indicated on the Drawings and are defined in Table 20300.3. All grades of concrete shall consist of Ordinary Portland Cement Type I as specified in ASTM C-150-97a mixed with suitable proportions of fine and coarse aggregates with an approved overall grading. The concrete shall be the most suitable combination of lean mix and low water/cement ratio, consistent with the method of compaction, strength and other requirements of this specification.

TABLE 20300.3 CONCRETE GRADES

Concrete Class	Max. Agg Size (mm)	Standard Desing Strength (N/mm ²)		Average Target Strength (N/mm ²)	Standard Slupm (cm)	Minimum Cement Content (Kg/mm ³)	Max. Free Water /Cement Ratio
		28 days	7 days	28 days			
SO: Caisson	20	24	13	29	10±2.5	390	0.55
S1: Wharf, (Reinforced Concrete)	25	24	13	29	6.5±2.0	350	0.50
S2: Block, Foundation	40	18	10	22	5.0±1.5	300	0.55
S3: Drainage, Utility	25	18	10	22	5.0±1.5	300	0.55
S4: Pavement	40	Bend (45 N/cm ²)	-	36	2.5	400	0.45
S5: ICB (Side Walk)	25	25	-	42	5.0	300	0.45
S6: Lean Concrete	25	13.5	NS	17	NS	290	0.60

20310.5 Minimum Cement Content

The minimum cement content of all concrete mixes to be used in the various parts of the works shall be as shown in Table 20300.3.

20310.6 Maximum Cement Content

The maximum cement content shall be 500 kg/m³ except when ambient temperatures exceed 25°C when it shall not exceed 450 kg/ m³.

20310.7 Workability

Workability shall be the minimum consistent with achieving dense well compacted concrete free from segregation, bleeding, honey-combing and surface imperfections. The Contractor shall be responsible for deciding the workability of the fresh concrete, subject to the approval of the Engineer, and shall submit either compaction factor test results or Vebe consistometer tests together with slump test results obtained from the trial mixes. These workability tests shall be in accordance with ASTM C-1077. The Engineer will approve the workability of trial mixes on the basis of either the compaction factor test results or the Vebe consistometer test results. The corresponding slump test results may subsequently be used during production of concrete as a control test only. If there should be doubt as to the workability of concrete measured by the slump test the workability shall be confirmed by either compaction factor tests or Vebe consistometer tests.

Notwithstanding that the Contractor shall be responsible for deciding the workability, the mix proportions after being accepted shall not be altered without the agreement of the Engineer.

20310.8 Classes

Concrete shall be referred to by class group for various combinations of the characteristic compressive strength, maximum aggregate size and minimum cement content. The classes of concrete required for the Works are shown in Table 20300.3.

20310.9 Concrete Specified

Concrete specified by class group is required to fulfill all criteria appropriate to that classification.

20310.10 Approval of All Materials

After approval of all materials to be used in the concrete and at least 4 weeks before the start of placing any structural concrete, the Contractor shall submit for approval the mix design he intends to use based on proportional weights of cement, aggregate and water (with due allowance for dry aggregate water absorption). The Contractor shall prepare trial mixes in the laboratory from representative materials intended for use in the Works. Results from all laboratory tests taken in accordance with ASTM C-1077 shall exceed characteristic strengths required by not less than one third or as the Engineer may approve and demonstrate that free water/cement requirements are met.

20310.11 Trial Mix

No concrete shall be placed in the Works until the trial mix results have been approved by the Engineer.

20310.12 Variation to Mix Design

When the mix has been approved, no variations beyond those permitted by this specification shall be made in the proportions, the original source of cement and aggregates, or in the type, size or grading without the consent of the Engineer who may require further tests to be made.

20310.13 Practical Test

The Engineer may also require practical tests to be made on site by filling trial moulds to confirm the suitability of the mix for the Works. In these tests the type of plant used for the mixing and the steel reinforcement bars shall be similar in all respects to those intended for use in the Works.

20310.14 Factory Made Precast Concrete

When the Contractor intends to purchase factory-made precast concrete units, the Engineer may dispense with trial mixes and laboratory tests provided that evidence is given which satisfies him that the factory regularly produces concrete which complies with the Specification. The evidence shall include details of mix proportions, water/cement ratio, workability and strengths obtained at 7 and 28 days.

20310.15 Temperature

The Contractor shall submit calculations showing the maximum temperature rise in mass concrete pours of 25 m³ volume, or greater, and any reinforced concrete member with a least dimension exceeding 1 m between faces, for the mix designs he proposes.

20311 Batching and Mixing Concrete

20311.1 Equipment

At least four weeks prior to carrying out any concrete works the Contractor shall submit to the Engineer for approval details of the batching and mixing equipment he proposes to use including the manufacturer's name, type of plant and estimated output. The plant shall be sufficient to meet requirements without overloading.

20311.2 Weigh of Aggregates, Water and Cement

The quantities of the ingredients shall be accurately gauged by weight before being mixed dry together. The aggregates shall be weighed separately for each size and the cement shall be weighed in a different container from that used for the aggregates. The weighing machines shall be of an approved type and manufacture and shall be fitted with scales which shall indicate the weight of each ingredient of the batch to an accuracy of ± 2 per cent. The range of the weighing machine shall not exceed twice the normal working load. Water shall be gauged either by volume or by weight to an accuracy of ± 2 per cent.

20311.3 Calibration of Batching plant

The weighing machines shall be maintained in a clean condition. Calibration shall be done under the supervision of the Engineer over the scale ranges, by placing known weights certified by an acceptable testing agency in the weighing compartments before commencement, and thereafter at least once for every 1,000 tonnes of material weighed or not less than once per week. Calibration of water measuring device shall also be done.

20311.4 Water Content

The water content of the aggregates shall be determined before mixing is commenced on every day that concrete is to be produced. Samples for determining the water content shall be taken from those stocks of aggregates which will be used during the day. When no precipitation occurs, the water content of the aggregates shall be checked once more during the day, after such time as the Engineer shall agree. During precipitation the water content shall be checked every two hours unless otherwise directed. The weighed quantity of aggregates shall be such that the correct weight of dry aggregates is taken into the batch mix and the amount of water added to the mix shall take into account the water content of the aggregates. All testing for water content, the frequency of testing and calculations of batch proportions shall be subject to the Engineer's approval.

20311.5 Mixing Plant

All concrete shall be mixed in power driven machines of approved type and capacity. The capacity of the mixing plant shall be such that the planned peak production rate and continuity of output are maintained under normal working conditions. The mixing plant shall comply with ASTM C-94.

The mixing time, speed and operation shall be those used by the mixer manufacturer to assess its performance and the Contractor shall submit manufacturer's data sheets to the Engineer for approval of the equipment. The type of plant shall be such that the concrete in the mixers may be observed and the consistency checked visually during the process of mixing.

20311.6 Mixing Temperature

Where concrete is batched and mixed in ambient temperatures exceeding 25°C batching and mixing plant shall be painted with a gloss finish white paint and kept clean on the outside as well as the inside. Batching and mixing plant shall be protected from the sun and from the wind to prevent loss of cement.

20311.7 Mixing Time

Mixing times shall be only as long as necessary to produce a uniform concrete mix. Water shall be added only when all the dry materials have been thoroughly mixed.

20311.8 Ready Mixed Concrete

Ready-mixed concrete, batched off the Site, may be used only with the agreement of the Engineer and shall comply with all requirements of the Contract. The concrete shall be carried in purpose-made agitators, operating continuously. The Contractor shall ensure that the concrete has not stiffened in the interval between batching and arrival on site. Batching times shall be recorded on the delivery notes. When truck-mixed concrete is used, water shall be added under supervision, either at the Site or

at the central batching plant, as agreed by the Engineer but in no circumstances shall water be added in transit. The time of water introduction shall be recorded on the delivery note. The ready-mixed concrete supplier shall provide the Engineer with inspection and testing facilities equal to those required by this contract for concrete batched on Site.

20311.9 Loading and Mixing of a Batch

The entire contents of the mixer shall be discharged from the drum before materials of a succeeding batch are loaded for mixing. No mixer having a rated capacity of less than one-bag batch shall be used nor shall a mixer be charged in excess of its rated capacity.

20311.10 Mixers

Mixers which have been out of use for more than 30 minutes or if the type or grade of mix is to be changed, shall be thoroughly cleaned before any fresh concrete is mixed. Unless otherwise agreed by the Engineer, the first batch through the mixer shall be a grout mix sufficient to coat blades, pan and discharge chute of the mixer. Mixing plant shall be thoroughly cleaned before changing from one type of cement to another. Concrete which has developed its initial set or has partially hardened shall not be re-mixed.

20311.11 Hand-mixing

No hand-mixing of concrete shall be permitted for structural or blinding concrete. If the Engineer permits the hand-mixing of concrete for temporary or non-structural work the designed or approved cement content of each batch shall be increased by one tenth. The size of each batch shall not exceed 0.1 cu. m. Mixing shall be carried out on a properly constructed timber platform with closed joints so to as avoid the loss of any grout or on a stone or concrete floor of adequate size to permit thorough mixing. The dry materials of the batch shall be thoroughly mixed by turning them over at least twice. Water shall then be added by a metering device after which the whole mixture shall be turned over until it has been thoroughly mixed.

20311.12 Workability

The workability of the concrete shall be measured at least once every two hours or as directed by the Engineer.

20311.13 Workability

Concrete will not be accepted for inclusion in the Works unless its workability is within the following limits of that measured and approved for the relevant trial mix.

Slump ± 25 mm or \pm one third of the required value, whichever is the greater;

Compaction ± 0.03 , where the required value is 0.90 or more;
 ± 0.04 , where the required value is less than 0.90 but more than 0.80;

± 0.05 , where the required value is 0.80 or less

The "required value" is the value for the approved design mix and all tests shall be in accordance with ASTM C-1077.

20311.14 Workability Test

The workability of the first batch of concrete for every grade produced on any day shall be measured either by the compaction factor test or the Vebe consistometer test. Comparative slump tests shall also be taken.

20311.15 Maintenance of Plant

All plant shall be properly maintained to the satisfaction of the Engineer

**20312
Transportation
and Placing
Concrete**

20311.16 Operator of Plant

At all times batching and mixing shall be carried out by an experienced operator.

20311.17 Cement Mortar

Cement mortar shall, unless otherwise specified or ordered, consist of one part of cement to three parts of fine sand by volume, mixed and thoroughly incorporated together with just enough water to render it workable.

20312.1 Transportation and Discharges

The concrete shall be discharged from the mixer and transported to the Works as quickly as practicable by means that shall be approved by the Engineer and which shall prevent adulteration, segregation or loss of ingredients, and ensure that the concrete is of the required workability at the point and time of placing.

20312.2 Prior to Concrete Placement

All concrete surfaces, formwork and reinforcement bars against which concrete is to be placed shall be properly prepared before mixing is commenced. Concrete droppings or grout shall be removed, reinforcement bars or metal items to be embedded or surrounded by concrete shall be free from any loose rust, mill scale or mould oil and other deleterious matter, and all surfaces against which concrete is to be placed shall be thoroughly cleaned. Formwork shall be free from standing water. The Contractor shall allow for and use mechanical or other means of removal of all foreign matter from these surfaces and provide all necessary temporary openings in the formwork for such removal. Concrete shall not be placed against concrete of a different designation until the concrete previously placed has properly hardened unless otherwise agreed by the Engineer.

20312.3 Blinding Concrete

Blinding concrete to foundations shall be a minimum of 50 mm in thickness and of the same class of concrete as that specified for the foundation.

20312.4 Placing Concrete

Concrete shall not be placed in any part of the Works until the Engineer's approval has been received. A system of inspection sheets shall be implemented for authorization by the Engineer and his nominated staff.

20312.5 Concreting

If concreting is not started within 24 hours of approval being given, approval shall again be obtained from the Engineer. Concreting shall then proceed continuously over the areas between construction joints.

20312.6 Temperature at Placing

The temperature of the concrete when deposited, shall not exceed the values shown in Table 20300.4. It shall be compacted in its final position within 30 minutes of discharge from the mixer. If the Contractor needs to use ice, cold water and/or a Chiller to keep the temperature below 32 °C no additional payment shall be done, in any case the Engineer shall approve the most appropriate cooling technique.

Table 20300.4 Permissible Concrete Temperatures at Placing

Thickness		Temperatures, °C	
		Minimum	Maximum
Of section, m			
Less than	0.3	10	35
	0.3-1	10	30
	1-2	5	25
More than	2	5	20

20312.7 Drop Height

Unless otherwise agreed by the Engineer concrete shall not be dropped into place from a height exceeding 1.5 metres. When trunking or chutes are used they shall be kept clean and used in such a way as to avoid segregation.

20312.8 Placement of Concrete in Layers

Concrete shall be placed in horizontal layers to a compacted depth not exceeding 450 mm where internal vibrators are used, or 300 mm in all other cases. Procedures for placing and compacting concrete in the Works shall be to the approval of the Engineer and shall be decided by the Contractor prior to commencement of concreting. Where concrete is to be placed in multiple layers, each layer shall be continuous and unless otherwise directed by the Engineer shall be placed and compacted while the concrete in the immediately underlying layer is still workable. When the concrete is placed in more than one layer, compaction of a layer shall extend into the underlying layer to ensure there is no segregation between successive layers but care shall be taken to avoid any disturbance of partially set layers which have been previously placed. Over-vibration shall be avoided.

20312.9 Subsequent Layers

If during concreting a previously placed layer or edge of concrete has set before a subsequent layer has been placed, concreting shall be stopped and the placed concrete cut back to a sound face at the Contractor's cost.

20312.10 Pumping

Placement of concrete by pumping will be permitted only if authorised by the Engineer in writing after approval of a modified mix design and preliminary trials as specified.

20312.11 Concrete Compaction

All concrete shall be compacted to produce a dense homogeneous mass. Unless otherwise agreed by the Engineer, it shall be compacted with the assistance of vibrators capable of transmitting frequencies of not less than 6000 cycles per minute and capable of imparting an acceleration of 69 units to the concrete immediately in contact with them. Sufficient vibrators in serviceable condition shall be on Site so that spare equipment is always readily available in the event of breakdowns. Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. Internal vibrators shall be inserted and withdrawn out of the concrete slowly. The vibration shall be of sufficient duration and intensity thoroughly to compact the concrete, but shall not be continued so as to cause segregation. Vibration shall not be continued at any one point to the extent that localised areas of grout are formed. Where immersion type vibrators are used, contact with reinforcement and all inserts shall be avoided, so far as practicable. Vibration shall not be used to make concrete flow in the forms over distance so great as to cause segregation, and vibrators shall not be used to transport concrete in the forms. Concrete shall be compacted in its final position as soon as it is placed in the forms but no later than 30 minutes after being placed.

20312.12 Slabs Compaction

Slabs not exceeding 150 mm in thickness may be compacted and screeded by a mechanically vibrated tamping beam of a type approved by the Engineer.

20312.13 Concrete Pumps

Where concrete is conveyed and placed by mechanically pumped pressure, the equipment shall be suitable in kind and adequate in capacity for the work and shall be so arranged that no vibrations result which might damage freshly placed concrete. The operation of the pump shall be such that a continuous stream of concrete shall be

ejected where it is to be used in such a manner that there will be no contamination of the concrete or separation of the ingredients. After completion of each concreting operation, the entire equipment shall be thoroughly cleaned.

20312.14 Cleaning of Plant

All plant used for placing and compacting concrete shall be kept clean and free from coats of hardened concrete, grout or other obstructions.

20312.15 Lighting

The Contractor shall provide adequate lighting, to the satisfaction of the Engineer, at such places where approval has been given for transportation or placing of concrete at night or where daylight is excluded or may be restricted during the concreting operations. Low voltage lighting shall be provided for overwater concreting operations.

20312.16 Steel Fixer and Carpenter

During the placing of concrete, a competent steel fixer and carpenter shall be in constant attendance, so as to make any necessary adjustment or correction of the reinforcement and formwork.

20312.17 Protection from Sea Water

The Contractor shall take all reasonable precautions to prevent sea water or sea spray from affecting concreting operations. In areas likely to be so affected, the formwork shall be adequately protected and all parts which are found to be affected shall be thoroughly washed down with clean fresh water. Under no circumstances shall concrete be contaminated by salt water during placing.

20312.18 Approval of Methods to Protect Concrete

The Contractor shall submit to the Engineer for approval before concreting, details of his proposed methods for placing and protecting concrete during adverse climatic conditions. All protective equipment, covering and the like for concreting operations during such conditions shall be ready for deployment at locations where protection may be required before placing of concrete is commenced.

20312.19 Plant Breakdown

If concreting is suspended due to plant breakdown or for any cause, a stop-end shall be formed square to the work without delay. Should the period of suspension not exceed thirty minutes, concreting may be recommenced provided that the surface is first cleaned. The fresh concrete shall be tamped so as to be contiguous with the concrete previously placed, to the satisfaction of the Engineer. Should the period of suspension exceed thirty minutes no further concreting shall be carried out until the previously placed concrete has hardened and its surface has been prepared as a construction joint. Where the concrete is visible, such as in exposed faces of a retaining wall etc., it shall be cut back to a horizontal construction joint to the extent and in a manner approved by the Engineer before concreting is recommended.

20312.20 Records

A complete record shall be kept by the Contractor of the date, time and placing of all grades of concrete in each portion of the work and this shall be available for inspection by the Engineer at any time. The Contractor shall supply suitable maximum/minimum thermometers and the records the ambient shade temperature adjacent to the concrete mixer and to all parts of the Works where the concrete is being placed. A record of the daily maximum and minimum temperatures during concreting shall be kept on Site and a copy shall be given to the Engineer each week during which concrete is placed.

20312.21 Finishes According to Drawings

Unformed concrete surfaces shall be screeded floated or trowelled to produce the finishes shown on the Drawings and specified herein. Before the initial set takes

place the surfaces shall be rescreeded, floated or travelled where necessary to close up cracks and prevent excessive bleeding.

**20313
Construction
Joints**

20313.1 Position and Detail

The position and detail of any construction joints not described in the Contract shall be subject to the approval of the Engineer and shall be so arranged as to minimise the possibility of the occurrence of shrinkage cracks.

20313.2 Upper Surface of Lifts

The upper surface of lifts of concrete walls and columns shall be horizontal unless otherwise described in the Contract and if the formwork extends above the joint on the exposed face it shall be cleaned of adhering concrete before the next lift is placed.

20313.3 Vertical and Inclined Construction Joints

Vertical and inclined construction joints shall be formed by the insertion of rigid stopping off forms so constructed that no loss of materials occurs through the joints. Temporary stopping-off forms shall be stripped as soon as practicable and in all cases within 24 hours of completion of placing. Sacrificial stopping-off forms may be permitted, subject to the approval of the Engineer, but the Engineer may still order that they will be removed on occasions where he has reason to suspect that, for example, honey-combing has occurred because of grout loss. Unless otherwise agreed or directed by the Engineer exposed faces of the concrete at the joints shall be thoroughly washed with a fine spray from a high-pressure hose and brushed, where practicable, with wire brushes as soon as the concrete is sufficiently hardened or by other approved means so as to remove laitance and expose the coarse aggregates.

20313.4 Horizontal Constructions Joints

Horizontal construction joints shall be washed with a fine spray of water from a high pressure hose within two hours of the completion of placing to expose the aggregate. Care shall be taken to ensure that no disturbance or loosening of the aggregate, or cracks or other defects in the concrete are caused.

20313.5 Unsatisfactory Treatment

Should the treatment of a construction joint by the methods described above not be satisfactory then the whole joint surface except for a strip 38 mm wide adjacent to exposed faces shall be scabbled to a depth of 13 mm.

20313.6 Exact horizontal Straight Finish

The Contractor shall take all necessary steps by means of timber edgings etc. to ensure an exact horizontal straight finish to the outside edge of any lift of concrete. This shall also apply to all vertical joints or to any stoppage joints which may occur during the construction of the work, the lines of which shall be straight and regular. Where a 'feather edge' might be produced at a construction joint, as in the sloped top surface of a wing wall, an insert formwork shall be used to produce a blocked-out portion in the preceding layer which shall produce an edge thickness of not less than 15 cm in the succeeding layer.

20313.7 Cleaning after Placement of Concrete

Immediately after the placing of concrete, all accumulations of mortar splashed on the reinforcing steel and the surface of forms shall be removed. Dried mortar chips and dust shall not be puddled into the unset concrete. If the accumulations are not removed prior to the concrete becoming set, care shall be exercised not to injure or break the concrete-steel bond at and near the surface of the concrete, while cleaning the reinforcing steel.

20313.8 Layout Drawings and Concreting Programs

The Contractor shall prepare and submit layout drawings and concreting programs for the Engineer's approval in adequate time prior to preparation for concreting to

enable any changes the Engineer may consider necessary to be made.

20313.9 Surface of Constructions Joints

Immediately before placing fresh concrete against faces of previously placed and hardened concrete, the surface of construction joints shall be thoroughly cleaned and wetted.

20313.10 Keyways

Keyways shall be formed in all horizontal and vertical construction joints except where ordered to be omitted by the Engineer. Keyways shall be accurately formed to approved dimensions with formwork which will not be displaced during concreting.

20313.11 Contraction Joints

Contraction joints, where required, shall be formed as deliberate planes of discontinuity in the concrete structure. The face of the concrete which is first placed shall be painted with two coats of an approved rubber bitumen paint before placing the adjoining concrete.

20313.12 Expansion Joints

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 laced in the joint to provide freedom for two adjacent concrete slabs or blocks to expand. The exposed edges of the joints shall be sealed with an approved synthetic rubber or similar resilient sealing compound.

20314

Curing Concrete

20314.1 General

All concrete shall be properly water-cured to the satisfaction of the Engineer. The concrete shall be protected from harmful effects of, for example, sunshine, wind, rain-fall, water and shock. All water for curing concrete shall be of mixing quality. Curing compounds will not be permitted except with the Engineer's approval and then only after the specified water curing has been satisfactorily carried out. No additional payments shall be allowed for the use curing compounds.

20314.2 Impermeable Sheeting

For the top exposed surfaces of concrete substantially free from starter bars or other obstructions, every part of the exposed surface shall be covered with polythene or similar impermeable sheeting immediately after finishing. The sheeting shall be in direct contact with the concrete or as directed by the Engineer where some initial separation is necessary to obtain a particular surface finish. The sheets should overlap adjacent sheets at the edges, and they should be fixed down at the ends and edges, to prevent air circulating over the concrete.

20314.3 Wet Hessian

As soon as the concrete has stiffened sufficiently, and in any case after not more than 24 hours, the sheeting shall be removed and the surface, covered with wet hessian. The sheeting shall be replaced immediately to reduce evaporation from the hessian. Additional water should frequently be introduced under the polythene sheeting to keep the hessian thoroughly and permanently wet. For top surfaces curing shall continue for not less than 28 days or such other time as the Engineer may direct. Ponding shall only be used where approved by the Engineer.

20314.4 Shades

Horizontal surface (e.g. slabs or floors) should be shaded from the sun by means of hessian or shade-netting on frames for 14 days after construction.

20314.5 Wet hessian – Vertical Surfaces

On removal of the formwork to vertical surfaces the concrete shall be closely wrapped with wet hessian and enclosed with polythene sheeting. Battening shall be

used to keep both hessian and polythene lightly in contact with the walls. The hessian shall be kept wet by frequent additions of water, and it shall be retained in position for not less than 28 days or such other times as the Engineer may direct.

20314.6 Vertical Surfaces – Curing Compound

On removal of the hessian and sheeting, the concrete shall be sprayed with an approved curing compound as soon as it is just surface dry.

20314.7 Shades - Walls

Walls facing the sun shall be shaded using hessian or shade-netting for 14 days after construction.

20314.8 Water Spraying

Water spraying may be sparingly used with the approval of the Engineer for curing inaccessible areas, but great care shall be taken to prevent the cooling action of a water spray from causing sudden thermal contraction on warm concrete surfaces.

20314.9 Thermal Insulation

Thermal insulation to large concrete pours shall be provided at the request of the Engineer.

20314.10 Curing Compound

If the Engineer approves the use of a curing compound it shall be applied in the manner and at the rate recommended by the manufacturer. Where spraying equipment is used, it shall be maintained in a thoroughly clean condition and shall not be used for any material other than the approved curing compound. The curing compound shall be applied to the surface of the concrete as soon as water curing has been finished but any free water allowed to dry out before the compound is applied. Care shall be taken not to damage the surface during the application. If the period of drying out exceeds one hour, water curing shall continue until conditions enable the surface to be dried within 1 hour and the curing compound applied.

20314.11 Wetter Absorbent

Where a wetted absorbent covering is used, the Contractor shall ensure that the covering is kept continually damp and that in no circumstances shall alternate wetting and drying occur. The Engineer may prohibit the use of wetted absorbent covering where the surface being protected is likely to be cooled excessively by drying winds and in such cases, the Contractor shall submit alternative proposals to the Engineer for approval.

20314.12 Protection to Newly Cast Surfaces

The Contractor shall take steps to prevent any damage to newly cast surfaces. Suitable barriers and warning notices shall be erected to prevent access over concrete which has been recently placed, and no plant, equipment and the like shall be placed thereon until the surface is hard enough to bear such loads without damage. Edges, corners and other areas shall be adequately protected against accidental damage.

20314.13 Protection Plan

The Contractor shall submit details of the proposals for curing and protecting each section of the work for the approval of the Engineer before placing any concrete or any precast units are cast. For areas, likely to be affected by sea water or salt water spray, proposals describing how the concrete is to be effectively protected there from up to the time when it has sufficiently hardened shall also be submitted for approval.

20314.14 Accelerated Curing

Accelerated curing will not be permitted except where approved by the Engineer.

**20315
Concrete
Sampling,**

20315.1 Test Cubes

Test cubes 150 mm in size shall be taken from the concrete mixes and tested as specified to check that the concrete complies with the Specification. These tests

**Testing and
Control**

shall be in accordance with JIS A 1108, ASTM C-39 and ASTM C-873.

20315.2 Acceptability of Concrete

The acceptability of the concrete shall be judged on the 28-day test results in accordance with JIS A 1108, ASTM C-39 and on the density and appearance of the concrete. Test results from 7-day old cubes, or cubes cured and tested in an approved accelerated testing programme, may be used only as a guide or indication of the acceptability or otherwise of the concrete.

20315.3 Number of Testing Specimens

A set of six cubes shall be made from each sample, two for testing at 7 days and four at 28 days. At least one set of cubes shall be taken from concrete of each particular grade each day the concrete of that grade is used. The actual rate may be modified by the Engineer.

20315.4 Concrete Failing to Comply Specifications

The action to be taken should the concrete not be acceptable will depend on the circumstances. Should any 7-day or earlier test indicate that the concrete may fail to comply with the Specification, the Engineer shall be informed immediately. Props, falsework and other supports shall not be removed without the approval of the Engineer who may order further tests to be carried out at his discretion.

20315.5 Modifications of Mix Desings

Where the control tests specified above and the provisions of ACI or ASCE show that mix proportions should be modified, the Contractor shall give details of the proposed modifications to the Engineer for his approval together with details of the results of trials upon the new mix before the new mix is used in the Works. Failure to modify the mix proportions adequately to maintain the specified requirements of the concrete and early enough to permit trial mixes to be tested may result in an instruction by the Engineer to the Contractor requiring him either to use prescribed proportions until such time as agreement on a mix design is reached or to cease concreting operations. Any additional cost arising from modifications of mix proportions necessary to satisfy the requirements of the Specification or the temporary use of prescribed proportions, or as a consequence of any order to cease concreting operations or for any other reason shall be borne by the Contractor. The contractor shall be permitted no extension of time for delays resulting from an order made under this clause.

20315.6 Additional Testing

If additional tests are ordered by the Engineer over and above those specified herein, he shall direct the Contractor to carry them out, without additional cost.

**20316
Precast
Concrete**

20316.1 Handling of Precast Concrete

Precast concrete shall be lifted or supported only at points described in the Contract and shall be handled and placed without impact.

20316.2 Fabrication of Precast Units

Precast concrete units shall be fabricated with concrete of the specified class placed into a grout-tight mould. If so required the mould shall be laid on a vibrating table and vibration applied while the concrete is placed. In all other cases the concrete shall be compacted as required by other relevant clauses of this Specification.

20316.3 Finish

Permanently exposed surfaces shall have a finish obtained by casting the unit in properly designed moulds of closely-jointed wrought boards or steel or other suitable material or as otherwise specified. The surface shall be improved by carefully removing all fins and other projections, thoroughly washing down and filling surface blemishes with a cement and fine aggregate paste matching the colour of the

concrete.

20316.4 Precast Suspended Slabs

In the case of precast suspended slabs, where the underside will be exposed, they may be cast upon a specially prepared smooth concrete surface which has been treated with an approved release agent. The edges of a slab cast in this way shall be formed by steel or timber shutters bolted rigidly to the concrete casting bed.

20316.5 Surface Preparation for After Casting

Surface which will subsequently receive grout or concrete to complete a structural connection or other composite structural component of which the precast unit forms a part, shall be prepared as early as possible after casting. The preparation shall be carried out preferably when the concrete has set but not hardened, by spraying with a fine spray of water and brushing with a stiff brush, just sufficiently to remove the outer mortar skin and to expose the large aggregate without its being disturbed. Where this treatment is impracticable, sand blasting or a needle gun shall be used to remove the surface skin and laitance providing the concrete is more than 24 hours old. Hacking shall be avoided.

20316.6 Precast Concrete Units from Outside Suppliers

The Contractor will be permitted to obtain precast concrete units from outside suppliers provided that they comply with the Specification and that the Contractor obtains the Engineer's approval for each supplier. Such supplier shall provide all those facilities for inspection by the Engineer required by this Contract for similar work on Site.

20316.7 Movements of Precast Concrete Units

No precast concrete units shall be removed from the casting beds until the cubes representing them reach a strength not less than that specified as the minimum works cube strength at seven days for the class of concrete concerned. Similarly no units shall be set in place until the cubes representing them reach a strength not less than that specified as the minimum works cube strength at twenty-eight days for the class of concrete. All units shall be clearly and indelibly marked with a serial number and date of casting.

20316.8 Plan for Handling Precast Concrete Beams and Units

The Contractor shall give the Engineer full details of his proposed methods of handling precast concrete beams and units. The Engineer will examine these details and will either approve the methods or order modifications designed to ensure that no excessive stresses are set up in the beams or units. Concrete shall at no time be subjected to loading, including its own weight, which will induce a compressive stress in it exceeding one third of its compressive strength at the time of loading or of the specified twenty-eight day strength.

20316.9 Bearing Surface Preparation

Where precast units, other than armour units and blocks for quay wall construction, are to be placed in the Works on an unyielding surface, the bearing surface shall be coated with a layer of cement mortar of 10 mm nominal thickness or of such a thickness as to achieve the specified levels, with the precast units being bedded while the mortar remains in a plastic state. Any mortar extruded during bedding shall be removed immediately and the joints shall be struck clear.

20317 Reinforcement Bars

20317.1 Shop Drawings

Shop drawings, bending schedules, and installation drawings for all reinforcement bars shall be prepared by the Contractor and submitted to the Engineer for approval prior to fabrication. Details shall conform to the requirements of Standard Specifications of Concrete, (hereinafter referred to as SSC) published by the Japan Society of Civil Engineers (JSCE) Clause 183 or ASTM A-615.

The Engineer's approval does not relieve the Contractor in any way of his responsibility for accuracy and/or completeness of the detailing work.

20317.2 Workmanship

The reinforcement bars shall be bent in accordance with ASTM A-615 or SSC (JSCE) Clause 138 except where otherwise specified.

No reinforcement bars shall be bent when in position in the Works, whether or not it is partially embedded in hardened concrete, unless specifically authorized by the Engineer.

The reinforcement bars shall be kept accurately in position by spacers and chairs secured tightly to the cage. Bars intended to be in contact with other bars shall be wired together at all points of contact with binding wire as specified. The type of spacers and chairs used shall be subject to the approval of the Engineer, and any part of a metal spacer or chair shall have at least the same cover as specified for the reinforcement bars. Mortar blocks shall be of the same strength as the parent concrete. No binding wire may project into cover concrete.

No splices shall be made in the reinforcement bars except where shown on the Drawings or where approved by the Engineer. The length of splices shall be as specified in ASTM A-616 or SSC (JSCE) Clause 20 except where otherwise shown on the Drawings.

Immediately before concreting, the reinforcement bars shall be examined for accuracy of placing and cleanliness and corrected if necessary. No concreting shall take place before inspection and approval of the reinforcement bars by the Engineer. Reinforcement bars projecting from work being concreted or already concreted shall not be bent out of its correct position without the approval of the Engineer and shall be protected from deformation or other damage by tying the reinforcement bars to adequate scaffolding or other supports.

Reinforcement bars projecting horizontally at construction joints shall be supported in correct position during concreting by providing sufficient scaffolding and spacer pieces to which the reinforcement bars shall be tied and held in place.

The concrete cover measured over the reinforcement bars shall be as shown on the Drawings. A tolerance of ± 4 mm will generally be permitted.

SECTION 20400 DREDGING

20401 Scope of Work

The scope of the works covers the dredging of all materials from within the areas for vessel manoeuvring, (turning basin and passenger turning basin), berthing areas, inner and outer access channels, and the construction of the reclamation areas and protective works as shown on the drawings and described in this Specification. The works shall include, but shall not necessarily be limited to:

- (a) Initial survey (before any dredging operation begins and progress and final surveys.)
- (b) Dredging of all materials to line and level including removal of any siltation which may occur to the Works.
- (c) Construction of temporary revetments and bunds for onshore dumping areas.
- (d) Disposal of materials rejected by the Engineer at areas allocated for the purpose.
- (e) Dumping of suitable materials on the reclamation areas.
- (f) Monitoring of environment and environmental protection measures.
- (g) Short distance relocation of live or dead sub-marine cables.

20402 Reclamation Direction

The Contractor shall fill the reclamation area from west to east with suitable dredged material accepted by the Engineer, Notwithstanding this requirement, the Employer reserves the right to instruct the Contractor, through the Engineer, to reclaim from south to north. Such an instruction to change direction, can be made only once.

20403 General Requirements

The following general requirements are applicable:

- a) The Contractor shall be deemed to have satisfied himself as to the Site conditions and other particulars whatsoever in connection with the dredging and dumping works.
- b) During the execution of the Works the Contractor shall ensure that his floating craft, floating pipelines, plant and equipment, and any staging or other temporary works provide minimal interference, prevent or obstruct the navigation of vessels in the existing approach channel or to other existing ports in the area. Any existing submerged pipelines or any other utilities crossing the approach channel or the port basin shall be handled in a way as to minimize disruption of services.
- c) The Contractor shall provide lights, markers, notices etc. at all times and place as may be required by concerned Authorities or the Engineer to indicate the dredging activity and working areas.
- d) The Contractor shall provide Radio Telecommunication between floating equipment and offices as specified in this Specifications
- e) Competent Dredging Officers, Hopper and Tug Masters shall be employed by the Contractor on all ships to ensure proper supervision of the Works.

- f) Dredged depths shall be maintained at the Contractor's expense until the date of certified completion for the dredging and disposal works.

**20404
Plant and
Method of
Dredging**

Notwithstanding requirements as to the submittal of method of work statements as part of the Conditions of Contract and the Tender Proposal, the Contractor shall submit a detailed statement of working methods within (thirty) 30 days after the issue of the Notice to Proceed.

The detailed statement shall include at least:

- Type of equipment proposed for dredging and disposal operations, including details of performance, both floating and land based.
- Working method and sequencing of dredging and disposal works; including details of production output/cycle times/control and monitoring of production output.
- Type of survey and accuracy of positioning equipment
- Safety, communications, plan for unobstructed free movement of vessels.
- Method of controlling and monitoring progress.
- Method of controlling and monitoring environmental requirements.
- Evidence to demonstrate that all the construction plants are of adequate capacity to complete the Works within the required time.

**20405
Limits and
Levels of Areas
to be Dredged/
Dumping**

The horizontal limits of the areas to be dredged/dumping are shown on the Drawings. The steepest side slopes around the dredged areas and the levels to which the areas shall be dredged are similarly shown on the Drawings. Stable dredged side slopes shall be formed outside those limits. No dredging except that necessary to form stable side slopes shall be carried out beyond such limits or levels as shown on the Drawings without the written authority of the Engineer.

The required dredged levels shown on the Drawings shall be attained over the whole of the areas to be dredged. Any high areas that remain after dredging shall be redredged to the required level.

**20406
Positioning
Surveys and
Soundings**

The Contractor shall install, operate and maintain a Global Positioning System (GPS) acceptable to the Engineer, which shall fully cover the site of the Works and be constantly in operation during the course of the dredging and the dumping works.

Type of GPS: RTK 500 or equivalent.

The GPS system shall consist of Base Station and Moving Station.

The GPS system shall be installed, tested and set to work for continuous operation during all dredging and survey operations. The system shall be fully operational, a minimum of 7 days before surveying operations commence including.

Field Calibration and base line check.

Once operational the GPS system shall remain in continuous operation until the last post-dredging survey is completed and the last post-dredging survey drawings has been signed and accepted by the Engineer.

The Global Positioning system should have one hundred percent build-in standby equipment to cater for the failure of any individual components.

The Global Positioning System shall at all times maintain repeatable accuracy, for any point within the work site of plus or minus 0.5 m in the horizontal planes.

The Contractor shall maintain an adequate stock of spare parts and exchange units on site to avoid disruption of the monitoring programme.

Before the commencement of dredging/dumping, the whole of the areas to be dredged/dumping and used for disposal of rejected material, together with any adjacent areas the levels of which might be affected by the dredging/dumping, are to be surveyed and sounded and plans and sections are to be drawn accordingly. The survey work is to be carried out by the Contractor in the presence of the Engineer in accordance with the detailed directions and requirements of the Engineer. The plans and sections shall, when mutually agreed, be signed by the Engineer and the Contractor as truly representing the configuration of the areas at the commencement of dredging, reclamation and dumping.

Echo soundings shall be taken in the presence of the Engineer using equipment which shall be to the approval of the Engineer.

Multi-frequency recording echo sounders with operating frequencies of approximately 210 KHz and 30 KHz shall be used. Unless otherwise approved by the Engineer, a frequency of 210 KHz shall be used for pre-and post-dredge surveys

Calibration by bar check shall be carried out by the Contractor to the satisfaction of the Engineer at the commencement, during, and on completion of every use of an echo sounder. Calibration checks shall be repeated until the echo sounding has been shown to be within ± 5 cm of the bar depth.

The Contractor shall maintain an adequate stock of spare parts and exchange units on site to avoid disruption of the construction program.

The sea bed levels of the areas to be dredged or reclaimed as shown on the Drawings are solely for the purpose of guidance and assistance in estimating the extent of the Work.

Before the Engineer accepts that the dredging has been completed the Contractor shall demonstrate by means of soundings, surveys, and/or sweeping that the Work has been executed to the required lines, levels and slopes. Such soundings, surveys and sweeps shall be carried out in the presence of the Engineer. Where areas are shown not to have been dredged to the required lines, level and slopes, the Contractor shall return and remove all high spots or trim slopes to the satisfaction of the Engineer.

At the conclusion of dredging and final surveys, plans and sections shall be made and the appropriate plans and sections shall, after due agreement and signed confirmation by the Engineer and the Contractor, be deemed to represent the final configuration of the dredging of the specified area.

Spacing between sounding lines shall comply with the following table unless otherwise instructed by the Engineer. Cross lines shall be perpendicular to the main sounding lines. All lines shall wherever possible be extended beyond the dredging edges as described in the table.

	Main Sounding Line Interval (m)	Cross Line Interval (m)	Line Extension Beyond Edges (m)
Port Basin	10	50	100
Reclamation Area	10	50	100

Approach Channel	10	50	100
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Upon receiving 48 hours notice from the Contractor of his intention to carry out a pre-or post-dredging hydrographic survey, and interim measurement or a siltation/maintenance survey, the Engineer will provide an Inspector to verify the acceptability of such work. No such survey will be accepted which has been carried out without an Inspector on board the survey vessel.

The Engineer reserves the right to order levels and soundings to be taken at any time as necessary for the proper supervision and measurement of the work.

The contractor shall carry out regular interim hydrographic surveys for the purpose of dredging control and the calculation of volumes for progress payment purposes as directed by the Engineer.

Prior to the final acceptance of the dredging works the Contractor shall notify the Engineer in writing that all the dredging works have been completed and that he intends to carry out the post dredging hydrographic survey. The post dredging hydrographic survey shall include areas used for disposal of rejected material and/or silt ponds as well as areas of the exiting port surveyed for siltation and maintenance dredging.

Upon receiving at least 48 hours notice from the Contractor of his intention to carry out a post dredging hydrographic survey the Engineer will provide an Inspector to verify the accuracy of such work. No post-dredging hydrographic survey will be accepted which has been carried out without an Inspector on board the survey vessel.

If it is subsequently shown by the post-dredging hydrographic survey that all material has not been removed to the satisfaction of the Engineer then following completion of further dredging work the entire dredging area and not merely the areas re-dredged will again be sounded before any subsequent post dredging hydrographic survey will be accepted by the Engineer.

Requirements for the post-dredging hydrographic surveys and predredging hydrographic surveys shall be as previously specified.

The Contractor shall make due allowance in his rates for dredging work for the removal of any sedimentation or siltation of the Works which may occur during the execution of the Works.

It is the Contractor's responsibility to ensure that the dredging works have achieved the required depths and profiles shown on the Drawings at the final acceptance of the Works by the Engineer. No additional payments shall be allowed for areas that due to siltation or any other reason does not meet the required dredging dept in the final post-dredging survey which shall take place immediately before the day of final approval of the whole project.

**20407
Disposal of
Dredged
Material**

Material shall be disposed of at three locations. Two onshore locations are for the disposal of material suitable for land reclamation and one offshore location is for the disposal of all the other dredged material. The offshore disposal area is limited by the following local lamber coordinates.

	EAST	NORTH		EAST	NORTH
Point OD-1	624138.18	219578.15	Point OD-2	628919.44	219578.15
Point OD-3	628941.53	215416.17	Point OD-4	624160.28	215394.87

The location of the equipment used for transport of dredged material shall be continuously logged and recorded through a suitable and approved Global

Positioning System (GPS) method. The contractor shall equip the ships to facilitate monitoring of their position from the Engineers office.

Furnishing, installation, operation and maintenance of the complete system shall deemed to be included in the contract unit rates and prices in the priced bill of quantities for 2 Channels, Port Basin dredging including disposal".

The intention is that the position of the transport equipment is recorded and may be continuously monitored to ascertain that dredged material will not be disposed of outside the boundaries of the designated sea dumping area.

The Contractor shall take such samples and carry out such test as may be necessary to determine the suitability of the material to be dredged and placed in the reclamation. Duplicate samples, and their test results, shall be submitted to the Engineer within two days of the samples having been taken. The suitability of the material for selective placement shall be subject to the approval of the Engineer.

If dredged material is deposited anywhere except within the designated spoil dumping grounds or reclamation areas, such material shall be removed by the Contractor to the satisfaction of the Engineer and the cost thereof will be borne by the Contractor.

Dredging disposed of in the reclamation areas shall be completely contained in bunds (either temporary or permanent) with adjustable weirs discharging surplus water directly back to the open sea. Bunds constructed in tidal areas exposed to wave action shall be suitably armoured to prevent future erosion leading to recommence of the deposited spoil.

The bunding and spoil disposal arrangements and method of working shall be such as to ensure that no interruption is caused to existing drainage, and that there shall be no flooding of land areas in the vicinity.

The spoil dumping ground for dredged material rejected by the Engineer is to be located within the confines of the revetments around the Outer East Reclamation, but outside the area to be initially reclaimed. The Engineer will advise the exact location of the area or areas to be used for reclamation with suitable approved material by the Engineer.

All arrangements for dumping dredged materials (including layout and details of temporary bunds) are to be subject to the approval or direction of the Engineer. Details shall be submitted for approval well in advance of the commencement of reclamation in each area and no dredging or reclamation shall commence until the details have been approved.

In filling the reclamation area it shall be progressively raised to a surface level as shown on the Drawings and shall be filled such that upon completion of dredging the area remains to full height shown on the Drawings, and to the specified tolerances.

Dumping Tolerance

a) Vertical Tolerance

The maximum dumping height shall not exceed 16 m below the sea water level at any time. Should the maximum dumping height be exceeded, the Contractor shall follow the instructions of the Engineer to rectify the matter at no cost to the Employer.

Areas which are naturally deep and do not need dredging should not increase their natural depth during the dredging operations. This will be confirmed by the comparison of depths at the commencement of the operations and at different intervals during the dredging, deposition and land reclamation. The Contractor will be held directly legally and

financially responsible to the Ministry of the Environment should any legal action arise due to the non compliance of the above.

b) Horizontal Tolerance

The maximum dumping Horizontal Tolerance outside the specified limits is of 100 m.

All dredged material shall be dumped within the specified limits of the offshore dumping area as given in this Section.

Should dredged material be dumped outside of the specified limits, the Contractor shall follow the instructions of the Engineer to rectify the matter at no extra cost to the Employer.

c) Method of Work

The Contractor shall mark the limits of the area indicated with suitable buoys and shall carry out the dumping in a way approved by the Engineer. To this effect, the Contractor shall carry out a depth survey of the dumping area before disposing commences (predredge survey), and thereafter interim surveys by echo sounding every two weeks during dredging operations or every 25 dumps, whichever one comes first.

The Contractor shall submit a detailed method statement of his proposed dumping activities subject to the Engineer's Approval within 60 days after receipt of the Notice to Proceed.

**20408
Dispersal of
Dredged
Material**

The Contractor shall take all possible and reasonable measures to reduce the dispersal of dredged material into the sea during dredging and reclamation operations. In particular the Contractor shall:

- a) Use the best practicable operating methods to minimize silt and sediment release from the dredger;
- b) If loading into barges or using hopper dredgers measures shall be taken or procedures adopted to minimized overspill and dispersion of sediments outside the dredging area;
- c) Regularly check and maintain barges, hoppers, discharge pipes etc. to prevent leakage from joints and seals;
- d) Adopt a pattern of dumping within the disposal areas to minimize the overlapping of unsettled plumes of sediment;
- e) Not discharge dredged material into reclamation areas until such areas are fully enclosed by revetments/bunds and equipped with appropriate discharge weirs with their corresponding silt courtains;
- f) Adopt any other appropriate measures to ensure that the requirements with regard to suspended solids limits are met;
- g) Ensure that the environmental requirements of Section 20417 are met at all times.

**20409
Measurement
and Calculation**

Dredging profiles shall be within the specified tolerances and as shown on the Drawings. Dredging works will be measured as the volume between the agreed predredged survey bed surface and the required cut of the dredged channel as shown on

**of Dredging
Works**

the Drawings or directed by the Engineer.

The volume of material removed shall be calculated by the method of average end areas.

For the purpose of calculation, cross sections shall be taken at intervals (as specified in Section 20400) from the pre-dredging hydrographic survey with sounding intervals along each cross section being a maximum of 10 meters apart.

Volumes for progress payments shall be agreed with the Engineer on a monthly basis and shall be based on the Contractors interim hydrographic surveys.

**20410
Survey Charts**

20410.1 General

All survey charts to be produced by the Contractor shall be referred to Chart Datum (CD), and the depths and/or heights shall be plotted in meters and centimeters. The charts are to be presented to the Engineer on an electronic file and in an approved number of copies.

20410.2 Scale of Survey Charts

Data generated by the surveys shall be elaborated in accordance with sound topographic and hydrographic practices and be presented on survey charts of the site on a scale and format to be agreed upon by the Engineer. All survey lines shall be shown on the charts with plot-intervals along the lines not exceeding 10 meters with intermediate plots, if necessary.

Furthermore, the charts shall incorporate all reference points, buoys, beacons, markers, gauges and benchmarks, together with the location and nature of obstructions, structures and facilities. Particular items of interest shall also be indicated on the Charts.

20410.3 Interpretation of Echo rolls etc

Interpretation of echo rolls, reduction of sounded depths for tidal heights obtained from tide gauges, corrections for squat and wave motions (to be made using appropriate observed data and/or compensating devices) and definition of bottom levels on the echo rolls are to be done to the satisfaction of the Engineer. Each fix on the echo roll shall be denoted on the track plot chart of the survey vessel, and there should be at least one fix for every 10m of cross section.

Echo sounding methods equipment shall conform to the requirements of Section 20406 of this Specification.

**20411
Registration of
Water Levels**

20411.1 Tide Gauges

The Contractor shall install and maintain a suitable automatic tide gauge at an approved location close to the Works. This gauge shall be placed and calibrated at least 30 days before commencement of the dredging works.

During echo sounding, water levels shall be recorded continuously.

20411.2 Reduction of sounded depth

The Contractor shall place special care and diligence on the accurate reduction of sounded depth in relation to the prevailing under water levels.

**20412
Inspection and
Records of
Dredging**

The Engineer shall at all times be given free and unhindered access to the Site, the dredging and survey vessels for purpose of inspection of dredging and hydrographic survey operations.

The Engineer will provide an Inspector on board the dredger during each working shift and the Contractor shall include the cost of victualling of Inspectors in the Rates entered in the Bill of quantities. The Contractor shall also provide a cabin or other approved working area on board the dredger to be used as an office by the Inspectors.

For hopper dredges or barges, for every load of material dredged the Contractor shall

measure by means of a lead line the average level of material in the hopper and from a certified table supplied by the builders of the vessel determine the volume of material in the hopper.

The Contractor shall keep daily written records showing the working times (cut, pump, move, etc), the output (if metered), the number of loads dredged, the measured volume and net tonnage of each load, the suction or dredging time, turning time, sailing time and dumping time of each load, etc as applicable to the type of dredger being used.

The written records shall also give full details of the location of dredging, the material being dredged and detail any delays to the dredging operation.

The Contractor shall lodge a certified copy of the daily record with the Engineer on the day following actual dredging operations.

20413
Obstacles or
Other Materials

When boulders, rock, obstacles, or abnormal materials other than those detailed previously, are encountered with the dredge the Contractor shall immediately notify the Engineer and shall take all necessary measures to identify the nature, extent, and location of such boulders, rock, obstacles, or abnormal materials. When the Contractor has submitted adequate information concerning the nature, extent, and location, the Engineer will then advise the Contractor what action is to be taken with respect to the removal of the boulders, rock, obstacles, or abnormal materials.

Wherever possible the Contractor shall continue to dredge around such boulders, rock, obstacles, or abnormal materials, without stopping the dredging operations.

20414
Standby Delays

The time of delays to dredging due to standby as instructed specifically in writing by the Engineer will be paid at the appropriate Rates shown on the Form of Bid irrespective of whether such times are normal working hours, overtime hours or recognized public holidays.

Standby delay times shall mean the time during which it is necessary to cease work at the specific written direction of the Engineer for reasons other than for shipping movements.

Where possible, the Engineer will give prior advice to the Contractor of the anticipated standby duration.

Time lost due to adverse weather, wave or tidal conditions, or when the dredge is inoperable due to a breakdown or as the result of damage due to undredgable material or due to industrial disputes or strikes, shall not be considered as qualifying for payment.

20415
Buoys,
Submarine
Cable and
Wrecks

The Contractor shall make his own arrangements for the lifting, marking and replacing of moorings, buoys and submarine cable in the area to be dredged.

Should any wreck or obstruction be found, the Contractor is to comply with such instruction as the Engineer may issue regarding its removal. Any wreck or obstruction caused by the Contractor shall be removed at the Contractor's expense.

20416
Removal of
Sunken Plant

The Contractor shall immediately and at his own cost, raise and remove any floating plant or other equipment belonging to him or to any Sub-Contractor or to any person employed by him (including also any plant which is held by the Contractor or any Sub-Contractor under agreement for hire or hire-purchase) which may be sunk within the limits of the Site in the course of the construction, completion or maintenance of the Works or otherwise deal with the same as the Engineer may direct. Until the same shall be raised and removed the Contractor shall set such buoys and display at night such lights and do all such things for the safety of navigation as may be required by the Engineer or by the Employer or any other authority having jurisdiction in connection with the Site. In the event of the

Contractor not carrying out the obligations imposed upon him by this Clause the Employer may buoy and light such sunken plant and raise and remove the same (without prejudice to the right of the Employer to hold the Contractor liable under the Contract) and the Contractor shall refund to the Employer all costs incurred in connection therewith.

**20417
Environmental
Protection
Measure**

20417.1 Environmental Management Plan

An Environmental Management and Monitoring Plan (EMMP) shall be prepared by the Contractor and submitted to the Engineer for approval within 60 days of the receipt by the Contractor of the Notice to Proceed.

The EMMP shall include measures to be taken by the Contractor to mitigate and/or protect the environment against impacts resulting from the execution of the Contract Works. The EMMP shall particularly deal with impacts resulting from the dredging and offshore/onshore dumping, which concern sea water pollution. The EMMP shall reflect the standards for environmental protection specified by MARN as follows:

Station Number	Grid Reference (Mercator Projection Or NAD UTM)		Trigger Level (SS, above ambient)
	North	East	
T1	1480000	409000	**60 mg/ltr.
T2	1479000	409000	**60 mg/ltr.
T3	1477000	408000	100 mg/ltr.
T4	1477000	411000	100 mg 1/ltr.
T5	1477000	414000	100 mg 1/ltr
T6	1475000	416000	200 mg 1/ltr
T7	500 m from overflow weir, or any dredging point in the soft soil removal area		200 mg 1/ltr
T8	1467000	414000	200 mg 1/ltr
T9	1460000	408000	200 mg 1/ltr
T10 (E2)	1447781.049	412556.121	200 mg 1/ltr
T11 (E3)	1447801.079	406776.020	200 mg 1/ltr
T12 (E4)	1442635.156	406761.215	200 mg 1/ltr

As the EMMP is a management tool for the Contractor's use, it shall present in detail how these measures should be operated, the resources required and the schedule of implementation. The plan should contain separate sections dealing with individual environmental aspects.

The general format of the EMMP shall be

- Objective
- Work plan
- Implementation schedule
- Man-power requirements
- Monitoring procedures

The Contractor shall implement the EMMP measures at the commencement of the permanent works activities. The costs of preparing, implementing and monitoring the EMMP shall be deemed to be included in the Contractor's Bid Price.

The number of water sampling in the wet and dry season will be determined based on the nature or rate of the activity under progress.

Water quality monitoring shall be constantly carried out to measure the extend of the impact in the water turbidity due to dredging, disposal, of any other activity which could alter the physical or chemical properties of the area in the La Unión Bay, Fonseca Gulf or disposal site.

The EMMP shall suit the planned work and aimed at meeting the environmental restrictions or limits imposed on the allowable impact of the environment by the port construction.

The EMMP shall consider all the monitoring and mitigation measures requested and approved by the Ministry of the Environment and Natural Resources (MARN) of the Republic of El Salvador for the construction of the new La Unión Port Project, these are stated in the Environmental Monitoring Plan developed and approved by the MARN during the design state and are summarized as follows:

- Monitoring of increases in water turbidity from natural condition and kept under approved limits for each each area and stations. Contingency plan is to immediately stop operation when the turbidity exceed the trigger levels. The contractor shall have the responsibility of ensuring and proving the effectiveness of the proposed alternative measures to control turbidity below the rigger levels.
- Installing silt curtains in all the outflow points from the settlement lagoons and kept a stand by silt curtain for any accidents.

20417.2 Pre-dredging Survey for Monitoring

The Contractor shall submit the details of the proposed turbidity meter to be used for monitoring during the dredging, reclamation and dumping works for the approval of the Engineer

The Contractor shall monitor turbidity with the approved turbidity monitoring equipment every day for at least a month before the dredging begins, 50 cm below the surface at the 12 monitoring stations.

The Contractor shall take 3 water samples from 50 cm below the surface at each station in the presence of the Engineer and send to a laboratory authorized by the Engineer for analysis of Suspend Sediment (SS) and Turbidity. From the data collected, calculate the overall relationship between turbidity and SS, and the background (average) value of SS at each monitoring station. Shall be examined and submit it with all relevant data for the approval by the Engineer and MARN.

2041.3 No Siltation/Pollution of Surrounding Sea/Seabed Areas

The Contractor shall include in his rates and prices to comply fully with the requirements that there will be no siltation or pollution in the surrounding sea/seabed areas.

The Contractor shall be solely and fully responsible for any siltation, pollution or coloration of sea waters or the deposition of fill material or dredged spoil or the formation of high spots or sand bars, etc. anywhere which are ascertained to be caused directly or indirectly by any of his sand filling works which include dredging, dumping, sand filling etc.

Should any of the aforesaid coloration, siltation, pollution, deposition of fill or dredged material, formation of high spots etc. occur at any of the surrounding sea waters due to his dredging/ reclamation works aforementioned, the Contractor shall stop all his dredging/ reclamation works immediately and take appropriate actions to remedy the causes of the discharge and to dredge and remove such siltation, high spots, etc. at his own costs and within the stipulated period as directed by the Engineer.

The Contractor shall not be entitled to any compensation or extension of Contract Period due to such stoppage of works resulting from the occurrence of the aforesaid siltation, coloration etc. and the necessary remedial works. The Engineer shall have

the right to suspend the Works for any indefinite period until the remedial action is carried out to the entire satisfaction of the Engineer. All costs of investigation and monitoring of siltation, pollution, coloration etc. such as hydrographic surveys, current measurements, extraction and testing of water samples and soil samples, etc. shall be fully borne by the Contractor.

2041.4 Suspended Solids Content Monitoring

The amount of suspended solids in the water surrounding the operating dredge cutter head shall similarly be controlled so that the amount of sediment in the sea water at 50 cm below surface 500 meters in any direction from the cutter head shall not exceed a total absolute max. of 200 mg/ltr. From background condition.

In the preceding sub-clauses "500 meters in any direction from" shall mean at a radius of 500 meters from the outlet or the cutter head. Measurements shall be made of "parts per million of total suspended solids" using a direct-reading, portable turbidity meters which shall be supplied by the Contractor to the Engineer and shall be subject to approval by the Engineer. At each location, measurements are to be taken at 50 cm below surface at the time of measurement and duplicated as a check. Measurements are to be taken daily or otherwise as directed by the Engineer. On each day of measurement there shall be four cycles of sampling throughout the day so as to cover a range of tidal conditions.

The contractor shall submit reports on the data observed to the Engineer within 5 hours of making the observations. He shall also consolidate results into a report every week.

Before taking measurements the Contractor shall advise the Engineer so that an Inspector can be assigned to check measurements and so that any particular requirements for measurement can be instructed. The turbidity meter shall remain on Site at all times, shall be calibrated periodically at the direction of the Engineer and shall be available for use by the Engineer at any time.

If at any time measurements indicate that acceptable turbidity levels are likely to be exceeded then the Contractor shall take all reasonable steps to counteract this. Such steps might include provision of silt curtains. Under no circumstances shall the levels of turbidity specified in Section 20417 be exceeded. Should prescribed levels be exceeded the Engineer may suspended the work. Should such suspension be ordered it shall not be allowable as the basis for a claim or an extension of time or additional cost.

20417.5 Barrier against Siltation

The Contractor shall provide, install and maintain adequate silt barriers throughout the Contract Period to prevent dredged/ reclamation materials from flowing/drifted away from the dredging and dumping, operations. The Contractor's proposal on the silt barriers including design details, quantity to be supplied, anchoring system, method of installation and maintenance procedures shall accompany the tender and shall be subject to the evaluation of the Engineer. The membrane that constitutes the main component of the silt barriers shall have properties as hereunder indicated but shall not be limited to the following for effective siltation control:

- | | | |
|----|---------------------|-------------------------------|
| a) | Weight: | 600g/m ² (minimum) |
| b) | Thickness: | 0.9mm (minimum) |
| c) | Mean Strip Tensile: | 320kg/3cm width (minimum) |
| | | Strength (ASTM D1682) |
| | | Wet Condition |

d)	Mean Strip:	Minimum 15%
	Extension at Maximum Load:	Maximum 30%
		Wet Condition
e)	Shrinkage under seawater:	0.2% (maximum)
f)	Seawater Permeability:	7.5×10^{-3} cm/sec (maximum)
g)	UV Resistance:	Shall retain 80% of the mean strip tensile strength after prolonged exposure to sunlight in Singapore
h)	Installation Depth:	From seabed to Mean High Water Spring (MHWS).

Any modification required by the Engineer to his proposal to ensure the effectiveness of his proposed system against siltation shall be complied with fully by the Contractor at no extra cost during the execution of the Works.

On completion of the work, the Contractor shall completely remove the silt barriers including sinkers/anchor blocks from site.

Notwithstanding the above, the Contractor shall be solely and fully responsible for any adverse siltation or any coloration in the surrounding sea waters, navigation channel and anchorages arising out of or in connection with his dredging, dumping, reclamation operations.

The required cost of barricade against siltation shall be indicated in the Contractor's Bid Price.

**20418
Protection of
General Filling**

The Contractor shall be fully responsible for protection of the filling from erosion if at any time the filling is left exposed to erosion. If the Contractor fails to protect such exposed faces he shall make good such losses at his own expense. He shall also be responsible for the removal of any obstruction that may be caused by the deposition of any material washed from the filled-area.

**20419
Short distance
relocation of
Live or dead
Sub marine
cable**

The Contractor shall be fully responsible for the relocation of live or dead sub marine cables in coordination with the appropriate utility company and to the satisfaction of the Engineer.

The costs of relocation of any live or dead sub marine cables shall be included in rate of dredging.

The final relocation of any sub marine cables along the dredged channel or any other dredged areas shall be placed at a depth of not less than 2 m below final dredging elevation shown in the dredging cross sections.

Any indication of location of any cables in the drawing is for reference purposes only the Contractor shall satisfy himself of real location.

SECTION 20500 RECLAMATION

20500 Reclamation

20500.1 Description

This Section covers excavation, disposal, placement, furnishing, and compaction of all materials within the limits of work required to construct the wharf, roads and paved areas, areas for building construction and construction of temporary bunds, drainage works, utilities or other purpose in accordance with these specifications and in conformity to the dimensions and typical sections shown on the Drawings or approved by the Engineer.

20500.2 Definitions

The following definitions or terms apply in relation to land leveling and land reclamation works.

- Excavation:** Excavation for the purpose of this Contract means excavation inclusive of disposal of excavation materials as specified.
- Fill:** Fill shall comprise material of the various classes which is in accordance with these Specifications for use in the Permanent Works as specified in these Specifications.
- Suitable Material:** The Contractor shall conduct his own investigation and/or research to find the best borrow area, where adequate filling materials can be obtained both in quality and quantity.
- The material to be used for reclamation by filling shall be well-graded and shall contain less than 5% in weight of particles passing sieve 74. or unless otherwise approved by the Engineer. The samples and sieving analysis results shall be submitted to the Engineer for approved prior to commencement of the reclamation work. The filling material shall be free from vegetation and roots.
- Suitable material shall not have topsoil, roots, vegetation, organic matter, silt, contaminating matter, and other materials which are combustible or which can decay.
- Notwithstanding any or all of the requirements of the Specification, the Engineer may reject any filling material which he considers unsuitable and the contractor shall remove such rejected filling material from the site and re-fill with approved material at his own expense.
- Unsuitable Material:** All materials which do not comply with the requirements for suitable material are unsuitable material. Unsuitable material include trash, refuse, all materials containing organic matter, top soil, roots, vegetation and other materials which are combustible or which can decay . The Engineer shall be notified of any contaminated material.

Hydraulic Excavation:	Hydraulic excavation means excavation which during the excavation process suspends solids in water in order to transport the same such as cutter suction dredger and trailing suction hopper dredger, etc.
Hydraulic Fill:	Hydraulic Fill means (sand) fill material which is still in suspension when placed.
Finished grade:	Finished grade means the design level of the pavements as shown on the Drawings minus (pavement) structure depth other than fill.
Design level:	Design level means the level of the completed pavement surface as shown on the Drawings to be attained at the Certification of Completion (after full settlement/ subsidence of the subsoil).

20500.3 Scope of Works

The Contractor shall construct and prepare a "Port Reclamation Area" designated as shown on the Drawings.

The Works in the above designated Port Reclamation Area include excavation and removal of high areas protruding above a specified level, hereinafter referred to as "Land leveling", and reclaiming of land from the sea or from the land, hereinafter referred to as "Land Reclamation"/ "Land Reclamation Area".

The Land Reclamation includes, but is not limited to the following main activities:

- Removal of unsuitable material.
- Excavation of soft soil as required, hereinafter referred to as soft soil Dredging.
- Filling material to be placed to the lines and levels as shown on the Drawings or as other wise directed by the Engineer.
- Compaction of filling material.

20500.4 General Requirements

a) Working Drawings and Design Obligations

The Drawings supplied to the Contractor including the temporary bunds documents regarding the Reclamation Works shall be read in conjunction with the Specifications and the Bills of Quantities to evaluate and assess the review and design work and the type and method of the land leveling, land reclamation and temporary bunds works under the Contract.

The Drawings shall not be considered as drawings "Issued for Construction" and the construction shall be based on approved Working Drawings.

The Contractor shall prepare and submit reclamation Working Drawings based on the Drawings, the Specifications and the Conditions of Contract specifically the Section "Inspection of Site".

A supplementary detailed design is required based on the additional field investigation. The Contractor shall prepare and submit such detailed design for the approval of the Engineer.

The Contractor shall prepare design and submit, but not limited to, the

following Working Drawings to the Engineer's Approval:

Working Drawings covering the land leveling, land reclamation and temporary bunds, Works based on:

- Fill material-criteria and sources approved by the Engineer.
- Results of soil investigations
- Topographical and hydrographical surveys.
- Construction sequence considerations and the Contract Construction Period.
- The obligation that the Contractor at all time is responsible for the stability of excavations and the embankments.

b) Construction Sequence

The Contractor shall be responsible to furnish all possible sites and suppliers for obtaining materials in due time to enable him to complete the land reclamation works without delays because of lack of materials, such as the required sandfill and fill materials.

The additional soil investigation shall be completed within 90 days after the Notice to Proceed unless otherwise approved by the Engineer.

c) Work Methods

The Contractor shall submit to the Engineer for his consent detailed methods of the Works hereinafter referred to as "Method Statements".

The Method Statements shall include detailed descriptions as required by the Engineer, in order to enable the Engineer to assess the work methods on technical merit and the Contractor's quality control aspects.

The methods shall include work description, superintendence, labour input, equipment inclusive of cycle times, environmental aspects. Consent of the "Method Statements" shall not relieve the Contractor from his responsibilities under the terms and Conditions of the Contract.

d) Construction Roads/ Access

The Contractor's attention is particularly drawn to his obligation of making a site inspection as per the Instruction to Bidders and the Conditions of Contract and making his own assessment as to the access to the land-leveling and land reclamation works.

No claim from the Contractor arising from difficulties in access to or on the site that was or should have been apparent to the Contractor at the time of Bid will be considered by the Engineer.

e) Transport/ Haul

All hauling and transport will be considered a necessary part of the land leveling and land reclamation work. Its costs shall be considered by the Contractor and included in the contract unit rates and prices in the Bills of Quantities for the pay items of work involved.

No payment will be made separately or directly for hauling or transport to/ from/ or on the Site.

f) Stockpiling for reuse

No payment will be made separately or directly for stockpiling and rehandling of rock, sand, fill, or other material. The quantity removed and placed in the land reclamation works shall be deemed incidental for the pay items of work involved.

g) Finished grade

At the time of Certification of Completion the finished surface of the pavements and other areas must be in accordance with the levels shown on the Drawings listed in the Bid Documents.

"Finished Grade" is directly interrelated to the above obligation and the Contractor shall finish the land reclamation surfaces in such a manner and to such levels that to obtain the Certification of Completion the levels of the overlying pavements have to be to specified levels and tolerance.

In consequence the Contractor shall make due allowance for settlement in order to arrive at the above specified Finished Grade.

h) Measurements of Fill and Land Reclamation

The unit to measure the volume of fill and land reclamation to attain "Finished Grade" shall be the cubic meter and the quantity shall be the net volume of materials between the existing ground level which is the basis of the joint survey stipulated. The Contractor shall consider settlement in the reclamation, and no additional payment shall be born by the Employer in order to reach the final levels according to the Drawings.

20501
Compaction of
Top Layer of
Fill

In areas directed by the Engineer, the top 2 meters of fill below finished level shall be mechanically compacted. The fill shall be placed in layers, the compacted thickness of which shall not exceed limits which shall be agreed with the Engineer and shall depend upon the method of compaction proposed by the Contractor in accordance with the provisions of Section 20600 – EARTHWORKS of the Specifications. Each layer shall be compacted to the density specified in accordance with AMST C-35, Tests 12 and 13 or other appropriate international standard. No additional payment shall be done for this activity, price should be included in the Bills of Quantities.

Should soft pockets of material become evident during compaction the soft materials shall be removed and replaced with approved materials. Removal and replacement of such materials shall be allowed for in the rate for compaction.

Any fill placed to make up levels after compaction shall receive the same degree of compaction specified for that part of the fill.

Fill extending from the final ground level to a depth of 0.8 m below that level shall be compacted to a density not less than 95% of the standard maximum dry density.

Fill 0.8 m below final ground level and not exceeding 2 m below final ground level shall be compacted to 90% of the standard maximum dry density.

The Contractor shall carry out trials to demonstrate that the equipment he proposes to use to compact the fill is capable of achieving the specified densities.

Following compaction of each layer, the Contractor shall carry out in situ density

tests as directed by the Engineer. In the event of any test giving a density less than that specified further compaction shall be carried out until the specified density is achieved.

**20502
Use of
Excavated
Dredged
Materials**

In the case of any surplus material resulting from construction progress, the Contractor may and with approval of the Engineer have the following options:

- a) Use of such material in land reclamation or another contract activity, providing such use is approved by the Engineer and is in conformity to the contract specifications applicable to such use; or,
- b) Remove such material from the site, upon written approval of the Engineer; or,
- c) Use such material for his own temporary construction on site; or,
- d) Use such material as intended by the terms of the contract.

Should the Contractor wish to exercise option a., b., c., or d., he shall request the Engineer's approval in advance of such use.

The Contractor shall consider in his prices an amount to remove unsuitable excavated materials which has to be replaced with an equal amount of suitable material for use in the construction of the land reclamation or additional material needed to complete the contract work. No additional payment shall be done for this activity.

It is understood and agreed that the Contractor shall make no claim for delays by reason of his exercise of option a., b., c., or d.

**20503
Environmental
Protection
Requirements
and
Environmental
Protection
Measure**

20503.1 Environmental Management and Monitoring Plan

A detailed Environmental Management and Monitoring Plan (EMMP) shall be prepared by the Contractor and submitted to the Engineer for approval within 60 days of the receipt by the Contractor of the Notice to Proceed of the Specifications. Environmental Management and Monitoring Plan to be prepared by the Contractor shall include the information specified in Section 20417.

20503.2 Suspended Solids Content Monitoring

The amount of total suspended solids in the water discharged from the reclamation into the sea shall be controlled so that the amount of sediments in the sea water at 50 cm below surface and at 500 meters in any direction from the reclamation weir box outlet or any soft soil removal point shall not exceed a total of 200 parts per million by weight from natural background value.

**20504
Protection of
General Filling**

The Contractor shall be fully responsible for protection of the filling from erosion if at any time the filling is left exposed to erosion. If the Contractor fails to protect such exposed faces he shall replace any loss of material at his own expense. He shall also be responsible for the removal of any obstruction that may be caused by the deposition of any material washed from the filled-area.

**20505
Temporary
Bunds**

Temporary bunds shown on the Drawings shall be designed by the Contractor and he shall submit drawings of the proposed bunds for the approval of the Engineer prior to commencement of their construction.

20506 Reclamation Levels Reclamation profiles shall be as shown on the Drawings. The surface level shall be filled to within a tolerance of + 0.1 to -0.0 m of the shown or instructed level in such a way that no undue ponding can occur. On completion of the reclamation a topographic survey shall be carried out to show that the reclamation profiles shown on the Drawings have been achieved.

20507 Settlement The Contractor shall make due allowances for settlement and consolidation of both the reclamation fill material and the seabed during the construction period. The profiles and reclamation levels shown on the Drawings are those of the completed reclamation at the date of certified completion for the whole of the Works.