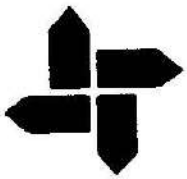

DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

MINISTRY OF PORTS & HIGHWAYS

ROAD DEVELOPMENT AUTHORITY

HAMBANTOTA HUB DEVELOPMENT PROJECT
CONSTRUCTION OF
EXTENSION OF SOUTHERN EXPRESSWAY FROM WATIYA TO ANDARAWEWA

CONTRACT AWARDED TO
CHINA STATE CONSTRUCTION ENGINEERING CORPORATION LIMITED

CIVIL WORK CONTRACT NO: RDA/RNIP/HH/01

VOLUME 3

TECHNICAL SPECIFICATION

-SECTION 2 (DIVISION 500 - 600)

AUGUST 2013

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DIVISION 550

STRUCTURAL CONCRETE

DIVISION 550
STRUCTURES

SECTION 551
STRUCTURAL CONCRETE

551.1 - DESCRIPTION:

This work consists of furnishing and placing Portland Cement Concrete for structures, and incidental construction, in line with these specifications and in reasonably close conformity with the lines, grades and dimensions as shown on the Drawings or established by the Engineer.

Classes of concrete shall be used as indicated below unless noted otherwise on the Drawings:

TABLE 551.1. A

TABLE OF MIXES

Class	Max. Agg. Size	Min Cement Content	Max Free Water Cement Ratio	7 day N/mm^2	28 day N/mm^2
45/20	20mm	400kg	0.425	33	45
35/20	20mm	330kg	0.525	25	35
30/20	20mm	310kg	0.550	20	30
25/20	20mm	275kg	0.600	16	25
20/20	20mm	265kg	0.625	13	20
15/20	20mm	250kg	0.650	10	15

Class 45/20

Class 35/20

Class 30/20

Class 25/20

Class 20/20

Class 15/20

If the Contractor so elects, the Engineer may permit the use of a higher class concrete than the particular class designated for the work, in which event the higher class concrete shall meet the Specifications applicable without additional compensation.

When called for on the Drawings, an admixture of water-reducing retarded shall be added to all concrete so specified. A retarder may be used in other concrete at the Contractor's option.

A water-reducing admixture may be used at the Contractor's option. A water-reducing admixture may not be used in conjunction with a water-reducing retarder. The work will be accepted in accordance with these Specifications.

551.2 - MATERIALS:

Materials shall meet the requirements specified in the following Sub-Sections of Division 700:

MATERIAL	SECTION OR SUBSECTION
*Portland Cement	701.1, 701.3
**Fine Aggregate	702.1
Coarse Aggregate	703
Air-Entraining Admixtures	707.1
Water-Reducing, Retarding Admixtures	707.2
Water Reducer	707.3
***Pozzolanic Additives	707.4
Curing Materials	707.6 - 707.10
Epoxy Resin Protective Coating	707.11
Boiled Linseed Oil	711.2
Petroleum Spirits (Mineral Spirits)	711.5
Water	715.7

*It is normally intended that the product of only one mill or of any one brand or type of Portland cement be used on any one structure.

**Only siliceous sand shall be used as fine aggregate in bridge deck wearing surfaces. The use of sea sand is not permitted in any concrete.

***The use of Pozzolanic additives will not be permitted when blended hydraulic cement is used. Unless otherwise permitted by the Engineer, only one source of a Pozzolanic additive shall be used in any one structure.

Shipping and Storage of Cement: Cement shall be shipped from pre-tested and approved bins at the mill or distribution terminals. Cement stored by the Contractor for a period longer than 90 days shall be retested before being used in the work. Cement failing to meet any of the specified requirements at any time prior to incorporation into the work will be rejected and shall be removed from the work. Coments of different brands, types, or from different mills shall be stored separately.

Shipping and Storage of Pozzolanic Additives: Pozzolanic additives shall be shipped from only those sources approved by the Engineer. Bulk Pozzolanic additives shall be stored at the job site in weatherproof bins. Pozzolanic additives from different sources or from different areas at the same source shall be stored separately.

CONSTRUCTION METHODS

551.3 - PROPORTIONING:

551.3.1 - Mix Design Requirements:

Prior to the start of construction, the Contractor shall design and submit to the Engineer for approval the proportion of materials, including admixtures, to be used which will result in a workable concrete having the applicable properties enumerated below, including those of Table 551.1.1A. A mix design prepared in accordance with ASTM C 192, ACI 214, shall be required for each class of concrete to be used in the work. The mix design shall be accompanied by a

statement giving the source of materials and certified test data from an Engineer approved laboratory demonstrating the adequacy of the mix design. The Contractor shall notify the Engineer of any change in the source of materials or the addition of admixtures during the progress of the work, since such change may necessitate a new mix design. The Contractor shall also state the A value of the fine aggregate and the A value of the combined grading of the coarse aggregate, fine aggregate, and cement used in the mix design.

551.3.2 - Field Tolerances and Adjustments:

551.3.2.1 - Consistency:

Concrete shall have the consistency, which will allow proper placement and consolidation in the required position. Every attempt shall be made to obtain a uniform consistency. The optimum consistency for various types of highway structures shall be as indicated in Table 551.3.2.

TABLE 551.3.2

CONSISTENCY

TYPE CONSISTENCY	OPTIMUM CONSISTENCY (mm of slump)
i. For structures which have exposed, inclined surfaces such as concrete gutters, cast in place concrete slope protection, etc., requiring low slump Concrete to allow proper placement and consolidation and the maintenance of the prescribed geometry; those structures which are placed by slip form construction methods where a low slump is required to maintain the prescribed geometry; and mass non reinforced concrete.□	25 mm
ii. For reinforced concrete structures which are sufficiently massive and generally have sufficient clearances to allow the access of workers into the immediate area of concrete placement, such as bridge piers, column and abutment footings; piers, large columns, and other similar type structures into which workers may enter to place and consolidate the concrete.	50 mm
Iii a) For reinforced concrete structures which are not easily accessible for spading and vibrating and offer a fair degree of difficulty in the placement and consolidation of the concrete, such as pier caps and abutments, beams and girders, box culverts, miscellaneous structure footings and other slab type structures, wall or vertical sections 200mm or greater in width with one line of reinforcement or 300mm or greater in width with two lines of reinforcement.□ b) For bridge decks with a mix design having water content between 15 and 19 litres per bag of cement.□c) For bridge decks with a mix design having maximum water content of 15 litres per bag of cement.	75 mm 62 mm 125 mm
iv. For structures, which are inaccessible to workers and generally, offer a considerable degree of difficulty in the placement and consolidation of the concrete, such as long slender columns and thin-walled 3 1/2 sections less than 200mm thickness.	87 mm
v. For structures which present peculiar conditions under which concreting must be done, such as structural steel encasement; other special structures which contain small openings through which the concrete must pass; tremie concrete which must be placed and consolidated into all spaces without mechanical disturbances; and other special structures which would require high consistency concrete for proper placement and consolidation	**

*If the consistency exceeds the target value plus 25mm, the Contractor shall take immediate steps to reduce the slump of succeeding loads by making necessary adjustments in the mixture. The Contractor will be allowed a reasonable time for the trucks already on the road for a central mix or truck mix operation. Failure to comply will be cause for rejection of the concrete. If the consistency exceeds the target value plus 25mm, the concrete will be rejected.
** The optimum consistency shall be that consistency which will allow a proper placement and consolidation of the concrete into all spaces.

551.3.2.2 - Air Content:

The value of the entrained air at the point of placement shall be 3% to 5%. If the entrained air does not conform to this range, the Contractor shall take immediate steps to adjust the air content of succeeding loads by making necessary adjustments in the mixture. The air content shall be measured on loads already batched and enrooted, as well as the first load to which any adjustments were made in batching procedures. If the air content exceeds the target value plus 3.0 percentage points the concrete-shall be rejected. When the concrete is delivered in a truck mixer and the air content is less than the target value minus 2.5 percentage points the concrete shall be rejected, or the Contractor may use additional air entraining agent in an amount that is intended to achieve the target value specified. The addition is permitted under the following conditions:

i. The air-entraining agent is the same as used in the approved mix design and is thoroughly mixed with a minimum of 7.57 litres of water. The solution will be directed to the front of the mixer.

ii. The mixer is turned a min. of 30 revolutions, at mixing speed, or the number of revolutions established in tests to comply with uniformity requirements, whichever is more.

iii. Immediately after mixing, the air content and slump shall be measured by a certified inspector or technician.

An air adjustment may be attempted twice per truck. If after the second addition the specified air content is not achieved, the concrete shall be rejected. These procedures do not alter the limits placed on time to discharge, the total revolutions of the mixing drum, or the specified slump.

551.3.2.3 - Yield:

The approved mix design shall be subject to modification under the conditions prescribed.

After the start of the first concreting operation and immediately after the specified consistency and entrained air have been established, three unit weight determinations shall be made from different batches and the average of the three determinations shall be considered the unit weight of the concrete. The actual yield shall be determined from the average unit weight. The design mix shall be adjusted as required to correct the actual yield to correspond to the theoretical.

During the progress of the work, the actual yield may be verified; and, if the yield based on a single unit weight determination should differ from the theoretical more than plus or minus two percent, two additional unit weight determinations shall be made and the average of the three determinations shall be considered the unit weight of the concrete. The actual yield shall be determined from the average unit weight, and the design mix shall again be adjusted as required to correct the actual yield to correspond to the theoretical.

In addition to the mix design adjustments specified above to correct for yield, other adjustments in the design mix proportions shall be made as necessary to maintain a plastic, workable mix with suitable finishing characteristics.

No change in the brands or sources of material shall be made without prior approval of the Engineer not replace throughout. Methods for determining-the properties enumerated above shall be in accordance with 551.4.

551.3.2.4 - Total Solids A:

The combined grading of the coarse aggregate, fine aggregate, and cement used in the structural concrete shall conform to the design mix A plus or minus the tolerance specified in the following table for the coarse aggregate size used.

TABLE 551.3.2.4

TOTAL SOLIDS A

COARSE AGGREGATE SIZE NUMBER	DESIGN MIX A TOLERANCE
3 or 4	+/- 0.35
57 or 67	+/- 0.25
7, 78 or 8	+/- 0.15

A is the value of total solids (coarse aggregate, fine aggregate and cement). The Contractor shall determine the grading of the total solids at least once each production day. Should the moving average of any five consecutive grading test results of the total solids have an A outside the specified mix design tolerance limits, production shall be discontinued until appropriate corrections are made. Corrections shall be made either in the proportions of the concrete (the mix design), the gradation of the aggregates, or the storage and loading of the aggregate, as the Contractor may elect.

551.4 - TESTING:

551.4.1 - Sampling and Testing Methods:

Sampling fresh concrete:	AASHTO T 141
Sampling aggregate:	AASHTO T –2-91
Sieve analysis of fine and coarse aggregates:	AASHTO T 27 and T 11
Slump of Portland Cement Concrete:	AASHTO T 119 (Note 1)
Air content of freshly mixed concrete:	AASHTO T 152 AASHTO T 196
Unit weight/Yield of Concrete:	AASHTO T 121
Making and curing concrete compressive specimens:	AASHTO T 23 with MP 601.04.20
Compressive strength of cylindrical concrete specimens:	AASHTO T 22
Total moisture content of aggregate by drying:	AASHTO T 255
Predicting potential strength of Portland cement concrete:	ACI214
Determination of A of total solids in concrete:	AASHTO- T-128-92, ASTM C-184-90

Determination of free moisture in fine aggregate using 20g or 26g A "Speedy Moisture Tester" determination of free moisture in fine aggregate using a speedy moisture Note 1 - When testing concrete produced by volumetric batching and continuous mixing, the consistency testing shall be delayed for approximately three to five minutes after mixing.

551.4.2 - Contractor's Quality Control:

Quality control of the structural concrete is the responsibility of the Contractor as designated in Contractor's Quality Control Plan. The Contractor shall maintain equipment and qualified personnel, including at least one certified Portland Cement Concrete technician who shall direct all field inspection, sampling and testing necessary to determine the magnitude of the various properties of concrete governed by the Specifications and shall maintain these properties within the limits of this Specification. The quality control plan designated in Contractor's Quality Control Plan shall be submitted to the Engineer at the pre-construction conference. Work shall not begin until the Drawing is reviewed for conformance with the contract documents.

551.4.3 - Acceptance Testing:

Acceptance sampling and testing of Portland Cement Concrete is the responsibility of the Engineer, except for furnishing of necessary materials.

The Engineer for acceptance purposes may utilize quality control sampling and testing performed by the Contractor.

Strength used in this specification, is only one indicator of the durability of the Portland Cement Concrete. Evaluation of structural concrete may include evaluation of the scaling characteristics, abrasion resistance, density and such other factors the Engineer deems appropriate.

551.4.4 - Compressive Strength Tests for Acceptance:

A strength test shall consist of three standard test specimens. The test shall be the average of the three specimens, except that if one specimen shows manifest evidence of improper sampling, moulding, or testing, it shall be discarded and the remaining two strengths averaged. Should more than one specimen representing a given test show definite defects due to improper sampling, moulding, or testing, the entire test shall be discarded.

Compressive strength tests shall conform to the requirements of approved design mix. Statistical analysis may indicate a percentage of production to be below nominal minimum design strength. Concrete represented by compressive strengths below the nominal minimum design strength may be removed and replaced by the Contractor. If the Contractor elects to leave the material in place, it will be evaluated as to adequacy for the use intended. All concrete evaluated as unsatisfactory for the use intended shall be removed and replaced or otherwise corrected by and at the expense of the Contractor.

When an evaluation indicates that the work may satisfactorily remain in place, a statistical analysis will be made of the material. If this statistical analysis indicates at least 93 percent of the material may be expected to have compressive strengths equal to or greater than that shown in Table 551.3.1 and 99.87 percent of the material may be expected to have compressive strengths at least one standard deviation above the allowable design stress (fc + s), the work will be accepted as substantially complying with the specification requirements. If this statistical analysis indicates that less than 93 percent of the material may be expected to have compressive strengths equal to or greater than the approved or less than 99.87 percent of the material may be

expected to have compressive strengths at least one standard deviation above the allowable design stress (fc + s), the Engineer will provide for an appropriate adjustment under the provisions of 551.15.
The Engineer's statistical analysis will be based on a minimum of 10 cylinder test results. These results may be from the concrete item being placed, the same class of concrete on the project or the same class of concrete from the producer.

551.5 - EQUIPMENT AND TOOLS:

551.5.1 - Field Laboratory:

Field laboratory provisions shall conform to the requirements prescribed in the Contractor's Quality Control Plan, as approved by the Engineer.

551.5.2 - Batching Plant and Equipment:

551.5.2.1 - General:

The batching plant shall include bins, weigh hoppers, and scales for each size of aggregate. If cement is used in bulk, a separate bin, weight hopper, and scale for cement shall be included. The cement weight hopper shall be properly sealed to preclude dusting during operation and shall be properly vented to prevent a build-up in pressure. The discharge chute shall not be suspended from the weighing hopper and shall be so arranged that cement will not lodge in it nor leak from it. When fly ash is used in the concrete a separate bin shall be included.

551.5.2.2 - Bins:

Adequate separate bins for each size aggregate shall be provided in the batching plant.

551.5.2.3 - Scales:

The scales for weighing aggregates and cement shall be sufficient for the size of Batch Plant. Scales shall be inspected and sealed as often as deemed necessary to assure their continued accuracy. The Contractor shall have on hand not less than ten 20 kg weights for testing scales.

551.5.2.4 - Automatic Weighing Devices:

Batching plants equipped to proportion aggregates and bulk cement by means of automatic weighing devices of an approved type may be used.

551.5.2.5 - Water Measuring Equipment:

Water shall be measured by volume or by weight. The device for the measurement of the water shall be readily adjustable and, under all operating conditions, shall have accuracy within one percent of the quantity of water required for the batch.

551.5.2.6 - Admixture Dispenser:

A positive, automatic method shall be used for adding each admixture in solution.

551.5.2.7 - Aggregate Sampling:

Provisions shall be made to allow a rapid sampling of the aggregates as they pass from the storage bin to the weigh hopper or as they pass from the storage bin into the conveyor feed.

551.5.3 - Mixers and Agitators:

Site and central mixers, truck mixers, truck agitators, and non-agitator trucks shall conform to the requirements of AASHTO M 157, except as modified.

Volumetric mixers shall conform to the requirements of AASHTO M 241, except as modified.

Central mixers shall be equipped with a device which will automatically lock the discharge lever when the drum has been charged and release it at the end of the mixing period. The device shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the mixer may be used for the balance of the day while it is being repaired, providing that each batch is mixed for the specified time period.

All mixers shall be cleaned at suitable intervals. The pickup and throw-over blades in the drum or drums shall be repaired or replaced when they are worn down 20mm or more. The Contractor shall either have available at the job site a copy of the manufacturer's design, showing dimensions and arrangements of blades in reference to original height and depth, or provide permanent marks on blades to show points of 20mm wear from new conditions. (Holes of 6mm diameter near each end and at midpoint of each blade are recommended).

551.6 - HANDLING, MEASURING, AND BATCHING OF MATERIALS:

551.7 - MIXING:

Central, truck or shrink-mixed concrete as defined in AASHTO M 157 will be designated as ready-mixed concrete. The production of ready-mixed concrete shall meet the applicable requirements of AASHTO M 157, paragraphs ten and eleven, except as otherwise specified.

Concrete for incidental construction items may be made be volumetric batching and continuous mixing as designated in ASTM C 685, except as otherwise specified. Concrete produced by this method will not be permitted in bridge, box culvert, pavement, or retaining wall construction.

When a truck mixer or agitator is used for transporting concrete, the concrete shall be delivered to the site of the work and discharge shall be completed within one and one-half hours after the addition of the cement to the aggregates. Each batch of the concrete delivered at the job site shall be accompanied by a batch ticket bearing complete batching information. In adverse weather or under other conditions contributing to quick stiffening of the concrete, or when the temperature of the concrete is 30° C or above, the time between the introduction of the cement to the aggregates and discharge shall not exceed one hour. When a truck mixer is used for the complete mixing of the concrete, the mixing operation shall begin within one hour after the cement has been added to the aggregate.

The addition of water after completion of initial mixing will not be permitted, except that when concrete is delivered in truck mixers, additional water may be added to adjust to a specified consistency. In this event, a minimum of 20 additional revolutions of the truck mixer drum at mixing speed shall be required before discharge of any concrete; the maximum allowable time

between the addition of the cement to the aggregates and the discharge of the batch shall not be exceeded. Concrete that is not within the specified consistency limits at the time of placement shall not be used.

Shrink-mixed concrete is a ready-mixed concrete, which is initially and partially mixed in a central mix plant and lastly mixed to completion in a truck mixer while in transit to or after arrival at the job site. Shrink-mixed concrete will be allowed for use in the work if specified in the Contract.

551.8 - FORMS:

551.8.1 - General:

Forms shall be of wood, metal or other approved material and shall be mortar tight and sufficiently rigid to prevent distortion due to pressure of the concrete and other loads incident to the construction operations including vibration. Wood forms shall be constructed and maintained so as to prevent the opening of joints due to shrinkage of the lumber. Stay-in-place forms will not be permitted unless provided for in the Contract.

All false work shall be designed and constructed to provide the necessary rigidity and to support the loads without appreciable settlement or deformation. Suitable jacks, wedges or other approved devices shall be used to maintain the forms at correct elevation and to permit lowering the centres gradually and uniformly without injury to the structure.

A "Telltale" or other approved type of indicator shall be attached to the forms and arranged in such a manner that any settlement or movement in the forms or false work is indicated. Forms shall be filleted and chamfered as shown on the Drawings and shall be given a bevel or draft in the case of all projections to assure easy removal.

A certified welder shall perform all field welding. Welding of form ties and supports to the beam will not be permitted. Welding of screed rail supports will not be permitted in the top flange in tension zone.

551.8.2 - Formwork Timber:

Formwork timber (lumber) for all exposed concrete surfaces shall be dressed at least on one side and two edges, and shall comply with the requirements of Section 662.

551.8.3 - Metal Ties:

Metal ties or anchorages within the forms shall be constructed to permit their removal to a depth of at least 25mm from the face without injury to the concrete. Only rods shall be used for internal ties. The cavities shall be filled with cement mortar and the surface left sound, smooth, even, and uniform in colour.

551.8.4 - Cleanouts:

Where the bottom of the form is inaccessible, the lower form area shall be left loose or other provisions made so that extraneous material may be removed from the forms immediately before placing the concrete

551.8.5 - Surface Treatment:

Forms shall be treated with oil in such manner as to prevent contamination of reinforcing steel. Oil, which will adhere to or discolour the concrete, shall not be used.

551.8.6 - Metal Forms:

The metal used for the forms shall be of such thickness that the forms will remain true to shape. All bolts and rivet heads shall be countersunk. Clamps, pins, and other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms, which do not present a smooth surface or do not line up properly, shall not be used. Metal forms shall be kept free of rust, grease, or other foreign matter.

551.8.7 - Removal of Forms and Construction of Superimposed Elements:

The forms for any portion of the structure shall not be removed until the concrete is strong enough to prevent damage. Methods of form removal likely to cause over stressing of the concrete shall not be used. The minimum requirements for removal of forms or supports and the construction of superimposed elements shall be as specified in Table 551.8.7.

TABLE 551.8.7

REQUIREMENTS FOR REMOVAL OF FORMS AND CONSTRUCTION OF SUPERIMPOSED ELEMENTS

STRUCTURAL ELEMENT	REMOVAL OF FORMS	PLACING CONCRETE IN SUPERIMPOSED ELEMENTS
	Compressive Strength (MPa)	Compressive Strength (MPa)
Bridge Decks	14.0	21
Columns	14.0	14.0
Walls & Beams	14.0	14.0
Footings	3.5	14.0
Components Supported by False work	21	21
Parapets	14.0 (See 557.11)	-

551.8.8 - Slip Forming:

Slip forming and related methods of placing concrete may be used. At the Contractor's option, parapet wall joints and median barrier on the bridge may be sawed in lieu of formed open joints and the joints shall be spaced as shown on the Drawings and shall be 6mm +/-1.6mm wide. Joints shall be sawed full width from the top of the wall to the upper break point in the wall. From the upper break point to the bottom of the wall a 50mm minimum depth saw cut should be made along the face and back of the wall. Joints shall be sealed in accordance with Section 557.16.1. The face of the back-up material shall be 13mm minimum from the concrete surface.

Initial sawing of joints shall commence as soon as the concrete has hardened sufficiently to permit sawing without excess ravelling, usually 4 to 24 hours. All joints shall be initially sawed before uncontrolled shrinkage cracking takes place, but no later than 24 hours after placement of concrete.

551.8.9 – Forms for Exposed Concrete Surfaces

Use U.S. Product Standard PS 1 for exterior B-B (Concrete form) class I plywood or other similar material that will produce a smooth and uniform concrete surface. Use only form panels in good condition free of defects on exposed surfaces. If form panel material other than plywood is used, it shall have flexural strength, modulus of elasticity, and other physical properties equal to or greater than the physical properties for the type of plywood specified.

Furnish and place form panels for exposed surfaces in uniform widths of not less than 1 metre and in uniform lengths of not less than 2 metres, except where the width of the member formed is less than 1 metre.

Arrange panels in symmetrical patterns conforming to the general lines of the structure. Place panels for vertical surfaces with the long dimension horizontal and with horizontal joints level and continuous. For walls with sloping footings, which do not abut other walls, panels may be placed with the long dimension parallel to the footing.

Precisely align form panels on each side of the panel joint by means of supports or fasteners common to both panels. Provide 19-millemetre triangular fillets at all sharp edges of the concrete.

Devices may be cast into the concrete for later use in supporting forms or for lifting precast members. Do not use driven devices for fastening forms or form supports to concrete. Use form ties consisting of form bolts, clamps, or other devices necessary to prevent spreading of the forms during concrete placement.

Do not use form ties consisting of twisted wire loops. Use form ties and anchors that can be removed without damaging the concrete surface. Construct metal ties or anchorages within the forms to permit their removal to a depth of at least 25 millimetres from the face without damage to the concrete. Fill cavities with cement mortar and finish to a sound, smooth, uniform collared surface.

Construct all exposed concrete surface that will not be completely enclosed or hidden below the permanent ground surface so the formed surface of the concrete does not undulate more than 2.5 millimetres or 1/360 of the centre to centre distance between studs, joists, form stiffeners, form fasteners, or whalers. Interior surfaces of underground drainage structures are considered to be completely enclosed surfaces. Form all exposed surfaces for each element of a concrete structure with the same forming material or with material that produce similar surface, colour and appearance.

Support roadway slab forms of box girder type structures on whalers or similar supports fastened, as nearly as possible, to the top of the web walls.

Construct concrete forms mortar-tight, true to the dimensions, lines, and grades of the structure, and of sufficient strength to prevent appreciable deflection during placement of concrete. Place all material required to be embedded in the concrete before concrete placement. Clean inside surfaces of forms of all dirt, mortar and foreign material. Remove all loose material before the

completion of forming for the roadway deck slab of cast-in-place box girders or cells or voids of other members in which the forms are to either remain in place or be removed.

Form exposed curved surfaces to follow the shape of the curve, expect on retaining wall that follow a horizontal curve. The wall stems may be a series of short chords if all of the following apply:

- Chords within the panel are the same length
- Chords do not vary form a true curve by more than 15 millimetres at any point.
- All panel points are on the true curve.

When architectural treatment is required, make the angle points for chords in wall stems fall at vertical rustication joints.

Coat forms to be removed with form oil. Use commercial quality form oil or an equivalent coating that permits release of the forms and does not discolour the concrete. Do not place concrete in forms until the forms have been inspected and approved.

(a) Stay in Place Deck Forms.

Use permanent or stay in place forms only when permitted by the contract.

Fabricate permanent steel bridge deck forms and support from steel conforming to ASTM A 653M coating designation 2600, any grade expect grade 340, class 3.

Install forms according to accepted fabrication and erection drawing. Do not rest form sheets directly on the top of stringer or floor beam flanges. Securely fasten sheets to form supports. Place form supports in direct contract with the stringer flange or floor beam. Make all attachments with permissible welds, bolts, or clips. Do not weld form supports to flanges of steels not considered weldable or to portions of flanges subject to tensile stresses.

Clean, wire brush, and paint with 2 coats of zinc dust zinc-oxide primer (FSS TT-P-641 type II, no colour added) any permanently exposed form metal where the galvanized coating has been damaged. Minor heat discoloration in areas of welds need not be touched up.

Locate transverse construction joints in slabs at the bottom of a flute. Field drill 6 millimetre diameter weep holes at not less than 300 millimetres on centre along the line of the joint.

(b) Void Forms.

Store void forms in a dry location to prevent distortion. Secure the forms using anchors and ties, which leave a minimum of metal or other supporting material exposed at the bottom of finished slab.

Make the outside surface of the forms waterproof. Cover the ends with waterproof mortar tight caps. Use a pre-moulded 6 millimetres thick rubber joint filler around the perimeter of the caps permit expansion.

Provide a PVC vent near each end of each void form. Construct vents so the vent tube shall not extend more than 13 millimetres below the bottom surface of the finished concrete after from removal. Protect void forms the weather until concrete is placed.

(c) Metal Forms.

The specifications for forms relative to design, mortar tightness, filleted corners, bevelled projections, bracing, alignment, removal, reuse, and oiling also apply to metal forms.

551.9 - ADVERSE WEATHER CONDITIONS:

551.9.1 - Hot Weather Concreting:

The Contractor will be required to state, at the pre-construction conference, his plan of action when the temperature of plastic concrete reaches 32°C.
When a free air, shaded thermometer in the vicinity of the concrete production plant reaches 30°C, thermometer readings of the temperature of the plastic concrete shall be taken at least hourly.

When the temperature of the plastic concrete reaches 30°C, the elapsed time between the introduction of the mixing water to the cement-aggregates and discharge of the mix shall not exceed 1 hour. At this temperature or above, particular attention shall be paid to the Specification provisions concerning the sprinkling and wetting of surfaces not oil-treated, the maintenance of coarse aggregate stock in saturated surface-dry condition, and the prompt start of concrete curing operations.

When the temperature of the plastic concrete reaches 32°C, immediate steps shall be taken to cool either mixing water or aggregates, or both, in order to maintain a plastic concrete temperature of 32°C or less. Crushed or flaked ice may be used to cool the mixing water. Crushed or flaked ice may also be introduced into the mixing drum when the concrete is batched and mixed in a truck mixer. The ice will be considered as part of the mix water in the mix proportions. The mixing operation shall not be considered complete until all ice in the drum has melted.

In no event shall concrete be placed when its temperature in the plastic state at the completion of mixing exceeds 32°C.

Bridge Decks: The Contractor's plan of action for all bridge deck concreting operations shall contain provisions designed to minimize the probability that any bridge deck concrete will be placed when the ambient temperature is greater than 32°C.

551.10 - PLACING CONCRETE:

551.10.1 - General:

Concrete shall not be placed until forms and reinforcing steel have been inspected and approved. The forms shall be cleaned of all debris immediately prior to placing concrete, and surfaces not oil treated shall be wetted. The method and sequence of placing concrete will be subject to approval by the Engineer. Concrete shall be placed so that no segregation will occur and no displacement of reinforcement will be caused. Concrete shall be placed in the forms as nearly as practical in its final position in order to avoid re-handling, and an approximately horizontal surface

of the plastic concrete shall be maintained. After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of projecting reinforcement. Concrete shall not be placed until all laitance, which may have formed on concrete previously placed, or any loose deleterious material on reinforcing bars, has been removed.

551.10.2 - Chutes and Troughs:

Concrete shall not be dropped in the forms a greater distance than 1.5 metres without the use of closed chutes or pipes. When chutes or troughs are used under steep slope conditions, they shall be equipped with baffle boards or shall be used in short lengths to reverse the direction of movement. All chutes, troughs or pipes shall be kept clean and free of hardened concrete by flushing with water after each run. Flushing water shall be discharged outside the forms. Aluminium chutes, troughs or pipes shall not be used.

551.10.3 - Vibrating:

Concrete shall be compacted by the operation of approved mechanical vibrators within the concrete. When required, vibrating shall be supplemented by hand spading to assure proper compacted, to force all coarse aggregate from the surface, and to bring mortar against the forms to produce a smooth finish. Vibrators shall be manipulated in such a manner that concrete is worked around reinforcement and imbedded features and into angles of the form. Vibration shall be of sufficient duration to accomplish compacted but shall not be prolonged to the point where segregation occurs. Vibration shall not be used to cause concrete to flow from point to point within forms.

551.10.4 - Placing Concrete Bridge Decks:

Concrete for bridge decks shall be placed and finished with mechanical equipment unless waived by the Engineer. The Contractor shall furnish the Engineer information as to the weight of the proposed machine, the volume of concrete to be placed per hour, and the operating procedure to be followed.

Where beam support screeds are used and the distance between the support and gutter line is in excess of 300mm, the Contractor shall use devices to control the grade of the gutter line during the deck finishing operations.

551.10.5 - Depositing Concrete Under Water:

Concrete shall not be placed until all laitance, which may have formed on concrete previously placed, has been removed. Still water shall be maintained at the point of deposit. While depositing foundation concrete, pumping shall be discontinued if it results in a flow of water inside the forms. All concrete deposited under water shall have the minimum cement content increased at least 10 percent.

Concrete deposited under water shall be carefully placed in a compact mass in its final position by means of a tremie, a closed bottom dump bucket, or other approved method and shall not be disturbed after being deposited.

551.10.6 Thermal Control of Hydration Generated Heat

1. Description

The aim of this specification is to produce a structure free of shrinkage cracks and other defects that may arise both in the short and long term that would be a result of heat of hydration during the curing of large concrete cross-sections. This is to be accomplished through appropriate concrete mix design and management of concrete temperature and temperature differential. Structural mass concrete is defined as any concrete element with a least dimension equal or greater than 1.5 m.

2. Construction

The contractor shall develop and submit a written "Thermal control Plan" describing the procedures that will be used during the period of heat dissipation following concrete placement, so the temperature differential does not exceed the requirements in clause 3.2. The contractor shall submit the Thermal Control Plan at least 30 calendar days before the first intended structural mass concrete placement.

Compliance with this specification may result in long cooling times. Consider options to control heat of hydration that are compatible with their desired construction schedule and erection procedures.

The contractor shall not place concrete covered by this specification until the thermal Control Plan has received written approval by the Engineer and the equipment and materials necessary to facilitate the plan are on site and ready for use. Provide and install temperature sensing devices according to Clause 3.3.

The location of construction joints shall be as shown in the plans or as approved by the Engineer.

The Thermal control Plan shall be developed by a Professional Engineer, competent in the modelling, design and temperature control of concrete in mass elements (T.C.Engineer). the T.C. Engineer shall submit a list containing at least three mass concrete projects, of similar dimension and thermal control requirements to those shown on the plans, completed in the last three years. In the list of projects include names and phone numbers of owner's representatives who can verify the T.C. Engineer's participation on those projects. *The T.C. Engineer shall follow the procedure outlined in section 207.4R-05 of the ACI Manual of Cooling and Insulating systems for Mass concrete to formulate, implement, administer and monitor a temperature control plan, making adjustments as necessary to ensure compliance with the contract Documents and this specification.*

The Thermal Control Plan shall include, but not be limited to the following:

1. Based on the concrete mix design, determined by lab testing the adiabatic heat generation for the concrete mix to be used.
2. Proposed methods to achieve required temperature and control concrete temperature differential through concrete mix design and construction practices for temperature control to prevent thermal cracking.
3. Design of cooling system consisting of non-corrosive piping to be embedded in the structural mass concrete for all mass concrete placements. (Should other control methods not yield the desired outcome)
4. Provide information on the temperature sensing and recording equipment to be used and details of installation locations of the temperature probes for each planned mass concrete placement.
5. Mass concrete placement plan to ensure prevention of concrete cold joints
6. Monitoring plan to control temperature gradient.
7. Cooling component materials prior to addition to the mix to reduce the temperature of the concrete while in its plastic state.
8. Adding ice to the mix water.
9. Sprinkle coarse aggregate with water or wet the stockpile.
10. Insulating the forms and the surface of the concrete to prevent temperature differential.
11. Placing concrete at times of day when the ambient temperature is the most favourable.
12. Other acceptable methods that may be developed by the Contractor and approved in writing by the Engineer.

Controlling rate of concrete placement by low lifts with associated construction joints is not an acceptable method of thermal control.

551.10.6.1.3 Thermal Control

3.1 Concrete Temperature Limits

Maximum concrete temperature at time of placement shall not exceed 32Ċ. The maximum concrete temperature during the period of heat dissipation shall not exceed 70Ċ.

3.2 Temperature Differential Requirements

The temperature differential between the interior of the section and the outside surface of the section shall not exceed 20Ċ.

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3.3 Temperature Sensing and Recording

For each placement of structural mass concrete, two temperature sensors shall be installed at each of the following locations (for a total of ten temperature sensors).

- Centre of the placement
- Midpoint of the side which is the shortest distance from the center (minimum 50mm cover to sensor)
- Midpoint of the top surface (minimum 50mm cover to sensor)
- Corner of the placement which is furthest distance from the centre (minimum 50mm cover to sensor)
- Air temperature.

The purpose for two sensors at each location is to provide a primary and secondary backup.

Temperatures shall be electronically recorded automatically by an approved recorder furnished by the contractor and shall be capable of continuously recording a minimum of one reading per hour for the duration of the mass concrete temperature monitoring period. Sensors and recorder shall be accurate to within 1Ċ in the temperature range of 0Ċ to 100Ċ. The Contractor shall provide a backup temperature sensing system, which shall include both backup temperature sensors and backup temperature readout device. The back-up system is intended to be used to complete the monitoring of a placement should the primary system fail. Primary system shall be repaired or replaced before the commencement of the next placement.

551.11 - FINISHING CONCRETE SURFACES:

The surface of the concrete shall be finished immediately after form removal.

The exposed surfaces of bridge parapets, wing walls and headwalls shall be given a Class 2, Rubbed Finish, or a Class 1 Ordinary Surface Finish supplemented with wood float rubbing. When the Class 1,Ordinary Finish is used, the forms shall be removed as early as practical, not to exceed six hours (in lieu of 551.8.7) after placing, and the finish completed including rubbing with a wood float and water. The rubbing shall produce a non - plastered, smooth textured and uniform colour surface. Other concrete surfaces except bridge decks shall be given a Class 1, Ordinary Finish.

551.11.1 - Class 1, Ordinary Surface Finish:

Immediately following the removal of the forms, all fins and irregular projections shall be removed from all surfaces except those, which are not to be exposed, or are not to be waterproofed. On all surfaces the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges and other defects shall be thoroughly cleaned, saturated with water, and carefully

pointed and trued with a mortar of cement and fine aggregate mixed in the proportions used in the class of concrete being finished. Mortar used in pointing shall be not more than 30 minutes old. The mortar patches shall be cured as specified in 551.12. All construction and expansion joints in the completed work shall be left carefully tooled and free of all mortar and concrete. The joint filler shall be left exposed for its full length with clean and true edges.

The resulting surfaces shall be true and uniform. All surfaces, which cannot be repaired to the satisfaction of the Engineer, shall be rubbed as specified for Class 2, Rubbed Finish.

551.11.2 - Class 2, Rubbed Finish:

After removal of forms, the rubbing shall be started as soon as the condition of the concrete will permit. The concrete shall be thoroughly saturated with water immediately prior to rubbing and shall be kept saturated throughout the rubbing operation.

Sufficient time shall have elapsed before wetting down to allow the mortar used in pointing to thoroughly set. Surfaces to be finished shall be rubbed with a medium coarse carborundum stone, using a small amount of mortar on its face. The mortar shall be composed of cement and fine sand in the same proportion as the concrete being finished. Rubbing shall be continued until all form marks, projections, and irregularities have been removed, all voids filled, and a uniform surface obtained. The paste produced by this rubbing shall be left in place. After all concrete above the surface being treated has been cast, rubbing the surface with fine carborundum stone, and water shall obtain the final finish. This rubbing shall be continued until all the paste produced by the first rubbing operation has been removed from the face of the concrete except from depressions and defects which have been filled with the paste. The surface of the concrete after rubbing shall have a non-plastered, smooth texture and a uniform colour.

After the final rubbing is completed and the surface has dried, the surface shall be rubbed with burlap to remove loose powder. The resulting surfaces shall be free from all unsound patches, paste, powder, and objectionable marks.

551.11.3 - Class 6, Float Finish:

Placing an excess of material in the form and removing or striking off the excess with a template, forcing the coarse aggregate below the mortar, shall achieve this finish, for horizontal surfaces. Creation of concave surfaces shall be avoided. After the concrete has been struck off, the surface shall be thoroughly worked and floated with a suitable floating tool of wood, canvas or cork. Before the finish has set, the surface cement film shall be removed with a fine brush in order to have a fine grained, smooth but sanded texture.

551.11.4 - Finishing Concrete Bridge Decks:

Addition of water to the surface of the concrete to assist in the finishing operations will not be permitted. When conditions are such that unusually rapid drying is occurring, an atomised mist may be used to prevent the rapid evaporation of water from the concrete surface during the final finishing.

After striking off, consolidating and floating have been complete, both while the concrete are still plastic, the surface shall be checked for trueness with a straightedge. The Contractor shall

furnish an accurate scraping type straightedge with a minimum length of 3.0 metre and swung from a handle at least 1 metre longer than one - half the width of the slab.

The straightedge shall be held in successive positions parallel to the road centreline and in contact with the roadway surface and operated from side to side until the surface is within the permissible tolerance provided. Advance along the roadway shall be in successive stages of not more than one-half of the length of the straightedge. Any depressions found shall be immediately filled with freshly mixed concrete, struck-off, consolidated, and re-floated. High areas shall be cut down and re-floated. The straightedge testing and reflecting shall continue until the surface is found to be free from observable departures from the straightedge and the slab has the required grade and contour.

Upon completion of the above operations, the surface shall be smoothed with a lute or smoothing float, 1.2 to 1.8 metres in length, after which the surfaces shall be tested with an accurate straightedge. This checking straightedge shall be 3.0 metres long and shall be held in a position parallel to the centreline of the roadway. The advance of this straightedge along the slab shall be in successive stages of not more than one-half of its length. When tested with this straightedge, the finished surface shall be free from observable departures from the straightedge.

Upon completion of the above operations, the surface of the concrete shall be given a groove (rough broom) finish while the concrete is still plastic. The tool used shall produce a groove that is approximately 2mm wide. The depth of this groove shall be 3mm to 5mm and spaced approximately 13mm centre to centre. The grooves shall be formed in a direction that is transverse to the centreline of the roadway or parallel to the skew. On any one bridge the direction of the grooves shall be consistent. Adjacent strokes to establish the texture shall abut one another without appreciable overlap. Texturing shall be performed when the concrete surface is of such plasticity as to prevent excessive ravelling (concrete too dry) or to prevent mortar from flowing back into the grooves (concrete too wet). All texturing shall be accomplished with a single pass of the tool. To facilitate drainage, the 300mm immediately adjacent to the curb line shall be left un-textured.

When the concrete finishing has been completed, and concrete hardened sufficiently, the surface shall be given a further test for trueness with a rolling straightedge. Areas showing high spots of more than 3mm shall be marked by the Engineer and, only when directed by the Engineer, such areas shall be ground with an approved grinding tool, utilizing carborundum stones or industrial diamond wheels; grinding shall be done to an elevation where the area or spot will not show a surface deviation in excess of 3mm when tested with the 3.0 metre rolling straightedge, except that the maximum depth of grinding shall not exceed 6mm. The ground areas shall be treated as directed by the Engineer. Where the initial deviation from the straightedge is 13mm or more, the Contractor will be required to remove and replace the complete pour in which the areas not meeting the required tolerance are located.

After grinding, all areas either high or low, not meeting the requirements of 3mm tolerance will be measured and disposition of these areas will be as set forth in 551.15.2.

551.12 - CURING AND PROTECTING CONCRETE:

551.12.1 - Curing Under Normal Conditions:

All concrete shall be protected, by one or more of the curing materials referred to in 551.2, as soon as possible after placement, to prevent loss of moisture from the surface. Burlap and water

curing shall be used on all bridge decks.

Concrete surfaces shall be kept completely and continuously moist. Curing shall be continued for a period of at least 7 days. This curing period may be reduced if the contractor presents evidence that the in place concrete has attained 70% of the specified strength for the class of concrete under cure. Under no circumstances, shall the period of cure be less than 3 days.. Surfaces may have coverings temporally removed for finishing, but the covering shall be restored as soon as possible.

Membrane forming curing compounds may be used providing they do not conflict with other requirements of these Specifications. If membrane forming curing compound is used, all surfaces shall be given the required finish prior to application of the curing compound with the concrete protected by some other method before finishing.

Curing compound shall be applied at a minimum rate of 13.6 litres of liquid coating per 100 square metre of concrete surface for each application. The curing compound shall be continuously agitated during use. All concrete cured by this method shall receive two applications of the curing compound. The first coat shall be applied immediately after acceptance of the concrete finish. If the surface is dry, the concrete shall be saturated with water and the curing compound applied as soon as the surface film of water disappears. The second application shall be made after the first application has set. Placement in more than two coats may be required to prevent streaking.

During the curing period, any coating marred or otherwise disturbed shall be given an additional coating. Should the surface coating be subjected continuously to injury, another method of cure shall be immediately substituted. If the use of an impervious compound results in a streaky or blotched appearance, the method shall be stopped and water curing applied until the cause of the defective appearance is corrected.

551.12.2 - Protection of Finished Surfaces:

All exposed finished surfaces of concrete shall be protected to prevent rust stains, paint splotches, scars or other blemishes tending to disfigure or discolour the finished surface. Where reinforcing steel bars or other steel inserts are left exposed for extended periods or over the winter, they shall be given a coat of neat cement paste to prevent rust staining. The Contractor shall correct any stains or other blemishes.

551.13 - PROTECTIVE SURFACE TREATMENT:

551.13.1 - Linseed Oil:

After the concrete is at least 14 days old, a protective surface treatment as specified shall be applied to the entire top surface of bridge decks, approach slabs when they are included in the Contract, concrete bridge medians, top and curb face of bridge sidewalks, and inside faces of parapets.

The surface shall be dry for at least 48 hours before treatment and shall be free from oil, grime, and loose dirt or particles. Immediately before application, the entire surface shall be air blown to remove any loose dust.

The surface treatment mixture shall consist of 50 percent boiled linseed oil and 50 percent petroleum spirits (mineral spirits), by volume.

The mixture shall be sprayed, and the nozzle shall be kept within 450mm of the surface. Hand tank type pressure sprayers will be permitted. The temperature of the concrete and air shall be 10°C or higher at the time of application.
The first coat shall be applied at the rate of 0.11 litres per square metre (8.8 square metre per litre) and the second coat at the rate of 0.068 litres per square metre (14.7 square metre per litre).

The second coat shall not be applied until the concrete has regained its dry appearance.

The Contractor is cautioned to guard against fire of all sorts, including cigarettes, as this material is flammable.

Metal handrails shall be protected from spray by shielding or masking.

The Contractor shall prohibit all pedestrian or vehicular traffic on the structure during the drying period of the protective coating.

The Contractor shall not apply a protective coating when it is anticipated that there will be precipitation within five hours of the time of application. Any coating damaged by rain or moisture shall be corrected by an additional application.

551.14 - METHOD OF MEASUREMENT:

The quantity of work done for Class 45/20, Class 35/20, Class 30/20, Class 25/20, Class 20/20 and Class 15/20 concrete will be measured in cubic metres, complete in place and accepted, as determined by the dimensions on the Drawings or Contract Documents, and will be the number of cubic metres established in the Proposal, subject to adjustment as provided for in Conditions of Contract Volume 2, Parts I & II.

No deductions will be made for the volume occupied by pipe less than 200mm in diameter, nor for reinforcing steel, anchors, conduits, weep holes or piling, or other small inserts.
Formwork shall be measured for surfaces of in situ concrete, which require temporary support during casting except where otherwise stated.

Formwork

Formwork shall be measured for in-situ concrete, which requires temporary support during casting except where otherwise stated. The type of form work shall be classified accordance with 551.8.9, wrought form work for smooth exposed concrete surfaces or ordinary sawn formwork for rough finish or any other finish stated in Drawings or by the Engineer.

Stay in place or Permanent deck formwork shall be used at the discretion of the contractor if permitted by the Engineer. But no additional payment shall be considered.

Formwork shall be measured for surfaces of in situ concrete, which require temporary support during casting except where otherwise stated.

Forms shall not be measured for following:

Edges of blinding concrete not exceeding 0.2m wide, joints and associated rebates and grooves, temporary surfaces formed at the discretion of the Contractor, concrete cast against excavated surfaces etc.

Forms shall be measured in square metres respective of the required finish.

Finishing of formed surfaces shall not be measured separately.

Items for joints shall be deemed to include formwork unless otherwise specifically stated. Water stops are measured in respective joints.

Items for water stops shall be deemed to include cutting and joining of waterstops and provision of special fittings at angles and junctions.

The cost of copper, copper-nickel alloy or other type of flashing, expansion joint filler, preformed joint filler, concrete bearing pads, drain pipes for weep drains through abutments, wings and walls or bridge floors, unless otherwise specified, shall be included in the unit prices bid for the several classes of concrete.

551.15.1 - General:

The quantities, determined as provided above, will be paid for at the contract unit prices bid or at the adjusted percent of contract price as specified for the items listed below, which prices and payments shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labour, tools, equipment, field laboratory, supplies and incidentals necessary to complete the work.

No additional payment will be allowed for concreting under adverse weather conditions or when the use of a higher class concrete than that specified is permitted.

551.15.2 - Price Adjustments:

The Contractor will be assessed an equitable deduction for areas of bridge decks not meeting the specified 3mm tolerance and not specified to be removed nor directed to be ground, and for any areas that have been ground but do not meet the specified tolerance. Deviations will be tested with a 3.0 metre rolling straightedge.

551.16 - PAY ITEMS:

ITEM	DESCRIPTION	UNIT
	Reinforced Concrete	
551.001	Class 40/20 concrete	Cubic metre
551.002/003/004/005/21/22/23	Class 30/20 concrete	Cubic metre
551.002a	Class 25/20 Concrete	Cubic metre
551.002b	Class 20/20 Concrete	Cubic metre
551.008/24/006	Class 15/20 concrete	Cubic metre
	Formwork	
551.009/25/11	Wrought form work	Square metre
551.010/26/12	Sawn form work	Square metre
551.027	Water stops to specification Clause 708.10	Square metre

SECTION 552
REINFORCING STEEL

552.1 - DESCRIPTION:

This work shall consist of furnishing and placing epoxy coated or uncoated reinforcing steel in accordance with these Specifications and in reasonably close conformity with the Drawings.

552.2 - MATERIALS:

Reinforcing steel bars and fabric reinforcement shall meet the requirements of 709.1 and 709.4 respectively, except rail-steel shall not be used in bridge decks or parapets.

Epoxy coated reinforcing steel bars shall meet the requirements of 709.1.2, except rail-steel shall not be used in bridge decks and parapets.

CONSTRUCTION METHODS

552.3 - ORDER LISTS:

The Contractor shall produce all order lists and bending diagrams. If requested by the Engineer, order lists and bending diagrams shall be submitted for approval. Approval of order lists and bending diagrams by the Engineer shall in no way relieve the Contractor of responsibility for the correctness of such lists and diagrams.

552.4 - PROTECTION OF MATERIALS:

Steel reinforcement shall be stored above the well-drained surface of the ground upon platforms, skids, or other supports and shall be protected from mechanical injury. Reinforcement shall be free from injurious defects such as cracks and laminations. Any loose scale, loose rust, dirt, paint, grease, oil or other foreign materials present on the reinforcement shall be removed by wire brushing, sand blasting or other approved methods before the placement of concrete.

Reinforcing steel, which will be exposed over the rainy season, shall be protected, within one week after the placing of the initial concrete, with a brush coat of neat cement, mixed with water to a consistency of thick paint. This coating shall be removed by lightly tapping with a hammer or other tool not more than one week before the placing of the adjacent pour.

552.5 - BENDING OF REINFORCING BARS:

Unless otherwise permitted, all reinforcing bars shall be cold bent in the shop. Bars partially embedded in concrete shall not be field bent except when shown on the Drawings or permitted by the Engineer. Only competent men shall be employed for cutting and bending, and proper appliances shall be provided for the work.

Bending shall be in accordance with the relevant British Standard recommendations as will be any splicing of bars.

Rail - steel bars shall not be field bent or straightened.

552.6 - PLACING AND FASTENING:

552.6.1 - General:

All reinforcing steel shall be accurately placed and, during the placing of concrete, firmly held by supports in the position shown on the Drawings. Reinforcing bars shall be securely fastened together. Bars shall be tied at all intersections except where spacing is less than 300mm in each direction, in which case alternate intersections shall be tied. Distance from the forms shall be maintained by means of stays, blocks, ties, hangers, chairs, or other approved supports. Blocks for holding reinforcement from contact with forms shall be precast mortar blocks of approved shape and dimension; the use of pebbles, broken stone, metal pipe or wooden blocks will not be permitted. Reinforcement in any member will be inspected and approved before any concrete is placed.

552.6.2 - Epoxy Coated Bars:

Epoxy coated bars shall be placed on plastic coated wire supports. Supports shall be installed in a manner to prevent planes of weakness in the hardened concrete. The reinforcing steel shall be held in place by use of plastic or plastic coated tie wires especially fabricated for this purpose.

Any visible damage to the epoxy coating of the reinforcing steel that occurs during shipment, storage and installation of the steel shall be repaired. The patching Supplier shall furnish patching material to the project with the first shipment of epoxy-coated steel. The patching material shall be pre-qualified as required for the coating material and shall be either identified on the container as meeting the requirements of BS4466 or shall be accompanied by a Certificate of compliance. Patching of damaged areas shall be performed in accordance with the patching material manufacturer's recommendations.

In the event it is anticipated that the epoxy bars will be stored on the project site, and/or placed in final position without the concrete cover for a period of 90 days or more, then the bars shall be stored in a temporary shed or covered with plastic to prevent damage to the epoxy coating due to ultra-violet rays or other atmospheric conditions. Any temporary storage means used, shall provide adequate ventilation to the bars to prevent the build up of moisture on the bar surface.

552.7 - BAR SPLICES:

552.7.1 - Lapping:

All reinforcement shall be furnished in full lengths as indicated on the Drawings. No splicing of bars, except where shown on the Drawings, will be permitted without the written approval of the Engineer. Lapped splices shall have a length of lap not less than 30 bar diameters and shall be well distributed or located at points of low tensile stress. The bars shall be rigidly clamped or wired at all splices in a manner approved by the Engineer.

552.7.2 - Welding:

Splicing by welding of reinforcement will be permitted only if detailed on the Drawings or if approved by the Engineer in writing.

552.7.3 - Mechanical Splice Connectors:

Mechanical splice connectors shall develop in tension or compression at least 125 percent of the specified yield strength of the bar.

552.8 - FABRIC REINFORCEMENT:

Mesh sheets or uncoated reinforcing steel, except steel mesh, will be measured by the kilogram, based on Drawing lengths and numbers of bars, using the unit weights in Table 552.9. The quantity for payment will be the number of kilograms established in the Proposal, placed as shown on the Drawings or directed, complete in place and accepted, subject to adjustment as provided for.

552.9 - METHOD OF MEASUREMENT:

Epoxy coated or uncoated reinforcing steel, except steel mesh, will be measured by the kilograms, based on Drawing lengths and numbers of bars, using the unit weights in Table 552.9. The quantity for payment will be the number of kilograms established in the Proposal, placed as shown on the Drawings or directed, complete in place and accepted, subject to adjustment as provided for.

TABLE 552.9

BAR DIAMETER MASS (DESIGNATION) Kg/METRE (BS 4449)

Bar diameter, mm	Weight, Kg/m
6	0.222
8	0.395
10	0.616
12	0.888
16	1.579
20	2.466
25	3.854
32	6.313

The cost of furnishing and placing steel mesh, if required, shall be included in the contract unit price for the concrete in which it is placed and no further payment will be made.

552.10 - BASIS OF PAYMENT:

The quantity, determined as provided above, will be paid for at the contract unit price bid for the items listed below, which price and payment shall be full compensation for furnishing, fabricating, transporting, storing and placing epoxy coated or uncoated reinforcing steel; and the furnishing of all other materials and doing all the work described in a workmanlike and acceptable manner, including all labour, tools, equipment, supplies, and incidentals necessary to complete the work.

552.11 - PAY ITEMS:

ITEM	DESCRIPTION	UNIT
552.001	Reinforcing steel bars	Kilogram

The BOQ to take into account possible alternate bids has separate sections for Bridges, and Concrete Underpasses. Therefore all steel reinforcement (except for piles) will be measured and paid for by the pay item unit rates per cubic tonne, for the various work items contained in each BOQ Section for these structures, thus no full item codes are given above.

SECTION 553
PRE-STRESSED CONCRETE MEMBERS

553.1 - DESCRIPTION:

This work consists of the construction of precast/pre-stressed concrete members, post tensioned or pre-tensioned in accordance with these specifications and in conformity with the Drawing details and notes. This work shall include manufacturing, inspection, handling, storing, transporting and erecting of structural members of precast/pre-stressed concrete, and, when specified, shall also include precast concrete members, which do not contain pretension steel components.

Concrete floors, curbs, parapets, curtain walls, and diaphragms shall be cast in place on the project unless otherwise provided for on the Drawings. When the above elements are specified as precast members, they shall be manufactured in accordance with this Specification.

553.2 - MATERIALS

553.2.1 - Materials Details:

Materials shall meet the requirements specified in the following Sections/Sub-Sections:

Precast / Pre-stressed Concrete Materials	Sections / Sub-Sections
Cement	701.1, 701.3
#Fine Aggregates	702.1
*Coarse Aggregates	703.1, 703.2, & 703.3
+Admixtures:	
Air Entraining Admixtures	707.1
Retarding Admixtures	707.2
Water Reducing Admixtures	707.3
**Pozzolanic Additives	707.4
Mixing Water	715.7
Reinforcing Steel	709.1
Pre-stressing Steel	709.2
Hot-Poured Elastic Type Concrete Joint Sealer	708.3
Preformed Expansion Joint Filler	708.1
Elastomeric Bearing Pads	715.14
Welded Wire Fabric	709.4
Steel Bolts and Nuts	709.23
Concrete Sealant	707.12
Shear-Key Grout	715.5

#Fine aggregate shall be crusher-produced sand. River and/or sea sand will not be permitted in the Works.

*The maximum size of coarse aggregate shall not exceed the minimum horizontal or vertical clear spacing between pre-tensioned or reinforcing steel elements divided by 1.33.

Lightweight aggregates shall not be used unless the Engineer in writing permits their use.

**The use of a Pozzolanic additive is not permitted when blended hydraulic cement is used.

Unless otherwise permitted by the Engineer, only one source of a Pozzolanic additive shall be used.

+ Calcium chloride or any admixture containing chloride ion in excess of 0.1 percent by weight shall not be used in pre-stressed concrete members.

553.2.2 - Inspection and Testing:

The Engineer shall have free entry at all times, while the work on the Contract is being performed, to all parts of the manufacturer's works which concern the manufacture of the materials ordered. The manufacturer shall afford the Engineer, without charge, all reasonable facilities to satisfy himself that the material is being furnished in accordance with these Specifications.

553.3 PLANT REQUIREMENTS AND APPROVAL:

553.3.1 - Plant Approval:

All fabricators of pre-stressed concrete members shall be certified in the appropriate Group and Category in accordance with the Precast/Pre-stressed Concrete Institute (PCI) Plant Certification Program or equivalent. Fabricators shall be certified in Group B3 or B4 for manufacture of pre-stressed straight strand bridge members. For pre-stressed draped strand bridge members, the fabricator shall be certified in Group B4 or equivalent. The Engineer shall approve all plants manufacturing pre-stressed and precast reinforced concrete bridge members before manufacture of the members may be started. Requests for such approvals shall be submitted to the Engineer at least three weeks prior to the date of manufacture of the members. Requests shall include details of the plant facilities, materials, and the production methods the manufacturer intends to use.

The manufacturer shall have an established quality control program in effective operation at the plant. This program shall be submitted to the Engineer for approval at least 30 days prior to the start of the production.

If a Contractor is found to consistently deviate from PCI guidelines, he will be required to use an independent laboratory for quality control testing and inspection until it can be shown that conformity with PCI guidelines has been re-established. The laboratory used is subject to the approval by the Engineer, all costs of the independent laboratory are to be borne by the Contractor.

553.3.2 - Supervision:

The contractor/fabricator shall provide a PCI Level II certified technician or equivalent, skilled in the use of the system of pre-stressing to be used, which shall supervise the work and give the Engineer or his representative such assistance as may be considered necessary.

553.3.3 - Equipment and Tools:

553.3.3.1 - General:

All equipment, tools and machinery used in the work shall be adequate for the purpose for which it is to be used and shall be maintained in a satisfactory working condition. The use of portable pretension beds for the manufacture of pre-stressed concrete members is not acceptable.

The Contractor shall provide all other equipment and tools necessary for the construction and the pre-stressing.

553.3.3.2 - Equipment:

The jacks shall be equipped with instruments for monitoring the hydraulic pressure. Electronic pressure transducers with digital indicators may be used. All pressure gauges or electronic pressure indicators shall indicate the load directly to one (1) percent of the maximum gauge or sensor/indicator capacity or (2) two percent of the maximum load applied, whichever is smaller.

Each jack and its gauge shall be calibrated as a unit with the cylinder extension in the approximate position that it will be at final jacking force. The calibration of the jack and gauge shall be done while the jack is in the identical configuration, as it will be used on the site, e.g., same length hydraulic lines. An independent laboratory shall furnish certified calibration charts with each jack and gauge used in the work. Certified calibration of each ram shall be made prior to the start of stressing operations and every six (6) months thereafter, or as requested by the Engineer. Any repair of the rams, such as replacing seals, changing length of hydraulic lines, changing type of pump or using gauges which have not been calibrated with the ram, shall be cause for recalibration of the jack and gauge with a load cell. No extra compensation will be allowed for the initial or subsequent ram calibrations.

553.3.3.3 - Forms and Casting Beds:

Forms and casting beds shall be subject to the approval of the Engineer. Unless otherwise approved, only metal forms on concrete founded casting beds shall be used. The forms and casting beds shall be well constructed, carefully aligned, substantial and firm, securely braced and fastened together, sufficiently tight to prevent leakage of mortar and strong enough to withstand the action of mechanical vibrators. The forms shall be constructed to permit movement of the members without damage during release of the pre-stressing force or movement caused by thermal expansion during curing. The casting beds and all formwork will be approved before any concrete is placed, but such approval shall not relieve the Contractor of responsibility for the results obtained.

553.4 - WORKING DRAWINGS:

553.4.1 - General:

The contractor/fabricator shall expressly understand that the Engineer's approval of the working drawings submitted by the Contractor covers the requirements for "strength and detail," and that the Engineer assumes no responsibility for errors in dimensions.

Working drawings must be approved prior to performance of the work involved and such approval shall not relieve the contractor/fabricator of any responsibility under the contract for the successful completion of the work.

All working drawings shall be in metric units. Use of metric and English units is not allowed.

553.4.2 - Shop Drawings:

The contractor/fabricator shall submit copies of the detailed shop drawings to the Engineer for approval. Shop drawings shall be submitted sufficiently in advance of the start of the work to allow time for review by the Engineer and for corrections by the contractor/fabricator without

delaying the work. The size of the original drawings shall be 559mm x 864mm including margins, unless otherwise permitted. The shop drawings submitted for approval may be reduced to half size but shall be clearly marked as half size and are clearly readable.

Shop drawings for concrete structures shall give full detailed dimensions and sizes of component parts of the structure and details of all miscellaneous parts.

553.4.3 - Erection Drawings:

The contractor shall submit drawings illustrating fully their proposed method of erection. The drawings shall show details of all false work bents, bracing, guys, dead-men, lifting devices, and attachments to the bridge members: sequence of erection, location of cranes and barges, crane capacities, location of lifting points on the bridge members, and weights of the members. The Drawing and drawings shall be complete in detail for all anticipated phases and conditions during erection. Design calculations, sealed by a Registered Professional Engineer, shall be submitted by the contractor/fabricator to the Engineer for approval, which will demonstrate that allowable stresses for false work and concrete members being erected are not exceeded and that member capacities and final geometry shall be correct.

When the designated concrete deck overhang exceeds 760mm, the erection drawings submitted by the contractor/fabricator shall include complete details of the forming and bracing for the overhang and shall transmit the concrete deck dead load to an area of the beam or stringer which will prevent distortion. All forming and bracing procedures are subject to approval of the Engineer.

553.5 - REINFORCEMENT:

All reinforcing bars and welded wire fabric shall meet all requirements of Section 552 and shall be free, loose rust, grease, dirt, oil, paint, mill scale, corrosion or other deleterious substances. Any steel, which cannot be satisfactorily cleaned, shall not be used.

Splicing laps for all reinforcing bars shall be for a length of at least 30 bar diameters.
Reinforcing bars, welded wire fabric and other embedded fixtures shall be accurately placed as indicated on the Drawings and shall be maintained in their correct position during the manufacture of the unit. Reinforcement shall not be held in position by tack welding.

The minimum concrete cover for reinforcing steel shall be as follows, unless otherwise shown on the Drawings:

Main Reinforcement.....	40 mm
Slab Reinforcement, top of slab.....	40 mm
Slab Reinforcement, bottom of slab.....	25 mm
Stirrups and Ties.....	25 mm

The longitudinal or main wires of welded wire fabric shall be placed transverse to the longitudinal axis of the unit. Laps of welded wire fabric shall be a minimum of 150mm unless otherwise approved by the Engineer.

553.6 - CONCRETE:

All concrete shall be Class 45/20, mixing, placing, testing and fishing shall be as per Section 551.

553.7 - PRE-STRESSING:

553.7.1 - Pre-stressing Steel:

Pre-stressing steel shall be high-tensile wire conforming to the requirements in ASTM Designation: A 421, including Supplement I; high-tensile wire strand conforming to the requirements in ASTM Designation: A 727, will not apply.

In addition to the requirements of ASTM Designation: A 722, for deformed bars, the reduction of area shall be determined from a bar from which the deformation has been removed. The bar shall be machined no more than necessary to remove the deformations over a length of 300 mm, and reduction will be based on the area of the machined portion.

All bars in any individual member shall be of the same grade, unless otherwise permitted by the Engineer.

When bars are to be extended by the use of couplers, the assembled units shall have a tensile strength of not less than the manufacturer's minimum guaranteed ultimate tensile strength of the bars. Failure of any one sample to meet this requirement will be cause for rejection of the heat bars and area of couplers. The location of couplers in the member shall be subject to approval by the Engineer.

Wires shall be straightened if necessary to produce equal stress in all wires groups or parallel lay cables that are to be stressed simultaneously or when necessary to ensure proper positioning in the ducts.

Where wires are to be button-headed, the buttons shall be cold formed symmetrically about the axes of the wires. The buttons shall develop the minimum guaranteed ultimate tensile strength of the wire. No cold forming shall be used that causes indentations in the wire. Button heads shall not contain wide open splits, more than 2 splits per head, or splits not parallel with the axis of the wire.

Pre-stressing steel shall be protected against physical damage and rust or other results of corrosion at all times from manufacture to grouting or encasing in concrete. Pre-stressing steel that has sustained physical damage at any time shall be rejected. The development of visible rust or other results of corrosion shall be cause for rejection, when ordered by the Engineer.

Pre-stressing steel shall be packaged in containers or shipping forms for the protection of the steel against physical damage and corrosion during shipping and storage. A corrosion inhibitor which, prevents rust or other results of corrosion, shall be placed in the package or form, or shall be incorporated in a corrosion inhibitor carrier type packaging material, or when permitted by the Engineer, may be applied directly to the steel. The corrosion inhibitor shall have no deleterious effect on the steel or concrete or bond strength of steel to concrete. Packaging or forms damaged from any cause shall be immediately replaced or restored to original condition.

The shipping package or form shall be clearly marked with a statement that the package contains high-strength pre-stressing steel, and the type of corrosion, until grouted, by means of corrosion inhibitor placed in the ducts or applied to the steel in the duct. The corrosion inhibitor shall conform to the provisions in specified herein.

When steam curing is used, pre-stressing steel for post-tensioning shall not be installed until the steam curing is completed.

Water used for flushing ducts shall contain either quick lime (calcium oxide) or slaked lime (calcium hydroxide) in the amount of 0.01 kg/L. Compressed air used to blow out ducts shall be oil free.

When acceptable pre-stressing steel for post-tensioning is installed in the ducts after completion of concrete curing, and if stressing and grouting are completed within 10 days after the installation of pre-stressing steel, rust which may form during those 10 days will not be cause for rejection of the steel. Pre-stressing steel installed, tensioned and grouted in this manner, all within 10 days, will not require the use of a corrosion inhibitor in the duct following installation of the pre-stressing steel. Pre-stressing steel installed as above but not grouted within 10 days shall be subject to all the requirements in this section pertaining to corrosion protection and rejection because of rust.

Any time acceptable pre-stressing steel for pretension is placed in the stressing bed and is exposed to the elements for more than 36 hours prior to encasement in concrete, adequate measures shall be taken by the Contractor, as approved by the Engineer, to protect the steel form contamination or corrosion.

Whenever electric welding is performed on or near members containing pre-stressing steel, the welding ground shall be attached directly to the steel being welded.

Pretension pre-stressing steel shall be cut off flush with the end of the member, and the exposed of the pre-stressing steel and a 25 mm strip of adjoining concrete shall be cleaned and painted. Cleaning shall be wire brushing or abrasive blast cleaning to remove all dirt and residue on the metal or concrete surfaces. The surfaces shall be covered with one application of untwined zinc-rich primer (organic vehicle type) except that 2 applications shall be applied to surfaces that will not be covered by concrete or mortar.

Aerosol cans are not to be used. The paint shall be thoroughly mixed at the time of application and shall be worked into any voids in the pre-stressing tendons.

Anchorages and Distribution

Post-tensioned pre-stressing steel shall be secured at the ends by means of approved permanent type anchoring devices.

Anchorage devices for post-tensioning shall hold the pre-stressing wire through a stressing washer or through an unthreaded bearing ring or plate shall not be less than 6 mm from the root of the thread of washer or from the edge of the ring or plate.

The load from the anchoring device shall be distributed to the concrete by means of approved devices that will effectively distribute the load to the concrete. Such approved devices shall conform to the following requirements.

The final unit compressive stress on the concrete directly underneath the plate or assembly shall not exceed 23 MPa.

Bending stresses in the plates or assemblies induced by the pull of the pre-stressing steel shall not exceed the yield point of the material or cause visible distortion in the anchorage plate when 95 percent of the specified ultimate tensile strength of the tendons is applied as determined by the Engineer.

Should the Contractor elect to furnish an anchorage device of a type which is sufficiently large and which is used in conjunction with a steel grillage embedded in the concrete that effectively distributes the compressive stresses to the concrete, the steel distribution plates or assemblies may be omitted.

Loop tendon anchorages if used, shall be enclosed in ducts for their entire length.

Where the end of a post-tensioned assembly will not be covered by concrete, the anchoring devices shall be recessed so that the ends of the pre-stressing steel and all parts of the anchoring devices will be at least 50 mm inside of the end surface of the members, unless a greater embedment is shown on the Drawings. Following post-tensioning, the recesses shall be filled with concrete conforming to the provisions for the structure and finished flush.

Ducts

Ducts enclosures for pre-stressing steel shall be rigid ferrous metal, galvanized, mortar tight and accurately placed at the locations shown on the Drawings or approved by the Engineer.

Ducts shall be fabricated with either welded or interlocked seams. Galvanizing of the welded seam will not be required. Ducts shall have sufficient strength to maintain their correct alignment during placing of concrete. Joints between sections of duct shall be positive metallic connections which do not result in angle changes at the joints. Waterproof tape shall be used at the connections. Ducts shall be bent without crimping or flattening. Transition couplings connecting the ducts to anchoring devices shall be either ferrous metal or polythene. Ferrous metal transition couplings need not be galvanized.

All ducts or anchorage assemblies shall be provided with pipes or other suitable connections for the injection of grout after pre-stressing.

Ducts for pre-stressing steel when bars are used shall have a minimum inside diameter 10mm larger than the bar diameter to be used, and shall be securely fastened in place to prevent movement.

After installation in the forms, the ends of ducts shall at all times be covered as necessary to prevent the entry of water or debris. If pre-stressing steel is to be installed after the concrete has been placed, the contractor shall demonstrate to the satisfaction of the Engineer that the ducts are free of water and debris immediately prior to installation of the steel.

All ducts with a total length of 120 m or more shall be vented. Vents shall be placed at not more than 120 m intervals and shall be located within 2 m of a high point in the duct profile. Vents shall be 12 mm minimum diameter standard pipe or suitable plastic pipe. Connections to ducts shall be made with metallic or plastic structural fasteners. Plastic components, if selected, shall not react with the concrete or enhance corrosion of the pre-stressing steel, and shall be free of water-soluble chlorides. The vents shall be mortar tight, taped as necessary, and shall provide means for injection of grout through the vents and for sealing the vents. Ends of vents shall be removed 25 mm below the roadway surface after grouting has been completed.

Application of Pre-stress

Pre-stressing steel shall be tensioned by means of hydraulic jacks so that the force in the pre-stressing steel shall not be less than the value shown on the Drawings.

The maximum temporary tensile stress (jacking stress) in pre-stressing steel shall not exceed 75% of the specified minimum ultimate tensile strength of the pre-stressing steel. Pretension pre-stressing steel shall be anchored at stresses that will result in the ultimate retention of working forces at not less than those shown on the Drawings, but in no case shall the stress at anchorages after seating exceed 70 percent for normal relaxation strand, or 75 percent for low relaxation strand, of the specified minimum ultimate tensile strength of the pre-stressing steel.

Working force and working stress will be considered as the force and stress remaining in the pre-stressing steel after all losses, including creep and shrinkage of concrete, elastic compression of concrete, creep of steel, losses in post-tensioned pre-stressing steel due to sequence of stressing, friction and take up of anchorages and all other losses peculiar to the method or system of pre-stressing have taken place or have been provided for.

The loss in stress in post-tensioned pre-stressing steel due to creep and shrinkage of concrete, creep of steel and sequence of stressing shall be assumed to be 221 MPa for normal relaxation wire or strand, 138 MPa for low relaxation wire or strand and 152 MPa for bars. If lightweight concrete is used, the loss shall be assumed to be 276 MPa for normal relaxation wire or strand and 207 MPa for low relaxation wire or strand.

The loss in stress in pretension pre-stressing steel due to creep and shrinkage of concrete, creep of steel and elastic compression of concrete shall be assumed to be 310 MPa for normal relaxation wire or strand and 242 MPa for low relaxation wire or strand. If lightweight concrete is used, the loss shall be assumed to be 345 MPa for normal relaxation strand or wire and 276 MPa for low relaxation strand or wire.

The following formula and friction coefficients shall be used in calculating friction losses in tendons:

$T_o = T_{xe}\,(Ua+Kl)$, where:

T_o = Steel stress at jacking end
T_x = Steel stress at any point (x)
e = base of logarithms
U = friction curvature coefficient
a = total angular change of pre-stressing steel profile in radians from jacking end to point (x)
K = friction wobble coefficient (1mm)
l = length of pre-stressing steel from jacking end to point x (mm)

PRE-STRESSING CONCRETE

Type of Steel	Type of duct	K	U
Wire or strand	Galvanized – rigid	0.0000	0.20
Plain bars	Galvanized	6.6×10^{-7}	0.15
Deformed bars	Galvanized	9.9×10^{-7}	0.30

Each jack used to stress tendons shall be equipped with either: (1) two pressure gauges or (2) one pressure gauge and a load cell, at the option of the Contractor. The jack body shall be permanently marked with the ram area. Each pressure gage shall be fully functional and have an accurately reading dial at least 150mm in diameter. The jack and each gage shall be calibrated as a unit with the cylinder extension in the approximate position that it will be at final jacking force. The load cell, if used, shall be calibrated and shall be provided with an indicator, which may be used to determine the pre-stressing force in the tendon. The range of the load cell shall

be such that the lower 10 percent of the manufacturer's rated capacity will not be used in determining the jacking stress. The jacking equipment calibration procedure shall be as follows:

Each jack used to stress tendons, which are permanently anchored at 25 percent or more of the specified minimum ultimate tensile strength of the pre-stressing steel, shall be calibrated by the Transportation Laboratory within one year prior to use and after each repair, unless otherwise directed. The Contractor shall be responsible for:

1. scheduling the calibration of the jacking equipment with the Transportation Laboratory;

2. verifying that the jack and supporting systems are complete, with proper components, and are in good operating condition;

3. mechanically calibrating the gages with a dead weight tester or other approved means prior to calibration of the jacking equipment by the Transportation Laboratory;

4. providing sufficient labour, equipment and material to install and support the jacking and calibration equipment and to remove the equipment after the calibration is complete; and

5. plotting the calibration results.

Each jack used to stress tendons, which are permanently anchored at less than 25 percent of the specified minimum ultimate tensile strength of the pre-stressing steel, shall be calibrated by a private laboratory approved by the Engineer, within 6 months prior to use and after each repair, unless otherwise directed.

The pre-stressing force may be tested by load cells or pressure cells, or with Vibra –Tension equipment.

The Contractor shall provide sufficient labour, equipment and material to install and support the testing equipment at the pre-stressing tendons and to remove the testing equipment after the testing is complete, as ordered by the Engineer.

Prior to placing forms for closing slabs of box finder cells, the Contractor shall demonstrate to the satisfaction of the Engineer that either the pre-stressing steel is free and unbounded in the duct or, if pre-stressing steel has not yet been placed, that all ducts are unobstructed.

Prior to post-tensioning any member, the Contractor shall demonstrate to the satisfaction of the Engineer that the pre-stressing steel is free and unbounded in the duct.

Pre-stressing forces shall not be applied to cast in place concrete until at least 10 days after the last concrete has been placed in the member to be pre-stressed and until the concrete complies with one of the following requirements:

When the concrete is designated by compressive strength, the concrete compressive strength shall have reached the strength shown on the Drawings at the time of stressing.

When the class of concrete is designated by compressive strength, the required concrete compressive strength shall have achieved prior to being pre-stressed.

Subject to prior approval by the Engineer, a portion of the total pre-stressing force may be applied to a precast member when the strength of the concrete in the member is less than the value shown on the Drawings and the member may then be moved. Approval by the Engineer of the partial pre-stressing and moving shall in no way relieve the Contractor of full responsibility for successfully constructing the members.

Pre-stressing steel in pretension members shall not be cut or released until the concrete in the member has attained a compressive strength of not less than the value shown on the Drawings or 28 MPa, whichever is the greater.

When ordered by the Engineer pre-stressing steel strands in pretension members, if tensioned individually, shall be checked by the Contractor for loss of pre-stress not more than 3 hours prior to placing concrete for the members. The method and equipment for checking the loss of pre-stress shall be subject to approval by the Engineer. Strands, which show a loss of pre-stress in excess of 3 percent, shall be re-tensioned to the original computed jacking stress.

When pre-stressing steel in pretension members is tensioned at a temperature appreciably lower than the estimated temperature of the concrete and the pre-stressing steel at the time of initial set of the concrete, the calculated elongation of the pre-stressing steel shall be increased to compensate for the loss in stress, but in no case shall the jacking stress exceed 75 percent of the specified minimum ultimate tensile strength of the pre-stressing steel.

The cutting and releasing of pre-stressing steel in pretension members shall be performed in such an order that lateral eccentricity of pre-stress will be a minimum.

The tensioning process as applied to post tensioned members shall be so conducted that tension being applied and the elongation of the pre-stressing steel may be measured at all times.

Except as provided herein, jacking at each end of the tendon shall tension tendons in continuous post-tensioned members. Where one end stressing is shown on the Drawings, tensioning of such tendons shall be done jacking from one end or both ends of the tendon at the option of the Contractor.

Jacking from one end only may tension pre-stressing tendons in simple span post-tensioned members.

Bonding and Grouting

Post-tensioned pre-stressing steel shall be bonded to the concrete by completely filling the entire void space between the duct and the tendon with grout.

Grout shall consist of Portland cement and water, and may contain an admixture if approved by the Engineer.

Portland cement shall conform to the provisions in Section 90-4, "Admixtures," except that the admixtures shall not contain chloride ions in excess of 0.25 percent by mass of admixture and the admixtures may be dispensed in solid form.

Water shall be first added to the mixer followed by cement and admixture.

The grout shall be mixed in mechanical mixing equipment of type that will produce uniform and thoroughly mixed grout. The water content shall be not more than 44 litres per 100 kg of cement. Re-tempering of grout will not be permitted. Grout shall be continuously agitated until the grout is pumped.

The Engineer shall determine the quality of the grout. The efflux time of a grout sample immediately after mixing shall be not less than 11 seconds.

Grouting equipment shall be capable of grouting at a pressure of at least 0.7 MPa.

Grouting equipment shall be furnished with a pressure gage having a full-scale reading of not more than 2.0 MPa.

When vents are required, standby flushing equipment capable of developing a pumping pressure of 1.7 MPa and of sufficient capacity to flush out any partially grouted ducts shall be provided.

Ducts shall be clean and free of water and deleterious materials that would impair bonding of the rout or interfere with grouting procedures.

Grout shall pass through a screen with 1.8mm maximum clear openings prior to being introduced into the grout pump.

Grout injection pipes, ejection pipes and vents shall be fitted with positive mechanical shutoff valves. Positive mechanical shutoff valves shall be capable of withstanding the pumping pressures. Valves shall not be removed or opened until the grout has set. Suitable alternatives, when satisfactorily demonstrated to the Engineer, may be substituted for mechanical valves.

Leakage of grout through the anchorage assembly shall be prevented by positive mechanical means.

Grout shall be pumped through the duct and continuously wasted at the outlet until no visible slugs or other evidence of water or air are ejected, and the efflux time of ejected grout is not less than 11 seconds. The outlet valve shall then be closed, and the pumping pressure held momentarily. The valve at the inlet shall then be closed while maintaining this pressure.

When hot weather conditions would contribute to quick stiffening of the grout, the grout shall be cooled by approved methods as necessary to prevent blockage during pumping operations.

The surfaces of concrete against which concrete encasement over anchorage assemblies is to be placed shall be abrasive blast cleaned, and cleaned aggregate exposed after grouting of the ducts has been completed.

Samples for Testing

Sampling and testing shall conform to the requirements in ASTM Designation: A 416 and ASTM Designation: A 421 and as specified in this Sub-Section 50.1.10.

Samples from each size and each heat of pre-stressing bars, from each manufactured reel of pre-stressing steel strand, from each coil of pre-stressing wire and from each area of anchorage assemblies and bar couplers to be used shall be furnished for testing. With each sample of pre-stressing steel wires, bars or strands furnished for testing, a certification shall be submitted stating the manufacturer's minimum guaranteed ultimate tensile strength of the sample furnished.

Materials for testing shall be furnished by the Contractor at the Contractor's expense. The Contractor shall have no claim for additional compensation in the event the work is delayed awaiting approval of the materials furnished for testing.

All bars of each size from each mill heat, all wire from each coil, and all strand from each manufactured reel delivered to the site shall be assigned an individual area number and shall be tagged in such a manner that each area can be accurately identified at the jobsite. Each area of anchorage assemblies and bar couplers to be installed at the site shall be likewise identified. Unidentified pre-stressing steel, anchorage assemblies and bar couplers received at the site will be rejected.

The Contractor shall furnish the following samples of materials and tendons, selected by the Engineer from the pre-stressing steel at the plant or jobsite, to the Engineer well in advance of anticipated use;

For wire or bars, one 2m long sample and for strand, one 1.5m long sample, of each size shall be furnished for each heat or reel.

If the pre-stressing tendon is a bar, one 2m length shall be furnished and in addition, if couplers are to be used with the bar, two 1.25m lengths of bar equipped with one coupler and fabricated to fit the coupler shall be furnished.

Approval of all pre-stressing systems will be contingent on approval, in writing by the Engineer.

For prefabricated tendons, the Contractor shall give the Engineer at least 10 days notice before commencing the installation of end fittings or the heading of wires. The Engineer will inspect end fitting installations and wire headings while such fabrication is in progress at the plant and will arrange for the required testing of the material to be shipped to the site.

No prefabricated tendon shall be shipped to the site without first having been approved in principle by the Engineer, and each tendon shall be tagged before shipment for identification purposes at the site. Unidentified tendons received at the site will be rejected.

Site as referred to herein shall be considered to mean the location where the members are to be manufactured, whether at the structure site or a removed casting yard.

The approval of any material by the Engineer shall not preclude subsequent rejection if the material is damaged in transit or later damaged or found to be defective.

553.8 - CURING

553.8.1 - General

Careful attention shall be given to the proper curing of concrete. Prior to placing of concrete, the contractor shall submit the proposed curing methods and procedures to the Engineer for approval. Elevated temperature curing facilities shall be tested prior to approval. Approved equipment and materials for curing shall be available for use prior to casting.

Inadequate curing facilities or lack of attention to the proper curing of concrete shall be sufficient cause for the Engineer to stop all concrete placement until approved curing is provided. Inadequate curing may be cause to reject the member. All test cylinders shall be cured in the same environment as the precast/pre-stressed concrete members.

Curing shall be commenced prior to the formation of surface shrinkage cracks. The curing mats, sheets, or blankets shall be carefully placed in contract with the concrete member to avoid damage to the freshly finished concrete.

The following curing requirements shall apply for precast/pre-stressed members. Any other special method of curing shall meet with the approval of the Engineer. Concrete shall not be exposed to temperatures below freezing until the specified minimum strength as shown in Drawing notes has been attained.

All concrete shall be cured by water curing, accelerated temperature curing, or any other method approved by the Engineer.

553.8.2 - Water Curing:

All exposed surfaces of the concrete shall be kept wet continuously for the required curing time. The water used for curing shall meet the requirements of 553.2. Water curing shall be permitted as follows:

553.8.2.1 - Wet Mat Method:

For water curing by the mat method, cotton mats, polyethylene sheeting, or polyethylene burlap blankets may be used. The mats, sheets or blankets shall be adequately anchored and weighted to provide continuous contact with all concrete surfaces. Any concrete surfaces, which cannot be cured by contact shall be enclosed by mats, adequately anchored, so that outside air cannot enter the enclosure. Sufficient moisture shall be provided inside the enclosure to keep all of the surfaces of the concrete wet for the required curing time, but in no case less than 36 hours.

553.8.2.2 - Saturated Cover Curing:

The member, covered as specified for the initial phase of curing, shall be maintained on the casting bed in an approved enclosure designed and equipped to insure complete saturation of the covering. The temperature within the enclosure and that of the covering material shall be maintained to provide a uniform curing temperature at the surface of the member, within the limits of 27°C to 54°C, until the specified strength is attained, but in no case less than 36 hours. The covering shall be kept thoroughly saturated throughout the entire curing period and the temperature of the water used shall be controlled uniformly to maintain the selected curing temperature of the surface of the member.

553.8.2.3 - Water Spray Curing:

The member, covered as specified for the initial phase of curing, shall be maintained in the casting bed in an approved enclosure. When the concrete is sufficiently hardened to resist damage, the covering shall be removed and the exposed surfaces of the unit shall be subjected to a continuous fine spray of water. The temperature within the enclosure and that of the water used shall be controlled to provide a uniform curing temperature at the surface of the member, within the limits of 27°C to 54C until the specified member strength is attained, but in no case less than 36 hours.

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553.8.3 - Accelerated Curing:

Accelerated curing of the concrete shall be, by low pressure steam curing, or radiant heat curing.

Transfer of stress shall be accomplished immediately after the heat curing has been discontinued. Accelerated curing shall be applied at a controlled rate following initial set of the concrete as per ASTM C403. Accelerated curing shall be done under suitable enclosures, which minimize all heat losses and maintain uniform cure conditions within the enclosed area. Members must be maintained wet during accelerated curing time.

If accelerated curing is used, the contractor/fabricator shall furnish recording thermometers showing the time-temperature relationship of the concrete throughout the entire curing period. Recording thermometers shall be kept in proper calibration and recalibrated at least annually.

553.8.3.1 - Low-Pressure Steam Curing:

Low-pressure steam curing shall be done under a suitable enclosure to contain the live steam and minimize moisture and heat losses. The concrete shall be allowed to attain its initial set before application of the live steam.

Application of live steam shall not be directed on the concrete or forms such as to cause localized high temperatures. During the initial application of live steam, the concrete temperature shall be raised at an average rate not exceeding 27°C / per hour, until the curing temperature is reached. The maximum sustained concrete temperature during the curing cycle shall not exceed 70°C. The maximum temperature shall be held until the concrete has reached the required release strength. The maximum peak concrete temperature during the curing cycle shall be 88°C. The concrete temperature shall be maintained uniformly throughout the extremities of the pre-stressed member. At the end of curing, the concrete temperature shall be reduced at an average rate not exceeding 10°C / per hour.

553.8.3.2 - Radiant Heat Curing:

Radiant heat may be applied by means of pipes circulating steam, hot oil or hot water, or by electric heating elements. Radiant heat curing shall be done under a suitable enclosure to contain the heat, and moisture loss shall be minimized by covering all exposed concrete surfaces with plastic sheeting or by applying an approved liquid membrane-curing compound to all exposed concrete surfaces. The heat application shall be maintained to create a uniform concrete temperature throughout the extremities of the member.

After the waiting period prior to application of the heat, the concrete temperature shall increase at an average rate not exceeding 27°C / per hour until the curing temperature is reached. The maximum sustained concrete temperature within the curing cycle shall not exceed 70°C. The maximum temperature shall be held until the concrete has reached the required release strength as shown in Drawing notes. The maximum peak concrete temperature during the curing cycle shall be 88°C. The maximum cooling rate from sustained concrete curing temperature shall be 10°C / per hour.

553.9 - FINISHING

To assure the production of well formed matching members, all surfaces of the concrete shall be finished, shall be true and even, and shall be free from rough, open, or honeycombed areas, depressions or projections. The edges shall be finished or chamfered, or both. Care shall be

exercised in removing forms to avoid spellings or otherwise damaging the concrete.

Top surfaces of pre-stressed members shall be screened or rough floated to bring mortar to the surface and cover all aggregate. The surface of members, which will receive cast-in-place concrete on the project site, shall have a rough wood float or stiff broom finish. Aggregate shall not be loosened when roughening the surface. The fascia surfaces of bridge members shall be finished with a "Class 2, rubbed finish" conforming to 551.11.2. Concrete on exposed reinforcing steel and loose laitance on concrete surfaces to be in contact with cast-in-place concrete shall be removed from all members.

Fabrication holes, except box beam vent holes, in the bottom of all beams, shall be filled with no shrink mortar and made flush with the surrounding surface. Care shall be taken in final cutting ends of strands to avoid damaging the concrete surface.

553.10 - WORKMANSHIP

553.10.1 - General:

Holes and voids in the surface of concrete resulting from bolts, ties, or large air pockets shall be wetted and filled with mortar having the same proportion of fine aggregate and cement as in the concrete, after which exposed mortar surfaces shall be finished smooth and even with a wood float.

Surfaces to be repaired and finished shall be kept wet for at least one hour before hydraulic cement mortar is applied. Immediately following patching work, repaired areas shall be wet cured for at least 48 hours. The wet cure may be accomplished by the use of steam, wet burlap or continuous spray wetting. A liquid membrane-curing compound may be used on non-composite surfaces.

Beams or girders having honeycomb of such extent to affect their strength or resistance to deterioration will not be accepted.

553.10.2 - Defects and Breakage:

Defective or damaged members which cannot be satisfactorily repaired, or which are not acceptable to the Engineer will not be incorporated into the work.

553.11 - DIMENSIONAL TOLERANCES

All tolerances shall be applied with respect to the theoretical positions and dimensions shown in the Drawings. The tolerances listed in this article represent the total allowable tolerance that will be accepted in the finished product.

The limits of tolerance do not necessarily represent fully acceptable construction; they are the limits at which construction becomes unacceptable. In general, workmanship shall be at a level of quality that will be well within the tolerance limits.

553.11.1 - Pre-stressed Concrete I-Beams and Bulb Tee Beams:

Characteristics	Value
Depth (flanges)	± 6 mm
Depth (Overall)	+15mm to -6 mm
Width (flanges)	+10mm to -6 mm
Width (Web)	+10mm to -6 mm
Length of Beam	±1mm/metre, 25 mm max
Sweep (variation from straight line parallel to centreline of the member)	±1 mm/metre
Sweep (variation from straight line parallel to centreline of the member)	±1 mm/metre
Camber variation from design Camber up to 24 m length	±1mm/metre±13mm max
Camber variation from design Camber over 24 m length	±1.5mm/metre ±25mm max
Position of Plates	±5mm
Position of Bearing Plates	±25mm
Diaphragm Inserts (spacing between centres of inserts and from centres of inserts to the ends of the beams)	±16mm
Stirrup bars (Projection above top of beam)	±15mm
Stirrup bars (Projection above top of beam)	±15mm
Stirrup bars (longitudinal spacing)	±20mm
Concrete Cover	±50mm
Position of inserts for structural connections	±6mm
Position of hold-down points for draped strands	±15mm
Position of Inserts	±125mm
Position of handling devices:	±15mm
Parallel to length	±150mm
Transverse to length	±25mm
Pre-stressing strand position (vertical or horizontal)	±6mm

553.12 - HANDLING, STORING, TRANSPORTING, AND ERECTION:

The Contractor shall be responsible for proper handling, lifting, storing, hauling, and erection of all members so that they are placed in the structure without damage.
Pre-stressed members shall be maintained in an upright position at all times and shall be handled and supported in a manner, which prevents torsion. No member shall be moved from the casting yard until the member has been accepted.

Storing of members shall be done with adequate blocking so that warpage or cracking will not occur. Blocking will be such that at least 150mm clearance is maintained above the surface on which the blocking is placed. Placement of the blocking from beam-ends shall be at locations not greater than (3) percent of the beam length. Concrete box beams shall be supported by the solid end block, area during handling, storage, hauling, and erection. Members which are improperly stored and which become cracked, warped, or otherwise damaged in storage will be rejected.

Members when stacked shall be separated by blocking capable of supporting the members. The blocking shall be arranged in vertical planes. Stacking of members shall be arranged such that lifting devices will be accessible and undamaged. Stacking shall not exceed two members high.

All concrete beams or girders when erected shall be securely tied and/or braced unless otherwise shown on the plans. When railroad or roadway traffic must be maintained beneath

girders or beams already placed, traffic shall be protected against falling objects during the erection of diaphragms and other structural members, during the placing of cast-in-place concrete, and during the erection and dismantling of forms. Protection shall consist of nets or flooring with openings not larger than 25mm.

When pre-cast / pre-stressed concrete adjacent box beams are erected, the fit of mating surfaces will be such that excessive grout leakage will not occur. If such fit is not provided the joint shall be filled with grout or sealed with an acceptable caulking suitable to the Engineer.

553.13 - MEASUREMENTS AND PAYMENT:

553.13.1 - Method of Measurement:

Pre-cast/Pre-stressed concrete structural members will be measured along the member centreline in metres. Deck panels shall be measured by area in square metres complete in place.

Precast reinforced concrete three-sided structures shall be measured along the centreline of the erected structure in linear metres.

Pre-cast reinforced concrete headwalls and wingwalls for use with precast reinforced concrete three-sided structures shall be measured in square metre as measured on the exterior face of the member.

Items for pre-cast concrete shall be inclusive of reinforcement, formwork, joints and finishes.

553.13.2 - Basis of Payment:

Pre-cast / Pre-stressed concrete beams, deck panels, precast reinforced concrete three-sided structures, and precast reinforced concrete headwalls and wingwalls will be paid for at the contract unit price bid for the items listed below, which price and payment shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner including the cost of furnishing and manufacturing the concrete members; for labour, concrete, forms, reinforcing steel, pre-stressing strands, inserts, anchorage devices, bearing pads, shims, grout, wingwalls and headwall connection hardware, joint sealing/waterproofing, and other devices, and for moving, transporting and erecting the finished product in accordance with the Drawings and Specifications. For precast reinforced concrete three-sided structures where the headwall is cast integral with the end structure unit, the headwall will be paid for in square metres as if it were not integral cast. Cast-in-place concrete diaphragms, curb, parapet, railing, and reinforcing steel for cast-in-place concrete are not included in this item.

553.13.3-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
	FABRICATION OF PC POST TENSION-T GIRDERS SUPPLIED AT SITE	
553.001	Precast Girders 30m long	Number
553.002	Precast Girders 30m long type II	Number
553.003	Precast Girders 25m long	Number
553.004	Precast Girders 20m long	Number
553.004a	Precast Girders 35m long	Number
	FABRICATION OF P.S.C CONCRETE BEAM SUPPLY AT SITE	
	19 long P.S.C Concrete Beam supply at site	Number
	LAUNCHING OF PC-T GIRDERS IN TO POSITIONS INCLUDING STRESSING AND GROUTING OF CONTINUOUS JOINTS	
553.005	Launching - 30m long	Number
553.006	Launching - 30m long type II	Number
553.007	Launching - 25m long	Number
553.008	Launching - 20m long	Number
553.009	Launching - 35 m long	Number
553.010	19m long P.S.C beam Launched in to position	Number
	TESTING OF BEAMS	
553.011	Testing Beams- 30m long	Number
553.012	Testing Beams - 30m long type II	Number
553.013	Testing Beams - 25m long	Number
553.014	Testing Beams - 20m long	Number
553.015	Testing Beams - 35m long	Number

SECTION 554
DRIVEN PILES

554.1 - DESCRIPTION

This work consists of furnishing and driving piles. This work also includes furnishing and placing reinforcing steel and concrete in concrete filled steel shell and concrete-filled pipe piles.

Piles are designated as steel H-piles, concrete-filled steel shell piles, concrete-filled pipe piles, precast concrete piles, pre-stressed concrete piles or timber piles. Pile load tests are designated as static or dynamic.

554.2- MATERIAL

Materials should conform to the following Sections and Sub-Sections:

Concrete	551.00
Paint	711.00
Pile shoes	709.08
Reinforcing steel	709.01

CONSTRUCTION REQUIREMENTS

554.3 - PILE DRIVING EQUIPMENT

Furnish equipment meeting the following requirements.

(A) Pile Hammers.

The Contractor will be permitted to use a 'drop weight' type hammer to drive precast concrete piles.

Gravity Hammers.

Gravity hammers can only be used to drive timber piles. Furnish a hammer with a ram weighing between 900 and 1600 kilograms and limit the drop height to 4.5 metres. The ram mass shall be greater than the combined mass of the drive head and pile. Provide hammer guides to ensure concentric impact on the drive head.

Open-end diesel hammers.

Equip open-end (single acting) diesel hammers with a device, such as rings on the ram or a scale (jump stick) extending above the ram cylinder, to permit visual determination of hammer stroke. Submit a chart from the hammer manufacturer equating stroke and blows per minute for the hammer to be used. A speed versus stroke calibration may be used if approved.

Closed-end Diesel Hammers.

Submit a chart, calibrated to actual hammer performance within 90 days of use, equating bounce chamber pressure to either equivalent energy or stroke for the hammer to be used. Equip hammers with a dial gauge for measuring pressure in the bounce chamber. Make the gauge

readable from ground level. Calibrate the dial gauge to allow for losses in the gauge hose. Verify the accuracy of the calibrated dial gauge during driving operations by ensuring that cylinder lift occurs when bounce chamber pressure is consistent with the maximum energy given in the hammer specifications. Do not use closed-end diesel hammers that do not attain cylinder lift at the maximum energy-bounce chamber pressure relationship given in the hammer specification.

Air or Steam Hammers.

Furnish plant and equipment for stem and air hammers with sufficient capacity to maintain the volume and pressure specified by the hammer manufacturer. Equip the hammer with accurate pressure gauges that are easily accessible. Use a hammer with the mass of the striking parts equal to or greater than one-third the combined mass of the driving head and pile. The combined mass shall be at least 1250 kilograms.

Measure inlet pressures for double-acting and differential-acting air or stream hammers with a needle gauge at the head of the hammer when driving test piles. If required, also measure inlet pressures when driving production piles. A pressure versus speed calibration may be developed for specific driving condition is the project as an alternative to periodic measurements with a needle gauge.

Non-impact Hammers.

Do not use non-impact hammers, such as vibratory hammers, unless permitted in writing or when specified in the contract. If permitted, use such equipment for installing production piles only after the pile tip elevation or embedment length for safe support of the pile load is established by static or dynamic load testing. Control the installation of production piles when using vibratory hammers by power consumption, rate of penetration, specified tip elevation, or other acceptable methods that will ensure the required pile load capacity is obtained. On one out of every 10 piles driven, strike with an impact hammer of suitable energy to verify the required pile capacity is obtained.

(B) Approval of Pile Driving Equipment.

Furnish pile-driving equipment of such size that the permanent piles can be driven with reasonable effort to the required lengths without damage.

The Engineer will evaluate the suitability of the equipment and will accept or reject the driving system within 14 days of receipt of the pile and driving equipment information. Approval of pile driving equipment will be based on a wave equation analysis when dynamic load testing is required, when ultimate pile capacities exceed 2400 kiloNewtons, or when precast or pre-stressed concrete piles are used. When the wave equation analysis is not used, approval of the pile driving equipment will be based on minimum hammer energy in Table 551-1. Approval of a pile hammer relative to driving stress damage does not relieve the Contractor of responsibility for damaged piles.

Approval of the pile driving system is specific to the equipment data submitted. If the proposed equipment is modified or replaced, resubmit the revised data for approval before using. The revised driving system will be accepted or rejected within 14 days of receipt of the revised pile, equipment, and wave equation analysis (if required) information. Use only the approved equipment during pile driving operations.

(i) Equipment Submittal.

Submit the following pile driving equipment information at least 30 days before driving piles. When dynamic load tests are required by the contract, submit a wave equation analysis performed by a pile specialty consultant meeting the requirements of Subsection 551.11. If dynamic load testing is not required by the contract, the ER will perform the wave equation analysis.

(a) General. Project and structure identification, pile driving contractor or subcontractor, and auxiliary methods of installation such as jetting or pre-boring and the type and use of the equipment.

(b) Hammer. Manufacturer, model, type, serial number, rated energy (____ at _____ length of stroke), and modifications.

(c) Cap block (hammer cushion). Material, thickness, area, modulus of elasticity (E), and coefficient of restitution (e).

(d) Pile cap. Helmet mass, bonnet mass, anvil block mass, and drive head mass.

(e) Pile cushion. Material, thickness, area, modulus of elasticity (E) & coefficient of restitution (e).

(f) Pile. Pile type, length (in leads), mass per metre, wall thickness, taper, cross-sectional area, designed pile capacity, description of splice, and tip treatment description.

(ii) Wave Equation.

The required number of hammer blows indicated by the wave equation at the ultimate pile capacity shall be between 3 and 15 per 25 millimetres. In addition, the pile stresses resulting from the wave equation analysis shall not exceed the values at which pile damage is impending. The point of impending damage is defined for steel, concrete, and timber piles as follows.

(a) Steel Piles. Limit the compressive driving stress to 90 percent of the yield stress of the pile material.

(b) Concrete Piles. Limit the tensile (TS) and compressive (CS) driving stresses to:

$$TS \leq TS \leq 3f_c'^{1/2} + EPV$$
$$CS \leq 0.85f_c'^{1/2} - EPV$$

Where:

f_c' = The 28-day design compressive strength of the concrete
EPV = The effective pre-stress value

(c) Timber Piles - Not used

(iii) Minimum Hammer Energy.

The energy of the driving equipment submitted for approval, as rated by the manufacturer, shall be at least the energy specified in Table 554-1 that corresponds to the required ultimate pile capacity.

TABLE 554-1

MINIMUM PILE HAMMER ENERGY

Ultimate Pile Capacity (kiloNewtons)	Minimum Rated Hammer Energy (Kilojoules)
≤ 800	14.0
1330	21.2
1600	28.1
1870	36.0
2140	44.9
2400	54.4
>2400	Wave equation required

(C) Driving Appurtenances.

(i) Hammer Cushion.

Equip all impact pile driving equipment, except gravity hammers, with a suitable thickness of hammer cushion material to prevent damage to the hammer or pile and to ensure uniforms driving behaviour. Fabricate hammer cushions from durable, manufactured material according to the hammer manufacturer's recommendations. Do not use wood, wire rope, or asbestos hammer cushions. Place a striker plate, as recommended by the hammer manufacturer, on the hammer cushion to ensure uniform compression of the cushion material. Inspect the hammer cushion in the presence of the Engineer Representative when beginning pile driving at each structure or after each 100 hours of pile driving, whichever is less. Replace the cushion when its thickness is reduced by more than 25 percent of its original thickness.

(ii) Pile Drive Head.

Provide adequate drive heads for impact hammers and provide appropriate drive heads, mandrels, or other devices for special piles according to the manufacturer's recommendation. Align the drive head axially with the hammer and pile. Fit the drive head around the pile head so that it will prevent transfer of torsional forces during driving while maintaining proper alignment of hammer and pile.

(iii) Leads.

Support piles in line and position with leads while driving. Construct pile driver leads to allow freedom of movement of the hammer while maintaining axial alignment of the hammer and the pile. Do not use swinging leads unless permitted in writing or specified in the contract. When swinging leads are permitted, fits winging leads with a pile gate at the bottom of the leads and, in the case of battered piles, with a horizontal brace between the crane and the leads. Adequately embed leads in the ground or constrain the pile in a structural frame (template) to maintain proper alignment. Provide leads of sufficient length that do not require a follower but will permit proper alignment of battered piles.

(iv) Followers

Followers are not permitted unless approved in writing. When followers are permitted, drive the first pile in each bent or substructure unit and every tenth pile thereafter, full length without a follower, to verify that adequate pile embedment is being attained to develop the required penetration. Hold and maintain follower and pile in proper alignment during driving.

(v) Jetting.

Do not use jetting unless approved in writing. Provide jetting equipment with sufficient capacity to deliver a consistent pressure equivalent to at least 700 kilopascals at two 20-millimetre jet nozzles. Jet so as not to affect the lateral stability of the final in place pile. Remove jet pipes hen the pile tip is at least 1.5 metres above the prescribed tip elevation and drive the pile to the required ultimate capacity with an impact hammer. Control, treat if necessary, and dispose of all jet water in an approved manner.

554.4 - PILE LENGTHS

Furnish piles with sufficient length to obtain the required penetration and to extend into the pile cap or footing as indicated on the Drawings. In addition, increase the length to provide fresh heading and to provide for the Contractor's method of operation. When test piles are required, furnish piles in the lengths determined by the test piles.

554.5 - TEST PILES

Install test piles when specified in the Contract. Excavate the ground at the site of each test pile or production pile to the elevation of the bottom of the footing before the pile is driven. Furnish test piles longer than the estimated length of production piles. Drive test piles with the same equipment as the production piles.

Drive test piles to the required ultimate capacity at the estimated tip elevation. Allow test piles that do not attain the required ultimate capacity at the estimated tip elevation to "set up" for 24 hours before re-driving. Warm the hammer before re-driving begins by applying at least 20 blows to another pile. If the required ultimate capacity is not attained on re-driving, drive a portion or all of the remaining test pile length and repeat the "set up" and re-drive procedure as directed. Splice and continue driving until the required ultimate pile capacity is obtained.

Test piles to be used in the completed structure shall conform to the requirements for production piles. Remove test piles not incorporated in the completed structure to at least 0.5 metre below finished grade.

554.6 - DRIVEN PILE CAPACITY

Drive piles to the specified penetration and to the depth necessary to obtain the required ultimate pile capacity. Splice piles not obtaining the required ultimate capacity at the ordered length and drive with an impact hammer until the required ultimate pile capacity is achieved.

Use the dynamic formula to determine ultimate pile capacity of the in place pile unless the wave equation is required according to Subsection 554.03(b)

(a) Wave Equation.

Adequate penetration shall be considered as obtained when the specified wave equation resistance criteria are achieved within 1.5 metres of the designated tip elevation. Drive piles that do not achieve the specified resistance within these limits to a penetration determined by the Engineer Representative.

b) Dynamic Formula.

Drive the piles to a penetration necessary to obtain the ultimate pile capacity according to the following formula:

$Ru = (7\sqrt{E}log(10N) - 550$, where:

Ru	=	Ultimate pile capacity in kiloNewtons
E	=	Manufacturer's rated hammer energy in joules at the ram stroke *observed or measured in the field*
Log(10N)	=	logarithm to the base 10 of the quantity 10 multiplied by N
N	=	Number of hammer blows per 25 millimetres at final penetration

Solving for N:

$$N = 10^{X}$$

$$X = \left(\frac{Ru + 550}{7\sqrt{E}} \right) - 1$$

Factor of safety = 3.0

(c) Jetted Piles

Determine the in place ultimate capacity of jetted piles based on impact hammer blow counts (dynamic formula) after the jet pipes have been removed. After the pile penetration length necessary to produce the required ultimate pile capacity has been determined by impact hammer blow count, install the remaining piles in each group or in each substructure unit to similar depths with similar methods. Confirm the required ultimate pile capacity has been achieved by using the dynamic formula.

(i) Conditions for dynamic formula. The dynamic formula is applicable only if all of the following apply:

(a) The hammer is in good condition and operating in a satisfactory manner.

(b) The hammer ram falls freely

(c) A follower is not used.

(d) The head of the pile is not boomed or crushed.

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554.7- PRE-BORING.

When piles are to be driven through compacted embankments more than 1.5 metres in depth pre-bore holes to natural ground level. Use auguring, wet rotary drilling, or other approved methods of preparing. Except for piles end-bearing on rock or hardpan, stop pre-boring at least 1.5 metres above the estimated pile tip elevation and drive the pile with an impact hammer to a penetration which achieves the required ultimate pile capacity. Pre-boring may extend to the surface of the rock or hardpan where piles are to be end bearing on rock or hardpan. Seat the piles into the end-bearing strata.

Pre-bore holes smaller than the diameter (or diagonal) of the pile cross-section, while allowing penetration of the pile to the specified depth, if subsurface obstructions such as boulders or rock layers are encountered, the hole diameter may be increased to the least dimension adequate for pile installation. Fill any void space remaining around the pile after completion of driving with sand or other approved material. Do not use a punch or a spud in lieu of pre-boring.

Do not impair the capacity of existing piles or the safety or condition of adjacent structures. If pre-boring disturbs the capacity of previously installed piles or structures restore the required ultimate capacity of piles and struts by approved methods.

554.8 - PREPARATION AND DRIVING

Perform the work under Section 207 make the head of all piles plane and perpendicular to the longitudinal axis of the pile. Coordinate pile driving so as not to damage other parts of the completed work.

Drive piles to within 50 millimetres of Drawing location at cut-off elevation for bent caps, and within 150 millimetres of Drawing location for piles capped below finished ground. The pile shall not be closer than 100 millimetres to any cap face. Drive piles so that the axial alignment is within 20 millimetres per metre of the required alignment. The Engineer may stop driving to check the pile alignment. Check alignment of piles that cannot be internally inspected after installation, before the last 1.5 metres are driven. Do no pull laterally on piles or splice to correct misalignment. Do not splice a properly aligned section on a misaligned pile.

Place individual piles in pile groups either starting from the centre of the group and proceeding outward in both directions or starting at the outside row and proceeding progressively across the group.

Correct all piles driven improperly, driven out of proper location, misaligned, or driven below the designated cut-off elevation in an approved manner. Replace piles damaged during handling or driving. Obtain approval for the proposed method(s) of correcting or repairing deficiencies.

(a) Timber piles. Not used

(b) Steel Piles.

Furnish full-length, un-spliced piles for lengths up to 18 metres. If splices are required in the first pile driven and it is anticipated that subsequent piles will also require splices, place ether splices in lower third of the pile. Splice lengths less than 3 metres are not permitted and only 2 splices per pile are allowed.

Load, transport, unload, store, and handle steel piles so the metal is kept clean and free from damage. Do not use piles that exceed the camber and sweep permitted by allowable mill tolerance. Steel piles damaged during installation are considered unsatisfactory unless the bearing capacity is proven to be 100 percent of the required ultimate capacity by load tests. Load tests performed will be at no cost to the Government.

(c) Precast and Pre-stressed Concrete Piles.

Support concrete piles during lifting or moving at the points shown on the Drawings or, if not so shown, provide support at the quarter points. Provide slings sort other equipment when raising or transporting concrete piles to avoid bending the pile or breaking edges.

Protect the heads of concrete piles with a pile cushion at least 100 millimetres thick. Cut the pile cushion to match the cross-section of the pile top. Replace the pile cushion if it is either compressed more than one half its original thickness or begins to burn. Provide a new pile cushion for each pile.

A concrete pile is rejected if it contains any defect that will affect the strength or long-term performance of the pile.

(d) Concrete-filled Pipe or Steel Shell Piles.

Furnish and handle the steel shells or pipes in accordance with (b) above. Cutting shoes for shells or pipes may be inside or outside the shell. Use high-carbon structural steel with a machined ledge for shell bearing or cast steel with a ledge designed for attachment with a simple weld.

When practicable, drive all pile shells or pipes for a substructure unit prior to placing concrete in any of the shell soar pipes. Do not drive pile shells or pipes within 5 metres of any concrete-filled pile shell or pipe until the concrete has cured for at least 7 days or 3 days if using high early-strength concrete. Do not drive any pile shell or pipe after it is filled with concrete.

Remove and replace shells that are deemed unacceptable for use due to breaks, bends, or kinks.

554.9 - SPLICES

Engineer's approval in writing is required for pile splicing. Align and connect pile sections so the axis of the spliced pile is straight.

(a) Steel Piles.

Submit a welder certification for each welder. Use welders certified for structural welding. Make surfaces to be welded smooth, uniform, and free from loose scale, slag, grease, or other material that prevents proper welding. Steel may be oxygen cut. Carbon-arc gouging, chipping, or grinding may be used for joint preparation.
Weld according to AASHTO (AWS D 1.5) Bridge Welding Code. Weld the entire pile cross-section using pre-qualified AWS groove welded butt joints. Weld so there is no visual evidence of cracks, lack of fusion, undercutting, excessive piping, porosity, or inadequate size. Manufactured splices may be used in place of full penetration groove butt welds.

(b) Concrete Pile Splices.

Submit drawings of proposed splices for acceptance. Use dowels or other acceptable mechanical means to splice precast concrete or precast pre-stressed concrete piles. The splice shall develop strengths in compression, tension, and bending equal to or exceeding the strength of the pile being spliced.

(c) Concrete Pile Extensions.

(i) Precast Concrete Piles.

Extend precast concrete piles by removing the concrete at the end of the pile and leaving 40 diameters of reinforcement steel exposed. Remove the concrete to produce a face perpendicular to the axis of the pile. Securely fasten reinforcement of the same size as that used in the pile to the projecting reinforcing steel. Form the extension to prevent leakage along the pile.

Immediately before placing concrete, wet the top of the pile thoroughly and cover with a thin coating of neat cement, re-tempered mortar, or other suitable bonding material. Place concrete of the same mix design and quality as that used in the pile. Keep forms in place for not less than 7 days after the concrete has been placed. Cure and finish according to Section 551.

(ii) Pre-stressed Piles.

Extend pre-stressed precast piles according to (b) above. Include reinforcement bars in the pile head for splicing to the extension bars. Do not drive extended pre-stressed precast piles.

(iii) Timber Piles. Not used

554.10 - HEAVED PILES.

Check for pile heave during the driving operation. Take level readings immediately after each pile is driven and again after piles within a radius of 5 metres are driven. Re-drive all piles that heave more than 5mm. Re-drive to the specified resistance or penetration.

554.11 - PILE LOAD TESTS.

Pile load tests are required as specified in the contract.

(a) Dynamic load test

Use a qualified pile specialist consultant with at lest 3 years experience in dynamic load testing and analysis program (CAPWAP), and the wave equation analysis including the initial wave equation analysis including the initial wave equation analysis specified in Sub-Section 554.03(b). Submit a resume of the specialty consultant for approval.

Furnish a shelter to protect the dynamic test equipment from the elements. Locate the shelter within 15 metres of the test location. Provide a shelter with a minimum floor size of 6 square metres and minimum ceiling height of 2 metres. Maintain the inside temperature between 10°C and 35°C.

Furnish equipment and perform dynamic load tests according to ASTMD 4945 under the supervision of the Engineer.

Place the piles designated as dynamic load test piles in a horizontal position and not in contract with other piles. Drill holes for mounting instruments near the head of the pile. Mount the instruments and take wave speed measurements. Place the designated pile in the leads. Provide at least a 1.2 by 1.2 metre rigid platform with a 1.1metre safety rail that can be raised to the top of the pile.

Provide a suitable electrical power supply for the test equipment. If field generators are used as the power source, provide functioning metres for monitoring power voltage and frequency.

Drive the pile to the depth at which the dynamic test equipment indicates that the required ultimate pile capacity is achieved. If necessary to maintain stresses in the pile below the values in Sub-Section 554.03(b)(2), reduce the driving energy transmitted to the pile by using additional cushions or reducing the energy output of the hammer. If no axial driving is indicated, immediately realign the driving system.

At least 24 hours after the initial driving re-drive each dynamic load test pile with instrumentation attached. Warm the hammer before re-driving by applying at least 20 blows to another pile. Re-drive the dynamic load test pile for a maximum penetration of 150 millimetres, a maximum of 50 blows, or to practical driving refusal, whichever occurs first. Practical driving refusal is defined as 15 blows per 25 millimetres for steel piles, 8 blows per 25 millimetres for concrete piles and 5 blows per 25 millimetres for timber piles.

Verify the assumptions used in the initial wave equation analysis submitted according to Subsection 554.03(b) using CAPWAP. Analyse one blow from the original driving and one blow from the re-driving for each pile tested.

Perform additional wave equation analyses with adjustments based on the CAPWAP results. Provide a graph showing blow count versus ultimate capacity. For open-ended diesel hammers, provide a blow count versus stroke graph for the ultimate capacity. Provide the driving stresses, transferred energy, and pile capacity as a function of depth for each dynamic Laos test.

Based on the results of the dynamic load testing, CAPWAP analyses, and wave equation analyses, the order list a production driving criteria may be approved and the required cut-off elevations provided, or additional test piles and load testing may be specified. This information will be provided within 7 days after receipt of the order list and all required test data for the test piles driven.

(b) Static Load Test

Perform static load tests according to ASTMD 1143 using the quick load test method except as modified herein. Submit drawings of the proposed loading apparatus for acceptance according to the following:

i) Have a licensed professional Engineer prepare the drawings.

ii) Furnish a loading system capable of applying 150 percent of the ultimate pile capacity or 9000 kiloNewtons, whichever is less.

iii) Construct the apparatus to allow increments of load to be place gradually without causing vibration to the test pile.

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When tension (anchor) piles are required, drive tension piles at the location of permanent piles when feasible. Do not use timber or tapered piles installed in permanent locations as tension piles. Take the test to plunging failure or the capacity of the loading system, whichever occurs first.

The allowable axial pile load is defined as 50 percent of the failure load. The failure load is defined as follows:

* For piles 600 millimetres or less in diameter or diagonal width, the load that produces a settlement at failure of the pile head equal to:

$$S_f = S + (3.8\text{-}0.008D)$$

$$S_f = \frac{S + D}{30} \quad \text{where:}$$

S_f = Settlement at failure in millimetres
D = Pile diameter or diagonal width in millimetres
S = Elastic deformation of pile in millimetres

Determine top elevation of the test pile immediately after driving and again just before load testing to check for heave. Wait a minimum of 3 days between the driving of any anchor or load test piles and the commencement of the load test. Prior to testing, re-drive or jack to the original elevation and pile that heaves more than 6 millimetres.

After completion of the load testing remove/ cut off any test/anchor piling not a part of the finished structure at least 0.5 metre below either the bottom of footing or the finished ground elevation.

Based on the results of the static load testing, the order list and production driving criteria may be approved and the required cut-off elevations provided or additional load tests may be specified. Test results are to be provided within 7 days of receipt of complete with all required test data.

554.12 - PILE CUT-OFFS

Cut off the tops of all permanent piles and pile casings at the required elevation.

Cut off the piles clean and straight parallel to the bottom face of the structural member in which they are embedded. Dispose of cut-off lengths according to Subsection 203.05(a).

(a) Steel Piles.

Do not paint steel to be embedded in concrete. Before painting the expressed steel pile, thoroughly clean the metal surface of any substance that will inhibit paint adhesion. Use aluminium collared paint system 2 according to Section 563. Paint portions of completed trestle or other exposed piling to a point no less that 1 metre below finished ground line or waterline with one shop prime coat and 2 shop finish coats. Shop coats applied in the field shall be applied before driving the pile. Paint exposed piling above finished ground line or waterline with one field finish coat.

(b) Wood Piles. Not used

554.14- UNSATISFACTORY PILES

Correct unsatisfactory piles, by an approved method.

Methods of correcting unsatisfactory piles may include one or more of the following:

(a) Use of the pile at a reduced capacity.
(b) Install additional piles
(c) Repair damaged piles
(d) Replace damaged piles.

554.15- PLACING CONCRETE IN STEEL SHELL OR PIPE PILES.

After driving, clean the inside of shells and pipes by removing all loose material. Keep the shell or pipe substantially water tight. Provide suitable equipment for inspecting the entire inside surface of the driven shell or pipe just before placing concrete.

(a) Reinforcing steel.

When reinforcing steel is required, make the spacing between adjacent cage elements at least 5 times the maximum size of aggregate in the concrete.

(b) Wood Piles.

Tract the heads of all treated timber piles which are not embedded in concrete by one of the following methods.

(1) Reduce the moisture content of the wood to no more than 25 percent with no free moisture on the surface. Brush apply one application of creosote-coal tar solution, as required in AWAY Standards.

Build up a protective cap by applying alternate layers of loosely woven fabric and hot asphalt or tar similar to membrane waterproofing, using 3 layers of asphalt or tar and 2 layers of fabric. Use fabric at least 150 millimetres wider in each direction than the diameter of the pile. Turn the fabric down over the pile and secure the edges by binding with 2 turns of 3-millimetre minimum diameter galvanized wire. Apply a final layer of asphalt or tar to cove the wire. Neatly trim the fabric below the wires.

(2) Cover the sawed surface with 3 applications of a hot mixture of 60 percent creosote and 40 percent roofing pitch, or thoroughly brush coat with 3 applications of hot creosote and cover with hot roofing pitch. Place a covering of galvanized sheet metal over the coating and bend down over the sides of each pile.

554.18 - ACCEPTANCE

Pile material will be evaluated under these Specifications.

Furnish production certifications with each delivery of the following:

a) Concrete piles

b) Sheet piles, steel H-piles, steel shells, and steel pipes

Driving piles and related work will be executed under these Specifications.

Concrete for steel shells or pipe piles will be evaluated under Section 551.

Reinforcing steel for steel shells or pipe piles will be evaluated under Section 552.

554.18 - METHOD OF MEASUREMENT

Mobilization, is to also cover demobilization, and will be measured by the number of times piling equipment is moved a to and from a structure location. Movement between pile or pile cap locations will not be measured for payment.

Measure piles by the metre length from the cut-off elevation to the tip.

Measure pile load tests, and test piles by the number.

Splices shall not be measured separately.

554.19 - BASIS OF PAYMENT

The quantities will be paid for at the contract unit prices bid for the pay items listed below, which prices and payments shall be full compensation for furnishing all materials and doing all the work herein prescribed in a workmanlike and acceptable manner, including all labour, tools, equipment, supplies, and incidentals necessary to complete the work. The cost of drilling, concrete, grout, whalers, splices, shoes and painting shall be included in the price bid for the piles.

554.20 - PAY ITEMS

ITEM	DESCRIPTION	UNIT
	DRIVEN PILES	
554.001	Mobilization	Number
554.002	400mm x 400mm pre cast concrete piles	Metre
554.003	400mm x 400mm pre cast concrete test piles	Number
554.004	Pile load test	PS
554.005	350 x 350 precast concrete pile for piled embankment	Metre
554.006	Pile caps to piled embankment	Cubic metre
554.007	Working platform (UC1) around piles and pile caps	Cubic metre

554 A CAST IN –SITU PILES (BORED PILES)

554 A.1 Description

This work shall consist of construction of pile foundations for structures using driven or cast in-situ (bored) piles.
Cast in – situ (bored) piles shall be of reinforced concrete.
They shall be furnished and installed or constructed in- situ as applicable, in accordance with these Specifications, in conformity with the requirements given in the Drawings or elsewhere in the Contract documents or as instructed by the Engineer.

554 A.2 Materials

Materials used for the manufacture of piles shall conform to the following requirements, unless otherwise specified.

(a) Concrete

Concrete for pre-cast or cast in- situ concrete piles shall be as specified. Grades of concrete shall not be less than 30 and 40 for pre-cast reinforced concrete and pre-stressed concrete piles respectively.

(b) Reinforcing Steel

Reinforcing steel for concrete piles to section 552.

554 A.3 Construction requirements of cast in-situ piles (bored piles)

General

This work shall consist of drilling holes; furnishing. installing and removing temporary casing; furnishing and installing reinforcing steel cage; placing concrete; and all other things necessary for installing cast in place concrete bored piles in accordance with these Specifications and with the Drawings and the direction of the Engineer. Where required and as stated on the Drawings and or in the Contract documents, furnishing and installing permanent casing shall be included in this work.

The Contractor shall submit to the Engineer for approval, complete details of the construction methods, which he proposes to use, including a Specification of the materials, testing during construction and all equipment. Prior approval of the Engineer shall be obtained in writing before any piling work is commenced.

A complete record of the construction of each pile shall be kept by the Contractor and these records shall be submitted to the Engineer for inspection when required and shall be approved finally by the Engineer.

The Contractor shall fill the form of piling record being provided commonly by the Engineer, according to the Engineer's requirement. If the Engineer shall require the Contractor to draw up a form of piling record by him, the said form shall be approved by the Engineer.

(a) Boring

In stable soils a casing may be omitted during excavation if agreed by the Engineer. In soils liable to flow into the borehole, a temporary casing shall be used. The bottom of the casing shall be kept sufficiently below the bored depth to prevent inflow of soil and the subsequent formation of cavities in the surrounding ground. The casings shall be water-tight steel tubes, and the joints in the tubes shall be reasonably water-tight. The metal casing shall be of sufficient thickness and strength to hold its original form and show no harmful distortion after it and adjacent casings have been driven and the driving core, if any has been withdrawn. The inflow of soil and groundwater from the bottom may be controlled by the use of a head of water with the Engineer's approval. The water level inside the casing shall be maintained, a minimum 1.5m to 2.0m above the natural groundwater level. Alternatively, drilling mud, such as bentonite suspension may be used instead of the water. In this case the casing will only be required close to the top when concreting. The relevant Specifications for the drilling mud or slurry shall be as stated in table 554 a -1-and approved by the Engineer prior to its adoption.

Table 554 a -1- Requirements for Slurry Property Targets

Boring Method	Geological Formation	Slurry Property Targets						
		Relative Density	Viscosity (Secs.)	Static Shear (Pa)	Sand Content Rate(%)	Colloidal Rate (%)	Water Loss Rate (ml/30min)	P_H Value
Positively Circulating Boring Percussion Boring	Clayey Soil	1.05-1.20	16-20	1.0-2.5	<8-4	>90-95	<25	9.5-12
	Sandy Soil, Broken, Stone Soil, Pebble, Boulder	1.10-1.25	19-28	3-5	<8-4	>90-95	<15	9.5-12
Rolling-Push Boring Percussion Grab Boring	Clayey Soil	1.10-1.20	18-24	1.0-2.5	<4	>95	<30	9.5-12
	Sandy Soil, Broken, Stone Soil	1.10-1.25	22-30	3-5	<4	>95	<20	9.5-12
Reversibly Circulating Boring	Clay Soil	1.02-1.06	16-20	1.0-2.5	<4	>95	<20	9.5-12
	Sandy Soil	1.06-1.10	19-28	1.0-2.5	<4	>95		
	Broken, Stone Soil	1.10-1.15	20-35	1.0-2.25	<4	<95		
Test Method	Not Applicable	Mud density balance	Marsh Cone	Shearo Meter	Sand Screen Set		Fluid loss test	P_{11} indicator paper strips

The frequency of testing the slurry at the very least shall be carried out at the time of mixing the slurry, prior to commencing the daily boring operations and fresh pile bore, during boring, depending on the depth of bore more than once during boring, on completion of boring/ clearing, prior to rebar cage installation, prior to placing concrete and at another fresh pile bare. The slurry samples during boring shall be taken from the pile toe.

Bells or under reams where specified shall be excavated from virgin material and be free from loose crumbs of soil.

The excavation of the bell or under reams shall be carried out immediately prior to concreting. When construction of enlarged Bases involves men going down holes the safety precautions shall be as specified in Contract documents.

Maximum tolerance in positioning the head of the pile shall be100mm. Maximum variation of shaft from vertical shall be 1 in 75.

Unless otherwise stated on the Drawings or specified in the Contract, piles shall be socketed to a minimum of 500mm into hard bed rock surface if the bed rock is not very steep. Where the rock is steeply sloping, the rock rocket shall be of such a length that the entire Cross-section for the pile is end bearing on hard rock unless otherwise stated on the Drawings or in the Contract.

(b) Cleaning of bore holes

(i) When the boreholes have reached the depth specified on the Drawings, and the quality of the boreholes has met the requirements specified on the Drawings or requirements of the Engineer, cleaning of boreholes shall be carried out promptly. During the cleaning operation, the water level in the bored shaft shall remain 1.5m to 2m above the groundwater table or the water level of river to prevent any falling-in of the borehole.

(ii) The pile toe shall be free of sediment, unless the Drawings show that the piles are fully frictional in which case sediment depth shall not exceed 100mm. For all other piles, the Contractor in his method - statement shall include a method of measuring the sedimentation. The depth of the sediment so established shall be such that it is displaced during the placing of concrete. This depth shall not exceed 40mm in any event.

(iii) Bentonite slurry after cleaning of boreholes shall have the following properties: relative density = 1.05 to 1.2 (as per test method of Founn Viscometer with the sample screened by 0.300 µm sieve); viscosity = 17 to 20; PH 9.5-12; sand content <4%.

(c) Reinforcement Cage

The cage of all pile reinforcing steel shall be placed in the excavation in one unit immediately prior to concrete placement. If concrete placement does not follow immediately after cage placement, the steel shal1 be removed from the excavation. Then the integrity of the boring, including the presence of loose material in the bottom of the hole, shall be checked and remedial action taken prior to reinstallation of the cage. The cage of reinforcing steel shall have stiff bracing to prevent distortion during moving and positioning. The reinforcement cage shall be supported from the top by a support system as stated below, so as to prevent the cage from lifting up. The support system shall be concentric to prevent bending and displacement of the cage, with the cage equipped with concrete spacer blocks (provided for keeping a clearance between reinforcement cage and the sides of the boring). These spacers shall be securely tied at equal distances and distributed around the cage perimeter and shall be spaced at intervals not to exceed twice the pile diameter along the length of the pile unless otherwise shown on the Drawings or as directed by the Engineer. The cage bottom shall have an elevation of 300mm with tolerances of 50mm.

(d) Concreting

(i) Before placing concrete, the thickness of sediment shall be inspected. If it does not conform to the requirements of clearing of boreholes and specified in Sub section 2.06 the bored shaft shall be re-cleaned.

(ii) When concrete mix is supplied to the placing site, uniformity and slump of concrete shall be checked.

(iii) Concrete placing shall commence immediately after Engineer's approval of the bore shaft and bottom, installation of the reinforcement cage and setting up the tremie/hopper. Concrete placing shall continue without interruption to complete the cast in –situ piles.

(iv) Concrete shall be placed by means of suitable tubes or tremie and hopper arrangement. The tremie shall consist of a tube having a diameter of not less than 205mm, constructed in sections having flanged coupling fitted with gaskets or screw joints. The tremies shall be tested to be water tight and joint strength in tension. At the commencement of concreting, the bottom of the tremie shall be placed between 50-100mm from the bottom of the borehole. The quantity of first lot concrete shall be such that it is sufficient to meet the requirement of initially submerged depth (>1.0m) for the tremie and the requirement for filling tremie bottom voids. A float/ plug shall be placed in the tremie over the support fluid or water. Concrete shall be discharged slowly onto the plug causing it to move very slowly to the bottom and fill the tremie length. The lower outlet of tremie shall at all times be kept submerged 2m in concrete to prevent water and grout from surging into the tube but not greater then 6m in previously deposited concrete. The location of outlet of the tremie tube relative to the surface of deposited concrete shall be kept under close surveillance at all times, and the tube shall be filed in such a way that no water is trapped in the tube. If the concrete is pumped, the pumping pipe shall be equipped with a bottom valve' or other device to prevent mixing of water with the concrete in the pipe. The pumping pipe shall be withdrawn slowly as the concrete in the piles rises, but the end shall, at all times, be a minimum of 2 meters below the surface of the concrete. Concrete, delivery to the pile shall proceed in one continuous operation. Prior to initial set, any contaminated concrete shall be cleaned from the top of the pile at the pile cut off level. Records shall be maintained of the full concrete placing. Such records shall include volume of each batch of concrete, times of arrival of concrete trucks and concrete discharge, slump test measurements, depth soundings to top of concrete in the bore and tremie for each batch of concrete placed. The recorded data shall be such that it is sufficient to be able to develop an accurate assessment of bore size for each batch of concrete placed.

(v) On depositing concrete, the overflowing slurry shall be led to a suitable place to be treated to check the ground pollution, river channel and traffic blocking.

(vi) The temporary casing below the ground surface or the pile top shall be withdrawn immediately after concrete placing subject to maintaining a 1.5m-2.0m difference between the support fluid / water within the pile bore and the ground water level / river water level. The removable casing part over ground surface can only be removed after the newly placed concrete reaches 5 MPa in compressive strength. When concrete is placed with the casing throughout the whole pile length, the removal of casing shall be carried out by successively withdrawing it, with the casing bottom remaining 1 m to 2m below the surface of newly deposited concrete.

(vii) The Contractor shall continue concreting until the surface of deposited concrete shall have a proper height above the theoretical cut-off level to ensure that all concrete below cut-off level is of a satisfactory quality. Such heights shall be l.4m minimum and up to 2.2m when pile cut-off level is up to 10m below ground level.

(viii) If the process of concreting deviates from the correct procedure, it shall be remedied in time, as directed by the Engineer.

When concrete can be placed in a dry excavation, it shall be discharged through a funnel with a length of tube so that the flow is directed and does not hit reinforcement bars or the side of the hole. No vibration is required but attention shall be paid to the compaction of the top1.5m or so of the pile. Where temporary casing is used the casing shall not be withdrawn before a sufficient head of concrete has been cast which can balance the groundwater pressure outside.

When concreting is carried out under water or in drilling mud, an efficient tremie technique shall be used. The pile shall be concreted wholly by trermie and the method of disposition shall not be changed as the pile is concreted.

The head of the pile shall be cut clean of all laitance.

Care shall be taken during concreting to prevent as far as possible the segregation of the ingredients. The displacement or distortion of reinforcement during concreting and also while extracting the tube shall be avoided.

The concrete shall be properly graded, shall be self-compacting and shall not get mixed with soil, excess water or other extraneous matter. Special care shall be taken in silty clays and other soils with the tendency to squeeze into the newly deposited concrete and cause necking. The placing of concrete shall be a continuous process from the toe level to the top of the pile. The rate of placing of concrete in the pile shaft shall be sufficient to ensure self compaction. Also for bored holes, the finishing of the bore, cleaning of the bore, lowering of the reinforcement cage and concreting of the pile for full height shall be accomplished in one continuous operation without any stoppage.

Bored cast in-situ piles in soils which are stable, may often be installed with only a small casing length at the top. A minimum of 2.0 m length of top of bore shall invariable be provided with casing to ensure against loose soil falling into the bore. In cases, where the bored hole penetrates through large depths of peaty or any collapsible soil the length of this steel casing shall be of sufficient length to ensure against side collapse. The casing may be left in position permanently especially in cases where the aggressive action of the ground water is to be avoided or in the cases of piles built in water or in cases where significant length of piles could be exposed due to scour.

(e) Testing of cast in-situ piles

(i) Where required in the Contract or as the Engineer directs, load tests shall be undertaken by the Contractor on the selected piles and the method of testing shall be approved by the Engineer. The test load shall be twice or one and a half times the working load on any pile depending on the type and purpose of the test unless otherwise specified. Where piles fail to satisfy the test the Contractor shall take remedial measures in accordance with the Contract or as directed by the Engineer.

(ii) Where required by the Contract or as directed by the Engineer, the Contractor shall undertake Pile Integrity Testing for the piles by way of employing a specialist. Details of the specialist including qualifications, past experience etc. shall be submitted for approval' by the Engineer prior to undertaking the test.

554 A.4 Pile Records

A detailed and accurate record of bore pile construction of all piles shall be kept by the Contractor and a. copy of the record of the work done each day shall be given to the Engineer within 24 hours, which shall include the details such as, details of piles equipment, particulars of level of the ground at the commencement of operations, details of any circumstances previously notified to the Engineer or occurring during boring and any other information required by the Engineer.

In the case of cast in-situ piles the following also to be recorded. The nominal diameter, length of finished pile excluding any enlarged Base, time interval between boring or driving and concreting of any pile not completed in the working day, volume of concrete placed in the pile and - enlarged Base, diameter of any under-ream, detail is of strata penetrated.

In addition to submitting the records the Contractor shall report immediately to the Engineer any circumstances which indicate that the ground conditions differ from those expected from the interpretation of the soil survey.

554 A.4/1 Tests & Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

554 A.5 Measurement and Payment

(a) Measurement

Cast in-situ piles shall be measured in metres from tip to cut-off.

Cut-off lengths shall not be measured for payment. Load tests shall be measured by number completed.

(b) Payment

The payment for the installing of cast in -situ piles, will be at the Contract unit rate for the particular item. The cast in-situ rate shall include, as applicable, full compensation for supplying and placing of all materials including reinforcement, for driving of casings and socketing of cast in - situ piles, for carrying out integrity testing of cast in – situ piles; for providing rigs, cranes, etc., for boring; and for providing all labour transport, machinery, equipment, tools and other incidentals necessary to complete the work to these Specifications.

The rate shall also include full compensation for driving of casings for cast in-situ piles. The pay items and pay units will be as follows.

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Pay Items and Pay Units shall be as follows;

PAY ITEM	DESCRIPTION	PAY UNIT
554A.001	Bored Piles 1800mm Dia	Meter
554A.002	Bored Piles 1500mm Dia	Meter
554A.003	Bored Piles 1200mm Dia	Meter
	Static Load Testing of Piles	
554A.004	Load Testing of 1800mm dia Bored piles to a load of 2200 tonnes	Number
554A.005	Load Testing of 1500mm dia Bored piles to a load of 2200 tonnes	Number
554A.006	Load Testing of 1200mm dia Bored piles to a load of 1050 tonnes	Number
	Pile Dynamic Analysis Tests	
554A.007	Load Testing of 1200mm dia Bored piles	Number
554A.008	Load Testing of 1500mm dia Bored piles	Number
554A.009	Load Testing of 1800mm dia Bored piles	Number

SECTION 555
BEARING DEVICES

555.1 - DESCRIPTION

This work consists of furnishing and installing bridge bearing. Bearing devices are designated as elastomeric, rocker, roller, and sliding plate.

555.2 - MATERIAL

Confirm to the following Sub-Sections:

Elastomeric bearing pads	715.14
Tetrafluoroethylene (TFE) surfaces for bearings	715.11

CONSTRUCTION REQUIREMENTS

555.3 - GENERAL

(a) Drawings.

Prepare and submit drawings for the bearings according to Sub-Section 104.03 and Section 18 of the AASHTO Standard Specifications for Highway Bridges Division II, Volume II. Show all details of the bearing including the material proposed for use. Obtain approval before beginning fabrication

(b) Fabrication.

Fabricate bearings according to Section 18 of the AASHTO Standard Specifications for Highway Bridges Division II, Volume II. The surface finish of bearing components in contact with each other or with concrete, but not embedded in concrete, shall conform to Sub-Section 555.8(e).

Pre-assemble bearing assemblies in the shop and check for proper completeness and geometry. Galvanize steel bearing components and anchor bolts according to Subsection 717.07. Do not galvanize stainless steel bearing components or anchor bolts.

(c) Packaging, Handling, and Storage.

Before shipping from the manufacturer, clearly identify each bearing component and mark on its top the location and orientation in the structure. Securely bolt, strap, or otherwise fasten the bearings to prevent any relative movement.

Package bearings so they are protected from damage due to shipping, handling, weather, or other hazards. Do not dismantle bearing assemblies at the sit except for inspection or installation.

Store all bearing devices and components at the work site in a location that provides protection from environmental and physical damage.

(d) Construction and Installation.

Clean the bearings of all deleterious substances. Install the bearings to the positions shown on the drawings. Set bearings and bearing components to the dimensions shown on the drawings or

as prescribe by the manufacturer. Adjust according to the manufacturer's instructions to compensate for installation temperature and future movements of the bridge.

Set bridge bearings level at elevation and position within the following tolerances:

Elevation +/- 1mm,

Position +/- 2 mm

Provide full and even bearing on all external bearing contact surfaces. If bearing surfaces are at improper elevation, not level, or if bearings cannot other wise be set properly, The Contractor shall submit a written proposal to modify the installation for the Engineer's approval.

Bed metallic bearing assemblies (not embedded in concrete),on concrete with an approved filler or fabric material.

Set electrometric bearing pads directly on properly prepared concrete surfaces without bedding material.

Machine bearing surfaces seated directly on steel to provide a level and planar surface upon which to place the bearing.

555.4 - ELASTOMERIC BEARINGS

The bearings include no reinforced pads (consisting of elastomer only) and reinforced bearings with steel or fabric laminates.

Reinforce elastomeric bearings more than 15 millimetres thick with laminates every 15 millimetres through the entire thickness.

If not specified, use 50-durometer elastomer capable of sustaining an average compressive stress of 7 megaPascals.

Fabricate elastomeric bearings according to AASHTO M 251. Determine compliance with AASHTO M 251, level I acceptance criteria.

Mark each reinforced bearing with indelible ink or flexible paint. The marking information shall include the order number, area number, bearing identification number, and elastomer type and grade number. Unless otherwise specified, mark on a face that is visible after erection of the bridge, Furnish a list of all individual bearing numbers.

Place bearings on a level surface. Concrete any misalignment in the support to form a level surface. Do not weld steel girders or base plates to the exterior plates of the bearing unless there is more than 40 millimetres of steel between the weld and elastomer. Do not expose the elastomer of elastomer bond to instantaneous temperatures greater than 200°C.

555.5 - ROCKER, ROLLER, AND SLIDING BEARINGS

When TFE coatings are required, use coatings conforming to Sub-Section 555.7.
Fabricate rocker, roller, and sliding bearings according to the details shown ton the Drawings and to Section 555. Perform fabrication according to the standard practice in modern commercial shops Remove burrs, rough and sharp edges, and other flaws. Stress relieve rocker, roller, and

other bearings that are built up by welding sections of plate together before boring, straightening or finished marching.

Thoroughly coat all contact surfaces with oil and graphite just before placing roller bearings. Install rocker, roller, and sliding bearings so they are vertical at the specified mean temperature after release of falsework and after any shortening due to pre-stressing forces. Take into account any Variation from mean temperature of the supported span at time of installation and any other anticipated changes in length of the supported span.

Make sure the superstructure has full and free movement at movable bearings. Carefully position cylindrical bearings so that their axes of rotation align and coincide with the axis of rotation of the superstructure.

555.6 - MASONRY, SOLE, AND SHIM PLATES FOR BEARINGS

Provide metal plates use in masonry, sole, and shim plates, conforming to AASHTO M 270M grade 250.

Fabricate and finish steel according to Section 555. Form holes in bearing plates by drilling, punching, or accurately controlled oxygen cutting. Remove all burrs by grinding

Accurately set bearing plates in level position as shown on the drawings and provide a uniform bearing over the bearing contact area. When plates are embedded in concrete, make provision to keep them in correct position, as the concrete is place.

555.7 - TETRAFLUOROETHYLENE (TFE) SURFACES FOR BEARINGS.

Furnish TFE material that is factory-bonded, mechanically connected, or recessed into the backup material as shown on the Drawings.

Bond or mechanically attach the fabric containing TFE fibres to a rigid substrate. Use a fabric capable of carrying unit loads of 70 megaPascals without cold flow. Use a fabric-substrate bond capable of withstanding, without delimitation, a shear force equal to 10 percent of the perpendicular or normal application loading plus any other bearing shear forces.

Determine compliance using approved test methods and procedures according to Section 18, Subsection 18.8.3, AASHTO *Standard Specifications for Highway Bridges* Division II, Volume II. If the test facility does not permit testing completed bearings, manufacture extra bearing and prepare samples of at least 450-kilonewton capacities at normal working stresses.

Determine static and dynamic coefficient of friction at first movement of the test bearing at a sliding speed of less than 25 millimetres per minute. The coefficient of friction shall not exceed the coefficient of friction as specified in Table 564-1 or by the manufacturer.

Furnish a listing of all individual bearing numbers.

TABLE 555-1

COEFFICIENT OF FRICTION

Material	Bearing Pressure (MegaPascals)	Friction Coefficient
Unfilled TFE, fabric containing TFE fibres, or TFE-perforated metal composite	3.5	0.08
	14	0.06
	24	0.04
Filled TFE	3.5	0.12
	14	0.10
	24	0.08
Interlocked bronze and filled TFE structures	3.5	0.10
	14	0.07
	24	0.05

555.8 - ANCHOR BOLTS.

Furnish wedge or thread anchor bolts conforming to ASTM A 307 or as shown on the Drawings or specified in the contract.

Drill holes for anchor bolts and set them in Portland cement non-shrink grout or preset them before placing the concrete.

Adjust bolt locations for superstructure temperature as required. Do not restrict free movement of the superstructure at movable bearings by anchor bolts or nuts.

555.9 - BEDDING OF MASONRY PLATES

Place filler or fabric as bedding material under masonry plates if required by the contract. Use the type of filler or fabric specified and install to provide full bearing on contract areas. Thoroughly clean the contact surfaces of the concrete and steel immediately before placing the bedding material and installing Bearings or masonry plates.

555.10 - ACCEPTANCE

Bearing devices will be evaluated under these Specifications.

555.11 - METHOD OF MEASUREMENT

Measurement will be by the number of bearings placed to the satisfaction of the Engineer.

555.12 - BASIS OF PAYMENT

The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement, for the pay item listed below.

555.13 - PAY ITEMS

ITEM	DESCRIPTION	UNIT
555.001	Elastomeric bearing pads	Number
555.002	Pot Bearing for Post tensioned Box Girder	Number
555.003	Hard Rubber Bearing Pad supplied and laid over capping beam and peirs as per the drawings	Number

SECTION 556
FALSEWORK

556.1 - DESCRIPTION

This work consists of designing, constructing, and removing forms and falsework to temporarily support concrete, girders, and other structural elements until the structure is completed to the point it can support itself.

556.2 - DESIGN AND CONSTRUCTION REQUIREMENTS

556.2.1 - Drawings

The Contractor shall prepare and submit, detailed working drawings as follows;

(a) Design and show the details for constructing safe and adequate forms and falsework that provide the necessary rigidity, support the loads imposed, and produce in the finished structure the required lines and grades. See Sub-Section 556.2.2 for design loads and Sub-Section 556.2.3 for allowable design stresses, loadings, and deflections.

(b) Show the maximum applied structural load on the foundation material. Include a drainage Drawing or description of how the foundations will be protected from saturation, erosion, and / or scour.

(c) Precisely describe all proposed material. Describe the material that is not readily describable by standard nomenclature (such as AASHTO, ASTM, BS, DIN specifications) based on manufacturer's tests and working loads. Evaluate falsework material and ascertain whether the physical properties and conditions of the material are such that it can support the loads assumed in the design.

(d) Furnish design calculations and material specifications showing the proposed system will support the imposed concrete pressures and other loads. Provide an outline of the proposed concrete placement operation listing the equipment, labour, and procedures to be used for the duration of each operation. Include the proposed placement rates and concrete pressures for each pour. Include a superstructure-placing diagram showing the concrete placing sequence and construction joint locations. The falsework design calculations shall show the stresses and deflections in load supporting members.

(e) Provide design calculations for proposed bridge falsework. An engineer, registered to practice structural engineering in Sri Lanka and proficient in formwork design, shall design and sign the drawings.

(f) Show anticipated total settlements of falsework and forms. Include falsework footing settlement and joint take-up. Design for anticipated settlements not to exceed 25mm. Design and detail falsework supporting deck slabs and overhangs on girder bridges so there is no differential settlement between the girders and deck forms during placement of deck concrete. Design and construct the falsework to elevations that include anticipated settlement during concrete placement and required camber to compensate for member deflections during construction.

(g) Show the support systems for form panels supporting concrete deck slabs and overhangs on girder bridges.

(h) Show details for strengthening and protecting falsework over or adjacent to roadways and / or railroads during each stage of erection and removal. See Subsection 556.7.

(i) Submit details of proposed anchorage and ties for void forms. See Subsection 556.10 for void form requirements.

Submit separate falsework drawings for each structure, except for identical structures with identical falsework design and details. Do not start construction of any unit of falsework until the drawings for that unit are reviewed and accepted.

556.2.2 - Design Loads

(a) Vertical design loads.

Dead loads include the mass of concrete, reinforcing steel, forms, and falsework. Consider the entire superstructure, or any concrete mass being supported by falsework to be a fluid dead load with no ability to support itself. If the concrete is to be pre-stressed, design the falsework to support any increased or adjusted loads caused by the pre-stressing forces.

Assume the density of the concrete, reinforcing steel, and forms to be not less than 2,600 kilograms per cubic metre for normal concrete and not less than 2,100 kilograms per cubic metre for lightweight concrete.

Consider live loads to be the actual mass of equipment to be supported by the falsework applied as concentrated loads at the point of contact, plus a uniform load of not less than 1,000 Pascals applied over the area supported, plus 1,100 Newtons per metre (N/m) applied at the outside edge of the deck formwork overhangs.

The total vertical load for falsework is the sum of the vertical dead and live loads. Use a total vertical design load of not less than 4,800 Pascals.

(b) Horizontal Design Loads.

Use an assumed horizontal design load on false work towers, bents, frames, and other false work structures to verify lateral stability. The assumed horizontal load is the sum of the actual horizontal loads due to equipment, construction sequencing, or other causes, and an allowance for wind. However, in no case is the assumed horizontal load to be less than 2 percent of the total supported dead load at the location under consideration.

The minimum wind allowance for each heavy-duty steel shoring having a vertical load carrying capacity exceeding 130 kiloNewtons per leg is the sum of the products of the wind impact area, shape factor, and the applicable wind pressure value for each height zone. The wind impact area is the total projected area of all the elements in the tower face normal to the applied wind. Assume the shape factor for heavy-duty shoring to be 2.2. Determine wind pressure value from Table 556-1.

The minimum wind allowance on all other types of falsework, including falsework supported on heavy-duty shoring, is the sum for the products of the wind impact area and the applicable wind pressure value for each bight zone. The wind impact area is the gross projected area of the false

work and unrestrained portion of the permanent structure, excluding the areas between false work posts or towers where diagonal bracing is not used. Use Design wind pressures from Table 556-2.
In all cases the Contractor is responsible for ensuring that formwork is capable for withstanding wind load conditions Prevailing locally at time of construction in Sri Lanka.

Design the false work so it has sufficient rigidity to resist the assumed horizontal load without vertical dead load. Neglect the effects of frictional resistance.

TABLE 556-1

DESIGN WIND PRESSURE – HEAVY DUTY STEEL SHORING

Height Zone Above Ground (metre)	Wind Pressure Value – Pa	
	Adjacent To Traffic	At Other Locations
0	960	720
9-15	1200	960
15-30	1450	1200
Over 30	1675	1450

TABLE 556-2

DESIGN WIND PRESSURE – OTHER TYPES OF FALSE WORK

Height Zone Above Ground (metre)	Wind pressure Value – Pa	
	For Members Over and Bents Adjacent To Traffic Openings	At Other Locations
0	320Q	240Q
9-15	400Q	320Q
15-30	480Q	400Q
Over 30	560Q	480Q

Note: Q = 0.3 + 0.2W, but not more than 3. W is the width of the false work system in metres measured in the direction f the wind force being considered.

(c) Lateral fluid pressure.

For concrete with retarding admixture, fly ash, or other pozzolan replacement for cement, design forms, from ties, and bracing for a lateral fluid pressure based on concrete with a density of 2400 kilograms per cubic metre. For concrete containing no pozzolan or admixtures, which affect the time to initial set, determine the lateral fluid pressure based on concrete temperature and rate of placement according to ACI standard 347R, *Guide for Formwork for Concrete.*

556.4 - DESIGN STRESSES, LOADS, AND DEFLECTIONS

The allowable maximum design stresses and loads listed in this section are based on the use of undamaged, high quality material.

If lesser quality material is used, reduce the allowable stresses and loads. Do not exceed the following maximum stresses, loads, and deflections in the false work design:

(a) Timber

Compression perpendicular to the grain = 3100 kilopascals

Compression parallel to the grain (1) = $\frac{3309}{(L/d)^2}$ megaPascals

Note: (1) Not to exceed 11 megaPascals.

Where:
L = Unsupported length
D = Least dimension of a square or rectangular column or the width of a square of equivalent cross-sectional area for round columns

Flexural stress = 12.4 megaPascals

Note : Reduced to 10 megaPascals for members with a nominal depth of 200mm or less.

Horizontal shear = 1300 kilopascals

Axial tension = 8.3 megaPascals

Deflection due to the mass of concrete may not exceed 1/500 of the span even if camber strips compensate for the deflection.

Modulus of elasticity (E) for timber = 11.7 megaPascals

Maximum axial loading on timber piles = 400 kiloNewtons

Design timber connections according to the stresses and loads allowed in the *National Design Specification for Wood Construction*, as published by the National Forest Products Association except:

(1) Reductions in allowable loads required therein for high moisture condition of the lumber and service conditions do not apply.

(2) Use 75 percent of the tabulated design value as the design value of bolts in two members connections (single shear).

(b) Steel.

For identified grades of steel, do not exceed the design stresses (other than stresses due to flexural compression) specified in the Manual of Steel Construction as published by the AISC.

When the grade of steel cannot be positively identified, do not exceed the design stresses, other than stresses due to flexural compression, either specified in the AISC Manual for ASTM A 36M steel or the following:

Tension, axial and flexural = 150 megaPascals

Compression, axial = 110 000 – 2.6(L/r)2 kilopascals

Note: L/r shall not exceed 120.

Shear on the web roses section of rolled shapes = 100 megaPascals

Web crippling for rolled shapes = 185 megaPascals

For all grades of steel, do not exceed the following design stresses and deflection:

Compression, flexural (1) = $\frac{82\,750}{Ld/bt}$ megaPascals

Note: (1) Not to exceed 150 megaPascals for unidentified steel or steel conforming to ASTM A 36. Not to exceed 0.6 F_y for other identified steel.

Where:
L = Unsupported length
D = Least dimension of a square or rectangular column or the width of a square of equivalent cross-sectional area for round columns or the depth of beams.
B = Width of the compression flange
T = Thickness of the compression Lange
R = Radius of gyration of the member.
Fy = Specified minimum yield stress for the grade of steel used.

Deflection due to the mass of concrete may not exceed 1/500 of the span even if camber strips compensate for the deflection.

Modulus of elasticity (E) for steel = 210 megaPascals

(c) Other requirements.

Limit falsework spans supporting T-beam girder bridges to 4.3 metres plus 8.5 times the overall depth of T-beam girder.

556.5 - MANUFACTURED ASSEMBLIES

For jacks, brackets, columns, joists and other manufactured devices, do not exceed the manufacturer's recommendations or 40 percent of the ultimate load carrying capacity of the

assembly based on the manufacturer's tests or additional tests ordered. Limit maximum allowable dead load deflection of joists to 1/500 of their spans.

Furnish catalogue of equivalent data showing the manufacturer's recommendations or perform tests, as necessary, to demonstrate the adequacy of any manufactured device proposed for use. Do not substitute other manufacturer's components unless the manufacturer's data encompasses such substitutions or field tests reaffirmed the integrity of the system.

If a component of the false work system consists of a steel frame tower exceeding 2 or more tiers high, the differential leg loading within the steel tower unit shall not exceed 4 to 1. An exception may be approved if the manufacturer of the steel frame certifies, based on manufacturer's tests, that the proposed differential loadings are not detrimental to the safe load carrying capacity of the steel frame.

556.6 - FALSEWORK FOUNDATIONS

Field verify all ground elevations at proposed foundation locations before design.

Where spread footing type foundations are used, determine the bearing capacity of the soil. The maximum allowable bearing capacity for foundation material, other than rock, is 190 kilopascals.

Do not locate the edge of footings closer than 300mm from the intersection of the bench and the top of the slope. Unless shoring adequately supports the excavation for footings, do not locate the edge of the footings closer than 1.2 metres or the depth of excavation whichever is greater, from the edge of the excavation.

When a pile-type foundation is used, use according to Section 551. When falsework is supported by footings placed on paved, well-compacted slopes of berm fills, do not strut the falsework to columns unless the columns is founded on rock or supported by pilling.

Size spread footing to support the footing design load at the assumed nearing capacity of the soil without exceeding anticipated settlements. Provide steel reinforcement in concrete footings.

When individual steel towers have maximum leg loads exceeding 130 kiloNewtons, provide for uniform settlement under all legs or each tower under all loading conditions.

Protect the foundation from adverse effects for the duration of its use. Advise the Engineer of action that will be taken to protect the foundation.

556.7 - FALSEWORK OVER OR ADJACENT TO ROADWAYS AND RAILROADS

Design and construct the falsework to be protected from vehicle impact. This includes falsework posts that support members crossing over a roadway or railroad and other falsework posts if they are located in the row of falsework posts nearest to the roadway or railroad and if the horizontal distance from the traffic side of the falsework to the edge of pavement or to a point 3 metres from the centreline of track is less than the total height of the falsework.

Provide additional features to ensure that this falsework will remain stable if subjected to impact by vehicles. Use vertical design loads for these falsework posts, columns, and tower (but not footings) that are greater than or equal to either of the following:

(a) 150 percent of the design load calculated according to Subsection 556.3, but not including any increased or readjusted loads caused by pre-stressing forces.

(b) the increased or adjusted loads caused by pre-stressing forces.

Install temporary traffic barriers before erecting falsework towers or columns adjacent to an open public roadway. Locate barriers so that falsework footing or pile caps are at least 75mm clear of concrete traffic barriers and all other falsework members are at least 300mm clear. Do not remove barriers until approved.
Use falsework columns that ate steel with a minimum section modulus about each axis of 156 000 cubic millimetres or sound timber with a minimum section modulus about each axis of 4 100 000 cubic millimetres.

Mechanically connect the base of each of column or tower frame supporting falsework over or immediately adjacent to an open public road to its supporting footing or provide other lateral restrain to withstand a force of not less than 9 kiloNewtons applied to the base of the column in any direction. Mechanically connect such columns or frame to the falsework cap or stringer to resist a horizontal force of not less than 4.5 kiloNewtons in any direction. Neglect the effect of frictional resistance.

Brace or tie exterior girders upon which overhanging bridge deck falsework brackets are hung, to the adjacent interior girders as necessary to prevent rotation of exterior girders or overstressing the exterior girder web.

Mechanically connect all exterior falsework stringers and stringers adjacent to the end of discontinuous caps, the stringer or stringers over point of minimum vertical clearance and every fifth remaining stringer, to the falsework cap or framing. Provide mechanical connections capable of resting a load in any direction, including uplift on the stringer, of not less than 2.2 kiloNewtons. Install connections before traffic is allowed to pass beneath the span.

Use 16 millimetres diameter or larger bolts to connect timber members used to brace falsework bents located adjacent to roadways or railroads.

Provide at least the minimum required vertical and horizontal clearances through falsework for roadways, railroads, pedestrians, and boats.

556.8 - FALSEWORK FOR STEEL STRUCTURES

(a) Use falsework design loads consisting of the mass of structural steel, the load of supported erection equipment, and all other loads supported by the falsework.

(b) Design falsework and forms for concrete supported on steel structures so that loads are applied to girder webs within 150 millimetres of a flange or stiffener. Distribute the loads in a manner that does not produce local distortion of the web. Do not use deck overhang forms that require holes to be drilled in to the girder webs.

(c) Strut and tie exterior girders supporting overhanging deck falsework brackets to adjacent interior girders to prevent distortion and overstressing of the exterior girder web.

(d) Do not apply loads to existing, new, or partially completed structures that exceed the load carrying capacity of any part of the structures according to the load factor design methods of the AASHTO Bridge Design Specifications using load group IB.

(e) Build supporting falsework that will accommodate the proposed method of erection without overstressing the structural steel, as required, and with produce the required final structural geometry, intended continuity, and structural action.

556.9 - FALSEWORK CONSTRUCTION

Construct falsework to conform to the accepted drawings.

When welding is required, submit a welder certification for each welder according to Subsection 555.18.

Build camber into the falsework to compensate for falsework deflection and anticipated structure deflection. Camber shown on the Drawings or specified by the Engineers Representative is for anticipated structure deflection only.

Attach tell-tales to soffit of concrete forms in enough systematically placed locations to be able to determine from the ground the total settlement of the structure while concrete is placed.

Do not apply dead loads, other than forms and reinforcing steel, to any falsework until authorized.

Discontinue concrete placement and take corrective action, if unanticipated events occur, including settlements that cause a deviation of more then 10 millimetres from those shown on the falsework drawings. If satisfactory corrective action is not taken before initial set, remove all unacceptable concrete.

556.10 - FORMS FOR EXPOSED CONCRETE SURFACES – NOT USED

556.11 - REMOVAL OF FORMS AND FALSEWORK

Remove all forms except as follows.

(a) Interior soffit forms for roadway deck slabs of cast-in place box girders.

(b) Forms for the interior voids of precast members

(c) Forms for abutments or piers when no permanent access is available into the cells or voids

Forms that do not support the dead load of concrete members and forms for railings and barriers may be removed 24 hours after the concrete is placed. Protect exposed concrete surfaces from damage. Cure all exposed concrete surfaces according to Sub-Section 552.15, if forms are removed less than 7 days after concrete placement.

Falsework is not to be removed until the strength and time requirements of Table 556-3 are met.

Remove falsework for arch bridges uniformly and gradually. Begin at the crown and work toward the springing. Remove lacework for adjacent arch spans simultaneously.

Do not release falsework for cast- in- place pre-stressed portions of structures until after the pre-stressing steel had been tensioned.

Do not remove falsework supporting the deck of rigid frame structures, excluding box culverts, until backfill material is placed and compacted against the vertical legs of the frame.
Install a re-shoring system if falsework supporting the sides of girder stems with slopes steeper than 1:1 are removed before placing deck slab concrete. Design the re-shoring system with lateral supports, which resist all rotational forces acting on the stem, including those caused by the placement of deck slab concrete. Install the lateral supports immediately after each form panel is removed and before release of supports for the adjacent form panel.

TABLE 556.3

MINIMUM FORM/SUPPORT RELEASE CRITERIA

Structural Element	Percent of Specified 28-Day Strength (f'_c)	Minimum Number of Days Since Last Pour
(a) Columns and wall faces (not yet supporting loads)	50	3
(b) Mass piers and mass abutments (not yet supporting loads) except pier caps)	50	3
(c) Box girders	80	14
(d) Simple span girders, T-beam girders slab brides, cross beams, caps pier caps not continuously supported, struts, and top slabs of concrete box culverts.	80	14
(e) Trestle slabs where supported on wood stringers	70	10
(f) Slabs and overhangs where supported on steel stringers or pre-stressed concrete girders	70	10
(g) Pier caps continuously supported	60	7
(h) Arches, continuous span bridges, rigid frames	90	21

Remove all falsework material. Remove falsework piling to at least 0.5 metre below the surface of the original ground or original streambed. Where falsework piling is driven within the limits of ditch or channel excavation, remove the piling to at least 0.5 metre below the bottom and side slopes of the excavated areas.

Leave the forms for footings constructed within a cofferdam or crib in place when their removal would endanger the safety of the cofferdam or crib, and where the forms will not be exposed to view in the finished structure.
Remove all other forms whether above or below ground line or water level.

556.11- ACCEPTANCE

Forms and falsework (including design, construction, and removal) will be evaluated under these Specifications.

When the falsework installation is complete and before concrete placement or removal begins, have the falsework inspected by licensed professional engineer proficient in structural design.

Certify in writing that the installation conforms to the contract, the approved falsework drawings (including approved changes), and acceptable engineering practices. Provide a copy of the certification before concrete placement.

556.12 - METHOD OF MEASUREMENT

Falsework

Falsework shall not be measured separately but deemed to be included in unit rates of measured work.

556.13 - BASIS OF PAYMENT – NOT USED

556.14 - PAY ITEMS: - NOT USED

SECTION 557
PORTLAND CEMENT CONCRETE PAVEMENT

557.1 - DESCRIPTION

This work shall consist of a pavement composed of Portland Cement concrete, with or without reinforcement as shown on the Drawings, constructed on a prepared subgrade or base course in accordance with these Specifications and in reasonably close conformity with the lines, grades, thicknesses, and typical cross sections shown on the Drawings or established by the Engineer.

At the option of the Contractor, pavement shall be constructed with equipment utilizing fixed-forms or by the use of slip-form paving equipment. Pozzolanic materials (fly ash, ground granulated blast furnace slag and micro silica) conforming to the provisions of these specifications may be used as an additive to Portland Cement Concrete Pavement at the Contractor's option. These additives are not permitted when a blended hydraulic cement is used.

A water-reducing admixture may be used at the Contractor's option. A water-reducing admixture shall not be used in conjunction with a water reducing retarder.

557.2 - MATERIALS

Materials shall meet the requirements of Division 700, as follows:

Material	**Sub-Section**
Portland Cement	701.1, 701.3
Air Entraining Admixture	707.1
*Fine Aggregate	702.1
Coarse Aggregate	703.1-4
Performed Elastomeric Joint Seals; Lubricant-Adhesive	708.2
Preformed Expansion Joint Filler	708.1.1 (Type 1) 708.1.2
Low Modulus Silicone Joint Sealant; Back-Up Material	708.4
Pavement Reinforcement	709.4, 709.6
Coated Dowel Bars	709.15
Tie Bars	709.1
Joint Tie Bolt Assembly	709.7
Water	715.7
Water Reducer	707.3
Pozzolanic Additives	707.4
Curing Materials	707.6-707.10

* NOTE: The use of limestone will not be permitted.

Shipping and Storage of Cement: Cement shall be shipped from pre-tested and approved bins at the mill or other terminal locations. Cement stored by the Contractor for a period longer than 90 days shall be retested before being used in the work. Cement failing to meet any of the specified requirements at any time prior to incorporation into the work will be rejected and removed from the work. Cements of different types shall be stored separately.

Shipping and Storage of Pozzolanic Additives: Pozzolanic additives shall be shipped from only those sources approved by the Engineer. Bulk Pozzolanic additives shall be stored at the job site in weatherproof bins. Pozzolanic additives from different sources or from different areas at the same source shall be stored separately.

557.2.1 - Recycled Pavement for Use as Coarse Aggregate for Concrete

557.2.1.1 - The existing Portland cement concrete pavement may be removed and crushed, when called for on the Drawings. If asphaltic concrete resurfacing is present, the asphaltic concrete shall be removed before the Portland cement concrete is crushed.

557.2.1.2 - Any existing reinforcing steel encountered shall be removed from the existing pavement prior to or during the crushing operation and shall be disposed of by the Contractor.

557.2.1.3 - The Contractor shall remove the pavement in a manner, which excludes subgrade and base material to the maximum extent practical.

557.2.1.4 - The pavement material shall be crushed to pass the 37.5mm sieve. Processing equipment shall include a No. 4 (4.75 mm) screen and 557.3 excessive fines in the crushed material shall be controlled by removal of fines passing the No. 4 (4.75 mm) screen.

557.2.1.5 - The Contractor shall dispose of any excess material removed during processing.

CONSTRUCTION METHODS

557.3 - PROPORTIONING

Prior to the start of construction, the Contractor shall design and submit to the Engineer for approval the proportions of materials, including admixtures, to be used which will result in a workable concrete having the properties enumerated below, including those of Table 557.3.1. The mix design shall include a statement giving the source of materials and certified test data from a Engineer approved laboratory demonstrating the adequacy of the mix design. The Contractor shall notify the Engineer of any change in the source of materials or the addition of admixtures during the process of the work since such change may necessitate a new mix design. The Contractor shall also state the A value of the combined grading of the coarse aggregate, fine aggregate, and cement used in the mix design.

The combined grading of the coarse aggregate, fine aggregate, and cement used in the pavement concrete shall conform to the design mix A plus or minus the tolerance specified in the following table for the coarse aggregate size used:

Coarse Aggregate Size No.	Design Mix A Tolerance
357 or 467	±0.35
57 or 67	±0.25

A is the values of total solids (coarse aggregate, fine aggregate and cement).

The Engineer shall determine the grading of the total solids at least once each production day. Should the moving average of any five consecutive grading test results of the total solids have an A outside the specified mix design tolerance limits, production shall be discontinued until appropriate corrections are made. Corrections shall be made either in the proportions of the

concrete (the mix design), the gradation of the aggregates, or the storage and loading of the aggregate, as the Contractor may elect 557.3.1

TABLE 557.3.1

Minimum 28-Day Design Strength Mpa	Minimum Cement Factor kg per cubic metre	Maximum Water Content Litres per cubic metre of concrete	Standard Size of Coarse Aggregate Number
20.7 Compressive or 3.5 Flexural*	335 kg**	163.4, 357, 467	57 or 67

*NOTE: Flexural strength when tested by the third point method.
**NOTE: An equal volume of a Pozzolanic additive may be substituted for Portland cement up to the following maximum amount. Only one Pozzolanic additive is permitted in a mix design.

557.3.1- Material Quantity

Fly Ash: 1 bag
Ground Granulated Blast Furnace Slag: 3 bags
Micro silica: 1/2 bag

Control of the cement factor in pavement concrete should be by of verifying the minimum 28- day design strength, providing a copy of the data for verifying the strength is submitted to the Engineer. When minimum 28-day strength is used to control the cement factor in Portland cement concrete pavements, then column two in Table 557.3.1 will be considered to contain a target cement factor instead of a minimum cement factor.

The amount of entrained air in freshly mixed concrete shall be 7 percent plus or minus 2.5%.

Concrete shall have the consistency, which will allow proper placement and consolidation in the required position. The optimum consistency shall be as indicated in Table 557.3.2.

557.3.2 - Optimum Consistency Type: mm of Slump

For pavements when concrete is permitted to be placed using a slip form paver, where a low slump is required to maintain the prescribed geometry: 25 mm

For pavements supplied by travel mixers of central mixers where the concrete is struck off and consolidated entirely by mechanical equipment: 50 mm

For pavements and approaches supplied by travel, central or transit mixtures where the concrete is struck off and consolidated partially by hand labour: 65 mm

*The consistency shall be that which will allow a proper placement and consolidation of the concrete, and will permit the prescribed geometry to be maintained. The concrete will be rejected when the consistency exceeds 50 mm.

**If the consistency exceeds the optimum plus (20 mm), the Contractor shall take immediate steps to reduce the slump of succeeding loads by making necessary adjustments in the mixture. The Contractor will be allowed a reasonable time for the trucks already on the road for a central mix or transit mix operation. Failure to comply will be cause for rejection of the concrete. If the consistency exceeds the optimum plus 50 mm, the concrete will be rejected.

The approved mix design shall be subject to modification under the following conditions:

After the start of the first concreting operation and immediately after the specified consistency and entrained air have been established, three unit weight determinations shall be made from different batches and the average of the three determinations shall be considered the unit weight of the concrete. The actual yield shall be adjusted as required to correct the actual yield to correspond to the theoretical.

During the progress of the work, the actual yield may be verified; and, if the yield based on a single unit weight determination should differ from the theoretical more than plus or minus two percent, two additional unit weight determinations shall be made from different batches and the average of the three determinations shall be considered the unit weight of the concrete. The actual yield shall be determined from the average unit weight, and the design mix shall again be adjusted as required to correct the actual yield to correspond to the theoretical.

In addition to the design mix adjustments specified above to correct for yield, other adjustments in the design mix proportions shall be made as necessary to maintain a plastic, workable mix with suitable finishing characteristics.

No change in the sources of material shall be made without prior approval of the Engineer.

Methods for determining the properties enumerated above shall be in accordance with 557.4.

557.4 - TESTING

557.4.1 - Test Methods:

Slump of Portland Cement Concrete	AASHTO T 119
Air Content of Freshly Mixed Concrete	AASHTO T 152 AASHTO T 196 AASHTO T 199
Unit Weight/Yield of Concrete	AASHTO T 121
Making and Curing Concrete Compressive Specimens with Flexural Strength	AASHTO T 23
Test Specimens in the Field and Compressive Strength of Cylindrical Concrete Specimens	AASHTO T 22
Flexural Strength of Concrete	AASHTO T 22
Obtaining and Testing Drilled Core Specimens	AASHTO T 97
Obtaining and Testing Drilled Core Specimens	AASHTO T 24
Measuring Length of Drilled Concrete Cores	AASHTO T 148
Total Moisture Content of Aggregate by Drying	AASHTO T 255
Sampling Fresh Concrete	AASHTO T 141
Sieve Analysis of Fine and Coarse Aggregates	AASHTO T 27 and T 11

Determination of Free Moisture in Fine Aggregate Using 20 Gram or 26 Gram "Speedy Moisture Tester"

A (82)

Determination of free moisture in fine aggregate using a speedy moisture tester
Sampling Aggregates ML 26

Determination of Total Solids in Concrete AASHTO- T-128-92, ASTM C-184-90

557.4.2 - Contractor's Quality Control

Quality Control of the Portland Cement Concrete is the responsibility of the Contractor.

557.4.3 - Acceptance Testing

Acceptance sampling and testing of Portland Cement Concrete is the responsibility of the Engineer, except for furnishing of necessary materials. Strength, as used in this Specification, is only one indicator of the durability of the Portland Cement Concrete. Evaluation of a pavement may include evaluation of the wearing surface durability, including scaling characteristics, abrasion resistance, density, and such other factors as the Engineer deems appropriate to the pavement.

A minimum of three sets of three concrete specimens (beams or cylinders) each shall be made for each day's paving operation. The three sets of specimens shall be treated in the following manner to determine when the pavement represented may be put into service under the provisions of 501.18, except that said determination and the action permitted shall in no way affect the treatment of concrete as specified in 557.21.1 and 557.14. One specimen from each of the three sets shall be tested at age four days and the results averaged to establish the test value. If the test value complies with the Specification, the portion of pavement, which is aged four days may be put into service.

In the event Specification compliance has not been verified at age four days, one specimen from each of the three sets shall be tested at age six days and the results averaged to establish the test value. If the test value complies with the specifications the portion of pavement, which is aged six days may be put into service.

In the event Specification compliance has not been verified at age six days, one specimen of the remaining specimen from each of the three set shall be tested at age eight days and the results averaged to establish the test value. If the test value complies with the Specification, the portion of pavement that has aged eight days may be put into service.

In the event the test value determined at age eight days does not comply with the Specification, the test values determined at ages four, six, and eight days may be plotted on a graph and a line drawn through the points in such a manner as to establish the age-strength relationship. The line may be projected to age 28 days, and if the projection indicates specification design strength compliance prior to age 28 days, then the pavement may be put into service at the age at which specification compliance is indicated.

When high early strength cement is used, the first test value may be established at age three days and all succeeding values established at 24-hour intervals.

557.4.5 - Compressive Strength Tests for Acceptance

Compressive strength test for acceptance will be in accordance with the requirements prescribed.

The compressive strength of concrete will be determined by testing cores, which are taken in the manner described in 557.19.1. These cores will generally be the same as those taken to verify pavement thickness and described in 557.19.2. The concrete shall be at least 28 days old before the cores are obtained and generally the cores will be obtained before the concrete is 90 days old. Compressive strength test results obtained at time of test will be used in statistical analysis to verify compliance with the strength requirement.

Compressive strength test data will be analysed statistically and the average compressive strength minus one standard deviation shall be equal to or greater than the 28-day design strength. Also, the average of any consecutive five strength tests representing a portion of the pavement concrete shall be equal to or greater than the 28-day design strength. Strength test data, which are determined to be statistical outliers, will be omitted from the computations which derive the statistical parameters, and the sub areas of pavement represented by outliers which occur in the region of low strength will be separately evaluated and disposed of in a manner deemed suitable by the Engineer.

If the specimens fail to meet the minimum standards of acceptance set forth above, the concrete in question will be considered substandard and disposition will be determined by the Engineer. If one or more sets of consecutive five strength tests should fail to comply with the Specifications and all other requirements of the Specifications are met, the portion of concrete represented by consecutive five sets which fail to comply will be considered substandard and the specified action will be related to the portion of concrete thus defined.

557.5 - EQUIPMENT AND TOOLS

Equipment and tools necessary for handling materials and performing all parts of the work shall be approved by the Engineer, as to design, capacity, and mechanical condition. The equipment shall be at the job site sufficiently ahead of the start of construction operations to be examined. Any equipment not maintained in satisfactory working order, or which is proved inadequate, shall be improved or new equipment substituted, as directed by the Engineer.

557.5.1 - Batching Plant Equipment, Production, Transporting and Placing Concrete

Refer to Subsection 551.

557.5.2 - Finishing Machine

The finishing machine shall be designed and operated to strike off, consolidate, and obtain a smooth finish. The top of the forms, if used, shall be kept free from accumulation by an effective device attached to the machine, and the travel of the machine on the forms shall be maintained true.

557.5.3 - Vibrators

For full width vibration of concrete paving slabs, vibrators may be either the surface pan type or the internal type with either immersed tube or multiple spuds. They may be attached to the spreader or the finishing machine, or may be mounted on a separate carriage. They shall not come in contact with the joint, load transfer devices, subgrade, or side forms.

The frequency of the surface vibrators shall not be less than 3,500 impulses per minute, and the frequency of the internal type shall not be less than 5,000 impulses per minute for tube vibrators and shall be between 5,000 and 10,000 impulses per minute for spud vibrators.

When spud type internal vibrators, either hand operated or attached to spreaders or finishing machines, are used adjacent to forms, they shall have a frequency of not less than 3,500 impulses per minute.

Other types of vibrators may be used when shown they perform the function intended.

557.5.4 - Concrete Saw

When sawing joints is elected or specified, the Contractor shall provide sawing equipment, adequate in number of units and power to complete the sawing to the required dimensions and at the required rate for preventing uncontrolled cracking. A standby saw and ample supply of saw blades shall be maintained at the site of the work at all times during sawing operations. The Contractor shall provide adequate artificial lighting facilities for night sawing. All of this equipment shall be on the job both before and continuously during concrete pavement.

557.5.5 - Forms

Straight side forms shall be of adequate design to support the paving train and to provide the proper pavement section without horizontal joints. Flexible or curved forms of proper radius shall be used for curves of 60-metre radius or less. Flexible or curved forms shall be of a design acceptable to the Engineer. Forms shall be provided with adequate devices for secure setting and shall have an attachment provision for forming the keyed joint between lanes. When in place they shall withstand, without visible springing or settlement, the impact and vibration of consolidating and finishing equipment. Forms with battered top surfaces, and bent, twisted, or broken forms shall be removed from the job. The top face of the forms shall not vary from a true plane more than 3 mm in 3 metres, and the upstanding leg shall not vary more than 6 mm from a plane normal to the subgrade. The forms shall contain provisions for locking the ends of abutting form sections together tightly, and for secure setting.

557.5.6 - Edging Tools

Edging tools shall have 6mm radius for all edges except outside edges, which shall have a 20mm radius.

557.6 - Preparation of Grade, Setting Forms, and Conditioning of Subgrade or Base

557.6.1 - Preparation of Grade

After the roadbed has been graded and compacted, as provided in 207 or 228, the grade shall be trimmed approximately to correct elevation, extending the work at least 600mm beyond each edge of the proposed concrete pavement to provide support for the fixed-forms or the slip-form paver tracks.

557.6.2 - Setting Forms

557.6.2.1 - Base Support

The foundation under the forms shall be hard and true to grade so that the form, when set, will be firmly in contact for its whole length and at the specified grade. Any grade, which at the form line is found below established grade shall be filled to grade with granular material, in lifts of 13mm or less for a distance of 450mm on each side of the base of the form, and thoroughly compacted.

Imperfections or variations above grade shall be corrected by tamping or by cutting as necessary.

557.6.2.2 - Form Setting

Forms shall be set sufficiently in advance of the point where concrete is being placed. After the forms have been set to correct grade, the grade shall be thoroughly tamped, mechanically or by hand, at both the inside and outside edges of the base of the forms. Form sections shall be tightly locked, free from play or movement in any direction. The forms shall not deviate from true line by more than 6 mm at any point.

Excessive settlement or springing of forms under the finishing machine will not be tolerated. Forms shall be cleaned and oiled prior to the placing of concrete. 557.6.2.3-Grade and Alignment: The alignment and grade elevations of the forms shall be checked and corrections made by the Contractor prior to placing the concrete. When any form has been disturbed or any grade has become unstable, the form shall be reset and rechecked.

557.6.3 - Conditioning of Subgrade or Base

The base shall be brought to the proper cross section and plan grade within the tolerances specified for the final course underlying the pavement. The finished grade shall be maintained in a smooth and compacted condition until the pavement is placed. The grade shall be constructed sufficiently in advance of the paver to prevent delays.

Unless waterproof subgrade or base course cover material is specified, the subgrade or base course shall be uniformly moist when the concrete is placed.

557.7 - HANDLING, MEASURING, AND BATCHING MATERIALS: Refer to 551.

557.8 - MIXING CONCRETE: Refer to 551

557.9 - PLACING CONCRETE

The concrete shall be deposited on the grade in such manner as to require as little re-handling as possible. Unless transit-mix trucks, agitators, or other hauling equipment units are equipped with means for discharge of concrete without segregation, the concrete shall be unloaded into a spreading device and mechanically spread on the grade in such manner as to prevent segregation of the materials. Placing shall be continuous between transverse joints without the use of intermediate bulkheads. Necessary hand spreading shall be done with shovels, not rakes. Workers shall not be allowed to walk in the fresh concrete with boots or shoes coated with earth or foreign substances.

The pavement shall be constructed by placing two longitudinal traffic lanes full width in one operation unless otherwise indicated in the Contract. Lane-at-a- time construction will be permitted in variable width sections or other sections designated by the Engineer.

When the Contract permits lane-at-a-time construction and concrete is to be placed adjoining a previously constructed lane of pavement and mechanical equipment other than finishing equipment will be operated upon the existing lane, that lane shall first meet the requirements of 551.18. If only finishing equipment is carried on the existing lane, paving in adjoining lanes may be permitted after three days.

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Concrete shall be deposited as near to expansion and contraction joints as possible without disturbing them, but shall not be dumped from the discharge bucket onto a joint assembly unless the bucket is well centred on the joint assembly.

When using a slip-form paver, or combination of pavers, they shall be designed to spread, consolidate, screed and float-finish the freshly placed concrete in one complete pass of the paving train in such manner that a minimum of hand finishing will be necessary to provide a dense and homogenous pavement in conformance with the Drawings and Specifications. The equipment shall vibrate the concrete for the full width and depth of the strip of pavement being placed. Such vibration shall be accomplished with vibrating tubes or arms working in the concrete or with a vibrating screed or pan operating on the surface of the concrete. No appreciable edge slumping of the in-place concrete will be allowed, and, if necessary, forms shall be trailed behind the paver to prevent slumping. If training forms are used, they shall be rigidly supported laterally.

Slip-form pavers shall be operated with as nearly a continuous forward movement as possible and all operations of mixing, delivering and spreading concrete shall be so coordinated as to provide uniform progress. If, for any reason, it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped immediately. No tractive force shall be applied to the machine, except that which is controlled from the machine.

Placement to essential full width is required when slip-form paving methods are used. However, the Engineer may permit lane-at-a-time placement on variable width, small, or otherwise restricted sections using standard forming methods detailed elsewhere in these Specifications.

Concrete shall be thoroughly consolidated against and along the faces of all forms and along the full length and on both sides of all joint assemblies by means of vibrators inserted in the concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the grade, or a side form. In no case shall the equipment-mounted vibrators be operated when the equipment is not moving in the forward direction. All equipment-mounted vibrators shall be stopped, either manually or automatically, when the equipment stops its forward progress.

Should any concrete material fall on or be worked into, the surface of a completed slab, it shall be immediately removed.

557.10 - STRIKE-OFF OF CONCRETE AND PLACEMENT OF REINFORCEMENT

Following placing, the concrete shall be struck off to conform to the cross section shown on the Drawings and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement will be at the elevation shown on the Drawings. When reinforced concrete pavement is placed in two layers, the entire width of the bottom layer shall be struck off to such length and depth that the sheet of fabric or bar mat may be laid full length on the concrete in its final position without further manipulation. The reinforcement shall then be placed directly upon the concrete, after when the top layer of the concrete shall be placed, struck off, and screeded. All portions of the bottom layer, which have been placed more than 30 minutes without being covered by the top layer, shall be replaced at the Contractor's expense.

When reinforced concrete pavement is placed in one layer, the reinforcement may be positioned in advance of concrete placement, or it may be placed in the plastic concrete, after spreading, by mechanical or vibratory means. When reinforcement is specified, it shall be placed in the centre portion of the pavement. Variation in the depth of reinforcement is permitted, but the minimum concrete cover shall be one-third of the plan depth of the pavement.

Reinforcement shall be as designated on the Drawings and shall be free from dirt, oil, paint, grease, and loose rust which could impair bond of the steel with the concrete.

557.11 - JOINTS

Joints shall be constructed of the type and dimensions and at the locations required by the Drawings.

557.11.1 - Longitudinal Joints

Deformed steel tie bars or tie bolt assemblies shall be placed perpendicular to the longitudinal joints. They shall be placed by suitable mechanical equipment or rigidly secured by suitable supports to prevent displacement. Tie bars shall not be painted, coated, or enclosed in tubes or sleeves.

All longitudinal joints shall be sawed normal to the surface of the pavement with a suitable concrete saw. Construction of longitudinal joints shall be in accordance with the appropriate requirements, as follows:

i. When the longitudinal joint separates adjacent pavement lanes or slabs that are poured at the same time, sawing of longitudinal joints shall be performed between 4 and 24 hours after the pavement is placed and before any equipment and vehicles are allowed on the pavement. The saw cut shall be to a minimum depth of one-third of the plan depth of pavement; the width shall be 6 mm, with a tolerance of plus or minus 2mm The groove shall be cleaned and cured in accordance with 557.11.8 and sealed in accordance with 557.16.

ii) When the longitudinal joint separates adjacent pavement lanes or slabs that are poured separately (lane-at-a-time construction), the longitudinal joint may be sawed, and cleaned in accordance with 557.11.8, just prior to sealing in accordance with 557.16. The saw cut shall be to a depth of 25 mm, plus 6mm; the width shall be 6mm plus or minus 2mm. If the joint is not sealed soon after the sawing operation, the groove shall be protected in accordance with 557.11.8 until just prior to the sealing operation.

iii) When formed joints are permitted, they shall be formed while the concrete is in the plastic state by a suitable mechanically operated device. The joints shall be formed to the dimensions and lines indicated on the Drawings. The groove shall be sealed in accordance with 557.16.

The longitudinal joints shall extend to and contact the transverse joints, if any.

557.11.2 - Transverse Expansion Joints

The expansion joint filler shall be one piece, continuous from form to form, shaped to the subgrade and to the cross section of concrete. The filler shall be depressed 13mm below the surface of the pavement.

The expansion joint filler shall be held in a vertical position. Finished joints shall not deviate more than 6mm in the horizontal alignment from a straight line at right angles to the centreline of the pavement. No plugs of concrete will be permitted anywhere within the expansion space.

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557.11.3 - Transverse Contraction Joints

Transverse contraction joints shall consist of planes of weakness created by sawing or forming grooves, normal to the grade, in the surface of the pavement as shown on the Drawings. These contraction joint grooves shall be centred, within 25mm of the mid-length of the dowels, over the coated dowel bars specified. Unless otherwise specified or authorized, all transverse contraction joint grooves shall be constructed in two steps as described, resulting in the dimensions detailed on the Drawings and at the spacing and locations shown on the Drawings. Grooves shall be cured in accordance with 557.11.8 and sealed in accordance with 557.16.

As soon as feasible after placing the concrete, the contraction joints shall be sawed or formed to the dimensions shown on the Drawings. Initial sawing of joints shall commence as soon as the concrete has hardened sufficiently to permit sawing without excess ravelling, usually 4 to 24 hours. All joints shall be initially sawed before uncontrolled shrinkage cracking takes place, but no later than 24 hours after placement of concrete. If necessary, initial sawing operations shall be continuous, through day and night, regardless of weather conditions. In general, all joints should be sawed in sequence. The initial sawing of any joint shall be omitted if cracking occurs at or near the joint location prior to the time of sawing. Initial sawing of a joint shall be discontinued when a crack develops ahead of the saw. If extreme conditions exist which make it impractical to prevent erratic cracking by early sawing, the contraction joints shall be formed in the plastic concrete.

When the concrete has hardened sufficiently, but no earlier than 72 hours after placement of the concrete, final or second-step sawing shall be performed. The sawing operation shall consist of widening the contraction joint to the depth and width shown on the Drawings and shall be conducted in such a manner as to provide smooth and uniform joint faces.

After the joints have been cleaned, following second-step sawing, they shall be inspected for irregularities. Any excessive irregularities of the joint faces, including spalled, cracked and honey combed areas or otherwise loose, unsound concrete, which would prevent proper contact between the sides of the seal and the joint faces, shall be corrected prior to installation of the seal. The loose, unsound concrete shall first be removed to the satisfaction of the Engineer. The damaged area shall then be repaired in an acceptable manner. For elastomeric seals, when a joint opening is larger than the specified width plus the allowable tolerance, which can be attributed to inaccurate sawing rather than contraction of the abutting slabs, the joint shall be "built up" with an acceptable epoxy resin mortar mix to its proper width. The concrete surface shall be clean and dry at the time of placing the epoxy mortar. All joint repair work shall be done at the Contractor's expense and to the satisfaction of the Engineer.

When formed joints are permitted, they shall be affected by an approved mechanically operated device to the dimensions specified and while the concrete is still in the plastic state. The grooves shall be filled as specified or, if forming is in lieu of initial sawing, shall be later widened by second-step sawing. Random cracking at transverse contraction joints, as described in 557.11.7, shall be sealed with silicone sealant.

557.11.4 - Transverse Construction Joints

Transverse construction joints shall be installed when there is an interruption of more than 30 minutes in the concreting operations. No construction joint shall be installed within 3 metres of an expansion or contraction joint. If sufficient concrete has not been placed to form a slab at least 3 metres long, the excess concrete back to the last proceeding joint shall be removed.

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Construction joints shall be constructed in a manner similar to transverse contraction joints. The groove for installation of the sealant shall have the same dimensions as for transverse contraction joints and shall be sealed in accordance with 557.16.

557.11.5 - Coated Dowel Bars

Coated dowel bars (load transfer reinforcement) shall be used across all transverse joints as shown on the Drawings.

Dowels shall be located at mid-depth of the pavement with a tolerance of placement within plus or minus 25mm of the lateral and vertical positions shown on the Drawings. Dowels shall be aligned parallel to the centreline and surface of the pavement with a tolerance for such alignments within plus of minus 6mm per dowel.

Dowels shall be held in position in the pavement by means of metal supports that remain in the pavement, except as noted. The combination of dowel bars and all the various components of the metal supports at a joint is commonly referred to as the dowel assembly or load transfer unit. Welding of dowels to the supports, to achieve a fixed end condition, shall be performed in accordance with the details shown on the Drawings. For dowel assemblies at contraction and construction joints, welding of dowels to any member of the supports will not be permitted within the middle one-third of the dowel's length.

The longitudinal misalignment of one end of a dowel assembly with respect to the other end in achieving a perpendicular alignment with the centreline of the pavement shall not exceed 25mm. Acceptance of a type of dowel assembly by the Division in no way relieves the Contractor of their responsibility for furnishing, as part of the assembly, coated dowel bars that meet the requirements of 709.15, nor does it relieve the Contractor of the Contractor's responsibility for placing and maintaining the assembly in its proper position and alignment during paving operations.

The mechanical implanting method of placing dowel bars is not permitted except when approved by the Engineer.

For coated dowel bar types that require a bond breaker, the bond breaking material, pre-qualified for use with that particular type coating, shall be carefully applied over the entire length of the bar just prior to placement of concrete unless an approved bond breaker lubricant has been applied in the shop. The free end of expansion joint dowels shall be provided with a close fitting metal cap or sleeve equipped with a stop to prevent closing during paving operations. A clearance of 25 mm shall be maintained between the closed end of the cap and the end of the dowel to accommodate future movement of the concrete slab.

557.11.6 - Expansion Joints Around Structures

Expansion joints shall be formed by placing pre-moulded expansion joint material about all structures and features projecting through, into or against the pavement. Unless otherwise indicated, such joints shall be 13mm in width.

557.11.7 - Random Cracks

Random cracks falling in an area 75mm on either side of the centre of the transverse contraction joint's dowel bars shall be sawed for the full width, widening and deepening the crack to the

dimensions of final or second-step sawing for transverse contraction joints, of the pavement slab and cleaned, just prior to sealing with silicone sealant.

If any random or uncontrolled crack occurs between 75mm and 3 metres from a doweled joint, the entire pavement within the lane where such crack occurs shall be removed for a distance of 3 metres from the joint and replaced. If such cracking occurs on both sides of the same joint, the pavement shall be removed for a distance of 3 metres in both directions. The dowel assembly or bars, as the case may be, shall be removed and replaced with a new dowel assembly. The new joint over the dowel assembly shall be initially formed by the use of a removable insert or by sawing and the joint later widened by second-step sawing for sealing in accordance with 501.16. The above-described work shall be done at no additional cost to the Government.

557.11.8 - Curing Saw Joints

Immediately upon completion of the final sawing operation both vertical faces shall be completely free of dirt and dust; leaving a clean, dry, newly exposed concrete surface. Joints shall be cleaned by sandblasting each face with the nozzle held at an angle to the joint face and within 25mm to 50mm of the pavement. Sandblasting shall be done to a depth at which the sealant and backer rod are to be installed.

557.11.8.1 - Rope or Rod

After the joint is cleaned, acceptable rope or rod material which is non-metallic, inert, resilient, compressible, non-absorbent and non-shrinking shall be installed along the top of the joint, flush with the pavement surface, and shall also extend down the pavement edge to the bottom of the joint. The diameter of the rope or rod material shall be approximately 25 percent larger than the joint width. The rope or rod material shall remain in the joint until just prior to the second-step sawing or, for longitudinal joints, until just prior to sealing.

When sealing operations for transverse contraction or construction joints do not commence immediately after the second-step sawing and cleaning, a rope or rod approximately 25 percent larger than the joint width shall be installed as previously specified and shall remain in place until just prior to sealing.

557.11.9 - Bridge Approach Expansion Joints for Jointed Pavement

Construction of bridge approach expansion joints for jointed pavement shall be performed at the locations and in accordance with the details and requirements specified on the Drawings. Construction of the concrete sub-slab may be Class 30/20 of 551or pavement concrete. Construction of the bituminous concrete courses shall conform to the requirements of 401.

557.12 - FINAL STRIKE-OFF, CONSOLIDATION AND FINISHING

557.12.1 - Sequence

The sequence of operations shall be strike-off and consolidation, floating and removal of laitance, straight-edging, and final surface finish.

Any addition of water to the surface of the concrete to assist in the finishing operations will not be permitted. When conditions are such that unusually rapid drying is occurring, an atomised mist may be used to prevent the rapid evaporation of water from the concrete surface during the final finishing.

557.12.2 - Finishing at Joints

The concrete adjacent to joints shall be consolidated or firmly placed without voids or segregation against the joint material, under and around all load transfer devices, joint assemblies, and other features designed to extend into the pavement. Concrete adjacent to the joints shall be mechanically vibrated as required in 557.9.

The operation of the finishing machine over the joints shall not cause segregation of concrete and damage to or misalignment of joints.

557.12.3 - Machine Finishing

The concrete shall be distributed as soon as placed. It shall immediately be struck off and screeded by the finishing machine.

Vibrators for full width vibration of concrete paving slab shall meet the requirements of 557.5.5. If uniform and satisfactory density of the concrete is not obtained by the vibratory method at joints, along forms, at structures, and throughout the pavement, the Contractor will be required to furnish equipment and methods, which will produce pavement conforming to the Specifications.

557.12.4 - Hand Finishing and Consolidation

Hand finishing will not be permitted except under the following conditions:

In the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade.

Areas of narrow widths or irregular dimensions, where operation of mechanical equipment is impractical, may be finished by hand. Concrete, as soon as placed, shall be struck off and screeded. A portable screed shall be used.

If reinforcement is used, a second screed shall be provided for striking off the bottom layer of concrete.

The surface screed shall be at least 600 mm longer than the maximum width of slab to be struck off. It shall be sufficiently rigid to retain its shape under all working conditions, and constructed either of metal or of other suitable material shod with metal.

Consolidation shall be attained by the use of suitable vibrator or other equipment.

In operation the screed shall be moved forward on the forms in the direction the work is progressing, using a combined longitudinal and transverse shearing motion, so manipulated that neither end is raised from the side forms during the striking process. This shall be repeated until the surface is of uniform texture, true to grade and cross section, and free from porous areas.

557.12.5 - Floating

After the concrete has been struck off and consolidated, it shall be further smoothed, trued, and consolidated by means of a mechanical longitudinal float, except when waived by the Engineer.

If necessary, following one of the methods of floating described, long-handled floats may be used to smooth and fill in open textured areas in the pavement. Care shall be taken not to work the crown out of the pavement during the operation.

557.12.5.1 - Mechanical Method

The mechanical longitudinal float shall be maintained in proper working order. At the beginning of each day's operation the float shall be checked and adjusted to the design crown of the pavement. A small amount of mortar shall be carried ahead of the float at all times. The forward speed shall be adjusted so that succeeding strokes of the float shall overlap on each transverse trip. The float shall pass over each area of pavement sufficient number of times until the surface shows no variation from straightedge requirements, but excessive operation over a given area will not be permitted. All excess water, laitance, or other foreign material shall be wasted over the side forms on each pass.

Pipe float devices may be used for longitudinal floating when slip form paving.

557.12.5.2 - Alternative Mechanical Method

As an alternate to the above method, the Contractor may use a machine composed of a cutting and smoothing float, or floats, suspended from and guided by a rigid frame. The frame shall be carried by at least four visible wheels riding on, and constantly in contact with, the side forms.

557.12.5.3 - Hand Method

The hand-operated longitudinal float shall be not less than 3.75 metres in length and 150mm in width, properly stiffened to prevent flexibility and warping. The float shall be operated from footbridges resting on the side forms and spanning but not touching the concrete.

The float shall be worked with a sawing motion, while held in a floating position parallel to the road centreline and passing gradually from one side of the pavement to the other. Movement ahead along the centreline of the pavement shall be in successive advances of not more than one-half the length of the float. Any excess water, laitance, and other foreign material shall be wasted over the side forms on each pass.

557.12.6 - Straightedge Checking and Surface Correction

After the floating has been completed and the excess water removed, but while the concrete is still plastic, the surface of the concrete shall be tested for trueness with a 3-metre straightedge. The Contractor shall furnish and use a 3 metre straightedge swung from handles at least 1 metre longer than on-half the width of the slab. The straightedge shall be held in contact with the surface in successive positions parallel to the road centreline and the whole area gone over from one side of the slab to the other as necessary. Advance along the road shall be in successive stages of not more than one-half the length of the straightedge. Any depressions found shall be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished. High areas shall be cut down and refinished. Special attention shall be given to assure that the surface across joints meet the requirements for smoothness. Straightedge testing and surface corrections shall continue until the entire surface is found to be free from observable departures from the straightedge and the slab conforms to the required grade and cross section.

557.12.7 - Final Finish

The surface of the mainline pavement, acceleration and deceleration lanes, ramps, and all travelled ways shall be given a final groove finish. The tool used shall produce a groove that it approximately 2mm wide. The depth of the groove shall be 3mm to 5mm and spaced approximately 13mm centre to centre. The grooves shall be formed in a direction transverse to the centreline of the roadway. Adjacent strokes to establish the texture shall abut one another without appreciable overlap. Texturing shall be performed when the concrete surface is of such plasticity as to prevent excessive ravelling (concrete too dry) or to prevent mortar from flowing back into the grooves (concrete too wet). All texturing shall be accomplished with a single pass of the tool.

557.12.8 - Edging at Forms and Joints

Before the concrete has taken its initial set, the edges of the pavement along each side of the slab and on each side of all formed joints, except joints initially formed that will be later widened by second-step sawing, shall be rounded. A 20mm radius-edging tool shall be used for rounding outside edges and a 6mm radius tool for other edges. A well-defined and continuous radius shall be produced and a smooth, dense mortar finish obtained. Tilting the tool during use shall not unduly disturb the surface of the slab. Brooming the surface without disturbing the radius shall eliminate any tool marks. All concrete on top of the joint filler shall be removed. All joints shall be checked with a straightedge before the concrete has set and all necessary corrections made if one side is higher than the other or if they are higher or lower than the adjacent slabs.

557.12.9 - Station Numbers

The Contractor shall impress station numbers into the pavement before it takes its final set. The complete station number is to be marked each 20 metres. Where equalities in alignment occur, they shall be marked in the pavement in the same manner as they are shown on the Drawings. The numerals shall be 75mm to 100mm in height and 6mm in depth. The station numbers shall be placed parallel to the transverse joints, approximately 300mm to 600mm from the outside edge of the pavement. Station numbers shall be placed along the right edge of a two-lane highway, readable in the direction of increasing stations. On multi-lane highways, numbers shall be placed along the outside edge of the two outside lanes of the roadway, readable in the direction of travel.

557.12.10 - Protection Against Rain

In order that the concrete may be properly protected against the effects of rain before the concrete is sufficiently hardened, the Contractor shall have available at all times materials for the protection of the edges and surface of the unhardened concrete. Such protective materials shall consist of metal forms or wood planks having a nominal thickness of not less than 50mm and nominal width of not less than the thickness of the pavement at its edge for protection of the pavement edges, and covering material such as burlap or cotton mats, curing paper, or plastic sheeting for protection of the surface. When rain appears imminent, all paving operations shall stop and all available personnel shall begin placing forms against the sides of the pavement and covering the surface of the unhardened concrete with the protective covering.

557.13 - SURFACE TESTS

The Engineer using an inertial Profilometer or Mays Ride Meter calibrated to an inertial Profilometer will determine the smoothness of the riding surface.
The smoothness testing will generally be accomplished within 30 days after the project is complete.

557.13.1 - Sampling Units

The pavement will be divided into sampling AREAS of 0.20 lane kilometre each. Each AREA shall exhibit a smoothness measurement, expressed in millimetres per kilometre.

557.13.2 - Smoothness Requirement

Each sampling unit shall exhibit a smoothness equal to or less than 1000 millimetres per kilometre. Sampling units exhibiting smoothness values greater than 1000 millimetres per kilometre shall be paid for at an adjusted price as follows:

Revised Unit Price = UBP - [(1.00-{127.86-0.028S }) (0.18 UBP)]

Where UBP = Unit Bid Price
Where S = Smoothness in millimetres per kilometre

When the measured smoothness value exceeds the specified value by 50 percent or more, the AREA shall be corrected to comply with these specifications.

557.14 - CURING

Immediately after the finishing operations have been completed and as soon as marring of the concrete will not occur, the entire surface of the newly placed concrete shall be cured in accordance with one of the methods described. In all cases in which curing requires the use of water, the curing shall have prior right to the use of all water supplies. Failure to provide sufficient curing materials of whatever kind the Contractor may elect to use will be cause for immediate suspension of concreting operations. The concrete shall not be left exposed for more than 30 minutes between stages of curing or during the curing period.

Concrete placed in cold weather, as defined in 557.21, shall be cured a minimum of seven calendar days or when the Contractor provides suitable means for documenting the maturity (degree-hours) of the concrete, based on slab surface temperature, the curing period may be terminated when the curing has been maintained for a minimum of 7,000 degree hours.

During the curing period the surface temperature of the concrete shall not be allowed to fall below freezing. The Contractor shall be responsible for the quality of the concrete placed or cured, or both, during cold weather. Any concrete injured by frost action shall be removed and replaced at the Contractor's expense.

Polyethylene coated burlap and white polyethylene sheeting will be permitted as a curing application only on areas where intimate contact with the concrete surface can be obtained and maintained.

557.14.1 - Burlap Mats

The surface of the pavement shall be entirely covered with the mats. The mats shall be of such length that they will extend at least twice the thickness of the pavement beyond the edges of the slab. The mat shall be placed so that the entire surface and both edges of the slab are completely covered. Before placing, the mats shall be thoroughly saturated with water. The mats shall be weighted down so as to remain in intimate contact with the surface covered and shall be maintained fully wetted and in position for 72 hours after the concrete has been placed, unless otherwise specified.

557.14.2 - Waterproof Paper

The top surface and sides of the pavement shall be entirely covered with waterproof paper. The units shall be lapped at least 450mm. The paper shall be weighted down so as to remain in intimate contact with the surface. Each unit as laid shall extend at least twice the thickness of the pavement beyond the edges of the slab. Paper not manufactured in sizes providing this width shall be securely sewed or cemented together, the joints being securely sealed in such a manner that they do not open up during curing. The surface shall be thoroughly wetted before placing the paper. Curing shall continue for 72 hours after the concrete is placed, unless otherwise specified.

557.14.3 - Straw Curing

When this type of curing is used, the pavement shall be cured initially with burlap or cotton mats, as specified above, until after final set of the concrete or, in any case, for 12 hours after placing the concrete.

As soon as the mats are removed, the surface and sides of the pavement shall be thoroughly wetted and covered with at least 200 mm of straw or hay, thickness to be measured after wetting. The straw or hay shall be kept thoroughly saturated with water for 72 hours after placing the concrete. If the straw or hay becomes displaced during the curing period, it shall be replaced to the original depth and saturated. Upon removal, the covering shall be disposed of in such a manner as to leave the right-of-way in a neat condition. The straw or hay shall not be burned on, or adjacent to, the pavement.

557.14.4 - White Pigmented Impervious Membrane

The entire surface of the pavement shall be sprayed uniformly with white pigmented curing compound immediately after the finishing operation and before initial set has taken place, or, if the pavement is initially cured with burlap or cotton mats, it may be applied upon removal of the mats. The curing compound shall not be applied during rainfall.

Mechanical sprayers shall apply curing compound under pressure. The spraying equipment shall be of the fully atomising type equipped with a tank agitator. The rate of application of the curing compound shall be as follows:

Pavement with Burlap Drag Finish: 0.27 litres per square metre
Pavement Requiring Groove Finish: 0.33 litres per square metre

At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. During application the compound shall be continuously agitated. Hand spraying of odd widths or shapes and surfaces exposed by removal of forms will be permitted. Curing compound shall not be applied to the inside faces of joints to be

sealed. Should the film become damaged from any cause within the required curing period (72 hours after placement of concrete, unless otherwise specified), the damaged portions shall be immediately repaired with additional compound. Upon removal of the side forms, the sides of the exposed slabs shall be protected immediately with a curing treatment equal to that of the surface.

557.14.5 - White Polyethylene Sheeting or Polyethylene Coated Burlap

The top surface and sides of the pavement shall be entirely covered with polyethylene sheeting or polyethylene coated burlap. Units shall be lapped at least 450mm. The covering shall be weighed down so as to remain in intimate contact with the surface covered. The covering shall extend at least twice the thickness of the pavement beyond the edges of the slab. The covering shall be maintained in place at least 72 hours after the concrete is placed, unless otherwise specified.

557.15 - REMOVING FORMS

Forms shall not be removed until at least 12 hours after placement of the concrete. Forms shall be removed carefully so as to avoid damage to the slab. As soon as the side forms have been removed, minor honeycombed areas shall be filled with mortar composed of one part cement to two parts fine sand and cured as outlined in one of the methods indicated above. Major honeycombed areas shall be removed and replaced. All areas or sections so removed shall be not less than 3.0m in length nor less than the full width of the traffic lane involved. Any remaining portion of the slab adjacent to the joints that is less than 3 metres in length shall also be removed and replaced. Slabs shall be cut ,by sawing, to the full depth for removal.

557.16 - SEALING JOINTS

All transverse contraction and construction joints to be sealed shall have the preformed elastomeric seal installed or shall be filled with silicone sealer before the pavement is opened to traffic, including construction traffic, and as soon after completion of curing as is feasible.

All longitudinal joints shall be sealed with silicone sealant.

557.16.1 - Silicone Sealant

Following forming, initial sawing and final or second-step sawing operations, the joints shall have been cleaned in accordance with 557.11.8. In preparation for sealing, all joints that have become contaminated since those forming or sawing operations shall be cleaned by wire brushing, sandblasting, or a high pressure water blast or by a combination of these methods.

Just prior to installing the back-up material, the joints shall be blown out with compressed air at a pressure of at least 620 kPa to remove all dust, loose particles and debris. Air compressors used for this purpose shall be equipped with traps capable of removing moisture and oil from the compressed air. A joint shall not be sealed until it is thoroughly clean and dry. When recommended by the manufacturer, the vertical surfaces of joints shall be fully wetted by a primer. The primer and application, including all safety precautions, shall be as per the manufacturer's recommendations. The primer shall be allowed to dry tack-free prior to installation of the backer rod.

The back-up material shall be installed in the joint at the required depth. The silicone sealant shall then be applied from inside the joint in a manner, which causes it to wet the joint faces and to reasonable close conformity with the required dimensions.

Immediately following placement of the sealant and before a skin forms, the sealant shall be tooled to force it against the joint faces and to provide a slightly concave surface with a depth of approximately 6mm (at the centre of the joint) below the pavement surface.

Any unreasonable deviation from the required joint or sealant dimensions will be just cause for rejection of the joint until satisfactory corrective measures are taken by the Contractor at no additional cost to the Client. Any failure of the joint material in either adhesion or cohesion will be cause for rejection of the joint, and the Contractor at no additional cost to the Client shall repair the joint to the Engineer's satisfaction.

Silicone sealant shall never be applied to dirty, wet, or damp concrete or during inclement weather conditions. Silicone sealant shall not be placed in the joints without the approval of the Engineer when the temperature at the surface of the concrete is less than 10°C.

557.16.2 - Preformed Elastomeric Seal

The dimensional requirements shall be as specified on the Drawings. Joints shall be clean and dry at the time the elastomeric seal is installed. Just prior to installation of the seal, the lubricant-adhesive shall be applied to the joint faces or the sides of the seal, or both, to facilitate installation of the seal and to help secure the seal in place in the joint.

The lubricant-adhesive shall be applied in such a manner as to cover both sides of the seal over the full area in contact with the joint faces. Any lubricant- adhesive that gets on top of the seal shall be immediately removed. Seals shall be installed in a substantially full compressed condition with the vertical axis of the seal parallel to the joint faces. Seals shall be installed in the joints to the depth shown on the Drawings using suitable machines or tools that will not twist, curl, nick, notch, or otherwise damage the seal and that will insert the seal in such a manner that elongation of the seal shall not exceed five percent. The in place seals shall be one-piece construction, without field or factory splices, for the full length of the joint. Any seal that is damaged during installation shall be removed and replaced with a new, undamaged seal. Any seal that is improperly installed or positioned in the joint or that shows more than five percent elongated following installation shall be removed and properly reinstalled or replaced.

557.17 - PROTECTION OF PAVEMENT

The Contractor shall protect the pavement and its appurtenances against both public traffic and the traffic caused by their own employees and agents. This protection shall include watchmen to direct traffic, and the erection and maintenance of warning signs, lights, barricades, pavement bridges, crossovers, etc. The above shall be arranged so as not to interfere with public traffic on any lane intended to be kept open.

All damage to the pavement occurring prior to final acceptance shall be repaired or the pavement replaced, as the Engineer may direct.

557.18 - OPENING PAVEMENT TO TRAFFIC

If approved by the Engineer, the Contractor may open the pavement to traffic prior to 28 days after placement of concrete, provided tests conducted in accordance with 557.4.4 indicate the pavement has attained the 28-day design strength. If the Contractor wishes to open pavement to traffic prior to age 28 days, then all provisions for making test specimens and conducting and reporting the tests shall be handled by the Contractor at their expense. However, the Engineer

may require that the pavement not be opened to traffic for a period of 28 days or longer, after placement of concrete, if conditions make it advisable to extend this time.

557.19 - TOLERANCE IN PAVEMENT THICKNESS

It is the intent of these Specifications that the pavement shall be constructed in substantial conformity with the specified thickness. Paving operations shall be directed toward obtaining an average and uniform thickness equal to or greater than the specified thickness.

For the purpose of establishing an adjusted unit price for pavement areas deficient in thickness, the thickness characteristics will be determined in accordance with the criteria specified.

557.19.1 - Sampling Units and Sampling Requirements

The pavement thickness characteristics will be determined from an analysis of measurements made on cores. The cores will be taken by the Engineer with a frequency of one core from each sampling unit as defined and will be analysed in accordance with 557.23.1.1.

557.19.1.1 - Highway Proper

The total length of paving lane in linear metres in the highway proper shall be divided by 500 to determine the largest whole number, which shall be the number of sampling units in the highway.

The width of the sampling unit shall be the width of the paving lane, and the length of the sampling unit shall be determined by dividing the total length of paving lane in linear metre in the highway proper by the number of sampling units determined in the manner set forth. When paving lane width exceeds 7.2 metres, the Engineer may establish shorter sampling units. When the number as determined above is less than 10, the total length of the paving lane in linear feet shall be divided into 10 equal sampling units.

557.19.1.2 - Auxiliary Features

Intersections, entrances, exits, crossovers, ramps, etc., may be considered individually or collectively so as to form sampling units most nearly the length previously established in the highway proper.

557.19.2 - Deficient Thickness (Detection and Delineation)

One core will be taken from each sampling unit and the length of the core will represent the thickness of the unit.

When a sampling unit is represented by a core measurement which is less than the specified thickness minus 7.8%T. T-7.8%T, the sampling unit will be evaluated as set forth in 557.19.2.1.

557.19.2.1 – Sampling

The part of the sampling unit considered to be deficient in thickness by T-7.8%T or more will be delineated by taking additional cores at approximately 6 metre intervals, parallel to the centreline, in each direction from the core obtained in 557.19.2, until a core is obtained, in each direction, which is not deficient in length by more than T-7.8%T. Areas thus defined shall be removed and replaced at no additional cost to the Government. These exploratory cores will not be used in the

analysis of the remainder of the unit. The balance of the sampling unit will be treated as a separate sampling unit.

One additional core will be obtained from the balance of the sampling unit to represent the unit. The thickness represented by this core, when greater than T-7.8%T, will be included in the measurements specified in 557.23.1.1.

557.19.3 - Refilling of Cores

As soon as the Engineer issues directions, the Contractor shall refill and properly cure all test holes at no additional cost to the Engineer.

557.20 - PAVEMENT WIDENING

When called for on the Drawings or directed by the Engineer to widen an existing pavement by means of strips of Portland Cement Concrete, on one or both sides, the construction methods and materials shall be as specified for regular Portland Cement Concrete pavement, except as modified.

Compaction of the fine grade may be by means of an approved special roller capable of exerting a compressive force of not less than 1.8 kg per mm of width and as further prescribed in 207.9

ii. Forms may be of steel or wood. They shall be secured as required by the Engineer.

557.21 - ADVERSE WEATHER CONDITIONS: Refer to 551

557.22 - METHOD OF MEASUREMENT

The quantity of concrete pavement to be paid for will be the number of square metres complete in place and accepted. The width for measurement will be the width of the pavement shown on the typical cross section of the Drawings and additional widening where called for or as otherwise directed in writing by the Engineer. The length will be measured on the surface along the centreline of each roadway ramp.

Bridge approach expansion joints will be measured separately and shall be the actual number of joints constructed, complete in place and accepted. In contracts where only widening is called for, the square metres of pavement widening will be determined from the length of strips, measured along the edges and upon the surface, times the width as measured at regular intervals, plus the area of any widening on curves, turnouts or intersections authorized and measured separately.

No extra payment will be made for removing and crushing the existing pavement for use as coarse aggregate for concrete.

557.23 - BASIS OF PAYMENT

557.23.1 - General

The quantities, determined as provided above, will be paid for at the contract unit prices less adjustments referred to below, which shall constitute full compensation for furnishing and preparing of all materials, including, transverse and longitudinal joints, expansion joint filler, elastomeric joint seals, silicone sealant, epoxy mortar for joint repair work, polyethylene tape,

rope or rod joint back-up material, lubricant-adhesive for elastomeric seals, and dowels or load transfer devices as are required in the Drawings; placing, finishing and curing; and all labour, equipment, tools, field laboratory, supplies and incidentals necessary to complete the work.

557.23.1.1 - The core measurements, which represent the thickness of the sampling units shall be analysed to determine the average value of the pavement thickness. This value will be used to determine the degree of compliance with the provisions set forth in 557.19 and to develop certain factors to be used in the derivation of equitable deductions as set forth in 557.23.1.2 and 557.23.1.3, in the event the provisions of this Specification are not met.

No payment will be made for pavement areas deficient in thickness by more than 7.8%T, the area being defined in the manner set forth in 557.19.2. Pavement, which is deficient in thickness by more than 18mm and is considered by the Engineer to be inadequate to perform satisfactorily shall be removed and replaced at no added cost to the Government. The balance of the item, the portion of the item not treated in the manner set forth above, will be treated in the manner set forth in 557.23.1.2 or 557.23.1.3.

557.23.1.2 - When the average value of the pavement thickness is equal to or greater than the specified thickness, the quantity of pavement represented by this average thickness will be paid at the contract unit price.

557.23.1.3 - When the average value of the pavement thickness is less than the specified thickness, the fraction of pavement having a thickness greater than the specified thickness minus 7.8%T will be paid for at a unit price as set forth in the following schedule, and no payment will be made for the remainder of the pavement being considered.

SCHEDULE OF UNIT PRICES

AVERAGE VALUE OF PAVEMENT THICKNESS	UNIT PRICE AS PERCENT OF CONTRACT UNIT PRICE
0.01 to 0.10 Less Than Specified Thickness	98.0
0.11 to 0.20 Less Than Specified Thickness	96.0
0.21 to 0.30 Less Than Specified Thickness	94.0
0.31 to 0.40 Less Than Specified Thickness	92.2
0.41 to 0.50 Less Than Specified Thickness	90.3
0.51 to 0.60 Less Than Specified Thickness	88.4
0.61 to 0.70 Less Than Specified Thickness	86.5
More Than 0.70 Less Than Specified Thickness	0

557.24 - PAY ITEMS:

ITEM	DESCRIPTION	UNIT
557.001	Reinforced Portland cement concrete pavement	Square metre

SECTION 558
APPROACH SLABS

558.1 - DESCRIPTION

This work shall consist of reinforced Portland cement concrete approach slabs for bridges, constructed on the completed and accepted subgrade, Subbase or other base course, in accordance with these Specifications and in reasonably close conformity with the lines, grades and dimensions specified on the Drawings or established by the Engineer.

558.2 - MATERIALS

Materials for this work shall conform to the requirements for materials in 551 except as modified.

Class 30/20 concrete, under the provisions of 551, except as may be shown differently on the Drawings or instructed by the Engineer.

Compressive strength tests of concrete shall be conducted in accordance with 551.4.4.

Reinforcing steel shall conform to the requirements prescribed in 552.

Joint materials shall conform to the requirements prescribed in 557 and 50

CONSTRUCTION METHODS

Construction methods and equipment used for this work shall conform to the requirements prescribed for construction methods and equipment in 557, except as modified.

558.3 - FORMS

Side forms may be of steel or wood and not be removed for at least 24 hours after concreting.

558.4 - PLACING

The subgrade or base shall be thoroughly moistened immediately prior to placing the concrete. The concrete shall not be placed until the forms and reinforcing steel have been checked. The Engineer shall approve the method and sequence of placing concrete.

Vibrators shall be so manipulated as to work the concrete thoroughly around the reinforcement and imbedded fixtures and into corners and angles of the forms.

558.5 - JOINTS

Approach slabs shall have longitudinal joints in line with the longitudinal joints of the adjacent pavement. Longitudinal joints shall be sawed to a minimum depth of one-fourth of the plan depth of the slab plus 6mm; the width shall be 6mm, with a tolerance of plus or minus 2mm. Sawing shall be performed within five days after the slab is placed and prior to opening to construction traffic. Joints shall be sealed in accordance with the requirements of 557.17 and 553.

558.6 - CURBS

The safety curbs shall be constructed using the same type of concrete as for the approach slab and shall be in accordance with the Drawings. The curb finish shall be in accordance with 610.

558.7 - METHOD OF MEASUREMENT

The quantity of work done will be measured in square metres of "Portland Cement Concrete Approach Slab" complete in place and accepted; the area will be measured to the extremity of the concrete.

Forms and reinforcing steel will be measured separately. Joints such as longitudinal joints and transverse joints joint fillers, dowels will be measured and paid according to section 553. Curbs will be measured separately according to Section 610.

Joints within concrete approach slabs shall not be measured separately but considered to be incidental to the pertinent placing of concrete items. Hence no separate payment shall be made for the construction of such joints.

558.8 - BASIS OF PAYMENT

The quantity, determined as provided above, will be paid for at the contract unit price bid for the item below, which price and payment shall be full compensation for furnishing all materials including, such transverse and longitudinal joints, and all labour equipment, tools and incidentals necessary to complete the work.

558.9 - PAY ITEM:

ITEM	DESCRIPTION	UNIT
558.001/2	Portland cement concrete approach slab	Square metre
558.003	Reinforcment – uncoated steel bars	Kilogram
558.004	Wrought formwork	Square metre
558.005	Sawn formwork	Square metre

SECTION 559
SEALING JOINTS AND CRACKS IN CONCRETE PAVEMENT

559.1 - DESCRIPTION

This work shall consist of the forming joints, cleaning and sealing of joints or cracks, or both, in concrete pavement in the manner and subject to the conditions and regulations prescribed.

559.2 - MATERIALS

For hot-poured joint sealing, the sealing material shall conform to the requirements of 708.3; sealing operations shall be as specified.

For sealing with preformed elastomeric seals, the sealing material shall conform to 708.2; requirements for installation of the seal shall be in accordance with 557.16.

CONSTRUCTION METHODS

559.3 - NEW CONSTRUCTION

On new concrete pavement construction, before opening to traffic all joints and cracks shall be cleaned to the full depth of the sawed cut or formed joint and sealed as prescribed.

559.4 - MAINTENANCE

In sealing joints and cracks in old concrete pavement, old filler and foreign material in the joints and cracks shall be removed. The joints and cracks shall then be sealed as prescribed.

559.5 - PREPARATION OF MATERIAL FOR USE

Before charging the compound into the melting unit, the unit shall be free from all foreign material. If the type of heater to be used requires that the sealing material, as shipped, be cut into smaller pieces before melting, the method used is subject to approval by the Engineer.

The heating kettle used for melting sealing materials shall be of the indirect heating or double boiler type, using oil as the heat transfer medium. It shall have a thermostatically controlled heat source, a built-in automatic agitator, and thermometers installed to indicate both the temperature of the melted sealing material and that of the oil bath. Other methods of indirect heating approved by the Engineer may be used. A positive means of controlling the temperature of the heat transfer medium at all points in the system shall be incorporated in the heater. Sealing material shall be uniformly heated until the pouring temperature recommended by the manufacturer is reached. Should the maximum pouring temperature recommended be exceeded, the material will be rejected. The material shall be poured as soon as possible after the pouring temperature is reached. Only sufficient material for the day's operation shall be heated each day.

559.6 - PREPARATION OF JOINTS AND CRACKS FOR SEALING

The joints shall be thoroughly cleaned of all loose scale, dirt, dust, other foreign matter, and loosely stuck particles of mortar and aggregate, so that sound and clean joint walls result. In new concrete pavement, joints shall be cleaned the full depth of the cut or formed opening; in old concrete pavement, the minimum depth of cleaning shall be 25mm, but the cleaning shall extend to a greater depth where necessary to remove loose or foreign material. This may be accomplished by use of hand tools, power tools such as rotary brushes, or by any method or combination of methods. Cracks shall be cleaned of all loose material and old sealing compound. The use of any tool, which results in damage to the pavement, is prohibited. Just prior to the actual sealing operation, the joint or crack shall be thoroughly blown out with an air jet having sufficient volume and pressure to remove any loose material left by the cleaning operation. Priming shall be required when resealing joints, which previously contained sealing material dissimilar to the new sealing material. Priming shall be accomplished by swabbing the joint walls with naphtha, varnelene, varsol, or other highly volatile type of solvent prior to the sealing operations. Moderate heating at relatively low temperature will be permitted to facilitate preparation of the primer.

Just prior to the actual hot-poured sealing operation for transverse contraction and construction joints, joint back-up material shall be inserted into the joint as shown on the Drawings. Joint back-up material shall be either stiff, self-adhering tape or acceptable rope or rod material. Joint back-up material shall be non-metallic, inert, resilient, compressible, non-absorbent, non-shrinking material compatible with the primer and sealant. Material impregnated with oil or bitumen shall not be used. The back-up material shall provide a bond breaker to insure the sealant adheres only to the joint faces and not the bottom of the reservoir. The back-up material shall also support the sealant so that it does not otherwise sag or slide into the joint below the back-up material.

559.7 - EQUIPMENT FOR APPLYING SEALER

The equipment used for the placing of sealing material in the joints may consist of conventional hand pouring pots, individual mechanical pouring kettles mounted on wheels with a pouring shoe, or heating units from which material may be discharged into the joint through the use of flexible lines and suitable shoes. Any heat, which it may be necessary to apply to sealing material after it leaves the main heating unit shall be applied by indirect and controlled methods as specified in 559.5. No direct heat will be permitted on the pouring unit in order to meet field controls set forth below. Any method of placing sealing material, which results in compliance with the following requirements, will be satisfactory.

559.8 - PLACEMENT REQUIREMENTS

All joints shall be filled to within 6mm, with a tolerance of plus or minus 2mm, of the surface of the pavement and to the depth required; in no case shall the joints be overflowed.

In resealing joints in old concrete, sealing material shall be poured to the full depth of the cleaned joint. Any spillage of sealing material on pavement areas shall be immediately removed. If pouring shoes are used which overlap the pavement surface adjacent to the joint, the resulting strip shall be straight and neat with no excess material left on the surface of the pavement. A neat and workmanlike job will be required at all times. At no time shall sealing material be placed in a joint which is either dirty or wet. The joint shall be clean and surface dry at the time of placement. Work will be suspended when joints are wet or damp and when atmospheric temperature is below the minimum specified by the manufacturer.

559.9 - METHOD OF MEASUREMENT

Forming any new joints shall not be measured separately but considered to be incidental to the pertinent placing of concrete pay items. Sealing cracks are to be Contractor's responsibility.

559.10 - BASIS OF PAYMENT

No separate payment will be made under this Subsection

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SECTION 560
WATERPROOFING

Due to the nature and configuration of box culverts, retaining walls and the outline designs provided by the Employer in respect of bridge structures, as they are defined in the bidding documents, there will be no requirement in respect of waterproofing for these structures. However, this statement shall not be construed to preclude waterproofing from any Alternative Design which a bidder may submit in respect of bridges structures.

Waterproofing of metal structures, as necessary, shall be included for in the supplier's (proprietary) design and shall be paid for as a component of the 'metre' pay unit in the Bills of Quantities.]

560.1 - DESCRIPTION

This work shall consist of waterproofing concrete retaining walls, abutments, earth-filled arches, and concrete decks, either in the form of damp proofing (primers with bituminous paint coat) or membrane waterproofing (primers with bituminous membrane fabric, with or without protection course) as specified on the Drawings. Damp proofing shall consist of a primer and two coats of bituminous materials. Membrane waterproofing shall consist of a primer, two layers of fabric, and three mappings of hot bituminous material. The work shall be done in accordance with the Specifications and as shown on the Drawings.

560.2 - MATERIALS

The materials shall conform to the requirement of the several Subsections of Division 700 of these Specifications as follows:

Material	Sub-Section	Type
Damp proofing Primer	705.4, 705.11 or 705.8	SS-1 or SS-1h CSS-1 or CSS-1h
Damp proofing Agent	705.4, 705.11 705.7	SS-1 or SS-1h CSS-1 or CSS-1h
Membrane Waterproofing	705.8	
Membrane Waterproofing	705.7	
Waterproofing Fabric	715.8	
Reinforcing Steel	709.3	
Hot-Poured Elastic Type Concrete Joint Sealer	708.3	

When the damp proofing agent is SS-1, the primer shall be SS-1 to which shall be added a maximum of 15 percent water by weight.

Membrane fabric shall be stored in a dry, protected place. The rolls shall not be stored on end.

CONSTRUCTION METHODS

560.3 - PREPARATION OF SURFACE

Before applying the primer coat, all rod holes and other voids shall be pointed, and all projections, loose material, and excess dust shall be removed from the surface.

When emulsion is used, the surface may be damp.

When asphalt is used, the surface shall be thoroughly dry. Should the surface be damp, it shall be covered with a 150mm layer of hot sand which shall be allowed to remain for two hours, after which it shall be swept back, uncovering sufficient surface for beginning of work, and the operation repeated as the work progresses. For surfaces too steep to hold sand, other satisfactory methods to produce a dry surface shall be used. No waterproofing shall be done in wet weather or when the temperature is below 2°C, without written authority of the Engineer.

560.4 - DAMPROOFING

The entire surface to be damp proofed shall be covered with the required primer by use of a mop. After this primer has been allowed to cure, two successive mappings with an asphalt cement or asphalt emulsion shall be applied. All coats shall be of uniform thickness throughout, and the total bituminous material used shall be not less than 4.5 litres per square metre of surface. Each coat shall be allowed to dry thoroughly before the following coat is applied.

Before damp proofing is started, all construction joints shall be waterproofed in accordance with 560.5, with fabric membranes 600mm wide for the full length of the joint.

560.5 - MEMBRANE WATERPROOFING

The asphalt primer shall be heated to a temperature between 38°C and 52°C, with frequent stirring to avoid local overheating. The asphalt for waterproofing shall be heated to a temperature between 150°C and 175°C, with frequent stirring to avoid local overheating. The heating kettles shall be equipped with thermometers.

In all cases, the waterproofing shall begin at the low point of the surface to be waterproofed so that water will run over and not against or along the laps. The first strip of fabric shall be of half width, the second shall be of full width, lapped the full width of the first sheet, and the third and each succeeding strip shall be the full width and lapped so that there will be two layers of fabric at all points with three-layer lap for a distance not less than 50mm. All two-layer end laps shall be at least 300mm.

The procedure for applying primer and waterproofing with membrane Fabric shall be as follows:

i. Beginning at the low point of the surface to be waterproofed, the entire surface shall be mopped with a primer of cutback asphalt and allowed to cure.

ii. A section slightly more than half the width of the membrane fabric and for the full length of the surface shall be mopped with asphalt cement and a half width of the fabric pressed into place.

iii. The half width of fabric and an adjacent section of the surface equal to slightly more than half the width of the fabric shall be mopped with asphalt cement and a full width of fabric pressed into place, completely covering the first strip.

lv. Slightly more than half of this second strip and an adjacent section of the concrete surface equal to slightly more than half the width of the fabric shall be mopped with an asphalt cement, and the third strip of fabric shingled on so as to lap the first strip more than 50mm. This process shall be continued until the entire surface is covered with two layers of fabric.

The entire surface shall then be given a final mopping with asphalt cement.

The completed waterproofing shall be firmly bonded membrane composed of two layers of fabric and three mappings of asphalt, together with a coating of primer. Under no circumstances shall one layer of fabric touch another layer at any point, or touch the surface of the structure, unless separated from that layer or surface by one coat of asphalt.

On horizontal surfaces, not less than 5 litres of asphalt shall have been used for each square metre of finished work; and on vertical surfaces, not less than 6.5 litres shall have been used. The work shall be so regulated that at the close of a day's work all fabric that is laid shall have received the final mopping of asphalt. Special care shall be taken at all laps to see that they are thoroughly sealed.

560.6 - DETAILS

At the edges of the membrane and at any point where it is punctured by drain, pipes, etc., suitable provisions shall be made to prevent water from getting between the waterproofing and the surface waterproofed. All flashing at curbs and against girders, spandrel walls, etc., shall be done with separate sheets lapping the main membrane not less, than 300mm. Flashing shall be closely sealed either with a metal counter flashing or by embedding the upper edges of the flashing in a groove poured full of joint sealing material.

Joints, which are essentially, open joints, but which are not designed to provide for expansion, shall first be caulked with oakum and lead wool and then filled with hot joint sealing material.

Expansion joints, both horizontal and vertical, shall be provided with sheet copper in "U" or "V" form, in accordance with the details shown on the Drawings, and shall be filled with hot joint filler sealing material. The membrane shall be carried continuously across all expansion or construction joints. At the ends of the structure, the membrane shall be carried well down on the abutments and suitable provision made for all movement.

Care shall be taken to prevent injury to the finished membrane by the passage over it of men, wheelbarrows, etc., or by throwing any material on it. Patching shall repair any damage, which may occur. The first layer of the membrane patch shall extend at least 300mm beyond the outermost damaged portion, and the second ply shall extend at least 75mm beyond the first ply.

560.7- PROTECTION COURSE

Over the waterproofing membrane constructed as specified above, there shall be placed a protection course, which shall be 75mm of Class 20/20 concrete. This concrete shall be reinforced midway between its top and bottom surfaces with wire mesh having 150mm openings each direction and using size # W 1.4 wire. The construction of the protection course shall immediately follow the waterproofing operations.

560.8 - METHOD OF MEASUREMENT

The quantities of work done will be measured in square metres of "Damproofing", "Membrane Waterproofing without Protection Course", or "Membrane Waterproofing with Protection Course", as the case may be, complete in place and accented, determined from actual measurement of the work.

All types of surfaces are added together irrespective of whether they are curved, isolated small surfaces or inclined.

Items for waterproofing shall be deemed to include preparing surfaces, forming joints, overlaps, mitres, angles, fillets, built-up edges and laying to falls or cambers.

560.9 - BASIS OF PAYMENT

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labour, tools, equipment, supplies, and incidentals necessary to complete the work.

560.10 - PAY ITEMS:

ITEM	DESCRIPTION	UNIT
560.001	Dampproofing	square metre
560.002	Membrane waterproofing without protection course	square metre
560.003	Membrane waterproofing with protection course	square metre

SECTION 561
PNEUMATICALLY APPLIED MORTAR

561.1 - DESCRIPTION

This work shall consist of repair of concrete structures, protection of structural steel, or any other type of work as may be designated on the Drawings, using pneumatically placed mortar, in accordance with these Specifications and in reasonably close conformity with the dimensions and design shown on the Drawings or as directed by the Engineer. It shall include removal of all loose, soft, honeycombed, and disintegrated concrete, the removal of sound surface concrete in areas designated for repair, the preparation of the surface, the furnished and placing of reinforcing steel, including wire fabric, dowels, and expansion anchor bolts, and mixing and applying pneumatically placed mortar composed of Portland Cement and sand.

Pneumatically placed mortar will be designated as Shotcrete. Shotcrete shall generally be used where the depth of repair does not exceed 150mm.

561.2 - MATERIALS

All materials shall conform to the requirements of Division 700, unless otherwise indicated.

For sandblasting operations the sand shall conform to the requirements in 688.2.4.1 and 688.2.4.3, III.

The reinforcing wire mesh shall be 75mm by 75mm by Size No. W 1.4 wire, unless noted otherwise on the Drawings.

CONSTRUCTION METHODS

561.3 - PROPORTIONING AND MIXING

Shotcrete shall consist of a mixture of Portland cement and sand (three to five percent moisture) in the proportion of one part cement to three parts sand (dry, loose measurement, due allowance being made for bulking). The materials shall be thoroughly mixed dry in a batch mixer. Before placing the mixture in the hopper, all lumps over 6mm shall be removed by screening.

561.4 - CLEANING

In concrete repair work, disintegrated concrete shall first be removed with pneumatic or hand tools. The surfaces shall then be thoroughly blasted to remove all dirt and loose materials, special care being taken in concrete repair work to thoroughly clean exposed reinforcing rods. Prior to applying each coat of Shotcrete, the concrete surfaces shall be cleaned and washed down with water and compressed air.

Structural steel shall be thoroughly cleaned of paint, rust, grease, and other foreign material. The Contractor may be required to Abrasive Blast Clean for this purpose.

561.5 - PLACING REINFORCING MESH

561.5.1 - Repairing Concrete Work

In repairing concrete work, the reinforcing mesh shall be fastened to the concrete with 6mm x 100mm expansion bolts spaced approximately 750mm each way. Lapping of adjacent sheets shall be at least 100mm in each direction and all laps shall be firmly tied together at intervals not exceeding 450mm.

Care shall be taken to place the mesh away from the proposed finished concrete surface so that approximately a 20mm layer of Shotcrete shall be maintained outside of the plane of the mesh. In places where repairs are necessary for depths of 75mm or more over considerable areas, two or more mesh layers may be used, the first being placed 20mm out from the existing concrete.

561.5.2 - Covering Structural Steel

In placing reinforcing mesh around structural steel, the mesh shall be cut in sheets of the proper size and separate sheets shall be bent carefully over templates in such a manner as to follow closely the outlines of the members to be covered and shall be securely held about 20mm out from the surfaces of the members. Adjacent sheets of mesh shall lap at least two meshes.

In placing the mesh, the rods shown on the Drawings shall first be fastened to the steel, and subsequently the mesh shall be securely tied outside of these rods with wires spaced at approximately 300mm intervals. To allow for fasteners for holding the rods, holes not less than 14mm diameter shall be punched or drilled in the webs of members as near as possible to the top and bottom flanges. These holes shall be spaced on approximately 900mm centres. Where steel members are more than 1200mm in depth, and additional row of holes, spaced on approximately 900mm centres, shall be provided on the centreline of the web.

561.6 - PLACING SHOTCRETE

561.6.1 - General

Only experienced men shall be employed in placing Shotcrete.

561.6.2 - Pressures

The pressure in the lower chamber of the cement gun shall be that which will produce a nozzle velocity of 115 to 150 metres per second when a tip with a 20mm or 25mm opening is used, and a nozzle velocity of 130 to 165 metres per second when a tip with a 32mm opening is used. These velocities must be steadily maintained and shall be determined by a suitable nozzle velocity meter attached to the cement gun.

Water used for hydration at the nozzle shall be maintained at a uniform pressure, which shall not be less than 100 kPa greater than the air pressure in the cement gun. In no case shall a greater amount of water be used than that necessary to produce proper hydration, especially when vertical surfaces are shotcreted.

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561.6.3 - Thickness of Covering

In repairing concrete, the Shotcrete shall be placed to a minimum total thickness of 25mm in two or more coats. In covering structural steel, the Shotcrete shall be placed to a thickness of 40mm and in two layers.

In all cases, the final coat shall be shotcreted to a thickness of 15mm against the previously straightened and thoroughly cleaned and wetted surfaces.
The stream of materials from the nozzle shall impinge as nearly as possible at right angles to the surface being covered. Any deposit of loose sand shall be removed prior to placing any original or succeeding layers of Shotcrete. After placing, all mortar patches shall be sounded and any indications of pockets shall be investigated and repaired as directed by the Engineer.

561.6.4 - Joints

At the end of any day's work or similar stopping period, the Shotcrete shall be sloped off to a thin edge. Before shooting the adjacent section, the sloped portion shall be thoroughly cleaned and wetted. No square joints will be allowed.

561.6.5 - Forms

Forms shall be structurally sufficient and of such design that rebound or accumulated loose sand can freely escape or be readily removed. Shooting strips shall be used at corners, edges, and on surfaces where necessary to obtain true lines and proper thickness.

561.6.6 - Finishing and Curing

Following applicable layers of Shotcrete, the concrete surface shall be wood or steel finished as directed by the Engineer.

The Shotcrete shall be covered with burlap mats and kept wet for at least one week after placing; but where not practicable to use mats, it shall be kept wet by sprinkling for the same length of time.

561.7 - METHOD OF MEASUREMENT

561.7.1 - Repairing Concrete Structures

Measurements will be based on the amount of cement in hundred kilograms used in the Shotcrete, the kilogram of Shotcrete reinforcing mesh, and the number of hook expansion bolts. Measurement will only be made for repairs to existing structures, and not to any structures constructed under this project.

561.7.2 - Covering Structural Steel

Measurement of all areas of Shotcrete shall be the actual area of the members to be covered, to the lines of the members, all as instructed by the Engineer ands/or shown on the Drawings.

561.8 - BASIS OF PAYMENT

561.8.1 - Repairing Concrete Structures

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the works to existing, and not new structures.

561.8.2 - Covering Structural Steel: The quantity, determined as provided above, will be paid for at the contract unit price bid for the item in 623.9.2, which price and payment shall be full compensation for furnishing all the materials, including reinforcing mesh and rods, and doing all the work prescribed in a workmanlike and acceptable manner, including all labour, tools, equipment, supplies and incidentals necessary to complete the work.

561.9 - PAY ITEMS:

561.9.1 - Repairing Concrete Structures:

561.9.2 – Covering Structural Steel:

ITEM	DESCRIPTION	UNIT
561.001	Cement for shotcrete	Kilogram
561.002	Reinforcing mesh	Kilogram
561.003	Hook expansion anchor bolt	Each
561.004	Shotcrete to concrete surface	Square metre
561.005	Shotcrete to steel surface	Square metre

SECTION 562
PREFORMED ELASTOMERIC JOINT SEALER AND BRIDGE EXPANSION JOINT

562.1 - DESCRIPTION

This work shall include furnishing and installing preformed elastomeric joint sealers and expansion joints for bridge decks in accordance with these Specifications, the Drawings and/or instructed by the Engineer.

562.2 - MATERIALS

Material for preformed elastomeric joint sealer shall conform to the requirements of 708.2.

CONSTRUCTION METHODS

562.3 - PREPARATION PREFORMED ELASTOMERIC JOINT

The joint shall be formed to provide the nominal opening at the specified temperature as shown on the Drawings, edges of concrete or epoxy mortar adjacent to the joint shall be rounded to a radius of not more than 6mm. A joint having insufficient opening may be required to be sawed or ground to the proper size. Where a joint opening is larger than that specified, the Contractor may be required, at his own expense, to build up the joint with epoxy mortar or to furnish a larger size sealer as determined by the Engineer. Before placement of the sealer, the joint shall be thoroughly cleaned by brushing, compressed air or other means, so that it is free from dust, oil, grease or other foreign materials.

562.4 – INSTALLATION OF PREFORMED ELASTOMERIC JOINT

The sealer shall be installed by suitable hand or machine tools, which will not cause injury to the material during installation. A lubricant or lubricant-adhesive shall be used if, and as, recommended by the manufacturer of the sealer. During installation, the sealer shall not be subjected to lengthwise stretching; the length to be installed shall be measured prior to installation and cut or marked to indicate the installed length. Sealer for transverse joints shall be in one continuous length; longitudinal joint sealers may be spliced at intervals of not less than 15 metres except where intersected by transverse joints. The top surface of the sealer after installation shall be 6mm, with a plus 2mm tolerance, below the adjacent roadway surface.

562.5 – PREPARATION OF BRIDGE EXPANSION JOINT

The joint shall be formed to provide the nominal opening at the specified temperature as shown on the Drawings. Preparations for the installation of bridge expansion joints shall be in accordance with the manufacturer's instructions.

562.6 – INSTALLATION OF BRIDGE EXPANSION JOINT

Expansion joints shall have good riding quality and skid resistance and shall not cause a hazard to any class of road user. Expansion joints shall be capable of sustaining the designed loads and movements without damage to the surfacing or the supporting structure during their working lives. The fixing to the bridge structure of the appropriate components of all expansion joints shall be in accordance with the manufacturer's instructions. Where described in the manufacturer's details the expansion gap joint shall be sealed with a joint seal. The interface between the expansion joint and the deck shall be watertight. Expansion joints shall be generally installed in a

straight line and where there is an expansion joint gap it shall be of a uniform width never less than 10% of the range of movement or 6mm whichever is the greater. The joint is to be installed by a competent contractor familiar with the system.

562.7 - METHOD OF MEASUREMENT

Joints will be measured in place in linear metres to include filler, sealant, fixing devices, cover plate and runners.

562.8 - BASIS OF PAYMENT

The cost of preformed elastomeric joint sealer and bridge expansion joint, complete in place, including lubricant or lubricant-adhesive, cover plates, runners and seals will be paid for at the contract unit price bid for the pay items listed below, which price and payment shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner including all labour, tools, equipment, supplies and incidentals necessary to complete the work.

562.9 - PAY ITEMS:

ITEM	DESCRIPTION	UNIT
562.001	Elastomeric joint seal	Linear metre
562.002	Bridge expansion joint	Linear metre

SECTION 563
DRILLED CAISSON FOUNDATIONS

563.1 - DESCRIPTION

The work of this section includes the furnishing of all materials and the construction of foundations consisting of reinforced concrete caissons placed within drilled excavations. Each drilled caisson foundation shall consist of a shaft section, with the lower portion in a drilled rock socket and with the upper portion in a steel casing. This casing will normally be removed during concrete placement unless otherwise shown in the Drawings or directed by the Engineer.

563.2 - TESTS AND SUBMITTALS

The Contractor shall deliver all submittals required by this specification to the Engineer no later than one month prior to constructing any drilled caissons shown in the Drawings. No drilled caissons shall be constructed prior to the Engineer's review and acceptance of all submittals and test hole results.

563.2.1 - Experience

A satisfactory record of experience in drilled caisson construction is considered to be of the utmost importance in obtaining a satisfactory drilled caisson installation. The installation of the drilled caisson is required to be performed by a contractor or specialty subcontractor specializing in installing drilled caissons and having experience with caissons of similar length, diameter, and subsurface conditions as those shown in the contract documents.

The Contractor shall submit data on at least two projects performed during the past ten years, for which the Contractor (or the Sub-Contractor if applicable) has installed drilled caissons of a range of diameters and lengths similar to those shown in the Drawings, in similar quantities, and under similar subsurface conditions. The list of projects shall contain names and phone numbers of owners' representatives who can verify the participation in those projects.

The Engineer shall review and approve the Contractor's (Sub-Contractor's) caisson. If in the opinion of the Engineer, the Contractor's qualifications are not adequate, the Contractor shall submit to the Engineer a proposed method of obtaining the necessary qualifications.

The installation of all components of the drilled caisson including; drilling, reinforcement placement, concrete placement, and required wet hole condition work, casing installation and removal, slurry placement, and any other work required to complete the drilled caisson, shall be performed by the approved contractor or specialty subcontractor.

563.2.2 - Site Inspection:

A signed statement shall be submitted affirming that the Contractor (or the Sub-Contractor if applicable) has inspected the project site and the available subsurface information including any available soil or rock samples.

563.2.3 - Installation Plan:

The Contractor shall submit an Installation Plan for review by the ER. This plan shall provide information on the following:

Name and experience record of the drilled caisson superintendent in charge of drilled caisson operations for this project.

List of proposed equipment to be used on the project, including barges, cranes, templates, drill rigs, drills, augers, bailing buckets, final cleaning equipment, slurry de-sanding equipment, slurry pumps, core sampling equipment, welding equipment, tremie or concrete pumps, casing, etc.

Details of overall construction operation sequence and the sequence of caisson construction in the piers and/or the abutments; taking due care not to damage fresh concrete by drilling in the immediate vicinity too quickly.

Method for maintaining drilled caisson position and alignment during excavation, and details and sequencing of caisson excavation.

Details of casing and splices to be used, including calculations (signed and stamped by a Professional Engineer knowledgeable in drilled caissons) showing ability of casing to withstand anticipated hydraulic and earth pressures and to withstand stresses due to installation without undue deformation. Description for withdrawal of casings to demonstrate that concrete will not be lifted during withdrawal.

When the use of slurry is anticipated, details of the methods to mix, circulate, and de-sand slurry. Any request to use a slurry displacement method for the construction of caissons shall also provide information for the Engineer's approval as follows:

(i) Detailed description of proposed construction method.
(ii) Concrete mix, as modified for use with the slurry displacement method.
(iii) Components and proportions in proposed slurry mixture. 412
(iv) Tests proving slurry mixture will not degrade rock or interfere with bond.
(v) Methods to agitate slurry mixture prior to concrete placement.
(vi) Methods to clean slurry mixture for re-use.
(vii) Disposal methods for used slurry.

Details of methods to thoroughly clean the caisson excavation.

Details of reinforcing cage fabrication and placement including support of the reinforcing cage during handling, after installation, and during concrete placement, along with methods and devices that will be used to centre the reinforcing cage and maintain concrete cover over the bars.

Details of concrete placement including proposed operational procedures for free-fall, tremie, pumping or other methods.

Sample of proposed drilled caisson report, proposed drilled caisson log, and proposed Pre--installation core hole log.

Welding procedures and qualifications of welders and tackers as specified in ANSI/AWS D1.1 for casing steel and in ANSI/AWS D1.4 for reinforcing steel.

Pre-installation Coring procedure:

Qualifications and experience record of firm proposed to perform Pre-installation Coring, including experience record of the supervisor designated to oversee the work.

Mix design for concrete and for non-shrink grout.

Plan to minimize vibration and wheel loads in the vicinity of newly placed caissons.

Plan for compliance with applicable environmental regulations, including but not limited to the protection of river water from degradation due to material excavated from drilled caisson locations or due to other harmful erosion, protection of the environment from slurry spillage or discharge if slurry is used, and general environmental protection of the area from all operations related to drilled caissons.

The Engineer will evaluate the Drilled Caisson Installation Plan for conformance with the Drawings and Specifications. Within 14 days after receipt of the Drawing, the Engineer will notify the Contractor in writing of any additional information required and/or changes necessary to meet the contract requirements. All procedural approvals given by the Engineer shall be subject to trial in the field and shall not result in any additional cost to the client if they fail to perform also shall not relieve the Contractor of the responsibility to satisfactorily complete the work as detailed in the Drawings and Specifications.

563.2.4 - As-Built Records:

Within 24 hours of the completed construction of each drilled caisson, the Contractor shall submit a report on the actual location, alignment, elevation, and dimensions of the drilled caisson, and will also submit a completed drilled caisson log as specified herein.

563.2.5 - Test Hole:

A test hole shall be drilled at the location and to the diameter and depth shown in the Drawings. The test hole shall be un-reinforced but shall otherwise be constructed the same as other drilled caissons in this specification. The Contractor shall revise his methods and equipment as necessary during construction of the test hole when he is unable to carry out the requirements of this specification. Completed test holes shall be left in place except that the top of the caisson shall be removed to a depth of 600mm below final ground line. Disturbed areas at the site of the test hole shall be restored to their original condition. If the Contractor fails to demonstrate the adequacy of his methods or equipment, the Engineer shall require additional test holes be provided at the Contractor's expense.

563.2.6 - Non-destructive Testing

563.2.6.1 - General Requirements:

The non-destructive testing method known, as Cross Hole Sonic Logging (CSL) shall be used on any drilled caisson, which is constructed with the placement of concrete underwater, or as required in the Drawings. The testing shall not be conducted until at least twenty-four hours after placement of concrete is concluded in the caisson, and will be completed within 14 calendar days after such placement.

The Engineer with the cooperation of the Contractor shall conduct the CSL tests. The Contractor shall provide suitable working space and access to every tested caisson and shall provide a reliable 1000-watt generator for use by the Engineer.

563.2.6.2 - Preparation for Testing:

To accommodate the CSL test requirements, the Contractor shall install a number of tubes in each caisson to be tested. The number of tubes per caisson shall be as tabulated below:

TABLE 563.2.6.2

Caisson Diameter	Number of Tubes	Tube Spacing
Up to 1 049 mm	3	120°
1 050 mm to 1 499 mm	4	90°
1 500 mm to 2 399 mm	6	60°
2 400 mm and larger	8	45°

The tubes shall be per 563.4.4. Each tube shall have a round, regular internal diameter free of defects or obstructions including defects or obstructions at pipe joints; in order to permit the free, unobstructed passage of 35mm diameter source and receiver probes. The tubes shall be watertight and free from corrosion with clean internal and external faces to ensure passage of the probes inside and a good bond with the concrete outside. Each tube shall be fitted with a watertight shoe on the bottom and a removable cap or plug on the top. The tubes shall be securely attached to the interior of the reinforcing steel cage. The tubes are typically wire-tied to the reinforcing cage every 1,000mm, or otherwise secured such that the tubes stay in position during placement of the cage and during placement of concrete. The tubes shall be installed in each shaft in a regular, symmetric pattern such that the tube spacing in degrees will correspond to that shown in the table above.

The tubes shall be as near to parallel as possible. They shall extend from 150mm above the caisson bottom to at least 1,000mm above the caisson top. No tube may be allowed to rest on the bottom of a drilled excavation. If the caisson top is sub-surface, then the tubes shall extend at least 600mm above the ground surface or above the water surface if the ground surface is below water. Any joints required to achieve full-length tubes shall be made watertight. Care shall be taken during placement of the reinforcing steel cage so as not to damage the tubes.

After placement of the cage, and before placement of concrete, the tubes shall be filled with clean water and the tube tops shall be capped or sealed to keep debris or other foreign matter out of the tubes. Care shall be exercised in the removal of caps or plugs so as not to apply excess torque, hammering, or other stresses that could break the bond between the tubes and the concrete.

563.2.6.3 - CSL Logging Procedures:

Before placement of concrete, the Contractor shall investigate at least one tube per shaft. This investigation is to make sure that there are no bends, crimps, obstructions or other impediments to the free passage of the testing probes. A record of the tube length or lengths, including a note of the projection of the tubes above the top of the shaft shall be made. The Contractor shall provide information on the shaft bottom and top elevations, length and construction dates to the Engineer prior to the CSL tests.

The Contractor shall make the caisson and the caisson site available to the Engineer for the conduct of the CSL tests. The Engineer shall evaluate any defects indicated by tests and further tests may be conducted in regard to the extent of such defects. Any time required by such tests

will be considered incidental to the work and will not be cause for extra compensation related to a claim or extension of contract.

563.2.6.4 - CSL Testing Results:

The CSL test results will be compiled into a caisson integrity testing report for each caisson. The report will summarize and analyse any defect zones indicated on the logs. A copy of each report will be provided to the Contractor.

563.2.6.5 - Evaluation of CSL Test Results:

The Engineer will evaluate the CSL test results and will determine whether or not the drilled caisson as constructed is acceptable. If the Engineer determines that the drilled caisson is acceptable based on the CSL tests, then the caisson and the caisson site will be turned back to the Contractor and further construction may proceed.

The acceptance of each drilled caisson shall be the decision of the Engineer, based on the results of the caisson integrity testing report and other information on the caisson placement. Rejection of a caisson shall require conclusive evidence that a defect exists in the caisson, which will result in inadequate or unsafe performance under service loads. If the Non Destructive Testing records are complex or inconclusive, the Engineer may require the Contractor to verify caisson conditions, in accordance with 563.2.6.6. If a defect is confirmed, the Contractor shall pay for all coring and grouting costs. If no defect is encountered, compensation for all coring and grouting will be in accordance with these Specifications. In the case that any caisson is determined to be unacceptable, the Contractor shall submit a plan for remedial action to the Engineer for approval. Any modifications to the foundation caisson and load transfer mechanisms caused by the remedial action will require calculations and working drawings stamped by a professional engineer for all foundation elements affected. All labour and materials required to perform remedial caisson action shall be provided at no cost to the Employer and with no extension of the contract time.

563.2.6.6 - Evaluation by Core Drilling:

A drilled caisson that is found to be unacceptable shall be cored by the Contractor using double tube core barrels. One or more core holes shall be drilled at the location(s) as determined by the Engineer . A core sample shall be taken from each defect location, at a length specified by the Engineer. An accurate log of the core shall be kept and the core shall be crated and properly marked showing the caisson depth at each interval of core recovery. The core along with five copies of the coring log shall be provided to the Engineer.

If the quality of the caisson, as represented by the core samples, is determined to be acceptable, then the caisson and the caisson site will be turned back to the Contractor and further construction may proceed. If the quality of the caisson is determined to be unacceptable, then the Contractor shall proceed in accordance with 563.2.6.5.

563.3 - DIMENSIONAL REQUIREMENTS:

The dimensional requirements for Placement Tolerances and Caisson Diameters shall be met prior to placement of reinforcing steel. The Contractor shall submit his corrective plan for any deviation from the caisson location, alignment and elevation tolerances, and reinforcement dimensional requirements to the Engineer for approval. The cost of any corrective action shall be borne by the Contractor.

563.3.1 - Placement Tolerances:

For any drilled caisson the maximum permissible deviation from plumb shall be 1% or a ratio of 1:100 with respect to a truly vertical axis. For any drilled caisson at its top, the maximum deviation of the centre shall be 75mm from its project plan location.

563.3.2 - Caisson Diameters:

Rock sockets shall be of a minimum diameter equal to the caisson diameter shown in the Drawings. Casings, extending upward from the rock surface, shall have a minimum inside diameter equal to the caisson diameter shown in the Drawings, but may be larger in diameter to expedite the Contractor's operations.

563.3.3 - Bottom Excavation:

Excavation equipment and methods shall provide the completed caisson excavation with a flat bottom. The cutting edges of excavation equipment shall be normal to the vertical axis of the equipment within a tolerance of plus or minus 30mm per 1,000mm of diameter.

563.3.4 - Caisson Cut-off Elevations:

For any drilled caisson the maximum permissible deviation from finished top of shaft elevation shall be minus 25mm and plus 25mm.

563.3.5 - Reinforcement:

After all concrete has been placed, the top of the reinforcing steel cage shall be no more than 100mm above, and no more than 50mm below, the plan elevation. The clearance to the reinforcing steel shall be 100mm, plus or minus 25mm. An absolute minimum clearance of 75mm to the reinforcing steel is strictly required.

563.4 - MATERIALS:

563.4.1 - Concrete:

Concrete for the drilled caissons shall be Class 30/20 and shall conform to the requirements of Section 551 of the General Specifications. The design 28-day compressive strength shall be not less than 30 Mpa unless shown otherwise in the Drawings. The Contractor will prepare a mix design to attain this strength, retaining the basic characteristics of Class 30/20 concrete. Slump for dry placement will be 175mm plus-or-minus 25mm. unless otherwise specified in the Drawings; the cement shall be Type I.

For placement of caisson concrete by tremie or pumping, the cement content shall be increased to 435 kg/m^3, the slump shall be 200mm plus-or-minus 25mm and shall maintain a slump in excess of 100mm throughout the concrete placement, and the maximum aggregate size shall be 25mm.

563.4.2 - Reinforcing Steel:

Reinforcing steel for main vertical bars and ties shall conform to Section 552.

563.4.3 - Casing:

Metal casing shall be used whenever required to prevent caving of the soil material or to exclude ground water. Casing shall be metal, of unit or sectional construction, be strong enough to withstand handling stresses, withstand the pressures of concrete and of the surrounding earth and ground water, and prevent seepage of water. Also, the casing used shall be selected by the Contractor to control dimensions and alignment of excavations within tolerances, to seal the casing into impervious materials, and to execute all other construction operations.

Casing pipe shall conform to ASTM A 252/A 252M, Grade 2, for either temporary or permanent application. Any required casing splices shall be welded in accordance with Section 563.2.3 e) of this specification with no interior splice plates, producing true and straight casing. All welding shall be in accordance with ANSI/AWS D1.1.

Permanent casing is required in all caissons where noted on the Drawings. All temporary casing shall be removed during placement of concrete unless otherwise noted on the Drawings. Should the Contractor be unable to remove the temporary casing, the Contractor shall pressure grout the annular space between the casing and soil. Materials and methods for grouting operation shall be submitted to the Engineer for approval for the grouting operation at no additional cost to the Employer.

563.4.4 - CSL Testing Tubes:

Tubes required for CSL Tests shall be ASTM A53, Grade B, nominal 50mm diameter. Hydrostatic test requirements are waived. Threaded Couplings shall be used per ASTM A 865.

563.5 - CONSTRUCTION:

563.5.1 - General:

The following sequence describes a generalized construction method that is expected to be appropriate for the installation of the drilled caissons. Deviations will be permitted with the Engineer's approval.

a) Excavate to top of shaft elevation.

b) Drilling of a "Pre-installation Core Hole" prior to drilling of caisson hole. The drilling and sampling of the pre-installation core holes shall be done by use of double tube core barrels. Additional pre-installation core holes in other locations may be required where directed by the Engineer Representative . Such additional core holes shall be paid for at the contract unit bid price. The pre-installation core hole will be drilled at the bottom of the rock socket, downward a distance equal to the caisson diameter below the expected bottom of rock socket. Its purpose is to assure that the rock just below the socket is sound and able to carry the loads that will be imposed on it. A pre-installation core hole is a 50mm nominal diameter hole, with coring, where the quality of the rock core and the rate of drilling are used to determine if there is satisfactory rock of sufficient type and thickness, and to locate the presence of open joints, voids, soft rock or other deleterious material. Logs of the core hole shall be provided to the Engineer within 24

hours of completion of coring. All cores shall be maintained by the Contractor until completion of the project and shall then become the property of the Engineer.

c) Drilling of cased hole through the soil overburden down to top of competent rock. Sealing bottom of casing if necessary to prevent entry of ground water.

d) Drilling of rock socket to the minimum diameter shown in the Drawings and to a depth shown on the drawings or otherwise directed by the Engineer.

e) Cleaning of the drilled hole, particularly the rock socket and the inside face of the casing; inspection of the hole and approval for placement of the caisson material.

f) Placement of the pre-assembled cage of reinforcing steel and securing it in place against movement during concreting and during casing withdrawal. It also must be secured in such a way that the minimum clear cover over the bars is maintained. Placement of tubes as required for CSL testing.

g) Placement of concrete in either dry or wet conditions. In the case of dry conditions, concrete placement shall be by the free-fall method with the concrete carefully directed down the centre of the caisson without striking the casing, the reinforcing steel, the CSL tubes or the sides of the rock socket. In the case of wet conditions, concrete placement shall be by tremie or pumping with the mix adjusted accordingly. If the temporary casing is to be removed it shall be withdrawn carefully and slowly so as not to leave any voids in the concrete and so as not to dislocate any reinforcing steel. Any concrete not meeting this specification's slump requirements shall be rejected.

h) For any parts of any caisson that extend above either the existing or permanent grade, that portion shall be placed by use of forms of the diameters shown in the Drawings. Curing, stripping, and finishing shall be the same as for other structural concrete. Casing may be used as forms.

i) Turning the site over to the Engineer for CSL testing if required. Cooperation with the Engineer in the conduct of the testing, as specified herein. Corrective measures for any unacceptable caissons. Removal of water from the CSL tubes and filling with an approved grout. All core holes must be filled with an approved grout.

563.5.2 - Excavation:

563.5.2.1 - Scope:

All excavation of the foundations in which drilled caissons are to be constructed shall be completed down to the bottom of the footing before caisson construction begins, unless otherwise authorized by the Engineer . The Contractor shall drill one core hole at each caisson location. The Contractor shall perform all excavations required for the caissons and the rock sockets, through whatever materials are encountered, to the dimensions shown in the Drawings, or required by the site conditions, or directed by the Engineer . The Contractor shall make each caisson excavation available to the Engineer for inspection, providing tools, equipment, and safety measures as hereinafter specified. Upon direction of the Engineer, the Contractor will drill pre-installation core holes. Based on pre-installation core hole information or on general inspection of the rock socket, the Contractor shall drill the rock socket deeper if directed by the Engineer.

563.5.2.2 - Excavation through Overburden:

Unless otherwise shown in the Drawings, drilled caisson excavations in the overburden shall be vertical bored holes extending from the ground surface down to the surface of competent rock.

Temporary or permanent casings will be required down to the competent rock surface and shall be seated in rock in a manner that prevents caving and prevents the entry of ground water. In the event of a groundwater condition, appropriate measures shall be taken subject to the Engineer Representative approval. Such measures may include pumping from within the excavation, external dewatering, or excavation through a slurry-filled hole until the casing can be seated and sealed. In cases in which the water is difficult to control, the Engineer may permit wet excavation which could require later inspection by diving methods and would require later placement of concrete by underwater methods.

563.5.2.3 - Excavation in Rock:

Rock sockets shall be excavated to the dimensions and depths shown in the Drawings, forming a flat bearing area at the bottom of the socket. Each socket shall be excavated into continuous rock for the indicated length, by use of methods subject to the Engineer approval. Blasting methods will not be permitted.

Upon completion of each rock socket excavation, the Engineer may (1) accept the socket, or (2) order deeper excavation based upon pre-installation core hole data or general inspection of the socket. The adequacy of each socket will depend on the soundness of its bottom surface and on the soundness of its underlying layers. The Contractor shall drill required pre-installation core holes as directed and shall excavate sockets to the depth directed by the Engineer.

Contractor is cautioned not to over-drill the rock sockets. Unauthorized over-drilling will be at the Contractor's expense. In the case where over-drilling would bring the caisson base too close to a coal seam or other weak layer, then drilling must be extended through such weak layer, at the Contractor's expense, to a satisfactory deeper bearing level as determined by the Engineer.

No portion of the rock socket shall be exposed to drilling fluid or groundwater for more than 96 hours. Any portion of the rock socket exposed to drilling fluid or water for more than 96 hours, and any portion of the rock socket which, in the opinion of the Engineer, has deteriorated due to exposure to air or water, shall be reamed with an approved grooving tool to a depth of not less than 6mm, or as directed by the Engineer. Reaming of the socket, if necessary, is considered incidental to the cost of drilling the rock socket, and no separate payment will be made for this work.

563.5.2.4 - Providing for Socket Inspection:

Upon completion of the excavation of each rock socket, and upon thorough cleaning of the socket, the Contractor shall make the socket available to the Engineer for inspection. The Contractor shall provide suitable access for inspection, electric lighting, devices for checking dimensions, alignment and plumbness, ventilation equipment, the protective cage, radio communication, and auxiliary safety line. The air in the caisson shall be tested for noxious and/or explosive gases prior to and during entry of inspection personnel, to assure a safe working environment.

563.5.2.5 - Disposal of Materials:

Disposal of excavated materials shall be accomplished under the general provisions of 207.6 of the General Specifications.

563.5.2.6 - River Area:

Drilled caisson construction in the river shall employ whatever special methods the Contractor finds necessary for access and for accomplishing the work. These methods may include cofferdams, temporary sand islands, or other suitable measures. The Contractor will be responsible for conforming to all regulatory and environmental requirements related to the river, and for obtaining any permits that are required by his river operations.

563.5.2.7 - Safety Measures:

Safety of all persons is to be considered an objective of the utmost importance on this project. Therefore, the Contractor will take whatever measures are necessary to protect his own personnel, his subcontractors' personnel, the Engineer or other agents of the state, regulatory personnel, and others including the general public. The following list is presented as representative of issues that the Contractor must address. It is not intended as all-inclusive and does not relieve the Contractor of conforming to other regulations, laws, requirements, or other measures reasonably required for safe excavating operations. The Contractor shall develop a safety Drawing in accordance with these requirements and provide this Drawing to the Engineer for his review.

a) Any required equipment within an excavation shall be operated by air or electricity. The use of gasoline-driven engines or diesel engines within an excavation will not be permitted. All lighting shall be electric and precautions shall be taken in regard to potential short circuits of electric current within ground water.

b) The Contractor will take precautions to assure that no explosive or noxious gases are present. Fresh air shall be supplied into the excavation and foul air shall be removed whenever any personnel are present in the hole.

c) A safety harness or chair lift, with separate safety line, protective cage, and two-way radio communication shall be used for any entry into an excavation.

d) No open excavation shall be left unattended. During non-working hours excavations shall be protected by the use of solid, safe covers that are firmly fastened in place.

563.5.3 - Reinforcing Steel Installation:

Prior to installation of reinforcing steel, the steel cage shall be checked and cleaned of any materials that would tend to prevent bonding. The excavated hole shall also be checked and any remaining or newly deposited debris shall be removed. Immediately upon the Engineer's approval of the condition of the cage and his acceptance of the socket, and just prior to placement of concrete, the fully assembled cage of reinforcing steel shall be installed into the excavation.

The cage will consist of longitudinal (vertical) bars, spiral or tie bars, cage stiffener bars as required, spacing devices, and any other appurtenances required to maintain alignment, shape,

and clearances. Cages shall include steel tubes in shafts where CSL testing is to occur. Each cage shall be placed in one unit by lowering into the hole in a manner that will prevent distortion.

Concrete spacers or other approved non-corrosive spacing devices shall be used at sufficient intervals (near the bottom and at intervals not exceeding 3,000mm along the caisson) to ensure concentric spacing for the entire cage length. The minimum number of centring devices at each level shall be three.

All steel centring devices shall be epoxy coated unless otherwise approved. The cage shall be supported from the top by use of a ground surface frame or other positive means. Setting the cage on the socket bottom without support will not be permitted.

All intersections of drilled caisson reinforcing steel shall be tied with cross or "figure 8" ties. The reinforcing steel in the caisson shall be 100 percent tied and supported so that the reinforcing steel will remain within allowable tolerances for position. Unless otherwise shown in the Drawings, splicing shall be by mechanical connectors or couplers, which develop at least 125 percent of, yield strength of the reinforcing bar. No more than 50 percent of the longitudinal reinforcing shall be spliced within 60 bar diameters of any lapped splice location or within 600mm of any mechanical splice or coupler location. Cage stiffener bars shall be used as required to provide a reinforcement cage of sufficient rigidity to prevent racking, permanent deformations, etc. during installation. If the concrete is to be placed by the free-fall method, these bars must first be removed.

In the event that the caisson has been excavated below the anticipated tip elevation, the reinforcing cage may be extended at the tip (low) end by lap splices, mechanical connectors, or welded splices in conformance with the General Specifications. In this instance, splices need not be staggered and 100 percent of the reinforcing bars may be spliced at a given location. Lap splice lengths shall be as shown in the Drawings or approved by the Engineer.

Prior to placing the reinforcement cage, the Contractor shall demonstrate to the satisfaction of the Engineer that the fabrication and handling methods to be used will result in a reinforcing cage placed in the proper position, with the proper clearances, and without permanent bending or racking of the reinforcement cage.

The elevation of the top of the steel cage shall be checked before and after the concrete is placed. If the rebar cage is not maintained within the specified tolerances, the Contractor shall make corrections to the satisfaction of the Engineer. No additional caissons shall be constructed until the Contractor has modified his rebar cage support system in a manner satisfactory to the Engineer.

563.5.4 - Placement of Concrete:

Prior to concrete placement, the Contractor shall make all necessary arrangements to assure the uninterrupted delivery of concrete so that there will not be any cold joints in the caissons.

Placement of concrete shall generally conform to the applicable portions of Section 551.10 of the Standard Specifications. The rate of placement of concrete, as related to the height of fresh concrete at any time, will be subject to the Engineer's approval. The Contractor, taking account of set time, hydraulic pressures and casing removal, will develop the placement method. The placement of concrete in dry conditions may be by a free-fall method. The height of free fall is not limited, but segregation of the concrete is not permitted. In order to qualify as a dry condition the caisson excavation must meet two requirements. The first requirement is the infiltration rate shall

not exceed 75mm of depth per hour as measured in the bottom 450mm of the rock socket. The second requirement is that at the time of concrete placement the depth of water in the bottom of the rock socket shall not exceed 50mm. The dry concrete placement method may be used only when the sides and the bottom of the caisson excavation remain stable without detrimental caving, sloughing or swelling, and water can be satisfactorily removed prior to inspection and prior to placing concrete.

In a case where the Engineer determines that dry conditions cannot be attained, he will require placement by the wet placement method shown in the approved Installation Plan. The casing shall be filled with clean water to an elevation not less than 1,200mm) above the water elevation outside the casing, to provide a positive water pressure inside the casing. Concrete will then be placed by conventional tremie or pumping methods. Tremie or pump placement methods shall not utilize aluminium parts, which would be in contact with the concrete.

Tremies used to place concrete shall consist of a tube of sufficient length, weight, and diameter to discharge concrete at the caisson base elevation. The tremie inside diameter shall not be less than 250mm. The inside and outside surfaces of the tremie shall be clean and smooth to permit both flow of concrete and unimpeded withdrawal during concreting. The wall thickness of the tremie shall be adequate to prevent crimping or sharp bends, which restrict concrete placement.

The tremie used for concrete placement shall be watertight. Concrete placement shall not begin until the tremie is placed at the caisson base elevation.

Valves, bottom plates, or plugs may be used only if concrete discharge starts within approximately 50mm above the excavation bottom. Plugs shall either be removed from the excavation or be of a material approved by the Engineer, which will not cause defects in the caisson if not removed. The discharge end of the tremie shall be constructed to permit the free radial flow of concrete during placement operations. The tremie discharge end shall remain at or near the bottom of excavation as long as practicable during concrete placement. The tremie discharge end shall remain immersed as deep as practicable in the concrete, consistent with the Contractor's construction methods, and shall be immersed at least 3,000mm in concrete at all times after starting the flow of concrete. The flow of the concrete shall be continuous. The concrete in the tremie shall be maintained at a positive pressure differential at all times to prevent water or slurry intrusion into the caisson concrete.

All pump lines shall have a minimum diameter of 125mm and shall be constructed with watertight joints. Concrete placement shall not begin until the pump line discharge orifice is at the caisson base elevation. A plug or similar device shall be used to separate the concrete from the fluid in the hole until pumping begins. The plug shall either be removed from the excavation or be of a material approved by the Engineer, which will not cause a defect in the caisson if the plug is not removed. The discharge orifice shall remain at least 3000mm below the surface of the fluid concrete.

If at any time during the concrete pour, the tremie line orifice or the pump line orifice is removed from the fluid concrete column and discharges concrete above the rising concrete level, the entire drilled caisson shall be considered defective. In such case, the Contractor shall remove the reinforcing cage and concrete, complete any necessary sidewall removal directed by the Engineer and re-pour the caisson. All costs of replacement of defective caissons shall be the responsibility of the Contractor and shall be at no cost to the Employer.

After the concrete level has reached the required top elevation, it will be forced to overflow in the case of tremie or pump placement, leaving only fresh, uncontaminated concrete. In the case of

placement by free fall (dry conditions), the concrete will be continued high enough to compensate for any settlement due to removal of casing.

The top 3,000mm of each drilled caisson shall be vibrated except, when more than 3,000mm is to be exposed above the ground line or the riverbed, then the entire exposed portion shall be vibrated. Exposed portions of each drilled caisson shall be cured in accordance with Section 551.12 of the Standard Specifications.

563.5.5 - Removal of Casing:

Removal of the casing from a shaft may occur gradually as concrete is placed. In all cases, extraction of casing shall begin within one hour from the beginning of concrete placement in the cased portion of the shaft. Insofar as possible, casing extraction shall be done at a slow uniform rate by application of a steady vertical upward pull in the direction of the axis of the shaft. To facilitate extraction, tapping on the casing, exertion of temporary downward pressure, and slight rotation will be permitted, but care must be taken to avoid harmful impacts or disturbances to the fresh concrete. Vibration or rodding may not be used to break the casing loose for extraction.

If, during extraction of casing, upward movement of concrete and/or reinforcing steel occurs, the Engineer shall be notified immediately. If he considers the movement to be minor, he may permit the extraction of the casing to continue. If, however, the movement is deemed significant and indicative of squeezing of the surrounding soil thus resulting in a reduction of the caisson diameter, then he may order the casing to be left in place, or he may permit extraction to proceed and order a later non-destructive load test, or may order other procedures as appropriate at no additional cost to the client.

For the upper portions of drilled caissons that will be exposed and visible, the casing may remain in place as a form until the concrete has attained a strength that enables it to stand alone without further deformation. Casing shall then be removed.

563.6 - INSPECTION OF SOCKETS:

563.6.1 - Depth of Rock Socket:

Each rock socket shall be drilled to the shaft diameter shown in the Drawings unless otherwise directed by the Engineer based on subsurface conditions encountered.

The top elevation of competent rock must be confirmed as the socket drilling is started. The effective "top elevation" is based on observation of the boundary zone where broken or weathered rock becomes competent rock, and is also influenced by the presence of any shale or coal seams. Based on that elevation, and the information from the pre-installation core hole, the Engineer will determine the final depth of socket and bottom elevation. The drilled rock socket will then be inspected per 561.5.2.3 and will either be accepted or drilled deeper as determined by the Engineer Representative.

563.6.2 - Inspection Under Water:

In a case where it is considered unfeasible to dewater a caisson, the Contractor shall provide drilled caisson logs and screenings to the Engineer for evaluation. If this material is not sufficient for a proper judgement, the Engineer will reserve the right to order an inspection by diving or other methods either through a separate specialty subcontractor or through the Contractor. Any time required for inspection under water will be considered incidental to the work and will not be cause for extra compensation related to a claim or extension of contract time.

563.7 - METHOD OF MEASUREMENT:

Drilled caissons and Rock Socket foundations will be measured by the linear metre. Drilled Caissons are the portions from the finished top of each caisson to the top of competent rock. Rock Socket is the portion from the top of competent rock to the bottom of the caisson as shown in the Drawings or as directed by the Engineer. Each measured caisson is to be complete in place, accepted, and ready to function. "Top of caisson" is the top of concrete as shown in the Drawings. "Top of competent rock" is as tabulated in the drilled shaft schedules in the Drawings unless a difference of 300mm or more is found during drilling.

No separate measurement will be made for excavation, concrete, or reinforcing steel, nor placing and removing casings.

Drilled Caisson test hole will be measured in Lump Sum basis.

Pre-installation core hole shall be measured by the linear metre based upon actual length drilled.

563.9 - PAY ITEMS:

D = Diameter of drilled caisson, in millimetres

ITEM	DESCRIPTION	UNIT
563.001	Drilled Caissons "D" diameter	Lump sum

SECTION 564
RETAINING WALL SYSTEMS

564.1 - DESCRIPTION:

This work shall consist of furnishing the design, wall construction Drawings, materials, and construction of cast-in-place reinforced concrete or Mechanically Stabilized Earth (MSE) walls in accordance with these Specifications and in reasonably close conformity with the lines, grades, design, and dimensions shown in the Drawings.

564.2 - GENERAL:

Unless specified otherwise in the Contract Documents the wall may be, at the Contractor's option, any one of the wall systems on the approved vendor list corresponding to the applicable pay Item.

The Contractor shall indicate which wall system is to be constructed by the bid alternative chosen in the proposal. No change of the wall system indicated in the bid proposal shall be permitted after the bid opening unless approved by the Engineer.

The wall design and detail Drawings for construction shall be submitted to the Engineer for approval. The time required for preparation and review of these submittals shall be charged to the allowable contract time. Delays caused by untimely submittals or insufficient data will not be considered justification for time extensions. No additional compensation will be made for any additional material, equipment, or other items found necessary to comply with the project specifications as a result of the Engineer's review. The proposed wall design shall be compatible with the Contractor's proposed method of construction, and shall be compatible with any method of construction shown in the Drawings. The Employer does not assume nor warrant any wall system's compatibility with any particular construction methods.

564.3 - DESIGN CRITERIA:

564.3.1 - General:

The size of all structural elements shall be determined so that the design load stresses do not exceed the allowable stresses in the AASHTO LRFD Bridge Design Specifications, latest edition.

Analysis of external stability of the in-place retaining wall system will be the responsibility of the Contractor. Any staged or temporary construction affecting wall stability shall be the responsibility of the Contractor. The parapets on any portion of the retaining walls as shown in the Drawings shall be designed to resist traffic loads in accordance with the AASHTO LRFD Bridge Design Specifications, latest edition.

564.3.2 - Mechanically Stabilized Earth:

The design for the MSE wall shall consider the internal stability of the wall mass. The design shall conform to the requirements found in AASHTO LRFD Bridge Design Specifications, latest edition. External loads which affect the internal stability such as those, applied through piling, bridge footings, temporary construction, etc. shall be accounted for in the design. A design life of 120 years shall be used throughout the design. The factor of safety for pullout resistance shall not be less than 1.50 based on pullout resistance at 19mm deflection.

The allowable bearing pressure under the stabilized mass shall be as shown in the Drawings. The minimum length of the soil reinforcing system, as measured from the back of the front face to the end at the back of the soil stabilized mass, shall be as shown in Drawings, and shall be the same from top to bottom of the wall at any cross section.

All appurtenances behind, in front of, under, mounted upon, or passing through the wall such as drainage structures, utilities, or other items shown in the Drawings must be accounted for in the design of the wall.

564.3.3 - Cast-in-Place Reinforced Concrete:

When a Cast-in-Place Reinforced Concrete option is included in the Drawings the following shall be applicable:

The information shown in the Drawings for the cast-in-place alternative is schematic; however, all dimensions shown in the Drawings shall be considered minimums.

The allowable bearing pressure of the foundation soils, the unit weight of the retained soils, and the characteristics of the retained soils necessary for design purposes shall be as shown in the Drawings.

564.4 - SUBMITTALS:

564.4.1 - General:
The Contractor shall submit complete design calculations, explanatory notes, and detail Drawings for the proposed wall system. The detail Drawings shall include all details, dimensions, quantities, and cross sections necessary to construct the wall and shall include but not be limited to the following items:

A plan and elevation sheet or sheets for the wall, which shall contain the following:

1.An elevation view of the wall which shall indicate the elevations at the top of the wall at all horizontal and vertical break points and at least every 15 metres along the face of the wall, all steps in the footings or levelling pads, the original and final ground lines, the maximum bearing pressures, and the summary of quantities for each wall.

2.A plan view of the wall which shall indicate the offsets from the construction centreline to the face of the wall at all changes in horizontal alignment and the centreline of any drainage structure or drainage pipe behind, passing through, or under the wall.

3. A typical cross section or cross sections showing elevation relationship between existing ground conditions and proposed grades.

4. All general notes required for constructing the wall. The required batter to compensate for the elongation of the soil reinforcing during erection shall be shown for each different required height.

5. All horizontal and vertical curve data affecting the wall.

6. All details for footings or levelling pads shall be shown including details for steps in the footings or levelling pads.

7. All details for construction of walls with appurtenances behind, under, mounted upon, or passing through the wall such as drainage structures or utilities shall be clearly indicated.

8. Required architectural treatments shall be as indicated and as detailed in the Drawings. All details for any required architectural treatments shall be shown including:

9. Product data and installation instructions for manufactured form systems, form liners, release agents, ties, and accessories. The release agent manufacturer shall certify that the products supplied comply with regulations controlling the use of volatile organic compounds (VOCs).

10. Shop drawings for fabrication and erection. These drawings shall show all items that visually affect the exposed concrete, including, but not limited to, general form construction, jointing, specially formed joints or reveals, and patterns of placement. The Engineer's review will be for general architectural applications and features only. Formwork design for structural stability and sufficiency is the Contractor's responsibility and shall not be submitted for the Engineer's review.

11. The wall manufacture shall submit copies of their Quality Assurance/Quality Control Manuals on each project.

12. Mockup or Sample Panels. The Contractor shall construct a mock-up or sample panel using the proposed formwork and facing materials in order to demonstrate the required finishes and textures. Actual construction of concrete shall not proceed until the Engineer has accepted the sample units.

At the time the detail Drawings are submitted for review, they shall be accompanied by design calculations and explanatory wall notes. These documents shall be legible and shall demonstrate that the design criteria have been met. Specified minimum factors of safety and the maximum soil pressure beneath the wall footing or earth stabilized mass shall be clearly indicated.

The Drawings shall be prepared on reproducible sheets 550mm x 850 mm including borders. Each sheet shall have a title block in the lower right hand corner. The title block shall include the sheet number of the drawing, name or designation of the wall, the project designation, and the Contractor. Design calculations and notes shall be prepared on A-4 size sheets, and shall contain the project designation, wall designation, date of preparation, initials of designer and checker, and page number at the top of the page. The Detail Drawings, Design Calculations, and Explanatory Notes shall be signed and stamped by a Professional Engineer registered in Sri Lanka and knowledgeable in the proposed alternative wall system.

The initial submission shall include three sets of the detail Drawings, calculations, and notes. One set of notes and Drawings will be returned to the Contractor with any indicated corrections. When the Drawings and notes are stamped approved by the Engineer, the Contractor shall furnish the Engineer with the requested number of sets of prints and a Mylar set of the Drawings for distribution by the Client. The Contractor shall perform no work or ordering of materials for the structures until the Engineer has approved the submittal.

564.4.2 - Mechanically Stabilized Earth:

The details and material specifications for the wall panels and incidental accessories shall be included with the detail Drawings for approval by the Engineer.

The designation as to the type of panel, the length of the soil reinforcing systems, the distance along the face of the wall where changes in lengths of the soil reinforcing systems occur, and the limit of widest mesh, strip, or anchor shall be clearly shown in the Drawings.

All wall panels shall be detailed. The details shall show all dimensions necessary to construct the element, all reinforcing steel in the element, and the location of soil reinforcing system devices embedded in the panels.

564.4.3 - Cast-in-Place Reinforced Concrete:

The Drawings for the cast-in-place wall shall contain a complete reinforcing bar schedule showing all bending details and bar marks. The Drawings shall also show the location of all construction joints, expansion joints, or other joints in the wall. All wall thickness shall be shown and transition details at wall thickness changes.

564.5 - MATERIALS:

564.5.1 - Mechanically Stabilized Earth Components:

The Contractor shall make arrangements to purchase the facing elements, reinforcing mesh or strips, attachment devices, joint materials, and all other necessary components. Materials not conforming to this section of the specifications or from sources not listed in the contract documents shall not be used without written consent from the Engineer.

564.5.1.1 - Reinforced Concrete Facing Panels:

The panels shall be fabricated in accordance with Section 551 of the General Specifications with the following exceptions and additions:

A. Concrete for the precast facing panels shall attain a minimum compressive strength of 30 Mpa at 28 days. All concrete shall have air entrainment of 3 TO 5%. Specified concrete properties are to be tested in accordance with applicable provision of Section 551.4.1 of the Standard Specifications. Acceptance of a Production AREA will be made if the compressive strength test result is greater than or equal to, 30 Mpa. A Production AREA is defined as a group of panels that will be represented by a single compressive strength sample and will consist of a single day's production. A minimum of two cylinders shall be required for every compressive strength sample.

B. The units shall be fully supported until the concrete reaches a minimum compressive strength of 97 Mpa.

C. Unless otherwise indicated in the Drawings or elsewhere in the Specifications, the concrete surface for the front face shall have a Class 1 finish as defined by Section 551.11 and a uniform surface finish for the rear face. The rear face of the panel shall be screeded to eliminate open pockets of aggregate and surface distortions in excess of 6mm. The panels shall be cast on a flat area. The clevis loops, tie strip guide, or other galvanized devices shall not contact or be attached to the face panel reinforcement steel.

D. The date of manufacture, the production area number, and the piece mark shall be clearly scribed on an unexposed face of each panel.

E. All units shall be handled, stored, and shipped in such a manner as to eliminate the dangers of chipping, discoloration, cracks, fractures, and excessive bending stresses. Panels in storage shall be supported in firm blocking to protect the panel connection devices and the exposed exterior finish.

F. All units shall be manufactured within the following tolerances:

1. Panel Dimensions: Position of panel connection devices within 25mm, except for coil and loop embeds which shall be 5mm. All other dimensions within 5mm.

2. Panel Squareness: Squareness as determined by the difference between the two diagonals shall not exceed 13mm.

3. Panel Surface Finish: Surface defects on smooth formed surfaces measured over a length of 1.5 metre shall not exceed 6mm. Surface defects on the textured-finished surfaces measured over a length of 1.5 metre shall not exceed 8mm.

Units shall be rejected because of failure to meet any of the requirements specified above. In addition, any or all of the following defects shall be sufficient cause for rejection:

1. Defects that indicate imperfect moulding.
2. Defects indicating honeycombed or open textured concrete.
3. Cracked or severely chipped panels.
4. Colour variation on front face of panel due to excess form oil or other reasons.

All reinforcing steel shall be in accordance with Section 552 of: the General Specifications.

564.5.1.2 - Soil Reinforcing and Attachment Devices:

All reinforcing and attachment devices shall be carefully inspected to insure they are true to size and free from defects that may impair their strength and durability.

Cutting of reinforcing strips or mesh at vertical obstacles, shall not be permitted. Care must be taken to avoid damage to the galvanized coating during handling, storing, and shipping.

The following requirements shall apply to all soil reinforcing and attachment devices:

A. Reinforcing strips shall be hot rolled from bars to the required shape and dimensions. Their physical and mechanical properties shall conform to ASTM A-36 (AASHTO M-183) or equal. Galvanization shall be required and shall conform to the minimum requirements of ASTM A-123 (AASHTO M-111).

B. Reinforcing mesh shall be shop fabricated of cold drawn steel wire conforming to the requirements of paragraph one of Section 709.4.

Galvanization shall be applied after the mesh is fabricated and shall conform to the minimum requirements of ASTM A-123 (AASHTO M-111).

C. The tie strips shall be shop fabricated of a hot rolled steel conforming to the minimum requirements of ASTM A-570, Grade 50 or equivalent. Galvanization shall be required and shall conform to ASTM A-123 (AASHTO M-111).

D. Loop embeds shall be fabricated of cold drawn steel wire conforming to ASTM A-510, UNS G-10350 or ASTM A-82. Loop embeds shall be welded in accordance with ASTM A-185. Both shall be galvanized in accordance with ASTM B-633 or ASTM A-123 (AASHTO M-111.

E. Bolts shall meet the requirements of ASTM A-325. Nuts shall meet the requirements of ASTM A-563 Grade DH or ASTM A-194 2H.
Fasteners shall be galvanized in accordance with ASTM A-153.

F. Connector pins and mat bars shall be fabricated from cold drawn steel conforming to ASTM A-82 and welded to the soil reinforcement mats as shown in the Drawings. Galvanization shall be required and shall conform to ASTM A-123 (AASHTO M-111).

564.5.1.3. - Joint Materials:

Joint materials are to be installed to the dimensions and thicknesses in accordance with the Drawings or approved shop drawings, unless otherwise indicated:

A. Provide either preformed EPDM rubber pads conforming to ASTM D-2000 for 4AA, 812 rubbers; neoprene elastomeric pads have a Durometer Hardness of 55 ± 5; or polyethylene bearing pads meeting the density requirements of ASTM D-1505 in horizontal joints between panels.

B. Cover all joints between panels on the backside of the wall with a geotextile fabric that meets the requirements of Section 715.11.4 of the General Specifications. The minimum width and lap of the fabric shall be as follows:
Vertical and horizontal joints: 300 mm ; lap-100 mm .

564.5.1.4 - Acceptance:

The Contractor shall furnish the Engineer a Certificate of Compliance certifying the above materials comply with the applicable contract specifications.

564.5.2 - Concrete Levelling Pad:

All concrete used in the levelling pad 30 as a Minimum conform to Section 551 of the General Specifications for Class 30/20 concrete

564.5.3 - Select Granular Backfill

564.5.3.1- Test Requirements:

A11 backfill material used in the structure volume shall conform to the following gradation limits as determined by AASHTO T-27:

Sieve Size	Percent Passing
100mm	100
No. 40 mesh sieve	0 - 60
No. 200 mesh sieve	0 – 15

The backfill shall conform to the following additional requirements:

A. The plasticity index (P.I.) as determined by AASHTO T-90 shall not exceed 6, or the material is described as non-plastic.

B. The material shall exhibit an angle of internal friction of not less than 34 degrees, as determined by the standard Direct Shear Test, utilizing a sample of the material compacted to 95 percent of AASHTO T-99, Methods C or D (with oversized correction as outlined in Note 7) at optimum moisture content.

C. Soundness: The materials shall be substantially free of shale or other soft, poor durability particles. The material shall have a magnesium sulphate soundness loss of less than 30 percent after four cycles as determined by AASHTO T-104, or a sodium sulphate loss of less than 15 percent after five cycles as determined in accordance with AASHTO T-104.

D. Electrochemical Requirements: The backfill materials shall meet the following criteria:

Requirements	Test Methods
Resistivity greater than 3,000 ohm Centimetres	AASHTO T-288
Ph 5-10	AASHTO T-289
*Chlorides less than 100 parts per million	AASHTO T-291
*Sulphates less than 200 parts per million	AASHTO T-290
Organic Content: 1 percent maximum	AASHTO T-267

* If resistivity is greater than 5,000 ohm-cm, the chlorides and sulphates requirements may be waived.

564.5.3.2 - Quality Control Testing:

Quality control of the select granular material is the responsibility of the Contractor.

The Contractor shall maintain equipment and qualified personnel to perform all sampling and testing necessary to determine the magnitude of the various properties of the material governed by the Specifications and shall maintain these properties within the limits of the Specifications. The Contractor shall design a Quality Control Plan detailing the methods by which the Quality Control Program will be conducted. The plan prepared in accordance with the guidelines set forth in the appropriate portions AASHTO T 99, T 180, shall be submitted to the Engineer at the pre-

construction conference. The work shall not begin until the plan is reviewed for conformance with the contract documents.

564.5.3.3 - Sampling and Testing:

Frequency of sampling and testing shall be in accordance with the Contractor's Quality Control Plan. The minimum frequencies for gradation and plastic limits shall be as stated in AASHTO T 99, T 180, Table D, for subgrade.

564.5.3.4 - Acceptance:

The Contractor shall furnish certified test results that the select granular backfill meets the contract specifications. The test results for the select granular backfill shall not be used to verify compliance for a period exceeding one year. The Engineer may request that the tests be performed at any time if the material changes. Additional tests for gradations and plastic limits shall be determined during the placement of the material.
Backfill placement shall closely follow erection of each course of panels. Backfill shall be placed in such a manner as to avoid any damage or disturbance of the wall materials or the Contractor at his expense shall correct misalignment or distortion of the wall facing panels due to placement of backfill outside the limits of this specification. At each reinforcement level, the backfill shall be placed to the level of the connection. Backfill placement methods near the facing shall assure that no voids directly beneath the reinforcing elements.

The backfill in front of the wall, from the levelling pad to finished ground, shall be placed immediately after the Select Granular Backfill is above the first layer of Soil Reinforcing.

The maximum lift thickness after compaction shall not exceed 150mm unless approved by the Engineer. The Contractor shall decrease this lift thickness, if necessary, to obtain the specified density. Compaction within 1,000mm of back face of the wall shall be achieved by at least three passes of a lightweight mechanical tamper, roller, or vibratory system.

At the end of each day's operation, the Contractor shall slope the last level of the backfill away from the wall facing to rapidly direct runoff away from the wall face. In addition, the Contractor shall not allow surface runoff from adjacent areas to enter the wall construction site.

Acceptance for compaction shall be on an area-by-area basis. An area shall be divided into five approximately equal sized sub-areas. A sub-area shall consist of the quantity of material to backfill a single lift for 30 metres of wall and at least one test per lift. One nuclear moisture and density measurement shall be made at a random location within each of the five sub-areas according to AASHTO 99 method C for material having less than 40 percent retained on the 75mm sieve and AASHTO T- 238- 86 for material having 40 percent or more retained on the 75mm sieve. The moisture tolerance shall be from optimum to two percentage points below optimum. The random locations shall be determined in accordance with AASHTO T 21, T 248 . The target percentage of dry density shall be 95 percent. For applications where spread footings are used to support a bridge or other structural loads, the target percentage of dry density shall be 100 percent. If the results of five density tests on an area indicates that at least 80 percent of the material has been compacted to the specified target percentage of dry density, the area will be accepted. If less than 80 percent has been compacted to the specified target percentage of dry density and/or the moisture content is outside the tolerance range, no additional material shall be placed until the area has been reworked to meet the specified requirements. Reworking and retesting shall be at the expense of the Contractor. When the Engineer performs the testing

in the evaluation of reworked areas, the testing will be at the expense of the Contractor at the unit cost specified in these Specifications.

The backfill material must compact to a stable condition. If the material is not stable under the weight of construction equipment, the contractor must correct the problem or replace the material even if test results indicate that the material meets the moisture and density specifications.

564.6 - CONSTRUCTION METHODS:

564.6.1 - Mechanically Stabilized Earth:

564.6.1.1 - Foundation Preparation:

The foundation for the structure shall be graded level for a width equal to the length of reinforcement elements plus 300mm or as shown in the Drawings. Prior to wall construction, except where constructed on rock, the foundation shall be compacted with a smooth wheel vibratory roller. Any foundation soils found to be unsuitable shall be removed and replaced with select granular backfill as per these specifications.

564.6.1.2 - Wall Erection:

A MSE wall supplier representative shall be present a minimum of three (3) days and as required thereafter during erection of the wall to assist the fabricator, contractor, and Engineer. The cost of the representative shall be considered incidental to the unit price of the MSE Wall System.

Precast concrete panels shall be placed so that their final position is vertical or battered as shown in the Drawings. Panels shall be handled by means of lifting devices connected to the upper edge of the panel. Panels should be placed in successive horizontal lifts in the sequence shown in the Drawings as backfill placement proceeds. As backfill material is placed behind the panels, the panels shall be maintained in position by means of temporary wedges or bracing according to the wall supplier's recommendations. The Contractor shall not have more than two levels of temporary wedges in place at any time during wall erection. Concrete facing vertical tolerances and horizontal alignment tolerances shall not exceed 19mm. The overall vertical tolerance of the wall (top to bottom) shall not exceed 13mm per 3 metres of wall height.

Reinforcement elements shall be placed normal to the face of the wall, unless otherwise shown in the Drawings. Prior to placement of the reinforcing elements, backfill shall be compacted in accordance with these Specifications.

564.6.1.3 - Backfill Placement:

Backfill placement shall closely follow erection of each course of panels. Backfill shall be placed in such a manner as to avoid any damage or disturbance of the wall materials or misalignment of the facing panels or reinforcing element. Any wall materials that become damaged during backfill placement shall be removed and replaced at the Contractor's expense. The Contractor at his expense shall correct any misalignment or distortion of the wall facing panels due to placement of backfill outside the limits of this specification. At each reinforcement level, the backfill shall be placed to the level of the connection. Backfill placement methods near the facing shall assure that no voids exist directly beneath the reinforcing elements.

The moisture content of the backfill material prior to and during compaction shall be uniformly distributed throughout each layer. Backfill materials shall have placement moisture content less

than or equal to the optimum moisture content. Backfill material with a placement moisture content in excess of the optimum moisture content shall be removed and reworked until the moisture content is uniformly acceptable throughout the entire lift.

The maximum lift thickness after compaction shall not exceed 300mm. The Contractor shall decrease this lift thickness, if necessary, to obtain the specified density.

Compaction within 1,000mm of back face of the wall shall be achieved by at least three passes of a lightweight mechanical tamper, roller, or vibratory system.

At the end of each day's operation, the Contractor shall slope the last level of the backfill away from the wall facing to rapidly direct runoff away from the wall face. In addition, the Contractor shall not allow surface runoff from adjacent areas to enter the wall construction site.

564.6.2 - Cast-in-Place Reinforced Concrete:

564.6.2.1 - General:

Except as otherwise shown in the Drawings or herein, construction methods for cast-in-place retaining walls shall comply with the General Specifications.

Construction methods for the following shall be per the indicated section of the General Specifications:

Item	Section
Unclassified Excavation	211
Structure Excavation	212
Wet Excavation	212
Rock Excavation	212
Select Material for Backfilling	212
Concrete	551
Reinforcing Steel	552

564.6.2.2 - Architectural Forms:

564.6.2.2.1 - General:

Construct forms to sizes, shapes, lines, and dimensions shown, and as required to obtain accurate alignment, location, level, and plumb work in finished structures. Provide for openings, offsets, keyways, recesses, chamfers, blocking, screeds, bulkheads, and other as required.

Fabricate forms to prevent cement paste from leaking while placing concrete and for easy removal without hammering or prying against exposed concrete surfaces. Provide crush plates where stripping might damage cast concrete surfaces. Provide top forms for inclined surfaces where slope is too steep to place concrete. Solidly butt joints and provide backup material at joints to prevent leakage and fins. Assemble forms so that they may be easily removed without damaging exposed concrete surfaces.

Provide temporary form openings where inaccessible formwork interior can be cleaned and inspected before placing concrete. Place temporary form openings as inconspicuously as possible, consistent with project requirements.

When drilling forms used for exposed concrete, drill from the contact face to the outside to suit the ties used and to prevent leakage of concrete mortar. Do not splinter the forms by driving ties through improperly prepared holes.

Unless otherwise shown in the Drawings:

Provide sharp, clean corners at intersecting planes with no visible edges or offsets.
Provide accurately formed chamfered corners using 20mm x 20mm strips, surfaced to produce uniformly straight lines and tight edge joints.

564.6.2.2.2 - Form Coatings:

Coat form contact surfaces with form-release agent before placing reinforcement. Do not allow excess material to accumulate in forms or to come into contact with reinforcement or surfaces that will be bonded to fresh concrete. Apply coating according to manufacturer's instructions.

Coat steel forms with non-staining, rust-preventative release agent, or otherwise protect from rusting. Rust-stained steel formwork is not acceptable.

564.6.2.2.3 - Reusing Forms:

Split, frayed, delaminated, or otherwise damaged form-facing materials are not acceptable. Clean and apply a new form-release agent to concrete contact surfaces.

564.7 - METHOD OF MEASUREMENT:

564.7.1 - General:

The unit of measurements shall be the gross area in square metres lying in a plane outside the front face of the structure as determined by the dimensions in the contract documents. . The gross area shall not include barriers, footings, or levelling pads. The gross area shall be the number of square metres evaluated from the Drawings.

No adjustment of pay quantity shall be allowed for changes in wall design to facilitate the Contractor's methods of construction of wall type.

Unless otherwise specified in the contract documents, items such as concrete barriers that are not part of normal retaining wall construction shall be measured separately for payment.

The quantity of earthwork shown in the Drawings does not include any work within the wall pay limits shown in the Drawings. Any adjustments to the required amount of embankment or select granular backfill due to the particular wall system proposed by the contractor shall be considered incidental to the project.

No separate payment shall be made for increased embankment or increased select granular backfill requirements. The Contractor shall be responsible for any of the cost of changes in waste, borrow, or earthwork quantities from those shown in the Drawings caused by the requirements of the proposed wall system.

564.7.2 - Mechanically Stabilized Earth:

The unit price shall include in place: concrete facing panels, soil reinforcing and attachment devices and associated hardware, coping and trim, or similar items that are normal parts of wall construction. No separate measurement of these items shall be made.

The unit price shall also include in place: all the following items shown within the wall pay limits in the Drawings: select granular backfill, excavation, embankment, foundation preparation, and levelling pads. No separate measurement of these items shall be made.

564.7.3 - Cast-in-Place Reinforced Concrete:

The unit price shall include in place: concrete, forms, reinforcing, joint materials, underdrains, weep holes, or similar items that are normal parts of wall construction. No separate measurement of these items shall be made.

The unit price shall also include in place: all the following items shown within the wall pay limits in the Drawings: select material for backfilling, excavation, embankment, and foundation preparation. No separate measurement of these items shall be made.

564.8 - BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract price per unit of measurement, respectively, for each pay item listed below and shown in the bid schedule, which prices and payment will be full compensation for the work prescribed in this section 564.9

564.9 PAY ITEMS:

ITEM	DESCRIPTION	UNIT
564.001	Precast concrete facing panel	Square metre
564.002	Reinforced soil	Cubic metre
564.003	Interlocking blocks	Square metre
564.004	Reinforced soil to interlocking blocks	Cubic metre

DIVISION 600
INCIDENTAL STRUCTURES

DIVISION 600
INCIDENTAL STRUCTURES

SECTIONS 601 – 602 : Not Used

SECTION 603
METAL STRUCTURES

603.1 - DESCRIPTION:

This work shall consist of the construction or reconstruction or extension of metal underpasses, arch structures, culverts and pipelines, referred to jointly as "metal structures", in accordance with these Specifications and in conformity with the lines, grades, dimensions, and locations shown on the Drawings or established by the Engineer.

The corrugated metal underpasses have been designed generally for minimum cover over the structure. The plate thickness varies with the size of the structure and cover.

603.2 - MATERIALS:

Materials shall meet the requirement specified in the following Sub-Sections of Division 700:

MATERIAL	SUB SECTION
Metallic Coated Corrugated Steel Pipe or Pipe Arch	713.2
Fibre Bonded Full Bituminous Coated and Paved Invert Corrugated Steel Pipe	713.2
Bituminous Coated and Paved Invert Corrugated Steel Pipe or Pipe arch	713.3
Full Bituminous Coated and Full Paved Corrugated Steel Pipe	713.4
Fibre Bonded Full Bituminous Coated Corrugated Steel Pipe	713.5
Fibre Bonded Full Bituminous Coated Corrugated Steel Pipe Arch	713.5
Fibre Bonded Full Bituminous Coated and Paved Invert Corrugated Steel Pipe Arch	713.5
Structural Plate Pipe or Pipe Arch	713.8
Bituminous Coated Structural Plate Pipe or Pipe Arch	713.9
Structural Plate Arch	713.8
Bituminous Coated Structural Plate Arch	713.9
End Section for Corrugated Steel Pipe or Pipe Arch	713.20
Bituminous Plastic Cement	708.9
Granular Material for Culvert Bedding	716.1.1.2
Controlled Low Strength Material	219
Crushed Aggregate Backfill	704.6
*Fine Aggregate	702*

*Fine Aggregate shall consist of crushed or uncrushed mineral aggregate, which has 100 percent passing the 9.5mm sieve.

When the locations of manufacturing plants allow, the plants may be inspected periodically for compliance with specified manufacturing methods, and material samples may be obtained for

laboratory testing for compliance with material quality requirements. This may be the basis for quality acceptance of manufactured lots.

All materials will be subject to inspection for acceptance as to condition at the latest practicable time the Engineer has the opportunity to check for compliance prior to or during incorporation of materials in the work.

All references to "corrugated steel pipe" are considered applicable to uncoated pipe and the various combinations of coated pipes (bituminous coated, fibre bonded, pre-coated, etc.) and paving classes (paved invert, full paved, etc.) for which the base metal conforms to AASHTO M 218 or AASHTO M 274.

The sheet thickness for corrugated steel pipe and corrugated aluminium alloy pipe shall be as designated on the Drawings.

Corrugated metal pipe of 68mm by 13mm corrugation shall be furnished unless otherwise specified. Corrugated steel pipe and pipe arch with 68mm x 13mm, 75mm x 25mm and 125mm x 25mm corrugations shall be helically fabricated, except for fibre bonded pipe which may be fabricated with annular corrugations of 68mm x 13mm and 75mm x 25mm. Corrugated aluminium alloy pipe with 68mm x 13mm, 75mm x 25mm, 75mm x 25mm, and 150mm x 25mm corrugations and corrugated aluminium alloy pipe arch with 68mm x 13mm corrugations shall be helically fabricated. Where 125mm x 25mm corrugations are specified for corrugated steel pipe and pipe arch, 75mm x 25mm corrugations may be substituted.

603.2.1 - QUALITY CONTROL TESTING:

Quality control of the fine aggregate, granular material and crushed aggregate backfill is the responsibility of the Contractor.

Acceptance for gradation will be on the basis of the Contractor's written certification that all such material used for this conforms to the specified requirements. The certification is to include the results of testing from samples obtained at a minimum frequency of one sample per one-half day of aggregate production or stockpiling.

CONSTRUCTION METHODS

603.3 - GENERAL:

Subject to the provisions prescribed, the flow line of a metal structure may be altered from that shown on the Drawings. If a firm metal structure foundation is not encountered at the specified elevation, the unsatisfactory material shall be replaced with suitable material to a depth directed by the Engineer.

Galvanized steel pipe or bands shall not come in contact with aluminised steel pipe or bands.

The 'diameter' of metal structures in this Section, is the largest dimension, horizontal or vertical.

603.4 - TRENCH EXCAVATION:

603.4.1 - Metal Structures 450mm through 1400mm:

In complete or partial fill sections, before trenching is begun, the fill shall be constructed for a minimum distance of six diameters on each side of the metal structure and to a height of 600mm over the top of the metal structure or to the surface of the completed embankment if less than 600mm above the top of the metal structure. The width of the trench, in either cut of fill sections, shall not be less than the outside diameter of the metal structure or encasement plus 450mm on each side of the metal structure measured to the face of the trench or to the sheeting when used.

603.4.2 - Metal Structures 1500mm through 2700mm:

In complete or partial fill sections, before trenching is begun, the fill shall be constructed for a distance of six diameters on each side of the metal structure and to a minimum height of 25 percent of the vertical dimension of the metal structure. The width of the trench shall not be less than the outside horizontal diameter of the metal structure plus one diameter on each side of the metal structure. When using a Controlled low strength material the width of the trench shall not be less than the outside horizontal diameter of the metal structure plus one half diameter on each side of the metal structure.

In rock or shale cut section, the width of the trench shall not be greater than required to obtain the backfill compaction specified. Soil cut trenches shall be treated as complete or partial fill sections. For rigid pipe, the width of the trench shall not be less than the outside horizontal diameter of the metal structure plus 600mm on each side of the metal structure.

603.4.3 - Metal Structures Greater than 2700mm:

In complete or partial fill sections, before trenching is begun, the fill shall be constructed for a distance of six diameters on each side of the metal structure and to a minimum height of 25 percent of the vertical dimension of the metal structure.

Installation of the metal structure shall be as detailed in the Drawings, including the type and amount of backfill and bedding.

For flexible metal structure, the Contractor shall submit shop drawings detailing all erection procedures including anticipated movements during backfilling operations. Backfill operations shall also be detailed to show lift thicknesses, sequence of lifts and shape of the metal structure during these operations.

The Contractor shall submit a plan of field control for the installation insuring the metal structure is erected in accordance with the shop and erection drawings.

603.4.4 - Structural Plate Arches:

Excavation for the foundations of structural plate arches shall be as for metal structures and in accordance with 212.3.

603.5 - BEDDING

603.5.1 - General:

The metal structure bedding shall conform to one of the classes described below as specified. When no bedding class is specified, the requirements for Class B bedding shall apply. When a firm foundation is not found at grade due to the presence of foreign material or trash, or due to the presence of moisture eight percent in excess of optimum, the unsatisfactory material shall be removed for the width of the conduit plus 450mm on each side and replaced with granular material.

603.5.2 - Class A Bedding:

Class A bedding shall consist of a continuous concrete cradle conforming to the plan details.

603.5.3 - Class B Bedding:

Class B bedding shall consist of bedding the metal structure in an earth foundation of uniform density, carefully shaped by means of a template to fit the lower metal structure exterior for at least 15 percent of the overall height of the metal structure. Exception is made in the case of structural plate pipe where the length of the bedding arc need not exceed the width of the bottom plate. However, if the structural plate pipe is first assembled and then placed in the trench, the 15 percent embedment specified above shall apply. Recesses shall be made in the trench bottom to accommodate the bell when bell and spigot type metal structure is used. Fine aggregate shall be used to level the foundation. When rock is encountered, it shall be removed and replaced with specified material having a thickness under the metal structure of 150mm per metre height of fill over the top of the metal structure, with a min. thickness of 300mm and a max. thickness of 600mm.

603.5.4 - Class C Bedding:

Class C bedding shall be in accordance with the details shown on the Drawings. Recesses shall be made in the trench bottom to accommodate pipe joints.

603.6 - LAYING AND JOINING:

603.6.1 - Metal Structures:

The metal structure placing, unless the Contractor is otherwise directed, shall begin at the downstream end of the metal structure. The lower segment of the metal structure shall be in contact with the shaped bedding throughout its full length. Bell or groove ends of rigid metal structures and outside circumferential laps of corrugated steel pipe and corrugated aluminium alloy pipe metal structures shall be placed facing upstream.

Paved or partially lined metal structure shall be laid so that the longitudinal centreline of the paved segment coincides with the flow line.

Rigid metal structures may be of either bell and spigot or tongue and groove design, unless one type is specified. The method of joining metal structure sections shall be such that the ends are fully entered and the inner surfaces are reasonably flush and even.

Joints for rigid metal structures shall be made with (1) Portland cement mortar or grout, (2) flexible watertight gaskets, (3) bituminous plastic cement, (4) oakum and mortar, (5) oakum and joint compound, (6) vitrified clay pipe joints, (7) hot pour mineral filler joint sealer, or by a combination of these types.

When mortar joints are used for tongue and groove and bell and spigot metal structure, they shall be made by plastering up to the quarter point the joint mortar before the succeeding joint is placed. Thickness of mortar shall be sufficient to maintain proper invert grade. The accessible outer joint shall then be filled with an excess of mortar to form a bead around the outside of the metal structure and finished smooth on the inside. For grouted joints, melds or runners shall be used to retain the poured grout. When Portland cement mixtures are used, the completed joints shall be protected against rapid drying by suitable covering material. Where oakum is used, the joint shall be caulked with oakum and then sealed with the joint compound. When rubber or plastic gaskets are used, they shall be installed to form a flexible watertight seal.

Flexible metal structures shall be joined by couplings in accordance with manufacturers recommendations, and the pipe shall be fastened to preserve the alignment and prevent the separation of sections.

Metal structure shall be inspected before any backfill is placed. Any pipe found to be out of alignment, unduly settled, or damaged shall be removed and re-laid or replaced.

603.6.2 - Structural Plate Pipe and Pipe Arches:

The bottom plates of structural plate pipe and pipe arches shall be assembled in a line, placing each section in the order recommended by the manufacturer. Side and top plates shall then be placed in the order recommended by the manufacturer. Bolts shall be placed in the location and number as recommended by the manufacturer. Plates shall lap each other the width of one corrugation, and bolts shall be inserted and nuts hand tightened as each plate is placed. Drift pins may be used to facilitate matching holes. When all the plates are in position and all bolts placed, all bolts shall be gone over a second time to insure proper tightening. Steel bolts shall be torqued during installation to a minimum of 135 Newton-metres, and a maximum of 400 Newton-metres. Aluminium bolts shall be torqued during installation to a minimum of 135 Newton-metres, and a maximum of 200 Newton-metres.

For power driven tools, the hold-on period may vary from 2 to 5 seconds. Bolts shall be of sufficient length to provide for a full nut. When the structure is bituminous coated, all bolts and nuts shall be coated inside and outside of the structure, after completion of bolt tightening, with bituminous material conforming to the requirements of 713.3.

603.6.3 - Structural Plate Arches:

Plate arches shall be set on footings as shown on the Drawings. Beginning at the upstream end, the first side plates shall be set on the base angles. Then the remaining side plates and the top plates of the arch shall be bolted into place using only enough bolts to hold them without tightening securely. Drift pins may be used to assist in matching boltholes. Temporary props may be used to hold plates in place until connections are made. After the plates comprising the first arch have been assembled, the next set shall be placed in the same manner, finishing each set of side plates with a top plate before placing in the same manner, finishing each set of side plates with a top plate before placing the next set of side plates. New plates shall be lapped one corrugation on the outside of the preceding plates. When all the plates are in position, the remaining bolts shall be inserted and all

nuts firmly tightened. Steel bolts shall be torqued during installation to a minimum of 135 metres-metres, and a maximum of 400 metres-metres Aluminium bolts shall be torqued during installation to a minimum of 135 metres-metres, and a maximum of 200 metres-metres.

For power driven tools, the hold-on period may vary from 2 to 5 seconds. Bolts shall be of sufficient length to provide for a full nut. When the structure is bituminous coated, all bolts and nuts shall be coated inside and outside of the structure, after completion of bolt tightening, with bituminous material conforming to the requirements of 713.3.

603.7 - ELONGATION:

When specified on the Drawings, factory elongation of flexible pipe shall be between four to six percent vertically. Elongation shall be maintained during shipping, storing and handling.

603.8 - BACKFILLING:

Backfill material shall be suitable random material free from particles larger than 75mm, crushed aggregate backfill, or controlled low strength material. After the metal structure is installed, random material and crushed aggregate backfill shall be placed along the metal structure in layers not to exceed 100mm compacted. Controlled low strength material shall be placed according to Section 219. Any of the types of controlled low strength material may be used. For flexible metal structure 1,500mm through 2,700mm, the backfill material shall be crushed aggregate backfill or controlled low strength material.

Quality control testing and acceptance of controlled low strength material shall be according to Section 219.

The quality control testing and acceptance for compaction of the random backfill material shall be in accordance with Sections 207 and 716 and crushed aggregate backfill according to Section 717, with the following exception:

Testing will be conducted on both sides of the metal structure and testing within a lot may include tests on both sides of the metal structure. For metal structure installations in an embankment where existing tests are on file for the adjacent embankment material, the target percentage of dry density for the metal structure backfill will be equal to the average of the values for the tests in the adjacent lots of embankment material or a minimum value of 95, whichever is greater. For embankments where no tests are on file, the target percentage of dry density will be 95. A lot shall have five (5) density tests performed for quality control.

For metal structures less than 1,500mm in diameter, a lot will normally consist of the quantity of backfill required for each 23 metres of metal structure installed.

For metal structures 1,500mm in diameter and larger, a lot will normally consist of not more than 5 lifts of backfill. For metal structure with lifts of backfill placed for the full length of the metal structure, a sub-area will normally consist of a lift of backfill placed on both sides for the full length of the metal structure. For metal structures that are backfilled in segments, a sub-area will normally consist of a lift of backfill placed on both sides for the length of each segment of metal structure backfilled.

Backfill placed outside embankments and roadbed is to be compacted to or better than the average total dry density for the existing soil. An average total dry density will be determined from representative density tests conducted for each existing soil. Quality control testing will normally

consist of one test per 30 m of metal structure installed and area evaluations are not required.

The moisture tolerance is not applicable.

The use of a bulldozer or other bladed equipment in placing backfill is expressly forbidden. Mechanical equipment with various type buckets may be used. Care shall be taken to compact the material under the haunches of the metal structure, to place the backfill evenly on each side of the metal structure to retain its vertical axis, and to avoid displacement. This method of backfilling and compacting shall be followed until the top of the trench is reached. In the case of metal structure 1,500mm through 2,700mm in diameter, not in trench condition, this backfilling and compacting shall be carried to a height of 600mm over the top of the metal structure and to a width not less than the outside diameter of the metal structure plus one diameter on each side. Above this elevation, the embankment shall be placed and compacted in the normal manner. All metal structures, after being bedded and backfilled, shall be protected by a 1,200mm cover of fill, or more if necessary, before heavy equipment is permitted to cross during the construction of the roadway.

The Contractor will be held responsible for any damage to the conduit resulting from movement of equipment over the structure.

603.9 - FIELD PAVING:

When field paving is required for structural plate pipe and pipe arches, the following provisions shall govern:

The surface to be field paved shall be thoroughly cleaned and dried, and the priming material shall be sufficiently applied with a brush or a mop to coat the surface and to fill all seams or joints. After the priming material has been applied, a wire mesh, having not less than Size No. W 1.4 wire and having openings not more than 100mm by 150mm, shall be placed on top of the corrugations and securely fastened to the bolts with wire or suitable clips.

The reinforcing mesh shall have a width 300mm less than the width of the finished paving and shall be fastened to the structure near each edge and at the centre of the mesh at points not more than 600mm apart along the longitudinal barrel of the structure. The paving material shall consist of five parts of clean fine aggregate, three parts of cement or other fine filler such as limestone dust or lime, and approximately two parts of asphalt cement. The quantity of asphalt may be adjusted to provide a plastic workable mix. Before mixing, the mortar shall be dried by heating to approximately 150°C. After drying, the fine aggregate shall be mixed with the fine filler in a steel mortar box or other suitable equipment and heated to 150°C. The asphalt shall be heated in a separate container to a temperature of 200°C and then thoroughly mixed with the fine aggregate and filler until a workable mix is obtained. All lumps shall be removed by mixing with a mortar hoe or other suitable implement. The mixture shall be kept hot and shall be applied to the primed surface before cooling. The mixture shall be applied in such a manner that smooth pavement will be formed in the invert, filling the corrugations for at least 25 percent of the circumference of a pipe or 38 percent of the circumference of a pipe arch. The paving thickness shall be sufficient to cover the crests of the corrugations a minimum of 25mm. The placing of the mastic shall be followed closely by the application of a seal coat and hot asphalt cement to be poured uniformly over the paving. The seal coat shall be applied while the paving material is still hot.

The Contractor may pave with Portland Cement Concrete or use shotcrete. If practicable, such paving shall be delayed until completion of the fill over the structure. Before the placing of the paving, the surface of the plates shall be cleaned to the plates or to the asphalt coating if asphalt coated plates are used. When paving with Portland Cement Concrete or shotcrete, mesh

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reinforcement, fastening of mesh, and paving dimensions shall be as specified for bituminous paving except that the minimum thickness over the crest of the corrugations shall be 40mm.

Concrete used shall have a design 28-day characteristic strength of 35 Nmm^2 concrete may be hand mixed and shall be handled and placed as directed by the Engineer. After initial set has taken place, the paving shall be flooded or kept moist by sprinkling for three days. Liquid membrane-forming compound, conforming to 707.9 may be used for curing at a minimum application rate of 0.25 litres per square metre of concrete surface. Other methods of curing may be used if approved by the Engineer.

Field paving with shotcrete shall conform to the applicable provisions of Section 623. When paving with shotcrete, the exposed surface shall be brought to a uniform surface by screeding or troweling. After completion of the shotcrete paving, the rebound material shall be cleaned from the metal structure above the paved surface. Shotcrete shall be cured by (a) covering with burlap mats and keeping them wet for at least seven days after placing, (b) flooding for a period of at least seven days or, (c) applying liquid membrane curing compound, conforming to 707.9, at a minimum rate of 0.25 litres per square metre of shotcrete surface for each application. Shotcrete cured by membrane forming compound shall receive two applications; the second application shall be made after the first application has set. Other methods of curing may be used if approved by the Engineer.

After the completion of the fill over the pipe or pipe arch, any gaps which develop between the plates and the concrete or shotcrete paving shall be filled by pouring heated bituminous material complying with requirements of 713.3.

When field paving is specified for metal pipes and metal pipe arches, the methods and materials used shall be the same as specified except that the wire mesh shall be tied to the corrugated metal at points not exceeding 750mm in any direction and not exceeding 225mm from the edges of paving. Attachment may be by use of 12mm (minimum) commercially available galvanized or cadmium-plated lag screws twisted firmly into holes drilled in the valleys of the corrugations or by other approved means.

Prior to using Portland cement concrete or shotcrete for paving aluminium alloy metal structures or metal structures with coatings containing aluminium, the concrete-concrete contact area shall be coated with commercially available paint.

603.10 - RE-LAID METAL STRUCTURE:

The construction requirements in this Section shall apply equally in the case of re-laid metal structures. All metal structures salvaged for relaying shall be cleaned of all foreign material prior to reinstallation.

603.11 - JACKING METAL STRUCTURE:

Jacking or may be designated on the Drawings or may be permitted if written approval is obtained. Metal structure to be jacked may be either reinforced concrete or corrugated steel, as called for in the Drawings. The strength of metal structure designated in the Contract will be designated as required for vertical load only. Additional reinforcement or strength of metal structure required to withstand jacking pressure shall be determined and furnished by the Contractor without additional cost to the Employer. Variation from theoretical alignment and grade at the time of completion of jacking placement shall not exceed 10mm per linear metre of metal structure so placed. Corrugated steel pipe section to be jacked shall be prepared for making field joints either by riveting or bolting.

An approach trench shall be constructed on the side from which jacking operations shall take place. The end of the approach trench away from the jacking face shall be cut perpendicular to the axis of the jacking operation to provide bearing surface for the backstop and the jack blocking. The length of the approach trench shall be such that the distance between the jack blocking and the face of the bore shall be equal to 1,500mm plus the length of the individual pipe sections in the case of corrugated steel pipe. When concrete pipe is jacked, the maximum length of the approach trench shall be equal to two lengths of pipe plus a minimum of 2 metres for jack and blocking. The jacking face shall be a minimum of 1 metre above the top of the pipe; the face shall be cut vertically and shall be shored to prevent ravelling and slipping. A sump shall be constructed in one corner of the trench to provide drainage. In the case of corrugated steel pipe, a transverse trench shall be constructed at the jacking face to provide clearance for the riveting and bolting of joints. The backstop shall be constructed of heavy timbers or steel rails capable of withstanding the jacking force.

In the event the site of jacking operations is such that an approach trench cannot be constructed, the jack blocking shall be constructed to carry the reaction of the jack to the ground. This may be accomplished by means of timber, steel, or concrete vertical backstops set into the ground with the tops supported by diagonal members bearing against an embedded anchorage.

Directly opposite the approach trench, an exit trench shall be constructed to line and grade. The exit trench shall be constructed in the same manner as the approach trench except that no back wall is necessary.

Jacks shall be of sufficient capacity to overcome soil resistance to the jacking operation and shall be operated in pairs. As a guide, capacity of jacks for corrugated steel pipe shall be a minimum of 32 tonnes each and for concrete pipe a minimum of 45 tonnes each. For large pipe, more than one pair of jacks may be required. Small track jacks may be used to start the pipe.

Pipe guides shall be constructed in the approach trench and may be either timber or steel rail or concrete guides on a cradle. Since the pipe guides will support the pipe as it enters the jacking face, the pipe guides shall be accurately set to line and grade, and excavation for the guides shall be made to grade to avoid occurrence of settlement. Guides shall be spaced at 1/2 the pipe diameter inside face to inside face of the guides for corrugated steel pipe and at 4/10 the outside diameter for concrete pipe.

Reaction of the jack to the pipe shall be transmitted by either a jacking frame or jacking beams constructed of timber or steel. Jacking frames and beams shall be so placed as to exert equal pressure on each side of the pipe. For pipes 900mm in diameter or smaller, a steel jacking ring may be used instead of the jacking frame.

Joints of concrete pipe shall be cushioned and protected from infiltration of fine materials occurring during the jacking operation by insertion of a cushioning material into each pipe joint. After the pipe is in position, the joints shall be pointed from the inside with mortar joint compound.

Steel cutting edges on the lead section of pipe may be used, and the use of a jacking shield is permitted.

Excavation for the bore shall be to grade at the bottom and approximately 25mm greater than the diameter of the pipe at the top and sides. As excavation proceeds, the jacking shall proceed until the effective limit of the jacking is reached, at which time additional blocking shall be added. This

process shall be continued until there is room for an additional pipe section. For long runs of pipe, the use of intermediate jacking stations will be allowed as approved by the Engineer.

Pipe cover shall be a minimum of one diameter or 900mm from top of pipe to bottom of the subgrade of ballast when jacking under a bituminous concrete highway. When jacking under reinforced concrete pavement, the cover may be reduced to the depth of the base course plus the pavement thickness with a minimum cover of the pavement thickness plus 150mm.

After the pipe has been jacked into place, the backfill shall be tightly compacted around both ends of the metal structure to prevent erosion. Any departure from the above specifications necessitated due to site conditions shall be approved in writing by the Engineer.

Areas resulting from caving or excavation outside the above limits shall be backfilled with fine aggregate or grout by a method, which will fill the voids. Joints shall be completed as specified for the type of metal structure being installed.

603.12 - METHOD OF MEASUREMENT:

Metal structure of the different types and sizes, both new, re-laid and extended will be measured by the linear metre in place, the measurement being made along the centreline of each pipe installed. Branch connections, tees, wyes, and elbows will be measured along their centrelines and these lengths included in the total lengths of the appropriate metal structure. Wyes, tees, and other branch connections will be measured along the centrelines to points of intersection. Metal structure with sloped or skewed ends will be measured along the invert. The portion of pipe extending through to the inside face of headwalls of all types, manholes, inlets, boxes, or other structures shall be included in the measurement, and the cost is included in unit cost of pipes.

End sections and joints will not be measured separately.

Connection ring beams (head walls) are not measured separately and are deemed to be included within 603.14 Pay Items. The related work shall include all the necessary demolition of already constructed works, concrete, reinforcement, formwork, falsework and all other necessary items, labour and plant to complete the work according to requirements. Connection details and works shall all be in accordance with the requirements of the manufacturer and supplier approved by the Engineer.

The head walls (ring beams) are measured separately under items 603.007 to 603.012. Rates to include for all work in connection with design and construction of reinforced concrete, plain concrete, reinforced earth, wing wall facings and associated backfill.

Excavation is measured separately according to Section 212.

Bedding will be classified according to this section and measured separately in cubic metres. The concrete for bedding shall be complied with Section 551. The bedding concrete shall include forms and reinforcements in addition to items described in 551.15.

Jointing of pipes shall be enumerated separately irrespective of the type of joint. The classification of joint will be varied according to the diameter of the pipe.

Backfilling will be measured separately in cubic metres.

Metal structure designated on the Drawings to be installed by the jacking method will be measured

separately by the linear metre in place and shall be the actual portion jacked, completed in place, and accepted.

It is confirmed that the Bill of Quantities Items 603.007 to 603.012 inclusive "Bills of Quantities including Dayworks" include for the precast facing walls for the corresponding sizes of metal structure.

Professional indemnity insurance will be required on the part of the Contractor in respect of the design of all metal structures, valid until the end of the Defects Liability Period. Premiums for this insurance will not be measured separately.

603.13 - BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the pay items listed in 604.14, and appropriate sections which prices and payments shall be full compensation for excavation and bedding, except as otherwise provided, backfilling, jacking when called for, furnishing all materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labour, tools, equipment, supplies, and incidentals necessary to complete the work. The unit price bid for end sections shall include excavation and backfill.

603.14 - PAY ITEMS:

ITEM	DESCRIPTION	UNIT
603.001	Metal arch underpass MAUP 47N including concrete foundation and thrust blocks	Metre
603.002	Metal arch underpass MAUP 55N including concrete foundation and thrust blocks	Metre
603.003	Metal arch underpass MAUP 67N including concrete foundation and thrust blocks	Metre
603.004	Metal arch underpass HPA 60N including concrete foundation and thrust blocks	Metre
603.005	Metal arch underpass HPA 74N including concrete foundation and thrust blocks	Metre
603.006	Metal arch underpass HES 87N including concrete foundation and thrust blocks	Metre
603.007	Headwall for MAUP 47N	Number
603.008	Headwall for MAUP 55N	Number
603.009	Headwall for MAUP 67N	Number
603.010	Headwall for HPA 60N	Number
603.011	Headwall for HPA 74N	Number
603.012	Headwall for HPA 87N	Number
603.013	Pipe bedding Class 'A'	Cubic metre
603.014	Pipe bedding Class 'B'	Cubic metre
603.015	Pipe bedding Class 'C'	Cubic metre

SECTION 604
CONCRETE PIPELINES AND PIPE CROSSINGS

604.1 - DESCRIPTION:

This work shall consist of the construction or reconstruction of concrete pipelines or pipe crossings, referred to jointly as "pipeline", in accordance with these Specifications and in conformity with the lines, grades, dimensions, and locations shown on the Drawings or established by the Engineer.

604.2 - MATERIALS:

Materials shall meet the requirement specified in the following Sub-Sections of Division 700:

MATERIAL	SUB-SECTION
Reinforced Concrete Pipe	714.2
Reinforced Concrete End Section for Round Concrete Pipe.	714.18
Reinforced Concrete Pipe Arch	714.3
Reinforced Concrete End Section for Arch-Shaped Concrete Pipe	714.18
Reinforced Concrete Elliptical Pipe	714.4
Reinforced Concrete End Section for Elliptical Concrete Pipe	714.18
Joint Mortar	708.8
Bituminous Plastic Cement	708.9
Granular Material for Pipeline Bedding	716.1.1.2
Controlled Low Strength Material	219
Crushed Aggregate Backfill	704.6
*Fine Aggregate	702*

*Fine Aggregate shall consist of crushed or uncrushed mineral aggregate, which has 100 percent passing the 9.5mm sieve.

When the locations of manufacturing plants allow, the plants may be inspected periodically for compliance with specified manufacturing methods, and material samples may be obtained for laboratory testing for compliance with material quality requirements. This may be the basis for quality acceptance of manufactured areas.

All materials will be subject to inspection for acceptance as to condition at the latest practicable time the Engineer has the opportunity to check for compliance prior to or during incorporation of materials in the work.

unreinforced concrete pipes shall conform to AASHTO M 86M for the diameter and strength.

Reinforced concrete pipes shall conform to AASHTO M 170M for the diameter and strength.

Bidders are required to ensure that locally manufactured pipes shall meet in all respects the standards required in the Technical Specifications.

604.2.1 - QUALITY CONTROL TESTING:

Quality control of the fine aggregate, granular material and crushed aggregate backfill is the responsibility of the Contractor.

Acceptance for gradation will be on the basis of the Contractor's written certification that all such material used for this conforms to the specified requirements. The certification is to include the results of testing from samples obtained at a minimum frequency of one sample per one-half day of aggregate production or stockpiling.

CONSTRUCTION METHODS

604.3 - GENERAL:

Subject to the provisions prescribed, the flow line of a pipeline may be altered from that shown on the Drawings. If a firm pipeline foundation is not encountered at the specified elevation, the unsatisfactory material shall be replaced with suitable material to a depth directed by the Engineer.

Galvanized steel pipe or bands shall not come in contact with aluminised steel pipe or bands.

The nom. internal diameter of pipes in this Section is the largest dimension, horizontal or vertical.

604.4 - TRENCH EXCAVATION:

604.4.1 - Pipelines 450mm through 1400mm:

In complete or partial fill sections, before trenching is begun, the fill shall be constructed for a minimum distance of six diameters on each side of the pipeline and to a height of 600mm over the top of the pipeline or to the surface of the completed embankment if less than 600mm above the top of the pipeline. The width of the trench, in either cut of fill sections, shall not be less than the outside diameter of the pipeline or encasement plus 450mm on each side of the pipeline measured to the face of the trench or to the sheeting when used.

604.4.2 - Pipelines 1500mm through 2700mm:

In complete or partial fill sections, before trenching is begun, the fill shall be constructed for a distance of six diameters on each side of the pipeline and to a minimum height of 25 percent of the vertical dimension of the pipeline. The width of the trench shall not be less than the outside horizontal diameter of the pipeline plus one diameter on each side of the pipeline. When using a Controlled low strength material the width of the trench shall not be less than the outside horizontal diameter of the pipeline plus one half diameter on each side of the pipeline.

In rock or shale cut section, the width of the trench shall not be greater than required to obtain the backfill compaction specified. Soil cut trenches shall be treated as complete or partial fill sections. For rigid pipe, the width of the trench shall not be less than the outside horizontal diameter of the culvert plus 600mm on each side of the culvert.

604.4.3 - Pipeline Greater than 2700mm:

In complete or partial fill sections, before trenching is begun, the fill shall be constructed for a distance of six diameters on each side of the pipeline and to a minimum height of 25 percent of the vertical dimension of the pipeline.

Installation of the pipeline shall be as detailed in the Drawings, including the type and amount of backfill and bedding.

The Contractor shall submit a plan of field control for the installation ensuring the pipeline is erected in accordance with the shop and erection drawings.

604.5 - BEDDING

604.5.1 - General:

The pipeline bedding shall conform to one of the classes described below as specified. When no bedding class is specified, the requirements for Class B bedding shall apply.

When a firm foundation is not found at grade due to the presence of foreign material or trash, or due to the presence of moisture eight percent in excess of optimum, the unsatisfactory material shall be removed for the width of the pipeline plus 450mm on each side and replaced with granular material.

604.5.2 - Class A Bedding:

Class A bedding shall consist of a continuous concrete cradle conforming to the plan details.

604.5.3 - Class B Bedding:

Class B bedding shall consist of bedding the pipeline in an earth foundation of uniform density, carefully shaped by means of a template to fit the lower pipeline exterior for at least 15 percent of the overall height of the pipeline. However, if the structural plate pipe is first assembled and then placed in the trench, the 15 percent embedment specified above shall apply. Recesses shall be made in the trench bottom to accommodate the bell when bell and spigot type pipeline is used. Fine aggregate shall be used to level the foundation. When rock is encountered, it shall be removed and replaced with specified material having a thickness under the pipeline of 150mm per metre height of fill over the top of the pipeline, with a minimum thickness of 300mm and a maximum thickness of 600mm.

604.5.4 - Class C Bedding:

Class C bedding shall be in accordance with the details shown on the Drawings. Recesses shall be made in the trench bottom to accommodate the bell when bell and spigot type pipeline is used.

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604.6 - LAYING AND JOINING:

604.6.1 - Rigid Pipelines:

The pipeline placing, unless the Contractor is otherwise directed, shall begin at the downstream end of the pipeline. The lower segment of the pipeline shall be in contact with the shaped bedding throughout its full length. Bell or groove ends of pipelines shall be placed facing upstream.

Paved or partially lined pipeline shall be laid so that the longitudinal centreline of the paved segment coincides with the flow line.

Pipelines may be of either bell and spigot or tongue and groove design, unless one type is specified. The method of joining pipeline sections shall be such that the ends are fully entered and the inner surfaces are reasonably flush and even.

Joints for rigid pipelines shall be made with (1) Portland cement mortar or grout, (2) flexible watertight gaskets, (3) bituminous plastic cement, (4) oakum and mortar, (5) oakum and joint compound, (6) vitrified clay pipe joints, (7) hot pour mineral filler joint sealer, or by a combination of these types.

When mortar joints are used for tongue and groove and bell and spigot pipeline, they shall be made by plastering up to the quarter point the joint mortar before the succeeding joint is placed. Thickness of mortar shall be sufficient to maintain proper invert grade. The accessible outer joint shall then be filled with an excess of mortar to form a bead around the outside of the pipeline and finished smooth on the inside. For grouted joints, moulds or runners shall be used to retain the poured grout. When Portland cement mixtures are used, the completed joints shall be protected against rapid drying by suitable covering material. Where oakum in used, the joint shall be caulked with oakum and then sealed with the joint compound. When rubber or plastic gaskets are used, they shall be installed to form a flexible watertight seal.

Pipeline shall be inspected before any backfill is placed. Any pipe found to be out of alignment, unduly settled, or damaged should be removed and re-laid or replaced.

604.6.2 - Structural Plate Pipe and Pipe Arches: & 604.6.3 - Structural Plate Arches: Not used

604.7 - ELONGATION: Not Used

604.8 - BACKFILLING:

Backfill material shall be suitable random material free from particles larger than 75mm, crushed aggregate backfill, or controlled low strength material. After the pipeline is installed, random material and crushed aggregate backfill shall be placed along the pipeline in layers not to exceed 100mm compacted. Controlled low strength material shall be placed according to Section 219. Any of the types of controlled low strength material may be used.

Quality control testing and acceptance of controlled low strength material shall be according to Section 219.

The quality control testing and acceptance for compaction of the random backfill material shall be in accordance with applicable sections of 207 and 716 and crushed aggregate backfill according to 717, with the following exception:

Testing will be conducted on both sides of the pipeline and testing within a lot may include tests on both sides of the pipeline. For pipeline installations in an embankment where existing tests are on file for the adjacent embankment material, the target percentage of dry density for the pipeline backfill will be equal to the average of values for the tests in the adjacent lots of embankment material or a minimum value of 95, whichever is greater. For embankments where no tests are on file, the target percentage of dry density will be 95. A lot shall have five (5) density tests performed for quality control.

For pipelines less than 1,500mm in diameter, a lot will normally consist of the quantity of backfill required for each 23 metres of pipeline installed.

For pipelines 1,500mm in diameter and larger, a lot will normally consist of not more than 5 lifts of backfill. For pipeline with lifts of backfill placed for the full length of the pipeline, a lot will normally consist of a lift of backfill placed on both sides for the full length of the pipeline. For pipelines that are backfilled in segments, a sub-area will normally consist of a lift of backfill placed on both sides for the length of each segment of pipeline backfilled.

Backfill placed outside embankments and roadbed is to be compacted to or better than the average total dry density for the existing soil. An average total dry density will be determined from representative density tests conducted for each existing soil. Quality control testing will normally consist of one test per 30 m of pipeline installed and lot evaluations are not required. The moisture tolerance is not applicable.

The use of a bulldozer or other bladed equipment in placing backfill is expressly forbidden. Mechanical equipment with various type buckets may be used. Care shall be taken to compact the material under the haunches of the pipeline, to place the backfill evenly on each side of the pipeline to retain its vertical axis, and to avoid displacement. This method of backfilling and compacting shall be followed until the top of the trench is reached. In the case of pipeline 1,500mm through 2,700mm in diameter, not in trench condition, this backfilling and compacting shall be carried to a height of 600mm over the top of the pipeline and to a width not less than the outside diameter of the pipeline plus one diameter on each side. Above this elevation, the embankment shall be placed and compacted in the normal manner. All pipeline, after being bedded and backfilled, shall be protected by a 1,200mm cover of fill, or more if necessary, before heavy equipment is permitted to cross during the construction of the roadway. The Contractor will be held responsible for any damage to the pipeline resulting from movement of equipment over the structure.

604.9 - FIELD PAVING:

When field paving is required for structural concrete pipelines, the following provisions shall govern:

The surface to be field paved shall be thoroughly cleaned and dried, and the priming material shall be sufficiently applied with a brush or a mop to coat the surface and to fill all seams or joints. After the priming material has been applied, a wire mesh, having not less than Size No. W 1.4 wire and having openings not more than 100mm by 150mm, shall be placed on top of the corrugations and securely fastened to the bolts with wire or suitable clips.

The reinforcing mesh shall have a width 300mm less than the width of the finished paving and shall be fastened to the pipeline near each edge and at the centre of the mesh at points not more than 600mm apart along the longitudinal barrel of the pipeline. The paving material shall consist of five parts of clean fine aggregate, three parts of cement or other fine filler such as limestone dust or lime, and approximately two parts of asphalt cement. The quantity of asphalt may be adjusted to provide a plastic workable mix. Before mixing, the mortar fine aggregate shall be dried by heating to approximately 150°C. After drying, the fine aggregate shall be mixed with the fine filler in a steel mortar box or other suitable equipment and heated to 150°C. The asphalt shall be heated in a separate container to a temperature of 200°C and then thoroughly mixed with the fine aggregate and filler until a workable mix is obtained. All lumps shall be removed by mixing with a mortar hoe or other suitable implement. The mixture shall be kept hot and shall be applied to the primed surface before cooling. The mixture shall be applied in such a manner that smooth pavement will be formed in the invert, filling the corrugations for at least 25 percent of the circumference of a pipe or 38 percent of the circumference of a pipe arch. The paving thickness shall be sufficient to cover the crests of the corrugations a minimum of 25mm. The placing of the mastic shall be followed closely by the application of a seal coat and hot asphalt cement to be poured uniformly over the paving. The seal coat shall be applied while the paving material is still hot.

The Contractor may pave with Portland Cement Concrete or use shotcrete. If practicable, such paving shall be delayed until completion of the fill over the structure. Before the placing of the paving, the surface of the plates shall be cleaned to the plates or to the asphalt coating if asphalt coated plates are used. When paving with Portland Cement Concrete or shotcrete, mesh reinforcement, fastening of mesh, and paving dimensions shall be as specified for bituminous paving except that the minimum thickness over the crest of the corrugations shall be 40mm.

Concrete used shall have a design 28-day characteristic strength of 35Nmm^2 concrete may be hand mixed and shall be handled and placed as directed by the Engineer. After initial set has taken place, the paving shall be flooded or kept moist by sprinkling for three days. Liquid membrane-forming compound, conforming to 707.9 may be used for curing at a minimum application rate of 0.25 litres per square metre of concrete surface. Other methods of curing may be used if approved by the Engineer.

Field paving with shotcrete shall conform to the applicable provisions of Section 623. When paving with shotcrete, the exposed surface shall be brought to a uniform surface by screeding or troweling. After completion of the shotcrete paving, the rebound material shall be cleaned from the pipeline above the paved surface. Shotcrete shall be cured by (a) covering with burlap mats and keeping them wet for at least seven days after placing, (b) flooding for a period of at least seven days or, (c) applying liquid membrane curing compound, conforming to 707.9, at a minimum rate of 0.25 litres per square metre of shotcrete surface for each application. Shotcrete cured by membrane forming compound shall receive two applications; the second application shall be made after the first application has set. Other methods of curing may be used if approved by the Engineer.

After the completion of the fill over the pipe, any gaps which develop between concrete or shotcrete paving shall be filled by pouring heated bituminous material complying with requirements of 713.3

When field paving is specified for metal pipes and metal pipe arches, the methods and materials used shall be the same as specified except that the wire mesh shall be tied to the corrugated metal at points not exceeding 750mm in any direction and not exceeding 225mm from the edges of paving. Attachment may be by use of 12mm (minimum) commercially available galvanized or cadmium-plated lag screws twisted firmly into holes drilled in the valleys of the corrugations or by other approved means.

604.10 - RE-LAID PIPELINE:

The construction requirements in this Section shall apply equally in the case of re-laid culverts. All culverts salvaged for relaying shall be cleaned of all foreign material prior to reinstallation.

604.11 - JACKING PIPELINE:

Jacking or may be designated on the Drawings or may be permitted if written approval is obtained. Pipeline to be jacked may be either reinforced concrete or corrugated steel, as called for in the Drawings. Additional reinforcement or strength of pipeline required to withstand jacking pressure shall be determined and furnished by the Contractor without additional cost to the Government. Variation from theoretical alignment and grade at the time of completion of jacking placement shall not exceed 10mm per linear metre of pipeline so placed. Concrete pipe to be jacked shall be tongue and groove type.

An approach trench shall be constructed on the side from which jacking operations shall take place. The end of the approach trench away from the jacking face shall be cut perpendicular to the axis of the jacking operation to provide bearing surface for the backstop and the jack blocking. When concrete pipe is jacked, the maximum length of the approach trench shall be equal to two lengths of pipe plus a minimum of 2 metres for jack and blocking. The jacking face shall be a minimum of 1 metre above the top of the pipe; the face shall be cut vertically and shall be shored to prevent ravelling and slipping. A sump shall be constructed in one corner of the trench to provide drainage. The backstop shall be constructed of heavy timbers or steel rails capable of withstanding the jacking force.

In the event the site of jacking operations is such that an approach trench cannot be constructed, the jack blocking shall be constructed to carry the reaction of the jack to the ground. This may be accomplished by means of timber, steel, or concrete vertical backstops set into the ground with the tops supported by diagonal members bearing against an embedded anchorage.

Directly opposite the approach trench, an exit trench shall be constructed to line and grade. The exit trench shall be constructed as for the approach trench except that no back wall is necessary.

Jacks shall be of sufficient capacity to overcome soil resistance to the jacking operation and shall be operated in pairs. As a guide, capacity of jacks for concrete pipe shall be a minimum of 45 tonnes each. For large pipe, more than one pair of jacks may be required.

Pipe guides shall be constructed in the approach trench and may be either timber or steel rail or concrete guides on a cradle. Since the pipe guides will support the pipe as it enters the jacking face, the pipe guides shall be accurately set to line and grade, and excavation for the guides shall be made to grade to avoid occurrence of settlement. Guides shall be spaced at 4/10 of the outside diameter for concrete pipe .

Reaction of the jack to the pipe shall be transmitted by either a jacking frame or jacking beams constructed of timber or steel. Jacking frames and beams shall be so placed as to exert equal pressure on each side of the pipe. For pipes 900mm in diameter or smaller, a steel jacking ring may be used in lieu of the jacking frame.

The pressure from the jacking frame or beams may be transmitted to a jacking collar or head on the pipe itself. Jacking collars or heads for concrete pipe shall be constructed to prevent damage to the pipe ends. Jacking collars and jacking frames shall be constructed to allow passage of men and material.

Joints of concrete pipe shall be cushioned and protected from infiltration of fine materials occurring during the jacking operation by insertion of a cushioning material into each pipe joint. After the pipe is in position, the joints shall be pointed from the inside with mortar joint compound.

Excavation for the bore shall be to grade at the bottom and approximately 25mm greater than the diameter of the pipe at the top and sides. Initial jacking of concrete pipe shall begin with two sections of pipe in the trench. As excavation proceeds, the jacking shall proceed until the effective limit of the jacking is reached, at which time additional blocking shall be added. This process shall be continued until there is room for an additional pipe section. For long runs of pipe, the use of intermediate jacking stations will be allowed as approved by the Engineer.

Pipe cover shall be a minimum of one diameter or 900mm from top of pipe to bottom of the subgrade of ballast when jacking under a bituminous concrete highway. When jacking under reinforced concrete pavement, the cover may be reduced to the depth of the base course plus the pavement thickness with a minimum cover of the pavement thickness plus 150mm.

After the pipe has been jacked into place, the backfill shall be tightly compacted around both ends of the pipeline to prevent erosion. Any departure from the above specifications necessitated due to site conditions shall be approved in writing by the Engineer.

Areas resulting from caving or excavation outside the above limits shall be backfilled with fine aggregate or grout by a method, which will fill the voids. Joints shall be completed as specified for the type of pipeline being installed.

604.12 - METHOD OF MEASUREMENT:

Pipeline of the different types and sizes, both new and re-laid, will be measured by the linear metre in place, the measurement being made along the centreline of each pipeline installed. Branch connections, tees, wyes, and elbows will be measured along their centrelines and these lengths included in the total lengths of the appropriate pipeline. Wyes, tees, and other branch connections will be measured along the centrelines to points of intersection. Pipeline with sloped or skewed ends will be measured along the pipeline invert. The portion of pipe extending through to the inside face of headwalls of all types, manholes, inlets, boxes, or other structures shall be included in the measurement and the cost is included in unit cost of pipes .

End sections and pipe joints will not be measured and paid for separately.
The head walls are measured separately as per Sections 551 and 552

.

Excavation is measured separately according to Section 212.
Bedding will be classified according to this Section and measured separately in cubic metres.

The concrete for bedding shall be complied to Section 551 and include for forms and reinforcement.

Only pipelines designated on the Drawings (if any) to be installed by the jacking method will be measured separately by the linear metre in place and shall be the actual approved length jacked.

The bidders' attention is drawn to the reference to Section 212 in Sub-Section 604.12 of the Technical Specifications, Page 20 of 118, three lines from the bottom of the page. Excavation for drainage structures (including culvert pipes) shall be measured under Bill of Quantities Items 212.001, 212.003, and 212.005. Backfill for same shall be measured under Bill of Quantities Item 212.007.

604.13 - BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the pay items listed in 604.14, and appropriate sections. These prices and payments shall be full compensation for excavation, bedding and backfilling (except as otherwise provided for) backfilling, furnishing all materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labour, tools, equipment, supplies, and incidentals necessary to complete the work. All costs for pipe jacking ,when called for, are to be deemed included in pay item unit rates.

When, by the authority of the Engineer, the invert of a pipeline is lowered from that shown on Approved Working Drawings, due to either to a lack of a firm foundation, or to a solid rock foundation, unsatisfactory material is removed and replaced with suitable material.

604.14 - PAY ITEMS

ITEM	DESCRIPTION	UNIT
604.001	Reinforced concrete pipe dia. 450mm (provisional)	Metre
604.002	Reinforced concrete pipe dia. 600mm (provisional)	Metre
604.003	Reinforced concrete pipe dia. 900mm	Metre
604.004	Reinforced concrete pipe dia. 1,000mm	Metre
604.005	Reinforced concrete pipe dia. 1,200mm	Metre
604.006	Reinforced concrete pipe dia. 1,500mm	Metre
604.007a	End section for concrete pipe dia. 450mm (RRM with RC)	Number
604.007b	End section for concrete pipe dia. 450mm (RRM only)	Number
604.008a	End section for concrete pipe dia. 600mm (RRM with RC)	Number
604.008b	End section for concrete pipe dia. 600mm (RRM only)	Number
604.009a	End section for concrete pipe dia. 900mm (RRM with RC)	Number
604.009b	End section for concrete pipe dia. 900mm (RRM only)	Number
604.010a	End section for concrete pipe dia. 1,000mm (RRM with RC)	Number
604.010b	End section for concrete pipe dia. 1,000mm (RRM only)	Number
604.011a	End section for concrete pipe dia. 1,200mm (RRM with RC)	Number
604.011b	End section for concrete pipe dia. 1,200mm (RRM only)	Number
604.012a	End section for concrete pipe dia. 1,500mm (RRM with RC)	Number
604.012b	End section for concrete pipe dia. 1,500mm (RRM only)	Number
604.013	Pipe bedding Class 'A'	Cubic metre
604.014	Pipe bedding Class 'B'	Cubic metre
604.015	Pipe bedding Class 'C'	Cubic metre

Payment items for excavation and backfilling for various concrete pipe culverts and drop inlets shall be made separately under bill of quantities item 212.001 and 212.007 respectively.

SECTION 605
MANHOLES AND INLETS

605.1 - DESCRIPTION:

This work shall consist of the construction of new and adjustment of existing manholes and/or inlets in accordance with these Specifications and in conformity with the lines, grades, dimensions and locations shown on the Drawings or established by the Engineer. Types of manholes and/or inlets shall be as shown on the Drawings.

605.2 - MATERIALS:

Cast-In-Place concrete and reinforcing steel for manholes and inlets shall meet the requirements of Section 551 (Class 30/20) and Section 552 respectively. Precast concrete manholes shall conform to 715.19. Portland cement concrete for precast inlets shall meet the requirements in 715.19. Other requirements and details for precast inlets shall be as specified on the drawings.

Other materials shall meet the requirements specified in the following Sub-Sections of Division 700:

MATERIAL	SUB-SECTION
Concrete Brick	715.17
Concrete Masonry Blocks	715.18
Joint Mortar	708.8
Grey Iron Castings	709.10
Manhole Steps	709.10, 715.19, 715.38
Pipe for Slot Inlets	713.2
Aggregate for Slot Inlets (Aggregate For Fabric Underdrain)	606.2
Fabric for Slot Inlets	715.11

Lean grout backfill, where specified on the Plans, shall consist of 167 kg of cement per cubic metre of material suitable to the Engineer.

Component materials shall be sampled, tested, and approved prior to the start of manufacture. Manholes and inlets shall be inspected at the manufacturing plant, if acceptable they shall be identified in accordance with ASTM D 223 4 E 105.

All materials will be subject to inspection for acceptance as to condition at the latest practicable time the Engineer has the opportunity to check for compliance prior to or during incorporation of materials in the work.

Covers and frames for manholes and grates, frames, and grate support bars for inlets shall be grey iron castings except for Type G Inlets, which require structural steel meeting 709.12.

605.3 - CONSTRUCTION METHODS:

Concrete construction shall conform to the requirements for Section 551. Masonry shall conform to the requirements for the respective type. Exposed masonry surfaces shall be cured with wet burlap for a period of not less than 48 hours. Concrete surfaces shall be cured in accordance with 551.12.

Metal frames for inlets shall be set in a full mortar bed or cast into the concrete. Pipe sections shall be flush on the inside of the structure wall and project outside sufficiently for proper connection with the next pipe section.

Masonry shall fit neatly and tightly around the pipe. The flow line of the outlet pipe shall match the bottom elevation of the inlet or manhole. When the bell or groove of concrete pipe is placed in an inlet, the inside of the bell or groove shall be filled with concrete up to the flow line.

Bearing areas of frames, covers, and grates shall be so fitted and finished as to provide a firm, even seat for the entire cover or grate in the frame. No projections shall exist on the bearing areas of the castings; and the cover or grate shall seat in the frame without rocking.

Concrete inlets and manholes may be precast when shapes and dimensions conform to those shown on the Plans and when final installed top surfaces are flush with adjacent finish surfaces such as pavement, gutters, curbs, and sidewalks. Precast units shall include lifting hooks, which will be out of sight after placement of the units and sufficient reinforcement to resist handling stresses.

Excavation and backfill shall be done in accordance with Section 212.

When grade adjustment of existing structures is specified, the work shall be accomplished by one of the following methods:

Carefully remove the existing frame; reconstruct the walls as necessary; clean and reset the existing frame in a full mortar bed at the required elevation.

Carefully remove the existing cover or grate and furnish and install an approved adjusting ring or casting.

Upon completion, each structure shall be cleaned of any accumulations of silt, debris, or foreign matter of any kind and shall be kept clear of such accumulation until final acceptance of the work.

605.4 - METHOD OF MEASUREMENT:

Manholes and/or inlets, new or adjusted will be measured by the unit; slot inlets will be measured by the linear metre in place.

Items for work in this class shall be deemed to include excavation, preparation of surfaces, disposal of excavated material, upholding sides of excavation backfilling and removal of dead services, except to the extent that such work is included in other sections.

Items for work in this section shall be deemed to include concrete, reinforcement, formwork, joints and finishes and metal work and pipe work other than valves.

Items for manholes with backdrops shall be deemed to include the pipework and associated fittings comprising the backdrop.

605.5 - BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for as provided below, which prices and payments shall be full compensation for furnishing the excavation, backfill, Shoring, dewatering,

concrete, aggregate, reinforcing steel, fabric, grates, covers, frames, hardware, and other materials shown on the Plans and for doing all the work, including all labour, tools, equipment, supplies and incidentals necessary to complete the work.

When changes in Plans during construction require increases of depth in excess of 300mm, the equitable price adjustment will be equal to the bid amount increased by a factor of the constructed depth less 300mm divided by the Plan depth.

When grade and drain contracts are bid separately from paving contracts, the structure may be designated to be partially built by the grade and drain Contractor and later completed by the paving Contractor.

605.6 - PAY ITEMS:

ITEM	DESCRIPTION	UNIT
605.001	Drop inlet 900 x 800 x 1000 (maximum pipe dia. 450mm)	Number
605.002	Drop inlet 900 x 1200 x 1300 (maximum pipe dia. 600mm)	Number
605.003	Drop inlet 900 x 1300 x 1400 (maximum pipe dia. 900mm)	Number
605.004	Drop inlet 900 x 1500 x 1600 (maximum pipe dia. 1,200mm)	Number
605.005	Drop inlet 900 x 1900 x 1900 (maximum pipe dia. 1,500mm)	Number

SECTION 606

UNDERDRAINS

606.1 - DESCRIPTION:

This work shall consist of constructing underdrains and free draining base trenches using pipe and granular material, blind drains, aggregate filled engineering fabric, prefabricated pavement edge drain and underdrain pipe outlets in accordance with these Specifications and in conformity with the lines, grades, dimensions and locations shown on the Drawings or established by the Engineer.

When "underdrain pipe" per linear metre, is included as a pay item in the Contract, any of the following pipe types may be furnished for construction of the underdrain: bituminous coated corrugated steel underdrain pipe, corrugated aluminium alloy underdrain pipe, non-reinforced perforated concrete underdrain pipe, porous concrete pipe, standard strength perforated clay pipe, extra strength perforated clay pipe perforated bituminous fibre underdrain pipe, corrugated stainless steel underdrain pipe, pre-coated, galvanized steel pipe for underdrains, corrugated polyethylene underdrain pipe or perforated plastic semicircular pipe.

606.2 - MATERIALS:

Material shall meet the requirements specified in the following Subsections of Division 700:

MATERIAL	SUBSECTION	TYPE OR GRADATION
Metallic Coated Corrugated Steel Pipe for underdrains	713.11	Class I, II or III
*Bituminous Coated Corrugated Steel Pipe for underdrains	713.12	Class I, II or III
***Corrugated Aluminium Alloy Pipe for underdrains	713.16	Type I, II, II or IV
***Bituminous Coated Corrugated Aluminium Alloy Pipe for Underdrains	713.17	Type I, II, II or IV
*Pre-coated Metallic Coated Coating Steel Pipe for Underdrains	713.23	Class I or II, Type B
Corrugated Stainless Steel Pipe for Underdrains	713.7	
Non-Reinforced Perforated Concrete Underdrain Pipe	714.5	Class I, 2 or 3
Porous Concrete Pipe Class I or II	714.6	
Standard Quality Concrete Drain Tile	714.7	
Extra Quality Concrete Drain Tile	714.7	
Special Quality Concrete Drain Tile	714.7	
**Bituminous Fibre Pipe:		
Non-Perforated	714.14	
Perforated	714.15	
Crushed Stone for Underdrains	703.1 & 703.4	AASHTO Size # 67, 7 or 78
Gravel for Underdrains	703.2 & 703.4	AASHTO Size # 67, 7 or 78
Silica Fine aggregate for Underdrains	702.1.2, 702.1.3 & 702.6	

Engineering Fabric	715.11
Concrete for Miscellaneous Uses	715.12
Prefabricated Pavement Edge Drain	715.10.1

* Unless otherwise specified, Class IV, semicircular pipe 117mm in diameter, may be furnished when 150mm diameter pipe is called for on the Drawings.

** Unless otherwise specified. Perforated pipe shall be used.

*** Unless otherwise specified. Type V, semicircular pipe 117mm in diameter, may be furnished when 150mm diameter pipe is called for on the Drawings.

**** Plastic semicircular pipe may be furnished only when 150mm diameter is called for on the Drawings.

***** Aggregate for aggregate filled fabric underdrain shall consist of crushed stone conforming to the requirements of 703.1 or gravel conforming to the requirements of 703.2. The grading may be any standard AASHTO size between No. 2 and No. 57, inclusive, but only one size may be used at any one installation. Pea gravel as described in 703.2.3 shall not be used on this project unless a shortfall of excavated crushed rock occurs. When the locations of manufacturing plants allow, the plants may be inspected periodically for compliance with specified manufacturing methods, and material samples may be obtained for laboratory testing for compliance with material quality requirements. This may be the basis for acceptance of manufacturing lots as to quality.

All materials will be subject to inspection for acceptance as to condition at the latest practicable time the Engineer has the opportunity to check for compliance prior to or during incorporation of materials in the work.

CONSTRUCTION METHODS

606.3 - PIPE INSTALLATION:

606.3.1 - Trenching:

Trenches shall be excavated to a width of the outside diameter of the pipe plus 300mm, to a depth of 100mm below the flow line, and to the grade required by the Drawings or as directed. Trench walls shall be as nearly vertical as practicable.

606.3.2 - Bedding and Placing Pipe:

A minimum 100mm bedding layer of crushed aggregate shall be placed in the bottom of the trench for its full width and length.

Sub-drainage pipe of the type and size specified shall be embedded firmly in the bedding material. Upgrade ends of all underdrain pipe installations shall be closed with suitable plugs to prevent entry of soil materials.

Perforated pipe shall normally be placed with the perforations down. Flexible pipe sections shall be joined with couplings or bands as recommended by the manufacturer. Non-perforated pipe and rigid pipe shall be firmly set and laid with the bell and groove ends upgrade and with open joints, wrapped with suitable material when specified, to permit entry of water.

606.3.3 - Placing Filter Material:

After the pipe installations have been inspected and approved, crushed stone or crushed gravel shall be placed to a height of 150mm above the top of pipe. The trench shall then be filled with fine aggregate to a minimum thickness of 300mm over the top of the filter stone or gravel. In the event damp trench sides indicate the necessity; the Engineer may direct an increase in the thickness of the silica and cover. When the underdrain is used to drain the base or subbase, course, the fine aggregate filter shall be carried vertically to the bottom of the base or subbase. Care shall be taken not to displace the pipe or the covering at open joints.

When there is a heavy percolation of water into the trench at underdrain level, the Engineer may substitute fine aggregate for the crushed stone or gravel bedding, cover and filter.

606.3.4 - Backfill:

Above the fine aggregate filter, when underdrains are not used to drain the base or subbase, the trench shall be filled with suitable random material, as shown on the Drawings or as directed by the Engineer, in layers not exceeding 100mm after compaction. The use of bulldozers or other blade equipment in backfilling is expressly prohibited.

Quality control testing and acceptance of suitable soil, soft shale or granular material will be in accordance with Sections 207 and 716, with the following exceptions:

A lot normally consist of the quantity of backfill material required to backfill 30 metres of the installation, or as directed by the Engineer.

For underdrain installations in an embankment, where existing tests are on file for the adjacent embankment material, the target percentage of dry density for the suitable random backfill will be equal to the X value of the tests in the adjacent lot of embankment material or a minimum value of 95, whichever is greater. For embankments where no tests are on file, the target percentage of dry density will be 95.

606.3.5 - Underdrain Outlets:

Trenches for underdrain outlets shall be excavated as for underdrains, except that the depth of the trench shall be limited to the flow line. Pipe shall be laid in the trench with all ends firmly joined by the applicable methods and means. The use of perforated pipe may be omitted or, if used, it shall be laid with perforations up. No filter material shall be used. After inspection and approval of the pipe installation, the trench shall be backfilled with suitable material in layers and compacted as provided for underdrains.

606.4 - UNDERDRAIN STRUCTURES:

606.4.1 - Underdrain Junction Boxes:

Underdrain junction boxes shall be constructed to the dimensions and elevations at locations as shown on the Drawings or as directed by the Engineer.

606.4.2 - Wingwalls for Underdrains:

Wingwalls for underdrains shall be constructed of concrete conforming to the requirements of 715.12 of the Specifications and shall be constructed to the dimensions and elevations at locations as shown on the Drawings or as directed.

606.5 - SPRING CONTROL:

Underdrain spring boxes and underdrain for spring control shall be constructed to the dimensions and elevations at locations as shown on the Drawings, or as directed. Any remaining upper portion of the trench shall be filled and compacted as for underdrains.

606.6 - AGGREGATE FILLED FABRIC UNDERDRAIN AND BLIND DRAINS:

Trenches for aggregate filled fabric underdrains and blind drains shall be excavated to the width and depth shown on the Drawings. The trench shall be prepared to a relative smooth state, free of sharp protrusions, depressions, and debris.

When fabric is used, it shall be placed with the long dimension parallel to and cantered with the alignment of the trench. It shall be placed in the trench in reasonable conformance with the shape of the trench and shall be smooth and free of tension, stress, folds, wrinkles or creases. The fabric shall be installed so that any splice joints have a minimum overlap of at least 600mm in the direction of flow. The overlap of the closure at the top shall be approximately the width of the trench and shall be temporarily used to cover the excavated material on either side of the trench.
The aggregate shall be placed by any method, which will result in the trench being completely filled to the line shown. The filling process shall not cause the permeability of fabric to be impeded.

The fabric, when used, shall be overlapped at the top of the aggregate. Any portion of the trench not filled with aggregate shall be backfilled in accordance with 606.3.4.

606.7 - PREFABRICATED PAVEMENT EDGE DRAIN:

Trenches for prefabricated pavement edge drain shall be excavated to the dimensions and grade shown on the Drawings.

The edge drain shall be placed against the pavement side of the trench and held firmly in place while backfill is placed to a compacted height of not more than 150mm. For one-sided drains, the more open side shall be placed toward the pavement. After the first lift is compacted and any tears in the fabric have been satisfactorily repaired, the remainder of the backfill shall be placed and compacted in layers not exceeding 150mm deep. All compaction shall be accomplished with a vibratory compaction system. The backfill shall be the material excavated from the trench. Unless otherwise approved by the Engineer, the excavation of the trench, the placement of the edge drain, and the placement of the first lift of backfill shall be accomplished in a single continuous operation.

Each segment of edge drain shall be joined to the adjacent segment prior to installation. Splices shall keep the adjoining edge drain in proper alignment and shall not separate during installation.

100mm diameter non-perforated outlet pipes shall be installed to provide positive drainage at low points of sags, at the low ends of all runs and at intervals not exceeding 150m on continuous runs, except edge drains with two separate flow channels shall have a crossover coupling at approximately 75 metres. The manufacturers' recommended fitting should be provided for attaching the edge drains to the outlet pipes. A standard underdrain concrete wingwall shall be used at each pipe outlet unless the pipe is connected to a drainage structure. Wingwalls shall be fitted with a galvanized rodent screen.

The outlet pipe trench shall be constructed in accordance with 606.3.4 and 606.3.5 using as backfill the material excavated from the trench.

606.8 - FREE DRAIN BASE TRENCH:

This work shall consist of constructing free draining base trenches and Outlet Pipes in accordance with these specifications and in reasonably close conformity with the lines, grades, dimensions, and locations shown on the Drawings or established by the Engineer.

606.8.1 - MATERIALS:

The perforated pipe as detailed on the Drawings shall meet the requirements of this Section.

Aggregate backfill as detailed on the Drawings shall meet the requirements of Section 311.2

Engineering fabric shall meet the requirements of Sub-Section 715.11.8.

The Outlet pipe as detailed on the Drawings shall meet the requirements of Sub-Section 715.10.1.5

CONSTRUCTION METHODS

606.8.2 - FDB TRENCH:

606.8.2.1 - Trenching:

The FDB trench shall be excavated to the width and depth as detailed on the Drawings. Trench walls shall be as nearly vertical as practicable.

606.8.2.2 - Bedding and Placing Perforated Pipe:

After excavating the trench, engineering fabric shall be placed in the trench in reasonable conformance with the shape of the trench. The Engineering fabric shall be smooth and free of tension, stress, folds, wrinkles, or creases. The Engineering fabric shall be installed so that any splice joints have a minimum overlap of at least 300mm any direction. Enough Engineering fabric will be placed in order to properly tie to the mainline placement of Engineering fabric (Section 207).

A 50mm bedding layer of crushed stone or gravel conforming to Section 311.2 aggregate shall be placed in the bottom of the trench for its full width and length.

The pipe shall then be placed in the trench. The pipe sections shall be joined with couplings or bands as recommended by the manufacturer.

After pipe installation, the remainder of the trench will be backfilled with crushed stone or gravel conforming to Section 311.2 aggregate.

606.8.3 - OUTLET PIPE:

606.8.3.1 - Connection to Perforated Pipe:

At locations designated on the Drawings or as directed by the Engineer, rigid outlet pipe will be connected to the perforated pipe. A drop connection utilizing a "T" or "Y" or other means as satisfactory to the Engineer will be used for this connection. This operation may be performed concurrently with the placement of the perforated pipe or separately.

606.8.3.2 - Trenching:

The outlet pipe trench shall be excavated to the depth of the flow line of the outlet pipe. Minimum slope of the outlet pipe is to be 3 percent. Width of the trench will be that width which will allow proper room for pipe placement and backfilling operations.

606.8.3.3 - Placing and Backfilling Pipe:

The outlet pipe shall be placed in the trench with all ends firmly joined by couplings or bands as recommended by the manufacturer.

The outlet pipe shall be backfilled with random material in accordance with Sub-Section 606.3.4.

606.8.3.4 - Pipe End Treatment:

The outlet end of all outlet pipes not tied to drainage structures shall be equipped with a wingwall. Outlet pipes shall be tied to inlets or pipelines by the use of pipe saddles, grouting cementing, or other means satisfactory to the Engineer.

606.9 - METHOD OF MEASUREMENT:

606.9.1 - FDB Trench:

The quantity of work done will be measured by the linear metre of FDB trench installed, complete in place and accepted. The perforated pipe is a component of the FDB trench. Length will be determined from actual measurements once the FDB trench is in place. No deductions will be made for placement of the drop connection required at outlet pipe locations.

606.9.2 - Outlet Pipe:

The quantity of work done will be measured by the metre of rigid pipe complete in place and accepted. Angles, tees, wyes, and other branches, which may be required, will be included in the length of the outlet pipe. Measurement shall begin at the intersection of the perforated pipe and the rigid pipe.

Wingwalls for outlet pipe and the connection of outlet pipes to drainage structures will be paid for separately.

Crushed stone, gravel, or fine aggregate for bedding, filter, and spring control will be measured by the volume; the volume will be the product of the specified trench width and depth, and the length in place, less the volume of the pipe computed on the basis of the outside diameter of the barrel or corrugations.

Blind drains will be measured by the volume of granular material.

The quantity of work done for "Aggregate Filled Fabric Underdrains" (French drains) will be measured in linear metres of trench, complete in place and accepted.
The quantity of work done for "Prefabricated Edge Drain" will be measured in linear metres of edge drain and outlet pipe, complete in place and accepted.

Volume will be calculated based of the specified trench depth and width, and the length in place.

Underdrain junction boxes will be measured by the unit.

Wingwalls for underdrains will be paid for separately in units.

Drains shall be measured excluding pipes and pipes shall be measured separately.

Excavation measured separately according to Section 212

606.10 - BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for as provided below, which prices and payments shall be full compensation for furnishing the materials, excavation, placing pipe, filter material, edge drain, outlet pipe, backfill, disposing all surplus material and doing all the work, including all labour, tools, equipment, supplies and incidentals necessary to complete the work.

Payment for engineering fabric for Free Drain Base Trench will be according to Section 207

606.11 - PAY ITEMS:

ITEM	DESCRIPTION	UNIT
606.001	150mm Pipe underdrain (provisional)	Metre
606.002	Fabric lined aggregate underdrain (provisional)	Metre
606.003	Geocomposite underdrain (provisional)	Metre
606.004	Pipe edge drain (provisional)	Metre
606.005	Geocomposite edge drain (provisional)	Metre
606.006	Geocomposite drain without pipe (provisional)	Metre
606.007	Geocomposite drain with pipe (provisional)	Metre
606.008	Underdrain junction boxes (provisional)	Number
606.011	150mmoutlet Pipe (provisional)	Metre
606.013	Side slope walls to outlet pipes (provisional)	Number
606.015	Underdrain pipe outlets treated with fastening (provisional)	Number
606.018	Drainage wicks at the bottom of the embankment foundations (provisional)	Metre
606.019	Provide and install Piezometers	Number
606.020	Maintain and take readings at Piezometers	Metre
606.021	Provide and install Settlement Plates	Number
606.022	Maintain and take readings at Settlement Plates	Metre
606.023	Provide and install Stand Pipes	Number
606.024	Maintain and take readings at Stand Pipes	Metre
606.025	Provide and install Settlement Blocks	Number
606.026	Maintain and take readings at Settlement Blocks	Metre
606.027	Provide and install Toe Stakes	Number
606.028	Maintain and take readings at Toe Stakes	Metre
606.029	Piezocone tests (provisional)	Number
606.030	Pre- Construction investigations at wick drain area (static cone, Pieza cone, bore-holing, van shear testing etc or as specified by engineer)	PS
606.031	Post Construction Monitoring of Pore Pressure and settlement including installation of Piezmeters, Toe – stakes, settlement-gauges etc.	PS

SECTION 607
GUARDRAIL

607.1 - DESCRIPTION:

This work shall consist of the construction of guardrail in accordance with these Specifications and in conformity with the lines and grades shown on the Drawings or established by the Engineer.

The types of guardrail are designated as follows:

Type 1, Not used
Type 2, Not used
Type 3, As per Drawings
Type 4, As per Drawings
Type 5, Not used

The construction of the guardrail shall include the complete furnishing, assembling and erecting of all component parts and materials at the location shown on the Drawings or directed by the Engineer.

A Modified Cut Slope Terminal shall consist of supplying and installing additional length guardrail posts, an additional W-beam guardrail section (bottom beam), and standard guardrail cut slope terminal components

607.2 - MATERIALS:

Materials shall meet the requirements of the following Sub-Sections of Division 712:

CONSTRUCTION METHODS

607.3 - SETTING POSTS AND PLACING FOOTERS:

607.3.1 - General:

Unless one type is specified, posts may be of steel, or wood, and the Contractor shall indicate at the pre construction conference the type of post the Contractor elects to use and that type shall be used throughout the Project.

Post dimensions and details shall conform to the requirements shown on the Drawings

Guardrail posts shall be placed as shown on the Drawings.

Posts shall be set plumb in holes dug by hand or mechanically. When posts are driven, the manner of driving shall be such as to avoid battering or distorting of posts. Postholes shall be backfilled with acceptance material placed in maximum 150 mm loose layers and thoroughly compacted. All posts damaged during erection or driving shall be removed and replaced without additional cost. Any damage to post galvanizing shall be repaired by a material meeting the requirements of 711.21.

Painting, when called for, shall not be done in damp weather and shall only be done when the posts are thoroughly dry.

607.3.2 - Steel Posts:

Galvanized steel posts shall not be painted except for touch up with zinc primer as specified.

607.3.3 & 607.3.4 Not used

607.3.5 - Offset Blocks:

Offset blocks shall be used when called for by the Drawings.

607.3.6 - Footers for Breakaway Cable Terminal and Special Trailing End Terminal: Type 3E End Anchorage

Footers for breakaway cable terminal and special trailing end terminal shall be constructed of cast-in-place concrete meeting the requirements of 715.12. Concrete shall be placed promptly and without segregation after mixing.

Concrete footers shall be carried down to at least the depth, and shall be not less than the dimensions shown on the Drawings. The top of all footers shall be not less than the dimensions shown on the Drawings. The top of all footers shall be flush with the ground line and shall be towelled to a smooth finish with a slope to drain away from the post.

After excavating for the footer, the earth that will be in contact with the concrete must be moistened to a depth of at least 50mm just prior to placing the concrete in the hole. No curing will be required other than the placing of not less than 100mm of loose moistened earth, free from clods or gravel, over the top of the footer immediately after placing the concrete. All excess excavation from footers and loose material used for curing shall be disposed of in a manner satisfactory to the Engineer.

607.4 - ERECTING RAIL ELEMENTS:

607.4.1 - General:

Rail elements shall be erected in a manner resulting in a smooth, continuous installation.

All bolts, except where otherwise required, such as expansion joint bolts and adjustment bolts, shall be drawn tight. Bolts through expansion joints shall be drawn up as tight as possible without being tight enough to prevent the rail elements from slipping past one another longitudinally. Bolts shall be sufficiently long to extend at least 6mm beyond the nuts. Except where required for adjustment, bolts shall not extend more than 13mm beyond the nuts. Bolts through variable thickness posts shall be cut off a maximum of 13mm beyond the nuts.

All metal shall be fabricated in the shop. Burning, drilling or welding may be done in the field when shown on the Drawings. Field punching, cutting, and drilling may be permitted after it has been demonstrated that it will not result in damage to the surrounding metal and if approved by the Engineer.

Galvanized surfaces which have been abraded so that the base metal is exposed, any field welded surfaces, threaded portions of all fittings and fasteners, and cut ends of bolts shall be protected with zinc rich primer or by field galvanizing, when approved by the Engineer.

607.4.2 - Type 3 Guardrail (Galvanized Steel / Corrosion resistant steel Deep Beam):

The rail shall be erected so that the bolts at expansion joints will be located near the centres of the slotted holes. The rail elements shall be spliced by lapping in the direction of traffic. The rail elements at each splice shall make contact throughout the area of the splice. Shop-curved rail shall be used on curves with radii less than 45 metres.

Any surface damage to galvanized beams shall be repaired with a material meeting the requirements of 711.21.

Guardrail end terminals conforming to the details shown on the Drawings shall be constructed.

607.4.3 - Type 4 Guard Rail Concrete Barrier Precast or Cast in place

Precast concrete barrier styles PA and PD prepared by Concrete Class 30/20 as per Section 551. and steel reinforcement shall be provided according to drawings and Section 552. The cast-in-place 3.6m transition section external dimensions are identical to those for the precast 3.6 m section. The cast-in-place 3.6m transition section does not require steel reinforcement but does require the foundation option on sheet 1 that is consistent with the barrier adjacent to the transition section.

The barrier is prepared to the lines and grades shown on the Drawings or established. Holes in the concrete of the pre cast barrier used for fixtures to lift the section shall be filled with an approved sealing compound, mortar or plug as directed. The finish of the concrete shall be Class 1 Ordinary surface finish in accordance with 551.11.1.

The drainage slot may be omitted on instances where specifically stated. The recesses for drift pins and lifting coils shall be provided as specified or shown on Drawings.

607.4.4 - Not used

607.4.5 - Type 5 Guardrail (Galvanized Steel, Double-Faced):

This rail shall be erected in accordance with 607.4.2 and as shown on the Drawings.

607.5 - GUARDRAIL REMOVED AND REBUILT OR STORED:

This item shall consist of carefully dismantling, removing, and re-erecting or storing, at the location specified on the Drawings, of existing guardrail. Rebuilt units shall be of the same type, spacing of members, etc., as original guardrail.

New material specified on the Drawings shall conform to the requirements for the construction of new guardrail of the type being reset.

All salvageable materials shall be removed and re erected (or stored if so specified) with reasonable care. Posts, rails, fabric, and cables for re erected rails shall be obtained from salvage sources, but the Contractor shall furnish whatever additional bolts, clips, or incidental hardware as may be necessary to complete the guardrail.

Methods of re-erection shall conform to the requirements for the construction of new guardrail of the type being reset, except as modified on the Drawings.

Where removal and storage is specified, the bolts, cables, and other hardware shall be carefully removed from all rails, posts, and other members, and all parts shall be sorted and stored at the locations specified. Rails shall be properly stacked, cable shall be free from kinks and rewound on the cable spools, and all such reasonable care shall be exercised in the handling, storing, and preserving of materials as will insure the maximum salvage value for the entire operation.

607.6 - METHOD OF MEASUREMENT:

The quantity of work done will be measured in linear metres of guardrail or as a unit of the type indicated on the Drawings, complete in place and accepted, measured along the face of the rail from centre to centre of end posts. The linear metres of double-faced guardrail will be measured along the face of one rail only.

When end terminals or attenuators for steel beam type guardrail are used, they will be measured separately distinguishing different types and will be the actual number of end terminals or attenuators constructed, complete in place and accepted.

Where 1,620mm sections of steel deep beam guardrail having 950mm or 1,905mm post spacing are utilized at bridges, they will be measured and paid for as 1,905mm post spacing with blocks (Class I) and in accordance with their appropriate guardrail type.

Where 5,715mm sections of guardrail - bridge transitions, having 950mm and 475mm post spacing, are utilized at bridges or in conjunction with other structures, these sections shall be measured and paid for as W-Beam Guardrail Bridge Transition. The cost of the double, top w-beam 3,810mm section, bottom w-beam (rub rail), guardrail end special hardware, connectors and incidentals utilized in guardrail - bridge transit shall be included in W-Beam Guardrail Bridge Transition.

Where w-thrie beam guardrail - bridge transitions consisting of two nested thrie beam panels and a transition section from w-beam to the thrie beam guardrail having a total length of 5,715mm are utilized at bridges or in conjunction with other structures, these sections shall be measured, and paid for as Thrie Beam Guardrail Bridge Transition. The cost of the double thrie beam 3,810mm sections, the 1,905mm section of w-thrie beam transition, the 1,900mm length steel posts, guardrail terminal connectors, and all special hardware, connectors, and incidentals utilized in this guardrail - bridge transition shall be included in Thrie Beam Guardrail Bridge Transition.

Guard rail Type 4 is measured as a unit of the type indicated on the Drawings, complete in place and accepted.

Guard Rail Type 3 as referred to in Bill of Quantities Item 607.001 shall have barrier rail on one side of the supports only.

Type 3B End Treatment is as shown on Drawings, 30.48m on a 12:1 flare plus 15.24m parabolic curve, and includes the 26.6m. rub rail and the concrete anchor block.

607.7 - BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall constitute full compensation for furnishing, preparing, placing, and erecting all materials, and all labour, tools, equipment, supplies such as nuts, bolts, washers, cables and any other incidentals necessary to complete the work.

Payment for modified cut slope terminals will include extra length guardrail posts as required, excavating and backfilling, reshaping, seeding and mulching of the cut slope for Cut Slope Terminal Type A Modified; shall include extra length guardrail posts as required, drilling holes into the cut slope, furnishing and installing rock bolts (2), end shoes (2), and hardware for Cut Slope Terminal Type B Modified: and shall be paid for Cut Slope Terminal Type A or B Modified ", per each.

607.8 - PAY ITEMS:

ITEM	DESCRIPTION	UNIT
607.001	Guardrail Type '3'	Metre
607.002	End treatment Type '3B'	Number
607.003	End treatment Type '3D'	Number
607.004	End treatment Type '3E'	Number
607.005	End treatment Type '3G'	Number
607.006	Guardrail Type '4'	Metre
607.007	Guardrail Type '5'	Metre
607.028	Cyclone fence 1.05m high	Metre
607.029	Pedestrian guard rail 1.05m high	Metre

SECTION 608
RIGHT-OF-WAY FENCE

608.1 - DESCRIPTION:

This work shall consist of the construction of fences and gates of the types designated, in accordance with these Specifications and in conformity with the lines, grades, locations, and dimensions shown on the Drawings or established by the Engineer.

608.2 - MATERIALS:

Chain link fence fabric shell be PVC-coated steel and shall be comply with Sri Lankan standard SLS 1148zinc coated and plastic coated steel chain link fence fabric . The minimum galvanising to the wires shall be 270 g/m^2 . The wire ends that have been cut during the manufacture of the fence fabric shall be galvanised. The PVC coating colour for the fence fabric shall be green and the text Road Development Authority shall be print out of embossed on each wire at least 3 times per each one meter length. The text "RDA" shall also be embossed on each ROW fence post.

Concrete fence posts , braces and concrete gates posts shall comply with Sri Lanka Standard SLS 217 specification for Reinforced concrete fence posts , except for minimum cross sectional dimerision required of 100mmx110 mm at top and tapered.

Zinc Rich paint shall meet the requirements specified in sub section 711.21.

Gate frames shall be constructed of tubing having the dimensions and weights called for on the Drawings.

Gate frames may be constructed using Standard G.I. pipe or acceptable equivalent, or may be provided with heavy malleable iron corner fittings or otherwise shall be of an adequate, sturdy design. Gate frame corner attachments may be of welded construction, if the gate frame receives its coating protection after fabrication of the gate structure is completed. All gate frames shall have truss rods as shown on the Drawings.

All gates shall be equipped with approved latches, stops, suitable locking devices, and satisfactory provisions for padlocking. Means shall be provided for securing and supporting the free ends of vehicular gates in the open position. Hinges shall be Galvanized steel or Aluminium of standard make, pivot type, heavy and strong, with large bearing surfaces for clamping onto the posts, or equal. Hinges shall not twist or turn under the action of the gate and shall be so arranged that a closed gate cannot be lifted off its hinges to obtain entry. In lieu of standard make latches it will be permissible to use an Electro – Galvanized chain, eyebolt and snap hook type latch. The eyebolt, chain and snap hook assembly to be secured to latch side of gate. Vehicular gates shall be capable of being operated easily by one person and shall be of the full 180 degree open swing type. Pedestrian gates (Walk gates) shall be equipped with a positive stop, which will not permit the gate to swing toward the highway and shall be provided with a satisfactory spring or other positive means to maintain the gate in a closed position.

The filler fabric for pedestrian gates and vehicular gates shall comply with the requirements for the fencing fabric of the fence in which the gate is to be installed.

Miscellaneous hardware and fittings shall conform to the details shown on the Drawings or other

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alternate designs acceptable to the Engineer.

When the locations of manufacturing plants allow, the plants will be inspected periodically for compliance with specified manufacturing methods, and material samples will be obtained for laboratory testing for compliance with materials quality requirements. This may be the basis for acceptance of manufacturing lots as to quality.

All materials must be protected from damage during storage and handling. All materials, including materials, which have been approved previously, will be subject to inspection by the Engineer as to condition at any time prior to or during incorporated of the material in the work. Materials, which have been damaged, shall not be used.

CONSTRUCTION METHODS

608.3 - GENERAL:

The Contractor's activities and operation shall be confined to the area immediately adjacent to the right-of-way fence and within the highway right-of- way. The Contractor shall be responsible for satisfactory arrangements for such permits as required by them from adjacent owners in performing the work.

If the installation of certain portions or lengths of the right-of-way fence is more essential than other portions or lengths, the Engineer may designate the portions or lengths of the fence that are most essential, and the Contractor shall conduct his operations so as to give priority to the erection of such portions or lengths.

608.4 - CLEARING, GRUBBING, AND TRENCH EXCAVATION:

The Contractor shall perform such clearing and grubbing as may be necessary to construct the fence to the required grade and alignment.

When necessary in areas of irregular ground to secure clearance between the ground line and the bottom of the fence fabric, to obtain the established grade, or to permit placing steel barbed wire below the bottom of the fence fabric at stream crossings and minor depressions, a trench shall be excavated to the grade and line established or designated. In the areas where rock is encountered, the rock shall be excavated as may be necessary, in the opinion of the Engineer, to the required grade and line. Any excavation of rock below the required grade shall be backfilled with suitable materials as directed. Trenches shall be so constructed as to insure proper drainage and shall be of the cross section shown on the Drawings or as directed. In general, the bottom of the fence shall follow the contour of the ground in accordance with usual practice in constructing fence of the type specified, and it is not anticipated that a great amount of shallow trench excavation will be required.

608.5 - CONCRETE FOOTERS:

Concrete footings shall be constricted to the dimensions shown on the Drawings.
The height of post above the rock surface shall be same as the posts set in earth.

Grade 20 concrete shall be used for footings where concrete grading have not specified on the drawings. The concrete filling shall be tamped to from a compacted mass.

Concrete footings shall be carried down to at least the depth, and shall be not less than the dimensions, shown on the Drawings. The top of all footings shall extend slightly above the ground line and shall be steel towelled to a smooth finish with a slope to drain away from the post. Posts, braces, and other units shall be approximately centred in their footings.

If the ground is firm enough to permit excavation of a hole to neat dimensions, the concrete may be placed without forms by completely filling the hole. In this case, the earth coming in contact with the concrete must be moistened to a depth of at least 50mm just prior to placing the concrete in the hole. No curing will be required other than the placing of not less than 100mm on loose moistened earth, free from clods or gravel, over the top of the footing immediately after placing the concrete.

Where the ground cannot be satisfactorily excavated to neat dimensions, forms shall be used for footings. In this case, where the soil is not moist, not less than 4.0 litres water shall be placed in the bottom of each hole; and, as soon as the water has been absorbed, the concrete shall be placed.

Forms shall be removed not sooner than 24 hours after placing of concrete. As soon as each form is removed, the footing shall immediately be backfilled with thoroughly moistened material in 150mm loose layers and solidly tamped. The top shall be covered with not less than 100mm of loose moistened earth. All excess excavation from footings and loose material used for curing shall be disposed of in a manner satisfactory to the Engineer.

608.6 - SPACING AND SETTING POSTS

608.6.1 - General:

Posts shall be spaced in the line of fence as shown on the Drawings with a tolerance of minus 300mm. Spacing of posts shall be as uniform as practicable under local conditions.

In general, in determining the post spacing, measurements shall be made parallel to the ground slope, and posts shall be placed in a vertical position except in unusual locations where it would be more satisfactory to place the posts perpendicular to the ground slope and the Engineer so directs.

At all horizontal angle points, vertical angle points, and terminal points of the right-of-way fence, corner, pull, or end posts shall be placed, as the situation may demand, along with the necessary amount of bracing and number of approach posts as shown on the Drawings. Bracing post shall be provided on every 10th pole for straight section. Gateposts shall be placed in the fence line where required and as directed by the Engineer. Details of all installations shall be as shown on the Drawings.

Extra length posts shall be required at small ground depressions and also at stream crossings, less than 3 metres, where it is not practicable for the fencing to closely follow the contour of the ground. The location of extra length shall be as dictated by the topography and as directed. Additional bracing shall be provided for extra length posts when shown on the Drawings or directed. The Contractor shall close the space below the bottom of the fence fabric with barbed wire, tautly between posts either on horizontal lines or fanned, at locations instructed by the Engineer. No special payment will be made for extra length posts, bracing, wire, fittings, etc., required at stream crossings or depressions.

Attention is directed to the fact that some posts may occur at or on existing roadway pavements, on old concrete foundations, or similar solid surfaces. There will be no additional compensation for breaking up such surfaces to set the posts. The Contractor may adjust the spacing to reduce the

number of posts occurring on such surfaces subject to the maximum spacing specified, and there will be no additional compensation due to any increase in the number of posts when the Contractor elects to do so.

608.6.2 - Reinforced Concrete Posts

Pre-cast reinforced concrete posts shall be set in concrete footings, as per Drawings and/or the Engineer's instructions. In any event, the posts shall be set solidly and any space left around the posts shall be backfilled and compacted as specified.

608.6.4 - Posts Set in Rock:

Reinforced concrete posts shall be set in hard rock where excavation is not possible without blasting, as per drawings and/ or specified by the Engineer.

608.7 - ERECTION OF FENCING:

608.7.1 - General:

Contractor shall prepare and submit ROW fence location drawing for the Engineer's approval before commencing the work.

Following shall be adhered for the installation of ROW fence.

1. Fence shall enclose maximum practicable area of ROW
2. For the local roads, fence shall be located close to inner side boundary of local road. Where the local road is parallel to and within the Expressway ROW, additional fencing will be provided on the ROW boundary.
3. Fence shall enclose all elements of drainage structures which are constructed for exclusively expressways drainage purposes.
4. Fence shall enclose inlet/outlet element of minor cross drainage structures; RCP's less than 1200mm dia/ RCBC's less than 1200mm wide x1200mm height.
5. Fence shall connect to inlet/ outlet elements of major cross drainage structures and drainage structures provided for partial requirement of expressway drainage, like irrigation canals.
6. For underpass structures fence shall connect to the face of structure including wing walls.
7. For gabion walls, priority is given to locate fence in front of gabions. In case of unavailability of land as above, fence needs to continue over the gabion top.
8. Potential illegal encroachment at junctions of local roads shall be minimised by locating the fence as close as possible to local road ROW.

In cases where the controlled access line and the right-of-way line are not coincident, fence shall normally be erected along the controlled access line. When fencing follows either line, the fence

shall normally be erected parallel to and 1 metre inside the line. If this would result in undesirable appearances or unsatisfactory operational characteristics, the fence location shall be adjusted accordingly. In any case, the fence shall be erected to the lines and grades shown on the Drawings or established by the Engineer.

The Contractor shall clear the area, from the line of fence to a line approximately 1,200 mm within the line of fence, of brush, undergrowth, etc., as directed by the Engineer. Such clearing shall be conducted in such a manner as to leave intact valuable trees and selected native growth. Only such trees as are directly on the line of the fence or that would otherwise, in the opinion of the Engineer, interfere with the construction of the fence, shall be removed by cutting then flush with the ground.

Materials removed in clearing shall be disposed of by the Contractor outside of the right-of-way and out of sight of any part of the highway in a manner approved by the Engineer, unless disposal within the right-of-way is specifically approved in writing by the Engineer.

Tension for stretching the fence shall be applied by of mechanical fence stretchers and single wire stretchers. Stretchers should be designed and made in accordance with the fence manufacturer's recommendations. The finished fence is to be true to line, taut, and solid at all points.

Posts shall be permanently positioned and concrete footings fully set before fabric is placed. Unless otherwise permitted, no fencing materials shall be installed on posts until seven days have elapsed from the time of placing of the concrete.

Barbed wire shall be placed at locations where instructed by the Engineer.

608.7.2 – PVC Coated Chain Link Fence:

Corner, pull, and intermediate assembly posts shall be braced in two directions, and end gateposts Shall be braced in one direction. These posts shall be braced as detailed on the Drawings.

The bottom of the fabric of farm-field fence shall be placed a normal distance of 75mm above the ground line; however, over irregular ground a minimum clearance of 50mm and a maximum clearance of 150mm will be permitted for a distance not to exceed 2.5 metres. Any necessary excavation and backfilling required in order to comply with these provisions shall be made as specified.

4.5 mm dia PVC coated galvanize tension wires shall be attached to top, middle and bottom of the fence fabric for the entire length of the fence and shall be suitably tensioned. Tension wires shall be threaded through the chain link fabric mesh and tension wires shall be tautly stretched during erection. The ends of the fabric and secured by the use of stretcher bars threaded trough the loops of the fabric and secured to corner, pull, end, gate, and intermediate assembly pots by means of bolts and nuts. The number of clamps shall be as indicted on the Drawings. All bolts, nuts and other fittings shall be temper proof and will be subjected to the approval of the Engineer. Securing one end of the fabric to the stretcher bar and applying sufficient tension to remove all slack before making the attachment vat the other end of the fabric shall place the fabric. Following those attachments, the fabric shall be fastened to line and approach posts and to top and bottom tension wire with tie wires or clips.

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608.8 - PAINTS AND PAINTING:

Zinc-coated, triple-coated and aluminium-coated metal parts in the fence structure shall not be painted. After erection is completed, the Engineer will inspect all fence construction. All parts of the fence and gates (including bolts and nuts) from which the coating has been abraded so that the base metal is exposed shall be spot-painted with a zinc rich primer in the case of zinc-coated steel.

608.9 - JUNCTIONS WITH EXISTING FENCES:

Where the right-of-way fence intersects or joins an existing fence, the Contractor shall make the junction between the fences in the manner specified. An end post corresponding in strength to the type used in the right-of-way fence shall be set on the line of the existing fence and approximately 100mm outside the centreline of the highway right-of-way fence. Existing fencing fabric, or similar, shall be stretched and tied to this end post in conformance with the construction requirements for the right-of-way fence. No direct connection shall be made between the existing fence and the highway right-of-way fence. All junctions shall be made in a workmanlike manner and will be subject to the approval of the Engineer.

608.10 - METHOD OF MEASUREMENT

The fence shall be measured in linear meters. Measurement will be along the bottom wire of the fence from outside to outside of end posts for each continuous run of fence. The lengths occupied by gates will not be included in this measurement.

Gates will be measured separately as complete units of the size and type specified and gate posts shall be included in the payment item for each type of gate.

The height used for classification of fences shall be measured from the commencing surface. The width used for classification of gates shall be measured between the inside faces of posts.

The linear measurement of the fences shall be deemed to include fence posts all fixtures and erection including excavation, preparation of surfaces, disposal of excavated material, upholding sides of excavation, backfilling, removal of existing services, concrete, formwork, fence pots, fixtures, erection and reinforcement.

608.11 - BASIS OF PAYMENT:

The accepted quantities of fencing materials will be paid for at the contract unit price per linear metre for fence and per each for gates of the types and sizes specified, complete in place by the Engineer.

This price will include the cost of clearing, grubbing, excavating, trenching, concrete footings, backfilling, drilling in rock, grouting posts in place, painting, electrical grounds, connections to existing fences where required, furnishing all materials, labour, equipment, tools, and incidentals necessary to complete the work.

No payment shall be made for the temporary fences.

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608.14 - PAY ITEMS:

ITEM	DESCRIPTION	UNIT
608.001	Woven wire fence with RC posts	Metre
608.002	Woven wire gate 4.80 m minimum and 6.0 m maximum opening	Number
608.003	Walk gates approximately1.0 opening	Number
608.004	Cattle Guard in Steel as Drawings	Number

SECTION 609
WIRE ROPE SAFETY BARRIER

609.1 - DESCRIPTION:

This work shall consist of the construction of wire rope safety barrier, WRSB, in accordance with these Specifications and in conformity with the lines and grades shown on the Drawings or established by the Engineer.

The construction of the WRSB shall include the complete furnishing, assembling and erecting of all component parts and materials at the location shown on the Drawings or directed by the Engineer.

609.2 - MATERIALS:

Materials shall meet the requirements of Sub-Sections of Division 712:

CONSTRUCTION METHODS

609.3 - SETTING POSTS AND PLACING ANCHORS:

609.3.1 - General:

Installation of posts and anchors are to comply with suppliers requirements and recommendations.

Posts are to be steel and the Contractor shall indicate at the pre construction conference the type of post the Contractor elects to use and that type shall be used throughout the Project.

Post dimensions, alignments and details shall conform to the requirements shown on the Drawings

WRSB posts shall be placed as shown on the Drawings.

Posts shall be set plumb in sockets set in concrete in holes dug mechanically. Holes cut in pavement materials must be clean cut with vertical faces. All posts damaged during erection shall be removed and replaced without additional cost. Any damage to post galvanizing shall be repaired by a material meeting the requirements of 711.21.

Painting, when called for, shall not be done in damp weather and shall only be done when the posts are thoroughly dry.

Precast concrete post foundations shall be inserted on a firm level base. Any lateral overbreak of the excavation shall be filled with class 10/10 concrete.

In-situ concrete post foundations and anchor blocks shall be constructed using concrete class 25/20. Temporary formwork shall be used where the sides of excavations cannot be kept vertical for in-situ concrete post foundations and anchor blocks. The formwork shall be installed immediately after excavation. Any lateral overbreak of the excavation shall be filled with class 10/10 concrete.

All anchor frames, check posts, sockets and reinforcing rings shall be positioned to the line and levels described in the Contract and they shall be secured against displacement during placing of the concrete.

609.3.2 - Steel Posts:

Galvanized steel posts shall not be painted except for touch up with zinc primer as specified.

609.4 - ERECTING WIRE ROPE ELEMENTS:

609.4.1 - General:

Installation of wire ropes is to comply with suppliers requirements and recommendations and shall be erected in a manner resulting in a smooth, continuous installation.

Galvanized surfaces which have been abraded so that the base metal is exposed, any field welded surfaces, threaded portions of all fittings and fasteners, and cut ends of bolts shall be protected with zinc rich primer or by field galvanizing, when approved by the Engineer.

609.5 - METHOD OF MEASUREMENT:

The quantity of work done will be measured in linear metres of WRSB in place and accepted, measured along the centreline of the WRSB from centre to centre of anchors. The linear metres of overlapping WRSB will be measured along the centreline of one WRSB only.

609.6 - BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall constitute full compensation for furnishing, preparing, placing, and erecting all materials, and all labour, tools, equipment, supplies such as nuts, bolts, washers, cables and any other incidentals necessary to complete the work.

609.7 - PAY ITEMS:

ITEM	DESCRIPTION	UNIT
609.001	Wire Rope Safety Barrier	Metre

SECTION 610
CATTLE GUARDS

610.1 - DESCRIPTION:

This work consists of the construction of cattle guards in accordance with these specifications and in conformity with the lines, grades, and details shown on the plans or established.

610.2 - MATERIALS:

Concrete shall conform to the requirements of Section 551. Reinforcing steel shall conform to the requirements of Section 552. Structure steel shall conform to the requirements of Section 709. Fencing items shall conform to the requirements of Section 608.

610.3 - CONSTRUCTION REQUIREMENTS:

Cattle guards shall be constructed in accordance with the details shown on the plans. The actual locations of cattle guards shall be determined by the Engineer. All work shall be done in accordance with the applicable construction methods contained in these specifications.

610.4 - METHOD OF MEASUREMENT:

Cattle guards to be paid, will be actual no of units of the various sizes installed in accordance with these specifications and drawings and accepted.

610.5 - BASIS OF PAYMENT:

The accepted quantities of cattle guards of the various sizes will be paid for at the contract unit price per each and shall be full compensation for excavating, backfilling, furnishing and erecting all materials including all labour, tools, testing and incidentals necessary to complete the work.

610.6 PAY ITEMS:

Item	Description	Unit
608.004	Steel Cattle Guard	Number

SECTION 611 – 650: Not used

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SECTION 651
FURNISHING AND PLACING TOPSOIL

651.1 - DESCRIPTION:

This work shall consist of acquiring sites outside the right-of-way from which topsoil can be obtained and the hauling and placing of such material, or hauling and placing of topsoil from stockpiles within the right-of-way, all in accordance with these Specifications and at locations indicated on the Drawings or designated by the Engineer.

651.2 - MATERIALS:

Topsoil shall consist of the uppermost layers of fertile and friable soil that contains humus material. This material varies in thickness in accordance with soil groups and usually possesses a darker colour than the subsoil. The texture of the topsoil may vary within the range of natural loam, silty clay loam, and sandy loam. Acceptable topsoil shall contain organic matter in the range of 1.5 percent of 20 percent.

CONSTRUCTION METHODS

651.3 - STRIPPING TOPSOIL:

Prior to removal from the site, the soil will be tested by the Engineer to determine the humus and nutrient value. Care shall be exercised as to the depth of stripping, and any loads with an excess of subsoil shall be discarded. The Contractor shall mow or otherwise remove all heavy grass, weeds, or other vegetation over the areas before stripping. Approval by the Engineer must be obtained prior to transporting any material from the stripping site.

651.4 - TRANSPORTING:

Topsoil material shall not be placed until the entire roadway (including surfacing) has been completed, unless otherwise provided for on the Drawings or approved in writing. During hauling operations, the surface of the highway shall be kept clean to avoid creating a traffic hazard.

651.5 - PLACING AND MANIPULATING:

Areas to be top soiled shall be brought to the lines and grades shown on the Drawings or established by the Engineer.

The Contractor shall scarify the surface of the subsoil before the topsoil is placed, unless otherwise permitted, for bonding the topsoil layer with the subsoil.

Scarification shall be accomplished by disking, harrowing, raking, or other approved methods. Depressions and ridges formed by construction equipment, during final grading or scarifying, shall be parallel to the contours.

Topsoil shall not be spread to a greater depth than that required to make the work conform to the natural terrain after shrinkage and settlement have taken place. After spreading the soil, all deleterious materials (large lumps or clods, brush, litters, or other foreign material, and stones exceeding 50 mm approximately in any dimension shall be raked up and removed from the site.

The Contractor shall take all reasonable precautions to avoid injury to existing plant growth,

structures, and roadway surface.

651.6 - METHOD OF MEASUREMENT:

The quantity of work done will be measured in cubic metres of "Furnishing and Placing Topsoil" or "Placing Stockpiled Topsoil", which shall be the material actually removed from previously selected site or sites outside the right-of-way of or from stockpiles within the right-of-way, and acceptably placed and spread on the areas designated to receive it, as determined from the net total of load tickets of vehicles.

651.7 - BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labour, tools, equipment, supplies, and incidentals necessary to complete the work. No separate payment will be made for stripping topsoil within the right-of-way limits and transporting or stockpiling of such material.

651.8 - PAY ITEMS:

ITEM	DESCRIPTION	UNIT
651.001	Furnishing and placing topsoil	Cubic metre
651.002	Placing stockpiled topsoil	Cubic metre

Item 207.001 covers the stripping of topsoil from on-Site sources and its stockpiling for subsequent use in the Works.

Item 651.001 covers the furnishing and placing of topsoil where topsoil shall have to be obtained from an off-Site source.

651.002 covers the obtaining of topsoil previously stockpiled from excavation for the Works and its incorporation into the finished Works.

Topsoil placing shall be measured in cubic metres in accordance with Bill of Quantities Items 651.001 and 651.002. The nominal thickness of topsoil to be placed shall be 100mm unless otherwise specified by the Engineer.

SECTION 652
SEEDING AND MULCHING

652.1 - DESCRIPTION:

This work shall cover all operations incidental to the establishment of grass and legume vegetation, including the furnishing and sowing of seed, furnishing and applying fertilizer, agricultural limestone, and mulch material, all in accordance with these Specifications and at locations indicated on the Drawings or designated by the Engineer.

652.2 - MATERIALS:

Materials shall meet the requirements in the following Sub-Sections of Division 700:

MATERIAL	SUBSECTION
Ground Agricultural Limestone	715.25
Fertilizers	715.26
Mulch Materials	715.27
Inoculating Bacteria	715.29
Matting for Erosion Control	715.24
Water	*

*Water shall be reasonably free from injurious chemicals and other toxic substances harmful to plant life. The source of water used is subject to the approval of the Engineer.

Temporary seed, such as Cynodon dactydon, and Avonopus compresseus used in the seed mixtures shall be of a commercial grade.

Seed other than that specified shall meet the requirements of 715.28.

Asphalt for anchoring mulch shall be of a commercial grade. Chemical mulch binders shall conform to the requirements in 715.27.1.

Topsoil, if called for, shall conform to the requirements in Section 651. All materials will be subject to approval or rejection, in part or in whole.

CONSTRUCTION METHODS

652.3 - SEASON OF WORK:

Seeding, under Section 652, shall be performed between May to June and October to November. Seeding under Section 642 shall be applied following construction at any time the weather will allow seeding equipment to operate; without regard to seasons.

652.4 - AREA PREPARATION FOR SEEDING AND MULCHING:

Seeding and mulching shall not be applied until the specified areas have been brought to lines and grades shown on the Drawings. Topsoil, when called for, shall be spread to the depths indicated on the Drawings.

The application rate for agricultural limestone will be determined by a pH test after cuts and embankments are completed just prior to seeding. The Drawings will show the estimated tonnes of lime needed for the job based on general knowledge of the soils in the area. The Engineer based on the pH test, conducted, will determine the final application rate.

Interchanges, medians and similar areas with 3 to 1 slope or flatter, excluding areas involving subsurface drainage from base course material, shall be scarified sufficiently to produce a seed bed as directed by the Engineer. All large sticks, brush, loose roots, stones exceeding 50mm approximately in any dimension, and other debris shall be removed prior to seeding operations. The area shall be back dragged to eliminate depressions, ruts, or equipment track marks on slopes. Seedbed preparation will not be necessary on slopes steeper than 3 to 1.

Preparation of Lawn Type Area for Seeding:

The finished grade in rest areas shall be uniform and free of irregularities or water pockets. The finished grade shall be free of weed and plant growth, stones over 25mm in diameter, or other debris. This debris will be disposed of as directed by the Engineer. Immediately prior to seeding, all areas shall be cultivated to provide a reasonably firm but friable seedbed. The depth of tillage shall be 75mm or as directed by the Engineer. Limestone as required and fertilizer as specified shall be worked into the upper 75mm of the seedbed before seeding.

652.5 - SOWING SEED:

Immediately following area preparation, seed shall be sown. Legume seed shall be inoculated with approved cultures, in accordance with the instruction of the manufacturer. When using a hydroseeder, the inoculant shall be increased to five times the normal rate.

Seed shall be sown by approved methods, which provide for uniform distribution of seed. Rates of application and type of seed mixture shall be in accordance with Table 652.5 unless otherwise specified on the Drawings. For lawn areas, the broadcast seeding shall be made in two applications, using one half the seed each time and the second sowing to be at right angles to the first. After broadcasting or otherwise applying the seed, the seedbed shall be firmed by means of a roller or cultipacker.

TABLE 652.5 - SEED MIXTURES

A. Cynodon dactydon
B. Avonopos compresseus
C. Bracharia decumbens (signal grass)
D. Axonopus affinis (carpet grass)

Re-seeding, Re-fertilizing and Re-mulching: Any area failing to establish a stand due to weather conditions or adverse soil conditions shall be reseeded, re-fertilized and re-mulched as directed by the Engineer.

652.6 - APPLYING MULCH AND FERTILIZER:

652.6.1 - General:

Whenever permanent or temporary seeding is made on bare soil or newly completed construction work, the following criteria shall be followed in regard to mulching.

Mulch shall be used on all areas and slopes 1-1/2 to 1 or flatter. The Engineer may make adjustments in the type of mulch to meet local conditions on the job.

The seed may be sown before or after the mulch is spread. However, when the seed is sown first, the mulch shall be placed within 24 hours. Erosion control blanket shall be provided where specified by the Engineer.

When permanent seeding follows a temporary cover crop, wood cellulose fibre mulch shall be used and the quantity of mulch shall be determined by the amount of living and dead plant residue on the soil surface in accordance with 652.6.3.2.

Where the temporary seeding has been destroyed by subsequent construction, the mulch will be the same type and amount as required for bare soil or new construction.

652.6.2 - Mulch:

Mulch shall be applied at the rate of approximately 4.5 Tonnes per hectare. The mulch may be anchored with 95 Litres of asphalt per hectare. The asphalt may be sprayed on the mulch as it leaves the blower or it may be applied in a separate operation. The Contractor shall be responsible for any damage to the structures from the asphalt spray.

Mulch around buildings, sidewalks or other structures may be held in place with a form of netting or may be sprayed with asphalt by hand while protecting the structures from the asphalt spray.

Other types of chemical mulch binders may be substituted for asphalt material. These mulch binders shall be applied according to the manufacturers' specifications through the asphalt spray system or by an agricultural crop sprayer.

652.6.3 - Hydraulic Application of Wood Cellulose Fibre or Re-cycled Paper Mulch as a Mulching Agent (Hydroseeding):

652.6.3.1 - Equipment:

Suitable hydro – mulch mixer and applicator of sufficient capacity to enable application to slope of cuttings shall be used:

652.6.3.2 - Preparation of Slurry and Application of Fertilizer, Seed, and Mulch:

Wood cellulose fibre shall be applied at a minimum rate of 1,680 kg net dry weight per hectare when seeding bare soil or new construction. When seeding into a residue or growth where temporary seeding has previously been performed, the rate will be determined by the Engineer, usually net dry weight of 1,120 kg per hectare. The seed, fertilizer, wood cellulose fibre, and water shall all be combined into the slurry tank for distribution of all ingredients in one operation by the hydraulic seeding method. The agitator shall be operating at a rate sufficient to keep all materials in suspension at the time such material is added. Seed shall be added first, shall be thoroughly mixed, and the fertilizer then added and put into suspension. When the tank is 40 percent full, the mulch material may be added and shall be in complete suspension by the time the tank is 75 percent full. Such increased mixing speed as is necessary for putting the entire admixture in suspension shall be maintained until the tank is emptied. Spraying may commence at such time as the full complement of water has been mixed into the slurry. It is the intent of this Specification to maintain the slurry, during the spraying operation, as a homogenous mixture of suspended solids in the tank until the tank is emptied.

652.6.4 - Fertilizer:

The kind and amount of fertilizer per hectare shall consist of any type with 1-2-1 ratio (nitrogen, phosphoric acid, and potash) providing the minimum nutrient equivalent of 1,100 kg of 10-20-10. In addition, 335 kg per hectare of slow release urea formaldehyde fertilizer shall be added whenever second step seeding and fertilizing is not feasible due to the Contract completion date. When hydraulic seeding methods are used, the fertilizer shall be applied concurrently with the seeding and mulching operation as part of the slurry mix. When commercial fertilizer is applied by the spray or hydraulic method, it need not be worked into the soil.

Fertilizer applications for second and third step seeding shall be in accordance with 652.8.

652.6.5 - Wood Chips:

Wood chips, recovered from clearing and grubbing operations, or bark will be acceptable as mulch for seeding and shall be used at a rate of 66 cubic metres per hectare in lieu of straw or hay.

652.7 - MAINTENANCE OF SEEDED AND MULCHED AREAS:

The Contractor shall maintain all seeded areas until final acceptance of the project. All areas shall be protected from equipment traffic and any damaged areas shall be repaired and reseeded.

652.8 - SECOND AND THIRD STEP SEEDING, FERTILIZING AND MULCHING:

The Engineer will require second or third step seeding, or both, depending upon the completion date and estimated completion time of any remaining items on the project.

The second application of fertilizer, seed and mulch shall be applied as directed by the Engineer. The application rates will be based on the stand of grass, severity of erosion and condition or growth of grass as described. The following shall be used as a guide for second step application:

i. For areas with less than 50 percent stand or subject to severe erosion, apply the complete amount of seed, fertilizer, and mulch (wood cellulose fibre) as specified in the original seeding.

ii. For areas with over 50 percent of grass and slight to moderate erosion, apply one half the original fertilizer and seed. If erosion is a problem apply one half the original wood fibre mulch.

The third step seeding, mulching, and fertilizing shall consist of spot application on areas not showing a satisfactory stand after the second step application. The quantity of material will be determined on the same basis as for the second step application. No urea formaldehyde fertilizer will be needed for third step seeding.

652.9 - METHOD OF MEASUREMENT:

Seeding will be measured by the square metre of seed mixture sawn and vigorous growth of grass covering at least 70% of sawn area.

Second and third step seeding operations will be measured and included for payment under items in 652.11.

Ground agricultural limestone, fertilizer, mulch, wood chips or bark, asphalt for anchoring mulch, or

other chemical mulch binders, will not be measured separately, but their cost shall be included in the unit price bid for seed mixtures.

652.10 - BASIS OF PAYMENT:

The quantities determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be considered full compensation for furnishing all materials and performing all the work prescribed in a workmanlike and acceptable manner, including all labour, tools, equipment, supplies, and incidentals necessary to complete the work.

Topsoil will be measured and paid for in accordance with the provisions of Section 651.

The bid price for fertilizer is based on 10-20-10 type. When other types of fertilizer are used, pay quantities will be determined using the following table.

TYPE OF FERTILIZER	ACTUAL QUANTITY USED (Kg.)	PAY QUANTITY (Kg.)
5-10-5	100	50
8-16-8	100	80
10-20-10	100	100
12-24-12	100	120
15-30-15	100	150

When fertilizer types other than those shown above are used, the relationship between the pay quantity and the actual quantity used will be established by the Engineer.

652.11 - PAY ITEMS:

ITEM	DESCRIPTION	UNIT
652.004	Grassing of embankment slope	Square metre
652.005	Slope protection for cut slope upto 15m in height	Square metre
652.006	Slope protection for cut slope above 15m in height	Square metre

SECTION 653
VINE (CREEPING PLANT) AND GROUND COVER PLANTING

653.1 - DESCRIPTION:

This work shall consist of furnishing and planting vine and ground cover of the species called for on the Drawings and in the manner prescribed or as directed by the Engineer.

653.2 - MATERIALS

653.2.1 - Topsoil:

Topsoil shall conform to the applicable requirements of Section 651.

653.2.2 - Water:

Water shall conform to the requirements of 652.2.

653.2.3 - Ground Agricultural Limestone:

Ground agricultural limestone shall conform to the requirements of 715.25.

653.2.4 - Fertilizer:

Fertilizer for landscape plantings shall conform to the applicable requirements of 715.26.

653.2.5 - Mulch and Mulch Anchor:

Mulch material for landscape plantings shall conform to the requirements of 715.27.2.

653.2.6 - Vine and Ground Cover Plants:

Vine and ground cover plants shall conform to the requirements specified on landscape drawings.

The vine and ground cover plants shall be true to the type and size indicated on the Drawings.

CONSTRUCTION METHODS

653.3 - PLANTING OF VINES AND GROUND COVER PLANTS:

The method of planting vine and ground cover plants will be determined to a great extent by the site conditions, namely soil, slope, and type of cover. Methods of planting ground cover as shown on the Drawings.

Row Planting--On areas covered with grass or weed mass, the equivalent of a square 300mm on a side of sod including roots shall be removed and replaced on the lower side of the plant hole to help retain moisture runoff. The cleared square area around each individual plant shall be mulched as directed by the Engineer.

Bed Planting--All plant beds shall be free of weeds and grass prior to planting. The bed preparation can be accomplished with either herbicide spray or tillage as described on the Drawings.

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Bed areas shall be mulched as shown on the Drawings.

Plant backfill mixture for vines and ground covers shall be two parts topsoil to two parts organic or natural manure. For plants in containers or pots 75mm size or less, the backfill mix shall be applied at the rate of one half litre per plant. For plants in larger containers, the planting specifications will be as shown on the Drawings. Any other additives will be shown on the Drawings. In loose shale or sand without a sod cover, selection of plant location shall be where the soil is stable and not subject to rapid accumulation or erosion. On steep banks 1-1/2 to 1 or steeper, a slit shall be opened large enough to receive the plant roots and the replaced soil tamped leaving a slight depression to collect moisture. On slopes 2 to 1 or flatter, a small rain basin shall be formed by tamping with the heel and placing sod or excess soil on the slopes below the plant. Plants shall be watered during planting operations as directed by the Engineer.

The Contractor shall furnish material and mark location of all vine and ground cover plants for future reference. A row shall be identified by a stake at each end and a bed or mass identified by stakes around the perimeter. Wire stakes with flags are acceptable as markers.

Planting Season: The general planting can start in April and continue in May with the on set of the South West Monsoon. June is the best month for planting season. The second planting season will begin with the North East Monsoon and continue till end of November.

653.4 - CARE OF VINES AND GROUND COVER:

The Contractor shall maintain the plants in a healthy, living condition during the life of the contract, and shall maintain an adequate supply of moisture in the root zone at all times.

The Contractor and the Engineer shall make a monthly inspection of the plantings to determine the need for maintenance and water. Any maintenance determined necessary shall be taken care of during the two-week period immediately following the inspection. When moisture in the root zone is deficient, watering shall be started within 48 hours with sufficient labour and equipment to completely water all the plants within a two-week period unless otherwise directed by the Engineer. Other maintenance required during the contract period shall include:

i. The control of weeds and grass growth in beds and around individual plants.
ii. Protect plants from damage by insects and diseases.
iii. Any other practices necessary to maintain the plants in a healthy, live condition.

653.5 - REPLACEMENT OF VINES AND GROUND COVER:

Following the initial planting period, the Contractor and Engineer will make an inspection of all vines and ground cover plants to determine the replacement necessary.

If it is estimated that 85 percent or more of the Plan quantity of any individual item in a specific area is living, healthy and in good growing condition, replacements will not be required for that area. Any specific grouping shall have a reasonable distribution of live plants and the allowable 15 percent loss shall not be concentrated.

If it is determined there is a loss of more than 15 percent in any specific area, the Contractor shall be required to replace all the dead, missing or defective plants in the specific area. All replacements shall be completed and maintained until the completion of the Contract.

653.6 - CARE DURING AND AFTER DELIVERY:

There is a tendency for bare-root plants to dry out during transporting and during the planting operation; therefore it is important that the roots of all plant material shall be kept moist during transporting and during their planting period.

653.7 - METHOD OF MEASUREMENT:

Measurement of vines and ground cover plants shall be the square metre of plants originally planted, providing a survival of 85 percent was established, or the necessary replacements were made as directed.

The final acceptance and payment for any particular plant will be made after completing proper care and replacement as described in 653.4 and 653.5.

Water for maintenance during the period of establishment will be measured by the litre, expressed in thousand-litre units.

653.8 - BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit price bid for the items listed below, which prices and payments shall be full compensation for furnishing all the materials, including water required during the process of planting, topsoil, ground limestone, fertilizer, and mulch, and doing all the work prescribed in a workmanlike and acceptable manner, including all labour, tools, equipment, supplies, and incidentals necessary to complete the work.

Maintenance work other than watering shall be included in the contract unit price bid for each plant.

The accepted quantities of watering during the period of establishment will be paid for at the contract unit price per 1,000 Litres, which price shall be full compensation for furnishing, delivering, applying and performing all other work. No payment will be made for watering at the time of original planting or when planting replacements.

653.9 - PAY ITEMS:

ITEM	DESCRIPTION	UNIT
653.001	Vines	Square metre
653.002	Ground cover	Square metre

The quantities in the Bills of Quantities, against Items 653.001 and 653.002 are confirmed for the purpose of the preparation of bids.

In the cases of plants covered by Bills of Quantities Nos. 653.001 and 653.002 the nominal number of plants per square metre shall be fifty (50).

SECTION 654
TREE AND SHRUB PLANTING

654.1 - DESCRIPTION:

This work shall consist of furnishing, delivering, and planting nursery-grown or collected plants, in accordance with these Specifications and at locations shown on the Drawings or designated by the Engineer. This work shall include the furnishing of topsoil and related materials together with all other work including clean up of planted areas.

654.2 – MATERIALS:

654.2.1 – Topsoil:

Topsoil for plant backfill shall conform to the applicable requirements of Section 651.

654.2.2 – Water:

Water shall conform to the requirements in 652.2.

654.2.3 – Ground Agricultural Limestone:

Ground agricultural limestone shall conform to the requirements of 715.25.

654.2.4 – Fertilizer:

Fertilizer for landscape plantings shall conform to the applicable requirements of 715.26.

654.2.5 – Mulch and Mulch Anchor:

Mulch for landscape plantings shall conform to the requirements of 715.27.2.

654.2.6 – Trees and Shrubs:

Trees and shrubs shall conform to the requirements of 715.35. The trees and shrubs shall be true to the type and size indicated on the Drawings.

Collected plants may be used in place of nursery plants only when called for on the Drawings.

654.2.7 – Tree Paint

Tree paint shall confirm to the requirements of section 715.36 of the "Additional Addenda 1 – July 2008"

654.2.8 – Miscellaneous Materials:

Wire, hose, stakes, tree wrapping paper, anti-desiccant spray, and other incidental materials shall conform to the requirements of 715.37.

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CONSTRUCTION METHODS

654.3 – INSPECTION AND DELIVERY OF PLANT MATERIAL:

The Contractor shall notify the Engineer at least five days in advance of digging or shipping of plants from the nursery or collecting source. All plants will be subject to inspection where growing in the nurseries or collecting areas.

All plants shall be dug with care by experienced workmen, retaining essential roots and avoiding mechanical damage to root systems. All plants shall arrive with their roots in a moist and healthy condition. Each species or variety shall be handled and packaged in an approved manner and as required by soil and climatic conditions at the time of digging, with due regard to conditions of shipment and time to be consumed in transit and delivery. All plants shall be legibly tagged with name and size.

All such plants shall be so dug and transported as to provide and retain a firm ball of earth. All balled and all bare-root material shall be adequately protected.

Upon delivery to the Project, plants will be inspected for number, type, species, size, quality, and condition. Defects or injuries, such as dried out or broken roots and tops, will be cause for rejection, and immediate steps shall be taken to replace rejected plants.

654.4 – CARE AFTER DELIVERY:

Plant material delivered to the Project and accepted shall be planted immediately, or "heeled-in" in moist soil or other approved moist material in a manner as shown on the Drawings. All "heeled-in" plants shall be kept moist and protected until planted.

654.5 – DIGGING HOLES FOR PLANTS:

Planting holes shall be excavated according to the following table:

PLANTING HOLE DIAMETER

Rootball Diameter (mm) (Specified)	Planting Hole Diameter (mm) (Approximate)	Rootball Diameter(mm) (Specified)	Planting Hole Diameter (mm) (Approximate)
200	500	600	1,050
250	550	700	1,225
300	600	800	1,400
350	700	950	1,650
400	800	1,050	1,825
450	850	1,200	2,100
500	900	1,350	2,350
550	950	1,500	2,625
600	1,050	1,800	3,150

The depth of the hole shall extend 200mm below the depth of the rootball. During normal weather conditions, digging and planting holes may be allowed as much as two weeks in advance of planting. During hot dry weather, the planting holes shall be dug just prior to planting. When holes present a hazard along the highway, they should be dug immediately prior to planting.

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Planting holes for container grown plants shall be dug to the size required for the equivalent balled and burlapped plants.

654.6 – PLANT BACKFILL:

All backfill for planting shall be two parts topsoil mixed with two parts of organic manure or other approved additive.

Any adjustment needed in the pH reaction of the backfill material will be specified in the Drawings.

The rate of fertilizer application for individual plant replacement shall be as follows:

Trees- 0.5 kg per tree
Shrubs- 0.25 kg per plant.

No backfill material in a muddy condition shall be used.

654.7 – PLANTING:

654.7.1 – Planting Season:

All initial planting shall be completed as prescribed by the Engineer or according to the program by end of June and after the second planting season in October end in November.

654.7.2 – Planting Method:

All balled plants shall be planted so the top of the ball is slightly above the natural ground level to allow for normal settlement unless otherwise specified on the Drawings. When planting beds, the individual plants shall be selected and arranged according to spread and height to present a uniform appearance.

Backfill material under the root all or roots shall be tamped prior to placing the plant in the hole.

Bare-rooted plants shall be placed in the planting holes with the roots spread out in a natural position while the specified backfill is placed. Non-plantable containers shall be carefully removed from all container grown or potted plants immediately prior to planting.

Planting beds shall be prepared by destroying the existing vegetation before excavating the planting holes. Recommendations for control of existing vegetation will be shown on the Drawings.

Sufficient amounts of water, without puddling, shall be used in the process of planting to settle the backfill material around the roots or ball. Additional backfill material shall be placed and further compaction accomplished by tamping. This watering is not to be confused with the maintenance procedure in 654.14.1.

During the initial planting period May to June, any plant determined by the Engineer not to be in an acceptable growing condition, or failing to meet other requirements of these specifications, shall be removed from the project and replaced immediately with nursery stock meeting the specifications. It is the intent of this specification that all plants shall be alive at the beginning of the growing season.

654.8 – PRUNING:

Primarily, all dead and broken branches shall be removed from plant material during the process of planting. Further pruning shall be carried on in accordance with the normal nursery practice or as directed by the Engineer. All cuts over 25 mm shall be painted with a tree paint.

654.9 – STAKING AND GUYING:

All trees and all ornamental flowering trees (including multiple stem) shall be staked in accordance with tree staking details shown on the Drawings and to the satisfaction of the Engineer.

654.10 – MULCHING:

Mulch material shall be furnished and placed around the plants a soon as possible after planting. However, during extremely wet periods, the application of mulch shall be delayed and placed as directed by the Engineer.
The mulch shall be applied in the saucer areas of individual trees and shrubs and over the entire area of shrub beds. Heavy mulches like woodchips and wood bark products shall be applied to a depth of 75mm. Light mulch material shall be applied 100mm deep.

654.11 – WRAPPING AND FOLIAGE PROTECTION:

654.12 – RAIN BASINS:

A shallow rain basin equal to the diameter of the planting hole shall be formed by shaping the soil around each tree or shrub and shall be maintained until final inspection and acceptance of the work.

654.13 – CLEAN-UP AFTER PLANTING:

After the planting has been completed, all planting sites shall be cleaned up. Subsoil, rock, excess topsoil, and other waste material shall be removed and disposed of as directed.

All holes dug and not used, or areas disturbed in attempting to find a suitable planting site, shall be refilled by the Contractor, and the area shall be restored to its original condition and reseeded.

654.14 – CARE AND REPLACEMENT OF PLANTS:

654.14.1 – Care:

The Contractor shall maintain the plants in a healthy, living condition during the life of the Contract, which includes any warranty period indicated in the Contract, and shall maintain an adequate supply of moisture in the root zone at all times.

The Contractor and the Engineer shall make a monthly inspection of the plantings to determine the need for maintenance and water during the first growing season. Any maintenance determined necessary shall be taken care of during the two-week period immediately following the inspection. When moisture in the root zone is deficient, watering shall be started within 48 hours with sufficient labour and equipment to completely water all the plants within a two-week period unless otherwise directed by the Engineer.

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Other maintenance required during the contract period shall include:

i. The control of weed and grass growth, by destroying the top growth as well as roots, in plant beds and individual plant saucers.
ii. Protect plants from damage by insects and diseases.
iii. Repair rain collars and replace any lost mulch.
iv. Maintain stakes and guys supporting trees, and any other practices necessary to maintain the plants in a healthy, living condition.

654.14.2 – Replacement of Plants:

The Contractor and the Engineer will make an inspection of the plantings between July 1 and 10 the initial planting period, to determine the number of dead, missing or defective plants, for which replacement will be required.

During this fall replacement period, October through November 30, all maintenance including stake and wire tightening, mulch replacement, rain collar repair, pruning or trimming, trunk wrapping, and removal of any wire tags shall be accomplished.

The replacement plants shall be planted in the same manner as the original plants with necessary backfill and mulch added to accomplish the job. The fertilizer shall be added in the hole prior to replacing the plant. However, when a plant has been lost due to poor drainage or other adverse soil condition, the replacement shall be planted at a more acceptable location, and the old site shall be restored to its original condition.

All replanting and maintenance shall be completed according to the program for final acceptance of the Contract.

654.15 – METHOD OF MEASUREMENT:

The quantity of plants to be paid for will be the number of living trees or shrubs planted in accordance with these Specifications and accepted. Only living plants in healthy condition at the time of final inspection will be accepted.

Progress payment for the initial planting of trees and shrubs will be based on the premise that 90 percent of the work has been completed when the plants have been completely planted. The remaining 10 percent withheld will be considered for maintenance, plant replacement, and for any delayed mulching when authorized by the Engineer. The final acceptance and payment for any particular plant will be made after completing proper care and replacement as described in 654.14.

654.16 – BASIS OF PAYMENT:

The number of plants, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments will constitute full compensation for furnishing and delivering plants and all incidental materials including water required during the process of planting, topsoil, mulch, fertilizer, ground agricultural limestone, and additives; for planting, staking, pruning and for performing all the work prescribed in a workmanlike and acceptable manner, including all labour, equipment, tools, and incidentals necessary to complete the work.

Maintenance work including watering must be included in the contract unit prices bid for each type of plant.

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654.17 – PAY ITEMS:

ITEM	DESCRIPTION	UNIT
654.001	Tree	Number
654.002	Shrub	Number

The quantities in the Bills of Quantities, against Items 652.001, 654.001, and 654.002 are confirmed for the purpose of the preparation of bids. In the individual locations of such planting the actual numbers of such plants and areas of seeding shall be determined by the Engineer.

The Contractor shall provide healthy plant material capable of complying with Section 654 of the Technical Specifications. In this respect he is expected to have taken the advice of his supplier of such material as to the appropriate optimum age and size of each species.

SECTIONS 655 – 656 NOT USED

SECTION 657
ROAD SIGNS

657.1 - TRAFFIC SIGNS

657.1.1 – General Description

This work shall consist of furnishing, assembling and erecting posts and signs of a permanent nature in accordance with the details shown on the Drawings and as specified herein, at the locations shown on the Drawings or as directed by the Engineer.

The work shall include all necessary foundations, excavation, backfill, anchorages, fixtures and fastenings, brackets, application of paints and finishes and all the processes necessary to complete the work.

657.1.2 – Sizes, Colours and Types

Signs and their supports shall be of the sizes, colours and types indicated on the Drawings unless otherwise directed by the Engineer. Reference shall be made to the Sri Lanka Manual on Traffic Control Devises, Part 1 when specific requirements are not detailed.

657.1.3 – Alternative Designs and Materials

The Contractor may submit or recommend alternative designs and construction materials to those specified or shown on the Drawings but these must meet the requirements of the Sri Lanka Manual on Traffic Control Devises, Part 1 and have the consent of the Employer.

657.2 – MATERIALS

657.2.1 – Mounting Posts

Mounting posts shall be steel posts unless otherwise noted on the drawings. Unless otherwise detailed on the Drawings or directed by the Engineer, steel posts shall be in the form of heavy galvanised round tubes, or pipes, of not less than 50 mm nominal bore or other approved sections of adequate torsional rigidity and strength complying with the appropriate specifications of the American Society for Testing Materials, the British Standards Institution, the American Association of State Highway Officials or a similar internationally recognised body.

Post Caps, Caps for hollow posts or other hollow sections used in construction may be approved cast or sheet metal or a suitable weather-resisting plastics material.

657.2.2 – Sign Plates

Prior to commencement of fabrication the Contractor shall submit details of the proposed form of manufacture of traffic signs to the Engineer for approval. Such approval will only be effective when provided in writing by the Engineer.

Aluminium alloy plates and panels shall have a minimum thickness of 2 mm. Steel plates and panels shall have a minimum thickness of 1.5 mm.

It is preferred that traffic signs be manufactured from aluminium sheet, complying with BS1470 or ASTM Specifications B209 or other internationally recognised specification as is acceptable to the Engineer.

Other types of metal sheeting may be considered but where reflective sheeting is to be applied the Contractor may be required to provide an acknowledgement from the manufacturer of the reflective sheeting, that the reflective sheeting is compatible with the metal sheeting. The Contractor may also be requested to provide an extended guarantee in relation to the traffic signs.

657.2.3 – Frames and Stiffening

Except as otherwise provided in the Drawings sign plates requiring frames or stiffening as specified under sub-clause 657.3.4, shall have adequate ribs or flanges as an integral part of the sign plate or shall have frames or stiffening members of material complying with the following:

A metal frame or stiffening bars constructed of structural sections in steel or aluminium alloy complying with 657.2.1 and 657.2.2.

The metal used for frames and stiffening shall be the same as, or compatible with, the metal used for the faceplate.

657.2.4 – Fixtures and Fittings

Brackets and clips shall be manufactured from approved cast metal, steel, stainless steel or aluminium alloy.

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

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

657.2.5 – Preservatives, Paints and Finishes

657.2.5.1 – General

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

All steel parts used shall have a Zinc coating (galvanizing), which shall comply with ASTM Specification A 123 or A 153 as appropriate. Such Zinc coated parts shall not require painting unless indicated on the Drawings.

Where painting of steel parts is required, the paint shall be high zinc oxide content coating material of approved formulation containing a minimum of seven kilograms of zinc oxide (acicular type) per

one hundred litres of coating material. The colour of the primer shall be different from succeeding coatings.

If painting of aluminium alloy parts is noted on the Drawings, priming paint shall be pigmented with chromates or chromes (excluding lead chromes) except on sign faces where the specified finish is unsuitable for use with such primers.

657.2.5 – Reflective Sign Faces

Sign faces shall be made reflective by the application of approved reflective sheeting as described below, or be painted, as described in 657.3.6 and 657.3.7

Reflective sheeting intended for use on sign facings shall be approved in writing by the Engineer following submission by the Contractor, 15 days prior to commencement of manufacture, of a test report from an approved testing laboratory together with a sample of the intended sheeting. The Engineer may request a warranty from the Contractor, endorsed by the sheeting manufacturer, to cover the quality and field performance of the reflective sheeting per this Specification for seven years. The sheeting shall generally conform to the following requirements:

The coefficient of retro-reflection shall not be less than the minimum values specified in the table below:

Minimum Coefficient of Retro-reflection

Candelas per Lux per Square metre
(0.2 degrees observation angle and – 4-degree entrance angle)

SHEETING COLOUR	COEFFICIENT OF RETRO- REFLECTION	
	Initial	Minimum after 7 years
White	250	200
Yellow	170	136
Red	45	36
Green	45	36
Blue	20	16

Testing in accordance with ASTM E810

The sheeting, processed and applied to the aluminium sign plate in accordance with the sheeting manufacturer's recommendations, shall perform effectively for 7 years

The surface of the sheeting shall be smooth and flexible. No cracking shall occur when bent. Reflective sheeting shall have high durability under all weather conditions, heat and moisture and be strongly fungus-resistant.

The sheeting shall not delaminate, blister, crack, peel and chip during the manufacturing process and during its expected service life.

The sheeting supplied shall be free from dirt, solid lumps, scales and ragged edges.

The colour of the sheeting shall be even and free from any spots or loss of colour. The colour shall not fade appreciably under local weather conditions during its expected service life.

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Colours of sheeting used must correspond to the colours of sheeting supplied as samples.

All inks, sheeting, and film used on the sign must either be from the same manufacturer or be approved by the main sheeting manufacturer.

The reflective surface of the sheeting shall be durable and remain sharp and glare less during its expected service life. Bad weather conditions such as rain, dew, etc. shall not considerably reduce the reflectivity.

The reflective surface of the sheeting shall be easily cleaned with soap and water with no adverse effect on its reflectivity and durability when used on the roads.

The adhesive used on the backing of the sheeting shall give a high quality bonding to clean, smooth and grease-free aluminium or other sign plates approved by the sheeting manufacturer. The adhesive shall withstand the conditions without allowing the sheeting to peel.

657.3 - CONSTRUCTION METHODS

657.3.1 - General

The obstruction of footways shall be avoided. Design and construction of signs shall be such that all sign plates, posts, fittings, lighting units, electrical equipment and pipeline can be assembled and erected without site modification.

657.3.2 - Mounting Posts

Posts shall be adequate in number and size to support the signs attached to the frames or posts.

Posts shall be such that, at a wind pressure of 150 kg per square metre, the maximum deflection at the centre of the sign is limited to one fortieth (1/40th) of the height measured from the ground for signs mounted on a single post and to one eightieth (1/80th) for signs mounted on more than one post.

The lengths of posts shall be adequate for the requirements allowing for embedment in the ground. All posts shall be effectively prevented from rotation in the ground and if necessary in the case of metal posts, suitable metal base plates shall be provided for this purpose. Unless otherwise shown on the Drawings base plates shall be not less than 4.5 mm thick and shall have an area of not less than five times the plan area of the post. Effective means for securing the base plate to the post shall be provided.

Where a post has to be sited close to a wall either the top of the post shall be angled away from the wall to provide adequate clearance for the sign or an adequate bracket or brackets shall be provided from the post for this purpose. In either case the post shall be of adequate strength and rigidity to withstand the additional bending moments and torsion resulting from the arrangement.

All open-ended posts, or other hollow sections used in construction shall be effectively capped to prevent the entry of water.

Construction of reinforced concrete and pre-stressed reinforced concrete posts shall be in accordance with 5.1, 5.2 and 5.3 of these Specifications, respectively, and as approved by the Engineer.

657.3.3 - Sign Plates

Sign plates and panels shall be cut accurately to the shapes and sizes specified on the Drawings. All mounting holes shall be accurately located and, after drilling or punching, any burrs, rough spots and loose material shall be removed. All holes shall be drilled before painting.

657.3.4 - Frames and Stiffening

Except where ribs or flanges are an integral part of the sign plate and provide the necessary stiffening, sheet metal sign plates exceeding 500mm in any dimension shall be stiffened by the attachment of a frame or stiffening member(s) to the back of the sign plate.

The post or posts supporting a sign may be taken into consideration for stiffening purposes. A bracket may form the stiffening frame or part of it.

The frame for a sign plate or plates shall be simple in design and shall have the minimum number of members to give it the required stiffness.

The stiffening or frame for a sheet metal sign plate may take the form of flanges round the edges of a sign, welded ribs or steel or aluminium sections with a minimum thickness of 2 mm. Where flanges are provided they shall be uniform on all edges of the sign.

Where metal frame members join they may be welded or joined with suitable brackets and nuts and bolts but in all cases the joints shall be strong enough to withstand the stresses induced in them.

657.3.5 - Fixtures and Fittings

Where necessary or desirable signs shall be mounted on existing suitable highway furniture, buildings or structures by means of a properly designed bracket or brackets.

The method of fixing sign plates, frames and brackets to posts shall be such as will facilitate removal for replacement or maintenance purposes and permit adjustment in the position of a sign without detaching it from its post or posts, but the sign and any framing shall be held firmly enough to withstand the load to which it will be subjected. Signs mounted on single posts shall have a fixing to prevent the forced rotation of the signs on the posts. Clips and brackets shall be shaped to secure a firm hold on the post without placing any bending strain on the sign plate.

Where dissimilar metals are joined together, precautions shall be taken to prevent electrolytic action, particularly in the case of screws and rivets. This may be accomplished by using paint, lacquer or other suitable means to eliminate metal-to-metal contact.

Brackets used in the construction of signs may be manufactured from sheet or strip aluminium alloy, extruded sections, cast aluminium alloy or may be fabricated from steel sections. The minimum thickness of material shall be 3mm. Welded joints shall be sound and their surfaces smooth. Holes shall be drilled before painting and shall be accurately located. Steel or aluminium strip used for clips shall not be less than 2mm thick.

Screws and bolts shall not be less than 8mm in diameter and of adequate length, but without excessive projection of the screwed ends. In any situation where, if a screw were removed, the assembly would be insecure, that screw shall have not less than four full threads protruding when it is tight and shall be fitted with a locknut or a spring washer.

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Where hollow rivets are used to connect sign plates to frames or fixings the holes shall be effectively blocked to prevent light shining through. Screw, bolt or rivet heads on the face of a sign shall be as unobtrusive as possible and each shall match the colour of the part of the sign where it is located.

Caps for posts of hollow section shall be shaped to shed rainwater to the outside of the posts and adequate means of securing the caps to the posts shall be provided.

657.3.6 - Preparation and Painting

a) General. All painting and finishing shall be carried out in clean, dry surroundings using heat lamps for drying and ovens for baking as may be needed. All paints shall be applied with a pressure spray to form a smooth even film and all surfaces and edges shall be coated unless stated otherwise. Paint shall be applied only when the surface or previous coat is dry.
The following requirements shall, unless otherwise provided on the Drawings, apply to preparation and painting of sign components, but excluding plastic signs and components with finishes of reflective and plastic sheeting, film, sheathings and other proprietary finishes.

b) Aluminium Alloys. Aluminium alloys, other than sign faces, shall not be treated or painted unless they are in contact with earth Surfaces.

Before painting, the surfaces of aluminium alloy sign plates shall be thoroughly degreased and pre-treated by anodising or by an equivalent process or by using an etching primer.

The prime coat shall then be applied. The back and edges of the plate shall receive a finish coat of light grey enamel.

c) Steel Surfaces - all steel components shall be rust proofed by galvanising, or other approved treatment prior to painting. Where necessary the surfaces shall be cleaned and degreased before painting. All surfaces other than screws, bolts, nuts and washers, shall then receive one prime coat of high zinc oxide paint, tinted light grey.

657.3.7 - Finish of Sign Faces

a) Reflective Signs

Reflective sheeting used for sign facing shall be applied to the metal backing plate in a manner strictly according to the manufacturer's instructions. Such application shall take place in a clean and dry environment suitably set up with benches, clamps and forms to ensure regularity of cutting and application of symbols and lettering.

The finish on the face of a sign shall present an even surface free from twists, cracks or faults or any other blemishes. When reflecting sheeting is used it shall, where possible, be in complete sheets. Joints shall be kept to a minimum but where they are necessary they shall be constructed in accordance with the manufacturer's instructions. Care shall be taken to ensure a proper day and night colour match at joints.

b) Painted Signs

Spraying enamel paint using appropriate templates shall form the legends, borders, symbols, designs etc. An undercoat and a topcoat shall be applied and the latter shall be of uniform thickness and homogenous and uniform in colour with an eggshell flat finish. The painted surfaces shall be

free from cracks and blisters. All painted surfaces shall be considered warranted against peeling, blistering and excessive fading and as such these effects when noted will be considered as defects.

657.3.8 - Concrete Embedment of Posts

Where so indicated on the Drawings the bases of posts shall be embedded in concrete. Concrete shall be rammed round the base of the post such that the post will be firmly held in position immediately after completion of placing and compaction.

The minimum thickness of concrete embedment and its height shall be as shown on the Drawings or be a minimum of 0.1 cubic metres of class 15 concrete.

The post shall be carefully positioned and plumbed and struts and stays applied as necessary to hold it in position during embedment. The concrete shall then be placed round the post in uniform lifts not exceeding 200 mm and each lift thoroughly rammed. Care shall be taken to avoid contamination of the concrete from the surrounding surface and soils. Any contaminating material falling into the concrete shall be immediately removed.

All the concrete embedment for a post shall be provided in one operation and where the surface of the concrete embedment is above the level of the surrounding surface the exposed portion shall be formed to present a neat and tidy appearance and sloped to shed water away from the post.

657.4 - METHOD OF MEASUREMENT

The quantity to be measured for payment shall be the actual number of completed road signs of each type and size furnished, placed and accepted. Sign Posts shall be measured separately.

657.5 - BASIS OF PAYMENT

The work, measured as provided in 657.4 above, shall be paid for at the Contract unit price for each type and size of sign which price and payment shall be full compensation for furnishing and erecting all materials including all labour, tools, testing and incidentals necessary to complete the work.

Payment for signposts shall include all excavation, concreting etc.

657.6 PAY ITEMS:

ITEM	DESCRIPTION	UNIT
	DANGER /WARNING SIGNS (INCL. POSTS) **ROAD TRAFFIC SIGN AND INFOMATIVE SIGNS**	
657.001	Sign board area up to 0.50 m2	m^2
657.002	Sign board area over 0.50 m2 to 1.00 m2	m^2
657.003	Sign board area over 1.00 m2	m^2
657.004	Sign board area up to 0.50 m2, but without post and fix to the concrete structure with necessary anchored bolts	m^2
657.005	Sign board area over 0.50 m2 to 1.00 m2	m^2
657.006	Sign board area over 1.00 m2	m^2

SECTIONS 658 – 659 NOT USED

SECTION 660
TRAFFIC SIGNALS

660.1 - DESCRIPTION

660.1.1 - General

The work shall consist of furnishing installation and commissioning of, traffic signals, in accordance with the details shown on the drawings and as specified herein at the location shown on the drawings and as directed by the Engineer. Only well proven equipment designed and constructed to the highest standards will be acceptable. Traffic control equipment will therefore only be accepted after a demonstration to the Engineer of its adequacy in design, construction and reliability.

Variations to the requirements of this specification will be considered where the Contractor provides a full justification for the variations explicitly stated. Only those variations authorised by the Engineer will be permitted.

660.1.2 - Approval

Where the specification calls for the approval of the Engineer to be given to any part of the equipment or works, no equipment shall be shipped from the Contractor's premises until the appropriate approvals have been given by the Engineer in writing.

660.2 - DEFINITIONS

660.2.1 - Controller

660.2.1.1 - Minimum Green Running Period

The duration of a green signal following the extinction of a red / amber signal during which no change of signal light can occur.

660.2.1.2 - Maximum Green Running Period

The maximum time that a green signal can run after a demand has been made by traffic on another phase.

660.2.1.3 - Phase

The sequence of conditions applied to one or more streams of traffic which during the cycle, receive identical signal light conditions. Two or more phases may overlap in time. A series of phases is usually arranged in a pre-determined order but some phases can be omitted if required by the situation.

660.2.1.4 - Stage

A condition of the signal lights which permits a particular movement of traffic. They are arranged to follow each other in a pre-determined order but stages can be skipped, if not demanded, to reduce delay.

660.2.1.5 - Inter Green Period

The period between the end of the green display on one stage and the start of the green display on the next stage is known as the inter-green period termination of the green signals for one stage and the beginning of the green signals for the next stage to receive right-of-way. This period comprises the time between leaving amber for the stage losing right-of-way and the starting amber for the stage gaining right-of-way separated by a variable length all red period. For pedestrian phases, the inter-green period as defined, will display a red man.

660.2.1.6 - Cycle-time

A cycle is a complete series of stages during which all traffic movements are served in turn. The cycle time is the sum of the stages.

660.2.1.7 - Demand

A request for right of way for traffic on a phase that has no right of way when the request is made. The demands, normally being stored in the controller and served in a pre-arranged order.

660.2.1.8 - Detector

A device that detects the presence or passage of a vehicle on the roadway.

660.2.1.9 - Traffic Signals

A system of different coloured lights, including arrow shaped lights, for controlling conflicting streams of traffic.

660.2.1.10 - Traffic Signal Controller

The electronic control equipment which activates the signal phases at an intersection.

6602.1.11 - Vehicle-actuated Signals

Traffic signalling equipment in which the duration of the green time and cycle length varies in relation to the traffic flow on its approaches.

660.3 - REGULATIONS, CODES AND SPECIFICATIONS

All equipment and materials supplied shall comply with the following statutory and other regulations, and codes of practice. The said regulations, codes of practice, and other documents shall form part of the specification, together with all other regulations, requirements, conditions or specifications referred to therein. Where proprietary equipment has been designed to equivalent regulations, codes of practice and specification, these shall be stated by the tendered at the time of tender and all differences explicitly stated.

660.3.1 - Regulations

(a) Institution of Electrical Engineers UK – Regulations for Electrical Installations (16th Edition, 1991). (BS 7671)

(b) Ceylon Electricity Board

660.3.2 - British Standards Institution Codes of Practice

CP 1006 General aspects of radio interference suppression
CP 1013 Earthing

660.3.3 - Specifications

BS EN 12368:2000 Traffic Control Equipment. Signal Heads

BS 800	**Radio Interference**
BS 2011 1977	**Methods for the environmental testing of electronic components and electronic equipment:**
Part 2.1a	Cold (including AMD 3144 – June 1980);
Part 2.1b	Dry heat (including AMD 3145 – June 1980).
BS 5378	**Safety Signs and Colours**:
Part 1 1980	Specification for Colour and Design;
Part 2 1980	Specification for Colourimetric and Photometric Properties of Materials;
Part 3 1982	Specification for Additional Signs to those given in Part I.

660.4 - TRAFFIC SIGNAL EQUIPMENT

660.4.1 - General

All equipment shall be supplied in a new and unused condition except insofar as it has been tested in the course of manufacture.

All equipment supplied shall be of a type suitable for use on public roads in Sri Lanka.

The equipment shall be subject to acceptance tests prior to installation. These tests, which shall be conducted at the manufacturers' premises, shall be in accordance with accepted good practice and all to the satisfaction of the Engineer.

Installation, engineering and commissioning will be carried out at the sites specified in accordance with accepted good practice and all to the satisfaction of the Engineer.

The equipment shall be suitable for the climatic conditions prevalent in Sri Lanka.

On pedestrian operated signals the legends on the push button box will be in Sinhala, Tamil and English.

Initial signal timings will be provide by the Engineer where appropriate.

The supplier will be responsible for the training of the clients in the use of the signal control equipment. Any equipment necessary for the reprogramming of the controllers will be supplied.

660.4.2 - Requirements for Controller

Traffic Signal Aspect Sequence shall be RED, RED and AMBER, GREEN, AMBER, RED. It shall also be possible to flash AMBER aspects as described in 4.2.4 (f).

i) On stand alone pedestrian crossing signals the pedestrian aspect sequence shall be: red standing man, green walking man, flashing green man, red standing man.

ii) On signal controlled junctions incorporating pedestrians the pedestrian aspect sequence shall be: red standing man, green walking man, blackout, red standing man.

The controller shall be a microprocessor based programmable controller.

All controllers shall be fully equipped to meet the method of control specified for a given location and shall be capable of expansion by the addition of at least one phase on site without back wiring changes. Each phase provided shall be configured as either a vehicle or pedestrian phase, and it shall be possible to combine phases in any order to provide stage sequences.

Controllers shall be capable of operating in the following modes:

(a) Fixed Time

In this mode the controller shall cycle through all stages in a pre-determined sequence, when the duration of the red and green signals and the time of the cycle is fixed;

(b) Demand Dependent

In this mode two or more stages shall be equipped as demand dependent stages. These stages shall be served only when an external demand is present for the stage. The controller shall cycle through all stages in a pre-determined sequence, omitting any demand dependent stage for which no demand is present. When a demand is present the controller shall step to that stage in its correct sequence and shall then step to the next stage on the expiry of the minimum green interval or extensions. In the case of the pedestrian demand dependent stages, demands shall be registered by pedestrian push buttons. In the case of vehicular demand dependent stages, demands shall be registered by approved vehicle detectors;

(c) Manual

In this mode it shall be possible to step the controller through all its stages (including demand dependent or vehicle actuated stages) in the pre-determined sequence by the operation of a push button. It shall not be possible to step from one stage to the next until the minimum green period for the running stage has expired. It shall not be possible by use of this mode to override any prohibited stage-to-stage movements. The controller shall remain on the running stage until stopped by the operation of the push button. Provision shall be made for rendering this facility inoperative;

(d) Cable-less Link

In this mode (defined in Section 6 the maximum green timings only of the controller will be overridden. This facility shall have the capacity for at least eight plans and have a battery back-up system which shall last for 24 hours under fully charged conditions. It shall be possible to programme a plan change:

- on every day of the week;
- on every day, Monday to Friday; and,
- on Saturday and Sunday only.

The number of programmable plan changes in a week shall not be less than 24. Plans shall be changed automatically at times of the week defined by:

- day of week;
- hours;
- minutes; and,
- seconds.

The flashing amber mode shall be accessible via the cableless linking facility.

(f) Computer Control

Facilities shall be provided such that at a later date the controller shall be remotely controlled as part of a computer controlled system;

(g) Flashing Amber

All amber aspects will flash at a nominal rate of 75 beats per minutes. This mode shall be introduced only when the running stage terminating amber period has finished. During this mode all other vehicle and pedestrian signal indications shall be extinguished; it shall be possible to use the flashing amber mode for specified plans only;

(h) Flashing of Pedestrian Indicators

When the flashing of either pedestrian walk or clearance intervals is required the sequence should be specified;

(i) Vehicle and/or Pedestrian Activated

In this mode stages shall run in the standard sequence when vehicle or pedestrian demands are registered. Each stage, when called, shall run for at least the minimum green period and shall be extended by further detection of vehicles on the appropriate approaches. The stage shall terminate when a demand is registered for an opposing stage and either no further demands are present for the running stage or the maximum green time for the running has expired.

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660.4.3 - Priority of Modes

The priority of modes shall be:

a) manual;

b) computer control;

c) cable-less link;

d) demand dependent;

e) vehicle actuated;

f) fixed time;

g) flashing amber.

660.4.4.1 - The following timing intervals and ranges shall apply to any appropriate stage:

a)	maximum green	7-100 seconds in one-second steps;
b)	leaving amber, amber only	three seconds fixed;
c)	starting amber, amber and red	two seconds fixed;
d)	inter-green	4-20 seconds in one-second steps;
e)	pedestrian	5-25 seconds in one-second steps;
f)	flashing amber	6-18 seconds in one-second steps;
g)	minimum green	1-15 seconds in one second steps;
h)	vehicle extensions	1-10 seconds in one/two second steps.

660.4.4.2 - All the controller software and intersection parameters shall be held in non-corruptible Programmable Read Only Memory (PROM), or equivalent.

660.4.4.3 - The controller shall monitor each green signal to ensure signal to ensure against conflicts as set in the PROM by hardware and software means.

Checks shall also be made by means of a 'watchdog' to monitor the correct operation of the controller. Detection of conflict or faulty operation shall put the controller into a fault condition.

660.4.4.4 - A keyboard or similar plug in unit shall be provided, to input variable parameters to the controller's Random Access Memory (RAM). This input shall be able to operate whilst the controller is running without interfering with the safe working of the controller. A fixing for plug in display shall be provided to display all the programmable timings including those held in the cableless linking unit.

660.4.4.5 - The controller shall have a fault log which shall be accessible from the keyboard and display as specified in Clause 4.2.9.

660.4.4.6 - Under controller fault conditions the controller will go into a flashing amber mode, and will cause all amber aspects for vehicles at the intersection to flash.

660.4.4.7 - The start-up sequence upon switch on or resumption of power supply after a failure shall be a blackout period followed by a three second amber to all aspects and a one second red to all aspects. The stage cycle will then commence with the normal signal sequence.

660.4.5 - Construction and Design

The controller housing and control equipment shall be of a suitable manufacture for the climatic conditions of Sri Lanka which will include high temperatures and high humidity.

One main door on the controller case shall give access to:

a) control equipment;

b) keypad input point or push button unit;

c) main power fuses and switches.

The control facilities supplied for the use of the police shall be accessible without opening the main controller door and shall be behind a lockable flap or door.

All timing shall be digitally derived, with a timing accuracy of ± 1%.

The cableless linking unit shall be controlled by an electronic digital clock synchronised to the mains supply. The accuracy of the clock shall be equal to the accuracy of the mains supply for all conditions except a mains failure of greater than 50 ms.

In the event of a mains failure of greater than 50 ms, all clocks and the cableless linking unit shall be supplied from batteries capable of maintaining the unit in operation for at least 24 hours, under fully charged conditions, over the whole ambient temperature range. The batteries shall be automatically charged when the mains supply is restored. After restoration of the mains supply, the unit shall re-synchronise itself to the mains and continue normal operation.

Under power failure conditions the cableless linking unit shall disconnect itself from the controller if the battery voltage falls below the level at which the unit and its clock can be relied upon to operate faultlessly.

A facility should be provided to indicate the state of charge of the batteries.

During periods of any mains failure of up to 24 hours stored data shall not be corrupted or lost.

Facilities shall be provided to set the digital clock to the correct day, hour, minute and second.

Digital displays shall be provided to allow the clock time to be observed.

Operation of all signals shall be positive without flickering or excessive dark periods.

Visual indications shall be provided within the controller to indicate the running stage and the interval currently being timed.

Power supply units shall employ double-wound transformers which shall include an earth screen. Transformers shall be provided with primary tapping from 200 to 250 volts in steps of 10 volts. Voltage stabilisation will be required.

Lamp switching devices shall be solid stage and each circuit shall be capable of switching 5 A.

All wiring and equipment shall be accessible without removing the controller from its case.

All contacts or terminals carrying mains voltage shall be shrouded or covered to avoid the possibility of accidental contact. A warming label shall also be attached to the cover.

Each controller shall be fitted with two circuit breakers or double pole fused switch units to isolate:

(a) incoming supply to the installation, and

(b) voltages to the controller electronics.

The controller shall have a switched socket outlet for the connection of mains operated tools and test equipment. It shall be compatible with socket outlets in common use in Sri Lanka. The socket shall not be isolated by the switch specified in 4.3.15 (b)
A switch shall be provided to switch off all signals while leaving the controller operation. This switch shall be accessible without opening the main controller door and protected by the lockable flap specified in 4.3.3.

Screw terminations shall be of the kind which do not allow the screws to come directly into contact with the wires.

The controller shall continually monitor the mains supply voltage. Should it fall below the controller's requirements all the signals shall be extinguished. Upon the restoration of the supply the controller shall automatically restart using the procedure stated in 4.2.12.

The Engineer will be responsible for providing the timings and daily plans to the supplier, for entering into the controller.

The Contractor will allow in his quotation, for the re-blowing of the site PROM (s) with information to be provided by the Engineer following the commissioning of the installation. This information need not be limited to timing changes. A period of six months should be allowed for between commissioning and re-blowing the PROM(s).

660.4.6 - Environmental Requirements

The Contractor shall conduct environmental tests as specified in this section, on all equipment to be provided, to the satisfaction of the specification or, shall provide documentary evidence to show that the specified tests have been conducted to the satisfaction of an independent testing authority and acceptable to the Engineer.

The basic environmental tests shall be conducted in accordance with BS 2011 specified herein, or an internationally recognised specification. The Contractor will submit evidence of tests conducted to comply with an alternative internationally recognised specification, which when submitted must be accompanied by the alternative specification.

660.4.6.1 - Environmental Tests

(a) Dry Heat

The purpose of the test is to determine the suitability of the equipment to withstand conditions of high temperature.

(b) Damp Heat

The purpose of the test is to determine the suitability of the equipment for use under conditions of high humidity.

(c) Solar Radiation

The object of the test is to determine the suitability of the equipment for use when exposed to solar radiation.

(d) Driving Rain

The object of the test shall be to determine the suitability of equipment to withstand the effects of driving rain.

(e) Bump

The object of the test is to determine the suitability of equipment to withstand bumping in transit and to assess structural integrity.

(f) Random Vibration

The object of the test is to determine the ability of equipment to withstand random vibration whilst in service.

(g) Dust Sealing

The object of the test is to determine the ability of the equipment to prevent the ingress of dust.

660.4.7 - Detection

The method of vehicle detection at signal controlled junctions and at pedestrian crossings controlled by signals shall be provided by above ground vehicle detection to TRL 2123 or an internationally approved equivalent. The detection equipment provided shall be able to detect all types of moving vehicles through a controlled area, and all type of stationery vehicles in a defined location.

660.4.7.1 - Detector Failure Alarm

The failure of any vehicle detecting equipment specified herein shall cause a 'detector failure' alarm lamp to be lit at the signal controller. The indicator shall be coloured red. The lamp shall be easily visible from the outside of the signal controller case and be of such intensity that it may be readily seen under conditions of bright sunlight. The lamp shall be lit within a 'delay period' of a detecting equipment failure and shall be extinguished only by the operation of a manual reset switch.

660.5 - SIGNALS

660.5.1 - General

The traffic signal equipment shall comply with BS EN12368:2000, or equivalent, with the following exceptions:

(a) The post shall be manufactured from medium steel tube with an outer diameter of approximately 114 mm and finished in black and white painted stripes of 300mm width. The poles should also be supplied with pole caps, pole head terminating assemblies, including support for the signal cables and an earthling terminal. The protective paint and/or coatings shall be suitable for the climatic conditions in Sri Lanka.

(b) The lamp supplied shall be a tungsten Halogen lamp with a bayonet type fixing. The spring contract of the lamp holder shall be so designed as to maintain adequate electrical conductivity and to ensure that the lamp remains securely located under traffic vibration. The lamp supplied shall have a rated life of at least 1000 hours. The light output requirements from each signal shall comply with an international standard for a tungsten Halogen lamp signals. The tenderer shall specify the standard to which his equipment complies:

(c) Supports for overheads mounted signal shall have the pole section for a height of 3 m above ground level painted with black and white stripes of 300 mm width;

(d) Signal heads shall be supplied complete with fixing brackets and accessories;

(e) Backing boards for signal heads shall be provided, but shall not form an integral part of the signal head, such that they can be omitted if site conditions dictate.

The pedestrian signal equipment and push button unit shall comply with BS EN 12368:2000 or equivalent. Legends shall be in Sinhala, Tamil and English.

660.6 – CABLE-LESS LINKING UNIT

660.6.1 – Cable-less Linking Unit

The cable-less linking unit (CLUE) facility shall allow a method of linking adjacent traffic signals along a route in an area using timing information derived from other master clock systems. All signal controllers in a linked system are related to a common cycle time for any particular traffic plan. The unit instructs the controller to change from one traffic plan o another and during the plan when to exert specific influences, (e.g. to move from one nominated stage to another). In this way a variety of signal linking can be achieved ranging from a simple coordinate two-controller link to a fully coordinated multi-plan system.

660.6.1.2 - Plan Facilities

a) Plan Timings

The necessary timing signals for the execution of a specific plan are derived from the Group Timer Clock.

b) Offset Times

This time relates the start of the timing cycle on the individual controller to reference time. Alternatively offset times can be derived by varying the times of introduction of particular plans on linked controllers.

c) Cycle Time

One complete sequence of signalling operations.

d) Group Time

The time period for which specific group influence are exerted on the controller operation.

e) Group Influences

The function of each group and the number of groups within a cycle shall be programmable within the individual plan to exert one of the following influences upon the main controller:

(i) an immediate move to the specified stage. (This is subject to the constraints imposed by safety timings and stage-to-stage movement restrictions);
(ii) a demand dependence move. A move to a specified stage if demanded by street demands; and,

(iii) isolate (allow the controller to follow its own timings)

f) Stage Structure

The plan may also allow stages to be introduced or deleted, within the constraints of the basic stage/phase definitions.

660.6.1.3 - Timetable

Plans shall be called into operation by timetable.

(a) When a new plan is implemented by the timetable it shall always commence with the first group.

(b) A plan is a total set of timings, (Offset, Cycle Group times) for the signal.

660.7 - DOCUMENTATION

660.7.1 - Technical Handbook

The Contractor shall supply two copies of the technical handbook for each type of traffic signal controller installed as part of the Contract. The handbook shall contain a full technical description of the controller. Contents shall include, but is not confined to, the subject matter described in this section of the specification.

660.7.1.1 - Hardware

a) Brief technical description including layout and block diagram.

b) Full technical description including circuit diagrams of all modules (and exploded component diagrams where necessary to aid comprehension).

c) Maintenance procedures and fault finding guide.

d) Parts list and wiring schedules.

660.7.1.2 - Software

a) Brief description for the software including the system philosophy.

b) Overall description of the system program its routines, sub-routines and interaction between the software segments.

c) Flow charts

d) Software source code listing which shall be annotated to provide ease of understanding.

e) Site data management and storage area description.

660.7.1.3 - Controller/Operator Interface

The manual shall pay particular attention to all interfaces, both hardware and software, between the controller and operator.

A full technical and operational description shall be included of the terminal device and the names of communication between it and the controller.

660.7.2 - Site Handbook

The Contractor shall provide two copies of each individual site handbook. The site handbook shall contain:

a) component module layout of the controller, including reference numbers;

b) controller cable layouts;

c) full details and configurations of the monitoring system of conflicting green signal outputs;

d) full description of operator interfaces for the controller, and operating procedures;

e) site plan, with position of poles, signals detectors, cable runs, stage diagrams etc;

f) initial time settings for the controller,

g) first line maintenance procedures;

h) site installation details, cable core allocation, etc.

660.7.2.1 - A draft handbook shall be supplied with the site acceptance test and the final site handbooks shall be approved by the Engineer and delivered within two months following the completion of each installation. The Contractor shall distribute the site handbooks as follows:

- one copy to the Engineer

- one copy in the controller cabinet

660.7.2.2 - The Contractor shall provide a splash-proof wallet in the controller to contain the site documentation and protect it from the environment. This wallet shall be sealable and shall be attached to the inside of the controller case so that it may not be removed.

660.8 - SUPPLY OF EQUIPMENT

660.8.1 - Storage

All equipment should be held in storage by the Contractor, until required for installation.

660.8.2 - Delivery

Each controller may be subject to the tests specified in clause 4.1.3 and may not be delivered to site until the said test has been successfully completed or approval has been given by the Engineer.

The controller electronics shall be delivered to site by the Contractor immediately prior to commissioning. At no time shall the controller be left on site and switched off without form of heating in the cabinet to prevent condensation.

660.8.3 - Spares

The bidder shall specify the levels of spares he deems necessary for the maintenance of equipment supplied under this specification. The spares shall be supplied to the designated maintenance company, responsible for the maintenance of the equipment. The level of spares should not be less than two years.

660.9 - INSTALLATION

660.9.1 - Civil Engineering Works

This section of the Specification details the civil engineering works for the installation of traffic signals.

Install all signal poles defined in the specification.

Signal poles shall be installed in the footway at a minimum distance from the edge of the road pavement to comply with the requirements of clause 9.1.9.

Install the controller housing in the position defined by the engineer. Ensure that the position of the base is such that when the housing is installed, the access doors when fully opened, do not obstruct the footway or cause a danger in any way to members of the public. The housing shall not be positioned adjacent to the kerb as to tender it liable to damage by vehicles or so that the safety of persons working on the controller is endangered.

The controller housing shall be installed and secured in an upright and vertical position. Ducts are to extend approximately 100 mm into the area above the foundation and shall be secured in position. An extra duct shall be fitted above the immediate requirement and it shall be firmly sealed at both ends.

Cover all new traffic signal heads, pedestrian lanterns and push button boxes with an opaque material so that during subsequent installation and commissioning signal aspects are not visible to motorists or pedestrians. The covers shall only be removed at the direction of the Engineer.

At the time of commissioning, provide and install signs on all approaches to the signals with a suitably worded legend warning road users.

Install all cables required at the intersections as specified in the specification, and ensure that all draw wires remain in-situ after the cable installation.

Position all equipment and ensure that all cable apertures and fixing holes for signal heads and push button units are correctly aligned so as to meet the requirements of the specification.

Ensure that signal heads are mounted so that a clearance of 450 mm exists between the kerb edge or edge of the carriageway and the nearest part of the complete pole assembly.

Ensure that the height of the centre of the amber optical assembly shall not be less than 2.4 m nor more than 4.0 m above the carriageway. Ensure that signal heads are not amounted so that they present a hazard to members of the public.

Pole mounted pedestrian push button units shall be mounted so that the top of the unit is 1.5 m from ground level and positioned at 90 degrees to the kerb facing the crossing. The wait indicator lamp shall be fed by an extra low voltage supply.

Ensure that all on-street equipment supplied is correctly installed.

Unless specified otherwise by the Engineer, direct each signal aspect at a point approximately 1.5m above the centre of the half of the carriageway concerned at a distance of 50 m from the primary signal face.

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Do not allow any signal aspect to be illuminated during installation or commissioning unless it has been covered in accordance with Clause 9.1.5

660.9.2 - Electrical Engineering Works

This section of the specification details the electrical requirements for the installation of traffic signals.

660.9.2.1 - Electricity Supply

The electrical controller shall provide a 230 V ac 50 Hz 40A single-phase supply to the equipment.

The Contractor's earthing conductor shall be connected to the earth bar in the feeder control pillar.

The Contractor shall ensure that his equipment complies in all respects with the regulations and requirements of the Electricity Authority, which shall form part of this specification. (The Ceylon Electricity Board's regulations and requirements are to British Standards and Specifications.)

The Contractor shall be responsible for all wiring other than electricity services to the feeder pillar which will e provided by the Ceylon Electricity Board. It shall be the responsibility of the Contractor to inform the Engineer of the earliest date when he will be ready for the Electricity Board to make the service connections.

The Contractor shall supply the equipment to be terminated to the Electricity Board's service with phase and neutral conductors of not less than 4 mm^2 and earthing conductor of not less than 6 mm^2. The Electricity Board, or skilled person authorised by the Board, shall connect the controller conductors and earth conductor to the terminals provided by the Board.

The Electricity Board's cut-out shall incorporate a high breaking capacity fuse carrier and fuse to BS 88 OR BS 1361.The rating shall be specified by the Contractor to comply with the type requirements of Regulation 413-5 of the IEE Regulations.

660.9.2.2 - Electrical Cables

All cables hall comply with the requirements of the IEE Regulations and shall be of adequate size and rating to meet the electrical current carrying requirements and provide the necessary electrical protection for the system. Cables to signal poles shall be multi-cored 2.5mm^2 copper conductor, PVC insulated, PVC sheathed and armoured, 600-volt grade, or equivalent.

All multi-cored armoured cables, excluding feeder cables but including linking cables to all other equipment housings where specified, shall have a spare core capacity of at least 25% at the time of installation. Where this is not possible using a single cable, a second cable shall be provided which shall be correctly terminated at each end.

A separate neutral conductor shall be provided for each traffic signal head and pedestrian head, push button unit, photoelectric cell (if required) unit and regulatory signs.

All unused covers of cables at the various terminating points shall be cut to a minimum length, long enough to connect to the further terminating point of the particular unit in which the termination is housed, and so as to be of equal length. The ends of the cores shall be sealed against the ingress of moisture. The unused cores are to be laid and strapped in a suitable, unobtrusive position.

An extra low voltage supply to the push button unit shall be derived from the controller cabinet and not from within the associated head. Voltage not to exceed 50 V.

660.9.2.3 - Cable Joints

a) Cable joints are not permitted on new installations except with the written approval of the Engineer which will only be given in the most exceptional circumstances.

b) Where cable joints are unavoidable, in the opinion of the Engineer, the jointing methods and materials must be of a type approved by the Engineer and, in particular, must be of a type which allows the integrity of the protective earth conductor(s) to be maintained.

660.9.2.4 - Earthing Requirements

a) The Contractor shall provide protection against dangerous earth leakage currents by fuses or excess current circuit breakers compliant with the IEE regulations for electricity installation. The Contractor shall ensure that all installations shall be such as to allow for the operation of the protective devices upon the occurrence of a fault and that all non-current carrying metallic parts shall be connected to the earth terminal in such a manner as to ensure that a hazardous voltage cannot exist on exposed conductive metal work.

b) All cabinets, poles and other metal hardware comprised by the traffic signalling equipment shall be connected to the main terminal by a protective conductor.

c) Protective conductors shall be designed and installed so that they comply with the IEE Regulations for Electrical Installations (16th Edition, 1991) BS 7671.

d) All protective conductors shall be colour coded green/yellow stripe. Where an earth conductor is part of a multi-core cable and a green/yellow stripe colour coded core is not available, the Contractor shall ensure that the protective conductor is adequately identified as such.

e) The armouring of all the signal cables which enter the controller shall be clamped securely by means of a gland or clip. This shall then be correctly bonded to the earth bar in accordance with IEE regulations using a 6.00 mm^2 conductor.

f) Armoured cable to signal poles and other equipment mounting poles shall be terminated at the top of each pole with a gland or equivalent unit.

g) The earthing requirements at the head of each traffic signal pole shall be as follows:

   The earth terminal of the gland in Clause 9.4.4(f) above, shall be connected to the earth conductor of a minimum cross-sectional area of 6.00 mm^2 and correctly terminated with crimp connectors.

h) the protective conductors from each signal head, pedestrian head, push button unit or other equipment shall be connected together at the head of each pole and connected to the earth terminal in the controller housing using one core of the multi-core armoured cable;

i) the earth connection at the head of the pole specified in (ii) above shall be connected to the earth stud of the pole with a protective conductor terminated with crimp connectors;

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j) push button units fixed to a signal pole shall be earthed to the earth stud of the pole with a separate protective conductor terminated with crimp connectors and having a minimum cross-sectional read of 6.00 mm².

k) The main earthing terminal or bar shall comply with Regulation 542-19 of the IEE Regulations for Electrical Installation and shall be connected to the earthing point provided by the Authority with copper earthing conductor in accordance with Regulation 542-18. It shall have a minimum cross-area of 6.00 mm² and shall be green/yellow stripe coded. Where an ELK is used then the cross-sectional area of the earthing conductor shall comply with the requirements of Regulation 543.1.

Note: the earthing conductor is defined as protected conductor connecting a main earthing terminal or bar of an installation to an earth electrode or other means of earthing.

l) All electrical connections, in particular all earth connections, shall comply with Regulations 527-1 of the IEE Regulations.

m) Protective conductors shall be designed and installed so that they comply with Regulations 541-1 and 543-3 of the IEE Regulations. They shall have a cross-sectional area compliant with the requirements of Regulations 431-1. The minimum cross-Sectional area of each protective conductor shall be 2.50 mm² unless specified otherwise in this specification.

660.10 - COMMISSIONING

660.10.1 - Electrical Tests

On completion of installation, and before commissioning the controller, the following tests shall be carried out by the Contractor to the satisfaction of the Engineer and in accordance with Regulations 613-1 of the IEE Regulations:

(i) visual inspection in accordance with Regulations 612-1;

(ii) Continuity test of all protected conductors in accordance with Regulations 613-3 and Appendix 15(3);

(iii) Insulation resistance test in accordance with Regulations 613-8 inclusive. However, the insulation resistance shall not be less than 100 me ohms;

(iv) Polarity check in accordance with Regulation 613-14;

(v) Where an earth leakage circuit breaker is installed, then tests in accordance with Regulation 613-16 and Appendix 15(6) shall be complied.

The Contractor shall provide the equipment necessary to complete the above tests, and shall provide all other test equipment to demonstrate that the installation complies with the specification.

Upon the successful completion of the commissioning the controller base shall be sealed with a minimum of 5 mm of epoxy resin.

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660.11 – MAINTENANCE – Not used

660.12 - METHOD OF MEASUREMENT

The quantity to be measured for payment shall be for the complete traffic signal system for each junction as stated in the Bill of Quantities. The system shall included all equipment and materials, from and including the controller, for the provision of a fully operational traffic signal system. The contract drawings show the ducting to be provided for the system, by the highway contractor, at each junction. Should the contractor require any additional ducting he must include the cost of providing and installing this in his rates.

660.13 - BASIS OF PAYMENT

Payment for the provision of traffic signal system shall be paid for at the contract provisional sum unit rate for each junction. This shall be inclusive of all equipment and materials necessary for a fully operational system plus the cost of carriage, insurance and freight to the port of entry, Colombo, Sri Lanka, installation, commissioning, site hand books, maintenance and spares, keyboard to input parameters controllers RAM, and provision of Technical Handbooks.

660.14 - PAY ITEMS

ITEM	DESCRIPTION	UNIT
901.006	Traffic signals for A17 junction	Provisional sum
901.007	Traffic signals for A 2 junction	Provisional sum

SECTION 661 - NOT USED

SECTION 662
ELECTRICAL WORK & ROADWAY LIGHTING

662.1 - DESCRIPTION:

This item shall consist of manufacturing, furnishing and installation of an electrical system, including a lighting system in accordance with the requirements of the Drawings and of these Specifications. All details not specified or not shown on the Drawings shall conform to the details and requirements set forth in the following specifications and Standards:

662.1.1 - General

The Contractor shall select equipment, design, manufacture where necessary, test, procure, deliver, install, and commission, in accordance with the details provided in this specification, a complete electrical installation (the installation) as defined in this specification and the contract drawings, for the Southern Transport Development Project from Pinnaduwa to Matara, including the Galle Access Road and other side roads where indicated.

The Contractor shall liase with the Ceylon Electricity Board (CEB) and co-ordinate his activities where appropriate, with the CEB, in a timely manner, to enable the contract to be completed on time and to budget.

The CEB shall install any new sub stations and/or power supplies required for the system. The Contractor shall be responsible for all required work downstream of the CEB provided power supply.

All control cabinets, cables, lighting poles including holding down bolts with nuts and washers, brackets, luminaries, flood lights, lamps, service cut outs and appurtenances will be supplied, delivered, installed, tested and commissioned by the Contractor.

The Contractor shall be responsible for the civil works of the roadway lighting system (except as otherwise specified) the layout for which is shown on the drawings.

The works include also the provision and installation of ducting for service cables. The installation of ducts to the required diameter shall be according to Section 670 of these specifications.

The position, type of ducts and constructional details are shown on the drawings but final location will be determined on the basis of the approved shop drawings by the Engineer, and co-ordination, where required, with the relevant local authority.

Materials and equipment supplied shall be suitable for use under the prevailing conditions of a harsh marine environment.

662.1.2 - Definitions

"Supply" means select, design, manufacture (where necessary), procure, and deliver to site in the required location.

"Provide" means supply and install, and commission to the requirements of this specification or the relevant standards.

662.1.3 - Standards

Except where otherwise specified, the installation shall comply with the following:

Regulation for Electrical Installation (Sixteenth Edition) the Institution of Electrical Engineers, London.

Relevant British Standards and Codes of Practice, or equivalent as approved by the Engineer.

Standards and Recommendations issued by the International Electro-Technical Committee.

The general requirements of the CEB.

The requirements of AS/NZS 1158:1997

All Standards and Codes referred to shall be the latest issue at the time of invitation of bids.

662.1.4 - Check Of Equipment Supplied By Others

The Contractor shall ensure that all equipment supplied by others forming part of his installation shall be new and in accordance with the standards required. Any defect must be reported in writing within seven days of receipt of the equipment in order to allow changes to be made or replacements instructed by the Engineer.

662.1.5 - Installation Electrical Operating Conditions

The following are the general conditions under which the cable shall operate:
Supply system shall be single phase, two wire or three phase, four wire.
Electrical energy is generated as three phase alternating current at a frequency of 50 Hz ± 5%.

The working voltage on any of the systems shall be nominally 230/400 volts, ± 10%

662.1.6 - Precedence

Where there are conflicts between the requirements of this document and the general contract conditions, this document shall take precedence.

The legal statutes, acts or laws of Sri Lanka shall take precedence if there should be conflicts between these and this document.

662.2 - LIGHTING INSTALLATION

662.2.1 - Road Lighting Installation

662.2.1.1 - General

The Contractor shall provide lighting standards (hereafter referred to as poles) complete with outreach arm(s), luminaries(s) and lamp(s), service cut-out, wiring, and a base structure of suitable design. Equipment provided shall be as specified in Division 700 of this document, and as shown in the contract drawings.

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All poles installed as a part of this contract, with a separate base, shall be installed with the use of a precision made steel template to ensure correct horizontal and vertical base alignment, and/or holding down bolt alignment as specified.

662.2.1.2 - Road Lighting Pole Types

662.2.1.2.1 - Poles Behind Guard Rails

Where poles are installed in expressway equipped with guardrails, the poles shall be located behind the guardrail. The pole shall be directly "planted" in the ground, i.e. without a frangible base.

The minimum distance from the front of the guardrail to the front (side of the pole closest to the road centreline) of the pole shall be 1m and not more than 1.25m

662.2.1.2.2 - Poles Where There Are No Guard Rails

Where there is no guardrail installed at the pole position, the pole shall be of the frangible base type, designed to shear off with the impact of a vehicle. Particular care must be taken with the base installation to ensure correct orientation and height from finished ground level.

The minimum distance from the edge of the shoulder to the front of the pole shall be 1.0m and not more than 1.25m

Where poles are installed on medians the pole shall be located in the centre of the median.

662.2.1.2.3 - Poles On Bridges Or Other Structures

Poles mounted on bridges or other structures shall be mounted on the edge of the structure. In this case the Contractor shall co-ordinate with the bridge Contractor to ensure that a suitable mounting position and method is found. Structural calculations proving the adequacy of this mounting position and method shall be submitted to the Engineer before the bridge structure is manufactured.

A flange base mounting method shall be utilised to secure the pole to the structure.

The pole shall be mounted behind the guardrail or barrier, and out of any pedestrian walkways. Pole outreach shall be increased where required to maintain a luminaries position of between 1 – 1.5m into the road from the edge of the shoulder seal.

662.2.1.2.4 - Poles In Locations Of Rocky Ground

Where rocky ground prevents the economic installation of a ground planted lighting column or stub base, then a suitably designed reinforced concrete base similar to those shown in the contract drawings shall be used. Note that the Contractor shall carry out structural and civil design for the base, and a registered structural engineer shall verify this as fit for purpose. Copies of the design and the verification shall be submitted to the Engineer prior to the construction of any foundations.

The pole types shall be either flange mounted if behind a guardrail, or frangible base. Distances from shoulder/guardrail shall be as specified in above.

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662.2.2 - Underpass Lighting

The Contractor shall provide underpass lanterns complete with mounting bracket, and lamp(s), of suitable design. Equipment provided shall be as specified in Division 700 of this document, and as shown in the contract drawings.
Where the mounting height of the underpass lantern is less than 4.5m, a fluorescent lantern shall be utilised.

Where the mounting height of the underpass lantern is greater than 4.5m, a high-pressure sodium underpass lantern shall be utilised.

662.3 - ELECTRICAL INSTALLATION

662.3.1 - General

The Contractor shall provide electrical cabling, ducting, cable supports, conduits, cable protection slabs and warning tape, and feeder control pillars as specified in Division 700 of this document, and as shown in the contract drawings.

The Contractor shall liase with the traffic signalling sub contractors to provide suitable power supply for traffic lighting system where required by these Contractors.

In calculating the rating of electrical cables, switchgear and all items of equipment, the necessary de-rating factors shall be determined and applied to ensure that the equipment will operate satisfactorily and meet its design criteria.

The electrical supplies for the expressway electrical system shall be made available at appropriate locations by CEB, at the Contractor's cost.

Adequate safety measures shall be taken while working on electrical services. These shall include but not be limited to:

- Locking off the main supply circuit breaker(s)
- Installing identification tags on switchgear to prevent the energising of main supply or other circuits by others.
- Provision of a visible, solid connection to earth on cabling systems.

The contractor shall supply suitable as built information detailing cable route and depth from readily identifiable and permanent structures and survey points.

662.3.2 - Main Power Supply

The Contractor shall contact the supply authority at an early stage of the contract to make all the necessary arrangements for the relocation, removal and/or provision of power cables and supplies for this project.

The supply for the road lights, and traffic lights will be from new feeder pillars located as shown on the Drawings. Power supply to the feeder pillars shall be from new or existing CEB power network.

The Contractor shall include a provisional sum for the installation of power supplies by the local power authority to each feeder pillar.

The supply will be three phase and neutral 230/400V, 50 Hz.

The Contractor will not be required to include in his bid for any power usage costs in respect of public street lighting.

The designed feeder pillars are scheduled in Drawings. Any additional pillars required shall be as directed by the Engineer.

662.3.3 - Feeder Control Pillars

Feeder control pillars shall be provided by the Contractor to form the interface between CEB network and the expressway electrical network.

All damage to pillars prior to livening shall be made good at the contractors cost, to manufacturers recommendations, and to the satisfaction of the Engineer.

The Contractor shall liase with the local power authority to have suitably sized metering for the installation installed in each feeder control pillar.

Each complete pillar shall be provided with a plastic laminated copy of the CEB certificate of compliance for the installation, and a plastic laminated single line "As-Built" wiring diagram.

662.3.4 - Cable Installation

662.3.4.1 - General

The arrangements of cables and all methods of installation shall be subject to approval by the Engineer.

The Engineer shall inspect all ducting and cables laid in trenches before backfilling and compaction takes place.

Trenches backfilled and compacted without inspection may not be accepted. In these circumstances the Engineer may request the Contractor to expose the ducts or cabling for inspection at the Contractor's cost.

Cables shall be installed in one length from terminal point to terminal point.

The radius of each bend or change in direction of the route of any cable shall not be less than the minimum stated in the IEE regulations, the relevant BS specifications, or the cable manufacturer's recommendations, whichever is the greater.

Multi-core cables carrying alternating current for single or three phase working shall be laid strictly in accordance with the IEE Regulations.

All cabling shall be installed with suitable protection/covering such that it shall not be accessible to, or visible by the general public.

Trenching and backfilling shall be carried out in accordance with Division 200 of these specifications.

The Contractor shall install along with the power cable a single core copper earthing cable of conductor cross sectional area; not less than 16mm^2 for power cables up to and including 35mm2, not less than 25mm^2 for power cables up to and including 50mm2, not less than 35mm^2 for power cables up to and including 70mm2, respectively.

The earthing cable shall run all the way from the feeder pillar to the last column or fitting on each circuit. Looping of the earthing cable shall be made inside each column.

662.3.4.2 - Cables Laid Directly In The Ground

The Contractor shall excavate trenches along approved cable routes to the minimum depths shown in the drawings.

All loose rock, stones and other sharp materials shall be removed from the trench, prior to cable installation.

The thermal resistivity of backfill material within a radius of 75mm of the external cable sheath should not be greater than 1.2°C/W/m^2. If the Contractor is unable to obtain suitable backfill material, then the appropriate de-rating factor for the type of backfill material shall be obtained and applied to the cable. Any increase in cable size and resulting modifications to equipment to accommodate a larger cable to maintain the specified ratings shall be at the Contractor's cost.

The Contractor shall supply and install cable protection slabs and warning tapes along the trench route as specified in the drawings.

The Contractor shall lay, level and compact clean (sieved, unwashed) fine aggregate in the bottom of the trench to a minimum depth of 75mm before laying the cables. After laying the cables, he shall then cover them with a further 75mm of clean fine aggregate (measured from the top of the cable), level and compact. The backfilling of the trench, including the laying of cable protection slabs and PVC warning tape, shall then be completed in accordance with section 670.

The Contractor shall leave for future use in cable trench two loops, each of 1m diameter (or greater, depending upon the bending radius of the cable) immediately adjacent to each pole location.

662.3.4.3 - Cables Laid In Ducts

Where cables cross under roads and paved areas they shall be drawn into ducts provided complete with temporary end caps of suitable diameter to prevent the ingress of soil into the ducts.

The removal of temporary caps, rodding and cleaning of the ducts shall be carried out by the Contractor.

The ducts shall be sealed with suitable sealing material after the cables have been drawn through.

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662.3.4.4 - Cables Laid In Concrete Trenches

Cables in concrete trenches shall be installed in a support system comprising moulded reinforced nylon hooks and clamps attached into a heavy gauge galvanised steel channel, fixed to the walls by stainless steel grade AISI 316 cast in rag bolts or by stainless steel grade AISI 316 threaded studs grouted into percussion drilled holes with polyester resin anchor grout.

662.3.4.5 - Cables Fixed To Steel Work Or Concrete Walls

Cables shall be held in moulded reinforced nylon hooks and clamps, which shall be spaced so as to avoid sagging of cables. In no instance shall the spacing of the cleats exceed 750mm.

All cleats and runs of cables shall be arranged in the nearest and least obtrusive manner.

All steelwork required for supporting cable cleats shall be galvanised and painted as specified for Miscellaneous Metal Work.

662.3.4.6 - Cables In Saddles

Where MICC/PVC cables are required to be fixed in saddles, PVC sheathed copper fixing saddles shall be used. Saddles shall be fixed with stainless steel grade AISI 316. The PVC saddle sheath shall be manufactured such that it would not allow galvanic action between the saddle and it's fixing.

Runs shall be neat and free from kinks, care being taken in the routing to avoid risk of damage to or interference with other equipment.

662.3.4.7 - Cable Support Spacing

Spacing of cable supports shall be as laid down for the relevant size and type of the cable in the IEE Regulations and the relevant BS specification. In no case shall the spacing between cable supports exceed 0.75m.

662.3.5 - Termination Of Cables

The contractor shall terminate cables, using the appropriate terminations, in lighting poles, underpass lighting fixtures, and feeder control pillars.

All jointing/termination materials shall conform to the relevant requirements of the British Standard / IEC Standard and the Contractor shall state the types of compounds he proposes to use.

All glands shall be fitted with moulded PVC shrouds to completely cover the glands.

All cables shall be colour coded in accordance with the IEE Regulations. In the final sub-circuits, cores shall be identified by the colours red, yellow or blue as appropriate. Tapes and sleeves will not be permitted.

The Contractor shall allow for at least 300mm of the cable to be cut off immediately before the termination is made. This requirement shall apply to all cable ends.

All cable ends are to be sealed against the ingress of water, deleterious matter etc during laying.

662.3.6 - Earthing

662.3.6.1 - Earthing System

The Contractor shall install an earthing system to the last column of every circuit including all feeder pillars as shown on the Drawings. The earth installation shall in general be in accordance with the British Code of Practice CP1013, and in accordance with the requirements of the CEB.

Where the requirements of the CEB differ from those of the IEE Regulations, the former shall prevail.

Electrodes shall consist of 16mm minimum diameter hard drawn copper rod driven vertically to a minimum depth of 3.0m. Rods shall be complete with hardened steel tip and driving cap. Rods shall be capable of being extended in lengths, as necessary, by the provision of permanent screw mechanisms.

A PVC coated earth continuity conductor of 75mm^2 cross section copper cable shall be inserted between the earthing stud in the pillar or lighting column and the earth electrode. The connection of the copper tape cable to the earth electrode shall be made by means of a suitable conductor clamp. After final acceptance tests, the connection shall be wrapped in petrolatum impregnated tape.

The earthing conductors shall have a minimum current carrying capacity in accordance with CP1013.

Earth electrode distance should not exceed 5m out of centre of foundation of last column, and at an agreed location to the feeder pillar.

662.3.6.2 - Earth Electrode Terminations

Every connection of an earthing lead to an earth electrode shall be made in a pit measuring approximately 300x300x300mm. The connection shall be soundly made by use of hard soldered joints or clamps. All earth electrodes and earthing leads shall be of copper.

The Contractor shall ensure that throughout the installation all metallic parts of all equipment, other than current carrying conductors, are bonded to form a continuous path by way of connecting the armouring (or earth conductors) of the local authority's cables at feeder pillars, sub-stations etc.

After installation, the pit shall be filled with fine aggregate and a removable cover placed on the pit. The cover shall have the words "EARTH ELECTRODE" embossed on the top.

662.3.7 - Cable And Earth Testing

662.3.7.1 - Prior To Pole Installation/Cable Termination

After cable laying and installation of earthing systems but prior to erection of the lighting column the Contractor will perform the following tests:

662.3.7.1.1 - Continuity Of Conductors

A test shall be made to verify the continuity of each conductor, including the earth continuity conductor of each circuit.

662.3.7.1.2 - Insulation Resistance Test

This test will be applied to each section of cables and will comprise of:

Phase to phase insulation resistance.

Phase to neutral insulation resistance.

Phase to earth insulation resistance.

662.3.7.1.3 - Neutral To Earth Insulation Resistance

The resultant insulation resistance for any of the above measurements shall not be less than 8 – 10MΩ/m cable length and measured with 1000V.

For these tests, a voltage not less than 2.5 times the normal voltage of the supply shall be applied for the measurement of insulation resistance.

662.3.7.2 - After Pole Installation/Cable Termination

After cable laying, pole and feeder pillar installation, and cable termination, the following tests shall be carried out.

Continuity of Conductors – refer 662.3.7.1.1

Insulation Resistance Test – refer 662.3.7.1.2

Earth Resistance Test - To be performed with specific calibrated earth resistance meter. The resistance of any point in the earth continuity system of the installation to the main earth electrode shall not exceed 1Ω, and the resistance to earth at this termination shall not exceed 0.5Ω.

Inspection certificates, completed by the Contractor shall be generally in accordance with IEE regulations.

Polarity Test.

Brand type and calibration report of test equipment used for testing the electrical installation by the Contractor shall be subject to the approval of the Engineer.

These calibration reports are to be submitted in the maintenance manual along with all test results.

662.4 - INSTALLATION OF DUCTING

662.4.1 - General

The duct diameter shall be minimum 3 times the diameter of the cable placed inside the duct, but in all cases minimum 100mm diameter.

Ducts shall be installed at the depth required for correct cable cover, or as shown on the drawings. All ducts shall be installed with a minimum cover of 600mm.

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Ducts shall be installed with glued "airtight" joints, draw wire, and end caps to prevent the ingress of foreign material inside the duct before use.

Ducts shall be installed according to Section 670 of these specifications.

The position, type of ducts and constructional details may be shown on the drawings but final location will be determined on the basis of the approved shop drawings by the Engineer, and co-ordination, where required, with the relevant local authority.

The end position of all ducts shall be physically marked on site with the use of concrete slabs or markers with the words "DUCT BANK END" engraved in the slab. Minimum slab/marker size is 300mm x 300mm.

662.4.2 - Ducting For Local Authority/Utility Use

The contractor shall liase with the relevant local authority to determine their requirements for duct numbers and locations. The contractor shall provide ducts for the local authority's existing cabling systems where required, in order to assist the local authority in timely relocation of their lines to enable the project to proceed.

662.4.3 - Ducting For Electrical Installation

The contractor shall install ducting for cabling systems where the cables are required to cross under sealed portions of the Road. In selecting the number of ducts required for each crossing, the contractor shall use the ratio of one cable per duct.

662.5 - AS BUILT / MAINTENANCE MANUALS

The contractor shall submit, maintenance manuals in A3/A4 format. These manuals shall be bound securely and covered with stiff hardback covers. The manuals shall be split into volumes as necessary, and titled on the front cover and the spine of each volume as follows:

Volume 1 Electrical & Lighting
Southern Transport Development Project – ADB Funded Section
Pinnaduwa To Matara

- As Built Drawings
- Single Line Drawings

Volume 2 Electrical & Lighting
Southern Transport Development Project – ADB Funded Section
Pinnaduwa To Matara

- Equipment and Manufacturer Details and Guarantees/Warranties
- Test Certificates
- Compliance Certificates
- Maintenance Recommendations

The content and format of these manuals shall be to the requirements of the Engineer, and are required to be approved by the Engineer prior to the award of practical completion.

662.6 ELECTRICAL SURGE PROTECTION

All feeder pillars should incorporate a lightning protection system as per BS 6651,1992, and should comply with category C irrespective of their physical locations.

Category C, or Primary, protection systems have a device which incorporates a gas filled discharge tube or metal; box varistor. For three phase supply systems there should be a diverter across each phase and earth as well as a across neutral and earth.

662.7 - METHOD OF MEASUREMENT

Cables shall be measured by the linear metre, horizontally along the centreline between connection points, the Contractor is to allow in his rates for all upturns, loops, connection lengths and waste.

UPVC ducts through or adjacent to, the roadway embankments or cuttings shall be measured in linear metres, with excavation and backfilling.

Above ground conduit will not be measured separately, but be considered as incidental to cable laying.

Light poles will be measured by number, as will be underpass lights and feeder pillars.

662.8 - BASIS OF PAYMENT

Payment for cabling and ducts shall include for excavation and backfilling, measurement is for net horizontal lengths, therefore the Contractor will be deemed to have included in his rates for all waste, upturns, loops, bends etc. and other necessary works. Payment for ducts shall also include for draw-pits/utility chambers and draw wires.

Any conduit will not be paid for separately but considered included for in above ground cabling works.

Unit rates for light poles are to cover all works necessary for creating a full working unit, including all connections, fixtures, luminaries, internal cabling and pole foundation works.

Underpass lights unit rates are to include for full supply and installation of light unit.

Feeder pillar unit rates are to include for full supply and installation of unit.

662.9 - PAY ITEMS:

ITEM	DESCRIPTION	UNIT
662.001	Cable 4c x 25mm^2 swa/pvc/pvc/cu	Metre
662.002	Cable 4c x 16mm^2 swa/pvc/pvc/cu	Metre
662.003	Cable 4c x 10mm^2 swa/pvc/pvc/cu	Metre
662.004	Cable 3c x 10 mm2 pvc/pvc/cu	Metre
662.005	Cable 3c x 6 mm2 pvc/pvc/cu	Metre
662.006	Single arm 12.00 m high steel pole complete with type II or III **semi cut off** distribution and 250W HP sodium luminary	Number
662.007	Single arm 12.00 m high steel pole complete with type II or III **cut off** distribution and 250W HP sodium luminary	Number
662.008	Double arm 12.00 m high steel pole complete with type II or III **semi cut off** distribution and 250W HP sodium luminary	Number
662.009	Double arm 12.00 m high steel pole complete with type II or III **cut off** distribution and 250W HP sodium luminary	Number
662.01	Feeder pillar	Number
662.011	Feeder pillar Underpasses/Bridges	Number
662.012	Underpass lighting with 70 W HP sodium lamp	Number
662.013	Underpass lighting with 36 W twin florescent lamp	Number
662.014	u-PVC duct with concrete encased 2x1 10mm dia. uPVC	Number
662.015	u-PVC duct with concrete encased 4x1 10mm dia. uPVC	Number
662.016	Manholes for power cables	Number
662.017	Over-ground Junction Boxes (OGJBs)	Number

SECTION 663
PAVEMENT MARKINGS

663.1 - DESCRIPTION

This work shall consist of the provision and installation of reflecting road studs and application of continuous or intermittent lines, stop lines, arrows, letters or figures as shown on the Drawings, Sri Lanka Manual on Traffic Control Devices, Part 1 or as directed by the Engineer. The work shall include the supply of all labour, tools and equipment, materials, traffic signs as necessary for the safe and efficient completion of the entire work.

663.2 - MATERIALS

Materials for permanent road markings shall be thermoplastic material as described in 663.2.1 or road marking paint as described in 663.2.2. Kerb markings shall be painted with road marking paint as described in 663.2.2. Road markings shall be white or yellow as shown on the drawings. Reflecting road studs are described in 663.2.3.

663.2.1 - Hot Applied Thermoplastic Materials

The thermoplastic material shall be factory mixed, from an approved manufacturer and shall be of a tropical grade suitable for application, by the means proposed, to the specified road surfaces, and must demonstrate skid resistance appropriate to local traffic conditions. The material shall comply with BS3262: 1987 'Specification for Hot-applied Thermoplastic Road Marking Materials'.

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

Ballotini (glass beads) shall be incorporated in the mixture during the manufacture of the thermoplastic material. The quantity of ballotini included shall be between 13% and 22% by weight of the total mix and shall be counted as part of the aggregate. The Ballotini shall comply with BS6088: 1981 (1993) 'Specification for Solid Glass Beads for use with Road Markings'.

In addition to the Ballotini included in the mix, an additional quantity of glass beads shall be sprayed on to the hot thermoplastic marking at the time of application. The rate of application shall be about 0.5kg per sq.m.

663.2.2 - Road Marking Paint

All paints shall be road marking paint conforming to BS6044: 1987 'Specification for Pavement Marking Paints' and made by an approved manufacturer and suitable for application, by the means proposed, to the specified road surfaces.

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

Composition (analysis by weight)

Application (brush or spray)

Type and maximum amount of reducer (thinner)

Drying time (wheel dry)

Setting time (to recoat)

Recommended coverage (litres per linear kilometre of 100 mm stripe)

Heat resistance i.e. maximum road temperature

Details of any primer, undercoat or tack coat required.

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

If required Ballotini (glass beads) may be applied to the surface of the paint immediately application is complete. Application of the beads shall be at least 300 grams / square metre or as otherwise directed by the Engineer. The Ballotini shall comply with BS 6088 : 1981 (1993) 'Specification for Solid Glass Beads for use with Road Markings'.

663.2.2 - Reflecting Road Studs

Reflecting road studs shall conform to BS 873 : Part 4: 1987 'Road Traffic Signs and Internally Illuminated Bollards – Specification for Road Studs'. Road studs shall show red or white and be uni-directional, bi-directional or omni-directional, as shown on the Drawings or as otherwise directed by the Engineer. They shall incorporate one or more corner cube retro-reflective lenses, and the area of lens facing each direction of traffic shall be at least 300 square millimetres. The studs shall be capable of withstanding impacts and no contact shall be possible between the lenses and the vehicle tyres. The studs shall not project more than 20 mm above the level of the surrounding road surface and the lowest part of the lenses shall be more than 5 mm above the surrounding road surface. The studs may be either bonded to, or anchored within, the road surface. The design shall be such as to ensure ample key to the road pavement with adequate load distribution and such that it shall not be possible for heavy equipment such as road rollers and tracked vehicles travelling in the direction of the road axis to meet with any sharp edges whereby the removal of the stud might be facilitated.

CONSTRUCTION METHODS

663.3.1 - Thermoplastic Materials

a) Preparation of Road Surface

The material shall be applied only on a surface, which is clean and dry. It shall not be laid over loose detritus, mud or similar extraneous matter, or over an old paint marking, or over an old thermoplastic marking which is faulty. New surfaces must be allowed to weather and compact for at least 72 hours before applying the marking. In the case of smooth polished surfaces, e.g. smooth concrete, old asphalt surfacing with smooth polished surface stones, and/or where the method of application requires or the Engineer directs, a tack coat shall be applied to the surface prior to the application. The tack coat shall be as recommended by the manufacturer of the thermoplastic material and to the approval of the Engineer. Faulty thermoplastic markings shall be removed if required by the Engineer.

b) Preparation of Thermoplastic Material

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

c) Laying of Thermoplastic Material

Markings may be applied by hand-screeding, hand propelled machine or by self propelled machine as approved or directed by the Engineer. After transfer to the laying apparatus the material shall be maintained within the temperature range specified by the manufacturer and stirred to maintain the right consistency for laying.

For screeded applications, material shall be laid to a thickness of not less than 3 mm or more than 6 mm, unless specifically authorized by the Engineer. In the case of sprayed application, the material shall be laid to a thickness of not less than 1.5 mm unless specifically authorized by the Engineer. In all cases, the surface produced shall be uniform, appreciably free from bubbles and streaks.

The Contractor shall not proceed with the marking work until the Engineer has approved the equipment, method of application, and rate of application, as established by a test section.

The work shall be carried out very carefully to a regular alignment in accordance with the Drawings. Straight edges and templates shall be used if required by the Engineer.

Where applicable the Ballotini (glass beads) shall be applied to the surface of the thermoplastic immediately application is complete and shall be applied in a controlled manner by use of a spreading device which will permit an even spread from a fixed height of between 300mm and 400mm or otherwise as the Manufacturer may recommend. (A wheel mounted, variable width, funnel applicator may be suitable). The loss of glass beads after 3 weeks traffic shall not exceed 10 percent of the total applied.

d) Re-use of Thermoplastic Material

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

663.3.2 - Road Marking Paint

a) Preparation of Road Surface

The paint shall be applied only on a surface, which is clean and dry. It shall not be laid over loose detritus, mud or similar extraneous matter or over a thermoplastic marking or over an old paint marking which is faulty or incompatible with the paint being applied. New surfaces must be allowed to weather and compact for at least 72 hours before applying the marking. If a primer or undercoat is necessary to ensure proper adhesion of the marking paint to the road surface without bleeding or

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discolouration, the primer or undercoat shall be fully compatible with the marking paint and the road surface, and shall be applied only if, and at the rate of application approved by the Engineer.

b) Preparation of Paint

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

c) Laying of Paint

Markings shall be applied by brush, spray, hand-propelled or self-propelled machine according to the marking configuration and the type of paint approved for use or as directed by the Engineer. The rate of application of paint for each coat shall be that recommended by the manufacturer and shall produce a minimum total cover rate of un-thinned paint of 0.5 litre per square metre, unless otherwise directed by the Engineer.

Where a spray machine is to be used the Contractor shall not proceed with the marking work until the Engineer has approved the equipment, method of application, and rate of application, as established by a test section.

When more than one coat is used, the succeeding coat shall only be applied after the previous coat has fully set.

The work shall be carried out very carefully to a regular alignment in accordance with the Drawings. Straight edges and templates shall be used if required by the Engineer.

Ballotini (glass beads) is to be applied to the surface of the paint immediately application is complete and shall be applied in a controlled manner by use of a spreading device which will permit an even spread from a fixed height of between 300 - 400mm or otherwise as the Manufacturer may recommend. (A wheel mounted, variable width, funnel applicator may be suitable). The loss of glass beads after 3 weeks traffic shall not exceed 10 percent of the total applied.

d) Protection of Paint Markings

All markings shall be protected from traffic until they have dried sufficiently.

663.3.3 - Reflecting Road Studs

Road studs shall not be installed over road markings or joints in the road surface. The road surface shall be cleaned, and dust, oil, grease and other contaminants removed. New surfaces shall be allowed to compact and weather for at least 72 hours prior to the installation of the studs. Acceptable methods of fixing include: bonding with an adhesive; anchoring with a road nail; and setting the stud into a drilled cavity in the pavement. However, the method of fixing, including any adhesive or grout used, must be suitable for the specified road surface and the tropical climate. The studs shall be fixed in accordance with the manufacturer's instructions. Studs, which become loose or free during the defects liability period, will be considered a defect.

663.3.4 - Tolerances

All marking and road studs shall be subject to the following tolerances where applicable:

Longitudinal lines such as centre lines, edge lines and other lines of a continuous nature shall not vary from the design longitudinal dimensions by more than 10%. Transverse dimensions (line width) shall have a tolerance of 0% + 10%.

Longitudinal lines such as centre lines, edge lines, other lines of a continuous nature and road studs shall not vary from the designed alignment by more than 300mm on a curve or 150mm on a straight section.

Transverse and other incidental road markings shall not vary from the specified dimensions by more than ± 5% of the overall dimension. Alignments shall not vary by more than 20mm from the designed alignment except in the case of centre line chainage location, which shall not vary by more than 0.5 metres.

663.3.5 - Defective Materials of Workmanship

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

663.3.6 - Protection of Traffic

The Contractor shall protect pedestrian, vehicular and other traffic adjacent to the working area against damage or disfigurement by construction equipment, tools and materials or by splatters, splashes and smirches of paint or other construction materials and shall during the course of the work provide and maintain adequate signs and signals for the warning and guidance of traffic.

663.4 - METHOD OF MEASUREMENT

Markings shall be measured for payment by the area in square metres completed and accepted in place. Where the width or length of laid marking proves to be greater than that specified and is accepted by the Engineer, the specified width or length shall be used when calculating areas for payment. Where the width or length of laid marking proves to be less than that specified and is accepted by the Engineer, the actual width or length of laid marking shall be used when calculating areas for payment.

Temporary markings will not be measured, they will be considered incidental to the lump sum for maintenance of traffic.

Reflecting road studs shall be measured by the approved number of studs installed.

663.5 - BASIS OF PAYMENT

The work measured as provided above should be paid for at the Contract unit prices for each of the items listed in the Bill of Quantities.

The payment shall be full compensation for providing and applying the materials including all labour, equipment, tools and incidentals necessary to complete the work.

663.6 PAY ITEMS:

ITEM	DESCRIPTION	UNIT
663.001	Road marking, thermoplastic	Square metres
663.002	Road marking, road marking paint	Square metres
663.003	Reflecting road studs (provisional)	Number
663.004	Rumble strip clusters	Metres
663.005	Raised median rumble strips	Square metres

663 A CENTRE MEDIANS AND ROUNDABOUTS

663A.1 Description

The work shall consist of the construction of centre medians as shown on the Drawings and as directed by the Engineer or in accordance with the Specifications.

663A.2 Materials

All materials used for various items of work involved in the construction of centre medians such as, kerbs etc. shall be in accordance with the relevant sections of the Specifications.

663A.3 Construction Requirements

The various items of work involved in the construction of centre medians shall be in accordance with the relevant sections of the Specification.

663A.4 Measurement and Payment

The Construction of centre median shall be measured by liner meters. Payment shall be full compensation for all component included in the centre median.

663A.5 PAY ITEMS

ITEM	DESCRIPTION	UNIT
663 A.001	Raised Centre Median	Meters

SECTION 664
TRAFFIC SAFETY DEVICES

664.1 - MAINTENANCE AND PROTECTION OF TRAFFIC

664.1.1 - General

The Contractor shall at all times maintain the traffic flow along existing roads, rivers and canals and take all necessary measures for the safety of traffic, pedestrians and workers. The Contractor shall provide, erect, operate and maintain signs, markings, lights, barricades and traffic control equipment in accordance with the Sri Lanka Manual on Traffic Control Devices Part 1 , unless otherwise directed by the Engineer. The Contractor shall provide and maintain all detours, temporary roads, temporary bridges, necessary barricades, warning lights and signs as well as other equipment at all hours during the day or night.

The Engineer's approval of plan and section drawings of proposed detours, temporary roads and temporary bridges shall be obtained by the Contractor before any work is commenced. Where the work site takes up part of the road only, and the full width of the road can be restored for night time traffic, the Engineer may give permission for control of the traffic through the works area by use of flagmen or electronically controlled mobile traffic lights, without the need for construction of bypass roads, but the Engineer's approval will only be given if, and while, the Contractor demonstrates that sufficient resources are applied and maintained for this purpose.

Where construction interferes with the existing roads, track and footpaths, other than as noted above, provision shall be made to a similar standard that existed prior to the works for the free movement of traffic and pedestrians.

Notwithstanding the above any diversion of the National and Provincial Highways shall comply to at least the minimum standard stated as following:

Minimum carriageway width of 7.3 metres.
Minimum horizontal radius of 150 metres.
Maximum gradient of 1 in 33.

The construction shall be sufficient for the smooth uninterrupted passage of all traffic and have a bituminous surface.

Notwithstanding the above any diversion of Local Roads shall comply to at least the minimum standard stated as following:

Minimum carriageway width of 5.50 metres.
Minimum horizontal radius of 100 metres.
Maximum gradient of 1 in 33.
All weather surfaces.

The Contractor shall supply all temporary signs, lights and other equipment, to the approval of the Engineer, to ensure smooth and safe flows of traffic.

The Contractor shall in due time and at least seven days before any diversion, interruption or impediment to traffic takes place, submit a detailed stage programme for the Engineer's approval.

The programme shall show all arrangements necessary to ensure a smooth traffic flow. Upon completion of the Works, all temporary roads, temporary bridges, barricades, signs and other equipment shall be completely removed, unless otherwise approved in writing by the Engineer.

From the date of Commencement of the Contract to the date of the Taking Over Certificate the Contractor shall also be responsible for maintenance of, and repair of damage, to all existing features, constructions, structures, pavements etc. which come within the limits of the site irrespective of the cause of the damage, unless that cause is determined to be an accepted risk and the repairs are determined to be a compensation event.

If in the opinion of the Engineer the Contractor has failed to properly repair or maintain existing or temporary construction, or provide sufficient or appropriate warning signs, lights, barricades etc. he shall instruct the Contractor, in writing, to provide such signs as he considers appropriate for protection of traffic, pedestrians, employees and the works. If the Contractor fails to respond within the time given by the Engineer, the Engineer may suspend works which interfere with traffic until such time as the Contractor provides sufficient signs etc. as the Engineer has directed, or the Engineer may arrange to provide the required signs etc. at cost to the Contractor, these costs being deducted from monies due to the Contractor under the Contract. These costs will include any costs for missing or stolen items not returned to the Engineer at the completion of works or when replaced by the Contractor.

664.2 - MATERIAL

As per appropriate sub-sections of Division 700.

664.3 - MEASUREMENT AND PAYMENT

The works under this sub-section will not be measured and paid for separately but considered incidental to the works as a whole, and as such already included for in unit rates for all pay items included in the Bill of Quantities and Contract Sum.

SECTIONS 665 - 690 Not Used

SECTION 691
EMERGENCY TELEPHONE SYSTEM

691.1 - GENERAL

691.1.1 - Scope

This section describes the extent and location of the emergency telephone system works.

DEFINITIONS

Motorway Emergency Phone (MEP) – refers to the new emergency telephones required for the Southern Transport Development Project, STDP.

Master MEP – This is an MEP that is fully self contained, having its own aerial, radio equipment, power supply [mains or solar], charger, batteries. Generally these will be fixed to 12m poles with pole top mounted aerial, and in case of solar, pole top mounted solar panel.

Slave MEP – This MEP is across the expressway from its master MEP and acts as an extension phone from it. It provides the same user interface and user functionality as the Master MEP. It contains no radio equipment, batteries or charger, and has no separate aerial. Its power, communication signals, and control signals are cabled to it from the Master MEP. When calls are made they are affected via the Master MEP radio. Slave MEP is normally mounted a 12m pole same as the Master MEP.

OPTIONS

A provisional sum is included in the Contract for the provision of an emergency telephone system. Options are under consideration for either a microwave based, or cell phone network based system.

The contractor shall propose a system to the Engineer that complies with the functional specification outlined in these documents.

This is a performance based functional specification, in that it leaves much of the technical data to be provided by the Contractor. This specification considers different methodologies or architectures, and provides for technical details to be determined by the specialist radio & communication system designer to achieve the required functionality.

The tenderer shall submit a separate fully completed price schedule for each proposal, together with its separate methodological statement.

691.1.2 - Scope Of Works

The Contract work should include the detail design, equipment selection, manufacture, testing, procurement, delivery, installation and commissioning, in accordance with the details provided in this specification.

In summary, the contractor shall:

a] demonstrate that his design has considered and can achieve the functional requirements.

b] ensure that all costs and rates covering the required services have been included.

c] implement work practices, which create a safe and trouble free environment.

691.1.3 - Key Requirements

The Contract Work shall include the following key requirements:

Obtain all permits, pay all charges and liase with local Authorities. Comply with all relevant regulations and standards.

Provide suitable metal poles, and pole mounted MEP's and Slave MEP's along the expressway including the interchanges, positioned nominally as per the drawing plan, and within constraints specified.

Liase with electrical contractor to provide power supply to the Master MEP box, either from nearby lighting pole or CEB network [where available]. Where this is unavailable the contractor shall provide pole top mounted solar panel [otherwise]. All master MEP's shall be equipped with batteries and charger to suit duty, expected life, guarantee, and as specified.

Provide pole top mounted aerials, selected and aligned, to suit selected radio transport option and applicable frequency.

Provide a radio transport service to the breakdown maintenance Authority. This may be by a combination of radio and landlines, or by the use of the cell phone/landline combination, into the Expressway PABX.

Provide and install all equipment, components software, systems and services to deliver to Expressway Authority, a fully tested, commissioned and working system having all the specified features and functions.

Provide As-build drawings, system documentation and Maintenance Manuals.

Provide lightning and power surge protection as per the manufacturer's requirements.

691.2 - SPECIFIED TECHNICAL OPTIONS

The contractor is allowed to price both options, note that the lowest cost option shall not necessarily be accepted.

The contractor shall liase with the Employer to provide a suitable interface with the telephone and computer system operated by the Employer without sacrificing important functionality.

Particular attention should be given as to how calls from the MEP's will enter the Employer's call centre, whether they will go directly to Employer's PC, whether the Employer's PABX will be used, and what connection and interfaces will be needed between the PABX and the Employer's PC to achieve full integration.

The proposed software shall be fully described.

It will be important for the tenderer to demonstrate with this service that MEP calls can be given priority over other calls, with no risk of MEP calls being blocked – as by temporary over load, even in times of exceptional conditions such as disaster, national emergency, extreme weather, or major motorway accidents.

There may be other ways of doing what has been described here, and these descriptions should not be construed as limiting the contractor's ability to provide better solutions than those described.

691.2.1 - Option One

Here a microwave-based system shall be used. The network should be capable of receiving and transmitting calls from and to the MEP's. In this regard it acts functionally like a base repeater station. A critical decision with this method is to locate a base repeater station.

It is also likely to use the technology possibly to include other functionality, and probably will be shared private services used by a number of other clients.

The bidder shall explain how the MEP calls entering the existing telephone network from the microwave receiving station will be routed to the breakdown maintenance Authority. It will be important for the tenderer to describe functions, such as maintenance calls and call polling and MEP auto-identifications will be provided.

691.2.2 - Option Two

Here existing cell-site repeaters can be used, provided these cell-sites are equipped to give priority to emergency calls or they may have to upgrade the existing cell network in order for these cell-sites to give priority to MEP calls.

With this option it is assumed that the cellular calls will have to be routed to the maintenance PABX by means of existing telephone lines or a dedicated line, which can handle multiple calls. It will be important for the tenderer to describe functions, such as maintenance calls and call polling and MEP auto-identifications will be provided.

691.3 - LOCATION OF TELEPHONES

691.3.1 - Between Junctions

A] The expressway Telephones are to be installed at 1.5Km. intervals on the verge adjacent to the hard shoulders. These telephones are to be provided in pairs opposite each other.

B] To discourage motorist who break down near the start or finish of the motorway from leaving it to obtain assistance, telephones shall be provided within the first and last 300 m. These telephones are located first, followed by telephones at junctions. The remaining length of motorway is then infilled with telephones at even spacing within the 1.5km. limit.

691.3.2 - Junctions And Interchanges

At junctions, one pair of telephones each side of the junction should be provided. They should be located approximately 300m beyond the slip road.

A further pair of telephones should be located in the centre of the junction to minimize the risk of stranded motorists crossing slip roads to reach a telephone.

The arrangement of telephones within interchanges should eliminate the need for stranded motorists to cross slip roads.

Where safety rails are not installed protection from oncoming traffic shall be provided.

691.4 - TELEPHONE EQUIPMENT

691.4.1 - Design

The Box material and design shall be such as to make it strong, durable, weatherproof, virtually vandal-proof, and of finished appearance in keeping with the RDA requirements. Possible materials are cast aluminium, hot-dipped galvanized heavy gauge sheet steel.

Boxes to be powder coated finish and seal to IP65, unless otherwise approved. Boxes will require hinged access for inspection and servicing of internal components. A durable 'O' ring endless gasket or equal approved, capable of maintaining a seal to IP65 even after several years in service shall be provided.

Box shall be capable of dissipating internal heat from heat producing components without external ventilation, and without internal temperature exceeding 50 deg. C. It may be necessary to agree a reduction to IP65 in regard to microphone and speaker box penetrations, but these shall be sealed by the speaker cone or microphone perimeter, and weather resistant devices should be used.

The preferred orientation is for boxes to be side mounted to poles, with facility for mounting either side to the pole. The normal orientation will be for a person facing the front panel to be also facing on-coming traffic in the left lane, and for rear of box to be directly visible to approaching traffic, and to carry transfer or other painted or affixed sign identifying box as a motorway phone. All signs and labels are subject to the Engineer's approval before installation.

The contents may vary somewhat, due to requirement for both mains powered and solar powered versions. Also the particular option will determine the type of radios to be installed, and may influence sizing of batteries and chargers and power supplies.

691.4.2 - Batteries, Chargers, And Solar Panels

The DC system shall be a nominal 12 Volts system, with battery capacity, construction and performance characteristics selected to suit the application.

This involves daily cycling, and occasional prolonged loss of charging. Prolonged loss of charging includes up to 5 consecutive 24-hour days in the case of solar powered systems, or 3 consecutive days in the case of mains powered systems.

Batteries and solar panels must given a manufacturers un-conditional minimum 10year Warranty Certificate, in favour of the Employer, commencing from the date of issue of the Defects Liability Certificate.

691.4.2.1 - Batteries And Battery Charging System

The following minimum requirements shall be observed.

a) Batteries shall be sealed, maintenance free, gel-based, electrolyte, and have a minimum nominal design life of 10 years. A full replacement warranty is required as detailed in 691.4.2 above.

b) Batteries shall be charged by an electronic battery charger capable of switching between at least three charging modes: constant current mode, constant voltage mode and maintenance mode.

Switching from constant current to constant voltage shall be at a pre-set [servicemen adjustable] battery terminal voltage. Switching to maintenance mode may be after a pre-set time [servicemen adjustable], or equal approved, and shall be to a separate lower pre-set [servicemen adjustable] float-charge voltage.

Charger shall be complete with temperature compensation to prevent thermal drift from pre-set charge settings, Charger shall be continuously rated to allow operation indefinitely in any charging mode with any battery condition, without detriment to the charger.

Charger ripple shall be minimized to promote battery life. Ripple current shall not exceed 2% of charger current in any charging mode.

691.4.2.2 - Protection

Batteries shall be protected from excessive discharge by:

A shut down imminent alarm, which shall cause a maintenance phone call to be set to the call centre, to page the maintenance personnel.

A device shall automatically disconnect the battery from any further load when the voltage falls below 1.65 Volts per cell. Radios will be powered off.

691.4.2.3 - Battery Installation And Replacement

A convenient and effective method of mounting and connecting batteries shall be provided so as to facilitate ease of replacement. The need for batteries to breath shall be considered in the design and placement and protective measures shall be such as to not allow its vapours or voltaic effects to adversely effect electronic equipment, earthing etc., through corrosion.

691.5 - SOLAR PANELS

These shall be silicon photovoltaic of mono- or poly-crystalline type and of proven design and manufacture, and obtained from a reputable manufacturer who has been manufacturing photovoltaic of similar design for not less than 5 years, and purchased through a reputable local supplier who has been a supplier of this manufacture for not less than two years, and in their current business for not less than four years.

The minimum warranty shall be 10 years, as detailed in 691.4.2 above.

The solar panels shall be sized to provide the output required by the connected equipment and performance required, after allowing for 10 years in service operation in the motorway application, and the reduction in capacity that can be projected for these solar panels having regard to high UV component and test data on aging applicable to these panels.

691.6 - ELECTRICAL WIRING

For cables etc. refer the Electrical Specification Section 662 above.

691.6.1 MEP Wiring

All internal wiring should be with PVC insulated stranded cable minimum 1.5 mm^2 copper, except for data cables. A minimum of 5 colours shall be used. Use green/yellow only for wiring direct to earth terminal.

Black for earthed neutral connections

White for floating neutral, Orange for 12 V. DC wiring, red, yellow and blue for any phase wiring.

Equivalent alternative scheme can be submitted for consideration.

Maintain segregation in panel between 230V ac cables and low voltage cables, data cables, and analogue signal cables to a minimum of 50mm. Maintain screening of serial data cables and analogue signal cables right up to termination on electronic receiving or transmitting device.

Wiring to the door(s) shall be brought together into a single loom per door and anchored at both the panel side and door side with sufficient length provided in the loom to enable the door to swing fully open.

Wires shall not be joined or teed between terminals. All cable tails shall be number ferruled at each end of each core with ferrules neatly aligned adjacent to the terminal to enable easy readability as viewed horizontally from the front. Ferrules shall tightly grip the cable core and shall not be capable of falling off, or inclined to slip down the core. Low voltage ribbon cables shall be identified by a cable tag ID, since ferrules are not practical. All ferrules and cable tags at one end of a cable shall agree with those at the other end of the same cable.

691.6.2 - Cables

Analogue signal cables and serial data cables shall be screened and use 1.0 mm^2 Copper minimum core conductor size, and with 250 Vac insulated exterior cable sheath. A separate cable shall be used for each analogue and each serial communications link. All cables shall be identified by cable tags at each end, and these cross-referenced to the As-Built drawings.

691.6.3 - Terminations

Stud type terminals as may be provided on some equipment for earthing etc. shall have not more than three wires connected. Terminations shall be made with crimped spade connectors sized to snugly fit the stud diameter, and with insulating sleeves unless they are earthed connections.

Connections to screw terminals shall also be only by crimped spade connectors with insulated sleeves and correctly sized.

DIN rail mounted terminals shall be Phoenix type or approved equal. Each block of terminals shall be sequentially numbered and cross-referenced to terminal numbers on the drawings.

691.7 - COMMISSIONING

691.7.1 - General

[a] The Engineer may be present at all inspections and tests

[b[Responsibility for the commissioning shall belong to the Contractor who shall provide all labour, tools and instruments as required by the engineer.

[c] Scope of commissioning shall be to prove:

The installation shall provide a system fully compliant with all statutory and design requirements, including a high standard of safety

Functional testing to verify working of the installation in all respects as specified and required.

691.7.2 - Commissioning Procedures

Commissioning and inspection procedure shall generally be in accordance with the following unless instructed otherwise by the engineer.

Visual inspection at selected construction stages.

Static insulation tests of wiring and equipment.

Checking and setting of all protection devices and alarms to design requirements.

Setting installation to work and checking operations and completeness of As-Built documentation/drawings.

691.8 - METHOD OF MEASUREMENT AND PAYMENT

691.9 PAY ITEMS:

ITEM	DESCRIPTION	UNIT
901.005	Supply and install emergency Telephone System	Provisional sum