3.3.4 Falsework and Scaffolding

The design, erection and removal of falsework and scaffolding and shall comply with the requirements of Section TS 10 of the Technical Specification.

3.3.5 Placing of Concrete

3.3.5.1 Breaking Back Concrete and Bonding of New Concrete

Where applicable, concrete in the existing structure shall be broken back as shown on the Drawings. Any cracked or damaged concrete remaining after breaking back shall be removed and replaced with new concrete to the satisfaction of the Engineer.

All faces of concrete against which new concrete is to be placed shall be scabbled, brushed clean, and then coated with an approved epoxy resin or other approved bonding agent immediately ahead of the placing of the new concrete. Concrete or bonding agent shall not be placed until the surface against which the concrete is to be placed has been inspected and approved by the Engineer.

3.3.5.2 Chipping Back Surfaces of Existing Concrete Structures and Bonding of New Concrete

Where applicable, existing concrete structures shall be chipped back as shown on the Drawings for a minimum depth of 20 mm in order to expose concrete.

The chipped surfaces of existing concrete against which new concrete is to be placed shall be brushed clean, and wetted with water then coated thoroughly with a very thin coating of neat cement mortar immediately ahead of the placing of the new concrete. Concrete shall not be placed until the surface against which the concrete is to be placed has been inspected and approved by the Engineer.

3.3.5.3 Placing of Concrete

i. General

Concrete shall not be placed until the forms, and any other embedded items have been inspected by the Engineer and he has been given his consent.

The Contractor shall submit a scheme for the order of concreting the cast in-situ sections of the works six (6) weeks prior to placing.

Placing of concrete shall conform to the assumptions made in the design of the formwork.

If consent is given by the Engineer to pour concrete in other than daylight hours, lighting over the area of the pour, mixing plant, conveying equipment etc. shall be as specified in clause 1.6 of the General Specification.

The working surfaces of platforms and conveying equipment shall be cleaned of all foreign material and set concrete immediately prior to commencement of each continuous placing run.

Prior to and during the placing of concrete, the formwork and the space to be occupied by the fresh concrete, and all embedded items including

reinforcement shall be maintained in a clean condition, free of water, mud, oil and other deleterious materials.

After mixing, concrete shall be placed without delay. The methods of transport, handling and placing shall be such to prevent the segregation or loss of the ingredients. Dropping the concrete a height more than 2 metres will not be permitted unless thorough approved pipes or chutes. As far as practicable these pipes shall be kept full of concrete during placing, and their lower ends shall be kept close to the surface of the newly placed concrete.

When wheeled vehicles are used for transportation of concrete, a substantial gangway shall be erected above the reinforcement on supports resting on the formwork. The location and type of supports shall be to the consent of the Engineer. Gangways shall be kept back from the working face a distance of 2 or 3 metres.

Excessive quantities of concrete shall not be deposited at any one point and moved or worked along the forms.

Concrete which has developed its initial set, or which is not placed and compacted within 20 minutes after discharge from the mixer shall not be placed in position and shall be removed from the site immediately.

Between the ends of members, or between specified construction joints, concrete shall be placed in one continuous operation such that the face of the fresh concrete is in a plastic state when succeeding concrete is placed against it.

Where required by the Engineer, concrete shall be placed on a spreading platform transport from the mixer. It shall be turned over to ensure a uniform consistency before it is placed. Under no circumstances shall concrete be thrown from shovels.

Concrete shall not be placed at a rate of less than 2 metres per hour vertically without the consent of the Engineer.

ii. Pumping of Concrete

The Contractor shall assume all responsibility and risks involved in the pumping of concrete, and the Employer will not consider any claims for extra costs involved. Should the design of a mix suitable for pumping require cement additional to that specified in Clause 3.2.1 the cost of the additional cements shall be borne by the Contractor. Prior to commencement of placing concrete in the forms, the initial discharge of concrete shall be pumped to waste until a consistent workable mix is discharged, to the satisfaction of the Engineer. Aluminium pipes shall not be used for the delivery of concrete.

3.3.5.4 Placing Under Water

i. General

Concrete, other than sealing concrete, shall be placed under water only with the permission of the Engineer. Concrete shall not be placed in water flowing faster than one metre per second.

When the Contractor proposes to place concrete under water details of the method, equipment and materials proposed to be used shall be submitted to

the Engineer for his consent at least six (6) weeks prior to work being commenced.

Unless otherwise consented to by the Engineer, concrete shall only be placed by tremie pipe or bottom dump bucket.

ii. Tremie pipe

Concrete shall be placed through a smooth bore steel tremie tube sufficiently large to permit the free flow of concrete. Joints between sections of the tube shall be threaded, greases and wrapped with an approved tape to provide waterproof connections. Aluminium tubes shall not be used.

The methods, plant an equipment used for concrete placing shall be such that a continuous supply of concrete is available at the top of the tremie tube during the entire process of placing concrete.

The tremie shall be fitted with a valve or other device so that at no time shall concrete in the tube come in contact with water when it is being filled. The means of supporting the tremie shall be such as to permit its being lowered rapidly when necessary to prevent or retard the flow of concrete. The discharge end shall be completely submerged in concrete at all times and the tremie tube shall always be filled to a height to overcome the head of water. The rate of flow in the tremie shall be controlled by raising and lowering the tube and thus varying the external head of concrete at the lower and of the tube.

At no stage during the concreting operation shall the tremie be lifted to permit continuation of discharge unless sufficient concrete is available at the concreting point to enable the tube to be recharged immediately. Concrete shall be supplied to the tremie at a uniform rate to provide a continuous flow with the tremie tube as full concrete as reasonably practicable.

In the event that water enters the tremie tube or the tremie action is lost during casting and if the Engineer considers that as a result thereof a reasonable risk exist that the quality of the concrete will be impaired, the Contractor may be directed to immediately remove all the concrete placed in the current pouring operation.

The cost of removal of the concrete and all associated costs arising from failure of the tremie shall be borne by the Contractor and no extensions of time will be granted.

If most of the concrete has been placed prior to partial or full breakdown of the tremie action the Engineer may permit the previously placed concrete to remain but direct that no further concreting take place. In this case, the Contractor shall carry out any additional sealing which in the opinion of the Engineer is necessary, and dewater and prepare the surface of the previously placed concrete for re-concreting.

iii. Bottom Dump Bucket

Bottom dump buckets shall be of a type that cannot be discharged until it rests on the surface upon which the concrete is to be placed. The bottom doors when tipped open shall open freely downwards and outwards. The bucket shall be open at the top but the top surface of the concrete shall be protected from the wash of the water and the bucket shall be lowered and withdrawn slowly to avoid backwash. The bucket shall not be raised to such

a height that concrete will fall through water and no agitation, tamping or vibration of the concrete will be permitted during the placing.

iv. Pouring Operation

When concrete is placed by tremie dump bucket it shall be placed in one continuous operation keeping the top surfaces as nearly level as possible until it is brought above the water, or to the required height. The work shall be carried out with sufficient speed to prevent any one layer of concrete taking its initial set before the next layer is placed. No tamping or vibration will be allowed. After dewatering the top of the concrete, all laitance and weak concrete shall be removed and the surface shall be scabbled before subsequent placing of concrete.

3.3.5.5 Compacting

During and immediately after placing, the concrete shall be thoroughly compacted by means of vibration as specified hereunder.

Care shall be taken to fill every part of the works, to force the concrete under and around the reinforcement without displacing it, to work coarse aggregate back from the face, and to remove air bubbles and voids.

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

It shall not be used to make concrete flow in the forms over distances so great as to cause segregation, and vibrators shall not be used to transport concrete in the forms.

Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be inserted and withdrawn from the concrete slowly. The vibration shall be of sufficient duration and intensity to thoroughly compact the concrete, but shall not be continued so as to cause segregation. Vibration shall not at any one point be to the extent that localised areas of grout are formed. Application of vibrators shall be at points uniformly spaced and not further apart than twice the radius over which the vibration is visibly effective.

Workmen employed in compacting concrete shall be competent and experienced in this work. Any workman who is deemed by the Engineer to be unsatisfactory shall be replaced immediately at the request of the Engineer.

i. Internal Vibrators

Internal vibrators shall be of a type and design approved by the Engineer and shall have a minimum frequency of vibration of 7000 revolutions per minute. The intensity of vibration shall be such as to visibly affect a mass of concrete of 25 mm slump over a radius of at least 500 mm.

Table 3.7. gives the basis for the number of internal vibrators required for satisfactory compaction:

Table 3.7 – Number of Internal Vibrators Required

Rate of Placing Concrete	Number of Internal Vibrators[1]
3 cubic metres per hour	2
6 cubic metres per hour	3
9 cubic metres per hour	4
12 cubic metres per hour	5
15 cubic metres per hour	6

Note (1) Excluding standby capacity

ii. External vibrators

Internal vibration shall be supplemented by such external vibration as is necessary to ensure smooth surfaces and dense concrete adjacent to forms. The number and type of external vibrators and their method of use shall be as required by the Engineer. External vibrators shall have a minimum frequency of vibration of 7000 revolution per minute. One additional vibrator for every four working units or part thereof shall be provided, and kept in readiness for immediate use should a breakdown occur.

3.3.5.6 Deck or Slab Concrete

The upper surfaces of the concrete deck slabs shall be carefully screeded to the shape and levels shown on the Drawings.

Vibrating screeds may be used and shall consist of a screed board with one or more vibrating units fixed to it. Fixed screed support for screed boards shall be arranged parallel to the major axis of the deck or slab. Such screed supports shall be at centres not greater than 3 m.

Screed supports shall be set with sufficient camber to ensure that the finished slab levels are as shown on the Drawings or as directed by the Engineer. Screed supports shall be set to provide the specified deck thickness over the tops of the beams where relevant.

Screed supports shall be fabricated from materials and of sizes approved by the Engineer, and shall be rigidly held in position at a spacing such that there will be negligible deflection during screeding and so that the screed supports can be removed from the concrete at the completion of the screeding. Alternative screeding arrangements to those specified may be used subject to the consent of the Engineer.

Concrete shall be placed evenly and spread to a level slightly above the finished deck or slabs levels, compacted by vibrators, and then screeded by means of a vibrating screed board placed on the screed supports and at right angles to the direction of the screed supports. Immediately screeding has been completed the screed supports shall be removed and the surface made good with additional concrete, and trowelled to shape.

Final finishing operations to a concrete slab shall consist of floating, trowelling, and brooming. Any free surface water shall be removed prior to finishing. Additional materials such as cement, stone dust, or sand shall not be used to dry up surface moisture.

As soon as the concrete slab surface assumes a suitable condition, the surface shall be wood floated in order to fill in holes, remove lumps, and smooth off ridges.

After completion of wood floating, the surface shall be steel trowelled by hand or with a power trowel fitted with rotating steel floats. Power trowelling shall be followed by hand trowelling to remove small irregularities and touch up areas in corners, around openings or holes, and close to obstructions.

The whole surface shall then be roughened with a stiff broom to provide bond for the wearing surface, or to provide skid resistance where an asphaltic wearing surface is not to be applied.

Barrows or other conveyances shall not be wheeled directly on the concrete within a period of seven days of casting. If wheeling planks are placed with care on the slab surface, barrows may be permitted on the wheeling planks not less than 12 hours from the casting of the slab.

The finished slab surface shall comply with the requirements of Clause 3.3.9, Tolerances. Deviations from the slab surface greater than those specified above shall be rectified to the satisfaction of the Engineer.

Prices bid for slab concrete shall be based on the thickness and beam hogs as shown on the Drawings. Payment for the actual amount of additional concrete incorporated in slab thickening to offset variations in beam camber from that shown on the Drawings, will be made in accordance with the provisions of the General Conditions of Contract.

3.3.5.7 Concrete Above Deck

In the case of bridges, concrete above deck shall not be placed until the deck formwork or the falsework for the span has been removed.

Concrete above deck for cast-in-place post-tensioned structures shall not be placed until completion of the post-tensioning operation unless specified or consented to by the Engineer.

Forms shall be accurately built to the dimensions shown on the Drawings. All mouldings, panel work and bevel strips shall be straight and true with neatly mitred joints, and all corners in the finished work shall be true, sharp and clean cut.

The forms for cast-in-place members shall be erected to the specified line and grade, and shall be braced to remain in correct position during the placing of the concrete.

The tops of all posts, kerbs and parapets shall be formed by placing an excess of concrete in the forms and removing or striking off such excess with a wooden template moved on guides attached to the forms, forcing the coarse aggregate below the mortar surface. The use of mortar topping will not be permitted.

The finish shall be as specified in Clause 3.3.8.

3.3.5.8 Rubble or Cyclopean Concrete

Rubble or cyclopean concrete shall consist of concrete containing large embedded stones. It shall be used only with the consent of the Engineer in massive piers, gravity abutments, heavy footings and gravity walls. The

class of concrete shall be as shown on the Drawings or as directed by the Engineer. The stone for this class of the work shall conform to the requirements of Clause ..

The stone shall be carefully placed-not dropped or cast-so as to avoid injury to the form or to the partially set adjacent concrete. Stratified stone shall be placed upon its natural bed. All stone shall be washed and saturated with water before placing.

The total volume of the stone shall not be greater than one-third of the total volume of the portion of the work in which it is placed. For wall or piers greater than 600 mm thickness, stone having a maximum size of 250 mm may be used. Each stone shall be surrounded by at least 150 mm of concrete and no stone shall be closer than 300 mm to any top surface nor any closer than 150 mm to any coping.

Note: Rubble or cyclopean concrete is not applicable to this contract.

3.3.6 Curing

Subject to the consent of the Engineer, curing shall be carried out using one or both of the following methods.

3.3.6.1 Normal Curing

i. General

Exposed concrete surfaces shall be cured by covering with an approved material immediately after finishing and the surface small be kept moist. Alternatively, exposed surfaces may be cured by flooding or continuous sprinkling subjects to the consent of the Engineer.

Curing shall continue for a period of not less than seven days after placing the concrete.

Within 15 minutes if the completion of the finishing of any section of deck or slab, the concrete surface shall be protected by suitable means from the effects of sun and wind.

Freshly finished concrete surfaces shall be effectively protected from rain or damage from other sources until hard set has occurred.

ii. Use of Curing Compounds

Moist curing as specified above shall generally be used. The use of curing compounds will not be permitted on exposed surfaces which require class 2 or class 3 surface finishes.

Curing compounds shall be in accordance with AASHTO M 148 (ASTM C 309) "Standard Specifications for Liquid Membrane Forming Compounds for Curing Concrete" and shall only be used with the consent of the Engineer. Full details of curing compounds shall be submitted to the Engineer prior to their use, including the time and rate of application and documented evidence of the effectiveness of the compound as a curing agent. Such compounds shall be pigmented sufficiently to allow visual inspection to ensure full application on the surface to be coated and the pigment shall not be visible after a period of 14 days after application. Curing compounds shall not have a deleterious effect on the concrete. Compounds shall not darken

or yellow appreciably, and no compound shall be used which will stain the surface of the concrete.

Curing compounds shall be applied in accordance with the manufacturer's instructions. Application of curing compound shall commence after the final set has taken place and just as the surface film of water disappears. If the concrete surface is dry, it shall be thoroughly wetted with water and the surface film allowed to just disappear prior to application of the curing compound. Any damage caused to the applied coating shall be immediately repaired by the Contractor. If coatings are being repeatedly damaged the Engineer may direct that moist curing be resumed.

Curing compounds shall not be applied to construction joints unless the joint id to be scabbled or sandblasted at a later date.

Curing compounds shall not be applied to surfaces which are to be subsequently coated unless provision is made for removal of the compound from these surfaces prior to the application of the coating. Curing compounds to be used on bridge decks which are to be covered by a bitumen seal or asphalt shall be of a type which will not significantly reduce the adhesion of the seal or asphalt.

3.3.6.2 Steam Curing

The plant, and equipment, method of control, and the proposed curing cycle for any steam curing proposed by the Contractor shall be subject to the consent of the Engineer. After the initial maturity period, the concrete shall be cured in an atmosphere saturated with water vapour at a pressure not exceeding atmospheric pressure.

3.3.7 Quality of Concrete

3.3.7.1 Strength

The classes or strength grades of concrete to be used in the works shall be as shown on the Drawings. Test specimen moulds, of a type shown on the Drawings, shall be provided by the Contractor for all tests required to be performed by the Contractor or for independent testing by the Employer pursuant to clause 1.6.2 of the General Specification.

3.3.7.2 Sampling of Concrete

Test specimens shall be made and cured in accordance with AASHTO T 23 (ASTM C 31) "Standard Methods of Making and Storing Specimens of concrete in the Field". Eight test specimens shall be made from each sample of concrete and there shall be not less than 8 specimens made for every 40 cubic metres of concrete or fraction thereof placed during one day's run for every concrete pay item shown in the Bill of Quantities or as deemed necessary by the Engineer.

Additional specimens, as directed by the Engineer or detailed in Section TS 7 of this Specification, shall be taken for the assessment of the strength where early stripping of forms or the early application of prestress is proposed.

The Contractor shall provide the necessary curing facilities and shall cure the test specimens on site in accordance with AASHTO T 23 until they are

tested by the Contractor in accordance with his obligation for testing under the contract or delivered to the laboratory for independent testing pursuant to clause 1.6.2 of the General Specification.

As soon as practicable after the specimens are made they shall be placed in approved moisture proof containers until testing is to be carried out.

3.3.7.3 Sampling of Mortar and Grout

If required by the Engineer, test specimens shall be made for the purpose of determining the properties of mortar or grout. The specimens shall be made in accordance with Clause 3.3.7.2 above, except that the method of moulding shall be as directed by the Engineer.

Test specimens for shrinkage tests shall be in accordance with AASHTO T 23.

3.3.7.4 Testing

The concrete specimens will be tested in accordance with AASHTO T 22 (ASTM C 39).

Four of the above eight specimens shall be tested at 7 days for information and the other four at 28 days for acceptance.

A strength test shall be defined as the average of the compressive strengths of two specimens made from the same composite sample of concrete and tested at 28 days.

Where samples are taken from concrete which will be prestressed, four specimens will be tested to assess the concrete strength prior to stressing and four specimens will be tested at 28 days.

Should the average strength of the strength test above be less than the specified strength, application of prestress or removal of forms (as appropriate) shall not take place. Alternatively the Engineer may specify an age at which in his opinion the concrete will have reached the required strength to permit application of prestress or removal the forms. If the concrete was steam cured, the Engineer may request additional in accordance with the requirements of Clause TS 3.3.6.1.

The requirements for each class of concrete are as shown in Table 3.8.

Table 3.8- Compressive Strength Requirements

Classes of Concrete	Specified Compressive Strength			
	7 Days		28 Days	
	(MPa)	(kg/cm^2)	(MPa)	(kg/cm^2)
K125	9.0	90	12.5	125
K175	13.0	130	17.5	175
K225	17.0	170	22.5	225
K350	26.0	260	35.0	350
K400	30.0	300	40.0	400
K500	38.0	380	50.0	500

Irrespective of the quantity, every day's production of concrete shall be tested both for strength and for slump and every structure and every component of every structure shall likewise be so tested for strength and slump.

The Engineer may order an increase in the number of tests to be made or make other tests as he may deem necessary to ensure that the concrete is of the specified quality.

The concrete test specimens will be tested by the Contractor and witnessed by the Engineer at a laboratory approved by the Engineer.

The cost of testing the specimens will be borne by the Contractor.

Concrete test specimens shall be provided by the Contractor further to his obligation to allow independent testing by the Employer in accordance with clause 1.6.2. of the General Specification.

3.3.7.5 Acceptance of Concrete

The strength requirements of concrete in this Specification will be satisfied when, for any given sample, the strength requirements of Clause 3.2.1.4 are met and, in addition, no strength test (as defined in Clause 3.3.7.4 above) is less than the specified Characteristic Strength at 28 days by more than 3.5 MPa (35 kg/cm^2).

The Contractor may carry out tests on specimens made by him or his representatives in addition to the number specified above, to determinate the time at which the various strength requirements will be met. However, acceptance or rejection of the specified strength requirements will be based on test carried out under the supervision of the Engineer.

3.3.7.6 Rejection of Concrete

Should any sample fail to satisfy the strength requirements of consent as detailed in Clause 3.3.7.5 above, the Engineer may reject the whole or part of the concrete represented by the sample.

In the case of doubtful results the Engineer may proceed to check the compressive strengths by means of crushing tests performed on test

specimens taken with a rotary core borer at points indicated by the Engineer on structures already constructed. If such tests do not comply with the requirements the Engineer may reject whole or part of the concrete represented by the those tests. These tests shall comply with the requirements of ASTM C 42.

If the Contractor disputes any of the above test results the Engineer may require the Contractor to have confirmatory tests made at the Contractor's expense. Such tests shall consist, according to the Engineer's instructions, of crushing tests as described in the paragraph above or non- destructive tests using the sclerometer (refer to ASTM C 805).

Each non-destructive test shall be performed as follows:

- Around the point selected by the Engineer, an area not larger than 0.1 square metres shall be fixed, on which ten (10) blows with the sclerometer shall be made and the values of index read each time shall be recorded;
- The arithmetic mean of such values shall be determined;
- Values which differ from the arithmetic mean by more than fifteen hundredths (15/100) of the total range of the sclerometer scale shall be discarded;
- From the values not discarded the arithmetic mean shall be recalculated and by reference to the calibration table of the sclerometer scale will give the compressive strength of the concrete;

Generally, for each of type of sclerometer the calibration table supplied by the manufacturer will be used. Nevertheless the Engineer will have the right, as desired, to perform the calibration of the sclerometer directly on specimens which will afterwards be subjected to crushing tests by simple compression.

Rejected concrete shall be removed by the Engineer, at his own expense, in accordance with the provisions of the General Conditions of Contract.

The records of all tests shall be kept by the Engineer but results shall be available at all times to the Contractor. The Contractor shall be responsible for making such adjustments as may be necessary to produce specification concrete and the test results shall indicate whether or not the concrete is satisfactory.

3.3.8 Surface Finish

3.3.8.1 General

For any particular class of concrete surface finish, the method of construction and the materials used in the concrete and fomwork shall remain constant and shall be such as to meet the requirements of this Specification. Any formwork which in the opinion of the Engineer will not impart a surface finish in accordance with the requirements of this Specification will be rejected.

The standard of surface finish is dependent on the quality of formwork, the compaction of the concrete, and the manner in which the formwork is

removed. The higher the standard of surface finish required the greater care will be required to be given to these factors.

The following surface finishes are specified :

Unformed Surface Finish

Class 1 Surface Finish (Unexposed Formed Surface Finish)

Class 2 Surface Finish (Ordinary Formed Surface Finish)

Class 3 Surface Finish (Rubbed Formed Surface Finish)

All formed concrete shall receive at least a Class 1 surface finish. Unless otherwise consented to by the Engineer the surface of the concrete shall be finished immediately after the removal of forms.

Except where other surface finishes are shown on the Drawings or ordered by the Engineer, surface finishes Class 1, Class 2 and Class 3 shall be used as follows:

Substructures

The Back of abutments, culverts, concrete retaining walls and wingwalls shall receive Class 1 surface finish.

All exposed surfaces of abutments, wingwalls, concrete retaining walls,pumping station structure, gate structures, and piers from 300 mm below ground level shall receive Class 2 surface finish, except that in cellular structures the faces of wingwalls and ends piers or wall only shall receive Class 2 surface finish. Upper surfaces of concrete bearing pedestals shall receive Class 2 surface finish.

Bridge Decks and Beams

The underside of deck between beams and vertical faces of beams other than the outer face of outer beams shall receive Class 1 surface finish. The outer faces and undersides of the beams, the edges and the underside of the cantilevered deck slab, the interior and exterior faces of kerbs and the upper surfaces of the kerbs shall receive Class 2 surface finish.

Exposed Visible Surfaces

All surfaces above the tops of kerbs shall receive Class 3 surface finish. End posts shall receive Class 3 surface finish. Precast parapet units and associated cast-in-place concrete shall receive Class 3 surface finish.

Precast Concrete

Precast parapet units shall be given a Class 3 surface finish.

Other precast units shall receive Class 2 surface finish.

All precast units shall receive this finish within forty eight (48) hours of removal of forms.

3.3.8.2 Rejection of Surface Finishes

Any concrete surface that does not comply with the requirements of this Specification shall be subject to one of the following alternatives, at the sole discretion of the Engineer.

1) Rejection of the concrete, in which case the concrete shall be demolished and replaced.

2) Approval of the concrete cast will be withheld subject to remedial measures being carried out the satisfaction of the Engineer.

The cost of any demolition or restoration work to be undertaken shall be borne by the Contractor.

3.3.8.3 Unformed Surface Finishes

i. Surfaces other than Wearing Surfaces

Unformed surfaces shall be compacted and tamped so as to flush mortar to the surface, screeded off and finally dressed with a wooden float to an even surface. Care shall be taken to drain or otherwise remove promptly any water which comes to the surface. A capping of mortar will not be permitted.

All future contact surfaces in composite construction shall be left rough, with the coarse aggregate at the surface firmly embedded but not forced below the surface.

ii. Wearing Surfaces

Where a concrete is shown on the Drawings (for example for the deck of a bridge), the concrete shall be thoroughly compacted and the surface screeded off by a suitable vibrating screed. Immediately following compaction and screeding the concrete shall be finished and shall be finally dressed with a wooden template or float or by other suitable means. The departures from grade shall not exceed 5 mm in any 3 metre length.

Where an asphaltic deck wearing surface is specified, the surface of the concrete, after being compacted, screeded and corrected, shall be dressed with a wooden float to close drying shrinkage cracks. Unless otherwise shown on the Drawings, all deck slabs shall have a broomed finish applied to the top surface while the concrete is still plastic. Brooming shall be done in a direction transverse to the longitudinal axis of the slab.

3.3.8.4 Class 1 Surface Finish

For a Class 1 surface finish no defects which structurally affect the concrete or reduce the cover to the steel reinforcement will be permitted. As soon as the formwork is removed, rough or porous areas shall be filled with a suitable stiff cement mortar, having the same proportions of cement and fine aggregate as used in the concrete, and shall be brought to an even surface with a wooden float. Bolts, wires and other appliances passing through the concrete to hold the formwork shall be cut off set back a minimum of 25 mm from the surface of the concrete, and the ends covered with a suitable mortar. If concrete spacer blocks are used they shall be manufactured with concrete of the same mixture as the parent concrete in the structure.

3.3.8.5 Class 2 Surface Finish

Surfaces to receive a Class 2 finish shall have the treatment specified above for Class 1 finishes together with the additional requirements below.

A Class 2 surface finish shall achieve a concrete surface of invariable colour and free from any major surface defects. The design of the formwork shall

be such as to give a deflection under the loads imposed on it of not more than 5 mm between studs of frame supports. The formwork shall be assembled by skilled tradesmen from materials which are suitable for this standard of formwork. The formwork shall be constructed so as to prevent water run off carrying stains on to previously cats concrete surfaces. The finished concrete surfaces shall be protected from mortar slurry, physical damage, spillage and water borne staining. Timber in contact with a concrete surface shall be softwood and any steel shall be protected to prevent rust staining of the concrete surface. No defect which structurally affects the concrete or reduces the cover to the steel reinforcement or other embedded components will be permitted.

All mortar fins shall be tooled away to expose a surface of dense sound concrete.

Excessive colour variations in the finished concrete surfaces shall be remedied at the Contractor's expense.

Embedded spacers and reinforcement supports which project to the surface of the concrete shall generally match the colour of the concrete and be of such design that only a minimal area is exposed after stripping.

Details of the proposed spacers and supports shall be submitted to the Engineer for his consent.

The use of concrete spacer blocks will not be permitted.

If any of the surfaces for which Class 2 Surface Finish is specified do not exhibit the required finish off the forms they shall be treated as specified for Class 3 finish below.

3.3.8.6 Class 3 Surface Finish

Surfaces to receive a Class 3 finish shall have the treatment specified above for Class 2 finishes together with the additional requirements below.

A Class 3 surface finish shall achieve a concrete surface of uniform colour and texture and free from surface defects. The design of the formwork shall be such as to give a deflection under the loads imposed on it of not more than the following:

- 1.5 mm between adjacent framing members
- 3.0 mm over the vertical face for the full depth of a panel, or height of a lift, whichever is the lesser.
- 3.0 mm over a 3 metre length horizontally.

Formwork shall be assembled by skilled tradesmen from materials which are suitable for this standard of formwork. Hardwood shall not be used in formwork construction and any steel shall be protected to prevent rust staining of the concrete surface. The formwork shall be constructed so as to prevent water run off carrying stains on to previously cast concrete surfaces. The finished concrete surface shall be protected from mortar slurry, physical damage, spillage and water borne staining. No defect which structurally affects the concrete or reduces the cover to the steel reinforcement or other embedded components will be permitted. If the concrete surface finish is not of uniform colour and texture remedial measures shall be taken by the

Contractor to produce the required surface finish at his own expense and to the satisfaction of the Engineer.

After the forms are removed mortar fins and irregular shall be removed and the surface shall be thoroughly wetted. It shall then be rubbed with No. 16 carborundum stone or similar abrasive until all form marks are removed and the surface is uniform in texture and the arrises are true. The paste formed in the process shall be uniformly distributed over the surface while it is still wet and allowed to set. It shall then be rubbed off with dry hessian or canvas.

Sandblasting shall only be permitted where environmentally acceptable.

3.3.9 Tolerances

The tolerances listed in Table 3.9 will be the basis for acceptance of the work. Work outside the specified tolerances may be rejected by the Engineer.

Table 3.9 Tolerances for Concrete Construction

COMPONENT	ITEM	TOLERANCE
Precast Concrete Piles (including Sheet Piles)	Variation in cross sectional dimensions	± 5 mm
	Variation in length	± 25 mm
	Squareness of head to longitudinal axis	± 5 mm
	Variation of the point to centre of the pile	± 5 mm
	Surface irregularities measured with 3 m straight edge	5 mm
	Bow for the length in mm (Variation from the straight)	$\frac{\text{Pile length}}{1000}$
Footings and Piles Caps	Variation in dimensions	+ 50 to – 10 mm
	Misplacement from the specified position	15 mm
	Surface irregularities measured with a 3 m straight edge	5 mm
	Variation of reduced levels at the tops of footings or pile caps	± 25 mm
Post Tensioned Prestressed Concrete Beams	Variation in top and bottom flange thickness	- 5 mm to + 10 mm
	Variation in wall thickness	- 5 mm to + 10 mm
	Variation in overall depth or width	± 5 mm
	Variation in overall length and length between bearings shall not exceed ± 10 mm or ± 0.1 percent of the span length whichever is the lesser	
	Variation in hog from specified profile shall not exceed 0.1 percent of the span length. Sag will not be permitted unless specified. The hog of beams in any one span shall not vary from the other by more than 15 mm.	
	Bow shall not exceed 10 mm or 0.1 percent of the span length whichever is greater.	
	Permissible surface irregularities when measured with a 3 m straight edge or template	5 mm
In situ Beams, Slabs, Columns, Piers, Walls, Railings, Kerbs and other similar parts	Variation in dimensions	± 5 mm
	Misplacement from the specified position	5 mm
	Variation of reduced levels of the tops of columns, piers, wall beams or similar parts.	± 5 mm
	Variation of reduced levels of bearing areas	± 5 mm
	Variation from plumb over full height of columns	± 5 mm

3.3.10 Waterstops

3.3.10.1 General

Waterstop shall be provided where concrete structures require water-tightness- at joints as shown on the Drawings or as directed by the Engineer. The width of the waterstop shall be within a tolerance of 10 mm of the nominal width exclusive of the nailing strips.

3.3.10.2 Material

The waterstop shall be extruded from an elastomeric plastic compound, the basic resin of which shall be polyvinyl chloride (PVC). The compound shall contain any extruded additional resins, plasticisers, or other materials needed to ensure that, when the material is compounded, it will have the physical characteristics specified herein:

Physical Characteristics		Method of Test
Tensile Strength, min	140 kgf/cm²	ASTM D 412
Ultimate Elongation, min	300%	ASTM D 412
Hardness, Durometer (Type-A)	65 to 80	ASTM D 2240
Specific Gravity	1.40 ± 0.2	
Water Absorption, max	0.15%	
Tensile Strength after Accelerated Extraction Test, min	110 kgf / cm²	
Ultimate Elongation after Accelerated Extraction Test, min	240%	
Changes in Weight Effect of Alkali Test	± 5%	

The manufacturer's certification of conformity to the specified requirements shall be submitted to the Engineer for approval.

3.3.10.3 Fabrication

a) The shapes and dimensions of PVC waterstops shall be as shown on the Drawings or as approved by the Engineer.

b) Extruded waterstop shall be dense, homogeneous, and free form holes, scratches and other imperfections. The cross-section of PVC waterstop shall be uniform along its length and shall be transversely symmetrical so that the thickness at any given distance from either edge of the waterstop shall be uniform.

3.3.10.4 Splices

a) Splices in waterstops or at the intersection of runs of the PVC waterstop shall be made with fusion-welded butt splices in accordance with the manufacturer's instruction. All splices shall be neat with the ends of the joined surfaces in alignment and in good contract. The continuity of the characteristics patterns of the cross-sections of the waterstop shall be maintained across the splice. All intersection splices shall be prefabricated at the manufacturer's factory.

b) The number of splices in the waterstop shall be kept to a minimum and all splices shall be approved by the Engineer. The equipment used for making splices and the splicing method shall also be as approved. The equipment used for making field joints shall be a temperature controlled apparatus furnished by the Contractor.

c) The Contractor shall make the splices in such a manner as to ensure that the splices have a tensile strength not less than 80 percent of that of the unspliced material. The Contractor shall undertake testing to confirm the strength of field splices. The splice shall be watertight, free of air bubbles and the rib and centre bulb, where applicable, shall match up exactly and be continuous.

3.3.10.5 Installation

a) To eliminate faulty installation that may result in joint leakage, particular care shall be taken to see that the waterstops are correctly positioned during installation. Adequate provision shall be made to support the waterstops during the progress of work and to ensure the proper embedment in concrete. The method of securing the waterstops will be to the approval of the Engineer. The symmetrical halves of the waterstops shall be embedded in the concrete on each side of the joints. Waterstop shall be thoroughly cleaned of foreign material before concrete is placed.

b) Care shall be exercised in placing and vibrating the concrete about the waterstop to ensure complete filling of the concrete under and about the waterstop and to obtain a continuous bond between the concrete and the waterstop at all points around the perimeter of the waterstop.

c) Suitable guards shall be provided to protect exposed projecting edges and ends of partially embedded waterstop from mechanical damage at all times. The PVC waterstop which will remain exposed for more than 10 days shall be covered or shaded to protect it from the action of temperature and ultraviolet rays.

d) The Contractor shall replace or repair any punctured or damage waterstop.

3.3.11 Miscellaneous

3.3.11.1 Soffits

The soffits of beams and deck edges shall be continuous curves or straight lines as shown on the Drawings. All visible irregularities shall be made good to the satisfaction of the Engineer.

3.3.11.2 Anchor Bolts

All necessary anchor bolts as shown in the Drawings shall be set either before the concrete is placed, or in the concrete as it is being placed, or in holes formed while the concrete is being placed, or in holes drilled after the concrete has set.

If set in the concrete as it is being placed, a bolt shall be placed in a section of standard black pipe, at least 50 mm larger in diameter than the bolt, and shall be anchored by passing through a heavy steel washer at the bottom of the pipe. Holes may be formed by inserting in the fresh concrete oiled wooden plugs, metal pipe sleeves, or other approved devices, and withdrawing them after the concrete has partially set. Holes so formed shall be at least 100 mm in diameter. If drilled, holes shall be at least 25 mm larger in diameter than the bolts used.

Bolts shall be set to be at the levels as shown on the Drawings and deviation from line and level shall not exceed 5 mm. The bolts shall be fixed with grout completely filling holes. The grout shall consist of one part Portland cement to one part fine-grained sand.

Where a group of bolts is installed for anchorage of a fence post or similar, the bolt group shall be installed prior to the placing of concrete. The concrete over the support base plate area shall be scabbled to remove all laitance and loose or porous material and left in a roughened state.

3.3.11.3 Bridge Bearings

Bridge bearings shall be provided and installed in accordance with Section TS 11 of this specification.

3.3.11.4 Pipes, Conduits and Ducts

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

3.3.11.5 Block-outs

Block-outs to allow for the subsequent installation of metal components (e.g. gate guide frames) shall be formed as shown on the Drawings and to the tolerances shown in table 3.9.

Where block-outs are formed, the concrete surfaces shall be chipped, roughened and cleaned and kept moist for at least 4 hours. After such surfaces have been inspected and approved by the Engineer, concrete type C-2 as specified in table 3.1 shall be placed. Care shall be taken to ensure that the concrete is tightly bonded to the previously-placed concrete and the complete adhesion between the concrete and all metalwork or other items in the block-out is obtained.

3.4 STEEL REINFORCEMENT

3.4.1 Scope

This clause covers the supply, handling and placing of steel reinforcement for concrete.

3.4.2 Materials

Unless shown otherwise on the Drawings, reinforcement shall consist of deformed steel reinforcing bars, of a strength grade as shown on the Drawings, complying with the requirements of AASHTO M 31M (ASTM A 615).

Where the use of other reinforcement is shown on the Drawings, such reinforcement shall comply with the requirements of the appropriate following standards:

- AASHTO M 225 (ASTM A 496) Deformed Steel Wire for Concrete Reinforcement
- AASHTO M 32 (ASTM A 82) Cold Drawn Steel Wire for Concrete Reinforcement
- AASHTO M 55 (ASTM A 185) Welded Steel Wire Fabric for Concrete Reinforcement

Steel reinforcement shall be supplied free from loose millscale, mortar, loose or thick rust, or any other coating.

3.4.3 Order Lists

Before ordering material, all order lists and bending diagrams shall be furnished by the Contractor for the approval of the Engineer, and no material shall be ordered until such lists and bending diagrams have been approved. Approval of order lists will in no way relieve the Contractor of his responsibility for ascertaining accuracy of such lists and diagrams. Revision of material furnished in accordance with such lists and diagrams to meet compliance with the design drawings shall be at the expense of the Contractor.

3.4.4 Protection of Materials

Reinforcing steel shall be protected at all times from damage and shall be stored on blocks to prevent mud caking. Prior to placing concrete, reinforcing steel which is to be embedded shall be free from heavy rust, dirt, mud, loose scale, paint, oil, or any other foreign substance.

3.4.5 Bending

Unless otherwise permitted, all reinforcing bars requiring bending shall be bent cold and shall be bent in accordance with American Concrete Institute procedures unless otherwise detailed. All hooks and bends shall be in accordance with P.B.I 1971 N.I. 2 (Indonesian Reinforced Concrete Code). Bars partially embedded in concrete shall not be bent except as shown on the drawings or otherwise permitted. Qualified labour shall be employed for cutting and bending, and proper appliances shall be provided for such work. Should the Engineer consent to the application of heat for field bending

reinforcing bars, precautions shall be taken to assure the physical properties of the steel will not be materially altered.

3.4.6 Placing and Fastening

All reinforcing steel shall be accurately placed and during the placing of concrete, firmly held by approved supports in the position shown on the Drawings. Reinforcing bars shall be securely fastened together. Reinforcement placed in any member shall be inspected and approved before any concrete is placed.

3.4.7 Splicing

All reinforcement shall be furnished in the full lengths indicated on the Drawings. Splicing of bars, except where shown on the Drawings, will not be permitted without the written consent of the Engineer and then only welded spliced may be permitted. Splices shall be staggered as far as possible.

In the lapped splices, unless otherwise shown on the Drawings, bars shall be lapped 40 diameters to make the splice. Welding of reinforcing steel shall be done only if detailed on the drawings or if authorised by the Engineer in writing. In such cases, the Contractor shall submit to the Engineer for his approval a welding procedure and a list of welders to perform the welding, including their qualifications and details of welder qualification testing to be carried out.

3.4.8 Substitution

Substitution of different size bars will be permitted only upon the specific authorisation of the Engineer. If steel reinforcement is substituted, it shall be of a size equivalent to the design size or larger.

3.5 DEFECTIVE CONCRETE

3.5.1 General

Concrete which is not placed and completed in accordance with this Specification, or does not meet the requirements of this Specification in regards to surface finishes, or which is, in the opinion of the Engineer, defective, shall be removed within the limits assigned by the Engineer, and replaced in accordance with the requirements of Section TS 9, Concrete Repairs of this Specification except as modified below.

No repair to concrete shall be carried out without the consent of the Engineer. All repairs shall be performed by skilled workmen and shall be carried out within 24 hours of the removal of the forms and/or the defect becoming visible.

3.5.2 Materials for the Repair of Defective Concrete

Materials used shall be the same as those used in the parent concrete.

For repairs to Class 2 and Class 3 finishes the proportions of materials shall be determined by experiment to provide a matching colour at 28 days. White cement shall be substituted for a portion of the grey cement as required.

Cement mortar shall consist of one part cement by volume and not more that three parts of fine aggregate by volume and an appropriate quantity of water.

Dry pack shall be composed of a mix of one part of cement by volume to two and one half parts by volume of sand that will pass a 1.18 millimetre sieve, together with just enough water to produce a mortar which will just stick together when moulded into a ball by slight pressure of the hands and not exude water but will leave the hands damp.

Concrete shall have the same strength as the parent material.

3.5.3 Repair of Defective Concrete

All repairs shall be bonded tightly to the parent material, be sound and free from shrinkage cracks and drummy areas after curing and drying and have the surface finished smoothly and flush with the adjoining surfaces. Repairs to Class 2 and Class 3 finishes where permitted shall be carried out in accordance with the Engineer's directions. The area around the defective concrete shall be marked with saw cuts twenty (20) mm deep, cut on straight lines. Defective concrete shall be excavated to sound concrete to the satisfaction of the Engineer. The excavated area shall be primed with an suitable epoxy adhesive in accordance with the manufacturer's recommendation, and built up with dry-pack, cement mortar or concrete to bring the surface to the tolerances as set out in Clause 3.3.9. Bulges and abrupt irregularities shall be reduced by bush hammering and grinding until the surface is within the required tolerances. The treatment of this and adjoining areas shall be subject to the consent of the Engineer. Where dressing is required, all fins shall be removed and all blowholes and honeycombing shall be filled using cement mortar. The area shall be rubbed down with a cement mortar using only the portion of sand passing the 600 micron sieve and a cement ratio the same as the parent mix but with just sufficient water for workability. The excess material shall be rubbed off within hessian 24 hours later.

Drypack shall be used for filling narrow slots cut for the repair of cracks, for grouting holes and for filling tie rod fastener recesses. Drypack shall not be used for filling behind reinforcement.

Cement mortar filling placed under impact (shotcrete or similar) may be used for the repair of areas which are too wide for drypack, yet too shallow for concrete filling and no deeper than the inner face of the reinforcement nearest the surface.

Concrete filling shall be used for holes greater in area than 0.1 square metres or deeper than 100 mm, and for holes which are greater in area than 0.5 square metres and which extend beyond reinforcement.

Where required cracks shall be sealed and or injected with epoxy resin in accordance with the requirements of Sections TS 9 and TS12 of this Specification.

Any material spilled on or stains to adjacent areas of consent shall be cleaned to the satisfaction of the Engineer.

3.6 MEASUREMENT AND PAYMENT

3.6.1 Concrete

This clause refers to concrete of the various classes, as described in Section TS 3 of this Technical Specification.

Measurement for payment of concrete will be made in cubic metres (m3) in accordance with the dimensions shown on the Drawings or as directed and accepted by the Engineer but the measurement shall not include any concrete used for the construction of temporary work. No deduction will made for the volume occupied by pipes less than 200 mm in diameter nor for reinforcing steel, anchors, conduits, weep holes or piling except that deductions will be made for the volume of structural steel, encased in concrete. The measurement shall not include any concrete used in the construction of cofferdams or falsework, or the volume of forms or falsework. Requirements for any increased cement content, admixtures, or concrete finishing will not be measured separately.

Payment will be made at the rates entered in the Bill of Quantities and shall include the entire cost of completing the work including materials, labour, equipment, transportation, handling and storage of cement, aggregate, and admixtures (if any),mixing, placing, finishing and curing concrete, construction of joints, formwork, falsework and scaffolding and any other associated costs.

Categories of work to be paid under this clause are as follows:

Description	Unit of Measurement
Concrete, Type B including Formwork	m^3
Concrete, Type C1 including Formwork	m^3
Concrete, Type C1 including Formwork and Falsework	m^3
Concrete, Type C1 including Formwork, Scaffolding and Falsework	m^3
Secondary Concrete, Type C2	m^3
Concrete, Type E including Formwork	m^3

3.6.2 Steel Reinforcement

This clause refers to steel reinforcement, as described in Section TS 3 of this Technical Specification.

Measurement shall be made in kilograms of the masses of steel reinforcement placed in accordance with the Drawings and complying with the requirements of Section TS 3 of the technical specification. The mass so determined shall be based on the mass per metre as tabulated below. The lengths to be used in calculating the mass for the purpose of payment shall be as shown on the Drawings or ordered in writing by the Engineer.

No measurement or payment will be made for splices added by the Contractor for his convenience nor for splices not shown on the Drawings and consented to by the Engineer.

Mass per Metre of Bars for Measurement			
Bar Code	Mass per Metre (kg/m)	Bar Code	Mass per Metre (kg/m)
D10	0.617	D19	2.230
D12	0.888	D22	2.980
D13	1.040	D25	3.850
D14	1.210	D29	5.190
D16	1.580	D32	6.310
D18	2.000	D36	7.990

Payment will be made at the rates entered in the priced Bill of Quantities and shall include the entire cost of completing the work including materials, labour, equipment, transportation, handling and storage of reinforcement, fabrication, bending, assembling and welding of reinforcement, clips and ties and the like for positioning and fastening reinforcing bars and any other associated costs.

Categories of work to be paid under this clause are as follows:

Description	Unit of Measurement
Deformed Reinforcing Bars	kg
Dowel Bar. Dia. 19mm, 1.0m long (round bar and PVC pipe)	kg

3.6.3 Waterstops

This clause refers to waterstops as described in clause 3.3.10 of this Technical Specification

Measurement will be made of the length of water stop supplied, installed and accepted.

Payment will be made at the rate entered in the priced Bill of Quantities which shall include full payment for all labour, materials, tools, equipment and incidentals for furnishing, testing, cutting, splicing and installation and other work incidental to the installation of waterstops.

Categories of work to be paid under this clause are as follows:

Description	Unit of Measurement
Water Stop, 200 mm Wide	m

3.6.4 Chipping of Existing Concrete Surface

This clause refers to the breaking back of existing concrete as described in clause TS 3.3.5.1.

Measurement will be made of the area of existing concrete structure chipped back, prepared for the application of new concrete as specified and approved by the Engineer.

Payment will be made at the rate entered in the priced Bill of Quantities which shall include full payment for providing all labour, materials, tools, equipment and any other works incidental to the chipping and the subsequent preparation of the chipped surface for the application of new concrete.

Categories of work to be paid under this clause are as follows:

Description	Unit of Measurement
Chipping of Existing Concrete Surface	m^2

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SECTION TS 4. PRECAST CONCRETE

SECTION TS 4. PRECAST CONCRETE

4.1 GENERAL

This section of the technical specification covers the general and specific requirements of precast concrete. It shall apply wherever precast concrete is used in the Works, such as in pile, sheet piles, pipes, prestressed beams, and the like, as shown on the Drawings or specified in this and other technical specification clauses or where it is approved in writing by the Engineer in writing to be used as alternative form of construction.

Concrete in precast concrete units shall be in accordance with the requirements of Section TS 3 of this Specification.

Storage handling, transport from the site storage area and erection of the precast concrete members are covered in Section TS 8 of this Specification.

This section shall apply whether or not precast concrete units are manufactured directly by the Contractor or a specialist, reputable manufacturer approved by the Engineer. Where precast concrete units are obtained from an approved specialist manufacturer, other than the Contractor, the Engineer may, at his sole discretion, waive the need for the Contractor to submit detailed manufacturing plans and calculations.

4.2 FORMWORK

4.2.1 General

Formwork shall comply with the requirements of Section TS 3 of this Specification except as modified below.

Prior to the commencement of manufacture of this units, the Contractor shall submit detailed plans and calculations of the proposed formwork. These plans shall include details of all formwork, formwork joints, sealing procedures, ties, size and spacing of framing and details of any propriety fittings or systems proposed to be used.

The dimensions of formwork shall make allowance for changes in dimensions due to shrinkage, elastic shortening and creep, so that the completed unit conforms with the tolerances specified.

Formwork shall be constructed so that movement of the unit resulting from the effects of shrinkage, steam curing and prestress is not restrained and so that the unit is not damaged by movement within the formwork, Special attention shall be given to projecting reinforcement and bolts and to the methods of fixing base plates and devices for holding down deflected tendons.

4.2.2 Formwork Materials

Forms shall generally be manufactured from steel only. However, the Engineer may consent to the use of plywood and timber formwork for non-repetitive non-prestressed units.

4.2.3 Forms

Where forms incorporate insertions for forming voids in the units, the formers and the method of securing them in position shall be subject to the consent of the Engineer. Void formers shall be securely restrained in position vertically against the action of placing concrete and subsequent flotation under vibration. The void former shall likewise be laterally restrained against forces arising from differential pressure during placing of concrete.

4.3 STEEL REINFORCEMENT

The supply, bending, cutting and placing of reinforcement shall be in accordance with the requirements of Section TS 3 of this Specification except as modified below.

Reinforcement shall be supported at no more than 0.5 metre intervals transversely and 1.0 metre longitudinally or vertically unless otherwise consented to by the Engineer.

Unless shown otherwise on the Drawings the clear cover to bars shall be the greater of one and a half (11/2) times the diameter of the bar and 25 mm.

4.4 PROJECTING REINFORCEMENT

Where shown on the Drawings, steel reinforcement shall be left projecting for the purpose of bonding on subsequent work. Care shall be taken to avoid disturbing the bars during the specified period for curing of the concrete. Projecting reinforcement which has been damaged or dislodged or which is loose in the concrete will be cause for rejecting of the units.

4.5 BEARING PLATES

This clause is not applicable to this contract.

4.6 UNIFORMITY OF PROFILE-PRECAST BEAMS

Where a number of beams are to placed in one span, it is essential that the hog of these beams be as nearly uniform as practicable. Accordingly, the Contractor shall ensure that:

- The concrete in these beams is uniform in compensation, consistency, compaction and strength.
- The curing conditions are as uniform as practicable.
- The concrete in each beam is approximately the same age when tensioned.
- All the beams or segments for any one span are cast within as short a time as is reasonably practicable.

4.7 MARKING

The identification number, date of casting, the lifting positions and the word 'TOP' shall be marked on every unit.

Immediately after screeding, temporary identification shall be made on the top surface of the unit near an end. Final marking shall be made by indelible marking material, using letters approximately 75 mm high.

The ends of unsymmetrical members shall be clearly marked to indicate the manner in which they are to be oriented in the structure.

4.8 PREPARATION OF STORAGE AREA AND ACCESS TRACKS

The Contractor shall construct a storage area and access tracks in accordance with the requirements of this Clause.

The storage area shall be sufficient size to accommodate all units and allow for handling and manoeuvring of cranes and vehicles. The surfaces of storage areas and access tracks shall be paved to provide adequate drainage and ensure that surface water will not pond.

The width of access tracks shall not be less than 3.5 metres. Access tracks shall be widened on curves where required to accommodate trailing bogies for transport of long units.

Crossfall on access tracks shall not be greater than 1 in 30 unless consented to by the Engineer.

The alignment and grading of the access tracks shall be as shown on the Drawings or as consented to by the Engineer.

After completion of the works or at a time consented to by the Engineer, the Contractor shall reinstate the access track and storage area to the satisfaction of the Engineer.

4.9 DEFECTIVE CONCRETE

Concrete which is not placed and completed in accordance with this Specification, or does not meet the requirements of this Specification in regards to surface finishes, or which is, in the opinion of the Engineer, defective, shall be removed within the limits assigned by the Engineer and replaced in accordance with the requirements of Section TS 9, Concrete Repairs, of this Specification. Repairs to concrete shall not be carried without the consent of the Engineer.

If a unit is to be repaired the Contractor shall submit for consent details of the materials to be used and the method to be adopted in effecting the repair.

4.10 GENERAL STORAGE REQUIREMENTS

Where units are placed in storage side by side, the minimum lateral clearance between side faces of adjacent units shall be a nominal 50 mm unless otherwise directed by the Engineer.

Where lifting frames are used in handling units, the minimum lateral clearance shall be the overall width of the frame plus 100 mm unless otherwise directed by the Engineer.

Where are stored in the vicinity of trees, the units shall be protected from damage caused by staining from foliage.

Units shall not be stored in areas subject to flooding, within 10 m of existing or proposed overhead power or telephone lines, or over service conduits, drainage pipes or uncompacted fill without the consent of the Engineer.

Concrete foundations used for storage shall be removed from the storage area by the Contractor after the units have been erected.

4.10.1 Storage and Temporary Supports for Precast Beams

Temporary supports for beams shall be concrete unless otherwise specified or consented to by the Engineer.

The Contractor shall submit details of the proposed system of temporary supports for the consent of the Engineer. This information shall be submitted not less than 4 weeks prior to the proposed delivery of the units.

The width of temporary supports shall not be less than 100 mm for units under 7 tonnes in weight and not less than 200 mm for units 7 tonnes and over.

The length of the temporary support shall not less than the height of the unit, or the width of the bottom flange plus 600 mm, whichever is the greater, and the unit shall not be placed within 300 mm of the end of the support.

Temporary supports shall be clear of the sole plate.

The maximum ground bearing pressure for designing supports shall not exceed 500 kPa (50 t/m^2).

All beams shall be laterally supported. The lateral bracing shall be designed for 10% of the dead load of the beam at the mid height of the beam.

The ground or space between supports of a unit shall be carefully cleared and levelled to prevent the unit from being supported at intermediate points.

A minimum clearance of not less than 100 mm shall be provided between soffit of units and the ground. This amount shall be increased in instances where greater clearance is required for handling operations involving lifting frames.

4.10.2 Storage and Temporary Supports for Piles and Slabs

All units shall be supported on bearers clear of the ground. The bearers shall be either steel, concrete or merchant grade hardwood. The bearing pressures on supports and/or ground shall be as shown on the Drawings or as consented to by the Engineer. The safe bearing pressure on ground shall not exceed 500 kPa (50 t/m^2) where units are stacked. The bearing pressures of units on timber shall not exceed 2.0 MPa (200 t/m^2).

Each layer of stacked units shall be separated by seasoned hardwood timber bearers of at least 100 mm wide and not more than 75 mm thick and not less than 30 mm thick. The bearing stresses on these timbers shall not allowable stresses.

Units maybe stored in separate stacks of identical units up to a maximum height of 2 m or 2 units high, whichever is the greater, subject to the consent of the Engineer.

Each layer of units shall be separated by timber bearers in line vertically with the underlying supports.

Piles may be stacked to a maximum of six layers, if consented to by the Engineer. The minimum bearing width for the piles in each instance shall not be less than 200 mm.

4.11 HANDLING

Units shall be carefully handled at all times and shall not be subject to shock and impact loads. They shall be lifted at the positions, and in a manner required by the Drawings and Specification or as consented to by the Engineer. Where the method of handling is not specified the Contractor shall submit, for the consent of the Engineer, details of his proposals for handling the units.

Unless otherwise specified, units such as beams and structural slabs shall be lifted and supported with the top surface uppermost at all times. Beams shall be stored and handled with webs vertical at all times.

Stiffening frames, where required, shall be attached as shown on the Drawings during lifting and handling.

Where shown on the Drawings the Contractor shall provide lifting frames for lifting of the units. Except during the initial lift from the casting bed, units shall be lifted and moved with the lifting frame. When the units are first lifted off the casting bed they shall only be raised vertically and sufficiently to permit attachment of the lifting frame.

The position and mode of attachment of slings or other tackle for guiding and controlling the movement of the units during lifting and transport shall be subject to the consent of the Engineer. Special care shall be taken to protect the units from damage due to slings or other tackle.

The angle subtended by the slings and the longitudinal axis of the unit shall be not less than 60 degrees. A single sling lifting will not be permitted.

Guide ropes shall be attached to each end of units for the purpose of hand guiding the units when being lifted. The guide ropes shall have a nominal capacity of 10 kiloNewtons (1 tonne).

Temporary supports during handling operations shall comply with the relevant provision of this Specification unless otherwise to by the Engineer.

All handling, transport and erection operations shall be performed in the presence of the Engineer or his representative.

4.12 TRANSPORTING

Units shall not be transported to the temporary storage or the Site less than 7 days after casting nor until concrete test samples representing the concrete in the units have reached a strength of not less than the specified 28 days strength.

No unit shall be removed from the casting yard prior to a release note having been issued by the Engineer.

During transporting units shall be handled and supported as specified in Clause 4.11 above.

Units shall be securely fixed to the transporter by means of wire ropes or steel chains of adequate size at each end. They shall pass over the top

flange and shall be fitted with suitable tensioners. Provision shall be made to protect the units from damage caused bay these lashings. Adequate restraints shall be provided against lateral deflection.

4.13 DAMAGE TO UNITS

In the event of any unit sustaining damage such as cracking, spalling or deformation of projecting reinforcement or bolts, the unit shall be set aside until it has been inspected by the Engineer, who will decide whether it shall be rejected, tested or repaired.

If a unit is to be repaired, the Contractor shall submit for consent details of the materials to be used and method to be adopted in effecting the repair. Repairs shall be carried out in accordance with the requirements of Section TS 9, Concrete Repairs, of this Specification. Repairs to damaged units and the replacement of rejected units shall be at the expense of the Contractor.

4.14 ACCEPTANCE

Consent or comment given by the Engineer to any drawings, work or methods will be tentative only and will not relieve the Contractor of the responsibility for producing units in accordance with this Specification.

Any unit which is cracked, honeycombed or otherwise defective to an extent which, in the opinion of the Engineer renders it unfit for its intended purpose, will be rejected.

For units made at locations remote from the site, the Engineer will arrange to supervise and inspect the processes involved in the manufacture of the units only, with limited attention to the checking of dimensions of the forms and the finished units. On delivery to the Site, the units will be inspected by the Engineer who will advise the Contractor if the units are acceptable for incorporation into the Works.

Acceptance will only be made following Completion of the Works in accordance with the General Conditions of Contract.

4.15 MEASUREMENT AND PAYMENT

Measurement and Payment for Precast Concrete will not be made exclusively and all costs incurred by the Contractor in complying with the requirement of this clause shall be deemed to be included in the rates entered in the Bill of Quantities for works which incorporate the requirements of Precast Concrete. These shall include the entire cost of completing the work including materials, labour, equipment, transportation and any other associated costs.

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SECTION TS 5. PRESTRESSED CONCRETE

SECTION TS 5. PRESTRESSED CONCRETE

5.1 GENERAL

This section of the Technical Specification covers the general and specific requirements of precast prestressed concrete. It shall apply wherever precast prestressed concrete is used in the works, such as piles and precast prestressed beams, as shown on the Drawings or specified in this and other Technical Specification clauses or where it is approved in writing by the Engineer to be used as an alternative form of construction.

This Section covers the supply and tensioning of tendons for both post-tensioned and pre-tensioned units.

Concrete for prestressed concrete is covered by Section TS 3 of this Specification.

Tensioning shall not be commenced until the Engineer has consented to the Contractor's proposed method of prestressing.

Concrete shall not drilled or any portion cut or chipped away or otherwise disturbed after prestressing without the express consent of the Engineer.

Only under exceptional circumstances and with the consent of the Engineer shall the maximum jacking force exceed 80 percent of the rated capacity of the jacking equipment used, or 75 percent of the specified minimum breaking load of the tendon whichever is the lesser.

All materials necessary for the prestressing shall be supplied by the Contractor unless shown on the Drawings or in the Special Specifications.

This section shall apply whether or not prestressed concrete units are manufactured directly by the Contractor or by a specialist, reputable manufacturer approved by the Engineer

5.2 TENDONS

5.2.1 Materials

Prestressing tendons shall be as shown on the Drawings and shall comply with the requirements of:

AASHTO M 203	Uncoated Seven-Wire Stress-Relieved Strand for Prestressed Concrete (ASTM A 416)
AASHTO M 204	Uncoated Stress-Relieved Wire for Prestressed Concrete (ASTM A 421)
AASHTO M 275	Uncoated High Strength Steel Bar for Prestressed Concrete (ASTM A 722).

The material selected for use in the tendons shall have an ultimate tensile of not less than 167 percent of the specified forces shown on the Drawings after losses.

5.2.2 Manufacture

Fabrication of tendons shall not commence without the written consent of the Engineer.

Tendons shall be made to the required length plus an allowance, where applicable, at each end for stressing operations.

No welding will be permitted on or near tendons nor shall any heat be applied to tendons. Any tendons which have been affected by welding, weld spatter or heat will be rejected.

Spicing of strands or wires forming a tendon will not be permitted. Tendon couplings shall only be used where shown on the Drawings and the type shall be subject to the consent of the Engineer.

Flame cutting of wire or strand within 75 mm of where the tendon will be gripped by the anchorage or jacks will not be permitted.

A durable metal label on which shall be stamped the length of the tendon and the coil number of the wire or strand used shall be tied to each tendon.

5.2.3 Testing

A copy of the manufacturer's test certificates and load-extension graphs covering each coil to be used shall be supplied to the Engineer. If test certificates relating to the material cannot be supplied the Contractor shall arrange for testing of samples in accordance with the Standards in Clause 5. 2.1.above.

This testing shall be at the Contractor's expense.

If the test certificates are satisfactory further testing of tendons will not be required provided that a satisfactory correlation is obtained during the initial stressing stages.

Should the correlation between jacking force and extension be unacceptable to the Engineer, then testing of the tendon will be required prior to the commencement or continuation of the tensioning operation. In such cases, three samples, each 1.4 m long shall be tested at a laboratory approved by the Engineer at the Contractor's expense. The samples will be tested for the breaking load, modulus of elasticity, and percentage elongation at rupture on a 600 mm gauge length.

Where such testing is required the tendons represented by the test samples shall not be stressed until results acceptable to the Engineer have been obtained.

5.2.4 Handling and Storage

High tensile steel wire and strand shall be supplied in coils of sufficiently large diameter such that they shall retain their physical properties and shall be straight as they unwind from the coil. Wire or strand of any type that is damaged, kinked, or bent shall not be used.

Tendons shall be free from loose, oil, grease, tar, paint, mud or any other deleterious substance. A slight film of rust shall not be regarded as harmful but the steel shall not be pitted by rust. If cleaning is required, the tendons shall not be brought to a polished condition.

Material for tendons, whether made up or not, shall be stored under a waterproof shelter, supported above ground level and shall be protected from damage or deterioration.

5.3 SAFETY PRECAUTIONS

Care shall be taken during tensioning to ensure the safety of all persons in the vicinity.

Jacks shall be secured in such a manner that they will be held in position should they lose their grip on the tendons.

No person shall be allowed so stand behind the jacks or close to the line of the tendons while tensioning is in progress.

The operations of the jacks and the measurement of the elongation and associated operations shall be carried out in such a manner and from such a position that the safety of all concerned is ensured.

A safety barrier shall be provided, at both ends of the stressing bed or unit, to prevent any tendon which might become loose from recoiling unchecked.

When pretensioning, ligatures enclosing the tendons shall be used, or alternatively, timber planks or rolls of hessian shall be laid across the tendons to restrain lateral or vertical movement of tendons which may break under stress.

During actual tensioning operations suitable warning signs shall be displayed at both ends of tensioning bed or member.

5.4 EQUIPMENT

All tensioning equipment shall be subject to the consent of the Engineer prior to use. Hydraulic pumps shall be power-driven unless otherwise consented to by the Engineer.

The power unit shall be adjusted so that the rate of extension of the tendon is within the limits recommended by the equipment manufacturer and as consented to by the Engineer.

Dynamometers, and each set of equipment comprising pump, jack pressure gauge and mater gauge shall be calibrated by a registered immediately prior to use and then at intervals not exceeding 3 months and the true force determined from the calibration curve.

Pressure gauges shall be concentric scale type complying with the requirements of AS 1349 'Bourdon tube pressure and vacuum gauges', which requires gauges to be accurate to within one percent of their full capacity. They shall be so selected that when the tendon is stressed to 75 percent of its breaking load the gauge is reading between 50 percent and 90 percent of its full capacity. Suitable safety devices shall be fitted to protect pressure gauges against sudden release of pressure.

Provision shall be made for the attachment of a master gauge to be used as a check whenever requested by the Engineer.

The measuring equipment used shall permit tendon force and elongation to be determined within an accuracy of ± 1 mm or 2 percent, whichever is the lesser.

The equipment used shall prevent unwinding of the strand during tensioning.

5.5 MEASUREMENT OF TENSIONING FORCE

The tensioning force applied to any tendon shall be determined by direct measurement of the force and checked by measurement of the elongation of the tendon.

The secant modulus determined from test samples or test certificates shall be used when interpreting the measurement of elongation.

Should the secant modulus of batches of tendons differ by more than 3 percent, the required elongation shall be adjusted accordingly.

The average force in the tendon calculated from elongation measurements will, in general, differ from the force measured at the jack due to friction losses inside the duct and at the anchorage. Where not shown on the Drawings, the Engineer will specify the required values for the elongation and for the force in the tendon at the jack. Allowance shall be made for any anticipated draw-in at the member and for anticipated losses due to stressing of subsequent tendons.

If, on completion of tensioning each tendon to the required force, the check measurement of elongation differs from its required value by more than 5 percent the Engineer may direct that some or all of the following steps by taken:

- Re-calibration of equipment.
- Testing of tendon material to check secant modulus.
- Tendons released and re-stressed. (Secant modulus applicable to second stressing to be adopted).
- Lubrication of tendons to reduce friction losses. Only water soluble oils shall be used in ducted system and these shall be washed out before grouting.
- Where only one jack was used previously, the tendon to be tensioned from both ends using two jacks.
- Other methods as directed by the Engineer.

The cost of any of the above steps shall be borne by the Contractor

5.6 DATA TO BE RECORDED

The following data, where applicable, shall be recorded by the Contractor:

- Identification number of each dynamometer, gauge, pump and jack.
- Identification particulars of tendons.
- Initial forces (or pressure) when tendons are marked for measurement of elongation.
- Final forces (or pressures) and elongation obtained on completion of tensioning.
- Elongations remaining after release of jacks.

- Elongations obtaining at intervals during tensioning, together with corresponding forces (or pressures), as required by the Engineer.

Fully completed forms shall be forward to the Engineer no later than four days after stressing.

5.7 INITIAL PRESTRESS

Consideration will be given to the application of an initial partial prestress at an earlier date to overcome handling or shrinkage problems, or to permit early removal of falsework. Details of proposals shall be submitted to the Engineer for his consent.

5.8 MEASUREMENT AND PAYMENT

Measurement and Payment for Prestressed Concrete will not be made exclusively and all costs incurred by the Contractor in complying with the requirement of this clause shall be deemed to be included in the rates entered in the Bill of Quantities for works which incorporate the requirements of Prestressed Concrete. These shall include the entire cost of completing the work including materials, labour, equipment, transportation and any other associated costs.