

**STANDARD SPECIFICATIONS
FOR
BRIDGE CONSTRUCTION**



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STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

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Edmonton, Alberta

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STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

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SECTION 1

EXCAVATION

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1.1 General

Excavation is the removal of all material, of whatever nature, necessary for the construction of foundations, substructures or other works, in accordance with the drawings or as determined by the Consultant. Excavation shall include the construction of all cribs, cofferdams, dikes, berms or other devices necessary for the work, or necessary for maintaining the stability of adjacent headslopes, fills, or existing structures, the protection, dewatering and maintenance of the excavated region, and the disposal of excavated material not required or not suitable for backfill as determined by the Consultant. If any excavation or dredging is made at the site of the structure, the Contractor shall, without extra charge, after the foundation base is in place, backfill all such excavation to the original ground surface or river bed with material satisfactory to the Consultant. Material deposited within the stream area from foundation or other excavation, or from any other operations, shall be removed and the stream area freed from obstruction.

Where necessary, excavations shall be shored, braced or protected by cofferdams. The Contractor shall maintain the integrity and stability of existing headslopes and fills at all times.

For projects in which the existing asphalt concrete pavement (ACP) surfaces are to be retained, the Contractor shall provide suitable and adequate protection of the ACP during excavation, trimming, or other construction activities. Protection may include placement of filter fabric and sand or crushed granular material over the ACP. Protection of the existing ACP will be considered to be incidental to the work and no separate or additional payment will be made. Any damage to the ACP caused by the Contractor's operations shall be repaired at his expense to the satisfaction of the Consultant.

1.2 Clearing

Clearing required for the completion of the Bridge Work will be considered incidental to the Work and no separate or additional payment will be made.

1.3 Depth of Footings

The bottom of footing elevations shown on the drawings shall be considered as approximate only. The Department and Consultant may require changes in final dimensions or elevations of footings to establish a satisfactory foundation.

1.4 Preparation of Foundations for Footings

All rock or other hard foundation material shall be free of loose material, cleaned and cut to a firm surface as shown on the drawings. All seams shall be cleaned out and filled with concrete, mortar or grout.

When concrete is to be cast on an excavated surface other than rock, special care shall be taken not to disturb the bottom of the excavation, and the final removal of the foundation material to grade shall not be made until just before the concrete is to be placed.

In the case of concrete culverts or certain spread footings, when a firm foundation is not attained at the grade established, the foundation shall be deepened to an elevation determined by the Department and Consultant and backfilled with suitable clay or granular material as described under Section 2, "Backfill".

In the case of spread footings, the lower part of the excavation, for a depth corresponding to the height of the footings, shall be made neat to the same plan dimensions and shape as the footing, and the concrete shall be placed without forms. Seepage water shall be collected and drained or pumped away before it can enter the neat portion of the excavation.

1.5 Cofferdams, Dikes and Berms

1.5.1 General

All cofferdams, dikes and berms for foundation construction shall be carried to adequate depths and heights, be safely designed and constructed of good standard materials, and be made as watertight as is necessary for the proper performance of the work which must be done inside them. Their dimensions shall give sufficient clearance for construction and inspection of forms and permit pumping of water outside of the forms.

No separate or additional payment will be made for the supply, construction or removal of cofferdams, dikes or berms. Full compensation for the cost of such material, equipment, tools, labour and incidentals shall be considered included in the price bid for the specified work to be carried out inside the cofferdam, dike or berm.

1.5.2 Drawings Required

For substructure work, the Contractor shall submit drawings of the proposed cofferdam, shored excavation, dike or berm construction, and associated work procedures. The drawings and work procedures shall be signed and sealed by a Professional Engineer, registered in the Province of Alberta. The drawings shall be submitted to the Consultant two weeks prior to the commencement of the work for review and acceptance. The Consultant will review the drawings as to intent only, and any acceptance of such drawings by the Consultant shall in no way relieve the Contractor of his full responsibility for the work.

1.5.3 Concrete Seal

When conditions are encountered which in the opinion of the Department and Consultant make it impracticable to dewater the foundation before placing concrete, he may require or allow the construction of a concrete foundation seal below the elevation of the bottom of the foundation, of such dimensions as may be necessary. The foundation shall then be pumped out and the work completed in the dry. During the placing of a foundation seal the elevation of the water inside the cofferdam shall be controlled to prevent any flow through the seal and if the cofferdam is to remain in place, it shall be vented or ported at low water level. No separate or additional payment will be made for construction of the concrete seal unless it is specified on the drawings, in which case it will be paid for at the price bid.

1.5.4 Removal of Bracing

No timber or bracing shall be left in the cofferdams in such a way as to extend into the substructure concrete, without written permission of the Department and Consultant.

1.5.5 Pumping of Water

Pumping from the interior of any cofferdam shall be done in such a way as to prevent the flow of water through any fresh concrete. No pumping will be permitted during the placing of concrete or for a period of 24 hours after, unless the pumping is done from a suitable sump separated from the concrete by a watertight wall or other means accepted by the Consultant. Pumping to dewater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand hydrostatic pressures. In cases where turbid water is to be pumped from any excavation, a suitable settling pond shall be provided to ensure that only water free from suspended material finds its way into any stream. Details of the settling pond and monitoring programs shall be included in the Contractor's ECO plan.

1.5.6 Removal of Cofferdams, Dikes and Berms

Cofferdams, dikes and berms shall be removed after completion of the Work for which they were installed. The Contractor shall take care not to disturb or damage the finished works in any way during removal operations. Backfill required around the permanent work shall be placed prior to removal of cofferdams, dikes or berms.

The Consultant reserves the right to require the Contractor to remove all materials from the streambed at any time to prevent stream pollution or adverse environmental effects, including bank erosion, or effects on adjacent structures or any other installations or property. If the Contractor fails to comply with this requirement, the Department and Consultant further reserves the right to make immediate separate arrangements to remove such materials at the Contractor's expense. The Contractor shall be responsible for all costs incurred by the Department and Consultant to remove such material and/or all damages incurred.

1.6 Inspection of Excavation

After the excavation is completed to the elevation shown on the drawings, the Contractor shall notify the Consultant. The Consultant shall review and accept the depth of the excavation and the character of the foundation material before any further work proceeds.

The Consultant may require test pits, test drilling, further excavation, or other work as necessary to obtain an acceptable excavation.

Test pits and test drilling shall be paid for in accordance with 1.2.25 "Extra Work" of the General Specifications.

1.7 Classification of Excavation

Excavation shall be classified as follows:

Structural Excavation - Excavation related to the foundations and substructures,

Channel Excavation - Excavation carried out to improve the alignment or carrying capacity of the stream channel.

1.8 Measurement and Payment

Payment for **Excavation** will be either at the unit price bid per cubic metre or lump sum price basis. Such price shall include the cost of all labour, material, equipment, and other items of expense necessary for the successful completion of the excavation.

Payment will be determined as follows:

1.8.1 Unit Price per Cubic Metre

When payment is to be on unit price basis, the quantity to be paid for will be the actual number of cubic metres in the natural condition, of material acceptably excavated in conformity with the drawings or as determined by the Consultant. No quantity of excavation will be included in the measurement for payment which is outside the neat lines of the footing. The top and bottom limits of the computed volume shall be the original ground surface and the bottom of the completed footing, with no payment to be included for the removal of water and ice.

1.8.2 Lump Sum Price

When payment is to be on lump sum price basis, the lump sum price shall include full payment for the excavation of all material necessary in conformity with the drawings or as determined by the Consultant.

When it is necessary, in the opinion of the Department and Consultant, to carry the foundations below the elevations shown on the drawings, the additional quantity of excavation will be paid by a negotiated lump sum price or in accordance with 1.2.25 "Extra Work" of the General Specifications as determined by the Department and Consultant.

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SECTION 2

BACKFILL

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2.1 General

Backfill shall include material required to fill excavations adjacent to various bridge components or culvert installations. Backfill shall also include the supply and placing of materials necessary for construction of approach fills, roadway embankments, slopes, channel banks, and berms.

All materials shall be sourced and supplied by the Contractor. The Contractor shall be responsible for royalties, processing, loading, hauling, placing, compacting, QC testing and any other incidentals required to supply these materials in place.

2.2 Materials

All material used for backfill, including native material, shall be of a quality acceptable to the Consultant and shall be in a thawed state when placing and compacting and be free from rocks, large or frozen lumps, wood, or other unsuitable material. No backfill material will be permitted to be placed on frozen substrate.

2.2.1 Compacted Non-granular Material

Compacted non-granular material shall be inorganic soil such as clay. When reviewed and accepted by the Consultant, non-granular material can be substituted with granular material.

Material used for the construction of the "clay seals" shall be highly plastic clay. Material with high swelling potential such as bentonite clays will not be permitted. When the proposed material characteristics for clay seals are questionable the Consultant will require the Contractor to classify the material using Test Method ASTM D2487 - Classification of Soils for Engineering Purposes. Material shall have a minimum Plasticity Index of 40.

2.2.2 Gravel Material and Crushed Aggregate Material

Where Gravel Material or Crushed Aggregate Material is specified, it shall consist of clean sand and gravel, complying with the following requirements:

Designation/Class			
Metric Sieve Size (CGSB 8-GP-2M)	*Gravel Material Des 6 Class 80	Crushed Aggregate Material Des 2 Class 40	Crushed Aggregate Material Des 2 Class 25
Sieve Size µm	Percent Passing	Percent Passing	Percent Passing
125 000	--	--	
80 000	100	--	
50 000	55 - 100	--	
40 000	--	100	
25 000	38 - 100	70 - 94	100
20 000	--	--	82 - 97
16 000	32 - 85	55 - 85	70 - 94
10 000	--	44 - 74	52 - 79
5 000	20 - 65	32 - 62	35 - 64
1 250	--	17 - 43	18 - 43
630	--	12 - 34	12 - 34
315	6 - 30	8 - 26	8 - 26
160	--	5 - 18	5 - 18
80	2 - 10	2 - 10	2 - 10
% fractures by weight (2 faces)	N/A	50+	60+
Plasticity Index	NP - 8	NP - 6	NP - 6
L.A. Abrasion Loss Percent Maximum	N/A	50	50

*Note: Native Gravel Material may require processing in order to meet the gradation requirements.

2.2.3 Backfill Material Tests

The Contractor shall submit for the Consultant's review two weeks before placing of the granular material, a sieve analysis representing the material to be used at site. Sampling and testing shall have been done no more than 90 days prior to usage unless otherwise approved by the Consultant. For non-granular material, the source and material shall be approved by the Consultant two weeks prior to usage.

The Contractor shall be responsible for all costs associated to carry out the appropriate testing procedures to confirm specification requirements. The Contractor shall use professional engineering services and a qualified testing firm licensed in the Province of Alberta for all quality control work associated with backfilling procedures.

The Contractor shall be fully responsible for production of aggregate that meets all the specification requirements. Des 2 Class 25 Crushed Aggregate material can be used where Des 2 Class 40 material has been specified at no separate or additional cost to the Department.

Results of all quality control tests shall be submitted to the Consultant within 3 days of the test being completed.

Unless otherwise specified, the latest edition of the following standard Alberta Transportation Test methods (ATT) shall be used to determine material characteristics.

Test methods and minimum frequencies shall be as shown in Table 2.2.3 Quality Control Testing Requirements.

Table 2.2.3
Quality Control Testing Requirements

Description	Standard	Minimum Frequency
Aggregates Tests		
<u>Sieve Analysis</u>		
1. Crushed Aggregate	ATT-25 or ATT-26	One per Source
2. Gravel Material	ATT-25	One per Source
<u>Plasticity Index</u>		
	AASHTO T90	When requested by the Consultant
<u>Percent Fracture (crushed aggregate)</u>		
	ATT-50	One per Source
<u>L.A. Abrasion</u>		
	AASHTO T96	When requested by the Consultant
Backfill Tests		
<u>Moisture Density Tests (Proctor)</u>		
1. Crushed Aggregate (Des 2 Class 25)	ASTM D698	One test per source
2. Non Granular Material (Soil)	ASTM D698	One test for each soil type
<u>Density of Materials (In-place)</u>		
1. Crushed Aggregate (Des 2 Class 25) or (Des 2 Class 20) *	ASTM D6938 ATT 8 or 9	Three tests on Culvert Bedding taken at invert level Three tests for every four lifts of backfill
2. Crushed Aggregate (Des 2 Class 40 or Gravel Material)	ATT-58A (Control Strip Method)	For Culverts, control established on top lift of bedding material at invert level and the first lift of backfill material for each Bridge Component For Culverts, control re-established on each side of culvert at the 1/3 and mid-point of culvert backfill, and the mid-point of backfill for each Bridge Component Monitor for minimum number of passes on all other lifts
3. Non Granular Material (Soil)	ASTM D6938 ATT 8 or 9g	Embankment - Three tests per 2 m height of embankment, each side One test on clay seal at each end of Culvert

* At the Contractor's option, ATT-58A (Control Strip Method) can be used for Des 2 Class 25 or Des 2 Class 20 crushed aggregate material.

2.3 Placing

All spaces excavated and not occupied by permanent work shall be backfilled with compacted material up to the elevation indicated on the drawings or determined by the Department and Consultant. Compacted material may also be required in other locations as shown on the drawings or as required by the Department and Consultant.

All backfill material, regardless of type shall be placed in lifts not exceeding 150 mm in thickness of loose material, and each lift shall be mechanically tamped with pneumatic tampers or and approved equivalent. The rate of placing the backfill material shall be such that the tamper can compact thoroughly and uniformly. Compaction of Crushed Aggregate (Des 2 Class 25) and Non Granular Material (Soil) shall be a minimum of 95% Proctor density with optimum moisture content. Compaction acceptance of Gravel Material and Crushed Aggregate (Des 2 Class 40) shall be done using the Control Strip Method with a Nuclear Gauge.

On projects where Control Strips are being established, compaction equipment proposed by the Contractor must be reviewed and accepted by the Consultant.

Backfill material shall not be placed against any concrete abutment, wingwall or culvert until permission has been given by the Consultant. Generally, placement will not proceed until the concrete has been in place at least 7 days or the compressive strength of the concrete is 75% of the required 28 day strength.

Backfill material around culverts and concrete elements shall be placed simultaneously on both sides to the same elevation to avoid unbalanced loading. Special precautions shall be taken to prevent any wedging action against the concrete and the slope bounding the excavation for abutments and wingwalls. The slope shall be stepped to prevent wedge action. Jetting of backfill material behind abutments and wingwalls will not be permitted.

The Consultant may carry out quality assurance testing, if the Contractor's compaction methods and procedures are in the Consultant's opinion not meeting the specification requirements.

2.4 Measurement and Payment

Payment for **Backfill** of the type(s) specified will be at the unit price bid per cubic metre or lump sum price bid. The price bid shall include the cost for all labour, material, equipment, tools, and incidentals necessary to complete the Work.

2.4.1 Unit Price per Cubic Metre

When the Unit Price Schedule contains unit price bid for this work, payment will be made for the quantity of compacted **Backfill** incorporated in the work based on the dimensions and elevations indicated on the drawings or as determined by the Department and Consultant. The quantity will be determined by measuring the volume of the excavation.

2.4.2 Lump Sum Price

When the Unit Price Schedule contains lump sum price bid for this work, payment will be made for the compacted **Backfill** of all structural excavations and other areas shown on the drawings.

When excavations are taken below specified elevations at the Department and Consultant's request, the additional backfill quantity will be paid by a negotiated lump sum price or in accordance with 1.2.25 "Extra Work" of the General Specifications as determined by the Consultant.

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SECTION 3

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REFERENCE DRAWINGS

Drawing No.

Standard Timber Pile Splice..... S-1413
Standard Pipe Pile Splice..... S-1414
Standard H-Pile Splice..... S-1415
Standard Closed Pipe Pile End Plate..... S-1479

3.1 General

This specification is for the supply and installation of plain and galvanized steel H-piles and pipe piles, timber piles, precast concrete piles, and cast-in-place concrete piles. It includes driven piles, drilled cast-in-place concrete piles, and drilled cast-in-place concrete/steel pipe composite piles.

3.2 Materials

3.2.1 Steel "H" Piling

Steel "H" piling shall meet the requirements of Specification ASTM A36 or CSA G40.21M 350W. Where piling is designated in metric dimensions, imperial equivalent piling will be accepted. Mill certificates shall be provided to the Consultant for review and acceptance prior to pile installation.

Splice plates shall be fabricated to the dimensions shown on Standard Drawing S-1415 "Standard H-Pile Splice".

3.2.2 Steel Pipe Piling

Steel pipe piling shall meet the requirements of Specification ASTM 252 Grade 2, except that hydrostatic testing is not required. Although piling is designated in metric dimensions, imperial equivalent piling will be acceptable. Mill certificates shall be provided to the Consultant for review prior to pile installation. Some out-of-roundness of the pipe is acceptable provided an acceptable splice can be completed.

Galvanized piling shall be galvanized by the hot dip method, in accordance with the current edition of the ASTM A123/A123M Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

Splice backup rings and closed pipe pile end plates shall be fabricated as shown on Standard Drawing S-1414 "Standard Pipe Pile Splice" and Standard Drawing 1479 "Standard Closed Pipe Pile End Plate".

3.2.3 Timber Piling

Treated timber piling shall be fir or pine, and untreated timber piling shall be fir, spruce, pine or a species that is equivalent or better as determined by the Consultant. Timber piling shall conform to Section 23 - "Dimensional Structural Lumber and Piling", and shall be of the length specified on the drawings.

Timber pile splices shall be fabricated as shown on Standard Drawing S-1413 "Standard Timber Pile Splice".

3.2.4 Pile Concrete

Concrete shall meet the requirements of Pile Concrete as specified in Section 4 "Cast-In-Place

Concrete”.

3.2.5 Reinforcing Steel

Reinforcing steel incorporated in the pile concrete shall meet the requirements of Section 5 “Reinforcing Steel”.

3.3 Handling

Piling shall be handled, hauled and stored in a manner that avoids damage to the piling materials. Loading and unloading shall be by crane, loader or other appropriate hoisting equipment.

Care shall be taken in order to prevent damage of galvanized pile surfaces. Fabric slings, wood blocking or other approved methods shall be used to support and separate galvanized piling when handling, hauling or storing. Piling on which the galvanized coating has been damaged shall be replaced or repaired by the Contractor at his expense as determined by the Consultant. Where repair of damaged galvanizing is required, the repair shall be by metallizing in conformance with ASTM A780, Method A3, to a thickness of 180 μm .

Special care shall be taken to avoid breaking through the surface treatment of treated timber piles, and cant-hooks, dogs, or pike poles shall not be used. Cuts or breaks in the surface of treated timber piles shall be given three brush coats of preservative material of approved quality, and preservative material shall be poured into all bolt holes.

3.4 Driven Piles

3.4.1 Equipment and Driving Methods

All pile driving equipment, driving methods and procedures shall be reviewed and accepted by the Consultant before pile driving commences. Acceptable driving equipment includes diesel hammers, hydraulic hammers, vibratory hammers, driving frames or other equipment as determined by the Consultant. The use of multi-component drop hammers will not be permitted under any circumstances. The use of gravity hammers will not be permitted except when the required capacity is less than 350 kN, and the Consultant determines the gravity hammer and leads acceptable. Where the use of a gravity hammer is acceptable, the Contractor shall provide the Consultant acceptable proof of its weight including the weight of the follower.

The driving of piles with driving extensions shall be avoided if practicable, and shall be done only under written permission of the Consultant. When driving extensions are used, one pile from each group of 10 shall be a long pile driven without extensions, and shall be used as a test pile to determine the average capacity of the group. Driving heads, mandrels, or other devices shall be provided in accordance with the manufacturer's recommendations so that the pile may be driven without damage and unnecessary trimming.

For monitoring pile installation, the Contractor shall paint markings on each pile at 0.25 m intervals with a label at each 1.0 m interval starting from the toe of the pile.

The Contractor shall ensure that the piles are in proper position and alignment by using installation driving frames and fixed leads.

Piles shall not be out of the horizontal position shown on the Drawings by more than 150 mm after driving, except for fully integral abutments the piles shall not be out of horizontal position by more than 50 mm. In addition, for fully integral abutments, the variation in position between the pile casing center and the pile centre shall not be more than 25 mm.

Piles shall be not driven with a variation of more than 20 mm per metre from the vertical or the batter as shown on the Drawings. Piles in exposed bents shall not be out of position by more than 50 mm at the ground line or 25 mm in the pier cap.

If tolerances are not met, the Contractor shall make immediate changes to his piling procedures. Any pile out of the specified tolerance shall be corrected at the Contractor's expense to the full satisfaction of the Consultant.

3.4.2 Pile Capacity

Piles shall be driven to the tip elevations shown on the drawings, or lower as determined by the Consultant, to achieve the required stability and capacity. Pile capacity shall be determined by the Bearing Formulas of this Specification.

After pile driving operations have commenced, the Consultant may revise the required pile tip elevations, if necessary, using the pile driving data and Bearing Formulas.

In the event pile tip elevations are not shown on the Drawings, pile capacities shall be determined in accordance with Section 3.6 "Pile Capacity Test Methods".

Bearing Formulas

When not driven to practical refusal, the capacity of piles may be required to be determined by test methods as specified in Section 3.6 "Pile Capacity Test Methods". In the absence of capacity tests, the pile capacity shall be determined by the following formulas:

Diesel and Hydraulic Hammers

$$P = \frac{165 \times E \times F}{S + 5}$$

- Where
- P - Pile reaction at Service Limit State (SLS) (kilonewtons)
 - E - Rated (Potential) Energy output of hammer (kilojoules)
 - F - Efficiency factor
 - S - The average penetration per blow for the last 10 to 20 blows (mm per blow)

The Consultant will determine the efficiency factor of the hammer at site by comparing the actual recorded blows per minute to data provided by the manufacturer of the hammer.

The above formula is applicable only when:

- (1) The head of the pile is not broomed, crushed, or deformed.
- (2) The penetration is reasonably quick and uniform.
- (3) A driving extension is not used.

For Gravity Hammers (When accepted for use by the Consultant)

$$P = \frac{1650xWxH}{S + 25}$$

- Where
- P - Safe bearing value (kilonewtons)
 - W - Weight of striking parts of hammer (tonnes)
 - H - Height of fall (metres)
 - S - The average penetration per blow for the last 5 to 10 blows.

The above formula is applicable only when:

- (1) The hammer has a free fall.
- (2) The head of the pile is not broomed, crushed, or deformed.
- (3) The penetration is reasonably quick and uniform.
- (4) There is no sensible bounce after the blow, or twice the height of the bounce shall be deducted from "H" to determine its value in the formula.
- (5) A driving extension is not used.

The Contractor shall provide performance specifications for the type of hammer to be used. He will be required to demonstrate that the hammer is performing within the specified limits.

Test Piles

Test piles shall be driven where they are specified on the drawings or as required by the Consultant. Test piles shall be longer than the length assumed in design, in order to provide for variations in soil conditions and to explore conditions below the tips of permanent piles. Other dimensions of test piles shall be the same as permanent piles, and shall be driven with the same type and size of equipment.

3.4.3 Steel Piles

Steel piles shall consist of structural steel shapes or pipes of the section shown on the Drawings or otherwise specified.

When pipe piles are to be driven closed-ended, one section of pipe for each pile shall be supplied with a welded pipe pile end plate in accordance with Standard Drawing S-1479 "Standard Closed Pipe Pile End Plate".

When pipe piles are to be driven open-ended and the interiors cleaned out, a power screw rotary auger, acceptable to the Consultant shall be used to remove the required material. All loose material and all material adhering to the walls of the piles shall be removed.

After installation closed ended or open ended pipe piles shall be filled with pile concrete.

The total energy developed by the hammer shall be sufficient to achieve the required capacity or tip elevation, but in no case shall the total energy developed be less than 35 kJ per blow.

The head shall be cut squarely and a driving cap or follower shall be provided to hold the axis of the pile in line with the axis of the hammer. The follower shall be of adequate dimensions to allow driving the pile without trimming or reducing the cross-section of the pile. When damage or buckling is evident at the driving end of the pile in order to obtain the desired capacity or penetration of the pile, the Contractor shall at his own expense reinforce the driving end of the piling, or provide other suitable equipment or procedures, to prevent such damage.

Piles shall be cut off level at the required elevation. If capping is required, the connection shall be made according to details shown on the drawings.

The Contractor shall supply and secure temporary caps on all open pipe piles or drilled holes.

3.4.3.1 Steel Pile Splices

When splicing, the Contractor shall employ whatever means necessary to match out-of-round piling. Exposed pile splices shall be avoided. Refer to Standard Drawing S-1415 "Standard H-Pile Splice" and Standard Drawing S-1414 "Standard Pipe Pile Splice". All welding in the field shall be in accordance with section 13.4.1.

Where the upper portions of piling are specified to be galvanized, excess piling shall be removed from the ungalvanized portion of the piling to ensure that the galvanized portion extends to the elevation shown on the drawings. Splicing within the galvanized portion of the piling shall be avoided; however if splicing becomes necessary due to unforeseen circumstances, the damage galvanized area shall be metallized in accordance with ASTM A780, Method A3 to a thickness of 180 μm , by the Contractor at his cost.

3.4.3.2 Testing by the Contractor

The Contractor shall perform ultrasonic testing for a minimum of 20% of all full penetration compression splice welds for all piles for each bridge component. Ultrasonic testing shall also be completed for welds in which visual inspection indicates the presences of a potential defect. Additional testing may be required for the full penetration compression splice welds to ensure the integrity of the structure. The Contractor shall test 100% of full penetration tension splice welds as shown on the Drawings.

Ultrasonic testing shall be done by a company certified to CAN/CSA W178.1. Ultrasonic testing technicians shall be certified to Level II of Canadian General Standard Board (CGSB). A copy of test results shall be provided to the Consultant for his review within three days of the testing. The Consultant may require additional testing and inspection if determined necessary.

All costs associated with weld testing shall be included in the price bid for the Work and no separate or additional payment will be made.

3.4.4 Timber Piles

Gravity hammers when accepted for driving timber piles shall weigh not less than 1.5 t, and in no case shall the weight of the hammer be less than the combined weight of driving head and pile. The fall shall be so regulated as to avoid injury to the piles and in no case shall exceed 3 m. When a diesel hammer is used total energy developed by the hammer shall be not less than 15 kJ per blow.

The pile head shall be cut squarely and a driving cap or follower shall be provided to hold the axis of the pile in line with the axis of the hammer. The follower shall be of adequate dimensions to allow driving the pile without in any way trimming or reducing the cross-section of the pile.

The Contractor shall provide and install collars, bands, or other devices to prevent timber piles from splitting or brooming.

When the area of the head of any timber pile is greater than that of the face of the hammer, a suitable follower shall be provided to distribute the blow of the hammer throughout the cross-section of the pile and thus avoid splitting or shattering the pile.

Timber piles shall be pointed where soil conditions require it. When necessary, the piles shall be shod with metal shoes, supplied by the Contractor, of a design satisfactory to the Consultant, the points of the piles being carefully shaped to secure an even and uniform bearing on the shoes.

Full length piles shall be used where practicable. In exceptional circumstances splicing of piles may be permitted. The method of splicing shall be as shown on the drawings or as reviewed and accepted by the Consultant. Refer to Standard Drawing S-1413 "Standard Timber Pile Splice" included with these Specifications.

The tops of all piling shall be trimmed to a true plane at the elevation shown on the drawings or fixed by the Consultant. Piles which support timber caps or grillage shall be sawed to conform to the plane of the bottom of the super-imposed structure. In general, the length of pile above the elevation of cut-off shall be sufficient to permit the complete removal of all material injured by driving, but piles driven to very nearly the cut-off elevation shall be carefully trimmed and freed of all "broomed", splintered or otherwise injured material.

3.4.5 Defective Piles

The method used to drive piles shall not result in deformation of the steel, splitting, splintering or brooming of the wood, or crushing and spalling of the concrete. Manipulation of piles to force them into proper position, considered by the Consultant to be harmful, will not be permitted. Piles damaged by driving, or driven out of proper location, or driven below the cut-off elevation, shall be corrected by the Contractor at his expense by using one of the following methods acceptable to the Consultant:

- (a) The piles shall be withdrawn and replaced by new, and if necessary, longer piles, or

- (b) Replacement piles shall be driven adjacent to defective or low piles, or
- (c) The piles, except timber piles, shall be spliced or built up as determined by the Consultant, or
- (d) A sufficient portion of the footing extended to properly embed the piles.

All piles, pushed up by the driving of adjacent piles or by any other cause, shall be driven down again.

When the required penetration and capacity are not achieved, the Contractor shall provide a hammer of greater energy or, when accepted by the Consultant, pre-drill the piles. Providing a hammer with greater energy and/or pre-drilling the piles to achieve acceptable penetration and capacity will be considered incidental to the Work and no separate or additional payment will be made.

3.4.6 Measurement and Payment

Supply of Piling

Payment for **Supply of Piling** will be made on the basis of the unit price per metre bid for each type of piling supplied, which price shall include full compensation for the cost of furnishing and delivering the material to site. The unit prices shall include full compensation for the cost of all labour, tools, equipment and other necessary or incidental costs of handling, loading and hauling the piling.

The number of metres of piling to be paid for shall be the total number of metres acceptably driven and remaining in the completed structure. Where portions of steel piling are specified to be galvanized, only the lengths requiring galvanizing will be included in supply of galvanized steel piling. All steel piling below the level of the galvanized piling length shown on the drawings will be included in supply of plain steel piling.

Re-stocking Steel Piling

When quantities of plain Steel Pipe or H Piles are reduced by 15% or more due to conditions beyond the Contractor's control, the Department will reimburse re-stocking costs for 6.0 metre lengths or longer, incurred by the supplier to the Contractor.

The Contractor shall present vouchers giving details as to dates, quantities, rates, third party invoices, and such other supporting documentation to the Consultant. Payment will be made on the cost of re-stocking only based on third party invoices excluding labour burden, overhead and profit.

Pile Set-up

Payment for **Pile Set-up** will be made on the basis of the unit price per pile bid, which price shall include the expense and time to set the equipment over the pile, ready to commence driving. Payment will be made only for piles acceptably driven as determined by the Consultant.

Pile Driving

Payment for **Pile Driving** will be made on the basis of the unit price per metre bid, which price

shall include full compensation for the cost of furnishing all labour, tools, equipment and incidentals associated with handling, driving, splicing, cutting, and tip reinforcing necessary to obtain the required penetration or capacity.

The number of metres paid shall be the total number of metres of piling acceptably driven and remaining in the completed structure.

Pile Tip Reinforcement

When the Contract contains a bid item for **Pile Tip Reinforcement**, payment will be made on the basis of the unit price bid, which price shall include full compensation for all labour, materials, equipment, tools and all incidentals necessary to complete the work.

Pile Splicing

Where piles penetrate further than 20% of the estimated tip elevation, splicing will be paid for at the assigned unit price for pile splicing and will include all labour, materials, equipment, tools and incidentals necessary to complete the work. Only one splice for each additional length of pile, up to twelve metres, will be paid for.

The unit price for pile splicing shall be:

H-Piles:	\$1000
Pipe Piles:	\$1200

Pile Concrete

Pile Concrete shall be measured and paid for in accordance with Section 4 "Cast-In-Place Concrete".

Reinforcing Steel

Reinforcing Steel incorporated in the piling will be paid for in accordance with Section 5 "Reinforcing Steel".

Test Piles

Test piles retained in the structure will be paid for at the bid price of other piling used.

If test piles are not incorporated into the final structure, they will be paid for as Extra Work.

3.5 Drilled Cast-in-place Concrete Piles

3.5.1 General

In addition to drilled cast-in-place concrete piles this section shall include drilled cast-in-place concrete/steel pipe composite piles. The work shall include drilling and belling the holes, as required, supplying and placing the steel pipe and reinforcing steel, and supplying, placing, protecting and curing the concrete.

3.5.2 Equipment and Drilling Methods

Due to the nature of the work, the Department requires that the drilling subcontractor have adequate equipment and a proven record of competence in this work.

All pile drilling equipment, drilling methods and procedures shall be reviewed and accepted by the Consultant before drilling is started. Unless otherwise specified only powered screw rotary type augers will be acceptable.

The Contractor shall not proceed with the installation of further piling, if for any reason the quality of the adjacent piling is compromised due to the effects of vibration or other reasons.

3.5.3 Cast-In-Place Pile Capacity

Where cast-in-place piles are designed using semi-empirical methods and supported by a comprehensive geotechnical investigation with field testing and construction monitoring, the ultimate bearing capacity may be adjusted for Limit State Design by a geotechnical resistance factor of 0.4. If working state design methods are used the allowable loads shall be as determined by the Consultant.

3.5.4 Drilling Pile Holes

Drilled pile holes shall be stabilized and sealed by means of temporary casings or other methods to prevent the possible collapse of the pile holes or ingress of water. The Contractor shall make every attempt necessary to obtain dry pile holes prior to placing pile concrete. To assist in the Contractor's attempts to achieve a dry hole he shall, at a minimum, have available for use casings of appropriate size and lengths, bailing buckets, final cleanout buckets and water pumps.

Temporary casing, if used in drilling operations, shall be removed from the hole as pile concrete is being placed. The bottom of the casing shall be maintained below the top of the concrete during withdrawal and placing operations unless otherwise permitted by the Consultant. Separation of the concrete during withdrawal operations shall be avoided by hammering or otherwise vibrating the casing.

Pile hole elevations shown on the Drawings shall be considered approximate only, and the Consultant may determine further drilling is necessary to achieve satisfactory capacity of the piles.

Where bellling of the piles is specified, bellling shall proceed only after the pile hole has been drilled to an elevation acceptable to the Consultant.

The walls and bottoms of the pile holes shall be cleaned to remove all loose and extraneous material. The Contractor shall determine if any gas is present in the pile holes and shall provide whatever means and equipment necessary to ensure a safe work site. Pile reinforcement and pile concrete shall not be placed without the acceptance of the pile holes by the Consultant.

3.5.5 Open Drilled Holes

The Contractor shall be responsible for covering all open drilled holes on the site until the time they are filled with concrete or otherwise properly backfilled. The covers shall be of adequate strength and securely fitted so that machinery and workmen are protected against cave-in and surface water is prevented from running into the pile hole.

3.5.6 Reinforcement

Steel reinforcement shall be fabricated in the sizes and to the dimensions shown on the drawings and shall be placed, centered and braced in the pile hole to the acceptance of the Consultant.

Particular care shall be taken in locating projecting reinforcing steel, to a tolerance not exceeding 10 mm in any direction, and casting will not be permitted until the Consultant is satisfied that adequate provisions have been made.

Adequate “shoes” or spacers shall be firmly anchored to the reinforcement to ensure the reinforcement is kept centered in the concrete.

3.5.7 Concrete Placement

When the reinforcement has been acceptably placed, concrete shall be immediately deposited in the pile hole. The concrete shall be “Pile Concrete” and the provisions of Section 4 “Cast-In-Place Concrete” shall apply.

Suitable forms shall be used to maintain the specified dimensions of concrete piles above ground level.

Pile concrete placed under water shall be completed in accordance with Section 4 and requires validation by Crosshole Sonic Logging (CSL).

3.5.8 Cold Weather Conditions

When the ground against which pile concrete is placed is below -5°C, the pile hole shall be oversized by 100 mm. Immediately after placing and finishing the pile concrete, the top exposed surface shall be protected with insulated tarps or other means to adequately cure the concrete for a period of seven days. If the top of the pile extends above the ground surface it shall be protected in accordance with Section 4 “Concreting in Cold Weather”.

3.5.9 Pile Tolerance

Piles shall not be out of the horizontal position shown on the Drawings by more than 50 mm. Piles shall not be out of the vertical or batter position shown on the Drawings by more than 20 mm per metre.

If tolerances are not met, the Contractor shall make immediate changes to his piling procedures. Any pile out of the specified tolerance shall be corrected at the Contractor's expense to the full satisfaction of the Consultant.

3.5.10 Measurement and Payment

Drill Rig Set-up

Payment for **Drill Rig Set-up** will be made on the basis of the unit price per pile bid which shall include full compensation for the cost to set up the drilling equipment over the pile location

ready to commence drilling, and the cost to supply, install and remove temporary casing as required. Payment will be made only for piles acceptably constructed, as determined by the Consultant.

Pile Installation

Payment for **Pile Installation** will be made on the basis of the unit price per lineal metre bid which shall include full compensation for the cost of supplying all materials including piles, drilling, dewatering and cleaning out the holes to the dimensions shown, removal and disposal of the augured material, detection and purging of any gas hazard, and providing safe inspection access. The quantity to be paid for **Pile Installation** shall be the number of lineal metres required to install the piles in accordance with the drawings and specifications (measured from the pile tip to the underside of pile/pier cap). Drilling will be considered as part of pile installation and no separate or additional payment will be made.

Pile Concrete

Pile Concrete will be measured and paid for in accordance with Section 4 "Cast-In-Place Concrete".

Reinforcing Steel

Reinforcing Steel incorporated in the piling will be paid for in accordance with Section 5 "Reinforcing Steel".

3.6 Pile Capacity Test Methods

3.6.1 Static Load Testing

When specified in the Special Provisions, the load carrying capacity of piles shall be determined by static load tests. In general static load tests can be performed on any pile type. Static load tests shall consist of the application of a test load on a suitable platform supported by the pile, or through the use of adjacent reaction piles, with suitable apparatus for accurately measuring the test load and the settlement of the pile under each increment of load. Tests shall be in general conformance with ASTM D3689. Osterberg or Statnamic tests may be used in place of static load tests.

Where sufficient static load testing has been done to satisfy Limit State Design, Load and Resistance Factor Design (LRFD), or reliability-based design statistical requirements, the factored geotechnical resistance may be taken as 0.6. Where allowable or working state design methods are used in the design, or where the requirements of Limit State Design are not fulfilled, the allowable load shall be considered as 50% of that load which, after a continuous application of 48 hours, produces a permanent settlement not greater than 6 mm measured at the top of the pile. This maximum settlement shall not increase by a continuing application of the test load for a further period of 60 hours or longer. At least one pile for each group of 100 piles shall be tested unless a different testing frequency is specified in the Special Provisions. The frequency of testing shall be increased to account for changing soil conditions, pile sections and types, and construction methods.

3.6.2 Dynamic Load Testing / Pile Driving Analyzer (PDA) Testing

Dynamic Load Testing provides useful data on piling stresses and can be used as part of a quality control method during pile installation. Pile Driving Analyzer (PDA) testing can be used as an alternate or supplemental test method to static load tests for the determination of pile capacity. This method involves installing instruments on the pile head with accelerometers and strain gauges, then impacting the pile head using a pile driving hammer or similar device over a very short period of time (3-4 milliseconds). The impact imparted on the pile should be sufficient to fully mobilize the pile skin friction and end bearing resistances of the pile. In general, this requires that a net permanent set per blow of at least 3 mm (and not greater than 8 mm) be achieved upon impact from the pile hammer.

PDA testing can be conducted on either driven or cast-in-place piles. For driven piles, the PDA test shall be conducted at the end of the initial driving stage, such that the end bearing and skin friction resistances can be determined upon initial installation of the pile. Where time dependent changes in the soil conditions are anticipated, such as pile setup or relaxation, additional tests shall be conducted upon re-strike on a sample of previously tested piles to determine the bearing parameters after driving induced pore pressures have dissipated. The re-strike should be conducted approximately one to two weeks or longer after initial driving, as directed by the Consultant. It is permissible to initially drive piles to a capacity below the required ultimate capacity and rely on pile setup to produce the required capacity. Where the capacity of the pile at re-strike is relied upon for design, a minimum of one third of piles tested during initial drive should be tested again during re-strike.

If dynamic testing is only undertaken upon re-strike, then a minimum of 10% to 15% of all piles shall be PDA tested on re-strike.

The hammer energy used during PDA tests at the end of initial drive and during re-strike driving shall be such that the required ultimate pile capacity can be mobilized in a single blow without additional data interpretation.

For cast-in-place piles, the PDA test should be conducted at least one week after the installation of the pile, as directed by the Consultant.

The results of the test can be processed in the short term using the Wave Equation Analysis of Piles (WEAP) method to provide real time monitoring of pile stresses, pile integrity, hammer performance, and pile capacity; and in some cases can be used to confirm pile termination depths when borehole information is not available. This method should only be used as an initial determination of bearing capacity though, and where the test is being used to determine the capacity of the pile for design methods, a signal matching analysis using a Case Pile Wave Equation Program (CAPWAP) should be utilized.

To ensure good quality data resulting from the PDA test, ASTM D4945 should be followed. In addition, at least two accelerometers on a driven pile and four accelerometers on a cast-in-place

pile should be installed. All accelerometers and transducers should be calibrated and inspected to ensure proper attachment to the pile.

Since the PDA test method indirectly calculates the load and settlement characteristics of the pile based on strain and acceleration measurements, PDA testing is deemed secondary in accuracy to Static Load Tests. As a result, where the PDA methods are used strictly as a QA/QC tool, a minimum of 5% to 10% of production piles should be monitored dynamically. When used as a design or confirmatory tool, a minimum of 10% to 15% of piles (including tests at such substructure associated with the project or where soil conditions are expected to vary) should be tested, or as required for statistic validation of a LRFD design whichever is greater. The piles selected for testing should be representative of other piles in the same structure. Where driven piles exhibit lower driving resistances and/or shorter penetrations than normal, or where cast-in-place piles experience extraneous soil, ground water, and/or installation conditions, additional tests over and above minimum number of tests specified earlier may be required. Further, additional tests should accompany changes in piling equipment, procedure and pile requirements.

In the situation where one pile in a pile group does not meet capacity requirements, additional tests may be necessary to confirm that this pile is an isolated case. In such case, it may be permissible to rely on group effects to compensate for the lower pile capacity. The geotechnical and structural consultants will have final say in this situation. Under no circumstances will superposition of axial and shaft capacity from different strikes, re-strikes or any combination thereof be permitted.

Where sufficient dynamic load testing has been done to satisfy Limit State Design, LRFD or reliability-based design statistical requirements, the geotechnical resistance factor for design of pile foundations may be taken as 0.5.

Pile driving equipment shall be sized such that piles can be driven with reasonable effort to the specified ultimate bearing capacity, without damaging the pile. Approval of the pile driving equipment by the Consultant will be based on the WEAP analysis and/or PDA testing. The Contractor shall submit details of the proposed pile driving equipment for review by the Consultant a minimum of 14 days prior to the commencement of pile installation. The information provided shall include the following:

- Hammer Data: Hammer type, manufacturer, model number, serial number, maximum rated energy and range in operating energy, stroke at maximum rated energy and range of operating stroke, ram weight, modifications.
- Striker Plate Data: weight, diameter, thickness, composition
- Hammer Cushion Data: Manufacturers, area, thickness per plate, number of plates, total thickness, and composition
- Helmet Data: Weight, composition
- Pile Cushion Data: Material, area, thickness per sheet, number of sheets, total thickness of cushion

The PDA testing agency shall prepare a daily field report summarizing the preliminary test results including driving stresses, transferred energy and estimated pile capacity to the

Consultant within 24 hours of testing. The final test results shall be presented to the Department within 7 days of testing. The testing report shall be prepared in accordance with the requirements of ASTM D4945-08. As a minimum, the report shall include the following:

- Pile and driving system information
- Pile installation data
- PDA testing equipment and procedure
- Energy imparted
- Maximum driving stresses
- Hammer blow rate
- CAPWAP input parameters including quake and damping factors
- Shaft friction, end bearing and total pile capacity

The Consultant will use the test results to determine the subsequent termination criteria, requirements for modification of driving procedures or equipment, and pile acceptance. Any work done on the foundation elements (pile caps, cut-off, welding, etc) prior to received approval of test results from the Consultant will be at the Contractor's own risk.

3.6.3 Measurement and Payment

When the contract contains a bid item for **Static Load Testing**, payment will be made at the unit price bid and will be full compensation for static load testing and all labour, equipment, tools and incidentals to complete the work.

When the contract contains a bid item for **Dynamic Load Testing/Pile Driving Analyzer (PDA) Testing**, payment will be made at the unit price bid and will be full compensation for dynamic load testing and PDA testing, pile set up for re-strike, pile re-striking and all labour, equipment, tools and incidentals necessary to complete the work.

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 4

CAST-IN-PLACE CONCRETE

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Drawing No.

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ATTACHMENTS

- Concrete Test Results - Blank Form
- Concrete Test Results - Form Completion Example
- Concrete Test Results - Suggested Concrete Cylinder Coding Identification Labels

4.1 General

This specification prescribes the quality requirements, the sampling and testing of the materials and concrete, the methods of producing and handling the constituent materials, the batching, mixing, handling, transporting, placing and curing as outlined, which constitute good and acceptable construction practice in structural and similar work. The Contractor shall supply all necessary materials.

Where Standards and Standard Specifications are referred to, the version current at time of tendering shall govern. Metric versions are inferred, when available and relevant.

4.2 Materials

Concrete shall consist of hydraulic cement, aggregates, water and admixtures or additives which shall conform to the requirements as specified below:

Hydraulic Cement - Hydraulic cement shall conform to the requirements of CSA Standard A 3001. General Use (Normal) Type GU, or High Sulphate Resistant Type HS, or HSb shall be supplied unless otherwise specified.

As an alternative to Type HSb cement, concrete intended for placement in sulphate environments may be produced with combinations of Type GU cement and supplementary cementing materials provided current CSA A3004-C8 test data demonstrating compliance with CSA A3001 requirements for high sulfate resistance.

Silica Fume - Condensed silica fume shall conform to the requirements of CSA Standard A 3001 for a Type SF supplementary cementing material, with a SiO₂ content of at least 85%, a maximum loss on ignition of 10% and no more than 1% SO₃ content.

Fly Ash - All fly ash shall conform to the requirements of CSA Standard A3001 for Type F fly ash with a maximum calcium oxide (CaO) content of 12%.

Water - Water to be used for mixing concrete, approved patching products, or concrete finishing materials, shall conform to the requirements of CSA Standard A23.1 and shall be free from harmful amounts of alkali, organic materials or deleterious substances. The Contractor shall not use slurry water, treated wash water or water from shallow, stagnant or marshy sources.

Aggregates - Fine and coarse aggregates shall conform to the requirements of CSA Standard A23.1 and shall be stockpiled separately.

Admixtures - Admixtures shall be compatible with all mix constituents. Water reducing agents and superplasticizers shall conform to ASTM C494. The addition of calcium chloride, air-reducing agents or accelerators will not be permitted. Air entraining agents shall conform to ASTM C260.

The use of hydration stabilizing admixtures requires prior written acceptance of the Department and Consultant and their usage is limited to those projects where haul times are expected to exceed the specified times and/or projects which require hydration stabilization due to structural considerations. Hydration stabilizing admixtures shall meet ASTM C494 requirements for

Type D water reducing and retarding admixtures.

Steel Fibres - When specified, steel fibres shall be Novocon XR, Wiremix W50 or an acceptable equivalent. The fibres shall conform to ASTM A820/A820M-04 Type 1 or 5 and be 50 mm in length with the aluminum content no more than 0.020% by mass, when tested in accordance with test method Environmental Protection Agency (EPA) 3050B.

4.3 Storage of Materials

Cement, silica fume, fly ash and steel fibres shall be stored in a suitable weather-tight building which shall protect these materials from dampness. Cement, silica fume and fly ash shall be free from lumps at all times during their use in the work. The steel fibres shall be free from balls and clumps at all times during their use in the work.

All aggregates shall be handled so as to prevent segregation and to obtain uniformity of materials. The separated aggregates, and aggregates secured from different sources, shall be piled in separate stockpiles. The site of the stockpiles shall be cleaned of all foreign materials and shall be reasonably level and firm. If aggregates are placed directly on the ground, material shall not be removed from the stockpile within 150 mm of the ground level. This material shall remain undisturbed to avoid contaminating the aggregate being used with the ground material.

4.4 Class and Composition of Concrete

4.4.1 Class of Concrete

Class of Concrete ⁽⁴⁾	Minimum Specified Compressive Strength at 28 Days (MPa)	Nominal Maximum Aggregate Size (mm)	Range of Slump ⁽⁶⁾ (mm)	Total Air Content ⁽⁵⁾ (%)	Max. Water/Cementing Materials Ratio
C	35	20 to 5 ⁽¹⁾	100 ± 30	5 - 8	0.40
HPC ⁽³⁾	45	20 to 5 ⁽²⁾	120 ± 30	5 - 8	0.38
D	30	14 to 5	100 ± 30	5 - 8	0.42
S	20	28 to 5	100 ± 30	4 - 7	0.50
Pile	30	28 to 5	130 ± 30	4 - 7	0.42

Notes

1. The size of coarse aggregate shall be 28 to 5 mm for Class C concrete when used in mass pours such as piers and abutments.
2. When the thickness of deck overlay concrete is specified as 50 mm or less, the nominal maximum top size of aggregate shall be 14 mm.
3. Class HPC concrete shall be used for all decks, deck overlays with internal reinforcement, curbs, barriers, medians, roof slabs, approach slabs and MSE wall coping. Deck overlay concrete shall be Class HPC with steel fibres when no internal reinforcement exists.

4. The fly ash shall not exceed 30% by mass of cementing materials. For High Performance Concrete (HPC) it shall be in accordance with 4.4.2. Fly ash may be used in concrete mixes where the aggregate is assessed to be potentially alkali-silica reactive.
5. Range in air content to be in compliance with actual maximum aggregate size as per CSA A23.1 Table 4.
6. Slump ranges proposed by the Contractor that are outside those specified require acceptance from the Department.
7. For MSE Wall panels, smaller aggregate may be required to suit panel design.
8. Additional requirements for Class HPC and Class HPC with Steel Fibres are listed in Section 4.4.2.

4.4.2 Class HPC and Class HPC with Steel Fibres

- (a) Mix shall include silica fume and fly ash as supplementary cementing materials in combination with compatible air entraining, water reducing and/or superplasticizing admixtures, as required.
- (b) The gradation limits for the fine aggregate shall conform to CSA A23.1, except that the amount of material finer than 160 μm shall not exceed 5%.
- (c) Coarse aggregate shall conform to CSA A23.1 and the maximum combination of flat and elongated particles (4:1 ratio), as determined by CSA A23.2-13A, shall not exceed 10% of the mass of coarse aggregate.
- (d) Minimum cement content (excluding supplementary cementing materials) shall be 335 kg/m^3
- (e) Sum of silica fume and fly ash by mass of cementing materials shall be 17% to 20%.
- (f) Silica fume by mass of cementing materials shall be 6% to 8%.
- (g) Fly ash by mass of cementing materials shall be 11% to 15%.
- (h) Resistance to chloride ion penetration shall be determined in accordance with ASTM C1202 on duplicate laboratory moist cured samples at 28 days. The average of all tests shall not exceed 1000 coulombs with no single test greater than 1250 coulombs. When only two test values are used to calculate the average coulomb rating, no test shall exceed 1000 coulombs. For HPC with steel fibres, testing shall be done without the presence of steel fibres.
- (i) An air-void spacing factor shall be determined in accordance with ASTM C457, modified point-count method at 100 times magnification. The average of all tests shall not exceed 230 μm with no single test greater than 260 μm . When only two test values are used to calculate the average air-void spacing factor, no test shall exceed 230 μm .
- (j) When Class HPC with steel fibres is specified, it shall contain 60 kg of 50 mm long steel fibres, per m^3 . The Contractor shall provide test results of the aluminum content in the steel fibres, for the consultants review, a minimum of two weeks prior to placing concrete at site. When alternative steel fibres are proposed their equivalency and dosage rate

shall be determined in accordance with ASTM C1609. The toughness (T_{600}^D) shall be greater than or equal to that determined for the specified fibre type and dosage rate.

4.4.3 Temperature

The concrete temperature shall be between 10°C and 20°C at discharge for Class HPC and Class HPC with steel fibres. The concrete temperature at discharge shall be between 10°C and 25°C for all other classes of concrete.

4.4.4 Concrete Mix Design and Aggregate Testing

The Contractor shall submit a concrete mix design for each class of concrete including applicable material test reports for the Consultant's review a minimum of two weeks before concrete placement. A concrete mix design and material test reports are not required for concrete used in the construction of culvert collars or cut-off walls when culverts are less than 3 metres in diameter.

The sampling and testing of aggregates shall be completed by a concrete testing laboratory certified to CSA A283. Concrete mix designs, including the review of all material test reports, shall be signed and sealed by a Professional Engineer registered in the Province of Alberta employed by a concrete testing laboratory certified to CSA A283. The Engineer shall also provide a professional opinion indicating that the concrete mix is suitable for the intended use and can be expected to meet specification requirements.

Alternatively, concrete mix designs, including the sampling and testing of aggregates and review of material test reports may be completed by a qualified professional employed by the concrete supplier. When the concrete mix design is completed by the concrete supplier it shall be reviewed for compliance with the respective specifications, signed and sealed by a Professional Engineer registered in the Province of Alberta employed by an independent concrete testing laboratory certified to CSA A283. The independent review Engineer shall also provide a professional opinion indicating that the concrete mix is suitable for the intended use and can be expected to meet specification requirements.

Material test reports shall be current and fully represent materials to be used in production. For each mix design submission the source(s) of proposed aggregate(s) and following aggregate analysis shall be provided:

Aggregate Analysis	Standard	Required Frequency of Analysis (maximum days prior to production)
Fine and Coarse Aggregate Sieve	(CSA A23.2-2A)	90
Amount of material finer than 80 µm in aggregate	(CSA A23.2-5A)	90

Aggregate Analysis	Standard	Required Frequency of Analysis (maximum days prior to production)
Organic Impurities in Sands for Concrete	(CSA A23.2-7A)	90
Results of deleterious substances and physical properties of aggregates	(Table 12, CSA A23.1; A23.2-3A, A23.2-4A, A23.2-23A, A23.2-24A A23.2-29A)	180
Potential expansivity of aggregates	(CSA A23.2-14A)	24 months
Detection of alkali-silica reactive aggregate by accelerated expansion of mortar bars	(CSA A23.2-25A)	12 months
Petrographic Examination of Coarse Aggregate for Concrete	(CSA A23.2-15A)	180

Additional analyses shall be provided by the Contractor when requested by the Consultant to confirm that the mix constituents continue to meet specification requirements. A break in production of a particular class of concrete shall not constitute the need for additional testing when the Contractor provides conclusive evidence that the material initially tested is still representative.

If the fine aggregate consists of a blend from more than one source, the "Fine Aggregate Sieve" analysis shall show the gradation of the blended fine aggregates. Similarly in the case of blended coarse aggregates, the "Coarse Aggregate Sieve" analysis shall indicate the gradation of the blended coarse aggregates.

Fine aggregate, tested in accordance with CSA Test Method A23.2-7A, "Organic Impurities in Sands for Concrete", shall produce a colour not darker than the Standard colour (Organic Plate Number 3). Aggregate producing a colour darker than the Standard colour will be rejected in the absence of a satisfactory record of performance of a similar class of concrete (minimum 30 tests over the last 12 months); provisions 4.2.3.3.2 (a) & (b) of CSA Standard CAN3-A23.1-04 shall not apply. Ironstone content in fine aggregate (material retained on the 2.5 mm sieve) shall not exceed 1.5% by total dry mass of fine aggregate for all classes of concrete except pile concrete.

The potential for deleterious alkali-aggregate reactivity shall be assessed in accordance with CSA A23.2-27A. This assessment shall include the risk level associated with structure size and environment, the level of prevention related to service life requirements and the determination of

the appropriate preventative measures, including testing in accordance with CSA A23.2-28A. For bridge structures, the design service life is considered to be 75 years. Current test data evaluating the potential alkali-silica reactivity of aggregates tested in accordance with CSA A23.2-14A or CSA A23.2-25A is required. In the absence of current test data, the aggregate shall be presumed to be highly reactive.

Petrographic analysis on the proposed coarse aggregates shall be performed in accordance with CSA A23.2-15A by experienced personnel employed by a laboratory certified to CSA A283. The (weighted) petrographic number shall not exceed 130, and the ironstone content shall not exceed 0.8%. The Petrographic analysis report shall be signed and sealed by either a Professional Engineer, a Professional Geologist, or a Geological Engineer who is registered in the Province of Alberta.

4.4.5 Trial Batches

The Contractor is required to complete trial batch(es) for Class HPC, Class HPC with Steel Fibres, and/or any class of concrete containing hydration stabilizing admixtures. The Contractor shall produce evidence satisfactory to the Consultant that the proportions selected will produce concrete of the quality specified. The trial batch(es) shall be performed a minimum of 35 days prior to placement of concrete at site. Each trial batch shall be a minimum of 3 m³ or 50% of the rated mixer capacity (whichever is greater). For multi-year projects, all trial batch testing shall be repeated in conjunction with required aggregate testing.

(a) Class HPC and Class HPC with Steel Fibres

Slump retention shall be evaluated at 15, 30, 50, and 70 minutes after batching. At 70 minutes from the time of batching, samples shall be cast to determine compressive strength at 7 and 28 days, rapid chloride ion penetration, and hardened air void system in accordance with the requirements of Section 4.4.2. Shrinkage of the trial batch concrete shall be measured in accordance with CSA A23.2-21C. Shrinkage test results shall be submitted to the Consultant within seven days of test completion.

(b) Hydration Stabilized Concrete Mixes

The design length of hydration stabilization shall be the difference of the project haul time and the specified allowable haul time (not exceeding 90 minutes) or that required by structural considerations. The hydration stabilized mix design, including a detailed concrete batching procedure, shall be submitted and reviewed in accordance with Section 4.4.4. Hydration stabilized concrete mixes demonstrating significant inconsistencies, as determined by the Consultant, shall require additional trial batch testing to demonstrate compliance.

The time of initial and final set, compressive strength at 3, 7, and 28 days and hardened air void system shall be determined. Hardened air void systems shall meet the requirements of Section 4.4.2 (i). Slump retention shall be assessed at 15 minutes after batching, quarter points of the design hydration stabilization period and 30 minutes prior to the anticipated initial set. Trial batch(es) of Class HPC and Class HPC with steel fibres shall also meet the requirements for rapid chloride permeability and submission of

shrinkage test results to the Consultant within seven days of test completion.

4.4.6 Mix Adjustments

If during the progress of the work the initial approved mix design is modified or found to be unsatisfactory for any reason the Contractor shall resubmit a revised mix design, in accordance with the requirements of Section 4.4.4, to the Consultant for review and acceptance prior to continuing concrete operations.

4.5 Measurement of Materials

Coarse and fine aggregate materials shall be separated and measured separately by weighing, except as otherwise specified or where other methods are specifically authorized by the Consultant. The apparatus provided for weighing the aggregates and cement shall be suitably designed and constructed for this purpose. Each size of aggregate, and the cement, shall be weighed separately. The accuracy of all weighing devices shall be such that successive quantities can be measured to within one percent of the desired amount. The mixing water shall be measured by volume or by weight. The water measuring device shall be capable of control accurate to $\pm 0.5\%$ of the design quantity. All measuring devices shall be subject to acceptance. Unless otherwise accepted, air entraining agent and other admixtures shall be added to the mix in a water-diluted solution; the dilution of the solution shall be accepted by the Consultant. For mix adjustments at the site, the Contractor shall maintain facilities to control the amount of superplasticizer and air entrainment so that the required tolerances can be met.

4.6 Mixing Concrete

4.6.1 General

Mobile continuous mixers or other such volumetric concrete supply equipment shall not be used.

All concrete shall be mixed thoroughly with all ingredients uniformly distributed. The Consultant may require that the uniformity of the mixed concrete be tested for conformance with CSA A23.1, Clause 5.2.3.5. The "Batch" is considered as the quantity of concrete inside the mixer regardless of size of the mixer. The mixing period shall be measured from the time materials enter the mixing drum.

The Contractor shall in no case load the mixer above its rated capacity. The Contractor shall maintain the mixer in good condition. Inner surfaces of the mixer shall be kept free of hardened concrete and mortar. Mixer blades which are bent or worn down so as to affect the mixing efficiency shall be renewed. Any mixer, leaking mortar or causing waste of materials through faulty charging shall be taken out of service until repaired. The Contractor shall, at all times, operate the mixer at the speed recommended by the Manufacturer and shall, if requested, supply the Manufacturer's certification of the mixing capacity of the machine in use.

The mixer shall be fitted with an accurate and dependable means for measuring the water added, which is not affected by variation in pressure in the water supply line. All joints, valves and other parts shall be maintained so that there is no leakage of water into the mixer drum.

Failure of the Contractor to have an accurately working and dependable water gauge on a mixer shall be cause for the Consultant to prohibit the mixer to be used.

Water shall be released first and continue to flow while other materials are entering the mixer. The water discharge pipe shall be so arranged and be of such size that the flow into the mixer is completed within the first quarter of the mixing time, and the water is delivered well within the mixer where it will be quickly mixed with the entire batch.

Air entraining agents and admixtures shall be placed in the mixer after the initial water is in the mixer drum but before the remaining materials are added. Superplasticizer shall be added after initial mixing and as per the Manufacturer's recommendation.

4.6.2 Truck Mixing

Truck mixers, unless otherwise authorized by the Consultant, shall be of the revolving drum type, watertight, and so constructed that the concrete can be mixed to ensure uniform distribution of materials throughout the mass. All materials for the concrete shall be accurately measured in accordance with Section 4.5, and charged concurrently into the drum at the production plant, at the proportions satisfying the accepted mix design. Increases in the water to cementitious materials ratio will not be permitted.

Maximum size of the batch in truck mixers shall not exceed the maximum rated capacity of the mixer as stated by the manufacturer and stamped on the mixer. Truck mixing shall commence immediately upon introduction of ingredients into the drum and be continued for at least 70 revolutions with the mixing rate being in accordance with the Manufacturer's recommended rate, and shall be such as to thoroughly mix the concrete.

When adjustment to the mix by adding air entraining agent or superplasticizer at the site is authorized by the Consultant, the mixer shall rotate for a minimum of 70 additional revolutions to ensure homogeneity of the concrete before discharge. Discharge chutes shall be kept clean and free from hardened concrete and shall be wetted down prior to use.

4.6.3 Time of Hauling

The maximum time allowed for all classes of concrete other than Class HPC and Class HPC with steel fibres including delivery to the site of the work and discharge shall not exceed 90 minutes after batching. Batching of all classes of concrete is considered to occur when any of the mix ingredients are introduced into the truck mixer drum, regardless of whether or not the drum is revolved. For Class HPC and Class HPC with steel fibres this requirement is reduced to 70 minutes. In hot weather, or under conditions contributing to quick setting of the concrete, these haul times may be reduced as determined by the Consultant and such deviations will be addressed in the Special Provisions.

4.7 Delivery

The Concrete supplier shall have sufficient plant capacity and satisfactory transporting equipment to ensure continuous delivery at the rate required. The rate of delivery of concrete during concreting operations shall be such that the development of cold joints does not occur. The methods of delivering and handling the concrete shall facilitate placing with a minimum of

re-handling, and without damage to the structure or the concrete.

4.8 Pour Schedules

The Contractor shall inform to the Consultant of the proposed pour schedule for any particular pour. If in the opinion of the Consultant the amount of pour is deemed larger than can be poured with the methods proposed, the Contractor shall either:

- (a) Limit the amount to be poured at any time (using adequate construction joints), or
- (b) Augment his facilities in order to complete the proposed pour, or
- (c) In case of continuous pouring, provide additional crews and have adequate lighting to facilitate proper placing, finishing and inspection.

4.9 Inspection and Testing

The Consultant shall be afforded full facilities for the random quality assurance inspection and testing that may be carried out relative to the concrete itself and/or the constituent materials. This includes at the worksite and any plant used for the manufacture of concrete wherever this may be situated. The facilities shall be adequate in the opinion of the Consultant to permit proper sampling of concrete, making of test cylinders and testing slump and air content. The proper storage of all site cast concrete cylinders in accordance with the relevant specifications is the responsibility of the Contractor.

The results of the quality assurance testing carried out by the Consultant will serve to monitor and review the quality control program of the Contractor.

The Contractor shall utilize ACI or CSA certified testers with extensive related experience to test at site, the air content, density, slump and temperature of each batch; results of all such tests shall be provided to the Consultant. Additional tests will be required if the results are borderline or widely variable. In case of an unacceptable result, one check test will be permitted. The certified testers shall also cast the test cylinders as specified in section 4.9.3 "Test Cylinders".

The certified testers shall utilize the "Concrete Test Results" form contained at the end of this section. The completed forms shall accompany the concrete test cylinders to the testing laboratory.

The certification of the testers shall be current and available for examination by the Consultant.

4.9.1 Strength Tests

A "Strength Test" shall consist of the compression tests of four standard test specimens, sampled, made, cured, and tested in accordance with CSA Standard Specifications and as modified herewith. One cylinder shall be tested at seven days. The 28 day test result shall be the average of the strengths of the remaining three specimens, except that if any specimen in a test showing distinct evidence of improper sampling, moulding or testing, shall be discarded and the remaining strengths averaged. Additional cylinders may be cast, at the discretion of the Consultant or Contractor.

For Class HPC and Class HPC with steel fibres, the Contractor shall take a strength test to represent each approximate 20 m³ portion of the concrete pour, to a minimum of one strength test for every two batches of concrete. For all other concrete, the Contractor shall take a strength test to represent each bridge element or portion of the element (i.e. abutment seat, abutment backwall, pier footing, pier cap etc.). On larger pours, a strength test will be taken to represent each approximately 30 m³ portion of the concrete pour, to a minimum of one strength test for every three batches of concrete. Such tests shall be taken from representative batches as determined by the Consultant.

4.9.2 Sampling

Sampling of concrete shall be carried out in accordance with CSA Standard A23.2-1C. When a concrete pump is used to place concrete, sampling shall be at the end of the discharge hose with the exception that when concrete is being placed underwater by tremie methods, sampling may occur at the pump's hopper.

4.9.3 Test Cylinders

Making and curing concrete test cylinders shall be carried out in accordance with CSA Standard A23.2-3C, except that the time for cylinders to reach the testing laboratory shall be between 20 and 48 hours. The test cylinders shall be cast by the Contractor in standard CSA approved heavy duty steel or plastic moulds. Plastic moulds shall have a wall thickness of at least 6 mm. The Contractor shall provide properly designed temperature-controlled storage boxes for test cylinders, as specified in Section 8.3.2.1 of CSA Standard A23.2-3C, for a period of at least 24 hours, and further protection, as required, from adverse weather and mishandling until removed from the site. The Contractor shall provide a max-min thermometer for each storage box and record site curing temperatures for all test cylinders. Storage in a portable building which will be used by Contractor's personnel or the Consultant during the first 24 hour storage period will not be permitted. Storage facilities shall be provided, installed, and accepted by the Consultant before any concrete is placed.

The Contractor shall be responsible to deliver the test cylinders to an independent CSA certified testing laboratory. Handling and transporting of the cylinders shall be in accordance with CSA Standard A23.2-3C. No extra laboratory curing time will be allowed for cylinders that are delivered late to the laboratory. For Class HPC and HPC with steel fibres, the ends of cylinders shall be ground flat prior to testing. A copy of the test results shall be forwarded to the Consultant and Concrete Producer within 2 days of the break date.

If the test cylinders exhibit frost etchings or were stored at temperatures below 10°C or above 25°C, or are otherwise mishandled resulting in unreliable strength test results, the Department or Consultant may reject these portions of the Work, unless core-testing, at the Contractor's expense confirms the in-situ strength of the concrete.

The Contractor shall be responsible for all costs for concrete testing, including but not limited to making and curing test cylinders, transporting cylinders to an independent certified testing laboratory of his choice, storage, curing, strength testing, and providing written reports of the concrete test results to the Consultant.

The Contractor shall also be responsible for costs for supplying CSA approved heavy duty steel

or plastic moulds, curing and delivering test cylinders cast by the Consultant, for quality assurance purposes to the same independent certified testing laboratory that he selects. Quality assurance testing may be carried out by the Consultant and costs for testing and provision of concrete test cylinder reports will be paid for by the Department.

4.9.4 Slump

Slump tests shall be conducted in accordance with CSA Standard A23.2-5C.

4.9.5 Air Content and Density

Air content and density tests shall be conducted in accordance with CSA Standard A23.2- 4C and A23.2-6C respectively.

4.9.6 Testing Cylinders

Test cylinders will be tested in compression in accordance with CSA Standard A23.2-9C by an independent CSA certified engineering laboratory engaged by the Contractor.

4.9.7 Failure to Meet Slump or Air Content Specifications

In the event that slump and/or air content are outside the specified tolerance range, as determined by the Contractor's or the Consultant's testing, the Consultant may, accept adjustments of the deficient condition as an alternate to rejection provided adjustments are made within the maximum time allowed as specified in section 4.6.3 "Time of Hauling". Concrete that does not meet the specifications will be rejected after the maximum time is exceeded.

The Contractor will be allowed to adjust only the quantities of superplasticizer and air entraining agent. In no case shall an accepted batch adjustment relieve the Contractor of his responsibility for the eventual durability, strength, and acceptability of the concrete concerned. The Department or Consultant reserves the right to reject any batch in the event of confirmed unacceptability, and to require immediate removal of any rejected concrete which might have already been placed in the structure.

4.10 Falsework and Formwork

4.10.1 General

Detailed falsework and formwork drawings shall be supplied to the Consultant for review and examination as to concept only. The drawings shall be submitted three weeks before construction commences. The drawings shall bear the Seal of a Professional Engineer registered in the Province of Alberta, who shall assume full responsibility to ensure that his design is being followed in construction of the falsework and formwork. Compliance with the Occupational Health and Safety Act and Regulations therein, shall be integral parts of the design. All falsework and formwork shall be fabricated in accordance with the drawings.

The Contractor shall make every effort to accurately position formwork against hardened concrete so as to avoid form lines and discontinuities at the construction joint. Construction

tolerances for formwork misalignments are outlined in Section 4.25.8.

4.10.2 Design

For the design of falsework and formwork, the density of fresh concrete shall be assumed to be 2400 kg/m³. All forms shall be of wood, metal or other acceptable materials, and shall be designed and built mortar-tight and of sufficient rigidity to prevent distortion due to the pressure of vibrated concrete and other loads incidental to the construction operation. The forms shall be substantial and unyielding, and shall be designed so that finished concrete will conform to the design dimensions and contours. The shape, strength, rigidity, water tightness and surface smoothness of re-used forms shall be maintained at all times. Any warped or bulged formwork must be repaired or replaced before being used. Forms which are unsatisfactory in any respect shall not be used.

All falsework shall be designed and constructed to provide the necessary rigidity and to support the loads without appreciable settlement or deformation. Falsework which cannot be founded on a satisfactory footing shall be supported on piling which shall be spaced, driven and removed in a manner acceptable to the Consultant.

For timber formwork, drawings shall specify the type and grade of lumber and show the size and spacing of all members. The formwork drawings shall also show the type, size and spacing of all ties or other hardware, and the type, size and spacing of all bracing.

When forms appear to be unsatisfactory in the opinion of the Consultant, either before or during the placing of concrete, the Consultant will order the work stopped until the defects have been corrected.

For narrow walls and columns, where the bottom of the form is inaccessible, removable panels shall be provided in the bottom form panel to enable cleaning out of extraneous material immediately before placing the concrete.

4.10.3 Forms for Exposed Surfaces

Forms for exposed surfaces which require a Class 1 "Ordinary Surface Finish" shall be made of good quality plywood, or an acceptable equivalent, of uniform thickness, with or without a form liner. Forms for exposed surfaces requiring a Class 2 "Rubbed Surface Finish" or Class 3 "Bonded Concrete Surface Finish" shall be all new material, made of "Coated Formply", consisting of Douglas Fir substrate with resin-impregnated paper overlay and factory treated chemically active release agent. "ULTRAFORM", or "POURFORM 107", are acceptable formwork panels, however other forming panels will be considered if approved equal. All form material for exposed surfaces shall be full-sized sheets, as practical. The re-use of any forms must have the acceptance of the Consultant.

All forms for exposed surfaces shall be mortar-tight, filleted at all sharp corners, and given a bevel or draft in the case of all projections. At the top edges of exposed surfaces, the chamfers are to be formed by chamfer strips.

The minimum acceptable forming for all exposed concrete where the pour height is 1.5 m or less is 18 mm approved plywood supported at 300 mm maximum on centres. Where the pour

height is greater than 1.5 m, the minimum acceptable forming for all exposed concrete shall have 18 mm approved plywood, "Coated Formply", supported at 200 mm maximum on centres. The support spacing specified here assumed the use of new material. Closer spacing may be required in case of re-used material. Strong-backs or walers placed perpendicularly to the supports shall be employed to ensure straightness of the form.

Metal bolts or anchorages within the forms shall be so constructed as to permit their removal to a depth of at least 20 mm from the concrete surface. Break-back type form ties shall have all spacing washers removed and the tie shall be broken back a distance of at least 20 mm from the concrete surface. All fittings for metal ties shall be of such design that, upon their removal, the cavities which are left will be of the smallest possible size. Torch cutting of steel formwork hardware at concrete surfaces will not be permitted.

When plastic sleeves and removable inner rods are used, the plastic sleeve shall be removed for a distance of 100 mm from the face of the concrete except for curbs, barriers and medians where the entire plastic sleeve shall be removed. The cavity shall be filled with an approved non-shrink grout to 75 mm from the concrete surface and cured a minimum 24 hours. The remaining 75 mm of the cavity shall then be filled with an approved concrete patching material.

4.10.4 Forms for Unexposed Surfaces

The minimum acceptable forming for unexposed concrete shall have 15 mm plywood supported at 400 mm maximum on centres.

4.10.5 Standard Details

The Contractor shall use the standard details shown on Standard Drawings S-1411 "Standard Concrete Joints", S-1412 "Standard Construction Joints", and S-1443 "Deck Waterproofing".

4.10.6 Deck Formwork

Unless otherwise noted, diaphragms and girders will be designed in accordance with CSA-S6-06 Clause 3.16 for construction loads during casting of deck concrete. The loads assumed for such design will be shown on the Drawings. Where construction loads or loading conditions proposed by the Contractor vary from those shown, the Contractor shall be responsible for maintaining girder stability and alignment until the deck concrete has gained sufficient strength. Where required, deck formwork design shall include any additional bracing system to those shown on the Drawings. Care shall be taken in the design and installation of support brackets to avoid damage to girder flanges and webs. Where such brackets bear against girder webs, the girder webs shall be protected by timber or neoprene softeners. No drilling of additional holes or any other modifications including field welding shall be made to the superstructure elements. Effects of concentrated loads on thin webs shall be checked, and where necessary, sufficient means shall be provided to distribute or carry such concentrated loads to the supporting flanges or stiffeners.

Formwork hangers or ties for exposed surfaces of decks, including underside surfaces, shall be removable threaded type. No portion of the hardware associated with deck or deck overhang formwork shall be visible after all formwork has been removed. All cavities resulting from threaded rod removal along the underside of deck overhangs shall be adequately prepared and

filled with an approved concrete patching material. Deck overhang patches shall be placed level with adjacent surfaces and be similar in color and texture. For interior bays, all cavities resulting from threaded rod removal shall be filled with Sikaflex 15LM or an approved equivalent. The caulked surface shall be placed level with adjacent surfaces and be similar in color.

Formwork for decks, curbs, sidewalks, and parapets shall be fabricated so that the lines and grades shown on the Drawings are achieved. Girders will be erected to normally accepted industry standards of tolerance; however, it may be necessary to adjust the formwork to compensate for variances in girder dimensions, positioning, alignment, and sweep.

After girder elevations at the abutments, piers and splice locations have been reviewed and accepted by the Consultant and prior to commencing deck formwork, the Contractor shall profile all the girders at points corresponding to the camber diagram and determine the girder haunch dimensions required to achieve the specified gradeline. This information shall be provided to the Consultant for review and acceptance prior to commencing any deck formwork.

In the event that actual girder camber values vary significantly from the estimated values indicated on the drawings, the Consultant may require the Contractor to raise or lower the gradeline accordingly.

4.11 Protection of “Weathering” Steel Girders

Where steel girders are fabricated of “weathering” steel, it is essential that the uniformity of rust formation is not adversely affected by the Contractor's work.

The Contractor shall exercise utmost care and provide the necessary protection to prevent marking or staining of the girders. All joints between deck formwork and steel members (including interior girders, and diaphragms) shall be sealed to prevent leakage of cement paste or concrete. Caulking, duct tape, ethafoam, or any other suitable means or material, shall be used to achieve the seal.

Should foreign material spill onto the girders despite the protection provided, the Contractor shall clean off, wash, and sandblast the contaminated areas, to the satisfaction of the Consultant. Additionally, should the exterior face of an exterior girder become stained or marked, the entire exterior face of the girder line shall be lightly sandblasted and “weathered” so that uniformity of girder color, in the opinion of the Consultant, is achieved.

“Weathering” shall be achieved by repeatedly fogging the exterior girder faces with clean water and allowing them to dry. Fogging should leave the girders wet but not “running wet”, and should be repeated when the girders are completely dry.

The cost of sealing and stain-prevention shall be included in the unit price bid for the deck concrete; no separate or additional payment will be made for the cost of protecting the girders, nor for any cleaning, sandblasting or “weathering” made necessary by the Contractor's work.

4.12 Protection of Concrete Work and Bridge Components from Staining

The Contractor shall take precautions to protect all concrete work and bridge components from

staining. If staining occurs it shall be removed to the full satisfaction of the Consultant. Stained concrete surfaces that have received a Class 3 finish shall have the entire surface face of the component sandblasted and the Class 3 finish reapplied. Stained concrete surfaces that have received a Class 2 finish shall have the entire surface face of the component refinished. There shall be no trace of staining after the specified concrete finishing is completed.

4.13 Removal of Falsework, Forms and Housing

Forms and their supports shall not be removed without the acceptance of the Consultant. In determining the time for the removal of falsework, forms and housing, and the discontinuance of heating, consideration shall be given to the location and character of the structure, the weather and other conditions influencing the curing of the concrete, and the materials used in the mix.

The following guide for removal of forms and supports may be used if the temperature of the concrete is maintained at no less than 15°C:

<u>Portion of Work</u>	<u>Age or Minimum Strength</u>
Arches and girders	14 days or 80% of 28-day strength
Pier caps and beams	5 days or 50% of 28-day strength
Columns	1 to 3 days
Decks & Slabs	5 days or 50% of 28-day strength
Vertical faces less than or equal to 3 m in height	12 to 24 hours
Vertical faces over 3 m in height	2 days

Supports and forms may be removed from arches, girders, deck, pier caps and beams earlier than the minimum curing periods specified above, with the Consultant's acceptance. In seeking acceptance the Contractor shall, at his own expense, furnish evidence satisfactory to the Department and Consultant that the strength of the concrete in place has attained the above noted percentage of the specified 28-day strength before removal.

Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight.

All formwork must be removed from the completed structure. For certain special situations, formwork may remain in place, when the Contractor's formal request is approved by the Consultant and Department.

4.14 Handling and Placing Concrete

4.14.1 General

The Contractor shall give the Consultant a minimum of two days advance notice of a concrete pour date or a change to a pour date.

The method of concrete placement shall have a consistent, minimal impact on the concrete properties. All equipment proposed for use in mixing, conveying, placing and compacting the concrete shall be reviewed and accepted by the Consultant prior to its use. All the necessary equipment for any particular pour shall be on site and proven to be in working condition before

the pour commences, with backup equipment on site as determined by the Consultant. The equipment shall be well maintained, suitable for the intended purpose and adequate in capacity for the work.

In preparation for the placing of concrete, all sawdust, wood chips and other construction debris and extraneous matter shall be removed from the interior of forms. Struts, spreaders, stays, and braces, serving temporarily to secure the forms in correct shape and alignment, pending the placing of concrete at their locations, shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. These temporary members shall be entirely removed from the forms and not buried in the concrete.

Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. When placing operations consist of free dropping concrete more than 1 m, it shall be deposited by concrete pump, metal or plastic chutes or other means acceptable to the Consultant.

Concrete for the structure shall be deposited in the forms in the order indicated on the drawings, and each portion placed between construction joints shall be placed in one continuous operation. No other order of pouring shall be done unless otherwise accepted by the Consultant.

Concrete placing operations shall not work off, or transport concrete directly over concrete previously placed without the acceptance of the Consultant.

4.14.2 Consolidation

Concrete, during and immediately after depositing, shall be thoroughly consolidated. The consolidation shall be done by mechanical vibration subject to the following provisions:

- The vibration shall be internal unless special authorization of other methods is given by the Consultant, or the Consultant requests the use of other method(s).
- Vibrators shall be of a type and design acceptable to the Consultant. They shall be capable of transmitting vibrations to the concrete at frequencies of not less than 4500 impulses per minute
- The intensity of vibration shall be such as to visibly affect a mass of concrete of 25 mm slump over a radius of at least 0.5 m.
- The Contractor shall provide a sufficient number of vibrators to properly compact each batch, immediately after it is placed in the forms.
- Vibrator operators shall be suitably instructed in the use of vibrators, and the importance of adequate and thorough consolidation of the concrete.
- Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and imbedded fixtures and into the corners and angles of the forms. Vibration shall be applied at the point of deposit and in the area of freshly deposited

concrete. The vibrators shall be inserted vertically and withdrawn out of the concrete slowly. The vibration shall be of sufficient duration and intensity to thoroughly compact the concrete, but shall not be continued so as to cause segregation. Vibration shall not be continued at any point to the extent that localized areas of grout are formed. Application of vibrators shall be at points uniformly spaced and not farther apart than the radius over which the vibration is visibly effective.

- Vibration shall not be applied directly or through the reinforcement of sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibration. It shall not be used to make concrete flow in the forms over distances so great as to cause segregation, and vibrators shall not be used to transport concrete in the forms.
- Vibration shall be supplemented by spading as is necessary to ensure smooth and dense concrete along form surfaces and in corners and locations impossible to reach with the vibrators.
- Once vibrated the Contractor shall avoid disturbing concrete and shall not step into or add additional concrete after vibration.

4.14.3 Additional Requirements

When concrete placing is discontinued, for whatever reason, all accumulations of mortar splashed on the reinforcing steel and the form surfaces shall be removed. If the accumulations are not removed prior to the concrete becoming set, care shall be exercised not to injure or break the concrete-steel bond at and near the surface of the concrete, while cleaning the reinforcing steel.

Concrete shall be placed while fresh and before it has taken its initial set. Re-tempering of partially hardened concrete with additional water will not be permitted. Concrete that does not reach its final position in the forms within the time limits specified shall not be used.

After initial set of the concrete, the forms shall not be jarred or strain placed on the ends of projecting reinforcing bars.

Concrete which would be adversely affected by the presence of freestanding water shall be protected to prevent its occurrence, and the Contractor shall take whatever steps may be necessary to prevent free water build-up in the event of unexpected rainfall or similar occurrences for the first 24 hours.

Water used to keep equipment clean during the pour, or to clean equipment at the end of the pour, shall be discharged clear of the structure and water crossing.

4.14.4 Pumping

The operation of the pump shall produce a continuous flow of concrete without air pockets. The equipment shall be so arranged that the impact on the plastic air content of the concrete shall not vary by $\pm 0.5\%$ and that the freshly placed concrete is not damaged by any form of pump

vibration. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients.

4.15 Placing Pile Concrete

4.15.1 General

The Contractor shall make all attempts necessary to obtain a dry pile hole prior to placing pile concrete. If in the opinion of the Consultant and the Department that all attempts to achieve a dry pile hole have been taken and proven unsuccessful, placement of pile concrete under water will be required.

4.15.2 Concrete Placed in the Dry

Pile concrete shall be placed by means of a hopper equipped with a centre pipe drop tube. The pipe drop tube shall be a minimum of 200 mm in diameter and 2 m long. Concrete may be placed free fall, providing the fall is vertically down the centre of the casing or drilled hole and there are no transverse ties or spacers. Pile concrete shall have a slump range of 130 ± 30 mm at time of discharge. Concrete in the upper 3 m of the piles shall be consolidated by the use of an acceptable concrete vibrator.

4.15.3 Concrete Placed under Water

Placement of pile concrete under water shall be in accordance with Section 4.22 of this Specification and also with the following additional requirements:

Crosshole Sonic Logging

In order to test for voids or other abnormalities in the concrete, all drilled pile shafts cast under water shall be equipped with PVC or steel access tubes to permit inspection by Crosshole Sonic Logging (CSL). The Contractor shall submit the proposed method for the Consultant's review two weeks before beginning drilled pile work. The Contractor shall supply and install four 50 mm inside diameter tubes in each drilled pile with a diameter of 1.5 m or less and six tubes in each pile with a diameter of greater than 1.5 m.

Tubes supplied shall be round, have a regular internal diameter that is free from defects, obstructions and joints. Tubes shall be watertight, free from corrosion and have clean internal and external faces to ensure a good bond between the concrete and the tubes. Tubes may be extended with watertight mechanical couplings and all coupling locations shall be recorded. Tubes shall be installed by the Contractor in a manner that the CSL probes pass through the entire length of the tube without binding.

The Contractor shall fit the tubes with a watertight shoe on the bottom and a removable cap on the top. Tubes shall be secured to the interior of the reinforcement cage a minimum of every 1.2 m along the length of the pile. Tubes shall be installed uniformly and equidistantly around the circumference of the pile such that each tube is spaced parallel for the full length. Tubes shall extend to within 150 mm of the drilled shaft bottoms, and shall extend a minimum of 600 mm above the drilled shaft tops or where they are accessible. Tubes shall be capped to prevent debris from entering the access tubes.

The Contractor shall ensure that CSL tubes are not damaged during the installation of the reinforcement cage. If testing equipment does not pass through the entire length of the CSL tube, a 50 mm diameter core hole shall be drilled. Special care must be taken to avoid tube debonding between the concrete and the tubes. If tube debonding occurs, the Contractor shall core drill a 50 mm diameter hole to the depth of debonding for each debonded tube.

The Contractor shall make CSL measurements at depth intervals of 65 mm from the bottom of the tubes to the top of each pile. Upon completion of testing and acceptance of the pile concrete, the tubes shall be filled with an approved grout mix.

Qualification

The testing agency hired by the Contractor shall have a minimum of 3 years' experience in CSL testing and have a Professional Engineer registered in the Province of Alberta to assume responsibility for all testing at site and interpretation of results. The Contractor shall provide written evidence of completion of all CSL tests by the testing agency. The Contractor's submission shall also include personnel qualifications and descriptions of testing equipment.

CSL Results

The Contractor shall submit two original copies of the CSL report to the Consultant within 5 working days of completion of CSL testing. The report shall be signed and sealed by the CSL engineer and include test summaries, results, analyses, and an opinion of the pile concrete's suitability for intended use. Test summaries shall be in accordance with the criteria listed below:

Concrete Condition Rating Criteria

Rating	Velocity Reduction *	CSL Results
Good (G)	$\leq 10\%$	Good quality concrete
Questionable (Q)	$>10\% \ \& \ <20\%$	Minor contamination or intrusion Questionable quality concrete
Poor/Defect (P/D)	$\geq 20\%$	Defects exists, possible water/slurry contamination, soil intrusion and/or poor quality concrete
No Signal (NS)	No Signal Received	Soil intrusion or other severe defect absorbed the signal

* From highest measured signal velocity in the comparable zone

CSL test results with ratings other than "G" will be considered unacceptable and will result in rejection of the pile. In the event that the Contractor elects to carry out further investigation to prove the acceptability of the pile, the boundaries of any defective/unconsolidated zones shall be delineated by means of cross-hole tomography and supplemented with additional testing. Additional testing may include 3D tomographic imaging, single-hole sonic testing, sonic echo or impact response tests, or concrete coring.

The Consultant in consultation with the CSL engineer will determine the depth, location, diameter and number of core holes when concrete coring is required. If the Consultant is concerned about concrete strength or requires the use of a borehole camera for inspection, large diameter cores may be required. Minimum of two cores would be required to intercept the suspected defect zones.

The pile will not be considered acceptable until the Consultant and the Department has reviewed and accepted the report and determined if further remedial action is required. When the Consultant and Department determine a drilled pile is unacceptable, the Contractor shall submit a remedial action proposal with supporting calculations to the Department and the Consultant for review and acceptance. The remedial action shall be designed by the Contractor and signed and sealed by a Professional Engineer registered in the Province of Alberta. No compensation will be made for remedial work or losses or damages due to remedial work of drilled piles found defective or not in accordance with the Specifications.

Measurement and Payment

CSL will be considered incidental to the Work and no additional or separate payment will be made for procurement, conducting the CSL testing, reporting of results and incidentals necessary to complete the work including any other test required to determine the acceptability of the drilled pile.

4.16 Placing HPC Concrete and HPC Concrete with Steel Fibres

4.16.1 General

Concrete placing will not be permitted when the air temperature is below +5°C or above 25°C, in the event of rain or excessive wind or dust, or when there are other conditions judged by the Consultant to be harmful to the concrete. HPC concrete and HPC concrete with steel fibres shall be placed between the hours of 6:00 pm and 10:00 am of the following day, unless reviewed and accepted by the Department and Consultant. HPC concrete and HPC concrete with steel fibres shall not be placed when the evaporation rate exceeds 0.5 kg/m²/hr. The evaporation rate shall be determined using Figure D.1, of CSA A23.1 – Annex D. The rate of evaporation shall be recorded as concrete placing operations progress and the Contractor shall make all necessary adjustments to ensure the evaporation rate does not exceed the specified limit. Lighting is required for night pours and shall be reviewed and accepted by the Consultant. The temperature of the concrete during discharge shall be between 10°C and 20°C unless reviewed and accepted by the Consultant. The temperature of the mix shall be maintained below the 20°C maximum temperature by the inclusion of ice to the mix which shall not alter the design water-cementing materials ratio. Prior to placing concrete, substrate surfaces shall be brought to a saturated surface dry condition with clean water meeting the requirements of Section 4.2. Substrate surfaces shall be free of standing water.

The Contractor's project manager and field superintendent shall attend a pre-construction meeting at a location determined by the Consultant, prior to commencement of any site work.

All deck concrete and deck overlay concrete shall be consolidated in accordance with Section 4.14.2 even when vibratory drum type finishing machines are used.

Placing/Finishing Machines

For all deck concrete and deck overlay concrete, screeding shall be by concrete placing/finishing machines as follows or acceptable equivalents:

- Bidwell Models RF200, 364, 2450, 3600 and 4800
- Gomaco Models C450 and C750

The Contractor shall provide two work bridges, separate from the placing/finishing machine, of adequate length to completely span the width of the pour. The work bridges shall facilitate the operations of concrete finishing and placing of filter fabric and shall also be made available to the Consultant for straight-edge checking. The work bridges shall be supported essentially parallel to the concrete surface, between 250 mm and 600 mm above the concrete surface, and shall be at least 800 mm wide to permit diverse uses concurrently, and be rigid enough that dynamic deflections are insignificant.

4.16.2 Screed Guide Rails

Acceptable steel screed guide rails shall be installed to suit the profile of the required surface and to ensure a smooth and continuous surface from end to end of the bridge. Guide rails must be located outside of the finished surface of the pour for overlay and deck concrete, unless specified otherwise in the Special Provisions. Rails shall extend beyond the end of the bridge to accommodate finishing of the entire concrete surface with the deck finishing machine. All rails and supports shall be removed with minimal disturbance to the concrete.

4.16.3 Dry-Run

The finishing machine shall be set-up to match the skew angle of the bridge, when the skew angle exceeds 15°. For skewed bridge structures on vertical curves this requirement may be altered to suit actual site conditions.

The finishing machine and guide rails shall be adjusted so that the height of the screed will finish the concrete to the design gradeline and crown. To confirm the adjustment of the machine and guiderails, the screed shall be dry-run prior to the pour and clearance measurements taken at each of the girder points corresponding to the camber diagram, and provided to the Consultant for review and acceptance. Re-setting of the machine and/or screed rails shall be done as necessary, to obtain an acceptable dry-run. Adjustments to the machine or screed rails will not be permitted after an acceptable dry-run has been completed.

Where screed rails are supported on cantilevered formwork that may deflect under the weight of the fresh concrete and the deck finishing machine, the Contractor shall pre-load a test section of the cantilevered formwork on each side of the bridge to determine deflections occurring during concrete placement. The formwork, machine and/or screed rails shall be adjusted to compensate for the expected formwork deflection.

4.16.4 Screeding Concrete

Concrete shall be placed as close as practical ahead of the finishing machine, and at no time more than 6 m in front of the trailing end of the finishing machine's roller.

The screed shall be moved slowly and at a uniform rate. In general, the direction of pouring should be from the low end of the bridge to the high end. A roll of concrete shall be maintained along the entire front of the screed at all times to ensure the filling and consolidation of the concrete surface. The contractor shall also ensure that the required concrete thickness is being placed by continually probing the concrete behind the finishing machine.

Screeding shall be completed in no more than two passes. The screeded surface shall not be walked on or otherwise damaged and may require finishing machines or work bridges to be equipped or fitted with specialized work platforms to facilitate concrete finishing in front of curbs, barriers or medians.

4.16.5 Bull Floating/Surface Texturing

The concrete surface produced behind the finishing machine shall be manually bull floated with a magnesium bull float to ensure that the surface is free from open texturing, plucked aggregate and local projections or depressions. Bull floating and surface texturing shall follow as close as practically possible behind the screed. It is imperative that competent workers be employed to carryout bull floating and surface texturing.

Evaporation reducer or water shall not be finished into the concrete at any time during finishing operations.

The Contractor shall check the concrete surface with a 3 m long expanded polystyrene straight edge immediately after final bull floating and before texturing or application of evaporation reducer to ensure the required surface tolerances are met. Concrete surfaces that do not meet the surface tolerances described in 4.16.6 shall be corrected while the concrete is still plastic and before curing procedures are implemented.

4.16.6 Surface Defects and Tolerances

The finished surface of the concrete shall conform to the design gradeline profiles as indicated on the drawings and/or as determined on site. Any gradeline profile modifications shall be reviewed and accepted by the Consultant.

The surface shall be free from open texturing, plucked aggregate and local projections.

Except across the crown, the surface shall be such that when checked with a 3 m long straight edge placed anywhere in any direction on the surface, there shall not be any gap greater than 3 mm between the bottom of the straight edge and the surface of the deck concrete.

Areas that do not meet the required surface accuracy shall be clearly marked out and the Contractor shall, at his own expense:

- (a) Grind down any areas higher than 3 mm but not higher than 10 mm above the correct surface.
- (b) Correct any areas lower than 3 mm but not lower than 10 mm below the correct surface, by grinding down the adjacent high areas.
- (c) When the deviation exceeds 10 mm from the correct surface, the deck slab shall be removed and replaced in accordance with Section 20.3.2 "Partial Depth Repair", resulting in a product that is in no way inferior to the adjacent undisturbed slab. The perimeter of the joint created by the repair area shall be waterproofed in accordance with the details on S-1443. Replaced areas shall be at the Contractor's expense.

Grinding shall be carried out by an approved machine, of a type and capacity suitable for the total area of grinding involved, until the surface meets the specified requirements.

All corrective work will require the Contractor to submit a proposal for review and acceptance by the Department and Consultant, prior to commencement of any work.

Concrete surfaces that are damaged in any way by construction operations, or show signs of distress or scaling shall be repaired or replaced by the Contractor at his own expense.

4.17 Placing Approach Slab and Roof Slab Concrete

After properly placing and consolidating the concrete, it shall be struck off and screeded to conform to the required cross-section and grade. Concrete placing shall be carried out in a manner such that the newly deposited concrete is continually placed against fresh concrete across the entire face of the pour and the formation of cold joints is avoided. A slight excess of concrete shall be kept in front of the screed at all times.

The concrete surface shall then be manually bull floated longitudinally, transversely or in both directions as necessary to ensure that the surface is free from open texturing, plucked aggregates, and local projections or depressions. The surface shall be such that it does not vary by more than 3 mm from the required lines, under a 3 m straightedge placed anywhere, in any direction except across the crown.

4.18 Concreting Shear Keys and Diaphragms

Form work for shear keys and diaphragms shall be designed to accommodate variations in girder dimensions, positioning, alignment, camber and sweep. Girder keyways and diaphragms shall be brought to a saturated surface dry condition prior to concrete placement. Saturation with water shall not be less than 30 minutes prior to blowing free of standing water. Concrete placed in the keyways shall be adequately consolidated and trowelled smooth and level with the top surfaces of the girders. Immediately after trowelling, two layers of clean Nilex 4504 white colored filter fabric or an approved equivalent shall be placed on the shear keys and kept continuously wet for 72 hours.

4.19 Concrete Slope Protection

A minimum of one week prior to commencing concrete slope protection work, the Contractor shall submit a detailed layout and forming plan to the Consultant for review and acceptance. The detailed layout and forming plan shall comply with Standard Drawing S-1409 and these specifications.

All thickness measurements indicated herein are perpendicular to the slope surface.

The slopes to be covered with concrete slope protection shall be trimmed and dressed by the Contractor to within 150 mm of the lines and grades shown on the Drawings. The Contractor shall supply and place Des 2 Class 25 crushed aggregate material to a minimum thickness of 100 mm over the trimmed slopes. Crushed aggregate material shall conform to the requirements of section 2.2.2 Gravel Material and Crushed Aggregate Material.

Where slopes have been constructed by others, and excavation exceeding 250 mm or fill exceeding 150 mm is required due to discrepancies in position of the original surface, excavation beyond the 250 mm tolerance limit and/or fill beyond the 150 mm tolerance limit will be considered to be Extra Work. Depending upon the circumstances of the particular project the Department and Consultant may vary the specified concrete grades so as to minimize the amount of remedial trimming required. Excavation up to 250 mm and/or fill up to 150 mm will be considered as included in the bid price.

Concrete for slope protection shall be Class C.

Sheet reinforcing mesh shall be placed in accordance with Section 5 Reinforcing Steel. The method of securing and maintaining the wire mesh in its proper location shall be reviewed and accepted by the Consultant.

The concrete shall be placed in either horizontal or vertical courses, with one course being allowed to cure for at least 12 hours before the adjoining course is placed. Formwork shall be provided below and above the wire mesh to ensure proper slab thickness, correct positioning of the mesh, and the formation of proper cold joints between courses. Vertical or horizontal joints shall be formed or grooved 50 mm to the depth of the reinforcing mesh. All joints shall be finished with suitable edging and grooving tools and left unfilled. The concrete surfaces shall be given a Class 5 finish prior to edging and grooving. Finishing work shall be carried out by competent and experienced personnel only.

Backfill at the toe, top or edges shall be non-granular, conforming to the requirements of section 2.2.1 Compacted Non-granular Material, and shall not be placed until the completed slope protection work has been reviewed and accepted by the Consultant.

4.20 Construction Joints

4.20.1 General

Construction joints shall be made only where indicated on the drawings or shown in the pouring schedule unless otherwise reviewed and accepted by the Consultant.

If not detailed on the drawings, or in the case of emergency, construction joints shall be installed in accordance with Standard Drawings S1412 or as determined by the Consultant. Shear keys or inclined reinforcement shall be used where necessary to transmit shear, or to bond the two sections together. Construction joints shall be located to allow a minimum of 50 mm concrete cover on reinforcing steel running parallel to the joint.

4.20.2 Bonding

Before depositing new concrete on or against concrete which has hardened, the forms shall be retightened and the surface of the hardened concrete shall be thoroughly cleaned and saturated with water, with all free standing water removed. The placing of concrete shall be carried out continuously from joint to joint. The face edges of all joints which are exposed to view shall be carefully finished true to line and elevation.

4.21 Concreting in Cold Weather

When the ambient air temperature is, or is expected to be below 5°C during the placing and curing period, or when determined by the Consultant, a cold weather concreting plan shall be implemented. The Contractor shall submit details of his proposed cold weather concreting plan to the Consultant for review and acceptance a minimum of two weeks prior to any concrete placement. The Contractor's concreting plan shall incorporate the following requirements:

- (1) All aggregate and mixing water shall be heated to a temperature of at least 20°C but not more than 65°C. The aggregates may be heated by either dry heat or steam; in the latter case the quantity of mixing water may need to be reduced. The temperature of the concrete shall be in accordance with Section 4.4.3 at the time of placing in the forms. In the case of mass pours, the Consultant may alter the temperature requirements to suit.
- (2) The Contractor shall enclose the structure in such a way that the concrete and air within the enclosure can be kept above 15°C for a protection period of 7 days after placing the concrete. Enclosures shall be constructed with a minimum 300 mm clearance between the enclosure and the concrete.

For class HPC or HPC with steel fibres the 7 day protection period shall be increased to 21 days. The enclosure for class HPC or HPC with steel fibres shall be constructed large enough to comfortably accommodate the men and equipment necessary to place, finish and cure the concrete. The underside of the deck shall be suitably protected.

The relative humidity within the enclosure shall be maintained at not less than 85%. Heaters must be kept well clear of the formwork housing. Adequate ventilation is required to provide air for combustion, and to prevent the accumulation of carbon dioxide. The use of salamanders, coke stoves, oil or gas burners and similar spot heaters which have an open flame and intense local heat is prohibited without the Consultant's specific acceptance.

The system of heating, and positioning of steam outlets, heaters, and fans, shall be designed to give the most uniform distribution of heat possible.

- (3) Before placing concrete, adequate pre-heat shall be provided to raise the temperature of formwork, reinforcing steel, previously-placed concrete, and/or soil to between 10°C and 20°C.
- (4) Fully insulated formwork may be proposed as an alternative to providing further heat during the curing period. Such formwork shall be designed and insulated with approved materials so that the initial heat of the mix, and the heat generated during the hydration of the cement, is retained to provide the specified conditions.
- (5) Concrete curing shall be in accordance with the requirements of Subsection 4.23.
- (6) The adequacy of protection shall be monitored and recorded a minimum of every 4 hrs for the first 72 hrs and every 8 hrs for the remainder of the curing period, including measurement of internal and surface concrete temperatures. The protective measures shall be modified as necessary to maintain the specified conditions.

- (7) Protection and heating, where used, shall be withdrawn in such a manner so as not to induce thermal shock stresses in the concrete. The temperature of the concrete shall be gradually reduced at a rate not exceeding 10°C per day to that of the surrounding air. To achieve this, in an enclosure, the heat shall be slowly reduced. The temperature differential between the core of the element and the surface of the element shall not exceed 20°C. In addition the temperature differential between the surface of the element and the ambient air shall not exceed 15°C. Ambient air temperature is defined as the temperature at mid-height and 300 mm from the surface of the element. The Contractor shall measure the temperature of internal concrete, surface of the concrete and ambient air temperatures a minimum of every 4 hrs, and shall make adjustments as necessary to keep the rate of cooling within the specified parameters.

The Contractor shall demonstrate to the satisfaction of the Consultant that the requirements of the cold weather concreting plan are met.

4.22 Depositing Concrete under Water

Concrete shall not be deposited under water without the acceptance of the Consultant and under his immediate supervision. Concrete to be deposited in water shall be of the specified class, with the mix design modified to provide 170 mm ± 30 mm slump without segregation and a 15% increase in cementing materials above the initial mix design quantity. Anti-washout admixtures incorporating viscosity modifiers may be used in the mix design. The modified concrete mix design for placement under water shall be submitted by the Contractor for review and acceptance by the Consultant in accordance with Section 4.4.4. The concrete temperature at discharge shall be between 10°C and 25°C.

To prevent segregation, concrete shall be carefully placed in a compact mass, in its final position, by means of a concrete pump. When specifically reviewed and accepted by the Consultant, a properly designed and operated tremie may be used. The concrete shall not be disturbed after being deposited. Still water shall be maintained at the point of deposit and any formwork underwater shall be watertight.

The discharge end of the concrete pump line shall be lowered to the bottom of the form or hole. Pumping shall then proceed with the end of the discharge line being continually buried no less than 500 mm below the surface of fresh concrete at all times, to maintain a seal until the form or hole is completely filled with fresh uncontaminated concrete.

A tremie, when reviewed and accepted by the Consultant, shall consist of a rigid tube having a diameter between 200 mm and 300 mm, and if constructed in sections it shall have flanged couplings fitted with gaskets. The discharge end shall be closed at the start of the work to prevent water entering the tube. The tremie tube shall be kept full to the bottom of the hopper, and water shall be kept out at all times. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, always keeping it in the deposited concrete. The flow shall be continuous until the work is completed. Sufficient tremies shall be used to place the concrete under water such that it is not necessary to move any of the tremies from one portion of the pour to another. The use of non-rigid tremie tubes will not be permitted.

Concrete shall not be placed in water which is below 4°C.

The surface of the concrete shall be kept as nearly horizontal as is practicable at all times. The discharge end of the tremie shall be kept buried at least 500 mm in previously placed concrete.

Dewatering will not be permitted while concrete is being placed. Dewatering may proceed when the concrete seal has gained sufficient strength such that dewatering is not harmful to the performance of the concrete. The Contractor shall remove all laitance or other unsatisfactory material from the exposed concrete surface as determined by the Consultant by scraping, chipping or other acceptable means.

4.23 Curing Concrete

4.23.1 General

Freshly deposited concrete shall be protected from freezing, abnormally high temperatures or temperature differentials, premature drying, water damage and moisture loss for the curing period.

All concrete surfaces consisting of Class C or D concrete shall be wet cured. The Contractor shall cover the concrete surface(s) with two layers of clean Nilex 4504 white colored filter fabric or an approved equivalent as soon as the surface will not be marred by so doing. The filter fabric shall be kept continuously wet for 72 hours. Where the formwork is left in place for 72 hours or more, no additional curing will be required. Curing compounds shall not be used on any concrete surface other than concrete slope protection.

4.23.2 Curing Requirements for Concrete Slope Protection

Concrete slope protection shall receive 2 coats of a Type 2 curing compound meeting the requirements of ASTM C309 or ASTM C1315. The first coat is to be applied immediately after the concrete has been satisfactorily finished, and the second coat is to be applied within 3 hours after the application of the first coat. Each application shall be at a rate specified by the Manufacturer.

4.23.3 Curing Requirements for Class HPC and Class HPC with Steel Fibres

The Contractor shall prepare and submit details for his proposed curing procedures to the Consultant for review and acceptance a minimum of two weeks prior to the scheduled pour date. At a minimum, the details shall include a description of equipment, materials, and work methods/techniques employed to carry out the work.

During the cure period the Contractor shall provide protection to ensure that the temperature of the centre of the in-situ concrete shall not fall below 10°C or exceed 60°C and the temperature difference between the centre and the surface shall not exceed 20°C. In addition, the requirements of Table 21 of CSA A23.1 shall apply. The Contractor shall supply and install two thermocouples, one in the centre and one at the surface of the concrete, for every 100 m² of deck, at locations determined by the Consultant. The Contractor shall monitor and record the temperatures every four hours for the first 72 hrs after concrete placement and every 8 hours

thereafter for the remainder of the specified cure period. Daily temperature records shall be forwarded to the Consultant.

Immediately after final bull floating and/or surface texturing an evaporation reducer, such as "Confilm" manufactured by BASF or an approved equivalent, having a monomolecular film forming compound intended for application to fresh concrete for temporary protection against moisture loss, shall be applied by a hand sprayer with a misting nozzle at the manufacturer's recommended concentration and application rate.

Two layers of Nilex 4504 white filter fabric or an approved equivalent shall be placed on the concrete surface as soon as the surface will not be marred by its installation. The fabric shall be pre-wet or a fine spray of clean water immediately applied once placed. Edges of the filter fabric shall overlap a minimum of 150 mm and be held in place without marring the surface of the concrete. The filter fabric shall be in a continuously wet condition throughout the curing period by means of soaker hoses or other means reviewed and accepted by the Consultant. The use of polyethylene sheeting above the filter fabric to reduce moisture loss will only be permitted if the sheeting is manufactured with regular perforations to permit the adequate application of curing water from above and reduce the heat generated by greenhouse effects.

Curing with filter fabric and water shall be maintained for a minimum of 7 days for rehabilitation projects and 14 days for new bridge construction. When concreting in cold weather, curing with filter fabric and water shall be maintained for a minimum of 14 days followed by 7 days of air drying for both rehabilitation and new bridge construction projects.

Wet curing of deck joint blockout concrete for rehabilitation projects can be reduced to 3 days followed by the application of a Type 2 curing compound meeting the requirements of ASTM C309 or ASTM C1315.

For those locations where formwork is removed prior to the completion of this specified curing period, the resulting exposed concrete surfaces shall be wet cured for the remaining days.

In the event that curing is unacceptable, or any portion of the HPC or HPC with steel fibres becomes surface dry during the curing period, the Consultant will have cause to reject the concrete.

4.24 Concrete Finishing Under Bearings

Concrete on which bearing plates, pads or shims are to be placed shall be finished or ground to a smooth and even surface. When checked with a straight edge placed anywhere in any direction on the concrete surface, there shall not be any gap greater than 1 mm between the bottom of the straight edge and the concrete surface.

Air voids created by forming grout-pad recesses shall be filled with an approved patching material a minimum of 7 days in advance of girder erection. In cold weather conditions this work shall be completed while the substrate concrete is warm from hydration processes. If the filling of air voids does not occur while the substrate concrete is still warm it shall be carried out in accordance with Section 4.21.

4.25 Concrete Surface Finish

4.25.1 General

On exposed concrete surfaces to 600 mm below grade or, in the case of river piers, 600 mm below lowest water level, surface finishes shall be applied as follows:

Class 1 Ordinary Surface Finish

- All concrete surfaces unless other finishes are specified
- Top surfaces of pile caps, abutment seats and pier caps

Class 2 Rubbed Surface Finish

- Piers except grade separation piers
- Traffic side surfaces of curbs, barriers, medians and sidewalks
- Cast-in-place concrete girders except exterior fascia.

Class 3 Bonded Concrete Surface Finish *

- Abutment seats except top surface
- Pier caps except top surface
- Exterior faces of curtain walls/wingwalls,
- Cast-in-place walls, MSE wall panels, and wall copings
- Grade separation piers except top surfaces
- Exterior concrete girder faces
- Exposed end surfaces of cast-in-place concrete diaphragms
- Underside of the deck overhang to top flange of girder
- Exterior surfaces of deck slab, curb, barrier and sidewalk

* Class 3 bonded concrete surface finishes shall only be applied to the above listed components when specified in the Special Provisions of the Contract. When a Class 3 surface finish is not specified in the Special Provisions of the Contract, all above listed components shall receive a Class 2 finish.

Class 4 Floated Surface Finish

- Top surfaces of concrete deck, roof slabs, and approach slabs which are to receive waterproofing membranes and wearing surfaces

Class 5 Floated Surface Finish, Broomed Texture

- Top surfaces of curbs, sidewalks, and medians
- Approach slab concrete which will be covered by a wearing surface only (without waterproofing membrane)
- Concrete slope protection
- deck joint blockout concrete top surfaces

Class 6 Floated Surface Finish, Surface Textured

- Top surfaces of deck, deck overlay, roof and approach slabs which will not be covered with either waterproofing membrane or wearing surface

Wood or magnesium tools shall be used for finishing concrete and be of a type and quality

acceptable to the Consultant.

4.25.2 Class 1 Ordinary Surface Finish

Unformed Surfaces - Immediately following placing and consolidation, the concrete shall be screeded to conform to the required surface elevations, and then trowelled to ensure that the surface is free from open texturing, plucked aggregate, and local projections or depressions.

Concrete surfaces shall be such that when checked with a 1.2 m long straight edge placed anywhere in any direction on the surface, there shall not be any gap greater than 3 mm between the bottom of the straight edge and the concrete surface unless otherwise specified.

Formed Surfaces - Immediately following the removal of forms, all fins and irregular projections shall be removed from all surfaces. On all surfaces the cavities produced by form ties, and all other holes, honeycomb areas, broken corners or edges and other defects, shall be thoroughly chipped out, cleaned, and shall be filled with a Department approved patching product acceptable to the Consultant. The repair material shall be appropriate for the intended application and be placed in accordance with the manufacturer's recommendations. All repairs shall be wet cured for a minimum of 72 hrs. Curing compounds are not permitted.

4.25.3 Class 2 Rubbed Surface Finish

Immediately following the removal of forms, all concrete fins and irregular projections shall be removed. Prior to commencement of concrete finishing, surfaces that do not meet tolerance requirements shall be corrected by grinding or partial depth repair as outlined in Section 20. Parging or surface patching to correct irregularities will not be permitted. On all surfaces, the cavities produced by form ties, air bubbles and all other holes, honeycomb areas, broken corners or edges and any other defects, shall be thoroughly exposed by diamond grinding wheels or similar tools. Surface voids greater than 19 mm diameter but less than 0.05 m² in area or 30 mm deep shall be filled with a Department approved patching material. Surface voids less than 19 mm in diameter and 30 mm deep may be filled with a pre-bagged sack rub material. Sack rub materials shall be placed over the entire prepared surface in accordance with the manufacturer's recommendations. Both sack rub and patching materials shall be wet cured for a minimum of 72 hrs. When the patching and sack rub materials have adequately cured, a carborundum stone or approved equivalent methods shall be used to finish the surface to a smooth, uniform and closed texture. Any voids or cavities opened during the stone rubbing process shall be re-filled.

Class 2 concrete surfaces shall be such that when checked with a 1.2 m long straight edge placed anywhere in any direction on the surface, there shall not be any gap greater than 3 mm between the bottom of the straight edge and the concrete surface unless otherwise specified.

It is essential that all of the prepared concrete surfaces, including all patching and sack rubbing be uniform in colour and texture. After the surface preparation has been completed to the satisfaction of the Consultant, the Contractor shall apply sealer as specified in section 4.26 "Type 1c Sealer".

4.25.4 Class 3 Bonded Concrete Surface Finish

Surface preparation shall be done as specified for Class 2, "Rubbed Surface Finish", except that uniformity in colour is not required.

After the surface preparation has been completed to the satisfaction of the Consultant, the surface shall be pressure washed to remove all dust, dirt, laitance and all other bond breaking materials. After the concrete surface has dried for a minimum of 24 hours, the Contractor shall apply an approved pigmented concrete sealer, which meets the requirements for a Type 3 sealer of the Material Testing Specifications for Concrete Sealers - B388.

The pigmented concrete sealer shall be applied in accordance with the manufacturer's specifications and as a minimum two applications totaling the approved application rate of the pigmented sealer are required. The colour(s) of the proposed coating scheme, which typically shall be similar to the natural colour of cured concrete, must be acceptable to the Department and Consultant before application of the coating. If a colour scheme has been designed for the site it will be specified in the Special Provisions. When spray application is used the surface shall be back rolled. The Contractor shall ensure that no colour variation is visible, and shall match the colour of any previously painted adjoining surfaces. Acceptance of the pigmented sealer used will not be considered to relieve the Contractor of full responsibility for its acceptable performance and appearance.

4.25.5 Class 4 Floated Surface Finish

Unless otherwise noted on the Drawings, concrete surfaces receiving a waterproofing membrane and a final wearing surface, shall be manually bull floated and trowelled as necessary to provide a smooth surface.

4.25.6 Class 5 Floated Surface Finish, Broomed Texture

The concrete surface shall be floated and trowelled as necessary to produce a smooth surface. The surface shall not vary more than 3 mm under a 3 m long straightedge.

After the concrete has set sufficiently, the surface shall be given a transversely broomed finish using a coarse broom to produce regular corrugations to a maximum depth of 2 mm. An edging tool shall be used at all edges and expansion joints. Where indicated on the drawing, sidewalk surfaces shall be laid out in blocks using an acceptable grooving tool.

4.25.7 Class 6 Floated Surface Finish, Surface Textured

After the concrete has been bull floated, it shall be given a suitable texture with a "flat wire" texture broom having a single row of tines. The desired texture is transverse grooving which may vary from 1.5 mm width at 10 mm centres to 5 mm width at 20 mm centres, and the groove depth shall be 3 mm to 5 mm. This work shall be done at such time and in such manner that the desired texture will be achieved while minimizing the displacement of the larger aggregate particles or steel fibres. The textured surface shall be uniform and consistent.

Following surface texturing, a 300 mm width of concrete surface adjacent to the curb, barrier or

median shall be trowelled smooth and the surface left closed.

4.25.8 Repairing Concrete Defects

Honeycomb, cavities, cracking and other casting defects shall be immediately reported to the Consultant. Repair procedures shall be developed by the Contractor and submitted for review and acceptance by the Department and Consultant prior to the commencement of the repair. Damaged concrete shall be repaired by the Contractor at his own expense to the satisfaction of the Consultant.

(a) Honeycomb, Cavities, Casting Defects

Honeycomb, cavities and other deficiencies are defined as those areas that are greater than 30 mm in depth or 0.05m² in area. Defects less than 30 mm in depth or 0.05m² in area shall be repaired in accordance with Section 4.25.3.

As a minimum, the Contractor's repair procedure shall include removing and replacing the defective concrete with the originally specified class of concrete. Repair extents shall be saw cut 25 mm deep in neat perpendicular lines and concrete removed to a depth of 35 mm below reinforcing steel. Repair areas shall be roughened to remove all loose material and laitance. Exposed reinforcing steel shall be cleaned and repaired to its original condition. Repair areas shall be saturated with water for a period of 24 hrs prior to concrete placement. Repair areas shall be free of standing water immediately prior to concrete placement. Curing shall be in accordance with the requirements for the class of concrete.

Formwork misalignment for highly visible components, including medians, curbs, barriers, exterior deck fascia, pier shafts, and exterior faces of wingwalls shall be such that when checked with a 1.2 m long straight edge placed anywhere in any direction on the surface, there shall not be any gap greater than 3 mm between the bottom of the straight edge and the concrete surface. The gap for formwork misalignment of all other components shall not be greater than 5 mm. Concrete elements with formwork misalignments exceeding the allowable tolerances shall be removed and recast.

(b) Cracks

For class HPC and HPC with steel fibres the Contractor and the Consultant shall jointly inspect and identify all cracks after the curing period and before opening to traffic. The Consultant will plot the width in millimeters and length in linear meters of cracks and report the findings to the Department. The Contractor shall complete all required crack repairs prior to opening to traffic.

The Contractor shall repair cracks with widths greater than or equal to 0.2 mm using the following procedure:

- (i) Clean and dry cracks with oil-free compressed air.
- (ii) Seal cracks with a gravity flow concrete crack filler in accordance with the Manufacturer's recommendations. The crack filler shall maximize the penetration by taking into consideration the ambient temperature, substrate temperature, viscosity and

pot life of the material. The crack filler shall be chosen from the Alberta Transportation Product List/Crack Treatment/Concrete Crack filler/Proven Products and have a viscosity less than 105 centipoises (cP).

- (iii) When cracks extend the full depth of the deck slab, barriers or curbs or extend partial depth of decks that are cast to grade, epoxy injection will be required. The epoxy resin shall meet the requirements of ASTM C881 Type IV, Grade 1, Class B or C and have a viscosity less than 500 cP. An injection procedure shall be submitted by the Contractor to the Consultant for review and acceptance.

For all other classes of concrete, cracks 0.2 mm or greater in width identified prior to issuance of the construction completion certificate, shall be repaired by epoxy injection in accordance with the manufacturer's recommendations. The epoxy for crack injection shall meet the requirements of ASTM C881 Type IV, Grade 1, Class B or C. The viscosity shall not exceed 500 CPS.

All costs associated with crack repairs will be considered incidental to the Work and no separate or additional payment will be made.

4.26 Type 1c Sealer

An approved Type 1c sealer shall be applied to all concrete surfaces which are to receive a Class 2, Class 5 and Class 6 surface finish. This shall include all concrete surfaces to 600 mm below grade or in the case of river piers 600 mm below lowest water level. Surfaces that are to receive a waterproofing membrane shall not have sealer applied. Sealer will not be required on the underside of bridge decks or on concrete diaphragms in the interior bay areas, however, the faces of the end diaphragms nearest the abutment backwalls, inside face of backwall and top surface of abutment seat, excluding bearing recess pockets, shall be sealed.

Type 1c sealers shall meet the current Material Testing Specifications for Concrete Sealers - B388.

The sealer shall be applied in accordance with the Manufacturer's recommendations; however the application rate shall be increased by 30% from that indicated on the approved Product List. Before applying the sealer, the concrete shall be cured for at least 28 days. The concrete surface shall be dry, and air blasted to remove all dust and accepted by the Consultant prior to applying sealer. In order to ensure uniform and sufficient coverage rates the Contractor shall apply measured volumes of sealing compound to appropriately dimensioned areas of concrete surface, using a minimum of 2 coats. Asphalt concrete pavement surfaces shall be adequately protected from overspray and runoff during sealer application.

4.27 Concrete Strength Requirements

The Department reserves the right to reject any concrete whatsoever which does not meet all the requirements for that class of concrete. The Department may however, accept concrete, the strength of which falls below the specified strength requirements. In this case, payment will be made in accordance with 4.27.1. The bid price can either be unit price or lump sum.

4.27.1 Payment Scales

Class C Concrete, 35 MPa

Strength Test Results

35 MPa and over	Full bid price
34 MPa to 35 MPa	Bid price less \$30 per cubic metre
33 MPa to 34 MPa	Bid price less \$60 per cubic metre
32 MPa to 33 MPa	Bid price less \$90 per cubic metre
31 MPa to 32 MPa	Bid price less \$120 per cubic metre
30 MPa to 31 MPa	Bid price less \$160 per cubic metre
29 MPa to 30 MPa	Bid price less \$220 per cubic metre
28 MPa to 29 MPa	Bid price less \$300 per cubic metre
27 MPa to 28 MPa	Bid price less \$400 per cubic metre

Class HPC and Class HPC with Steel Fibres Concrete, 45 MPa

Strength Test Results

45 MPa and over	Full bid price
44 MPa to 45 MPa	Bid Price less \$40 per cubic metre
43 MPa to 44 MPa	Bid Price less \$100 per cubic metre
42 MPa to 43 MPa	Bid Price less \$180 per cubic metre
41 MPa to 42 MPa	Bid Price less \$280 per cubic metre
40 MPa to 41 MPa	Bid Price less \$400 per cubic metre

Class D, Class Pile Concrete, 30 MPa

Strength Test Results

30 MPa and over	Full bid price
29 MPa to 30 MPa	Bid price less \$30 per cubic metre
28 MPa to 29 MPa	Bid price less \$60 per cubic metre
27 MPa to 28 MPa	Bid price less \$90 per cubic metre
26 MPa to 27 MPa	Bid price less \$120 per cubic metre
25 MPa to 26 MPa	Bid price less \$160 per cubic metre
24 MPa to 25 MPa	Bid price less \$220 per cubic metre

Class S Concrete, 20 MPa

Strength Test Results

20 MPa and over	Full bid price
18 MPa to 20 MPa	Bid price less \$30 per cubic metre
16 MPa to 18 MPa	Bid price less \$70 per cubic metre

The reduced payment shall apply to the volume of concrete represented by the strength test as defined in Section 4.9.1.

Concrete will be rejected with representative strengths less than the following:

- Class C concrete - 27 MPa
- Class HPC and Class HPC with steel fibres concrete - 40 MPa
- Class D and Pile concrete - 24 MPa
- Class S concrete - 16 MPa

4.27.2 Open to Traffic

The bridge shall not be opened to traffic until the deck concrete has attained minimum compression strength of 70% of the design strength. The concrete shall be cured in accordance with Section 4.23 of the specification. The Contractor shall be responsible for all costs associated with any additional testing that may be required to satisfy the strength requirement.

4.27.3 Coring for Compressive Strength Testing

Coring to confirm or contest low concrete strength test results shall be reviewed and accepted by the Department. When coring is acceptable, arrangements shall be made by the Contractor to employ an independent, certified testing laboratory, all at the expense of the Contractor. The cores shall be taken and tested within seven days of the testing of the twenty-eight day cylinders representing the concrete in question. Where practical, three 100 mm diameter cores shall be taken for each strength test previously taken, and there shall be no doubt that the cores taken, and the cylinders under consideration represent the same batch of concrete. Cores may not be taken unless the Consultant's representative is present. Cores shall be tested by an independent CSA certified laboratory and in accordance with the requirements of CSA Standard A23.2-14C. CSA Standard A23.1-09, Clause 4.4.6.6.2 "Cores drilled from a structure" shall not apply. The average strength of each set of three cores shall be equal to or greater than the 28-day specified strength. The average strength of the cores as reported by the independent testing service shall constitute a test.

In cases where the concrete strength, as indicated by the cores, is higher than the strength based on the concrete cylinder results, the core results shall be used as the basis for acceptance of and payment for the concrete. If the core strengths are lower than the strength from the concrete cylinder tests, the cylinder tests shall govern.

4.28 Measurement and Payment

4.28.1 Concrete

Payment for the class of concrete specified will be made on the basis of the actual volume within the neat lines of the structures as shown on the drawings or as reviewed and accepted by the Department and Consultant. The volume of concrete displaced by ducts and voids, girder flanges/webs and by timber, pipe, or concrete piles will be deducted. No deduction will be made for the volume of concrete displaced by steel reinforcement, expansion material or steel H-piles, nor for fillets and chamfers.

When it is specified on the drawings that concrete in footings is to be placed against undisturbed soil or set in rock, and where the excavation is made wider than the neat lines of the footing as shown, the Contractor shall supply and place the excess volume of concrete at his own expense.

In the case of drilled cast-in-place concrete piles where the drilled holes are made larger than required by the drawings, the additional volume of pile concrete required to fill the enlarged hole shall be supplied and placed by the Contractor at his expense.

An interim payment in the amount of 80% of full value will be made if the concrete has been placed acceptably, and the 7 day test cylinder strength indicates that the concrete will reach the acceptance range of specified strength. Partial payment in advance of 28 day test results will not be deemed to constitute acceptance of the concrete nor limit in any way the requirements of Section 4.27 of these specifications.

Final payment will not be made until the specified concrete finish is acceptably completed, and the 28 day strength tests show that the concrete meets the strength requirement of the specification, or indicate what deduction is to be made for below strength concrete.

The payment for concrete shall include full compensation for the cost of furnishing all material, tools, equipment, falsework, forms, bracing, labour, curing, heating, surface finish including application of Type 1c sealer and/or Type 3 pigmented sealer and all other items of expense required to complete the concrete work shown on the drawings, and as outlined in the specifications.

4.28.2 Concrete Slope Protection

Payment for **Concrete Slope Protection** will be made at the unit price bid per square metre, and shall include full compensation for the cost of furnishing all tools, labour, equipment, materials, and incidentals necessary for the completed work, including the preparation of the slopes, supply and placing of reinforcing steel, steel mesh, concrete, and backfilling. The quantity to be paid for will be the number of square metres satisfactorily placed, and shall include trough drains adjoining the slope protection and the vertical surfaces of toe cut-off walls. No payment will be made for top cut-off walls or edge walls.

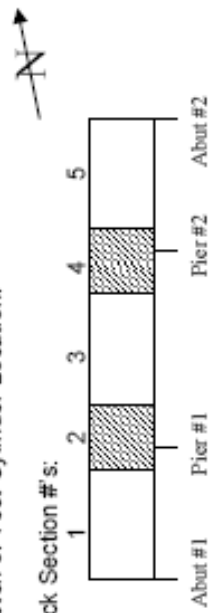
Concrete Test Results

Bridge File #: 12345 Bridge Project: HWY 555 over HWY 5 Grade Separation Location: Sometown Contract #: 2222/08 Contractor: ABC Contracting Concrete Supplier: XYZ Concrete Plant Location: Concrete Town Consultant: AAA Consulting	Date Tested: June 12, 2012 Weather: Light Breeze, Cloudy 12 °C Tested By: Joe Tester Certification: <input checked="" type="checkbox"/> CSA <input type="checkbox"/> ACI Cert. # 12345 Date of Certification / Expiry: July 1, 2011 / July 1, 2014 Cylinder Curing Facilities / Initial Temp: Curing Box / 17 - 23 °C Placing Method / Sampling Location: Pump Truck / Hose End Volume of Pour: 80 m ³
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Specification Requirements	Concrete Class : HPC	Strength: 45 MPa @ 28 Days	Air Content (%)
	Slump (mm)		
	Min.: 90 Max.: 150	Min.: 8.0 Max.: 8.0	Min of 1 set per : 2 Trucks or Min of 1 set per: 20 m ³

Pour Location	Cylinder Identification Labels*	Delivery Ticket No.	Load Amount (m ³)	Time		Slump (mm)	Air Content (%)	Unit Weight (kg/m ³)	Temperature	
				Batched	Tested				Off-Load	Air (°C)
Deck pour over Pier #1.	DS2-1,2,3,4	1	10	20:00	20:45	20:50	6.5	2400	15	16
Deck pour over Pier #1.	n/a	2	10	20:30	21:20	21:25	6.8	2395	15	16
Deck pour over Pier #1.	DS2-5,6,7,8	3	10	21:00	21:40	21:50	7.2	2405	14	14
Deck pour over Pier #1.	n/a	4	10	21:30	22:15	22:20	5.6	2395	14	15
Deck pour over Pier #2.	DS4-9,10,11,12	5	10	22:00	22:35	22:45	5.8	2400	13	13
Deck pour over Pier #2.	n/a	6	10	22:30	23:10	23:15	6.7	2400	13	17
Deck pour over Pier #2.	DS4-11,12,13,14	7	10	23:00	23:40	23:45	7.0	2405	13	16
Deck pour over Pier #2.	n/a	8	10	23:30	00:05	00:10	6.5	2402	12	15

Sketch of Test Cylinder Location:



Deck Section #'s:

Ticket No. 4 and 5 had 200 mL of superplasticizer added. Superplasticizer used was EZY 123.

Comments:

* See Concrete Cylinder Coding Sheet for Suggested Cylinder Identification Label(s)

Concrete Test Results

Suggested Concrete Cylinder Coding Identification Labels

<p><u>Abutments</u></p> <table style="width: 100%; border-collapse: collapse;"> <tr><td style="width: 15%;">A1S</td><td>Abutment #1 Seat</td></tr> <tr><td>A1BW</td><td>Abutment #1 Backwall</td></tr> <tr><td>A1LW</td><td>Abutment #1 Left Wingwall</td></tr> <tr><td>A1RW</td><td>Abutment #1 Right Wingwall</td></tr> <tr><td>A1WZ</td><td>Abutment #1 Both Wingwalls</td></tr> <tr><td>A1B&W</td><td>Abutment #1 Backwall and Wingwalls</td></tr> <tr><td>A1GB</td><td>Abutment #1 Grade Beam</td></tr> <tr><td>A1RS</td><td>Abutment #1 Roof Slab</td></tr> <tr><td>A1AS</td><td>Abutment #1 Approach Slab</td></tr> <tr><td>A1MC</td><td>Abutment #1 Median Curb</td></tr> <tr><td>A1RD</td><td>Abutment #1 Right Drain</td></tr> <tr><td>A1LD</td><td>Abutment #1 Left Drain</td></tr> <tr><td>A1SP</td><td>Abutment #1 Slope Protection</td></tr> <tr><td>A1LS</td><td>Abutment #1 Left Sidewalk</td></tr> <tr><td>A1RS</td><td>Abutment #1 Right Sidewalk</td></tr> </table> <p><u>Piers</u></p> <table style="width: 100%; border-collapse: collapse;"> <tr><td style="width: 15%;">P1DP</td><td>Pier #1 Drilled Pile</td></tr> <tr><td>P1PP</td><td>Pier #1 Pipe Pile</td></tr> <tr><td>P1F</td><td>Pier #1 Footing</td></tr> <tr><td>P1S</td><td>Pier #1 Shaft</td></tr> <tr><td>P1LS</td><td>Pier #1 Lower Shaft</td></tr> <tr><td>P1US</td><td>Pier #1 Upper Shaft</td></tr> <tr><td>P1PC</td><td>Pier #1 Pier Cap</td></tr> <tr><td>P1C</td><td>Pier #1 Columns</td></tr> </table> <p><u>Decks</u></p> <table style="width: 100%; border-collapse: collapse;"> <tr><td style="width: 15%;">DS1</td><td>Deck Section #1 *</td></tr> <tr><td>DS1RC</td><td>Deck Section #1 Right Curb</td></tr> <tr><td>DS1LC</td><td>Deck Section #1 Left Curb</td></tr> <tr><td>DS1RP</td><td>Deck Section #1 Right Parapet</td></tr> <tr><td>DS1LP</td><td>Deck Section #1 Left Parapet</td></tr> <tr><td>DS1MC</td><td>Deck Section #1 Median Curb</td></tr> <tr><td>DS1RS</td><td>Deck Section #1 Right Sidewalk</td></tr> <tr><td>DS1LS</td><td>Deck Section #1 Left Sidewalk</td></tr> </table> <p>* Deck Section #'s:</p> <div style="text-align: center; margin: 10px 0;"> </div> <p style="text-align: center; margin: 0 50px;">Abut #1 Pier #1 Pier #2 Abut #2</p> <p><u>Precast Units</u></p> <table style="width: 100%; border-collapse: collapse;"> <tr><td style="width: 15%;">S1GK</td><td>Span #1 Girder Keyways</td></tr> <tr><td>A1BK</td><td>Abutment #1 Blockout</td></tr> <tr><td>Pier #1</td><td>Pier #1 Diaphragm Beam</td></tr> <tr><td>S1IDB</td><td>Span #1 Intermediate Diaphragm Beam</td></tr> </table>	A1S	Abutment #1 Seat	A1BW	Abutment #1 Backwall	A1LW	Abutment #1 Left Wingwall	A1RW	Abutment #1 Right Wingwall	A1WZ	Abutment #1 Both Wingwalls	A1B&W	Abutment #1 Backwall and Wingwalls	A1GB	Abutment #1 Grade Beam	A1RS	Abutment #1 Roof Slab	A1AS	Abutment #1 Approach Slab	A1MC	Abutment #1 Median Curb	A1RD	Abutment #1 Right Drain	A1LD	Abutment #1 Left Drain	A1SP	Abutment #1 Slope Protection	A1LS	Abutment #1 Left Sidewalk	A1RS	Abutment #1 Right Sidewalk	P1DP	Pier #1 Drilled Pile	P1PP	Pier #1 Pipe Pile	P1F	Pier #1 Footing	P1S	Pier #1 Shaft	P1LS	Pier #1 Lower Shaft	P1US	Pier #1 Upper Shaft	P1PC	Pier #1 Pier Cap	P1C	Pier #1 Columns	DS1	Deck Section #1 *	DS1RC	Deck Section #1 Right Curb	DS1LC	Deck Section #1 Left Curb	DS1RP	Deck Section #1 Right Parapet	DS1LP	Deck Section #1 Left Parapet	DS1MC	Deck Section #1 Median Curb	DS1RS	Deck Section #1 Right Sidewalk	DS1LS	Deck Section #1 Left Sidewalk	S1GK	Span #1 Girder Keyways	A1BK	Abutment #1 Blockout	Pier #1	Pier #1 Diaphragm Beam	S1IDB	Span #1 Intermediate Diaphragm Beam	<p><u>Box Culverts</u></p> <table style="width: 100%; border-collapse: collapse;"> <tr><td style="width: 15%;">BCF</td><td>Box Culvert Floor Slab</td></tr> <tr><td>BCW</td><td>Box Culvert Walls</td></tr> <tr><td>BCRS</td><td>Box Culvert Roof Slab</td></tr> <tr><td>BCUA</td><td>Box Culvert U/S Apron</td></tr> <tr><td>BRDA</td><td>Box Culvert D/S Apron</td></tr> <tr><td>BCUW</td><td>Box Culvert U/S Wingwalls</td></tr> <tr><td>BCDW</td><td>Box Culvert D/S Wingwalls</td></tr> <tr><td>BCUF</td><td>Box Culvert U/S Wingwall Footing</td></tr> <tr><td>BCDF</td><td>Box Culvert D/S Wingwall Footing</td></tr> </table> <p><u>S.P.C.S.P. 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STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 5

REINFORCING STEEL

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5.1 General

This Specification is for the supply, fabrication, handling and placing of plain reinforcing steel, epoxy coated reinforcing steel, corrosion resistant reinforcing steel (CRR), and stainless reinforcing steel. All reinforcing steel shall be supplied and installed in the lengths and shapes shown on the Drawings. No substitution of bars or changes to bar details will be permitted without prior approval of the Consultant.

5.2 Material Types

5.2.1 Plain Reinforcing Steel

Plain reinforcing steel shall be Grade 400, meeting the requirements of CSA Standard G30.18M.

5.2.2 Epoxy Coated Reinforcing Steel

Plain reinforcing steel meeting the requirements of Subsection 5.2.1 shall be used in the production of epoxy coated reinforcing steel.

Epoxy coated reinforcing steel shall be coated by a Manufacturer certified under the Concrete Reinforcing Steel Institute (CRSI) Voluntary Certification program for Fusion-Bonded Epoxy Coating Applicator plants. Proof of certification shall be submitted to the Consultant prior to delivery of the material.

Epoxy coated reinforcing steel shall be prepared and coated in accordance with the requirements of Ontario Provincial Standard Specification OPSS 1442, Material Specification for Epoxy Coated Steel Reinforcement for Concrete, and the requirements contained herein.

The film thickness of the epoxy coating, after curing, shall be 175 μm to 300 μm (7 to 12 mils). The epoxy coating material shall conform to the requirements of OPSS 1443, Material Specification for Organic Coatings for Steel Reinforcement.

5.2.3 Corrosion Resistant Reinforcing Steel

Corrosion resistant reinforcing steel (CRR) shall consist of either low carbon/chromium reinforcing steel or stainless reinforcing steel.

Low carbon/chromium reinforcing steel shall meet the requirements of ASTM A1035. The minimum yield strength based on the 0.2% offset method shall be equal to 690 MPa.

Stainless reinforcing steel, if used, shall meet the requirements of Subsection 5.2.4, Stainless Reinforcing Steel.

Unless otherwise specified, only one type of CRR shall be supplied for use throughout the project.

5.2.4 Stainless Reinforcing Steel

Stainless reinforcing steel shall be of the following designations as defined by the Unified Numbering System (UNS):

- S31653
- S31603
- S31803
- S30400
- S32304

Stainless reinforcing steel shall meet the requirements of ASTM A276 and ASTM A955/A955M (including Annex 1.2 or 1.3). The minimum yield strength shall be 420 MPa.

Unless otherwise specified, only one type of stainless reinforcing steel shall be supplied for use throughout the project.

5.3 Material Production and Testing

Reinforcing steel shall be produced and tested in accordance with the applicable standard(s). Material manufacturer mill test certificates showing proof of compliance shall be submitted to the Consultant for review and acceptance prior to the placement of any reinforcing steel.

Mill test certificates shall be provided for each lot delivered to the site.

The following additional information, as applicable, shall be supplied for each lot of stainless reinforcing steel delivered to the site:

- Austenitic grades: Test results verifying compliance with ASTM A262, Practice E.
- Duplex grades: Test results verifying compliance with ASTM A923, Method A, by demonstrating an unaffected etched structure.

Stainless reinforcing steel shall be pickled to remove all mill scale and surface oxidation. Details of the Manufacturer's pickling process shall be included with the mill test certificate submissions.

5.4 Fabrication

All bars requiring bends shall be cold bent at the fabrication facility. Heating of bars to facilitate bending will not be permitted.

Bars shall be cut by shearing or with fluid-cooled saws. Torch cutting will not be permitted. Bars showing evidence of torch cutting will be rejected.

Unless otherwise specified, all hooks and bends shall be fabricated using the pin diameters and dimensions recommended in The Reinforcing Steel Institute of Canada (RSIC) Manual of Standard Practice. Bars shall conform accurately to the dimensions shown on the Drawings, and be within the fabricating tolerances detailed in the RSIC Manual of Standard Practice.

Fabrication of epoxy coated reinforcing steel after application of the coating shall be in accordance with the requirements of Ontario Provincial Standard Specification OPSS 1442.

Fabrication of stainless reinforcing steel shall be carried such that bar surfaces are not contaminated with deposits of iron or other non-stainless steels; or suffer damage due to straightening or bending.

Reinforcing steel shall be fabricated without laminations or burrs.

5.5 Shipping, Handling and Storage

Reinforcing steel shall be covered and protected at all times during transportation.

Reinforcing steel of differing material types shall be stored separately. Bar tags identifying the material type shall be clearly visible and shall be maintained in-place until installation of the material.

The Contractor shall store all reinforcing steel on platforms, skids, or other suitable means of support able to keep the material above the ground surface while protecting it from mechanical damage or deterioration.

Special care shall be taken when handling epoxy coated reinforcing steel to prevent damage to the epoxy coating. Epoxy coated reinforcing bars shall not be dropped or dragged, and shall be lifted with non-metallic slings. Protective measure shall be implemented to prevent bar-to-bar abrasion and excessive sagging of bundles.

On-site storage of epoxy coated reinforcing steel shall not exceed 120 days, and exposure to daylight shall not exceed 30 days. If the daylight exposure time is expected to exceed 30 days, the Contractor shall protect the reinforcing steel by covering with opaque polyethylene sheeting or equivalent protective material acceptable to the Consultant.

On-site storage of all other types of reinforcing steel shall not exceed 120 days unless protected with polyethylene sheeting or equivalent protective material acceptable to the Consultant.

The Contractor shall take all precautions necessary to prevent damage to the material during handling operations. Bundles shall be handled with spreaders and non-metallic slings, or by other methods acceptable to the Consultant. Damaged materials shall be replaced by the Contractor at his expense.

5.6 Placing and Fastening

Reinforcing steel incorporated into the work shall be free from loose rust, scale, dirt, paint, oil or other foreign materials.

Reinforcing steel shall be accurately placed in the positions shown on the Drawings, and shall be securely tied and chaired before placing the concrete. Bars shall be tied at all intersections except when the bar spacing is less than 250 mm in each direction; alternate intersections may be tied at these locations. Specified distances from forms shall be maintained by supports, spacers, or other means approved by the Consultant.

Reinforcing cover shall not be less than that specified on the Drawings. Supports used to prevent bars from contact with forms or for separation between layers of bars shall be of adequate strength, shape and dimension, and approved for use by the Consultant. Supports shall be either plastic or precast concrete. Where additional reinforcing support bars are proposed by the Contractor they shall be of the same material type and grade used in the work.

Supports and spacers fabricated from alternate material types may be used upon approval by the Consultant.

Plastic bolster slab supports shall be Aztec Strong Back Slab / Beam Bolster - PSBB manufactured by Dayton Superior or an approved equivalent. Bolster slab supports shall be staggered and configured to facilitate full concrete consolidation.

Precast concrete supports shall be used for all exposed faces of curbs, medians and barriers. Precast concrete supports shall be Total Bond Concrete Supports manufactured by Con Sys Inc or an approved equivalent. Precast concrete supports shall have the compressive strength, rapid chloride permeability, and air content meeting the specification requirements for the class of concrete being placed.

Except as noted herein, tie-wire shall be manufactured from the same material type as the reinforcing steel being tied. Plastic coated tie-wire may be used where low carbon/chromium reinforcing steel is being placed. Where stainless reinforcing steel is being placed, tie-wire shall be stainless steel of any grade listed in Subsection 5.2.4.

Welding of reinforcing steel will not be permitted.

Field bending of reinforcing steel, regardless of circumstance, will not be permitted unless specified on the Drawings.

Field cutting of epoxy coated reinforcing steel shall be carried out only where necessary and approved by the Consultant. Cuts shall be made by shearing or saw cutting only. The epoxy coating on sheared or saw cut ends shall be patched in accordance with the specifications contained herein.

5.7 Splicing

Splicing of bars, unless shown on the Drawings or approved in writing by the Consultant, is prohibited.

Splices, where permitted, shall be staggered. For lapped splices, bars shall be placed in contact and wired together while maintaining the minimum required clear distance to other bars and the required minimum distance to the surface of the concrete.

5.8 Repair of Epoxy Coated Reinforcing Steel

The Contractor shall be responsible for the repair of all damage to epoxy coating up to the time the reinforcing steel is acceptably incorporated into the concrete. Where field cutting of the epoxy coated reinforcing steel is necessary and accepted by the Consultant, cutting shall be either shearing or saw cutting.

Repair of damaged coating and sheared or sawed ends shall be carried out using a two component epoxy coating patching material approved for use by the reinforcing steel Manufacturer.

Surface preparation and material application shall be completed in accordance with the patching material Manufacturer's written recommendations; the following requirements; and to the satisfaction of the Consultant. The areas to be repaired shall be cleaned by removing all surface contaminants and damaged coating before applying the patching material. Where rust

is present, it shall be completely removed immediately prior to application of the patching material. The patching material shall be overlapped onto the original coating for a minimum distance of 25 mm or as recommended by the patching material Manufacturer. The dry film thickness of the patched areas shall be between 175 μm and 300 μm .

All costs associated with the repair of damaged epoxy coating will be considered incidental to the Work, and no separate or additional payment will be made.

5.9 Repair of Stainless Reinforcing Steel

Individual stainless steel reinforcing bars exhibiting any of the following defects shall be repaired or replaced at the Contractor's expense:

- Any single area of iron contamination greater than 100 mm in length.
- Two or more areas of iron contamination greater than 50 mm in length.
- Frequent small occurrences of iron contamination along the full length of the bar.

Bars exhibiting excessive staining, as determined by the Consultant, shall have the contaminants identified by energy dispersive x-ray analysis (EDXA). Contaminant identification shall be carried out by the Contractor at his expense.

Methods proposed for the repair of stainless reinforcing steel bars shall be approved by the Department and Consultant prior to implementation.

Stainless reinforcing steel bars exhibiting signs of mechanical damage shall be replaced.

5.10 Measurement and Payment

5.10.1 Measurement

Steel reinforcing incorporated in the concrete will be measured in kilograms, based on the total computed mass for the size and length of bars as shown on the Drawings or accepted by the Consultant.

Any proposed substitution of imperial reinforcing steel for metric reinforcing steel must be reviewed and approved by the Consultant prior to the substitution taking place. The nominal cross-sectional area of metric and imperial bar sizes used for evaluating substitutions will be in accordance with ASTM A1035, ASTM A955/A955M and CAN/CSA G30.18, respectively.

The mass for all reinforcing steel will be calculated as follows:

Metric Bar Designation	10M	15M	20M	25M	30M	35M	45M	55M
Imperial Bar Designation	4	5	6	8	9	11	14	18
Mass (kg/m)	0.785	1.570	2.355	3.925	5.495	7.850	11.775	19.625

5.10.2 Payment

5.10.2.1 Supply

Payment for the supply of reinforcing steel will be made at the unit prices bid per kilogram for "Plain Reinforcing Steel - Supply", "Epoxy Coated Reinforcing Steel - Supply", "Corrosion Resistant Reinforcing Steel - Supply" or "Stainless Reinforcing Steel - Supply", as applicable, and will be full compensation for the supply and fabrication of reinforcing steel; delivery to the project site; and all labour, materials, equipment, tools and incidentals necessary to complete the Work to the satisfaction of the Consultant.

When stainless steel is supplied for use where CRR is specified, payment will be made at the unit price bid for "Corrosion Resistant Reinforcing Steel - Supply". No separate or additional payment will be made.

Payment will be made for 90% of the unit price bid for material acceptably supplied and delivered to the site. Payment for the remainder of the unit price bid will be made as the materials are acceptably installed.

All costs associated with the handling and storage of reinforcing steel will be considered incidental to the Work, and no separate or additional payment will be made.

5.10.2.2 Placement

Payment for the installation of reinforcing steel will be made at the unit price bid per kilogram for "Reinforcing Steel - Place" for steel acceptably placed and remaining in the work, regardless of type; and will be full compensation for all labour, equipment, tools and incidental necessary to complete the work. No allowance will be made for tie wire, chairs or other materials used for fastening the reinforcing steel in place.

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 6

STRUCTURAL STEEL

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6.1 General

This specification is for the supply, fabrication, delivery and erection of structural steel and associated materials. Structural steel shall include steel girders, trusses, diaphragms, bracing, splice plates, deck drains, anchor bolts, dowels, deck joint assemblies, buffer angles, connector angles, anchor bolt sleeves, curb and median cover, trough plates, pier nose plates, steel caps, capitals pier bracing and miscellaneous components.

6.2 Supply and Fabrication

A pre-fabrication meeting is required prior to commencement of fabrication of structural steel girders, trusses, finger plate deck joint assemblies or when any other specialized construction is included in the Contract. The meeting will be held at fabricator's plant and the Contractor shall ensure the plant superintendent and plant manager responsible for the work and any manufacturer's representatives directly involved in the specialized work are in attendance. The Department/Consultant will conduct this meeting after the shop drawings and welding procedures have been reviewed. The Contractor shall provide two week notice to the Department/Consultant prior to the meeting.

6.2.1 Standards

Fabrication of structural steel shall conform to "AASHTO LRFD Bridge Construction Specifications" and the American Welding Society (AWS) - Bridge Welding Code D1.5.

Where imperial/metric conversions are necessary, The National Standard of Canada, CAN3-Z234.1-79 shall be used as the basis of conversion.

All welding, cutting and preparation shall be in accordance with the AWS - Bridge Welding Code, D1.5. The fabrication of steel structures composed of structural tubing shall be in accordance with the American Welding Society (AWS) – Structural Welding Code D1.1.

6.2.2 Qualification

The Contractor shall notify the Department and Consultant two weeks prior to fabrication of any subcontractors in his employ. The Contractor shall remain responsible for the work of the subcontractors. All terms of the contract, such as Canadian Welding Bureau (CWB) approval and Canadian Institute of Steel Construction (CISC) certification and right of access shall apply to the subcontractor.

The fabricator shall operate a recognized steel fabricating shop accepted by the Consultant.

The fabricator shall be fully approved by the CWB as per Canadian Standards Association (CSA) Standard W47.1 in the following Divisions:

- Fabrication of steel girders, girder components and welded steel trusses..... Division 1
- All other bridge components Division 1 or Division 2
- Field welding/repairs..... Division 1 or Division 2

In addition fabricators of steel girders, girder components and welded steel trusses shall be certified by the Canadian Institute of Steel Construction (CISC) as meeting the quality compliance requirements in the category of steel bridges.

Only welders, welding operators and tackers approved by the CWB in the particular category shall be permitted to perform weldments. Their qualifications shall be current and available for examination by the Consultant.

6.2.3 Engineering Data

6.2.3.1 Review of Plate Arrangement for Welded Plate Girders

Prior to the placing of material orders, the Contractor shall submit to the Department and Consultant for review, three copies of sketch drawings showing the general description of the proposed fabrication scheme. This shall include the general arrangement of plates or shapes, the location of all shop and field splices and such other information as may be requested by the Department and Consultant to permit an assessment of the acceptability of the proposal.

6.2.3.2 Welding Procedures

Welding procedures, including Welding Procedure Datasheets shall be submitted for each type of weld used in the structure. The procedures shall bear the approval of the CWB and shall also be reviewed by the Department and Consultant prior to use on the structure.

6.2.3.3 Shop Drawings

Five copies of the shop drawings showing all details shall be prepared by the Contractor and submitted to the Consultant for review prior to fabrication. The shop drawings shall be legible and of adequate quality to be reproduced and microfilmed. Each drawing shall have a sufficient blank space for the Consultant's review stamp. The Consultant's review of the shop drawings shall not be construed as relieving the Contractor from his responsibility for errors or omissions. All shop drawings will be stamped as follows:

"This review applies to general arrangements and details of design but not to dimensions or details of fabrication and is subject to the requirements of specifications and to such corrections as may be marked here on."

Fabrication shall not commence prior to the review of the shop drawings.

In addition to specific details, the shop drawings shall include the following:

- (a) Drawings showing details of connections designed by the Contractor shall bear the signature and stamp of a Professional Engineer registered in the Province of Alberta.
- (b) All dimensions shall be correct at 20°C unless otherwise noted.
- (c) Weld procedure identification shall be shown on the shop drawings in the tail of the weld symbols.

- (d) All material splice locations shall be shown on the drawings.
- (e) Bearings shall be centered at -5°C .
- (f) Shop assembly drawings shall indicate camber and splice joint offsets measured to the top of top flange at a maximum spacing of 4 m.
- (g) Alberta Transportation bridge file number and project name shall be shown on all the shop drawings.

6.2.3.4 Proposed Fabrication Sequence & Equipment

Prior to commencement of fabrication, the Contractor shall present for review an outline of the fabrication sequence and details of equipment which will be used for the fabrication. The fabrication scheme shall include the order of make-up and assembly of all the component parts, as well as shop assembly, inspection stations, and surface preparation. If any equipment causes repeated defective work as determined by the Department/Consultant, it shall be substituted with a suitable alternative.

6.2.3.5 Mill Certificates

Mill certificates shall be provided for all material before fabrication commences.

6.2.3.6 Schedules

The Contractor shall provide and keep current a complete fabrication schedule in a form satisfactory to the Consultant.

6.2.4 Materials

6.2.4.1 Structural Steel

Structural Steel shall conform to the standard noted on the drawings. Interpretation of equivalent steels will be as per Appendix "A" of the CSA Standard G40.21 (1976 only). Mill certificate data and results of impact tests shall be provided to the Consultant for review and acceptance prior to shipment of material from the mill to provide sufficient time for replacement or for heat treating of material that does not meet the specification.

Repair of steel plates or rolled shapes by welding at the producing mill is not permitted.

Where mill test certificates originate from a mill outside Canada or the United States of America, the Contractor shall have the material tested and the mill test certificate verified by a Canadian laboratory. This laboratory shall be certified by an organization accredited by the Standards Council of Canada to comply with the requirements of ISO/IEC 17025 for the specific tests or type of tests required by the material standard specified on the mill test certificate. The mill test certificates shall be stamped with the name of the Canadian laboratory and the signature of an authorized officer. It shall state that the material is in conformance with the specified Contract requirements.

6.2.4.2 Bolts

All bolts shall conform to American Society for Testing and Materials (ASTM) Standard A325 or shall meet property class 8.8 of the Industrial Fasteners Institute for metric high strength structural bolts. The nuts shall be conform to ASTM A563 and harden washers shall conform to ASTM F436. Metric bolts shall be marked with the symbol A325M and those of “weathering” steel shall have the A325M symbol underlined. Weathering steel nuts shall be marked with three circumferential lines or shall be marked with a symbol “3”. Weathering steel washers shall be identified by a symbol “3”. Certified mill test reports for the fastener material shall be provided.

For bolts supplied from a manufacturer outside Canada or the United States of America, the above information shall be verified by a Canadian testing laboratory as outlined in clause 6.2.4.1

6.2.4.3 Stud Shear Connectors

All stud shear connectors shall conform to the chemical requirements of ASTM Standard A108, Grades 1015, 1018 or 1020. In addition they shall meet the mechanical properties specified in AWS D1.5, Table 7.1 for Type B studs. Certified mill test reports for the stud material shall be provided.

6.2.4.4 Bearings

Bearings shall be in accordance with Section 8, of the Specifications for Bridge Construction.

6.2.5 Welding

6.2.5.1 Filler Metals & Welding Processes

Low hydrogen filler, fluxes and low hydrogen welding practices shall be used throughout. The deposited weld metal shall provide strength, durability, impact toughness and corrosion resistance equivalent to base metal. The low hydrogen covering and flux shall be protected and stored as specified by AWS Standard D1.5. Flux cored welding or use of cored filler wires in the submerged arc process or shielding gas process are not considered as conforming to low hydrogen practice. These methods will not be permitted.

(a) Submerged Arc Welding (SAW)

Submerged arc welding process is allowed for all flat and horizontal position welds. All flange and web butt joints shall be made by an approved semi or fully automatic submerged arc process. All web to flange fillet welds and all longitudinal stiffener to web fillet welds shall be made by an approved fully automatic submerged arc process.

(b) Shielded Metal Arc Welding (SMAW)

Shielded metal arc welding is allowed for girder vertical stiffener to flange fillet welds and for miscellaneous components such as deck drains, bridge bearings, deck joint assemblies, pier nose plates and buffer angles.

(c) Metal Core Arc Welding (MCAW)

Metal core welding process utilizing low hydrogen consumables with AWS designation of H4 is allowed for vertical stiffeners and horizontal gussets of the girders and miscellaneous components such as deck drains, bridge bearings, deck joint assemblies, pier nose plates and buffer angles.

Field application of metal core arc welding is not allowed.

6.2.5.2 Cleaning Prior to Welding

Weld areas must be clean, free of mill scale, dirt, grease, and other contaminants prior to welding.

6.2.5.3 Tack and Temporary Welds

Tack and temporary welds shall not be allowed unless they are to be incorporated in the final weld. Tack welds, where allowed, shall be of a minimum length of four times the nominal size of the weld and length shall not exceed 15 times the weld size, and shall be subject to the same quality requirements as the final welds. Tack welds shall be sufficiently ground-out prior to final weld in order to obtain a uniform weld bead. Cracked tack welds shall be completely removed prior to re-welding.

6.2.5.4 Run-off Tabs

Run-off tabs shall be used at the ends of all welds that terminate at the edge of a member. The tab shall be a minimum of 100 mm long unless greater length is required for satisfactory work. They shall be tack welded only to that portion of the material that will not remain a part of the structure, or where the tack will be welded over and fused into the final joint. After welding, the tabs are to be removed by flame cutting, not by breaking off.

6.2.5.5 Preheat

Preheat requirements shall be performed and maintained as per AWS D1.5, except that all welds on girder flanges shall be preheated to a minimum temperature of 100°C unless a higher temperature is required by AWS D1.5 for the flange thickness. The preheat temperature of the web to flange joint shall be measured 75 mm from the point of welding on the side of the flange opposite to the side where the weld is being applied.

6.2.5.6 Welding at Stiffener Ends

To prevent notching effects, stiffeners and attachments fillet welded to structural members shall have the fillet welds terminate 10 mm short of edges.

6.2.5.7 Submission for Repair Procedures

The Contractor shall submit repair procedures for damaged base metal and unsatisfactory weldments, prepared by a Professional Engineer registered in the Province of Alberta for review by the Department and Consultant prior to repair work commencing.

6.2.5.8 Arc Strikes

Arc strikes will not be permitted. In the event of accidental arc strikes, the Contractor shall submit to the Department and Consultant for review a proposed repair procedure. The repair procedure shall include the complete grinding out of the crater produced by the arc strike. These areas will be examined by the Consultant to ensure complete removal of the metal in the affected area.

6.2.5.9 Grinding of Welds

Flange butt welds shall be ground flush or to a specified slope on both sides. Web butt welds which are sufficiently smooth with a neat appearance and uniform profile as determined by the Consultant will not require grinding. Fillet welds shall be continuous with uniform size and profile. At locations which are not conforming to acceptable profile shall be ground to the proper profile without substantial removal of the base metal. Grinding shall be smooth and parallel to the line of stress. Caution shall be exercised to prevent over grinding. Acceptability of the welds without grinding will be determined by the Consultant.

6.2.5.10 Plug and Slot Welds

Plug welds or slot welds shall not be permitted.

6.2.5.11 Welding of Girder Flanges and Webs

With the exception of longitudinal web to flange welds, all stiffeners, gusset plates, or any other detail material welded to girder flanges shall be a minimum of 300 mm from the flange butt welds.

With the exception of longitudinal web to flange welds and longitudinal stiffeners to web welds, all stiffeners, gusset plate, or any other detail material welded to girder webs shall be a minimum of 300 mm from the web butt welds.

6.2.6 Fabrication

Fabrication shall be performed in a fully enclosed area which is adequately heated. The shop temperature shall be at least 10°C.

6.2.6.1 Heat Number Transfer

As the plate is subdivided for webs and flanges, all heat numbers shall be transferred to each individual section. The numbers shall remain legible until such time as the material location in the final assembly has been recorded. Mill identification numbers stamped into the material shall be removed by grinding at an appropriate time.

6.2.6.2 Marking Systems

Methods and medium of marking and the location of marks shall be accepted by the Consultant. Steel stamps shall not be used. The only exception is the match marking of splice plates which may be steel stamped using low stress stamps. The stamps and specific locations of such stamps must be shown on the drawings and accepted by the Consultant.

6.2.6.3 Cutting of Plate

All plate material for main members, splice plates and any plate material welded to the main member shall be flame cut using an automatic cutting machine.

6.2.6.4 Flange Stripping

All flange material shall be cut so that the direction of the applied stress will be parallel to the direction of the plate rolling.

6.2.6.5 Flame Cut Edges

The flame cut edges of girder flanges shall have a maximum Brinell hardness as stated by section 6.2.8.10. The surface roughness of the flame cut edge shall not be greater than ANSI B46.1 500 $\mu\text{in.}$ (12.5 μm) and be such that as to allow Brinell hardness testing without spot grinding. The Consultant will perform Brinell hardness tests at random on the as is flame cut edge. If the hardness exceeds the requirements, the Contractor shall submit for review, his procedures for repairing the edges to meet the requirements. The surface of flame cut apertures shall be finished by grinding and shall be free of nicks and gouges.

The Contractor shall report all blow backs or signs of lamination observed during the cutting of the material. In case of plate lamination, the Contractor at his expense shall arrange for a CAN/CSA 178.1 certified NDT company to determine the extent. The ultrasonic testing technician shall be certified to Level II of CGSB. The report shall be prepared by a Professional Engineer registered in the Province of Alberta indicating the material is suitable for the girder fabrication and shall be forwarded to the Consultant for review and acceptance of the material.

6.2.6.6 Additional Material Splices

Additional splices, other than those shown on the shop drawings, will require review and acceptance of the Department and Consultant. The Contractor shall bear the cost of inspection of these splices.

6.2.6.7 Vertical Alignment

The structure shall be fabricated to conform to the requirements of the deflection and vertical curve, as noted on the drawings. For rolled shapes, advantage shall be taken of mill camber that may be inherent in the material.

6.2.6.8 Shop Assembly

(a) Plate Girders

Shop assembly of girders shall be by the progressive assembly method according to AASHTO LRFD Bridge Construction Specifications, except that only two, instead of three, sections need to be assembled. The detailed method of assembly, including points of support, dimensional checks, method of trimming to length, drilling and marking of splices, shall be to the procedure submitted for review by the Consultant as per section 6.2.3.4. Each individual girder section shall meet the camber requirements for that particular length, with the splices between these sections falling on the theoretical camber line for the entire span. Correction for variation in flange thickness must be considered. When the camber of the girder fails to meet the required tolerance, the Contractor shall submit a proposed method of repair for review by the Consultant. The adjustment for camber will not be allowed without the prior review of the procedure and supervision of the repairs by the Consultant. The camber of each individual girder section must be known for the next two girder sections in the girder line prior to shop assembly of any particular girder section. This is to allow the Consultant to call for the best fit line to reduce the effect of any camber differences should it be deemed necessary. Camber for plate girders will be measured on the top of the top flange. The camber of plate girders shall be measured in the "no load" condition.

(b) Box Girders

The progressive shop assembly for box girders shall be as per section 6.2.6.8(a), items described in this section are specific to box girders.

The camber of box girders shall be measured on the top of the top flange, and each top flange of a box shall individually meet the required camber. Girder sections assembled for splicing shall be supported within 2 m of the end of each section. Girder sections shall be supported in such a manner as to provide the correct angular relationship at the splice between girder sections while the splices are being reamed or drilled. Shop drawings shall clearly indicate the expected dead load deflection of each section and the elevations of the sections while supported for the drilling or reaming of each splice.

(c) Drilling

All splices shall be drilled from solid material while assembled or shall be subpunched or sub-drilled and then reamed to full size while in the shop assembly position. No reaming shall take place until acceptance of the assembly has been obtained from the Consultant.

6.2.6.9 Splice Plates

After shop assembly, splice plates and girders shall be clearly match marked to assure proper orientation and location of splice material for erection. All holes shall align with holes in the attached member. Splice plates shall then be removed, de-burred, solvent cleaned to remove all oil and sandblasted to remove all mill scale, in order to provide a suitable faying surface. These plates shall then be securely ship-bolted to the girders. The match marking system shall be shown on the drawings.

6.2.6.10 Bolt Holes

Clause 11.4.8 of AASHTO LRFD Bridge Construction Specifications shall apply except that all bolt holes in load carrying segments of main members and any material welded to main members shall be drilled full size or subpunched 5 mm smaller and reamed to full size. Punching of full size holes for secondary members such as bracings which are not welded to main member is allowed for material less than 16 mm thick. All holes in girder splices shall be circular and perpendicular to the member and shall be deburred inside and outside to ensure a proper faying surface.

6.2.6.11 Dimensional Tolerances

Normal tolerance for structural steel fabrication and fitting between hole groups will be ± 3 mm unless specified otherwise. The dimensional tolerances for structural members shall be within the AWS Standard D1.5, Section 3.5, except as otherwise noted below:

(a) Combined Warpage & Tilt

Combined warpage and tilt of flange at any cross section of welded I-shape beams or girders shall be determined by measuring the offset at the toe of the flange from a line normal to the plane of the web through the intersection of the centerline of the web with the outside surface of the flange plate. This offset shall not exceed 1/200 of the total width of the flange or 3 mm whichever is greater at bolted splice location. Bolted splices of main stress carrying members shall have parallel planes and the surfaces shall be in full contact without any gap.

(b) Girder Camber

Camber of beams and girders shall be uniform, true and accurate to the centreline of the top flange. Permissible variation in camber shall be within $\pm (0.2L_t + 3)$ mm; where L_t is the test length in metres. This applies to fabricated pieces only, prior to shop assembly. During shop assembly, splice points shall be located on the theoretical camber line or at a specified amount from the line should the Consultant choose to correct for shop camber deviations.

Where field splices are eliminated by combining girder segments into longer girder lengths, the cambers of the girders at the eliminated splice points shall be within ± 3 mm.

(c) Box Girders

Tolerances for box girder camber, sweep and depth shall be measured relative to two imaginary surfaces: a vertical plane passing through the centre line of the girder, and a surface located at the theoretical underside of the top flanges following the theoretical camber of the girder.

(d) Splices

Fill plates shall not be permitted at main girder field splices unless specified. The tolerance for girder depth or box girder geometry shall be as specified by AWS D1.5, except that the difference between similar dimensions of the adjoining sections being spliced shall not exceed ± 3 mm.

(e) Fitted Stiffeners

The Bearing ends of bearing stiffeners shall be flush and square with the web and shall have at least 75% of this area in contact with the flanges whereas fitted stiffeners may have a gap of up to 1 mm between stiffener and flange.

(f) Facing of Flanges

Surfaces of flanges which are in contact with bearing sole plates shall have a flatness tolerance of $0.001 \times$ bearing dimension.

(g) Bearing to Bearing Dimension

Bearing to bearing distance is a set dimension and therefore has no tolerance.

(h) Deck Joint Assemblies

Deck joint assemblies shall be assembled for inspection in a relaxed condition with erection angles removed. Tolerances for straightness shall be considered over the length of the assembly between the crown and gutter line both before and after galvanizing. Deviation from straightness in a vertical plane shall not exceed ± 6 mm. Horizontal sweep or variations in gap setting shall not be greater than 3 mm.

6.2.6.12 Flange Corner Chamfer

Corners of all flanges shall be ground to a 2 mm chamfer. Corners of stiffeners, structural sections and plates shall be ground to a 1 mm chamfer.

6.2.6.13 Milling Tolerances

Tolerance for milled to bear stiffeners shall be 0.05 mm with at least 75% of the area in bearing.

6.2.6.14 Web Panning

The maximum variation from flatness for webs shall be $0.01d$ where d is the least dimension of the panel formed by the girder flanges and/or stiffeners. Should the panning in one panel convex and the panning in the adjacent panel concave then the sum of the panning in the two adjacent sections shall not exceed that allowed for one panel. Localized deformation in the web shall not exceed 3 mm in 1 m.

6.2.6.15 Field Weld Preparation

All material to be field welded shall be prepared in the shop.

6.2.6.16 Flame Straightening

Flame straightening shall not be performed on any material or member without a written request to the Department and the Consultant. The Contractor shall submit a procedure stating location, temperatures and cooling rates, to the Department and the Consultant for review. Straightening shall only be performed in the presence of the Consultant.

6.2.6.17 Stress Relieving

When stress relieving is specified, it shall be performed in accordance with AWS D1.5. Copies of the furnace charts shall be supplied to the Consultant.

6.2.6.18 Handling and Storage

All lifting and handling shall be done using devices that do not mark, damage, or distort the assemblies or members in any way. Girders shall be stored upright, supported on sufficient skids and safely shored to maintain the proper section without buckling, twisting or in any way damaging or misaligning the material.

6.2.7 Surface Preparation and Coating

6.2.7.1 Blast Cleaning

Unless otherwise noted, all steel components shall be blast cleaned after fabrication in accordance with the Society for Protective Coating Standard (SSPC) No. SP6. Essentially this is a surface from which all oil, grease, dirt, rust, foreign matter, mill scale and old paint have been completely removed except for slight shadows, streaks or discolorations caused by rust stain or mill scale oxide binder. The exterior face of the exterior girders shall be uniform in appearance as determined by the Consultant.

6.2.7.2 Prime Coating

At all bearing locations, girder bottom flanges shall be prime coated all around (bottom, top and edges) 100 mm beyond the bearing dimension. In addition, at locations where the abutments are incorporating deck joints, the prime coat shall be extended up the web, including bearing/jacking stiffeners and underside of top flange. The prime coat shall be an approved organic zinc epoxy primer that has been qualified by test as a Class B coating, in accordance with the "Testing Method to Determine the Slip Coefficient for Coatings Used in Bolted Joints" as described in Appendix A of the Research Council on Structural Connections "Specification for Structural Joints Using High-Strength Bolts". The coating supplier shall provide a certificate stating compliance with this specification for the coating proposed to the Consultant for review and acceptance.

6.2.7.3 Galvanizing

Galvanizing shall be by the hot dip method, after fabrication, in accordance with the current edition of ASTM A123/A123M Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products and ASTM F2329 Standard Specification for Zinc Coating Hot-Dip Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners with additions and exceptions as described in this specification.

The fabricator shall provide a smooth finish on all edges and surfaces, and remove all weld spatter and all welding flux residue from the steel components prior to galvanizing.

Repair of galvanizing shall only be done if bare areas are infrequent, small, and suitable for repair. A detailed repair procedure shall be submitted for review prior to its use. It should be noted that repairs may require complete removal of the galvanized coating and re-galvanizing.

Repair shall be in compliance with ASTM A780, Method A3 "Metallizing". However repair for areas not exceeding 100 mm² may be done in accordance with ASTM Method A1 "Repair Using Zinc-Based Alloy". The thickness of the coating for both methods shall be 180 µm, and the repair tested for adhesion. The finished appearance shall be similar to the adjacent galvanizing. The Consultant will determine the acceptability of repaired areas.

6.2.8 Testing and Inspection

6.2.8.1 Access

The Contractor shall provide full facilities for the inspection of material and workmanship. Free access shall be allowed to the Consultant to all parts of the works. When required by the Consultant, the Contractor shall provide needed manpower for assistance in checking layout and performing inspection duties.

6.2.8.2 Responsibility

It is the Contractor's responsibility to ensure that the supply of material and the fabrication are in accordance with the contract requirements. The inspection and testing by the Consultant shall not be deemed to relieve the Contractor of any of his/her obligations.

6.2.8.3 Testing by the Consultant

The visual, radiographic, ultrasonic, magnetic particle and any other inspection that may be specified or required will be performed by the Consultant or by his testing agencies at the Consultant's expense.

The Contractor shall be responsible for all travel, boarding and lodging costs incurred by the Consultant to inspect bridge girders and finger plate deck joints being fabricated outside the Province of Alberta. The cost shall also include for a Department's representative to attend the prejob meeting and three additional trips to oversee the inspection of girders during the course of fabrication. This requirement for attending the prejob meeting will also apply for the finger plate deck joint; however the additional trip requirement will be reduced to one for the Department's representative.

6.2.8.4 Testing by the Contractor

The exception to section 6.2.8.3 is that additional inspection required by the Consultant shall be paid by the Contractor for the following conditions:

- Any repair work during the course of cutting, welding, fabrication or handling,
- Evaluation of any defective material by the Consultant.
- Additional unspecified material splices.

Any test records made by the fabricating shop in the course of normal quality control shall be open to the Consultant for inspection.

6.2.8.5 Inspection Station

To insure that each stage of inspection is performed in an orderly manner, during the fabrication of major structures, Inspection Stations will be set up at specific points. Sub-assemblies of the work will then be checked by the Contractor, confirmed and tested by the Consultant, and all deficiencies shall be corrected, prior to the work being sent to the next stage of fabrication.

Typical check points for a plate girder are:

- Flange plates prepared.
- Web plates prepared.
- Web to flange welds completed prior to fitting any stiffeners.
- Completion of all welding prior to splicing.
- Splice set-up prior to drilling.
- Surface preparation and coating.
- Clearance to ship.

6.2.8.6 Non-destructive Methods of Examination

The methods of non-destructive examination shall be in accordance with the following standards:

- Radiography - AWS Standard D1.5
- Ultrasonic - AWS Standard D1.5
- Magnetic Particle - ASTM Standard E-709
- Dye-Penetrant - ASTM Standard E-165
- Hardness tests - ASTM Standard E-103

6.2.8.7 Radiographic Inspection Schedule

Unless otherwise noted, radiographic inspection of welded plate girders will be performed in accordance with the following schedule:

- (a) 100% of all tension flange and stress reversal butt welds, all stiffener butt welds and all diaphragm butt welds, and any groove welded attachments to flange plates.
- (b) A minimum of 25% of all other flange butt welds randomly selected by the Consultant for each structure.
- (c) All web butt welds in tension and stress reversal zones plus additional 300 mm of web butt weld in compression zone at the end of the web.
- (d) If defects are found during testing, additional areas will be tested to ensure the quality of welds.

6.2.8.8 Radiographic Inspection of Miscellaneous Material

Unless otherwise noted, radiographic inspection of miscellaneous material will be performed by the Contractor in accordance with the following schedule:

- (a) 100% of all tension members.
- (b) 50% of all other members.

The radiographic inspection report and the film shall be provided to the Consultant within 48 hours of the completion of inspection.

6.2.8.9 Magnetic Particle Inspection Schedule

Unless otherwise noted, magnetic particle inspection of welded plate girders will be performed in accordance with the following schedule:

- (a) 50% of the web to flange welds or any fillet welds placed on flange plates
- (b) 10% of the web to stiffener welds
- (c) 100% of the stiffener to flange welds
- (d) 100% of the bearing sole plate to flange welds
- (e) 20% of the diaphragm connector plate welds
- (f) 100% of all manual (SMAW) welds

6.2.8.10 Dye Penetrant Inspection

Dye penetrant inspection will be performed in areas of the structure deemed necessary by the Consultant. In particular, the ends of the weld metal of all flange butt welds after the removal of runoff tabs will be inspected using this method. Defects discovered by this inspection shall be repaired by the Contractor, and the suspect area re-inspected.

6.2.8.11 Hardness Tests

Hardness tests will be performed by the Consultant on the flame cut edges of the girder flange prior to assembly. Unless otherwise noted, the hardness of the flame cut edges shall not exceed a maximum Brinell as noted below:

- (a) For carbon steels with a yield strength less than and including 300 MPa, the maximum Brinell shall be 200 BHN.
- (b) For carbon steels with yield strengths greater than 300 MPa, the maximum Brinell shall be 220 BHN.

Remedial work to the edges which exceed the specified hardness shall be performed and re-inspected prior to assembly.

6.2.8.12 Testing Stud Shear Connectors

Stud shear connectors shall meet all requirements as outlined by AWS D1.5. When bend testing, the studs shall be bent towards the centre of the girder. All the remaining studs shall be tested by striking with a hammer. A dull sound indicates incomplete fusion and a bend test will then be required for a potentially defective stud to ensure the integrity.

6.2.8.13 Inspection Schedules

The Contractor shall ensure that adequate notice of scheduled inspection requirements be given to the Consultant and inspection agencies, and that access to the work is provided at all times. The Contractor shall provide the Consultant with his sequence of fabrication in order that the inspection program can be properly integrated and agreed to, prior to commencement of fabrication.

6.2.8.14 Strip Seal Deck Joint

The installation of strip seal shall be tested by the Contractor in the presence of the Consultant for leakage. The failed areas shall be corrected and retested. The defective or torn seal shall be replaced at the Contractor's expense.

The Contractor and the Strip Seal Deck Joint Supplier shall jointly provide warranty for the satisfactory performance of the deck joint assemblies for a period of five years. The joint warranty shall be provided to the Consultant prior to the issuance of the Construction Completion Certificate.

The deck joint warranty shall provide for the replacement and/or repair of the deck joint assemblies, including all necessary traffic control at no cost to the Department, should unsatisfactory performance occur during the five year period.

6.2.8.15 Notification

The Contractor shall notify the Consultant 48 hours prior to shipment to facilitate final inspection of the materials. Material that has not been inspected in the fabrication plant will not be paid for until such material has been inspected. The Contractor may be charged with all expenses incurred for inspection of the material at the site.

6.3 Structural Steel Erection

The Contractor shall erect the structural steel, remove any temporary construction and do all work required to complete the erection in accordance with the drawings and these specifications. No drilling of additional holes or any other modifications including field welding shall be made to steel elements other than deck joints. Lifting devices shall not be welded to the girders. The Contractor shall not erect the structural steel until the substructure concrete has been cured a minimum of three days and achieved 80% of the 28 day specified concrete strength requirement. Without restricting generality, erection includes:

- erecting of temporary supporting structures
- removing anchor bolt grout can lid
- erecting of structural steel
- placing of expansion assemblies
- touching up painting as required

6.3.1 Transportation, Handling and Storing Materials

Girders and beams shall be transported in the vertical position. However these elements may be transported in other positions provided:

- A Professional Engineer registered in the Province of Alberta shall determine static and dynamic forces during handling, transportation, and storage using a dynamic load allowance of 100%. Computed stresses shall be according to CAN/CSA-S6, Clause 10.10 and the maximum cyclic stress range shall not exceed the constant amplitude fatigue threshold for the appropriate fatigue categories specified in CAN/CSA-S6, Table 10.4. All the calculations and associated sketches, including reasons why the girders cannot be shipped with the webs in the vertical plane, shall be submitted by the Contractor to the Consultant for review two weeks prior to shipping. The calculations and sketches shall be signed and sealed by the Engineer who performed the analysis and includes a written statement that the proposed method will not damage the elements.

Upon arrival at the site and prior to erection, the elements shall be checked by the Contractor in the presence of the Consultant to ensure all tolerances are met. The Contractor shall provide an adequate flat storage area for the inspection.

Any structural steel member damaged during transportation, handling, storing or erection shall be immediately reported to the Department and the Consultant. The Contractor shall provide an engineering assessment report prepared by a Professional Engineer experienced in evaluation and inspection of damaged steel members.

The Consultant will also arrange to have an independent inspection and assessment performed on the damaged member. The Contractor shall provide at least three working day notice for the inspection and facilitate all the activities associated with the inspection. All costs associated with the independent inspection will be the responsibility of the Contractor.

Material to be stored shall be placed on timber blocking. It shall be kept clean, and stored in a properly drained area. Girders and beams shall be placed upright and shored. Long members, such as deck joint assemblies, buffer angles, columns and chords, shall be supported on timber blocking to prevent damage from deflection. Galvanized material shall be handled and stored as per section 12.2.8.

6.3.2 Bridge Girders

6.3.2.1 Temporary Supporting Structures and Berms

The temporary supporting structures and berms shall be designed, constructed and maintained

to safely support all loads. Berms shall be constructed in a manner and of such materials that they will not be eroded by stream flow nor introduce silt into the water. The Contractor shall prepare and submit drawings for the Consultant's review for temporary supporting structures and berms where applicable. Review of the Contractor's drawings shall not be considered as relieving the Contractor of any responsibility. All drawings submitted shall bear the seal of a Professional Engineer registered in Alberta.

Temporary supporting structures and/or berms will not be permitted to remain in any stream channel during spring break-up or runoff periods, unless all necessary approvals have been obtained from pertinent agencies and prior written acceptance obtained from the Consultant.

Repair to any damage to property, such as earth fills and stream banks, resulting from the existence of berms, shall be the responsibility of the Contractor.

6.3.2.2 Review of Erection Procedure

The Contractor shall submit to the Consultant, for record purposes and for examination four copies of the detailed erection procedure four weeks in advance of the scheduled start of erection. The erection procedure shall include all drawings and documents necessary to describe the following:

- (a) Traffic Accommodation Strategy (TAS), as applicable.
- (b) Access to work, earth berms and work bridges.
- (c) Type and capacity of equipment. Cranes shall be used for handling and erecting structural steel girders.
- (d) Sequence of operation including position of cranes, trucks with members.
- (e) Position of cranes relative to substructure elements such as abutment backwalls, with details of load distribution of wheels and outriggers.
- (f) Lifting devices and lifting points.
- (g) Details of temporary works, supporting structures drawings including proposed methods to be used to ensure the required splice elevations and structure shape prior to bolt torquing, method of providing temporary supports for stability, top of girder elevations at each bearing and each splice location where appropriate.
- (h) Bolt tightening sequence.
- (i) Grout Pad Construction. Refer to section 6.3.2.10 of these Specifications.
- (j) Details of release of temporary supporting structures.
- (k) Provide an "As-Constructed" detailed survey of the substructure showing the following:

- location and elevation of all bearing grout pad recesses including anchor bolt voids,
- shim height at each bearing location,
- top of girder elevations at each bearing and each splice location where appropriate.
- longitudinal measurements between centreline of bearings of all substructure elements.

The erection procedure shall bear the Seal of a Professional Engineer registered in Alberta, who shall assume full responsibility to ensure that his erection procedure is being followed. Safety and compliance with the Occupational Health and Safety Act and Regulations thereunder, shall be an integral part of the design.

The Contractor shall continue to be fully responsible for the results obtained by the use of these sealed drawings, with the Professional Engineer also assuming responsibility, as the Contractor's Agent, for the results obtained.

Site work shall not commence until review of the proposal by the Consultant has been obtained. The Contractor's project manager and field superintendent may be required to attend a pre-job meeting at a location determined by the Consultant prior to commencement of any field work.

The Consultant's review shall not be considered as relieving the Contractor of the responsibility for the safety of his methods or equipment, nor from carrying out the work in full accordance with the drawings and specifications.

Before erection begins the Contractor shall do a complete superstructure layout by means of chalk lines and markings applied to all substructure units, showing bearing and girder positions in accordance with the Contractor's reviewed layout plan.

6.3.2.3 Fall Protection for Girder Erection and Deck Forming

In order to provide a safe working area for girder erection and deck formwork, the Contractor shall provide 100% fall protection and a safe work procedure.

6.3.2.4 Straightening Bent Material

Straightening of plates, angles or other shapes will not be permitted without the acceptance of the Department and Consultant. In all cases a detailed procedure in writing must be submitted by the Contractor, and reviewed prior to any straightening being undertaken.

Following the accepted straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fractures, which may include nondestructive testing. All costs shall be the responsibility of the Contractor.

6.3.2.5 Assembly

The parts shall be accurately assembled as shown on the drawings and all match-marks shall be followed. The material shall be carefully handled to avoid damage. Hammering, which will injure or distort the members, shall not be permitted. Bearing surfaces and surfaces to be in

permanent contact shall be clean before the members are assembled.

Splices and field connections shall have one half of the holes filled with bolts and cylindrical erection pins (half bolts and half pins evenly distributed throughout the splice or connection) before bolting. Splices and connections carrying traffic during erection shall have three-fourths of the holes filled.

Fitting-up bolts shall be of the same nominal diameter as the bolts, and cylindrical erection pins shall be sized to accurately fit the holes.

Should adjustments in elevation of the girder splices become necessary, to allow free rotation of the joint, only enough pins or bolts shall be removed.

6.3.2.6 High-Tensile-Strength Bolted Connections

(a) General

Bolted parts shall fit solidly together when assembled. Contact surfaces, including those adjacent to the washers, shall be de-scaled or carry the normal tight mill scale. Contact surfaces shall be free of dirt, paint, oil, loose scale, burrs, pits and other defects that would prevent solid seating of the parts. Bolts in exterior girders shall be installed with the heads on the outside face of the girder web and on the bottom faces of lower flanges unless otherwise noted. Nuts for bolts that will be partially embedded in concrete shall be located on the side of the member that will be encased in concrete.

Connections shall be assembled with a hardened washer under the bolt head or nut, whichever is the element turned in tightening. Surfaces of bolted parts in contact with the bolt head and nut shall be parallel.

For sloped surfaces, bevelled washers shall be used. The bevelled washers shall be designed to produce a bearing surface normal to the bolt axis.

Bolts shall be of new quality and stored in weatherproof containers to prevent loss of lubrication or accumulation of dirt.

All girders shall be erected with elevations and alignments checked by the Consultant, prior to any bolt tightening unless otherwise accepted by the Department and the Consultant.

(b) Bolt Tension

Each bolt shall be tightened so as to provide, when all bolts in the joint are tight, at least the minimum bolt tension shown in the following table for the size of bolt used:

Table 1 BOLT TENSION

Specified Bolt Size (A325M Bolts)	Minimum Bolt Tension		Commonly Supplied Equivalent Imperial Size (A325 Bolts)	Minimum Bolt Tension	
	Kilonewtons	pounds-force		Kilonewtons	pounds-force
M16X2	94	21,180	5/8	85	19,200
M20X2.5	147	33,050	3/4	126	28,400
M22X2.5	181	40,700	7/8	175	39,250
M24X3	212	47,660	1	227	51,500
--	--	--	1 1/8	251	56,450
M30X3.5	337	75,760	1 1/4	319	71,700
--	--	--	1 3/8	380	85,450
M36X4	490	110,160	1 1/2	463	104,000

(c) Turn-of-nut tightening

Tightening of all high strength bolts shall be by the turn-of-nut method. Before final tightening there shall be a sufficient number of bolts brought to a "snug tight" condition to ensure that the parts of the joint are brought into full contact with each other. Snug tight is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Following this initial operation, bolts shall be placed in any remaining holes in the connection and brought to snug tightness. After all bolts have been taken to the snug tight condition, the Contractor shall match mark the outer face of each nut and protruding end of bolt to have a common reference line to determine the relative rotation. All bolts in the joint shall then be tightened additionally by the applicable amount of nut rotation specified below, with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation there shall be no rotation of the part not turned by the wrench.

Amount of rotation of nut relative to bolt, regardless of which is turned:

- 1/3 turn where bolt length is 4 bolt diameters or less
- 1/2 turn where bolt length is over 4 bolt diameters and not exceeding 8 bolt diameters
- 2/3 turn where bolt length exceeds 8 bolt diameters

Notes

- tolerance 1/6 turn (60°) over, nothing under
- length of bolt measured from underside of head

(d) Reuse of Fasteners

High strength bolts shall be tensioned only once and shall not be reused. Retightening previously tightened bolts, which may have been loosened by tightening of adjacent bolts shall not be considered as reuse.

(e) Inspection

The Contractor shall provide safe and adequate access meeting Occupational Health and Safety requirements to all working areas, including all necessary scaffolding to enable the Consultant to carry out his inspection. The Contractor shall provide a competent workman to assist the Consultant in the checking of bolt tightening work.

6.3.2.7 Misfits

The correction of minor misfits involving any reaming, cold cutting and chipping for secondary members may be allowed. However, if reaming is considered required, it shall be immediately reported to the Department and the Consultant. The Contractor shall submit a repair procedure to the Consultant for review. If accepted, the repairs shall be made in the Consultant's presence.

6.3.2.8 Girder Adjustment

It is essential that the girders are erected with utmost attention being given to girder positioning, alignment, and elevation. Adjustment to girder position, bearing location and bearing elevation shall be done in order to achieve as closely as possible the lines and grades shown on the drawings.

The Contractor shall ensure that the structural steel is maintained in correct alignment at all times during construction.

6.3.2.9 Removal of Temporary Supporting Structures, Berms, and Clean-Up

Upon completion of the erection and before final acceptance, the Contractor shall remove all earth material or temporary supporting structures placed in the stream channel or elsewhere during construction. He shall remove all piling, excavated or surplus materials, rubbish and temporary buildings, replace or renew any damaged fences, and restore in an acceptable manner all property damaged during the execution of his work. Disposal of surplus materials shall be in a manner and location satisfactory to the Consultant.

The Contractor shall leave the bridge site, roadway and adjacent property in a neatly restored and presentable condition, satisfactory to the Consultant. When required, he shall provide written evidence that affected property owners or regulatory agencies have been satisfied.

All steel shall be left clean and free of oil, grease, mud, dust, road spray or other foreign matter.

6.4 Payment

Payment for the **Supply of Structural Steel Girders and Associated Material** will be made on the basis of the lump sum price bid. Items to be included in **Supply of Structural Steel and Associated Material** shall be as indicated on the Drawings.

Payment for the **Delivery of Girders** will be made on the basis of the lump sum price bid and shall include full compensation for the costs to deliver all structural steel and associated materials to the bridge site including necessary approvals and permits from the Motor Transport Board and/or the appropriate local road authorities. Cleaning of girders to remove any foreign material will be considered incidental to the work and no separate payment will be made.

Payment for the **Erection of Girders** will be made on the basis of the lump sum price bid and shall include full compensation for the cost of furnishing all materials, labour, tools, equipment, and incidentals necessary to acceptably erect the structural steel girders and associated material and complete site clean-up.

Payment for the **Supply and Delivery of Deck Joint Assemblies** will be made on the basis of the lump sum price bid. Items to be included in **Supply of Deck Joint Assemblies** shall be as indicated on the Drawings.

Payment for the **Installation of Deck Joint Assemblies** will be made on the basis of the lump sum price bid. Items to be included in **Installation of Deck Joint Assemblies** shall be as indicated on the Drawings.

When materials are delivered to the work site, payments for **Supply of Structural Steel Girders and Associated Materials, Delivery of Girders, and Supply and Delivery of Deck Joint Assemblies**, will be made to a maximum of 90% of the bid price of the materials and delivery. Payment for the remainder of the prices bid for supply and delivery will be made as the materials are acceptably installed.

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 7

PRECAST CONCRETE UNITS

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7.1 General

This specification is for the supply, manufacture, delivery and erection of prestressed and precast concrete bridge units and miscellaneous precast components.

7.2 Supply and Manufacture

A pre-fabrication meeting is required prior to commencement of fabrication of precast concrete elements. The meeting will be held at fabricator's plant and the Contractor shall ensure the plant superintendent and plant manager responsible for the work and any manufacturer's representatives directly involved in the specialized work are in attendance. The Department/Consultant will conduct this meeting after the shop drawings have been reviewed. The Contractor shall provide two weeks notice to the Department/Consultant prior to the meeting.

7.2.1 Standards

The manufacture of prestressed and precast concrete bridge units shall be in accordance with The Canadian Standards Association (CSA) Standard A23.4.

Where imperial/metric conversions are necessary, The National Standard of Canada, CAN3-Z234.1-79 shall be used as the basis of conversion.

7.2.2 Qualification

The Contractor shall notify the Department and Consultant of any subcontractors in his employ. The Contractor shall remain responsible for the work of the subcontractors. All terms of the contract, such as right of access, shall apply to the subcontractor.

The fabricator shall operate a recognized precast concrete fabricating plant and be fully certified by the Canadian Precast/Prestressed Concrete Institute (CPCI) Certification Program in the applicable Product Group classification.

7.2.3 Engineering Data

7.2.3.1 Shop Drawings

Five copies of the shop drawings showing all necessary fabrication details of the precast units, such as reinforcing steel, blockouts, stressing system, anchorage devices, void support system and screed rail shall be submitted to the Consultant for review prior to manufacturing. The shop drawings shall be legible and of adequate quality to be reproduced and microfilmed. Each drawing shall have a sufficient blank space for the Consultant's review stamp. The Consultant's review of the shop drawings shall not be construed as relieving the Contractor from his responsibility for errors or omissions. All shop drawings will be stamped as follows:

"This review applies to general arrangements and details of design but not to dimensions or details of fabrication and is subject to the requirements of specifications and to such corrections

as may be marked here on.”

Fabrication shall not commence prior to the review of the shop drawings.

Alberta Transportation bridge file number and project name shall be shown on shop drawings.

7.2.3.2 Stressing Calculations

Four copies of the stressing calculations showing elongations and gauge pressures as well as the strand release sequence data shall be submitted to the Consultant for review prior to manufacturing. Jack calibrations, performed within the previous six months, shall be included.

7.2.3.3 Stressing Steel Certificate

A copy of the load/elongation curve for each lot of stressing steel shall be submitted to the Consultant for review two weeks prior to manufacturing.

7.2.3.4 Concrete and Grout Mix Design

A copy of the concrete mix design and the grouting mortar mix design including applicable material test reports shall be submitted to the Consultant for review a minimum of two weeks prior to manufacturing. Material test reports shall be current and fully represent materials to be used in production. The mix design shall indicate the design strength, proportions of the constituent materials, type and brand of cement, type and brand of silica fume, origin of aggregates and brand names of all admixtures.

The sampling and testing of aggregates shall be completed by a concrete testing laboratory certified to CSA A283. Concrete mix designs, including the review of all material test reports, shall be signed and sealed by a Professional Engineer registered in the Province of Alberta employed by a concrete testing laboratory certified to CSA A283. The Engineer shall also provide a professional opinion indicating that the concrete mix is suitable for the intended use and can be expected to meet specification requirements.

Alternatively, concrete mix designs, including the sampling and testing of aggregates and review of material test reports may be completed by a qualified professional employed by the concrete supplier. When the concrete mix design is completed by the concrete supplier it shall be reviewed for compliance with the respective specifications, signed and sealed by a Professional Engineer registered in the Province of Alberta employed by an independent concrete testing laboratory certified to CSA A283. The independent review Engineer shall also provide a professional opinion indicating that the concrete mix is suitable for the intended use and can be expected to meet specification requirements.

The mix design shall include one microscopic air-void analysis performed by an independent testing laboratory in order to determine the spacing factor of the hardened concrete. The test sample shall be made from a trial concrete batch, vibrated into a cylinder mould so as to represent the level of vibration of the production concrete in the forms. If adjustments to the mix design are necessary, the air-void analysis shall be repeated.

Only the reviewed mix design shall be used to cast units. Changes in cement type, and/or decreasing cement content shall be construed as a change in mix design and will not be allowed.

7.2.3.5 Construction Data Sheets

During manufacture, the Construction Data Sheets shall be kept up to date and available for the Consultant's inspection. Copies of the data sheets shall be provided to the Consultant upon completion of the contract. One copy of the stressing data sheets for each bridge unit shall also be submitted with the Construction Data Sheets.

7.2.4 Materials

7.2.4.1 Hydraulic Cement

Hydraulic cement conforming to the requirements of CSA Standard A3001 shall be used.

7.2.4.2 Water

Water to be used for mixing concrete or mortar shall conform to the requirements of CSA Standard A23.1 and shall be free from injurious amount of alkali, organic materials or deleterious substances. The Contractor shall not use water from shallow, stagnant or marshy sources.

7.2.4.3 Silica Fume

10% condensed silica fume by weight of cement ($\pm 0.5\%$) shall be used in all precast concrete. Condensed silica fume shall conform to the requirements of CSA Standard A3001 for a Type SF supplementary cementing material, with a SiO_2 content of at least 85%, a maximum loss on ignition of 10% and no more than 1% SO_3 content. An acceptable, compatible, superplasticizing admixture shall be used together with the silica fume.

7.2.4.4 Aggregate Testing

Aggregate tests and analysis shall be performed and submitted to the Consultant for review with the concrete mix design as follows:

(a) Standard Weight Aggregates

Fine and coarse standard weight aggregates shall be as per section 4.4.4 of Specifications for Bridge Construction with maximum aggregate size of 14 mm.

(b) Lightweight Aggregates

Fine and coarse lightweight aggregates shall conform to the requirements of the ASTM Standard C330, with maximum aggregate size of 14 mm.

7.2.4.5 Air Entraining Agent

Air entraining agent shall conform to the requirements of the ASTM Standard C260.

7.2.4.6 Chemical Admixtures

Chemical admixtures shall conform to the requirements of ASTM Standard C494 and shall be accepted by the Consultant. All chemical admixtures must be suitable for use in precast concrete, be supplied by the same manufacturer as the air entrainment agent, and be compatible with each other. The addition of calcium chloride, retarders, accelerators or set controlling admixtures and air reducing agents will not be permitted.

Acceptable admixtures are air-entraining agents, superplasticizers and water-reducing agents.

7.2.4.7 Concrete

Concrete shall consist of hydraulic cement, condensed silica fume, aggregates, water and acceptable admixtures. The type of concrete to be used will be specified on the drawings.

The density, entrained air and air void spacing requirements for the various types of concrete are specified in Table 7.1.

Table 7.1

Type of Concrete	Aggregates	Concrete Unit Weight (in plastic state) kg/m³	Minimum Entrained Air %	Maximum Air Void Spacing (hardened concrete) mm
Standard Weight	Fine and Coarse Standard Weight	--	5	0.23
Lightweight	Fine and Coarse Lightweight	1680 ± 5%	6	0.23
Semi-Lightweight	Fine Standard Weight & Coarse Lightweight	1920 ± 5%	6	0.23

7.2.4.8 Reinforcing Steel

Reinforcing steel shall conform to the Bridge Construction Specifications – Section 5 - Reinforcing Steel.

7.2.4.9 Stressing Strand

Stressing strand shall be uncoated Grade 1860, low relaxation 7-wire strand conforming to the requirements of the ASTM Standard A416. Shop drawings and stressing calculations shall clearly show the type of strand to be used, and changes will not be allowed during production.

7.2.4.10 Lifting Hooks

Lifting hooks made of stressing strand shall conform to the requirements of the ASTM Standard A416, and shall be fabricated in a manner that distributes the load evenly to all strands.

7.2.4.11 Miscellaneous Steel

Miscellaneous steel shall conform to the requirements of the CSA Standard CAN/CSA G40.21M-300W or ASTM Standard A36 or as specified on the drawings. The Consultant may request the Contractor to provide mill certificates to prove conformance to the standard. Fabrication shall conform to the Bridge Construction Specifications - Section 6 - Structural Steel.

7.2.4.12 Bridgerail and Anchor Bolts

Bolts for bridgerail anchor assemblies shall be as per section 12.2.4.2 of The Specifications for Bridge Construction. The assemblies shall be hot dip galvanized after fabrication. All nuts and washers shall be shop assembled on the anchor bolts.

7.2.4.13 Voids and Ducts

All void and duct material must be accepted by the Consultant and remain dimensionally stable during the casting and steaming of the units. Voids shorter than 400 mm should be eliminated except when noted otherwise on the drawings.

7.2.4.14 Bearings

Bearings shall be in accordance with Section 8, of the Specifications for Bridge Construction.

7.2.4.15 Galvanizing

Galvanizing shall be by the hot dip method, after fabrication, in accordance with the current edition of ASTM A123/A123M Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products and ASTM F2329 Standard Specification for Zinc Coating Hot-Dip Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners with additions and exceptions as described in this specification. The fabricator shall provide a smooth finish on all edges and surfaces, and remove all weld spatters and all welding flux residue from the steel components prior to galvanizing.

Repair of galvanizing shall only be done if bare areas are infrequent, small and suitable for repair. A detailed repair procedure shall be submitted for review prior to its use. It should be noted that repairs may require complete removal of the galvanized coating and re-galvanizing.

Repair shall be in compliance with ASTM A780, Method A3 "Metallizing". However repair for areas not exceeding 100 mm² may be done in accordance with ASTM Method A1 "Repair Using Zinc-Based Alloy". The thickness of the coating for both methods shall be 180 µm, and the repair tested for adhesion. The finished appearance shall be similar to the adjacent galvanizing. The Consultant will determine the acceptability of repaired areas.

7.2.5 Manufacture

7.2.5.1 Forms

Precast concrete units are to be manufactured in steel forms which are acceptable to the Consultant.

For all beam members the forms shall be designed to be removed without damaging the beam. For all "I" or "T" Beam members the side forms shall be designed to be removed without damaging the top flange of the beam. The forms shall be removed horizontally away from the beam by a method that prevents any contact of the form with the top flange after release of the form. The top flange shall not be subjected to a vertical force at any time.

Holes or voids cast into the top flange of "I" or "T" girders to accommodate deck formwork will not be permitted.

7.2.5.2 Reinforcing Steel

Fabrication, handling, storage, placement and fastening of all steel reinforcement shall conform to the Bridge Construction Specifications - Section 5 - Reinforcing Steel.

Reinforcement shall be placed, secured and inspected for acceptance by the Consultant prior to placement of concrete.

7.2.5.3 Stressing Strand

Stressing strand shall be free of corrosion, dirt, grease, rust, oil or other foreign material that may impede bond between the steel and the concrete. Stressing strand shall be protected at all times from manufacture to encasing in concrete or grouting. Stressing strand that has sustained physical damage at any time shall be rejected. Stressing strand splices shall not be placed within a precast concrete unit.

The Contractor shall submit for review the methods, procedures and devices to accurately position the stressing strand. The submission shall include strand anchorage, draping, hold downs, guides or any other required devices.

Stressing strands shall not be stressed more than 36 hours prior to being encased in concrete. The force in each strand shall be measured by both elongation and pressure gauge.

Each strand shall be stressed to a calculated elongation, and a gauge pressure reading shall be taken as a check against the calculated force. During stressing, each strand shall be first pulled

to a predetermined pre-pull gauge pressure to eliminate any slack and a reference mark be placed at the front of the stressing jack. A second mark shall be placed away from the first with a distance corresponding to the calculated elongation on the stressing sheet. Each strand shall then be pulled to the second reference mark and the gauge pressure reading taken.

This process may be reversed, i.e. each strand shall be stressed to a calculated force (Determined by a gauge pressure calibration chart) and the elongation shall be measured as a check against the calculated force. During stressing, each strand shall be first pulled to a predetermined pre-pull gauge pressure to eliminate any slack and a reference mark be placed at the front of the stressing jack. Each strand shall then be stressed to the gauge pressure corresponding to the stressing sheet and a second reference mark be placed at this gauge pressure. The elongation shall be the distance measured between the two reference marks.

The maximum allowable discrepancy between jack pressure and elongation shall be within 5%, or the factors contributing to the difference must be identified and corrected before proceeding. Changes in strand temperature and slippage at strand anchorages shall be measured between stressing and concrete encasement and any changes in strand stress due to these effects shall be accounted for in the design. The stressing procedure and stressing calculations shall be submitted for review by the Consultant.

Seven wire stressing strand with any broken wire shall be removed and replaced. All stressing strands shall be checked for wire breaks before placement of concrete.

The precast unit ends shall have 15 mm deep strand termination recesses formed around the strands. All strands shall be cut flush with the bottom of the recesses, and the recesses shall then be filled flush with the ends of the girders with a moisture insensitive epoxy paste adhesive meeting the requirements of ASTM C881, Type IV, Grade 3, Class B or C. The paste shall be grey in colour. An approved Type 1c sealer shall be applied over the patched recessed areas as per Subsection 7.2.5.14. Sealer shall not be applied to the patched recessed areas when precast unit ends are designed to be encased in field cast concrete.

7.2.5.4 Void and Duct Placement

Voids and ducts shall be placed as shown on the drawings and must be tied and securely held in the required positions to prevent movement. Continuous ducts shall align precisely. The ends of the voids shall be sealed by methods accepted by the Consultant. Voids found to be distorted, damaged or of insufficient strength will be rejected. Blow holes caused by air expanding within the voids and rising to the surface, shall be repaired when the concrete is in the plastic state.

7.2.5.5 Identification of Units

Fabricator's name, year of manufacture, unit serial number and design loading shall be cast into the bottom of the units in 50 mm letters about 1.0 m from the unit end.

7.2.5.6 Concrete Measuring, Mixing and Placing

The procedures outlined in the ACI Standard 304 "Guide for Measuring, Mixing, Transporting and Placing Concrete" shall be followed. The time from initial mixing of the concrete until placing the concrete in the forms shall not exceed one hour. The elapsed time between the successive placing of concrete onto previously placed concrete shall not exceed 45 minutes.

7.2.5.7 Concrete Temperature

The concrete temperature shall be between 10°C and 30°C at the time of placing in the forms.

7.2.5.8 Finished Riding Surface

Where the top surface of the girder is designed to be the riding surface, the use of a continuous screed rail, independent of the top of the grout keys, shall be employed. The top surface shall follow a smooth profile, which incorporates the required camber adjustments.

7.2.5.9 Camber Hubs

Three camber hubs shall be placed in each girder, located along the centerline of the girder at the midpoint and 150 mm from each end. The camber hubs shall consist of 10 mm galvanized bars, of sufficient length to project vertically 10 mm above the riding surface.

The Contractor shall store the members in such a manner as to provide access for measuring camber as determined by the Consultant. The Contractor shall provide personnel as requested to assist the Consultant with the camber readings. The Contractor shall record the girder camber at the midpoint of each girder within 24 hours of girder destressing.

7.2.5.10 Concrete Finish

The exterior concrete girder faces shall have a Class 2 Rubbed Surface Finish, unless specified otherwise. Except the top, all the remaining surfaces shall have a Class 1 Form Surface Finish.

(a) Class 1 Form Surface Finish

This finish is essentially that obtained when concrete has been cast and adequately compacted in a properly oiled steel form. All fins, honeycomb, irregularities, cavities over 10 mm diameter or other similar defects shall be thoroughly chipped out. These areas shall be saturated with water for a period of not less than thirty minutes, carefully pointed and trued with mortar of a colour which will match the existing concrete. Mortar used for pointing shall be less than one hour old. The patches shall be properly cured by placing the repaired unit in the steam cure for a period of four days immediately after patching.

The finished surfaces shall be true and uniform. All surfaces which cannot be repaired to the satisfaction of the Consultant shall be finished as specified for Class 2 at no expense to the Department.

(b) Class 2 Rubbed Surface Finish

Class 2 Finish shall be essentially the same as Class 1 except that all holes, cavities and defects shall be repaired so that the finished surface presents a smooth, true, dense, uniformly coloured, and non-stained appearance. The concrete surfaces shall be thoroughly wire brushed to expose any hole or cavity prior to repairs. All residue of form oil shall be removed from the surface.

(c) Class 3 Bonded Concrete Surface Finish

The surface shall be prepared in accordance with the requirements of Class 2 Rubbed Finish except that it need not be of uniform colour. After the surface preparation has been completed to the satisfaction of the Consultant, the surface shall be pressure washed to remove all dust, dirt, laitance and all other bond breaking materials. After the concrete surface has dried for a minimum of 24 hours, the Contractor shall then supply and apply an approved pigmented sealer, which meets the requirements for a Type 3 sealer of the Material Testing Specifications for Concrete Sealer - B388.

The pigmented sealer shall be applied in accordance with the Manufacturer's specifications. The colour(s) of the proposed coating scheme, which typically shall be similar to the natural colour of cured concrete, must be acceptable to the Consultant before application of the coating. A minimum of two applications of the pigmented sealer are required. When spray application is used the surface shall be back rolled. The Contractor shall ensure that no colour variation is visible and shall match the colour of any previously painted adjoining surfaces. Acceptance of the pigmented sealer used will not be considered to relieve the Contractor of full responsibility for its acceptable performance and appearance.

(d) Class 4 Floated Surface Finish

After the concrete has been consolidated and the surface carefully screeded to the cross section and profile shown on the drawings, it shall be floated and trowelled as necessary to provide a closed, uniformly textured surface without brooming.

(e) Class 5 Floated Surface Finish, Broomed Texture

After the concrete has been consolidated, the surface shall be carefully screeded to the cross section and profile shown on the drawings. When the concrete has hardened sufficiently, the surface shall be finished with a broom of an accepted type. The broom strokes shall be perpendicular to the edge of the unit, and extended from edge to edge, with adjacent strokes slightly overlapped producing corrugations of 2 to 3 mm in depth. Brooming shall be done when the concrete has set sufficiently to produce clear, crisp brooming marks which do not sag or slump, without tearing the surface or disturbing coarse aggregate particles. After final brooming the surface finish shall be free of porous spots, irregularities, depressions, pockets and rough spots and must not vary more than 5 mm when measured using a 3 m straight edge.

Accepted finishing and edging tools shall be used on all edges and expansion joints after brooming.

7.2.5.11 Curing

All prestressed concrete units shall be cured at an elevated temperature. The curing of prestressed concrete units shall essentially be in accordance with CSA A23.4 unless otherwise specified. The ambient curing temperature shall be increased at a rate not exceeding 20°C per hour until a maximum temperature of not more than 60°C is attained. After curing, the temperature of the units shall be reduced at a rate not exceeding 10°C per hour until the temperature of the concrete has fallen to within 10°C of the temperature of the outside air.

Care must be exercised to protect prestressed and non-prestressed concrete units from thermal shock at all times until these units have been fully cured.

(a) Prestressed Concrete

(i) Curing in the Form

The initial application of heat shall commence only after the last of the freshly placed concrete has attained its initial set, normally two to four hours after casting. Heat shall not be applied directly to the concrete, but by a method that will produce a consistent ambient temperature throughout the entire form and enclosure. The increase in temperature and the holding temperature shall be monitored and permanently recorded on a chart at a minimum of 3 quarter points along the form.

(ii) Steam Curing after Removal from the Form

Upon removal from the forms the units shall be cleaned, patched, finished within a period not exceeding 12 hours. The units shall be placed in a manner that will facilitate any clean up or repair work, and that will allow full inspection of all surfaces. Within 24 hours of removal from the form, the units shall be placed within a suitable enclosure, for curing.

The curing enclosure shall provide a minimum of 150 mm of free air space between the concrete surfaces and the coverings. Flexible coverings shall be secured to prevent any moisture loss.

The difference in ambient air temperature adjacent to the concrete at different locations within the enclosure shall not exceed 10°C at any time.

The curing process shall be continued for a period of four days with one of the following methods:

1) Steam Curing

Steam jets shall not directly impinge on the concrete surfaces. The steam must be in a saturated condition maintaining an atmosphere of 95% to 100% relative humidity and a uniform ambient temperature of 40°C to 60°C.

For days with periods of 4 or more hours within a 24 hour period, where measured temperature or humidity levels do not meet the required limits,

these days will not be counted as a full day of steam cure. An additional day of steam cure beyond the specified 4 days will be required for each non-compliant day.

2) Curing with Continuous Misting and Heat

Sufficient number of atomizing misting nozzles shall be strategically located to produce a fine mist with 95% to 100% relative humidity in the enclosure. The water shall be preheated to a temperature which will produce a misting temperature compatible with the ambient temperature. The enclosure shall be heated with radiant heaters to a temperature of 40°C to 60°C. Dry heat shall never touch the concrete surface at any time. A control system shall be installed to shut off the heat when the humidity level drops below 90% in the enclosure. Should the temperature in the concrete rise above 40°C without the misting, the unit will be rejected.

Two continuously recording thermometers and two continuously recording hygrometers are to be provided for each curing enclosure to monitor the concrete ambient temperature and relative humidity. All time-temperature and time-humidity recordings shall be clearly shown on the graph.

(b) Non-Prestressed Concrete

Curing of all non-prestressed concrete shall be in accordance with one of the following methods:

(i) Elevated Temperature Curing

Upon removal from the forms the units shall be cleaned, patched, finished and elevated temperature cured for four days as per section 7.2.5.11(a) "Prestressed Concrete".

(ii) Moist Curing

The units may be moist cured in lieu of elevated temperature curing in accordance with the following:

Upon removal from the forms the units shall be cleaned, patched, finished, and ready for inspection within a period not exceeding 12 hours. Patching shall be performed with an approved product and at an ambient temperature of 15°C to 30°C. After completion of patching and finishing, within 24 hours of removal from the form, the units shall be placed under two layers of light colored filter fabric at an ambient temperature of not less than 15°C. The filter fabric or burlap shall be kept in a continuously wet condition throughout the curing period by means of a soaker hose or other means as reviewed and accepted by the Department. Curing with filter fabric or burlap and water shall be maintained for a minimum period of seven days.

7.2.5.12 Release of Stressing Strand

The stressing strand shall not be released until the specified concrete release strength is attained, and the release shall be in accordance with the accepted sequence.

Evidence of casting defects shall be reported to the Consultant prior to release of the strands.

7.2.5.13 Repairing Damaged Concrete

Serious damage, honeycomb and other casting defects shall be immediately reported to the Department and Consultant. Repair procedures shall be developed by a Professional Engineer and submitted for review and acceptance by the Department and Consultant prior to the commencement of the repair. All repairs shall be completed prior to curing of the unit at an ambient temperature of 15°C to 30°C.

Repairs to defects such as cracks, honeycombs or spalls shall be carried out in accordance with this section. Any unacceptable cracks, honeycombs or spalls will result in rejection of the unit.

In this section the “bearing area” of a girder is defined as the portion of the girder bottom flange up to the underside, but not including the radius transition between the bottom flange and the web, directly above the bearing. The bearing area extends from the end of the unit to 75 mm beyond the edge of the shoe plate. The “anchorage area” of a girder is defined as the full height portion of the girder that is two times the girder depth from the end of the girder but is not in the bearing area.

(a) Cracks

The following cracks are unacceptable and may result in rejection of the unit unless reviewed and accepted by the Consultant and the Department:

- Cracks in the bearing area of a girder
- Cracks in the anchorage area of a girder exceeding 0.5 mm in width.
- Cracks outside of the girder bearing and anchorage areas exceeding 0.2 mm or longer than 300 mm.

All cracks 0.2 mm or greater in width shall be repaired by epoxy injection in accordance with the manufacturer’s instructions. Coring shall be carried out to confirm the penetration of the epoxy into the cracks if requested by the Department.

The Contractor shall immediately notify the Department and the Consultant, if a crack that has a potential to be a shear crack exceeds 0.15 mm in width and longer than 0.25 times the girder depth. Crack length shall be measured along the horizontal axis and a crack will be considered to be a shear crack if inclined at an angle between 30° and 60° from horizontal.

(b) Honeycombs and Spalls

The following conditions of honeycomb or spall are unacceptable and may result in rejection of the unit unless accepted and signed off by the Design Engineer and reviewed by the Department:

- Any honeycomb or spall in the bearing or anchorage areas of the girder
- Major honeycomb or spall in areas outside the bearing and anchorage areas of a girder. Major honeycombs and spalls are described as honeycombs and spalls that are more than 30 mm deep or more than 0.1 m² in area.

When accepted by the Consultant and the Department, repairs for honeycombs and spalls may be made using a cementitious material. Repairs of minor honeycombs and spalls may be made after destressing of the girder. However major honeycombs and spalls shall be repaired before destressing the girder.

7.2.5.14 Type 1c Sealer

The Contractor shall supply and apply an approved Type 1c sealer to the girder surfaces as shown on Standard Drawing S-1637 "Type 1c Sealer for Precast Girders".

Type 1c sealers shall meet the current Material Testing Specifications for Concrete Sealers - B388.

The sealer shall be applied on clean dry surfaces free of form oil, and in accordance with the manufacturer's recommendations however the application rate shall be increased by 30% from that indicated on the approved list. Before applying the sealer the concrete shall be cured for at least 14 days. Mortar patches shall be cured for at least two days. The concrete surface shall be dry, and air blasted to remove all dust and accepted by the Consultant prior to applying sealer. In order to ensure uniform and sufficient coverage rates the Contractor shall apply measured volumes of sealing compound to appropriately dimensioned areas of concrete surface, using a minimum of 2 coats.

The Contractor shall ensure that the sealer is not applied in the grout pockets, lifting hook pockets or areas of the girders that will have field concrete cast against them.

The Consultant reserves the right to sample and test the sealer supplied by the Contractor.

7.2.5.15 Sandblasting

The roughening of concrete surfaces in shear key, block out, diaphragm and girder end void locations shall be achieved by sandblasting or other acceptable methods by the Contractor to the acceptance of the Consultant. The roughening shall be sufficient to remove all laitance and uniformly expose the aggregate particles.

7.2.5.16 Dimensional Tolerances of Cast Units

The maximum dimensional deviation in mm, of cast units from that as detailed on the drawings shall not exceed the following:

Length	$\pm 20 \text{ mm x length (m)) } 50$
Width	$\pm 3 \text{ mm}$
Depth	$\pm 5 \text{ mm}$
Camber	$\pm 20 \text{ mm x length (m)) } 50$
Sweep (NU Girders)	1 mm/m
Sweep (Other Units)	deviation from true, 20 mm x length (m)) 50
Projection of Stirrups	
Top of Girder	$\pm 12 \text{ mm}$
Bearing Areas	out of flatness of bearing areas, 3 mm
Bulkheads	warpage or tilt of ends, 5 mm
Rail Anchor Bolts	out of line, 5 mm in spacing, 5 mm in projection, 5 mm
Dowel Holes	out of plumb, 5 mm
Void Location	surface to void dimension, $\pm 15 \text{ mm}$ after casting

7.2.5.17 Handling and Storage

Precast units shall be handled by means of accepted lifting devices at designated locations. Units shall be maintained in an upright position, supported near the ends and on stable foundations.

7.2.6 Testing and Inspection

7.2.6.1 Access

The Contractor shall provide the Consultant with suitable and safe access to the works for the purposes of testing and inspection. The Contractor shall provide the following:

- (a) Heated laboratory space, minimum of 3 m x 3 m, capable of being locked, located in the proximity of the work
- (b) A work bench 1 m x 3 m x 1 m high
- (c) Cylinder storage chest with temperature control and a max/min thermometer, as per CSA Standard A23.2-3C
- (d) A sump and a water supply suitable for cleaning all testing equipment
- (e) A calibrated weigh scale.

7.2.6.2 Inspection

The Contractor shall be responsible for quality control. Inspection of the units by the Consultant will not relieve the Contractor of his responsibility for quality control.

The following stages of manufacturing require the Consultant's acceptance:

- (a) Form dimensions and set-up
- (b) Placement of reinforcing steel
- (c) Placement of voids and hardware
- (d) Stressing
- (e) Concrete mixture and placement
- (f) Form stripping
- (g) Clean-up and repair
- (h) Finishing and application of sealer
- (i) Curing
- (j) Application of Class 3 finishes
- (k) Storage of units

7.2.6.3 Test Methods

Sampling, making, curing and testing concrete specimens shall be in accordance with the requirements of the following CSA standards:

- Sampling - A23.2-1C
- Concrete Test Cylinders - A23.2-3C
- Testing Concrete Cylinders - A23.2-9C
- Air Content - A23.2-4C
- Density of Concrete - A23.2-6C
- Air Void Determination - A23.2-17C

7.2.6.4 Testing by the Contractor

The Contractor shall provide testing equipment, facilities and personnel to ensure that the concrete supply meets all requirements of the specifications. He shall maintain the required air entrainment by testing and making adjustments to the mix prior to and during the placing of concrete in the forms. The Consultant may test the air content to ensure that this is being correctly maintained however testing of concrete by the Consultant will not relieve the Contractor of his overall responsibility for quality control of the concrete.

7.2.6.5 Release Strength Test Cylinders

The Contractor shall make and test concrete cylinders to prove that the required release strength as stated on the drawing has been attained prior to release of the stressing strand. When one or more units are cast continuously, at least two cylinders shall be taken from the concrete of the last unit poured to represent the release strength for all units. These cylinders shall be cured with the bridge unit. Only testing of the first cylinder will be necessary if the required release strength is obtained. In the event all cylinders are tested without the required strength being obtained, the Consultant shall be contacted and his acceptance obtained for the release of the units.

7.2.6.6 28 Day Strength Testing

The Contractor shall make concrete test cylinders to determine the 28-day strength. The Consultant will determine from which batch the test cylinders shall be taken. Samples for testing will be taken from the fresh concrete being placed in the forms at the rate of one set of cylinders for every three bridge units cast continuously. Additional cylinders may be cast at the discretion of the Consultant. A set shall consist of three cylinders. A strength test will be the average of the 28-day strengths of the three cylinders (one set). Continuous casting shall mean no break in the casting longer than one hour.

The Contractor shall be responsible for transporting the test cylinders to an independent CSA testing laboratory. The transportation and testing of concrete test cylinders will be at the Contractor's expense. These tests shall represent the strength of the cast concrete. Test results shall be forwarded to the Consultant within 24 hours of testing.

The Contractor shall be responsible for all travel, boarding and lodging costs incurred by the Consultant to inspect prestressed and precast concrete bridge units and miscellaneous precast components being fabricated outside the Province of Alberta. Also included shall be the costs for a department representative to attend the prejob meeting and three additional site visits during the course of fabrication.

7.2.6.7 Fabrication of Prestressed/Precast Units in Cold Weather

The Contractor shall accept full responsibility for the protection of prestressed/precast concrete units when fabricating in adverse weather conditions.

When the ambient temperature is, or is expected to be, below 5°C during fabrication the following provisions for cold weather casting shall be put in place:

- (a) The Contractor shall construct an enclosure capable of maintaining an ambient temperature within the structure of between 15°C and 30°C. The enclosure shall be sufficiently sized to accommodate steel forms, workers and the casting equipment. The enclosure temperature shall be constantly monitored and shall be maintained within the specific range.

- (b) The heating system shall be designed to provide uniform distribution of heat and the combustion by-products shall be kept out of the enclosure.
- (c) Before casting concrete, adequate preheat shall be provided to raise the temperature of the formwork, reinforcing steel, stressing strand, miscellaneous iron, etc. to at least 10°C.
- (d) The fabricated units shall be kept in the enclosure until they are patched, repaired and transferred to the curing enclosure.

7.2.7 Failure to Meet Strength Requirements

7.2.7.1 Right of Rejection

The Consultant reserves the right to reject any concrete whatsoever which does not meet the specified strength determined in accordance with this Specification. The Consultant may, however, at his discretion, accept concrete which does not meet the specified strength requirements, and in such case payment will be made in accordance with section 7.2.7.2.

7.2.7.2 Percentage Payment Schedule

When the specified 28-day concrete strength is not met, the precast bridge unit shall be paid as per the following percentage of the unit price:

Strength below the specified 28-day strength	Percentage of Unit Price to be paid
1 MPa or less	95%
1 MPa to 2 MPa	90%
2 MPa to 3 MPa	85%
3 MPa to 4 MPa	80%

In the event that the concrete tested is more than 4 MPa below the specified 28-day strength, the bridge units fabricated from the concrete represented by the test specimens shall be rejected. In the event that the unit has been delivered and/or erected in the field, it shall be removed and returned to the Contractor's plant for replacement. The entire cost of replacement, including delivery and erection costs, shall be at the Contractor's expense.

7.2.7.3 Coring

If any concrete tested fails to meet the specified strength, the Contractor may request permission to core. If the coring is accepted by the Consultant, the Contractor shall make arrangements, through the Consultant, to employ an independent, qualified testing service, at the Contractor's expense.

The Consultant will specify the location of the coring to ensure that the cores represent the same concrete as the cylinders. The average of three adjacent cores taken from one bridge unit shall constitute a test. The cores shall be taken and tested in accordance with CSA Standard A23.2-14C within seven days of the date of testing the 28-day cylinders. CSA Standard A23.1-09, Clause 4.4.6.6.2 "Cores drilled from a structure" shall not apply. The average strength of each set of three cores shall be equal to or greater than the 28-day specified strength. The core test will represent all bridge units represented by the strength test. Alternatively, the Contractor may choose to take a core test from each of the other units in question, in which case each of these core tests will then represent a bridge unit.

Where the concrete strength as indicated by the cores is higher than the strength based on the 28-day concrete cylinder tests, the core results shall be used as the basis for acceptance and payment of the concrete. If the core strengths are lower than the strength of the 28-day concrete strength cylinder tests, the cylinder tests shall govern.

7.3 Erection of Precast Concrete Girders

7.3.1 General

The Contractor shall erect the girders, remove any temporary construction, and do all work required to complete the erection in accordance with the drawings and these specifications. Drilling, coring or the installation of any fasteners or anchoring systems or any other modifications shall not be made to the concrete elements. The Contractor shall not erect the precast concrete girders until the substructure concrete has been cured a minimum of three days and achieved 80% of the 28 day specified concrete strength requirements.

Without restricting generality, erection includes:

- removing anchor bolt grout can lid
- erecting the girders
- placing and grouting of connector bolts and diaphragms
- post-tensioning
- cutting-off lifting hooks, and grouting lifting holes on exterior girders and all lifting hook pockets

7.3.2 Handling and Storing Materials

Precast concrete units to be stored shall be placed upright and shored on timber blocking and kept clean and properly drained.

7.3.3 Temporary Supporting Structures and Berms

The temporary supporting structures and berms shall be properly designed and substantially constructed and maintained for the forces which may come upon them. Berms shall be constructed in a manner and of such materials that they will not be eroded by stream flow nor introduce silt into the water. The Contractor shall prepare and submit to the Consultant, for review drawings for temporary supporting structures and berms, and for traffic control and

accommodation where applicable. Review of the Contractor's drawings shall not be considered as relieving the Contractor of any responsibility. All drawings submitted shall bear the seal of a Professional Engineer registered in Alberta.

Temporary supporting structures and/or berms will not be permitted to remain in any stream channel during spring break-up or run-off periods, unless all necessary approvals have been obtained by the Contractor from pertinent agencies.

Incidental damage to other property, such as fills and stream banks, resulting from the existence of berms, shall be the responsibility of the Contractor.

7.3.4 Review of Erection Procedure

The Contractor shall submit to the Consultant, for record purposes and for examination as to concept only, four copies of a detailed erection procedure three weeks in advance of the scheduled start of erection. The erection procedure shall include all drawings and documents necessary to describe the following:

- (a) Access to work, earth berms and work bridges.
- (b) Type and capacity of equipment. Cranes shall be used for handling and erecting precast concrete units.
- (c) Sequence of operation, including position of cranes, trucks with girders, and traffic accommodation.
- (d) Detailed crane position on the ground, particularly adjacent to substructure elements, such as abutment backwalls, with details of load distribution on wheels and outriggers.

Details of crane position on the structure, showing wheel loads and axle spacing of equipment moving on structure.
- (e) Loads and their position from crane wheels and outriggers during all positions of lifting when crane is on structure.
- (f) Details of temporary works, supporting structures drawings, including proposed methods to be used to ensure the required splice elevations and structure shape prior to placing concrete, and/or post-tensioning and method of providing temporary supports for stability.
- (g) Details of lifting of units, showing vertical forces at lifting hooks.
- (h) Provisions for control and adjustment of errors for width and positioning of curbs or exterior units.
- (i) Complete details of blocking for bearings where necessary to constrain movements due to horizontal forces and/or gravity effects.

- (j) Details of post-tensioning procedures, including strand specifications, jack dimensions, pressures, forces and elongations, and grouting.
- (k) Details of release of temporary supporting structures.
- (l) Provide an "As Constructed" detailed survey of the substructure showing the following:
 - location and elevation of all bearing grout pad recesses,
 - shim height at each bearing location,
 - top of girder elevations at each bearing (and each splice location where appropriate).

The erection procedure shall bear the Seal of a Professional Engineer registered in Alberta, who shall assume full responsibility to ensure that his design is being followed. Safety and compliance with the Occupational Health and Safety Act and Regulations thereunder, shall be integral parts of his design.

The Contractor shall continue to be fully responsible for the results obtained by the use of these sealed drawings, with the Professional Engineer also assuming responsibility, as the Contractor's Agent, for the results obtained.

Work shall not commence until the Consultant has reviewed the proposal. The Contractor's project manager and field superintendent may be required to attend a prejob meeting at a location determined by the Consultant prior to commencement of any field work.

Before erection begins the Contractor shall do a complete superstructure layout by means of chalk lines and markings applied to all substructure units, showing bearing and girder positions in accordance with the accepted layout plan.

The Consultant's review shall not be considered as relieving the Contractor of the responsibility for the safety of his methods or equipment, nor from carrying out the work in full accordance with the drawings and specifications.

7.3.5 Girder Adjustments

It is essential that the girders be erected with utmost attention being given to girder positioning, alignment, and elevation. The Contractor shall adjust girder position, bearing location and bearing elevation in order to achieve as closely as possible the lines and grades shown on the drawings. The Contractor shall minimize any differential camber (girder to girder), and the sweep of the girders by jacking, loading of girders, winching, or whatever means are necessary, and shall provide the necessary temporary attachments to hold the girders in position.

The maximum dimensional deviation in mm, of erected precast concrete units from that as detailed on the drawings shall not exceed the following:

Sweep (NU Girders)	1 mm/m
Sweep (Other Units)	deviation from true, 20 mm x length (m)) 50

7.3.6 Lifting Hooks and Lifting Holes

After the Consultant has approved the erected positions of the girders, all lifting holes on exterior girders shall be filled with an appropriate Alberta Transportation's approved patching material. All lifting hooks shall be cut off 50 mm below surface, and all lifting hook pockets shall be filled with an accepted grout.

7.3.7 Post-Tensioning System

7.3.7.1 General

This work consists of post-tensioning and grouting of cable ducts for cast-in-place and precast concrete.

7.3.7.2 Standards

Applicable requirements of the current edition of the following standards shall be followed:

- CSA A23.1/23.2 - Concrete Materials and Method of Concrete Construction
- CSA A23.4 - Precast Concrete Materials and Construction
- Section 4 of the Specifications for Bridge Construction
- Guide Specification Acceptance Standards for Post Tensioning Systems - PTI
- Specifications for Grouting of Post Tensioned-Structures - PTI
- AASHTO LRFD Bridge Construction Specifications

7.3.7.3 Qualification

The Contractor or the Sub-contractor shall have extensive experience in this work and shall utilize only fully trained, competent and experienced operators. The Contractor shall ensure the site supervisor responsible for the tensioning and grouting operations is at the site whenever these operations are being carried out.

7.3.7.4 Submittals

The Contractor shall submit the following information for the Consultant's review at least four weeks prior to commencement of post-tensioning work:

- Five sets of post tensioning drawings illustrating the stressing system and where appropriate, design details and sequence of stressing.
- Five sets of stressing calculations taking into account all applicable losses.

Information for mill reports and stress strain curves for the stressing strand shall be provided at least 5 days prior to stressing.

7.3.7.5 Materials

(a) Stressing Strand

Stressing strand shall conform to the requirements of sections 7.2.4.9 and 7.2.5.3.

Corrosion inhibitor is required when the stressing and grouting operations are not completed within 20 calendar days of the installation of the stressing steel. The corrosion inhibitor, when required, shall be water-soluble and shall have no deleterious effect on the steel, grout or concrete, or bond strength of the steel to concrete.

(b) Anchorage and Distribution

All stressing steel shall be secured at the ends by means of permanent anchoring devices accepted by the Consultant. These devices shall comply with S6-06 Clause 8.4.4.1.

Steel distribution plates or assemblies may be omitted when the anchoring devices are sufficiently large and used in conjunction with an embedded steel grillage that effectively distributes the compressive stresses to the concrete.

(c) Ducts

The Contractor shall provide mortar tight inlets and outlets in all ducts with a nominal diameter of 20 mm in the following locations:

- The anchorage area
- All high points of the duct, when the vertical distance between the highest and lowest point is more than 0.5 m
- Place an inlet at or near the lowest point
- Place free draining outlet at all low points of duct

The Contractor shall provide inlets and outlets with valves, caps or other devices capable of withstanding the grouting pressure. The ducts and vents shall be securely fastened in place to prevent movement. The Contractor shall provide details of inlets and outlets on the shop drawings.

(d) Concrete

Concrete shall be supplied in accordance with section 7.2.4, however the maximum size of coarse aggregate shall be 10 mm and 28 day minimum compressive strength of 50 MPa unless otherwise specified.

(e) Grout

Grout shall be Class C as described in Table 10.9.3-1 and the properties as described in Table 10.9.3-2 of the AASHTO LRFD Bridge Construction Specification. In addition to the requirements noted in the tables, a test for wet density shall also be performed in accordance with the "Standard Test Method for Density" ASTM C138. Pre-bagged grouts shall be packaged in plastic lined bags or coated containers, stamped with the date of manufacture, lot number and mixing instructions. Copies of the quality control data for each lot number and shipment sent to the job site shall be provided to the

Consultant for review. Materials with a total time from manufacture to usage in excess of six months shall be retested and certified by the supplier before use, or shall be removed from the job site and replaced.

The average minimum compressive strength of 3 cubes at 28 days shall be 50 MPa as per CSA A23.2-1B. The results for bleed test and fluidity test shall meet the requirements noted in Table 10.9.3-2 of the AASHTO LRFD Bridge Construction Specifications.

The Contractor is responsible to perform all grout testing in the field at his cost and he shall ensure that the testing is witnessed by the Consultant. The testing shall be completed by a qualified and experienced technician. The frequency of grout strength testing shall be as follows:

Strength Test

Precast Concrete Girders:	One strength test per girder line
Cast-In-Place Girders:	One strength test for every four longitudinal ducts

The strength test shall be done by an independent CSA certified testing lab.

Bleed Test

At the beginning of each day's grouting operation, perform a wick induced bleed test in accordance with ASTM C940 and with modifications noted in Table 10.9.3-2 of the AASHTO LRFD Bridge Construction Specifications.

Fluidity Test

At the inlet and outlet, perform fluidity test in accordance with the standard ASTM C939 flow cone test or the modified ASTM C939 test.

Wet Density Test

Perform wet density test in accordance with American Petroleum Institute (API) Mud Balance Test API Practice 13B-1: "Standard Procedures for Field Testing Water-based Drilling Fluids".

7.3.7.6 Equipment

(a) Stressing

- Hydraulic jacks and pumps of sufficient capacity shall be used for tensioning of strands.
- The force induced in the stressing strand shall be measured using calibrated jacking gauges, load cells or a calibrated dynamometer.
- The pressure gauge shall have an accurate reading dial at least 150 mm in diameter.
- The forces to be measured shall be within 25 and 75 percent of the total graduated capacity of the gauge, unless calibration data clearly establishes consistent accuracy over a wider range.
- The measuring devices shall be calibrated at least once every six months. The jack and the gauge shall be calibrated as a unit. A certified calibration chart shall be kept with each gauge.

(b) Grouting

- A high speed shear mixer shall be used that is capable of continuous mechanical mixing and producing grout that is free of lumps and undispersed cement. The water supply to the mixer shall be measured by an accurate gauge.
- The holding tank shall be capable of keeping the mixed grout in continuous motion until it is used. The outlet to the pump shall have a screen with 3 mm maximum clear opening.
- A positive displacement type pump shall be used which is capable of producing an outlet pressure of at least 1.0 MPa. A pressure gauge having a full-scale reading of no greater than 2 MPa shall be placed at some point in the grout line between the pump outlet and the duct inlet. A spare fully functional pump shall also be on site.
- Standby flushing equipment with water supply shall be available at the site prior to commencing grouting.
- The grouting equipment shall be of sufficient capacity to ensure that grouting of the longest duct can be completed within 30 minutes after mixing.
- Grout hoses and their rated pressure capacity shall be compatible with the pump output and the maximum grout pressure. All connections from the grout pump to the duct shall be airtight so that air cannot draw into the duct.

7.3.7.7 Construction

(a) Checking Post Tensioning Ducts

Prior to placing post-tensioning steel, the Contractor shall demonstrate to the satisfaction of the Consultant that all ducts are unobstructed.

(b) Welding

Welding of stressing tendons shall not be permitted. Stressing tendons shall not be used as an electrical "ground". Where the ends of strands are welded together to form a tendon so that the tendon may be pulled through the ducts, the length of the strands used as an electrical "ground" or 1 m, whichever is greater, shall be cut off from the welded end prior to stressing.

(c) Tensioning

Post-tensioning shall be carried out as per reviewed drawings and stressing calculations. The stressing and release of tendons shall be done in the sequence specified on the drawings. All strands in each tendon shall be stressed simultaneously with a multi-strand jack. The force in the tendons shall be measured by means of pressure gauge and shall be verified by means of tendon elongation. All tendons shall be tensioned to a preliminary force as necessary to eliminate any slack in the tensioning system before elongation readings are started. This preliminary force shall be between 15% and 25% of the final jacking force.

Stressing tails of post-tensioned tendons shall not be cut off until the record of gauge pressures and tendon elongations are provided by the Contractor to the Consultant for review and acceptance. A record of the following post-tensioning operations shall be kept for each tendon installed:

- Project Name & File Number
- Contractor/Subcontractor
- Tendon location & size
- Date tendon installed
- Tendon pack/heat number
- Modulus of elasticity (E)
- Date stressed
- Jack and gauge identifier
- Required jacking force and gauge pressures
- Elongation (anticipated and actual)
- Anchor set (anticipated and actual)
- Stressing sequence
- Witnesses to stressing operation
- Grout information (Brand Name)
- Time for grouting each tendon
- Date grouted

(d) Concreting

The anchorage recesses shall be concreted after tensioning but before grouting the tendons.

The concrete surface of the anchorage recesses shall be abrasive blasted. The recesses shall be thoroughly wetted and covered with a thin cement scrub coat immediately before placing fresh concrete.

(e) Grouting

All ducts or openings shall be clean and free of all deleterious matter that would impair bonding of the grout to the ducts and stressing steel. All ducts shall be thoroughly flushed out with water and blown out with compressed oil free air. All inlets and outlets shall be checked for their capacity to accept injection of grout by blowing compressed oil free air through the system.

A thoroughly mixed grout, meeting all the requirements described in 7.3.7.5(e) shall be passed through a screen with 3 mm maximum clear openings before entering the pump. All grout vents shall be opened prior to commencement of grouting. The duct shall be completely filled by injecting grout from the lowest end of the tendon on an uphill direction. Grout shall be pumped continuously through the duct until no visible signs of water or air are ejected at the outlet. A fully operational grout pump shall be on site for all pumping procedures. A continuous, one way flow of grout shall be maintained at a rate of 5 to 15 lineal metres of duct per minute. The grouting of a tendon shall be completed within 30 minutes of mixing unless otherwise accepted by the Consultant.

Normal pumping pressure shall be between 0.1 to 0.4 MPa, measured at the inlet. The pumping pressure at the injection vent shall not exceed 1 MPa. If the actual pressure exceeds the maximum allowed, the injection vent shall be closed and the grout shall be injected at the next vent that has been or is ready to be closed as long as one way flow is maintained. Grout shall not be injected a succeeding vent from which grout has not yet flowed. For each tendon, immediately after uncontaminated uniform grout discharge begins, a fluidity test shall be performed. The measured grout efflux time shall not be faster than the efflux time measured at the inlet or the minimum efflux time established. If the grout efflux time is not acceptable, additional grout shall be discharge from the discharge outlet. Grout efflux time shall be tested. This cycle shall be continued until acceptable grout fluidity is achieved. In addition to fluidity test, check the grout density using the Wet Density Method. The density at the final outlet shall not be less than the grout density at the inlet. To ensure the tendon remains filled with grout, the ejection and injection vents shall be closed in sequence, respectively under pressure when the tendon duct is completely filled with grout. Valves and caps are not to be removed until the grout has set.

Grouting will not be permitted when the air temperature is below 5°C or above 25°C, nor when there are other conditions judged by the Consultant to be detrimental to the grouting operations.

The Contractor shall provide 50 mm deep grout tube termination recesses formed around the tubes projecting from top of the deck. After grouting, all tubes shall be cut flush with the bottom of the recesses, and the recesses shall then be grouted flush with the top of the deck.

7.3.7.8 Inspection

The stressing and grouting will require the Consultant's presence. The Contractor shall ensure that adequate notice be given to the Consultant for these operations and access to the work is provided at all times.

7.3.8 Removal of Temporary supporting structures and Site Clean-up

Upon completion of the erection and before final acceptance, the Contractor shall remove all earth material or temporary supporting structures placed in the stream channel or elsewhere during construction. He shall remove all piling, excavated or surplus materials, rubbish and temporary buildings, replace or renew any damaged fences, and restore in an acceptable manner all property damaged during the execution of his work. Disposal of surplus materials shall be in a manner and location satisfactory to the Consultant.

The Contractor shall leave the bridge site, roadway and adjacent property in a neatly restore, and presentable condition, satisfactory to the Consultant; when required, he shall provide written evidence that affected property owners or regulatory agencies have been satisfied.

7.4 Payment

Payment for the **Supply of Precast Concrete Girders and Associated Material** will be made on the unit price bid per girder. The unit prices bid shall include full compensation for the cost of furnishing all materials, labour, tools, equipment and incidentals necessary for fabrication.

Payment for the **Delivery of Girders** will be made on the basis of the lump sum price bid and shall include full compensation for the costs to deliver all precast concrete girders and associated materials to the bridge site including necessary approvals and permits from the Motor Transport Board and/or the appropriate local road authorities. Cleaning of girders to remove any foreign material will be considered incidental to the work and no separate payment will be made.

Payment for the **Erection of Girders** will be made on the basis of the lump sum price bid and shall include full compensation for the cost of furnishing all materials, labour, tools, equipment, and incidentals necessary to acceptably erect the precast concrete girders and associated material and complete site clean-up.

Payment for **Post-Tensioning and Grouting** will be made on the basis of the lump sum price bid which price shall include full compensation for the cost of furnishing all materials, labour, tools, equipment and incidentals necessary to acceptably complete the post-tensioning and grouting process and clean-up.

When materials are delivered to the work site, payments for **Supply of Precast Concrete Girders and Associated Material, and Delivery of Girders** will be made to a maximum of 90% of the bid price of the materials and delivery. Payment for the remainder of the prices bid for supply and delivery will be made as the materials are acceptably installed.

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 8

Bridge Bearings

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REFERENCE DRAWINGS Drawing No.

Typical Expansion Bearing Details..... S-1761

8.1 General

This specification is for the supply, fabrication, delivery and installation of plain and steel reinforced elastomeric bearings, pot bearings and fixed rocker bearings. The steel reinforced elastomeric bearing and pot bearing components between sole plates and base plates shall be designed by the bearing supplier in accordance with the requirements of contract drawings and these specifications. Design details of elastomeric bearings shall also be in accordance with typical detail drawing S-1761.

8.2 Design Requirements

8.2.1 Elastomeric Bearings

8.2.1.1 General

The design of the elastomeric bearings shall be carried out by the bearing supplier. The bearing supplier's design engineer shall be a Professional Engineer registered in the Province of Alberta. Shop drawings shall be stamped, signed and sealed by the bearing supplier's design engineer.

The elastomeric bearings shall be designed to accommodate the loadings, translations and rotations specified on the contract drawings, in accordance with the requirements of CAN/CSA-S6, and the exceptions noted in this specification.

Sole plates and base plates shall be supplied by the bearing supplier, and shall conform to the details shown on the contract drawings. Any adjustments of these details shall be reviewed and accepted by the Consultant prior to fabrication.

8.2.1.2 Sliding Surfaces

Sliding surfaces shall allow translation by sliding of a stainless steel surface against a mating polytetrafluoroethylene (PTFE) element. The flat PTFE sheet shall be recessed and bonded into a 2.5 mm deep recess in the top of a 10 mm thick galvanized steel plate. The galvanized plate shall be vulcanized to the top of the elastomeric pad. The galvanized steel plate shall have the same plan dimensions as the elastomeric pad and act as the top laminate in the elastomeric bearing.

8.2.1.3 PTFE Element

The PTFE element shall be a 5.0 mm thick unfilled, unlubricated flat PTFE sheet.

8.2.1.4 Self-Rocking Pintle

A single self-rocking pintle welded under the base plate shall be used to ensure uniform contact between the elastomeric bearing pad and the girder bottom flange at erection. Where double pintles are shown on the contract drawings, the pintles shall be centred beneath the bearing along a line perpendicular to the longitudinal axis of the girder. The pintle or pintles shall be supported on galvanized steel shim stacks of the appropriate thickness to achieve the correct bearing elevation.

8.2.1.5 Replaceability

The entire bearing assembly, between the sole plate and the base plate shall be replaceable without damage to the structure and without removal of any concrete, welds or anchorages permanently attached to the structure and without lifting the superstructure more than 5 mm. Bearings shall not be recessed into plates that are permanently attached to the structure.

8.2.2 Pot Bearings

8.2.2.1 General

The design of pot bearings shall be carried out by the bearing supplier. The bearing supplier's design engineer shall be a Professional Engineer registered in the Province of Alberta. Shop drawings shall be stamped, signed and sealed by the bearing supplier's design engineer.

The pot bearing shall be designed for the loadings, translations and rotations specified on the contract drawings, in accordance with the requirements of CAN/CSA-S6 and the exceptions noted in this specification.

The average stress in the elastomer at serviceability limit state loads shall not exceed 30 MPa.

Sole plates and base plates shall be supplied by the bearing supplier, and shall conform to the details shown on the contract drawings. Any adjustments of these details shall be reviewed and accepted by the Consultant prior to fabrication.

8.2.2.2 Translations and Rotations

Provision for translation shall be through sliding of a stainless steel surface against a mating PTFE element. The translational capacity in an unrestrained direction shall be as specified on the contract drawings.

Provision for rotation about any horizontal axis shall be by means of a single disc of confined elastomer. Brass rings shall not be considered in determining the effective thickness of the elastomeric disc. The effective thickness of the elastomeric disc to evaluate the rotational capacity shall be limited to the thickness of the disc excluding the brass rings.

The rotational capacity about any horizontal axis shall be as specified on the contract drawings. The rotational capacity about the vertical axis through the centre of the bearing shall be as specified or $\pm 1^\circ$, whichever is greater.

Rotational bearings shall be capable of resisting the specified lateral loads in any direction in combination with the applicable vertical loads.

Brass sealing rings shall be flat and smooth on all surfaces and conform to the requirements of CAN/CSA-S6.

The depth of the pot wall shall be such that a minimum vertical distance of 2.5 mm remains between top of the pot wall and the closest point of contact of the brass sealing rings with the pot wall upon rotating the piston an amount equal to the specified rotation at ULS.

The pot and piston surfaces in contact with the confined elastomer shall be lubricated with silicone grease. The bearing shall be sealed by a one-piece continuous preformed closed-cell compressible ring against entry of dirt, dust, and moisture between the elastomer and the pot and piston contact surfaces. Any joint in the ring shall be bonded and the strength shall be at least equal to the strength of the ring.

8.2.2.3 Sliding Surfaces

Sliding surfaces shall allow translation by sliding of a metal surface against a mating PTFE element. For plane surfaces, the metal surface shall be stainless steel. The metal surface shall overlap the PTFE by at least 25 mm at extremes of movement on each side and, except for guides for lateral restraint, shall be positioned above the PTFE element.

Except when used as mating surfaces for guides for lateral restraint, the PTFE resin shall be virgin material and shall be used as unfilled sheets and shall contain spherical reservoirs for lubricant pressed into its surface. The diameter of the reservoirs shall not exceed 8 mm measured at the surface of the PTFE, and the depth shall not be less than 2 mm nor more than half the thickness of the PTFE. The reservoirs shall be evenly distributed across the surface of the PTFE and shall occupy 20% to 30% of the surface. PTFE used as mating surface for guides for lateral restraint shall not be dimpled or lubricated. All PTFE elements shall be fully bonded and recessed in a rigid backing material.

All PTFE surfaces except those that act as mating surfaces for guides for lateral restraint or that are subjected to a contact pressure of less than 5 MPa shall be permanently lubricated with silicone grease.

The average contact pressure for unfilled PTFE elements based on the gross area of the PTFE shall not exceed the values given in table 8-1.

**Table 8-1
Average Contact Pressure for unfilled PTFE Elements**

Limit State	Permanent Load, MPa	Total Load, MPa
Serviceability	25	35
Ultimate	40	55

The maximum contact pressures at the extreme edges of flat and curved PTFE elements shall not exceed 1.2 times the values indicated above.

The average contact pressure at serviceability limit state loads for PTFE elements filled with up to 15% mass of glass fibers used to face mating surfaces of guides for lateral restraints shall not exceed 45 MPa.

The coefficient of friction between stainless steel sliding surfaces and lubricated virgin PTFE shall be as per clause 14.7.2.5 and Table 14.7.2.5-1 of the 2012 AASHTO LRFD Bridge Design Specifications.

8.2.2.4 Fasteners, Anchorages, and Guides for Lateral Restraint

Fasteners, anchorages and translational elements with lateral restraints shall be capable of resisting either of the following lateral loads:

- a) For bearings with a capacity of 5,000 kN or less at serviceability limit state, 10% of the vertical load capacity.
- b) For bearings with a capacity over 5,000 kN at serviceability limit state, 500 kN plus 5% of the vertical load in excess of 5,000 kN.

Guides for lateral restraint shall be arranged to permit the required rotations about both the horizontal and vertical axis. The translational elements of guides for lateral restraint shall be faced with stainless steel and shall provide lateral restraint by sliding against mating surfaces faced with PTFE.

The beneficial effect of friction shall be neglected in proportioning fasteners and anchors, except for slip resistant connections which shall be designed to the requirements of CAN/CSA S6-06 Clause 10.18.2.

8.2.2.5 Replaceability

The entire bearing assembly, between the sole plate and the base plate shall be replaceable without damage to the structure and without removal of any concrete, welds or anchorages permanently attached to the structure and without lifting the superstructure more than 5 mm. Bearings shall not be recessed into plates that are permanently attached to the structure.

8.2.2.6 Durability

Bearings shall be designed to prevent moisture and dirt from entering the internal surfaces. The bearings shall be fabricated from materials that are durable and are protected against corrosion so as to perform the intended function.

8.2.3 Fixed Rocker Steel Bearings

8.2.3.1 General

Fixed rocker steel bearings shall conform to the details shown on the contract drawings. Any adjustments to these details shall be reviewed and accepted by the Consultant prior to fabrication.

8.3 Supply and Fabrication

8.3.1 Standards

Fabrication of plain and laminated elastomeric bearings, pot bearings and fixed rocker steel bearings shall conform to:

- The American Association of State Highway and Transport Officials (AASHTO) LRFD Bridge Construction Specifications,
- AASHTO's Standard Specifications for Transportation Materials and Methods of Sampling and Testing M251-06 Standard Specification for Plain and Laminated Elastomeric Bridge Bearings, and
- The American Welding Society (AWS) - Bridge Welding Code D1.5.

Where imperial/metric conversions are necessary, The National Standard of Canada, CAN3-Z234.1-79 shall be used as the basis of conversion.

8.3.2 Qualification

The Fabricator for the steel components shall be fully approved by the Canadian Welding Bureau (CWB) as per CSA Standard W47.1 in Divisions 1 or 2.

Only welders, welding operators and tackers approved by the Canadian Welding Bureau in the particular category shall be permitted to perform weldments. Their qualifications shall be current and available for examination by the Consultant.

8.3.3 Engineering Data

8.3.3.1 Welding Procedures

Welding procedures including welding procedure datasheets approved by the Canadian Welding Bureau required for the fabrication and field installation of bearings shall be submitted for each type of weld. The welding procedures shall be reviewed by the Department and Consultant before welding proceeds.

8.3.3.2 Shop Drawings

Shop drawing requirements shall be as per Section 6 of the Specifications for Bridge Construction. In addition, the following requirements shall be met:

The shop drawings shall clearly indicate all material properties, dimensions, connection attachments, fasteners and accessories, the bearing identification, and the load capacity at the serviceability and ultimate limit states as follows:

- a) Maximum vertical permanent and total load.
- b) Maximum lateral load and corresponding vertical load.
- c) Maximum rotational capacity about any horizontal axis and about the vertical axis at the centre of the bearing

When bearings for more than one bridge are included, individual shop and erection drawings shall be submitted for each bridge.

8.3.3.3 Mill Certificates and Quality Assurance Testing

Mill certificates and quality assurance test results shall be provided to the Consultant for all materials and fabricated components prior to shipping of the finished bearings from the facility of manufacture.

8.3.4 Materials

All materials shall be new and unused, with no reclaimed material incorporated in the finished bearing.

8.3.4.1 Steel

The steel laminates within reinforced elastomeric bearings shall be rolled mild steel with minimum yield strength of 230 MPa. The steel for base plate, keeper bars, pintels and shims shall conform to the requirements of CSA G40.21 Grade 300W. The steel for sole plate, top bearing plate and fixed rocker shall be as per the site specific drawings.

8.3.4.2 Stainless Steel

Stainless steel sheets shall conform to the requirements of the American Iron and Steel Institute (AISI) Type 304, no. 8 mirror (0.2 μm) finish. The chemical and mechanical properties shall conform to the requirements of ASTM A 240M.

8.3.4.3 Brass

Brass sealing rings for confined elastomer bearings shall be according to ASTM B36M, half-hard.

8.3.4.4 Elastomer

Elastomeric compounds shall be low temperature Grade 5 and meet the physical and low temperature brittleness requirements listed in Table 1 and Section 8.8.4 of AASHTO M251-06. It shall have 60 durometer hardness shore A for elastomeric bearing pads and 50 ± 5 durometer hardness shore A for pot bearings.

Elastomeric compounds for fully integral abutments and piers shall be low temperature Grade 3, 4, or 5 and meet the physical and low temperature brittleness requirements listed in Table 1 and Section 8.8.4 of AASHTO M251-06. It shall have 50 ± 5 durometer hardness shore A.

8.3.4.5 PTFE

PTFE shall be unfilled, 100% virgin polymer. It shall conform to Section 18.8.2.5 – Unfilled PTFE Sheet of the 2009 AASHTO LRFD Bridge Construction Specifications including all interim revisions.

Material used as the mating surface for guides for lateral restraint may be one of the following:

- a) Unfilled PTFE.
- b) PTFE filled with up to 15% by mass of glass fibres.

8.3.4.6 Lubricant

Lubricant shall be silicone grease, effective to -40°C , and comply with U.S. Department of Defense MIL-S-8660C.

8.3.4.7 Adhesives

Adhesive for bonding PTFE to metal shall be an epoxy resin producing a bond with a minimum peel strength of 4 N/mm, when tested according to ASTM D 429, Method B. Adhesives shall not degrade in the service environment.

8.3.4.8 Base Plate Corrosion Protection

Bearing base plate corrosion protection shall be as per Section 12 of the Specifications for Bridge Construction.

8.3.4.9 Anchor Rods and Connecting Bolts

For anchor rods and connecting bolts, the following material properties shall be used:

DESCRIPTION	GRADES
Galvanized mild steel anchor rods in contact with galvanized bearing plates.	Galvanized CSA G40.21M Grade 300W or ASTM A307
Galvanized high strength anchor rods in contact with galvanized bearing plates	Galvanized ASTM A193 GRADE B7 ($F_y=725\text{ MPa}$, $F_u=860\text{ MPa}$). Note galvanizing of high strength steel requires special procedures; refer to Standard Drawing S1642.
Bolts connecting galvanized bearing components.	Galvanized 22 mm diameter A325M Galvanized nuts A563M Galvanized hardened washers F436M

8.3.5 Welding

8.3.5.1 Filler Metals

Low hydrogen filler, fluxes and low hydrogen welding practices shall be used throughout. The low hydrogen covering and flux shall be protected and stored as specified by AWS Standard D1.5. Flux cored welding or use of cored filler wires in the submerged arc process or shielding gas processes are not considered as conforming to low hydrogen practice. These methods will not be permitted. However metal core welding process utilizing low hydrogen electrodes with

AWS designation of H4 will be allowed. The deposited weld metal shall provide strength, durability, impact toughness and corrosion resistance equivalent to base metal.

Field application of metal core arc welding is not permitted.

8.3.5.2 Cleaning Prior to Welding

Weld areas must be clean, free of mill scale, dirt, grease, and other contaminants prior to welding.

8.3.5.3 Tack and Temporary Welds

Tack and temporary welds shall not be allowed unless they are to be incorporated in the final weld. Tack welds, where allowed, shall be of a minimum length of four times the nominal size of the weld and shall be subject to the same quality requirements as the final welds. Cracked tack welds shall be completely removed prior to re-welding.

8.3.5.4 Methods of Weldment Repair

Repair procedures for unsatisfactory weldments shall be submitted for review and acceptance by the Department and Consultant prior to repair work commencing.

8.3.5.5 Arc Strikes

Arc strikes will not be permitted. In the event of accidental arc strikes, the Contractor shall submit to the Department and Consultant for review and acceptance a proposed repair procedure. The repair procedure shall include the complete grinding out of the crater produced by the arc strike. These areas will be examined by the Consultant to ensure complete removal of the metal in the affected area.

8.3.5.6 Plug and Slot Welds

Plug welds or slot welds will not be permitted.

8.3.6 Fabrication

Fabrication shall be performed in a fully enclosed area which is adequately heated. The shop temperature shall be at least 10°C.

(a) Plain Bearings

Plain bearing pads shall be moulded individually, cut from moulded strips or slabs of the required thickness, or extruded and cut to length.

(b) Laminated Bearings

Laminated bearings shall be moulded under pressure as a single unit and heated in moulds that have a smooth surface finish.

The steel laminates shall be of uniform 3.2 mm thickness without any sharp edges. The bond between the elastomer and the metal laminates shall be such that when a sample is

tested for separation, failure shall occur within the elastomer and not between the elastomer and metal laminate. The top 10 mm galvanized laminate for sliding bearings shall have a 2.5 mm recess. The recessed surface shall be machined as per clause 8.3.6.1 of the Specifications for Bridge Construction.

(c) Pot Bearings

Stainless steel sheets in contact with PTFE shall be continuously welded around the perimeter to its backing plate to prevent ingress of moisture. The weld shall be clean, uniform, and without overlaps and located outside the area in contact with PTFE.

The threaded portion of the bolts shall be coated with silicone grease prior to installation.

Virgin or glass filled PTFE elements shall be recessed in a rigid backing material and shall be bonded over the entire area with an adhesive. The rigid backing material shall be grit blasted and cleaned with oil free compressed air prior to applying the adhesive.

The PTFE elements used as mating surfaces for guides for lateral restraint shall extend to within 10 mm from the ends of the backing plates.

(d) Steel Rocker Bearings

The curved surface of steel rocker bearing shall be machined as per clause 8.3.6.1 of the Specifications for Bridge Construction.

8.3.6.1 Machining

Machining shall be done after welding. All metal to metal contact surfaces shall be machined.

For pot bearings, the pots and pistons shall be machined from solid metal plate or castings. There shall be no openings or discontinuities in the metal surfaces in contact with the confined elastomer or PTFE.

The surface finish of metal plate in contact with any metal plate or confined elastomer in pot bearings shall be machined to a surface finish of 6.4 μm and a flatness tolerance of 0.001 x bearing dimension.

8.3.6.2 Identification

Each bearing shall be marked with the fabricator's name, date of manufacture and unique identification number. The characters shall be not less than 10 mm in height.

8.3.6.3 Coating

Metal components described on the site specific drawings, except weathering steel (CSA G40.21 350 A and 350 AT) and stainless steel, shall be hot dip galvanized after fabrication in accordance with ASTM A123/A123M Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products and ASTM F2329 Standard Specification for Zinc Coating Hot-Dip Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.

For pot bearings, the pot and piston plates, except surfaces in contact with elastomer, shall be metallized as per ASTM A780, Method A3. The thickness of metallizing shall not be less than 180 microns.

Repair of galvanizing shall only be done if bare areas are infrequent, small, and suitable for repair. A detailed repair procedure shall be submitted for review prior to its use. It should be noted that repairs may require complete removal of the galvanized coating and re-galvanizing. Repair shall be in compliance with ASTM A780, Method A3 Metallizing. However repair for areas not exceeding 100 mm^2 may be done in accordance with ASTM Method A1 "Repair Using Zinc-Based Alloy". The thickness of the coating for both methods shall be $180 \text{ }\mu\text{m}$, and the repair tested for adhesion. The finished appearance shall be similar to the adjacent galvanizing. The Consultant will determine the acceptability of repaired areas.

Galvanized sole plates, slider plates and rocker plates bolted to the bottom flanges of weathering steel girders shall use galvanized A325 bolts. The bolt layout, size and configuration shall be as detailed on contract drawings. Girder bottom flanges at bearing connections shall be prime coated all around (bottom, top and edges) to 100 mm beyond the sole plate with an approved organic zinc epoxy primer having a certified Class B slip coefficient. The galvanized top surface of the bearings plates shall be hand wire brushed to a Class C slip coefficient surface condition. Slip coefficients surface conditions shall meet the requirements of CAN/CSA S6-06 Table 10.9.

8.3.6.4 Tolerances

Plain and laminated bearing tolerances shall be as per AASHTO Standard M251-06.

Pot bearing tolerances shall be as follows:

- a) The deviation from flatness of PTFE surfaces shall not exceed:
 - i) 0.2 mm, when the diameter or diagonal is equal to or less than 800.
 - ii) 0.00025 of the diameter or diagonal, when the diameter or diagonal is greater than 800 mm.
- b) The deviation from flatness of stainless steel in contact with PTFE for plane surfaces and from the theoretical surface for spherical surfaces shall not exceed:
 - i) 0.0003 LH mm for a rectangular PTFE element.
 - ii) 0.0006 RH mm for a circular PTFE element

where:

L = the greater plan dimension for a rectangular bearing,

R = the radius of a circular bearing, and,

H = the free height of PTFE element

- c) For confined elastomer bearings, the tolerance of fit between the piston and the pot shall be +0.75 to +1.25 mm. The inside diameter of the pot cylinder shall be the same as the nominal diameter of the elastomer and shall be machined to a tolerance of:

- i) 0 to +0.125 mm for diameters up to and including 500 mm.
 - ii) 0 to +0.175 mm for diameters over 500 mm.
- d) The plan dimensions of the recess for PTFE shall be the same as the nominal plan dimensions of the PTFE and shall be machined to a tolerance of 0 to +0.2% of the diameter or diagonal.
- i) Overall bearing plan dimension ± 3 mm
 - ii) Overall bearing height ± 3 mm
 - iii) Machined surface dimensions ± 0.4 mm
- e) Elastomeric components shall meet the following requirements:
- Diameter: 0.0 to -1.5 mm for diameters \leq 500 mm
 0.0 to -2.0 mm for diameters $>$ 500 mm
- Thickness 0.0 to +1.0 mm
- f) Brass rings shall meet the following requirements:
- i) Difference between internal diameter of brass ring and diameter of recess in the moulded elastomer shall be 0 to +0.5 mm.
 - ii) Difference between sum of thicknesses of brass rings and recess depth in the moulded elastomer 0 to +0.25 mm
- g) Recessed Guide Bars shall meet the requirements of the American Standard Clearance Locational Fit Class LC3 according to ANSI B4.1.
- h) Guides for lateral restraints shall have a 0.50 mm \pm 0.25 mm gap between metal restraints surfaces and mating PTFE elements.
- i) PTFE components shall meet the following requirements:
- i) The plan dimension of the PTFE shall be 0 to -0.2% of diameter or diagonal difference between internal diameter of brass ring and diameter of recess in the moulded elastomer shall be 0 to +0.5 mm.
 - ii) The thickness of the PTFE shall be within 0 to +10.0% of the design thickness.
The depth of recess of the PTFE shall be 0 to +0.3 mm

8.3.7 Testing and Inspection

8.3.7.1 Testing by the Contractor

The Contractor shall be responsible for quality control and quality assurance testing required to ensure the work meets the design parameters and specification requirements.

Any quality control/quality assurance testing and inspection records made by the Contractor shall be open to the Consultant for auditing.

The Contractor shall engage an independent accredited testing company at his expense to perform testing of bearing materials and the finished bearings.

The testing shall meet the acceptance criteria outlined in the specifications. The results shall be forwarded to the Consultant for review prior to shipping the bearings to the site. The Contractor shall also submit to the Consultant prior to shipping to the site, the manufacturer's certification, as a written affidavit, that the material supplied meets the contract requirements.

8.3.7.1.1 Elastomeric Bearings

Testing of elastomeric compounds shall be completed in accordance with AASHTO M251-06. Testing of the completed bearings shall be in accordance with AASHTO M251-06 with the exception that contrary to clauses 8.8.1 and 8.8.2, testing of all bearings is required. The optional testing described in section 8.9 of AASHTO M251-06 is not required.

The increment in compressive deformation of laminated bearings shall not exceed 0.05 of the effective rubber thickness, when the bearing load is increased from an initial pressure of 1.5 MPa to a pressure of 7 MPa when tested as per the requirements of Section 9.1 of the AASHTO M251-06.

8.3.7.1.2 Pot Bearings

Testing of elastomeric compounds shall be completed in accordance with AASHTO M251-06. Testing of the finished bearings shall be completed in accordance with requirements of 18.3.4 of the 2009 AASHTO LRFD Bridge Construction Specifications including all interim revisions. The long-term deterioration test described in 18.3.4.4.3 is not required. The proof load test described in 18.3.4.4.4 shall be carried out as per the long-term proof load test requirements.

8.3.7.2 Testing by the Consultant

Any additional or supplemental inspections that may be required will be performed by the Consultant or his testing agencies at the Consultant's expense.

The Contractor shall ensure that adequate notice for inspection and testing be given to the Consultant and that access to the work is assured at all times. When required by the Consultant, the Contractor shall provide needed manpower for assistance in checking layout and performing inspection duties.

8.3.8 Approved Pot Bearing Suppliers

The following Pot Bearing Manufacturers have been approved for the use of their products, based on compliance with the design parameters and specification requirements.

- Glacier
- Goodco Z-Tech
- LCL-Bridge

8.4 Installation

8.4.1 General

The Contractor shall submit to the Consultant, for review and acceptance a detailed bearing installation procedure four weeks in advance of the scheduled start of installation. The installation procedure shall include all drawings and documents necessary to describe the following:

- Survey information for location and elevation of grout pads, anchor rod voids.
- Placing of anchor rods and bearings.
- Grouting of anchor rods.
- Methods of forming, placing, curing, and sealing of grout pads.
- Enclosure and system of heating for grouting in cold weather.

8.4.2 Bearing and Anchorage

Masonry bearing plates shall not be placed upon bridge seat bearing areas which are improperly finished, deformed or irregular. Bearing plates shall be set level in their exact position.

The Contractor shall remove anchor rod void forming materials, and accurately set the anchor rods, except where the rods were cast into the concrete. Any residues on the concrete surfaces, such as oils, grease or other contaminants, shall be removed by sandblasting. Anchor rods and bearing pads shall not be grouted until girder erection of the entire superstructure is completed unless otherwise approved by the Consultant and the Department. All methods and materials for setting anchor rods and constructing bearing pads shall be subject to the Consultant's review and acceptance. The location of the anchor rods, in relation to the slotted holes in the expansion shoes, shall correspond with the temperature at the time of erection. The nuts on the anchor rods, at the expansion ends of spans, shall be adjusted to permit free movement of the spans.

When bearings are detailed in conjunction with grout pockets in the substructure, the bearings shall be set accurately on galvanized steel shims. The shims shall be located such that a minimum of 75 mm grout coverage is provided. When grout pockets are not detailed, the bearing shall be set on the properly finished bearing areas in exact position and shall have a full and even bearing on the concrete.

When required, field welding adjacent to elastomeric pads shall be performed with care to avoid damage to the elastomer. The temperature of the steel adjacent to the elastomer should be kept below 120°C. The distance between the weld and the elastomer should be at least 40 mm.

Top of the bearing sole plate shall be within a tolerance of ± 3 mm of the correct elevation prior to girder erection.

Sole plates shall be bolted or welded to girders in accordance with the contract drawings. Attachment of sole plates to girders by welding shall be in the longitudinal direction along the edge of the bottom flange or shoe plate. Transverse welding shall not be permitted. Transverse ends shall be sealed with Sikaflex 1a or an approved equivalent caulking material.

Galvanizing or metallizing damaged during field operation shall be repaired by metallizing as per ASTM A780 Method A3.

8.4.3 Anchor Rod Voids and Grout Pads

The Contractor shall fill the anchor rod voids and construct the grout pads using Sika 212 flowable grout or an approved equivalent. Dry-pack methods of constructing grout pads will not be accepted. Filling of anchor rod voids and construction of grout pads shall be done by workers competent in this work.

Grout shall be packaged in waterproof containers with the production date and shelf life of the material shown. It shall be mixed, placed, and cured in strict accordance with the manufacturer's recommendations stated on their published product data sheet.

The Contractor shall utilize experienced ACI or CSA certified testers to test the compressive strength of the grout. A set of compressive strength cubes shall be taken to represent each days production or 0.25 m³, whichever is more frequent. All test results shall be provided to the Consultant. Prior to casting deck concrete, the average minimum compressive strength of 3 cubes at 28 days shall be a 30 MPa measured in accordance with CSA A23.2-1B. A type 1C sealer shall be supplied and applied to the exposed grout pad surfaces in accordance with Section 4 of the Specifications for Bridge Construction.

8.4.4 Grouting in Cold Weather

When the daily minimum air temperature or the temperature of the girders, bearings or substructure concrete in the immediate area of the grouting is, or is expected to be below 5°C during the placing and curing period, the following provisions for cold weather grouting shall be applied:

- (a) Before grouting, adequate preheat shall be provided to raise the temperature of the adjacent areas of the girders, bearings and substructure concrete to at least 15°C.
- (b) Temperature of the grout during placing shall be between 10°C and 25°C.
- (c) The grout pads shall be enclosed and kept at 15°C to 25°C for a minimum of five days. The enclosure shall meet the requirements of Section 4 of the Specifications for Bridge Construction for concreting in cold weather.

8.4.5 Warranty

The Contractor shall provide a written five year Warranty for the bearing assemblies. The Warranty period shall commence on the date of Contract Completion, and shall provide for complete replacement of the bearing assemblies including but not limited to, all necessary traffic control, superstructure jacking, grout pads, concrete, and attachments to girders as required at no cost to the Department if any portion of the bearing assembly fails to perform satisfactorily within the designed range of movement or loading.

8.4.6 Payment

Payment for the **Supply and Delivery of Bearings** will be made at the lump sum price bid and shall include full compensation for the cost of furnishing all materials, labour, tools, equipment and incidentals necessary for fabrication and delivery to the bridge site. Payment will be made to a maximum of 90% of the bid price when the bearings are acceptably supplied and delivered. The remaining 10% of the bid price will be made as the bearings are acceptably installed.

Payment for the **Installation of Bearings**, including grouting, will be made at the lump sum price bid and shall include full compensation for the cost of furnishing all materials, labour, tools, equipment and incidentals necessary to acceptably complete installation. Temporary supports and the associated material, labour, tools, equipment required to stabilize superstructure components prior to grouting will be considered incidental to the work and no separate payment will be made.

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 9

DRAIN TROUGH TERMINAL PROTECTION

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REFERENCE DRAWINGS

Drawing No.

Standard Drain Trough Terminal Protection	S-1410
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9.1 General

Drain trough terminal protection shall be constructed with burlap or reinforced polyethylene bags filled approximately two-thirds full of fresh Class B Concrete and placed on a shaped and prepared foundation.

Refer to Standard Drawing S-1410 "Standard Drain Trough Terminal Protection" included with these Specifications.

9.2 Materials

All materials shall be supplied by the Contractor. The bags shall be approximately 400 x 700 mm in size. The concrete shall be as specified under Section 4 – "Cast-In-Place Concrete".

9.3 Preparation and Placing

A depression shall be formed at the toe of the drain trough as shown on Standard Drawing S-1410. The depression shall be compacted, and have the shape of a dish approximately 450 mm deep and 3 m in diameter.

The bags shall be two-thirds filled with fresh concrete. Bags shall be sewed, stapled or folded to form a straight-edge closure, and immediately placed in the work. The first bag shall be placed in the centre (bottom) of the dish with subsequent bags placed in a circular direction around the first bag. Each bag shall overlap the closed end of the bag previously placed, and also the bag beside it, so that a shingled effect is produced.

Folded bags must be handled so as to avoid spillage, and the folded part is to be on the underside when in place. The bags shall be rammed and packed against each other so as to obtain a closed and uniform surface. The placed drain trough terminal protection shall have an average thickness of 130 mm.

The outer edge of the concrete-filled burlap bags of the completed drain trough terminal shall be level.

9.4 Rock Riprap Alternate

In lieu of bags filled with concrete, the Consultant may approve Class 1M rock riprap placed to a minimum depth of 350 mm. The size of the terminal dish shall be the same as for bagged concrete terminal protection with the bed shaped to the extent that the dimension from the level surface to the top of rock riprap is 320 ± 100 mm.

The dish formed in the subgrade shall be covered with Terrafix 270R or approved equivalent filter fabric. The filter fabric shall be keyed 300 mm into the subgrade at the perimeter of the dish in order to anchor the fabric. The rock riprap shall be placed so that the filter fabric is fully covered.

9.5 Measurement and Payment

The construction of drain trough terminal protection, including the supply of all required materials, will be incidental to the Contract, and no separate or additional payment will be made.

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 10

HEAVY ROCK RIPRAP

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10.1 General

This specification is for the supply, delivery, and installation of heavy rock riprap. This work shall include all necessary trimming, excavation, and fill required to satisfactorily place the rock riprap, such as:

- excavation, trimming and shaping headslope
- excavation at headslope toe, and for rock apron
- excavation for rock in stream bank transition zone
- supply and placing of geotextile filter fabric
- supply and placing of gravel or granular bedding material
- backfill over rock in stream bank transition zone to restore lines of natural bank.

10.2 Permits

The Contractor shall obtain whatever permits, agreements, and authorizations are necessary, prior to loading the riprap. He shall advise the Consultant of any special provisions required under such permits, and must provide evidence satisfactory to the Consultant that the requirements of the permits have been fully complied with before final payment will be made.

10.3 Rock Material

The rock supplied shall be hard, durable and angular in shape, resistant to weathering and water action, free from overburden, spoil, shale or shale seams and organic material, and shall meet the gradation requirements for the class specified. In general, no sandstone will be permitted for all classes, however if the proposed material meets or exceeds the minimum requirements, consideration may be given to accepting the material. For these occurrences, further testing shall be done to ensure acceptability. This would include testing of the material in accordance with CSA A23.2-15A "Petrographic Examination of Aggregates". The minimum dimension of any single rock shall be not less than one third of its maximum dimension. The minimum acceptable unit weight of the rock is 2.5 t/m³.

The Contractor shall provide the Consultant with evidence of the acceptability of the riprap material. Reliable performance records of proposed material, other than fieldstone, will be considered evidence of acceptability. Angular fieldstone shall be considered to have a reliable performance record, and will be accepted if it meets the gradation requirements.

Sampling and testing are required for Class 2 and Class 3 rock riprap for which no performance records are available. Sampling and testing are not required for Class 1 rock riprap and field stone. Tests are based on the Durability Index and Durability Absorption Ratio as developed by the State of California, Department of Transportation. The Contractor shall submit samples of the proposed material to an independent certified testing laboratory of his choice and provide written reports of the test results to the Consultant. The reports shall be stamped by a Professional Engineer. The Contractor shall be responsible for all associated costs for rock riprap sample testing including, but not limited to, transporting samples to an independent certified testing laboratory, testing, disposing of samples after testing, and providing written reports to the Consultant.

A representative sample of 70 kg minimum is required for each type and source of rock to be tested, and shall contain a number of pieces ranging up to 25 kg mass.

The acceptance of rock samples from a particular source or quarry site shall not necessarily be construed as constituting acceptance of all material from that location.

The material provided for each class specified shall have a gradation that conforms to the following:

		CLASS			
		1M	1	2	3
Nominal Mass (kg)		7	40	200	700
Nominal Diameter (mm)		175	300	500	800
None greater than:	kg or mm	40 300	130 450	700 800	1800 1100
20% to 50%	kg or mm	10 200	70 350	300 600	1100 900
50% to 80%	kg or mm	7 175	40 300	200 500	700 800
100% greater than:	kg or mm	3 125	10 200	40 300	200 500

Percentages quoted are by mass.

Sizes quoted are equivalent spherical diameters, and are for guidance only.

Riprap shall meet the following minimum requirements for specific gravity, absorption and durability:

Method of test

California Department of Transportation
Method of Test for Specific Gravity and
Absorption of Coarse Aggregate
(California Test 206)

California Department of Transportation
Method of Test for Durability Index
(California Test 229)

Requirements

Minimum Specific Gravity = 2.60

Maximum Absorption = 2.0 %

Minimum Durability Index = 52
Durability Index may be less than 52
if DAR* > 23

* Durability Absorption Ratio (DAR) = Durability Index / (Absorption % + 1%)

10.4 Geotextile Filter Fabric

Where geotextile filter fabric is specified, the slope shall be graded to provide a smooth, uniform surface. All stumps, large rock, brush or other debris that could damage the fabric shall be removed. All holes and depressions shall be filled so that the fabric does not bridge them. Loose or unstable soils shall be replaced.

Non-woven geotextile filter fabric shall be used under all riprap in accordance with the following table of minimum average roll value properties (MARV's) for each specific Class of riprap:

Non-Woven Geotextile Filter Fabric		
Specifications and Physical Properties		
	Class 1M, 1 and 2	Class 3
Grab Strength (ASTM D4632)	650 N	875 N
Elongation (Failure) (ASTM D4632)	50%	50%
CBR Puncture Strength (ASTM D6241)	275N	550 N
Trapezoidal Tear (ASTM D4533)	250 N	350 N
Minimum Fabric Lap to be 300 mm		

The non-woven geotextile filter fabric shall meet the specifications and physical properties as listed above.

The fabric shall be laid parallel to the slope direction. It shall be placed in a loose fashion, however folds and wrinkles shall be avoided. Adjacent strips of fabric shall be overlapped a minimum of 300 mm, except where placed underwater, the minimum lap width shall be 1 m. Overlaps shall be pinned using 6 mm diameter steel pins fitted with washers and spaced at 1 m intervals along the overlaps.

The top edge of the filter fabric shall be anchored by digging a 300 mm deep trench, inserting the top edge of the fabric and backfilling with compacted soil.

Care shall be taken to prevent puncturing or tearing the geotextile. Any damage shall be repaired by use of patches that extend at least 1 m beyond the perimeter of the tear or puncture.

The fabric shall be covered by rock riprap within sufficient time so that ultraviolet damage does not occur; in no case shall this time exceed 7 days for ultraviolet material and 14 days for ultraviolet protected and low ultraviolet susceptible polymer geotextiles.

Riprap placement shall commence at the base of the blanket area and proceed up the slope. The height of drop of riprap shall be limited to 1.0 m or less, and the riprap shall not be allowed to roll down the slope. Heavy equipment will not be permitted to operate directly on the geotextile.

10.5 Placing of Rock

The rock shall be handled, dumped or placed into position to conform to the specified gradation and to the cross section shown on the drawings. The finished surface shall be reasonably uniform, free from bumps or depressions, and with no excessively large cavities below or individual stones projecting above the general surface.

10.6 Inspection of Rock

Control of gradation will be by visual inspection. The Contractor shall provide a minimum of two samples of rock, of the minimum sample size specified below. These samples shall be proven to acceptably conform to the required gradation by direct weighing of all the individual pieces with suitable scales; the mass of each piece in the sample shall be painted on the piece. These samples, located as required by the Consultant at the construction site and at the source or quarry site, may be incorporated in the finished riprap when they are no longer required for reference purposes. The samples shall be used for frequent reference in judging the gradation of the riprap being loaded at the source and placed at the site. The minimum sample size in area shall be as follows:

<u>Class</u>	<u>Minimum Sample Size</u>
1M	1 m x 1 m
1	2 m x 2 m
2	3 m x 3 m
3	4 m x 4 m

The Contractor shall provide, at no additional cost to the Department, whatever facilities are required to assist the Consultant in checking gradation and measuring riprap in place.

If, during the delivery of the material to the site, a particular load is found to be made up of pieces predominantly one size, or to be lacking in pieces of one size, it shall be dumped in a suitable location outside the area to be protected. Additional material as required to make up the deficient sizes shall be added to this load such that the combination can then be placed to ensure uniformity.

10.7 Measurement and Payment

The quantity of heavy rock riprap to be paid for will be measured in place. The volume of rock paid for will be calculated from the thickness of the riprap as shown on the drawings, and the actual area covered. Overages in thickness or area beyond the limits shown on the drawings will not be paid for unless these changes were requested by the Consultant.

Payment will be made at the unit price bid per cubic metre of **Heavy Rock Riprap** acceptably in place, which price shall include full compensation for all necessary materials, royalties, permits, haul of materials, equipment, tools, labour and incidentals necessary to complete the work, including the preparation of the subgrade for the riprap, geotextile filter fabric, bedding material, trimming, excavation, backfill as required, and labour for measurement.

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 11

DUCTS AND VOIDS

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11.1 General

This specification is for the supply and installation of all ducts, conduits or voids as set out in the drawings and these specifications. Included are the following:

- utility ducts and voids
- rigid conduits, end caps, conduit expansion joints, junction boxes
- lamp standard anchorage assemblies

11.2 Material

All utility ducts and voids, fittings and accompanying hardware, to be incorporated in or erected on the structure, shall be rigid PVC type DB2 meeting the requirements of CSA C22.2 No. 211.1 and in accordance with the Rules of the Canadian Electrical Code, Part 1. Coupling shall be solvent bell ends (SBE). Rigid conduit shall be bent only with a standard conduit bender.

Expansion assemblies shall be Scepter type 'O' ring expansion joints or an approved equivalent.

11.3 Installation

The various components shall be erected or placed in the locations shown on the drawings.

Ducts, conduits and voids shall be firmly secured to prevent floating during casting.

Continuous pull wires shall be installed in all service ducts and conduits unless specified otherwise. The pull wires shall be 12 gauge galvanized steel, unspliced, extending with a tight fit through the duct end caps and terminating one metre beyond in 300 mm loops. In lieu of the galvanized pull wire, an 8 mm mono-poly rope or equivalent may be substituted in ducts over 75 mm diameter. In this case, the rope shall be unspliced, with the extra length of 300 mm each end coiled up inside the duct and the duct end caps secured in place.

When specified, lamp standards shall be properly bedded, securely bolted, and painted with two field coats.

The installation of any electrical equipment shall be carried out to completion by a fully qualified electrician, tested and left in good working order. All runs of conduit or duct shall be proven in the presence of the Consultant to be clear by passing through the entire length, a round object no less than 75% of the conduit area. Any required permits will be the responsibility of the Contractor.

11.4 Payment

Unless **Ducts** is listed in the Unit Price Schedule of the Tender pages, this work shall be considered incidental to the Contract and no separate or additional payment will be made. When **Ducts** is listed in the Unit Price Schedule this work will be paid on the basis of the lump sum price bid which shall include full compensation for the cost of furnishing all material, labour, equipment, tools and incidentals necessary to acceptably complete the work

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 12

BRIDGERAIL

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12.1 General

This specification is for the supply, fabrication and installation of steel tube type bridgerail, thrie beam bridgerail, approach rail transition, and handrail. Bridgerail and handrail shall include all work constructed above the top of the bridge deck, curb, parapet, sidewalk, or culvert headwalls, and wing walls, and the supply and placing of anchor bolt assemblies, end connection plates and connection angles. Approach rail transition shall include thrie beam or W-beam guardrail sections, W-thrie beam transition section, terminal connectors, steel or timber guardrail posts, spacers, and guardrail connection and wing end sections where specified.

12.2 Supply and Fabrication

A pre-fabrication meeting is required prior to commencement of fabrication of bridgerail. The meeting will be held at fabricator's plant and the Contractor shall ensure the plant superintendent and plant manager responsible for the work and any manufacturer's representatives directly involved in the specialized work are in attendance. The Department/Consultant will conduct this meeting after the shop drawings have been approved and welding procedures have been reviewed. The Contractor shall provide one week notice to the Department/Consultant prior to the meeting.

12.2.1 Standards

The fabrication of bridgerail components shall conform to AASHTO LRFD Bridge Construction Specifications and the American Welding Society (AWS) - Bridge Welding Code D1.5.

Where imperial/metric conversions are necessary, the National Standard of Canada, CAN3 - Z234.1 - 79 shall be used as the basis of conversion.

All welding, cutting and preparation shall be in accordance with the American Welding Society (AWS) - Bridge Welding Code D1.5. The fabrication of bridgerail components composed of structural tubing shall be in accordance with the American Welding Society (AWS) – Structural Welding Code D1.1.

12.2.2 Qualification

The Contractor shall notify the Department and Consultant two weeks prior to fabrication of any subcontractors in his employ. The Contractor shall remain responsible for the work of the subcontractors. All terms of the contract, such as CWB approval, right of access, etc., shall apply to the subcontractor.

The fabricator shall be fully approved by the Canadian Welding Bureau (CWB) as per CSA Standard W47.1 in Divisions 1 or 2.

Only welders, welding operators and tackers approved by the Canadian Welding Bureau in the particular category shall be permitted to perform weldments. Their qualifications shall be current and available for examination by the Consultant.

12.2.3 Engineering Data

12.2.3.1 Welding Procedures

Welding procedures including Welding Procedure Datasheets bearing the approval of the Canadian Welding Bureau shall be submitted for each type of weld to be used. The welding procedures shall be reviewed by the Department and Consultant before welding proceeds.

12.2.3.2 Shop Drawings

Shop drawing requirements shall be as per section 6.2.3.3 of the Specifications for Bridge Construction.

When railing for more than one bridge is included, individual shop and erection drawings shall be submitted for each bridge. Shop drawing mark numbers must be unique for each bridge.

12.2.3.3 Mill Certificates

Mill certificates shall be provided for all material before fabrication commences.

Where mill test certificates originate from a mill outside Canada or the United States of America, the Contractor shall have the material tested and the mill test certificate verified by a Canadian laboratory. This laboratory shall be certified by an organization accredited by the Standards Council of Canada to comply with the requirements of ISO/IEC 17025 for the specific tests or type of tests required by the material standard specified on the mill test certificate. The mill test certificates shall be stamped with the name of the Canadian laboratory and the signature of an authorized officer. It shall state that the material is in conformance with the specified Contract requirements.

12.2.4 Materials

12.2.4.1 Steel

All steel shall conform to the standard noted on the drawings. The silicon content for various bridgerail and handrail components shall be as follows:

- Structural tubing less than 0.04%
- Structural sections, handrail bars, base plates less than 0.04% or between 0.15% to 0.25%

If substitutions are required they must be accepted by the Department and Consultant. In these cases interpretation of equivalent steel will be as per Appendix "A" of the CSA Standard G40.21 (1976 only).

12.2.4.2 Anchor Bolts

Anchor bolts shall conform to the standard noted on the drawings. The Contractor shall provide mill reports indicating the physical properties of the material to the Consultant.

12.2.4.3 Connection Plate and Angle

Steel for connection plate and angle shall conform to CSA Standard G40.21 Grade 300W or ASTM A36.

12.2.4.4 Grout

Grout for post bases shall be Sika 212 flowable grout or approved equivalent.

12.2.4.5 Approach Rail Transition

Thrie beam or W-beam guardrail sections, W-thrie beam transition section, terminal connectors, steel or timber guardrail posts, spacers, and guardrail connection and wing end sections shall be as specified in Section 14 "Guardrail".

12.2.5 Welding

12.2.5.1 Filler Metals

Low hydrogen fillers, fluxes and welding practices shall be used throughout. The low hydrogen covering and flux shall be protected and stored as specified by AWS Standard D1.5. Flux cored welding or use of cored filled wires in the submerged arc process or shielding gas processes will not be permitted.

Metal core welding process utilizing low hydrogen consumables with AWS designation of H4 is allowed. The deposited weld metal shall provide strength, durability, impact toughness and corrosion resistance equivalent to base metal.

Field application of metal core arc welding is not allowed.

12.2.5.2 Joint Preparation

Preparation of welded joints shall be as indicated on the drawings. Weld areas shall be clean, free of mill scale, dirt, grease, paint and other contaminants prior to welding.

12.2.5.3 Tack and Temporary Welds

Tack and temporary welds shall not be allowed unless they are to be incorporated into the final weld. Tack welds, where allowed, shall be of a minimum length of four times the nominal size of the weld, and shall be subject to the same quality requirements as the final welds. Cracked tack welds shall be completely removed prior to welding over.

12.2.5.4 Backing Bars

Backing bars shall be fitted all around the inside of the joint. The separation of faying surfaces between the backing bars and material to be welded shall not exceed 1 mm, 100% fusion must be obtained into the backing bar including the corners of HSS members.

12.2.5.5 Run-off Tabs

Run-off tabs shall be used at the ends of all welds that terminate at the edge of a member. They shall be tack welded only to the portion of the material that will not remain a part of the structure, or where the tack will be welded over and fused into the final joint. After welding, the tabs shall be removed by flame cutting, not by breaking off.

12.2.5.6 Arc Strikes

Arc strikes are not permitted.

12.2.5.7 Methods of Weldment Repair

Repair procedures for unsatisfactory weldments shall be submitted for review and acceptance by the Department and Consultant prior to repair work commencing.

12.2.5.8 Grinding of Welds

Fillet welds not conforming to acceptable profile shall be ground to the proper profile without substantial removal of the base metal. Grinding shall be smooth and parallel to the line of stress. Caution shall be exercised to prevent over grinding. Acceptability of welds without grinding will be determined by the Consultant.

12.2.6 Fabrication

Fabrication shall be performed in a fully enclosed area which is adequately heated to be at least 10°C.

12.2.6.1 Rail Fabrication

All rail splices will be radiographed. Splices shall be completed using properly fitted backing bars. Only one splice per rail section will be permitted, and shall occur in an accepted location, clear of openings and connection holes. All splices shall be ground flush. Rail sections shall be orientated such that the tube seam is always located at the bottom, except for rectangular tube sections which shall have the tube seam oriented towards the bottom or the outside of the bridge. Edges of holes shall be smooth and free of notches or burrs.

12.2.6.2 Rail Sleeve Fabrication

Sleeves shall be square and be properly aligned in the rail end. Corners of the sleeves shall be rounded and smooth to ensure a good fit. Expansion joint sleeves shall be shop bolted to the appropriate rail section after galvanizing.

12.2.6.3 Post Fabrication

(a) W Posts

Posts shall be perpendicular to the base plates, unless otherwise noted on the drawings.

Base plates for the posts shall be flat, have square cut edges and corners with no lips or gouges. Anchor bolt holes shall be drilled accurately in size and location.

The rail post to base plate shall be welded by using 60°C preheat.

(b) HSS Posts

The following requirements shall apply to HSS posts, in addition to the requirements noted under W Posts:

- The tube weld seam shall be kept on the back side of the post.
- The rail post shall be butt welded to the base plate using a backing bar and a full penetration bevel groove weld. The backing bar shall be properly fitted and the post tube prepared to a sharp edged 45 degree chamfer. The groove weld shall be placed in a minimum of two passes by using 100°C of preheat and maintain a root opening of 5 mm. A rod size no greater than 4.0 mm shall be used for the first pass. A reinforcing fillet weld shall be placed all around the joint.
- The Contractor shall arrange to have all post to base plate full penetration welds inspected either by ultrasonic testing or radiographic inspection methods. The NDT shall be done by a company certified to CAN/CSA W178.1. Ultrasonic and radiographic testing technicians shall be certified to Level II of CGSB. A copy of the test results shall be provided to the Consultant. Post caps shall be chamfered all around the top and match the contour of the post without burrs or overhang. The caps shall be attached to the posts in the shop after galvanizing. The caps shall fit tightly and include washers under the head of the cap attachment bolts.

12.2.6.4 Anchor Bolts

The threaded ends of all anchor bolts shall be chamfered. All anchor bolts, hardware and anchor bolt template shall be hot dip galvanized, after fabrication in accordance with ASTM F2329 Standard Specification for Zinc Coating Hot-Dip Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners. Nuts shall freely spin on the bolt threads after galvanizing. The anchor bolts shall be shop assembled in cages after galvanizing with bolts aligned square and plumb. Alignment nuts shall not exceed 16 mm in thickness.

12.2.6.5 Tolerances

(a) Sleeve to Rail

Clearance between the rail sections and the sleeves shall be sufficient to ensure an easy fit after galvanizing. The maximum radial clearance allowed around the sleeve when fitted into the rail shall be 1 mm (2 mm total) after galvanizing with the tube seam removed.

Two sleeve test samples shall be made by the fabricator from the material to be used. Both test sleeves are to be galvanized, with one being retained by the galvanizing subcontractor and the other at the fabricator's plant. The sleeves shall be used to check the sleeve to rail fit of all rails. In the case of handrail panels, the test samples shall consist of a welded unit with top and bottom tube, and sleeve sections spaced to match the handrail.

(b) Posts

Post assembly lengths shall be within 3 mm of the specified length.

(c) Rails

Individual rail sections shall be straight and true with no evidence of kinks or dents and with a maximum variation from straightness not exceeding 3 mm over a 3 m length. Welded splices shall not be evident in the final product, and shall be straight, kink free and conform to the same section as the adjacent tubing. Bolted splices shall be straight with no offset due to loose fitting sleeves.

(d) Anchor Bolts

The bolts in an anchor bolt assembly shall fit in a template comprised of accurately located holes 2 mm greater in diameter than the anchor bolts. The top of the bolts in the assembly shall be ± 3 mm from a level plane when the threaded portion is plumb. The threaded length shall not be less than specified, nor more than 15 mm greater than that specified.

12.2.6.6 Identification

To assist field erection, shop drawing mark numbers shall be stamped on the rails and posts. Rail mark numbers shall be stamped on the underside of the rail near the ends. Post mark numbers shall be stamped on the underside of the base plates. The areas to be stamped shall be ground to remove mill scale. Stamps shall be a minimum of 12 mm high, and the resulting marks shall be at least 1.0 mm deep to be legible after galvanizing.

12.2.6.7 Galvanizing

Galvanizing shall be by the hot dip method after fabrication, in accordance with the current edition of ASTM A123/A123M Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products and ASTM F2329 Standard Specification for Zinc Coating Hot-Dip Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners with additions and exceptions as described in this specification.

The fabricator shall provide a smooth finish on all edges and surfaces and remove all weld spatters and all welding flux residue from the steel components prior to galvanizing. The galvanized finish shall meet the aesthetic requirements of the application and shall have a continuous outer free zinc layer without any significant zinc-iron alloy showing through the outside surface. Lumps, globules or heavy deposits of zinc will not be permitted. Handrails shall be free of any sharp protrusions or edges.

Double dip galvanizing is not advised but will be accepted if a surface finish similar in appearance, colour and quality to that of single dip galvanizing is produced. The lapped area of the double dip shall be straight, the coating smooth, adherent and free of uncoated areas, blisters, flux deposits, dross inclusions, acid and black spots.

Repair of galvanizing shall only be done if bare areas are infrequent, small, and suitable for repair. A detailed repair procedure shall be submitted for review and acceptance prior to its use. It should be noted that repairs may require complete removal of the galvanized coating and re-galvanizing. Repair shall be in compliance with ASTM A780, Method A3 "Metallizing". However repair for areas not exceeding 100 mm² may be done in accordance with ASTM Method A1 "Repair Using Zinc-Based Alloy". The thickness of the coating for both methods shall be 180 µm, and the repair tested for adhesion. The finished appearance shall be similar to the adjacent galvanizing. The Consultant will determine the acceptability of lapped or repaired areas.

12.2.6.8 Base Plate Corrosion Protection

The bottom surface of each base plate shall be protected by a medium grey colour barrier coating accepted by the Consultant, to prevent contact between the zinc and the concrete. The galvanized surface must be roughened prior to application of barrier coating. The surface preparation of the galvanized surface and the dry film thickness (DFT) of the coating shall be in accordance with the coating Manufacturer's recommendations. The Consultant will test the adhesion of fully cured coating as per ASTM D3359 "Standard Test Methods for Measuring Adhesion by Tape Test". The method selected for testing (Method A or B) shall depend on the dry film thickness of the coating. The coating manufacturer's product data sheets shall be provided to the Consultant prior to the application of the coating. The adhesion test result shall meet a minimum of "4B" classification i.e. a maximum allowable flaking of 5%.

12.2.6.9 Schedule

The Contractor shall provide and keep current a complete fabrication schedule in a form satisfactory to the Consultant.

12.2.7 Testing and Inspection

12.2.7.1 Testing by the Consultant

Visual, radiographic, ultrasonic, magnetic particle and any other inspection that may be specified or required will be performed by the Consultant or his testing agencies at the Consultant's expense.

The Contractor shall ensure that adequate notice for inspection and testing be given to the Consultant and that access to the work is assured at all times. When required by the Consultant, the Contractor shall provide needed manpower for assistance in checking layout and performing inspection duties.

The Contractor shall be responsible for all travel, boarding and lodging costs incurred by the Consultant to inspect bridgerail being fabricated outside the Province of Alberta. The cost shall also include for a Department's representative to attend the prejob meeting and one additional trip during the course of fabrication.

12.2.7.2 Non-destructive Testing

The methods of non-destructive examination shall be in accordance with the following standards:

- Radiography - AWS Standard D1.5
- Ultrasonic - AWS Standard D1.5
- Magnetic Particle - ASTM Standard E-709
- Dye - Penetrant - ASTM Standard E-165

12.2.7.3 Testing by the Contractor

The Contractor shall be responsible for the cost of testing post to base plate weld as specified in clause 12.2.6.3 (b).

Testing and inspection made necessary by the repair of faulty work shall be paid for by the Contractor. All of the Contractor's records made in the course of quality control shall be open for examination by the Consultant.

12.2.7.4 Notification

The Contractor shall notify the Consultant 48 hours prior to shipment to facilitate final inspection of the materials. Material that has not been inspected in the fabrication plant will not be paid for until such material has been inspected and accepted. The Contractor may be charged with all expenses incurred for inspection of the material at the site.

12.2.8 Material Handling and Storage

All lifting and handling shall be done using devices that do not mark, mar, damage or distort the galvanized members and assemblies in any way. Galvanized material shall be stacked or bundled and stored to prevent wet storage stain as per the American Hot Dip Galvanizers Association (AHDGA) publication "Wet Storage Stain". Delivery of a damaged product will be a cause for rejection.

12.3 Erection

Anchor bolt assemblies shall be accurately positioned with anchor bolt projections as shown and specified.

The line and grade of the railing shall be true to that shown on the drawings, and not follow any unevenness in the superstructure. It will be necessary to adjust the height and plumbness of each post, in order to compensate for normal superstructure variations, and achieve the desired line and grade on the bridgerail.

Anchor bolts that project less than the full thickness of the nuts, by more than 2 threads, shall be extended. The proposed repair will require the acceptance of the Department and Consultant in writing and the repair shall be done at no cost to the Department. However, if the repair work described above is due to deficiency in the work of others, it will be paid for as "Extra Work".

The method of forming and pouring the grout shall be submitted to the Consultant for review and acceptance. Dry-pack methods of constructing grout pads will not be accepted.

All structural bolts shall be tightened by using turn of nut method as specified in Section 6.3.2.7.

Sealer shall be applied to the exposed grout pad surfaces in accordance with Section 4.26 "Type 1c Sealer".

12.3.1 Grouting in Cold Weather

When the daily minimum air temperature, or the temperature of the bridgerail, the bridge substructure or superstructure in the immediate area of the grouting falls below 5°C, the following provisions for cold weather grouting shall be put into place:

- (a) Before grouting, adequate preheat shall be provided to raise the temperature of the adjacent areas of the bridgerail, the bridge substructure and superstructure to at least 10°C.
- (b) Temperature of the grout during placing shall be between 10°C and 25°C.
- (c) The grout pad shall be enclosed and kept at 10°C to 25°C for at least 5 days. The system of heating shall be designed to prevent excessive drying-out of the grout.

12.3.2 Approach Rail Transition

The supply and installation of the approach rail transition including thrie beam or W-beam guardrail sections, W-thrie beam transition section, terminal connectors, steel or timber guardrail posts, spacers, and hardware as shown on the drawings shall be included as Bridgerail. These materials shall be supplied and installed in accordance with Section 14 "Guardrail", of the Specifications for Bridge Construction.

12.4 Payment

Payment for **Bridgerail** will be made on the basis of the lump sum price bid for Bridgerail acceptably completed. The price bid shall include full compensation for the cost of furnishing all labour, materials, equipment, tools, and incidentals necessary to supply, fabricate, and erect the bridgerail, including the approach rail transition and guardrail connection and wing end sections where specified. Payment for **Bridgerail** will be made at 80% of the lump sum price bid upon receipt and acceptance of the material at the site. The remaining payment will be made after the bridgerail is suitably installed and accepted by the Consultant.

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 13

MISCELLANEOUS IRON

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REFERENCE DRAWINGS

Drawing No.

Standard Irrigation Canal Bridge and Small Bridge Plaques.....	S-1424
Standard Large Bridge Plaque Installation Details	S-1477
Standard Bridge Bench Mark Tablet Installation.....	S-1478
Standard Large Bridge Plaque Castings Details.....	S-1617

13.1 General

Items included as Miscellaneous Iron will be listed in the Special Provisions, and typically include the following:

- steel drain troughs
- pier drip sheets
- deck buffer angles
- dowels
- connector angles
- anchor bolt sleeves
- bridge plaques
- bench mark tablets

13.2 Fabrication and Installation

Miscellaneous Iron shall be supplied, fabricated, placed and erected by the Contractor as shown on the drawings or as specified in the Special Provisions and applicable portions of Section 6 "Structural Steel".

Bridge plaques shall be fabricated and installed in accordance with the drawings and the following standard drawings:

- S-1424 "Standard Irrigation Canal Bridge and Small Bridge Plaques"
- S-1477 "Standard Large Bridge Plaque Installation Details"
- S-1617 "Cast Aluminum Bridge Foundry Casting Details"

Bench mark tablets shall be supplied and installed by the Contractor in accordance with the construction drawings and the following standard drawing:

- S-1478 "Standard Bridge Bench Mark Tablet Installation"

13.3 Handling Galvanized Steel

All lifting and handling shall be done using devices that do not mark, mar, damage or distort the galvanized members and assemblies in any way. Galvanized material shall be stacked or bundled and stored to prevent wet storage stain as per American Hot Dip Galvanizers Association (AHDGA) publication "Wet Storage Stain". Delivery of a damaged product will be a cause for rejection.

13.4 Field Welding of Miscellaneous Iron

13.4.1 Field Welding of Structural Members

Where the installation of Miscellaneous Iron includes field welding of structural members, the following requirements shall be met:

- (a) All welding, cutting and preparation shall be in accordance with the American Welding Society (AWS) - Bridge Welding Code D1.5.

- (b) Only welders approved by the Canadian Welding Bureau in the particular category shall be permitted to perform weldments. Their qualification shall be current and available for examination by the Consultant.
- (c) Welding procedures approved by the Canadian Welding Bureau shall be submitted for review by the Department and Consultant prior to welding.
- (d) Low hydrogen filler, fluxes and welding practices shall be used in accordance with 6.2.5.1.
- (e) When the air temperature is below 10°C, all material to be welded shall be preheated to 100°C for a distance of 80 mm beyond the weld and shall be sheltered from the wind.
- (f) When the air temperature is below 0°C, welding shall not be permitted unless suitable hoarding and heating, accepted by the Consultant, is provided.

13.4.2 Field Welding of Non-Structural Members

Where the installation of Miscellaneous Iron includes field welding of non-structural members, the following requirements shall be met:

- (a) Journeyman welders with Class B tickets shall be permitted to perform weldments. Their qualification shall be current and available for examination by the Consultant.
- (b) Welding procedures prepared and stamped by a Professional Engineer shall be submitted for review by the Department and Consultant prior to welding.
- (c) Low hydrogen filler, fluxes and welding practice shall be used in accordance with 6.2.5.1.
- (d) When the air temperature is below 5°C, all material to be welded shall be preheated to 100°C for a distance of 80 mm beyond the weld and shall be sheltered from the wind.
- (e) When the air temperature is below 0°C, welding shall not be permitted unless suitable hoarding and heating, is provided.

Unless otherwise determined by the Consultant, the following are examples of non-structural field welding.

- Type 1 deck joint splices
- Culvert struts
- Stitch welding of steel caps/corbels
- Field welding of the end bulkhead on culvert liner

13.5 Payment

Payment for **Miscellaneous Iron** will be made on the basis of the lump sum price bid for Miscellaneous Iron acceptably placed and remaining in the completed work, which price shall include full compensation for the cost of furnishing all materials, labour, equipment, tools and incidentals necessary to complete the work.

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 14

GUARDRAIL

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14.1 General

This specification is for the supply and installation of Modified Thrie Beam Guardrail, Strong Post W-beam Guardrail, Weak Post W-beam Guardrail, Transitions, W-beam Turn-Down End Terminals, and other approved crash-worthy end treatments. Work shall include all guardrail components, connections, treated timber posts, steel posts, winged and buried end sections, connections to other barriers and end terminals.

Drawings shall include TEB Standard Drawings for approach guardrails, Bridge Engineering Standard Drawings for bridgerails and bridgerail/approach guardrail transitions, drawings in the AASHTO-AGC-ARTBA publication "A Guide to standardized Highway Barrier Hardware", and other drawings provided in the contract.

14.2 Materials

14.2.1 Rails and Terminal Elements

Thrie beam/W-beam guardrail shall consist of rail sections fabricated for installation to develop the continuous beam strength with the necessary safety and feature components.

All rail sections and other components shall match the design profiles and dimensions of the AASHTO/ARTBA hardware requirements for full interchangeability of similar components regardless of the source of manufacturer.

The rails and terminal elements shall be manufactured from open hearth, electric furnace or basic oxygen semi-spring steel sheet, all in general accordance with the AASHTO Standard Designation M180 and shall conform to the TEB drawings or the drawings in the AASHTO-AGC-ARTBA publication "A Guide to Standardized Highway Barrier Hardware".

Rails shall be punched for splice and post bolts in conformity with the AASHTO Standard to the designated number of and centre to centre spacing of posts. If holes are punched after galvanizing the galvanizing around the hole shall be repaired in accordance with section 12.2.6.7 of the Specifications for Bridge Construction.

Curved W-beam rails shall be formed to the radius specified in accordance with drawing TEB 3.54.

The rails and terminal elements shall be manufactured according to the following standards:

14.2.1.1 Metal Properties

Properties of the base metal for the rails shall conform to the following requirements:

Minimum Yield Point	345 MPa
Minimum Tensile Strength	483 MPa
Minimum Elongation	Minimum 12% in 50 mm length

14.2.1.2 Sheet Thickness

The rails and terminal elements thickness shall be manufactured according to Table 2 (Class A, Type II) of AASHTO Standard M180 with nominal base metal thickness of 2.8 mm (2.57 mm minimum).

14.2.1.3 Sheet Width

Sheet width for the W-beam rail shall be 483 mm with a permissible tolerance of minus 3 mm.

Sheet width for the thrie beam rail shall be 750 mm with a permissible tolerance of minus 3 mm.

All welding required for the fabrication of terminal elements shall conform to the requirements of CSA W59M. Only welders, welding operators and tackers approved by the Canadian Welding Bureau in the particular category may be permitted to perform weldments.

All rails and terminal elements shall be hot dip galvanized after fabrication conforming to the current edition of ASTM A123/A123M Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

A copy of the producer's certificate, conforming to Section 16 of CSA G40.20M, for each of the mechanical and chemical tests, including impact tests, shall be provided to the Consultant upon request.

14.2.2 Bolts, Nuts and Washers

All bolts, nuts and washers shall conform to ASTM A307, unless noted otherwise on the drawings, and shall be hot dip galvanized conforming to the current edition of ASTM A153/A153M Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

14.2.3 Wood Posts

Posts and offset blocks shall be Douglas Fir, Hemlock, Lodgepole Pine or better and shall meet the current edition of the National Lumber Grades Authority (NLGA) for No.1 Structural Posts and Timbers graded conforming to the NLGA Standard Grading Rules for Canadian Lumber.

Posts shall be date stamped at the top of either side of the post not used for rail attachment with the last two digits of the year of installation. The stamp shall be 50 mm x 50 mm and have an indentation of 3 mm.

Posts and blocks shall be rough sawn and holes drilled to the finished dimensions shown in drawing TEB 3.01. Surfacing shall be completed and incised prior to treatment with allowable tolerance of 1.5 mm.

Wanes on any face shall not exceed the following width:

Above ground (including blocks)	25 mm
Below ground	60 mm

Posts and blocks shall be pressure preservative treated in accordance with the current requirements of CSA Standard 080.

The retention of preservatives shall be as per assay and shall conform to the requirements of CSA Standard 080.14 Table 1, minimum retention of preservatives in pressure treated wood for highway construction, under the headings "Post-Guardrail, Guide, Sign and Sight" for posts and "Bridge Hand Rails, Guard Rails and Posts" for timbers not in contact with the ground or water.

14.2.4 Steel Posts

Steel for posts, spacers and hardware shall conform to CSA Standard G40.21 Grade 350W or ASTM Standard A36 and shall be hot dip galvanized after fabrication conforming to ASTM A123/A123M Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

14.3 Inspection of Materials

All guardrail materials shall be inspected and materials which fail to meet these specifications will be rejected, and shall be replaced or repaired at no cost to the Department.

14.3.1 Guardrail Materials

The size and thickness of 2.67 mm nominal base metal thickness rails and terminal elements shall be within the tolerance specified below:

Base metal thickness	-	2.67 mm
Galvanized finished thickness	-	2.82 mm
Tolerance	-	0.23 mm

The size and thickness of 3.5 mm nominal base metal thickness rails and terminal elements shall be within the tolerance specified below:

Base metal thickness	-	3.43 mm
Galvanized finished thickness	-	3.58 mm
Tolerance	-	0.23 mm

14.3.2 Timber Material

Testing of the penetration of the preservative may be carried out by the Consultant. Warped wood posts will be rejected.

14.4 Installation

Guardrail shall be accurately set to the required depth and alignment, in a manner resulting in a smooth continuous installation, as shown on the drawings or as directed by the Consultant. Permissible tolerance for plumb and grade of posts shall be 20 mm maximum.

Holes for the guardrail posts shall be excavated by auger. The diameter of the holes augered shall be of sufficient size to allow for pneumatic tamping.

Unsuitable material at the bottom of the holes excavated shall be replaced with granular material at the Contractor's expense, as directed by the Consultant. The Contractor shall thoroughly compact the bottom of the hole. The guardrail posts shall rest directly and solidly on the bottom of the hole at the time of installation.

Excavated material which is unsuitable for use as backfill shall be replaced with granular material meeting the requirements of section 2.2.2 (Designation 2 Class 25). Backfill shall be thoroughly compacted, using pneumatic tampers, in layers not exceeding 150 mm, for the full depth of the excavation. Where posts are installed on paved surfaces, the backfill for the top 150 mm shall be completed using ACP in accordance with Section 17.

Any guardrail material requiring field modification to fit shall be reported to the Department and Consultant for their acceptance of the modification method use before work to be carried out. Modification by flame cutting method is prohibited. Modification by cold cutting method is allowed. Field guardrail modification is considered incidental to the work. Adequate edge distances of guardrail material shall be maintained during the modification process.

Guardrail laps shall be in the direction of traffic flow. Bolts shall be tightened to a torque of 100 Nm. Metal reflectors (Scotchlite or equivalent) shall be supplied and attached to the top of every third guardrail post with two 50 mm ring nails.

The Contractor shall take all necessary precautions to eliminate damage to galvanizing. Minor abrasions and exposed steel areas resulting from cold cutting shall be repaired in accordance with ASTM A780 Method A2 "Repair Using Paints Containing Zinc Dust". Major abrasions shall be repaired by regalvanizing. The method to be used for repair of any damage shall be accepted by the Consultant before such work is commenced. The Contractor shall repair or replace components to the satisfaction of the Consultant.

The guardrail shall be connected to bridgerail, parapets or existing guardrail as shown on the drawings.

Surplus excavated material and debris shall be removed from the site.

14.5 Payment

Payment for **Guardrail** will be made on the basis of the lump sum price bid for guardrail acceptably placed and remaining in the completed work, which price shall include full compensation for the cost of furnishing all labour, materials, equipment, tools, and incidentals necessary to supply the guardrail and all associated hardware.

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 15

NON-SKID POLYMER OVERLAY

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15.1 General

Resurfacing concrete bridge decks with non-skid polymer wearing surface consists of the repair of deck concrete, and application of a thin, flexible, multi-layered, polymer-aggregate wearing surface. This specification shall be used in conjunction with the "Specification for the Supply of Polymer Resins used in Polymer Overlays (B405)" and "Specification for Seed Aggregates used in Polymer Membranes and Overlays (B392)". The work includes mobilization, traffic accommodation, surface preparation and patching.

The Degussa Degadur System (MMA) is an approved alternate for the polymer overlay as specified. The Degussa Degadur System (MMA) does not meet the compressive strength and physical requirements of the "Specification for the Supply of Polymer Resins used in Polymer Overlay (B405)", and is applied in a different manner, but all other requirements of the specification shall still apply.

15.2 Materials

All polymer materials including aggregates shall be protected from moisture, dust, or other contaminants. Any wet or otherwise contaminated materials will be rejected.

15.2.1 Polymer

The polymer and the polymer mortar shall meet the requirements of the "Specification for the Supply of Polymer Resins used in Polymer Overlay (B405)".

The following products are currently approved by the Department for use in this work:

- Flexolith
- Flexogrid

15.2.2 Degadur System (MMA)

The DEGADUR B71 primer, DEGADUR 330 basecoat, and DEGADUR 410 sealer resins shall have the specified properties at the age of seven days noted below.

PROPERTIES OF DEGADUR RESINS					
Property	Units	Primer	Basecoat	Sealer	Test Method
Density	g/cm ³	1.05	1.01	0.98	--
Viscosity*	cps	220-330	1100-1300	450-550	ASTM D2393
Hardness	Shore D	83	56	61	ASTM D2240
Water Absorption	%	0.1	0.1	0.1	ASTM D570
Tensile Strength	MPa	29	8	9	ASTM D638
Elongation @ Break	%	3	300	140	ASTM D638

* at time of mixing

15.2.2.1 Initiator (MMA)

The initiator for the MMA resins shall be a 50% Benzoyl Peroxide powder such as AKZO Chemicals Inc., CADOX BFF-50, or an approved equivalent. Dosage rates shall be in accordance with the MMA Manufacturer's recommendations issued in the Degadur Catalyst Design Table.

15.2.2.2 Promoter (MMA)

The promoter required for use with the MMA resins at application temperatures below 4°C shall be N, N-Dimethyl-p-toluidine such as R.S.A. Corporation DMPT or an approved equivalent. Dosage rates shall be according to the MMA Manufacturer's recommendations.

15.2.2.3 Degadur Basecoat (MMA)

The basecoat shall have the specified properties at the age of seven days noted below.

PROPERTIES OF DEGADUR BASECOAT			
Property	Units	Required Value	Test Method
Compressive Strength*	MPa	16-21	ASTM C109
Tensile Strength	MPa	3-5	ASTM D638
Elongation @ Break	%	6	ASTM D638
Flexural Strength	MPa	9-10	ASTM C580 mod
Freeze/Thaw Resistance	- -	Pass	ASTM C666
Bond Strength to Concrete	MPa	1.7 minimum	ACI 503R
Coefficient of Thermal Expansion	10E-5/K	7.9	DIN
Vicat Temperature	°C	50	DIN

* Samples shall consist of 1 volume of Degadur Basecoat to 1 volume of Steillacoom.

The tests listed shall be conducted by a CSA approved testing lab, and shall include infrared and gas chromatography analysis (in accordance with BT008 Test Procedure for Finger Printing Sealers Using Infrared Spectroscopy and Gas Chromatographic Separation) for each component. All tests, including the spectro-analysis, shall be done on the same samples of material.

15.3 Aggregates

15.3.1 Seed Aggregate

The overlay aggregate provided by the Contractor shall conform to the current "Specification for

Seed Aggregates Used in Polymer Membrane and Overlays” (B392). The seed aggregates currently approved by the Department are Indag # 8 and Steilacoom 6X10 Bridge Topping.

15.3.2 Basecoat Filler Aggregate (Degussa Degadur System MMA)

Materials used in the basecoat shall consist of clean, dry (less than 0.2% moisture), angular grained silica sand and shall be free from dirt, clay, asphalt, and other organic materials. Materials shall conform to the following sieve analyses:

GRADATION OF BASECOAT FILLER AGGREGATES (MMA)						
0.045 mm Ground Silica Flour						
A minimum of 90% shall pass the 0.045 mm sieve.						
Basaltic Sand						
Sieve, mm	4.750	2.360	1.000	0.600	0.300	0.150
% Passing	99-100	92-100	61-70	45-65	10-20	0-10

15.4 Patching Materials

Type NH patching materials meeting the requirements of “Specification for the Supply of Bridge Concrete Patching Materials” (B391) may be used in place of concrete in partial depth repair provided they are used in accordance with the manufacturer's instructions.

Samples of the mixed patching material will be tested by the contractor according to ASTM C109 and in compliance with the Frequency of Test Table included in Clause 15.7.8 “Testing and Strength Requirements”. The average of three cubes will be used for acceptance and determination of payment range or rejection of the work as specified in the table below.

28 Day Minimum Compressive Strength as per Manufacturers Specified Strength Requirement	Amount of Payment
100% and above	Full bid price
90% to 99.9%	Bid price less \$25.00 per square metre
80% to 89.9%	Bid price less \$50.00 per square metre
70% to 79.9%	Bid price less \$100.00 per square metre
65% and below	Will be rejected

The Contractor shall pay all costs for testing, including but not limited to making test cubes, transporting cubes to an independent certified testing laboratory of his choice, storage, curing, breaking and providing written reports of the test results to the Consultant.

All patches consisting of Type NH patching materials shall be cured for 14 days and tested for moisture in accordance with section 15.7.3 prior to the application of polymer overlay.

15.5 Crack Repair

All deck cracks more than 2 metres in length and greater than 0.3 mm wide shall be treated with a Type 1c sealer meeting the current "Material Testing Specifications for Concrete Sealers" (B388). Application of the sealer shall be prior to shotblasting of the concrete deck, and shall consist of a 100 mm strip applied at the coverage rate as shown on the Approved Type 1c Sealer List. Payment for crack repair will be considered incidental to the Contract and no separate or additional payment will be made.

15.6 Bridge Deck Repair

Bridge deck repair consists of; Surface Patching, Partial Depth Repair, or Full Depth Repair.

Type of Patch	Depth of Patch (mm)	Repair Material	Description
Surface Patching	6 to 15	Polymer Mortar	Removal of surface deterioration without exposing rebar
Partial Depth Repair	15 to 200	Concrete	Chipping below corroded rebar and sandblasting of rebar is required
Full Depth Repair	Full depth of deck	Concrete	Forming of the underside of the deck is required

The concrete to be used for Partial and Full Depth Repair shall be Class HPC as specified in Section 4 "Cast-In-Place Concrete" of the Specifications for Bridge Construction.

15.6.1 Surface Patching

The Contractor shall patch surface voids and depressions in excess of 6 mm. The Consultant shall determine the area to be patched.

Polymer mortar, applied in accordance with the Manufacturer's instructions and these specifications, shall be used where surface patching is required. The patching polymer mortar shall consist of 3½-4½ volumes of an approved aggregate to each volume of polymer. The mortar shall yield a 40 MPa minimum compressive strength when tested at 7 days using 50 mm cube specimens, as described in Clause 15.7.8 "Testing and Strength Requirements".

Prior to placement of the polymer mortar, the surface of the concrete shall be shotblasted and/or sandblasted in accordance with Clause 15.7.1 "Surface Preparation".

The areas to be patched shall be primed with a 75 mm wide band of liquid polymer along their perimeter. The polymer mortar surface patch shall be placed while the liquid polymer primer is

liquid or tacky, and to the original gradeline or as directed by the Consultant.

Measurement and mixing of polymer components and aggregates shall be done in accordance with Clause 15.7.4 "Batching and Mixing of Polymer".

Aggregate shall be placed over the fresh patch in sufficient quantity to ensure a rough surface for bonding to the polymer overlay. Smooth textured patches will be rejected.

When the Degussa Degadur System is used, the surface patching of the deck and curb shall be done with an approved 100% solids MMA mortar supplied by the Manufacturer of the methacrylate polymer overlay. Application shall be completed according to the Manufacturer's instructions.

Payment for **Surface Patching** will be made at the unit price bid per square metre of surface patching, which price shall include surface preparation, full compensation for the cost of furnishing all labour, equipment, materials, tools and incidentals necessary to complete the work.

15.6.2 Partial and Full Depth Repair

In areas where partial depth and full depth repair are required, Clauses 20.4.2 "Partial Depth Repair" and 20.4.3 "Full Depth Repair" shall apply.

All concrete shall be cured for 28 days and tested for moisture in accordance with Clause 15.7.3 prior to the application of polymer overlay.

15.6.3 Surface Defects and Tolerances

The requirements for all new surface patching, partial and full depth repair shall conform to Clause 4.16.6 "Surface Defects and Tolerances".

All patching and levelling requires acceptance by the Consultant prior to commencing the overlay. Failure to obtain acceptance may be cause for rejection of the overlay.

15.7 Polymer Construction

The polymer coverage rates shown below are based on undiluted polymer applied to a clean shotblasted deck surface or previously applied seeded polymer layer. Where the deck surface is spalled, scaled, or roughened by surface preparation, to depths up to 6 mm, the coverage rates shall be increased. Additional polymer material may also be required due to coarse texturing or grooving of the deck surface, or porosity of the concrete. The first layer shall extend up the full height of the vertical face of curbs and medians, and up 200 mm on the vertical faces of parapets. The Contractor shall obtain the Consultant's acceptance prior to increasing, for any reason, the minimum polymer coverage requirements. No separate or additional payment will be made for any additional polymer required.

MINIMUM POLYMER COVERAGE REQUIREMENTS (P/m²)			
WEARING SURFACE CLASS	1st Layer	2nd Layer	3rd Layer
A	1.33	2.00	0.30
B	1.33	2.00	N/A
C	1.33	0.30	N/A

MINIMUM MMA POLYMER COVERAGE REQUIREMENTS FOR DEGUSSA DEGADUR SYSTEM (MMA) (P/m²)			
WEARING SURFACE	Primer Layer	Premixed Basecoat Layer	Sealer Layer
Degussa Degadur System	0.40	5.00	0.67

15.7.1 Surface Preparation

In order to prevent bond failures at overlay edges at high impact locations, 10 mm deep by 10 mm wide grooves shall be cut by router or saw and sandblasted in close proximity and parallel to all deck joints, snow slots, deck drains and all other transverse edges. These grooves or keys are intended to provide increased anchorage for the overlay and shall be filled with polymer and seeded in conjunction with application of the first layer. Rough spots exceeding 3 mm in height on or adjacent to, deck joints shall be ground to provide a smooth transition prior to placement of the overlay.

Proper surface preparation is essential to ensure adequate bond strength between the polymer wearing surface and deck concrete. The deck concrete surface shall be prepared by shotblasting to remove all bond inhibitors including concrete laitance, asphaltic material, sealers and oil, and to expose the coarse aggregate in the substrate concrete. Those areas which are inaccessible to shotblasting, such as the vertical faces of the curbs, medians, and parapets shall be similarly prepared by sandblasting.

If in the opinion of the Consultant, reblasting is required in the event of rain, delay in applying the overlay, or subsequent leakage onto the deck of other contaminants, it shall be done at the Contractor's expense.

15.7.2 Deck Layout for the Overlay

Prior to the application of each layer, the Contractor shall submit a sketch to the Consultant showing the deck surface divided into segments which will be covered by each polymer batch. The length of each segment shall be determined by taking into account the overlay width,

vertical faces, surface roughness, coverage rate, the amount of polymer in each batch, and losses in application equipment and containers.

After review of the sketches by the Consultant, the Contractor shall apply masking tape to the boundaries of the work area, except where these boundaries abut an existing polymer overlay mat of the same layer. The end of each overlay segment shall be marked at these boundaries. For the first layer only the layout area shall extend up the full height of the vertical curb and median faces and up 200 mm on the vertical faces of parapets. No overlay work shall commence until all layout by masking tape has been acceptably completed.

15.7.3 Weather Conditions, Dryness of Concrete Substrate and Polymer Layers

The work shall be done in suitable conditions of temperature, wind, dust, and moisture. If weather factors or moisture conditions of the substrate concrete are detrimental to the acceptable placement of overlay, the work shall be suspended until suitable conditions exist. Mixing, placing and curing of polymer shall be done at ambient air and substrate concrete temperatures between 10°C and 27°C.

The concrete substrate, including concrete patching and repairs shall be completely dry before the first layer of polymer is applied. Subsequent layers of polymer shall not be applied until previous layers are completely cured. Presence of moisture will be determined by the modified ASTM D4263, "Standard Test Method for Indicating Moisture in Concrete by Plastic Sheet Method". This test shall be carried out on the concrete substrate as well as on previous placed polymer overlays. The Contractor shall place a minimum of four test windows, per application area, at different time periods. The test windows shall consist of three layers of clear and one layer of black heavy duty 6 ml poly, 1000 mm x 500 mm located in moisture prone areas. The test windows shall be heated at a temperature of 55°C continuously for a time period of 6 hours for each test and at a time duration, period and frequency of test, as determined by the Consultant. Timing of the test windows shall not start until the temperature of the concrete surface has reached 55°C. This will not relieve the Contractor from his responsibility to ensure that the overlay does not debond. The Contractor shall provide four, 500 watt halogen lamp and a portable electric generator (3500 watt) and carry out the required testing which will be considered incidental to the Contract and no separate or additional payment will be made.

Application of the first layer is recommended when there is sufficient evidence of declining deck concrete temperatures.

15.7.4 Batching and Mixing of Polymer

Batching and mixing shall be done in accordance with the Manufacturer's instructions. The polymer shall be completely and thoroughly mixed before being deposited onto the deck. Any polymer not meeting the specification will be rejected, removed, and replaced at the Contractor's expense.

The temperature of the unmixed polymer constituents shall be between 10°C and 27°C. The polymer material shall be mixed in batches no larger than 20 ȁ. Each component shall be measured to within an accuracy of 3%. All containers shall be clean and free of contaminants of hardened polymer. Containers used for mixing and blending shall not be used for measuring.

In the absence of the Manufacturer's time limit for mixing, the minimum time for mixing shall be 3 minutes, however, for the Degussa Degadur System, the mixing time is a function of temperature. Attention shall be taken to blend the polymer adjacent to the mixing container surfaces. The presence of air, water bubbles or other contaminants in the mixed polymer will be cause for rejection of that batch.

The deck and adjacent areas shall be protected from spillage of polymer, solvents, and other materials. Any spilled materials shall be removed by the Contractor.

15.7.5 Application of Polymer Resin

Upon the Consultant's acceptance of the prepared deck surface and completion of the layout, the polymer shall be applied in accordance with the Manufacturer's instructions regarding mixing, blend time, temperature, time between layers, pot life, method of application, condition of substrate and any other requirements.

All cold joints in the overlay shall be offset 25 mm from cold joints of previous layers of the overlay. To ensure straightness, masking tape shall be applied along the perimeter of all areas to be overlay as well as along all steel deck joints, drains, curb faces or other edges of the layers of overlay. The first layer of polymer shall extend up the full height of the concrete curb and median faces and up 200 mm on the vertical faces of parapets. All masking tape used to define the boundaries of each segment shall be completely removed prior to gelling of the polymer.

The Contractor shall spread the polymer uniformly over the premeasured area using a squeegee and roller brush to carefully work the polymer into the surface and obtain the required coverage. Spiked footwear will be permitted for use by workers involved in the application work, but only prior to gelling of the polymer and with the constraint that all damage or defects in the surface will be repaired. Spreading and levelling of fresh polymer shall be completed while the material is in a state of low viscosity, and within seven minutes of batching. Failure to comply with the seven minute limit may result in rejection of the batch. Application of material which has begun to gel and increase in viscosity will not be permitted.

Application of the third layer of polymer (tie coat) shall be by airless spraying only. The polymer shall not be cut back with any solvents. This does not apply to the Degussa Degadur System, where the sealer layer may be applied with a roller.

The Contractor shall prevent or repair all bubbles, blisters, pinholes or other defects.

15.7.5.1 Degadur Base Coat (MMA)

The basecoat mixture shall be prepared by blending the silica flour and basaltic sand components with the resin in a suitable container (e.g. 20 l pail), followed by the addition and subsequent blending of the initiator. The mixture shall be applied over clean, dry, cured primer surfaces at the coverage rate specified in Clause 15.7, "Polymer Construction", using an approved spreading method. The applicator shall take care to allow the ridges between passes to self-level before broadcasting aggregate. Small areas may be touched up with a steel trowel.

The deck layout may be subdivided into coverage areas corresponding to a maximum of 150 ℓ of MMA mix rather than 20 ℓ as specified in Clause 15.7.2 “Deck Layout for the Overlay”.

Applicators shall not walk on a polymer layer after 4 minutes from time of placement.

15.7.5.2 Degadur Sealer (MMA)

The sealer mixture shall be applied to the cured and swept basecoat using paint rollers and brushes. Application shall be in a “dip-and-roll” manner from containers holding no more than 8 ℓ at a time; sealer shall not be poured directly onto the deck.

15.7.6 Seeding of Aggregate

The Contractor shall seed the first and second layer of polymer for Class A and B wearing surfaces and the first layer for Class C wearing surfaces. When the Degussa Degadur System (MMA) is used, the basecoat layer shall be seeded. The full height of the vertical face of curbs and median and up 200 mm of the vertical faces of the parapets shall not be seeded. The aggregate shall be seeded into the fresh polymer before gelling or increase in viscosity occurs. It shall be broadcast into the fresh polymer in such a manner that no ripples or waves are created and no segregation of the aggregate occurs. The aggregate shall impact the fresh polymer surface in a near vertical direction. Improper seeding technique will result in the work being suspended until proper methods are employed. The aggregate shall be placed so that an excess quantity covers the entire surface of the fresh polymer, no polymer is visible, and the surface has a dry appearance. As the aggregate settles into the fluid polymer, all “wet” spots which appear in the surface shall be promptly re-seeded before the polymer becomes viscous. At no time shall the Contractor disturb previously placed aggregate in an effort to cover “wet” surface spots. Once gelling begins, walking on the overlay will not be permitted until it has properly cured.

If insufficient aggregate has been placed and the “wet” areas harden to form glassy, resin-rich areas, the Contractor shall remove these areas to sound concrete, redo the deck surface preparation and replace the overlay.

After curing of the previous placed overlay and on acceptance of the Consultant, all excess aggregate or other contaminants shall be removed by power sweeping and air blasting. After cleaning to the satisfaction of the Consultant, the subsequent layer of polymer shall be applied.

Additional cleaning will be required if application of the subsequent layer of polymer is delayed and the overlay surface has become contaminated.

In the event that any layer of polymer material is subjected to rain or any other form of damage, the contractor shall do vertical pull out tests to confirm the adequacy of the material. This test consists of bonding a 64 mm diameter sandblasted steel disk to the prepared substrate by using an approved polymer, and pulling it from the substrate by applying a vertical force.

The polymer overlay in question will not be accepted unless at least 75% of the bonded steel disk surface has retained substrate concrete exceeding 3 mm in depth. At the discretion of the

Consultant the pull-out test may be carried out on any polymer layer. The minimum acceptable bond strength on normal weight concrete shall be 3.0 MPa. The Contractor shall repair all bond test locations with polymer overlay in accordance with this specification. The pull out equipment and repair of the polymer overlay will be considered incidental to the Contract.

15.7.7 Smoothness of Overlay Surface

Larger smoothness defects of the bridge deck, as determined by the Consultant shall be repaired by surface patching. Minor defects inherent in the concrete deck shall be smoothed by the application of the polymer overlay.

Roughness attributable to the overlay will be tested with a 3 m long straight edge. When placed anywhere in any direction on the surface except across the crown, the gap between the bottom of the straight edge and the surface of the overlay shall not exceed 3 mm. Overlays not meeting the criteria will be rejected, removed and replaced at the Contractor's expense.

The location and number of measurements taken will be at the discretion of the Consultant.

15.7.8 Testing and Strength Requirements

Two weeks prior to commencement of work, the Contractor shall be responsible for testing of infrared and gas chromatography analysis (in accordance with BT008) for each polymer component, compressive strength of the polymer mortar, modulus elasticity of the polymer, and grain size analysis of the aggregate. These results shall be provided to the Consultant for review.

During placement of the polymer, samples of the mixed polymer material will be randomly selected by the Consultant and the Contractor shall cast sets of three 50 mm cubes for compressive strength testing in accordance with test method ASTM C-109. These tests will be used for acceptance and determination of payment range or rejection of the work as specified in the applicable table below entitled "Partial Payment Schedule". The test cubes will be cast at a ratio of 22 volumes of approved aggregate to 1 volume of mixed polymer and cured for seven days in dry lab conditions. When the Degussa Degadur System is used, the test cubes will be cast at a ratio of 1 part base coat and 1 part approved aggregate, by volume and cured for seven days.

The compressive strength will be the maximum load measured or the load causing a 2.5 mm deflection, whichever occurs first. (This modified ASTM C-109 test method will also be used for acceptance testing of proposed overlay materials.) The compression test will be done using a steady loading rate of 0.5 MPa \pm 0.05 MPa per second.

The acceptable range of 7-day compressive strength for the polymer shall be 40 MPa to 70 MPa.

The MMA product shall have a 7-day compressive strength range of 16 MPa or over.

The Department reserves the right to reject any overlay whatsoever which does not meet the

applicable strength requirements. The Department may however, at the discretion of the Consultant, accept overlay which fails to meet the compressive strength range. In this case payment will be made in accordance with the following tables.

PARTIAL PAYMENT SCHEDULE FOR LOW STRENGTH POLYMER	
7-Day Compressive Strength (MPa)	Percentage of Unit Price
Between 40.0 and 70.0	100
38.0 to 40.0 or 70.0 to 72.0	90
36.0 to 38.0 or 72.0 to 74.0	80
34.0 to 36.0 or 74.0 to 76.0	70
32.0 to 34.0 or 76.0 to 78.0	60
30.0 to 32.0 or 78.0 to 80.0	50
Below 30.0 or over 80.0	Rejected

PARTIAL PAYMENT SCHEDULE FOR LOW STRENGTH MMA OVERLAY	
7-day Compressive Strength (MPa)	Percentage of Unit Price
16 and Over	100
15.0 to 15.9	90
14.0 to 14.9	80
13.0 to 13.9	70
12.0 to 12.9	60
11.0 to 11.9	50
Below 11.0	Rejected

Compressive strength tests may be carried out on any layer of the overlay. If a test result of any layer is below that specified, the reduced unit price shall apply to the full overlay thickness. Where compressive strength tests have been done on more than one layer, the lowest strength test result will be used to determine adjustment of the unit price. Each test will represent the 100 m² area poured during that batching operation. The Consultant will determine the test location of each test. The Contractor shall cast a set of three cubes to the frequency of test listed in the following table:

Frequency of Test	
Deck Area (m ²)	No. of Tests (Set of 3 Cubes)
1 - 500	4
501 - 1000	8
1001 - 2000	14
2001 - 3000	20
3001 - 4000	24

The Contractor shall pay all costs for testing, including but not limited to making test cubes, transporting cubes to an independent certified testing laboratory of his choice, storage, curing, breaking, and providing written reports of the polymer test results to the Consultant.

15.7.9 Opening to Traffic

The polymer overlay surfaces shall not be opened to traffic until a minimum of 60% of the 7 day compressive strength or 3.0 MPa of tensile strength is achieved based on the last batch of the day. It is recommended that the Contractor casts one additional set of cubes from the last batch of the day and have these tested at his cost. The cubes shall be cured in the field at ambient air temperature prior to testing.

No traffic will be allowed on the polymer overlay until all layers are acceptably placed and confirm to the strength requirement.

15.8 Payment

Payment for **Polymer Wearing Surface** will be made at the unit price bid per square metre of deck resurfaced, which price shall include surface preparation, full compensation for the cost of furnishing all labour, equipment, materials, tools and incidentals necessary to complete the work. The areas of the curb, median, deck joint or parapet vertical faces will be considered incidental and will not be included in the area of polymer wearing surface to be paid.

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 16

BRIDGE DECK WATERPROOFING

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REFERENCE DRAWINGS

Drawing No.

Deck Water Proofing System With 80mm Two Course Hot-Mix ACP S-1443

16.1 General

This specification is for the supply and installation of bridge deck waterproofing.

Bridge deck waterproofing shall be carried out in accordance with the following specifications; as shown on the drawings and standard drawing S-1443.

16.2 Material**16.2.1 General**

The materials supplied shall be able to withstand the heat generated during the waterproofing processes without affecting the performance of the material.

16.2.2 Submittals

The Contractor shall submit documentation indicating specification compliance of his proposed materials to the Consultant for review and acceptance a minimum of two weeks prior to the commencement of waterproofing installation operations.

16.2.3 Sampling and Testing

The Contractor is advised that the Consultant may carry out additional material testing to confirm compliance.

If requested by the Consultant or the Department, the Contractor shall provide sufficient additional quantities of the asphalt membrane, rubber membrane, membrane reinforcing fabric and/or protection board from the materials being used on the project.

16.2.4 Materials**Tack Coat**

The tack coat shall be a primer type meeting the requirements of CAN/CGSB-37-GP-9MA.

Asphalt Membrane

Asphalt membrane materials shall be supplied in cakes that are sealed and labeled by the manufacturer.

Material for the asphalt membrane shall be hot applied rubberized asphalt meeting the requirements of the Ontario Ministry of Transportation's OPSS 1213 Specification.

Rubber Membrane

Rubber membrane shall consist of 1.2 mm thick butyl and ethylene propylene diene monomer (EPDM) rubber. The membrane shall meet the requirements of CAN/CGSB 37.52M.

Membrane Reinforcing Fabric

Membrane reinforcing fabric shall consist of spun bonded sheet structure composed of 100%

continuous filament polyester fibres bonded together at their crossover points. The membrane shall be supplied in minimum widths of 300 mm.

Wick Drain

Wick drain shall consist of composite polypropylene with a total thickness of 3.6 mm, supplied in 100 mm widths. The puncture strength shall be a minimum of 45 N measured in accordance with ASTM D4833.

Waterproofing Protection Board

Waterproofing protection board shall consist of durable panels designed to provide a protective cushion between the hot mix asphaltic concrete pavement and the asphalt membrane.

The waterproofing protection board shall meet the requirements of the Ontario Ministry of Transportation's OPSS 1215 Specification for Protection Board.

16.3 Equipment

An approved heating and mixing kettle shall be used to heat the hot applied rubberized asphalt membrane. The kettle shall be a double boiler oil transfer type with a built in agitator, and shall be equipped with permanently installed dial type thermometers with an accuracy of ± 2 °C to measure the temperature of the melted compound and oil. A separate calibrated thermometer with an accuracy of ± 2 °C shall be available on site to verify material temperatures.

The unit shall be capable of keeping the contents continuously agitated, free flowing and lump free until the material is drawn for application.

16.4 Installation

16.4.1 General

The Contractor shall provide the Consultant with 48 hours advance notice prior to commencing any waterproofing operations.

Waterproofing operations shall only be carried out when the air and concrete surface temperatures are 5 °C or higher.

The Contractor shall carry out the operations involved in waterproofing in sequential order, and in such a manner that there are no delays between individual operations except those necessary to meet the requirements of these specifications.

Placement of the first asphalt concrete placement lift shall commence within 7 days of waterproofing installation or as determined by the Consultant based on anticipated exposure conditions.

16.4.2 Traffic Restriction

Once surface preparation operations have commenced the Contractor shall restrict all traffic

other than the construction equipment directly associated with waterproofing and bridge paving operations from traveling over the prepared areas.

These restrictions shall remain in place until such time that the asphalt concrete pavement has been placed and cooled to ambient temperature.

16.4.3 Surface Preparation

16.4.3.1 Grout Tubes

Grout tubes shall be cut flush with the concrete deck surface prior to surface preparation. If grout tubes project above the concrete after surface preparation, they shall be re-cut flush with the concrete deck surface. A 450 mm by 450 mm piece of membrane reinforcing fabric, centered on the tube, shall be installed as described in Section 16.4.5, Waterproofing of Joints and Cracks.

16.4.3.2 New Bridge Construction

Concrete surfaces to receive waterproofing shall be cured a minimum of 14 days and then allowed to dry a minimum of 3 days. Concrete surfaces shall be completely dry prior to commencing waterproofing operations. Drying of concrete surfaces by the use of torches or other means that, in the opinion of the Consultant, may be potentially harmful will not be permitted.

Once the concrete surfaces are completely dry, they shall be prepared for waterproofing installation by sandblasting or shotblasting to expose sound, laitance free concrete for the entire installation area. All dirt and debris shall be removed and disposed of leaving a prepared surface satisfactory for tack coating.

16.4.3.3 Bridge Rehabilitation

Concrete surfaces to receive waterproofing shall be ground, scabbled, or bush hammered to achieve a surface texture of 3 mm or less prior to sandblasting or shotblasting. Concrete surfaces shall also meet the requirements of Section 16.4.3.2, New Bridge Construction, prior to waterproofing installation.

New concrete overlays or concrete patches that are to receive waterproofing shall be cured for a minimum of 7 days unless otherwise specified and allowed to dry a minimum of 3 days.

16.4.4 Tack Coating

Tack coat shall be applied wherever waterproofing membrane is required. Tack coating and waterproofing installation shall not commence until the Consultant has inspected and accepted the surface preparation work.

Immediately prior to the application of the tack coat, the concrete surface shall be blown clean with oil and water free compressed air to remove all dust and other foreign material. The tack

coat shall be cut back with an equal volume of gasoline type solvent or an alternative cut back asphalt product compatible with the asphalt membrane.

The tack coat application shall be such that the tack material will be absorbed into the concrete, resulting in a surface that is dull and black in appearance. Excess application of tack coat, indicated by a shiny black surface, shall be avoided. Tack coat material shall be applied at an approximate rate of 0.25 L/m².

Waterproofing equipment or material shall not be permitted on the tack coat until it has fully cured and is completely tack free.

16.4.5 Waterproofing of Joints and Cracks

The Contractor shall pay particular attention to waterproofing installation over construction joints, lift hook pockets, grout tubes, patches and cracks.

After tack coat application and prior to application of the primary hot asphalt membrane, a coat of hot asphalt membrane 3 mm to 4 mm thick and wide enough to extend 200 mm on either side of each joint or crack shall be applied in accordance with Section 16.4.6, Application of Asphalt Membrane. A strip of membrane reinforcing fabric material wide enough to extend 150 mm on either side of the construction joint, lift hook pocket, grout tubes, patch or crack shall be applied while the asphalt membrane is still hot and tacky. The membrane reinforcing fabric shall then be covered with an additional layer of water proofing 2 mm to 3 mm thick. Membrane reinforcing fabric shall be overlapped for a minimum of 100 mm when multiple strips are used.

For areas along curbs, barrier walls, and deck drains, the hot asphalt membrane shall be applied to the height of the top of the hot mix ACP surface course and 150 mm onto the deck. Rubber membrane shall be applied into the first coat of asphalt membrane while it is still hot and tacky. The rubber membrane shall extend 50 mm up the vertical face and 100 mm onto the deck surface. Rubber membrane shall be overlapped for a minimum of 100 mm where multiple strips are used. A second coat of asphalt membrane shall then be applied to fully cover the rubber membrane.

16.4.6 Application of Asphalt Membrane

Cakes of asphalt membrane shall be melted in the heating and mixing kettle to a temperature not exceeding that recommended by the membrane Manufacturer.

The asphalt membrane shall not be applied until the tack coat has cured completely.

The application temperature of asphalt membrane shall be within the range recommended by the Manufacturer. The membrane shall be applied in a uniform film having a minimum thickness of 4 mm and a maximum thickness of 6 mm.

Application of the asphalt membrane shall be carried out in a continuous manner to the extent practicable. Where joints are unavoidable, they shall be overlapped by a minimum of 150 mm. The membrane shall be applied over all waterproofed joints and cracks, and shall extend up the

face of curbs, barrier walls, and deck drains, to the height of the top of the design hot mix asphalt surface course.

The Contractor shall conduct his operations in such a manner that plugging of deck drains and/or drainage tubes is avoided. Plugged deck drains or drainage tubes shall be cleaned out by the Contractor at his expense.

16.4.7 Wick Drain Installation

Wick drains shall be installed along the full lengths of the gutters, and shall be installed when the asphalt membrane is still hot and tacky. Special attention shall be given to waterproofing and wick drain modifications at deck drain pipe locations. Tack coat shall not be applied to wick drains.

16.4.8 Protection Board Installation

The Contractor shall ensure that the asphalt membrane thickness meets the specified requirements prior to placing the protection board. Protection boards shall be laid on the asphalt membrane while the membrane is still hot, with the length of the board running transversely on the deck. The protection boards shall be placed with edges overlapping a minimum 12 mm and a maximum of 25 mm, both longitudinally and transversely. The protection board edge shall be within 5 mm of all wick drains, vertical faces of drains, and vertical faces of expansion joints.

Protection board shall be lapped to produce a shingling effect in both the longitudinal and transverse directions. Protection boards shall be placed such that the longitudinal (direction of traffic flow) joints are staggered a minimum of 150 mm. Boards shall be rolled using a linoleum or lawn type roller while the membrane is still warm to ensure good contact with the membrane. Holes shall be cut through the protection board to allow water to drain freely through the drainage tubes. At locations where the edges of the protection board have curled-up, the curled-up edges shall be cemented down using hot membrane material to the satisfaction of the Consultant.

Protection boards that are warped, distorted or damaged in any way, whether by manufacture, storage, handling or exposure to the elements shall be replaced with new material.

16.5 Measurement and Payment

Measurement for payment of deck waterproofing will be by the square metre of waterproofing acceptably installed.

Payment will be made at the unit price bid for "Deck Waterproofing", and will be full compensation for traffic control; preparation of the concrete deck surface, including sandblasting and/or shotblasting; the supply and application of the tack coat; the supply and installation of asphalt membrane, membrane reinforcing fabric, rubber membrane, wick drain, protection board; and all labour, equipment, tools and incidentals necessary to complete the Work to the satisfaction of the Consultant.

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 17

ASPHALT CONCRETE PAVEMENT

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17.1 General

Asphalt Concrete Pavement (ACP) shall consist of crushed aggregates with reclaimed asphalt pavement (RAP), blend sand and filler material as required, and asphalt cement, combined in a hot mix plant as hereinafter specified, placed and compacted on bridges and approaches in conformity with the lines, grades, dimensions and cross-section as provided and as shown on the drawings.

This specification is for the following applications:

- ACP Wearing Surface applied over hot applied rubberized asphalt membrane waterproofing complete with protection board.
- ACP Wearing Surface applied on polymer membrane waterproofing.
- Asphalt Concrete Pavement transition and approach road paving.

For projects where transition ACP is required, the Contractor shall cold mill to achieve a 40 mm minimum thickness of ACP. The joint between the existing ACP and the new transition ACP shall be saw cut a minimum of 40 mm across the full width of roadway. Milling shall be considered as part of Asphalt Concrete Pavement and no separate or additional payment will be made.

This specification shall be used in conjunction with the Standard Specifications for Highway Construction. In areas of conflict between this specification and the Standard Specifications for Highway Construction, this specification shall govern.

17.2 Materials

The Contractor shall supply Asphalt Cement and Aggregate in accordance with sections 3.50.2.1 and 3.50.2.2 of the Standard Specifications for Highway Construction.

The liquid asphalt shall be applied as a tack coat to ensure a bond between the surface being paved and the subsequent course, and shall consist of SS-1 or RC 30/70. When SS-1 is used it shall be diluted with an equal volume of water. In all cases where weather conditions permit, SS-1 shall be used in preference to RC 30/70. The tack coat materials shall conform to the Specifications listed in Tables ASPH6 and ASPH7 of Specification 5.7 of the Standard Specifications for Highway Construction.

17.3 Asphalt Mix Design

The Contractor shall prepare and submit asphalt mix designs in accordance with section 3.50.3 Asphalt Mix Design and Job Mix Formula of the Standard Specifications for Highway Construction that are representative of materials to be used. For asphalt mix designs which were completed in excess of six months prior to anticipated production, additional analysis of more recent sampling shall be provided, as required to confirm that the mix ingredients continue to meet requirements.

The Type of Asphalt Mix to be used shall be as specified. Generally on Highways 1 - 216 a Type H2 Asphalt Mix using PG 58-28 asphalt cement grade will be specified, and on Highways 500 - 986 and local roads a Type M1 Asphalt Mix using a PG 52-34 asphalt cement grade will be specified.

When accepted by the Consultant the Contractor will be permitted to supply a Type H2 Asphalt Mix where a Type M1 Asphalt Mix has been specified.

17.4 Sampling and Testing

Sampling and testing procedures used to determine material characteristics shall be as outlined in the Standard Specifications for Highway Construction section 3.50.4 Sampling and Testing unless otherwise specified.

In addition to quality control testing completed by the Contractor described in Section 17.5, quality assurance (QA) testing will be completed by the Consultant. QA testing will be completed on two 6 kg samples per lift to determine the uncorrected asphalt content and aggregate gradation. The Consultant will use the Contractor's measured correction factor to establish the actual asphalt content. The actual asphalt content will be determined by test method ATT-12 or ATT-74, and includes the correction factor for asphalt binder lost due to absorption by the aggregate or aggregate loss.

In-place density testing may be carried out on an as required basis at locations determined by the Consultant.

The Consultant shall have access to the work at all times for taking samples. The Contractor shall provide any assistance necessary for taking samples and shall reinstate pavement lifts or other structures to the satisfaction of the Consultant at the positions where samples have been taken. Compensation for providing assistance with sampling and for reinstatement where samples are taken shall be included in the unit price bid for the various items of Work tested and no separate payment will be made.

The Consultant's acceptance of any materials or mixtures shall in no way relieve the Contractor from his obligation to provide materials, mixtures and workmanship in accordance with the specifications.

17.5 Quality Control Testing

Quality control testing shall be completed on all projects with 50 tonnes of ACP or more. The Contractor shall be responsible for all quality control testing and associated costs. Results of all quality control tests shall be submitted to the Consultant within 7 days of the test being completed.

The Contractor shall produce crushed aggregates in accordance with Specification 3.2, Aggregate Production and Stockpiling for Designation 1 aggregate and requirements listed in section 3.50.3.2 Design Requirements.

Unless otherwise specified, the latest edition of the following standard Alberta Transportation test methods (ATT) will be used to determine material characteristics. Test methods and minimum frequencies of testing are shown in Table 17.5 Quality Control Testing Requirements.

Table 17.5
Quality Control Testing Requirements

TEST	TEST METHOD	MINIMUM FREQUENCY
AGGREGATE PRODUCTION		See Specification 3.2
ASPHALT MIX PLANT		
1. Calibration	ATT-17	Once per project or as requested by the Consultant
2. Inspection	ATT-16	Minimum of one per lift.
SAMPLES		
1. Asphalt Cement	ATT-42	As requested by the Consultant
2. Tack, Prime and Fog Materials	ATT-42	As requested by the Consultant
3. Cold Feed Aggregate	ATT-38	(3)
4. Mix	ATT-37	Minimum of one per lift
5. QA Cores - Stratified Random Test Sites Chosen By The Consultant (Coring done by Contractor)	ATT-56	As requested by the Consultant
i) QA Cores for Pavement Density	ATT-5	As requested by the Consultant
ii) QA Cores for Asphalt Content and Gradation	ATT-5	As requested by the Consultant
ADDITIONAL TESTING REQUIREMENTS		
1. Sieve Analysis Crushed Aggregate	ATT- 26	Minimum of one test for each aggregate component.
ADDITIONAL TESTING REQUIREMENTS		
2. Percent Fracture of Crushed Aggregate	ATT-50	Minimum of one test for each aggregate component.
3. Mix Asphalt Content	AASHTO T-164, T287 or ATT-12 or ATT-74	Minimum of one per lift.
4. Correction Factors	ATT-12, Part III or ATT-74, Part II	Once for each mix design.
5. Mix Moisture Content	ATT-15	Minimum of one per lift.

TEST	TEST METHOD	MINIMUM FREQUENCY
6. Aggregate Sieve Analysis	ATT-26	(3)
7. Pavement Segregation	Paving Guidelines and Segregation Rating Manual	(4)
8. Field Formed Marshall Briquettes	ATT-13	(1)
9. Density Immersion Method, Saturated Surface Dry	ATT-7	(2)
10. Void Calculations, Cores or Formed Specimens	ATT-36	(1)
11. Temperatures	ATT-30	(1)
12. Percent Compaction, Cores, or Nuclear Density	ATT-67, ATT-5 or ATT-11	(2)
13. Correction Factors, Nuclear Moisture-Density Measurement	ATT-48	(2)
14. Pavement Smoothness	ATT-59	As requested by the Consultant

Notes: (1) Minimum frequency not specified.

(2) Nuclear Density Testing is required on all projects. The Consultant may require the Contractor to obtain pavement cores (top lift only) for QC testing.

(3) One sieve analysis of the combined aggregate (any combination of cold feed, extraction or ignition) is required per lift.

(4) At the end of paving each day or completion of a paving lift, the Consultant will perform an inspection of the paving to identify any areas of pavement segregation.

17.6 Equipment and Methods

17.6.1 General

Equipment and methods used on this work shall be adequate to produce and place the material as specified herein, and shall be subject to the acceptance of the Consultant. The Department reserves the right to order changes or the discontinuance of use of any equipment or method which, in the opinion of the Consultant, fails to produce satisfactory results.

17.6.2 Asphalt Mixing Plant Requirements

All asphalt mixing plants used by the Contractor for the preparation of asphalt concrete material shall conform to the requirements of section 3.50.5.1.2 of the Standard Specifications for Highway Construction. The Contractor shall provide the Consultant with a certificate of calibration which certifies that the plant has been calibrated to produce a uniform mixture in accordance with the Job Mix Formula.

17.6.3 Equipment for Transportation of Mixture

The mixture shall be transported from the asphalt plant to the worksite in trucks with smooth metal boxes in good and leak proof condition, previously cleaned of all foreign materials or hardened asphalt concrete mixture. Each vehicle shall be equipped with a tarpaulin of suitable material and of sufficient size to overhang the vehicle box when fully loaded. Tarpaulins shall be on the haul unit at all times and shall be used to cover the mixture completely unless otherwise determined by the Consultant. Tarpaulins shall be securely fastened on all sides of the box.

Excess truck box lubricants such as detergent or lime solutions shall not be allowed to contaminate the mix. Petroleum based truck box lubricants shall not be used.

17.6.4 Paver

Pavers shall be acceptable to the Consultant and be self-propelled and operated to maintain required levels, cross-falls and joint matching.

17.6.5 Compaction Equipment

The Contractor shall provide sufficient self-propelled equipment to obtain the required degree of compaction of the asphalt concrete mixture. The compaction capability of the equipment used shall equal or exceed the placing rate of the spreading operations and shall be capable of obtaining the required compaction before the temperature of the mat falls below specified levels. Compaction equipment shall be of a suitable size, weight and type as acceptable to the Consultant, such that displacement of the mat and/or disruption of underlying materials does not occur.

Compaction equipment shall be in proper mechanical condition and operated such that uniform and complete compaction is obtained throughout the entire width, depth and length of the pavement being constructed. Rollers shall be configured to ensure uniform and complete compaction up to the face of barriers, curbs and medians. Rollers provided shall leave a smooth, properly finished surface, true to grade and cross-section without ruts or other irregularities. All compaction equipment shall be equipped with methods of wetting the tires or drums to prevent adhesion or pickup of the asphalt mixture.

The Contractor shall provide as a minimum of one rubber tired roller and one smooth steel drum type roller. The rollers shall have a minimum 10 tonnes mass. Vibrators on vibratory rollers shall not be activated. Specialized equipment may be required to achieve adequate compaction and smoothness in tight corners at expansion assemblies and deck joints.

17.7 Construction

17.7.1 Asphalt Temperatures

The asphalt tank supplying the plant mixer shall be equipped with heating apparatus capable of producing asphalt temperatures up to but not greater than 155°C uniformly throughout the entire

contents of the tank. The Contractor shall maintain the asphalt temperature within plus or minus 10°C of the specified mixing temperature.

17.7.2 Mix Production

The Contractor shall produce an asphalt mixture in accordance with section 3.50.5.1.3 Mix Production of the Standard Specifications for Highway Construction.

17.7.3 Protection of Adjacent Bridge Components

The Contractor shall protect all bridge components to prevent splatter or staining from asphaltic materials.

17.7.4 Tack Coat

Asphalt tack coat shall be applied to the existing protection board, polymer membrane waterproofing, granular base course, or existing asphalt concrete substrate and between lifts of asphalt concrete pavement, at the locations and to the dimensions designated by the Consultant.

Tack coat shall not be applied to wick drains.

The surface to be tacked shall be dry and free of loose or deleterious material when the tack is applied.

The asphalt tack coat shall be applied in a uniform manner at an application rate of 0.5 l/m² and asphalt temperature designated by the Consultant. The ambient air temperature at the time of application shall be 5°C or higher.

On areas where the Contractor is required to accommodate traffic, the surface shall be tacked in two operations. In the first operation one half of the width shall be tacked with the remaining half being tacked after the first half has cured.

The tack coat shall be protected from traffic or other damage. Areas on which the tack has been damaged by traffic shall be retacked at the Contractor's expense.

17.7.5 Spreading and Compaction

17.7.5.1 General

The mixture shall be placed only upon a dry, frost free substrate on which the tack coat has cured and when the ambient air temperature is 5°C or higher. Prior to the delivery of the mixture on the work, the base shall be cleaned of all loose or foreign material. The mixture shall be spread and compacted during daylight hours only, unless artificial light satisfactory to the Consultant is provided.

During spreading and compaction operations, care shall be taken at all times to ensure that:

- Asphalt mixture is not wasted over the side or onto the adjacent surface mat.

- Damage is not done to the waterproofing membrane, curbs, barriers, medians, concrete paving lips, manholes, or drains.
- Damage is not done to guide posts, guardrails, signs, power conduits or any other roadside installations.

The Contractor shall make immediate and adequate repair of any damage resulting from his operations at his own expense.

17.7.5.2 Spreading

The mix shall be spread at a temperature sufficient for the specified compaction and finishing at the final placement area.

The manner of placing shall be as acceptable to the Consultant to ensure safe accommodation of traffic, quality control and drainage. The longitudinal and transverse edges of each lane shall be straight in alignment, uniform, and of the same thickness as the adjoining pavement layer. Adequate measures for the protection of the exposed edges shall be maintained throughout the work.

Each layer shall be placed, finished and compacted for the full width, and then allowed to cool down to 50°C or colder prior to commencing the subsequent layer.

In the placing of successive lifts, the individual mixture spreads shall be aligned in a manner such that the longitudinal joints in successive lifts do not coincide. Unless otherwise directed, the lateral distance between the longitudinal joints in the successive lifts shall be not less than 0.30 m. The longitudinal joint of the final lift of asphalt concrete pavement shall not be located within the wheel path areas.

The surface of all lifts should not exhibit evidence of segregation.

All longitudinal and transverse joints shall be of the vertical butt joint type, made in a careful manner, well bonded and sealed, and shall be finished to provide a continuous, smooth profile across the joints.

17.7.5.3 Compaction

The Contractor shall monitor the compaction process using a Control Strip Method. Control Strips are generally established on each mat placed.

The Control Strip lift shall be compacted using at least the following equipment:

- (a) One steel roller weighing not less than 10 tonnes; and
- (b) One self-propelled pneumatic rollers, ballasted to its maximum capacity, weighing not less than 10 tonnes.

Once the mix has been spread by the paver and the initial pass of the breakdown roller has been done, moisture and density measurements for determining the Control Density will

commence at five locations within the Control Strip area, and will continue following repeated passes of the compaction equipment until the apparent maximum density is attained. These measurements shall be taken by the Contractor using nuclear testing equipment.

The Contractor shall compact the pavement to a minimum average density of 97% of Marshall Density, with no individual density less than 95%.

When the compaction methods and procedures, in the opinion of the Consultant are not achieving the desired compaction specifications, the Consultant may require the Contractor, at any time to obtain cores of the top lift pavement. The number of cores will be determined by the Consultant. The cores will be tested by the Contractor and the results provided to the Consultant as they become available.

Percent compaction will be expressed in percent of Marshall Standard Density. The Marshall Standard Density used for determining pavement compaction shall be as follows:

- (a) Marshall Densities determined on field sampled mix, or if not available then;
- (b) Marshall Design Density as reported in the approved mix design.

Coring shall be done using methods which will not damage the rubberized asphalt membrane or protection board. Core holes shall be completely de-watered and dried. A generous application of liquid asphalt shall be applied to the bottom and sides of the core hole and allowed to cure. Asphalt mix shall then be tamped in lifts into the core hole until flush with the surface of the surrounding pavement.

The Contractor shall not undertake any coring unless approved by the Consultant and the Department.

The Contractor shall be reimbursed for obtaining, preparing and testing cores at the rate of \$100 per core location.

In order to maintain the crown of the bridge deck and approaches, the contractor shall avoid operating the compaction equipment on or across the crown. Compaction procedures and equipment shall be such that displacement of the mixture does not occur. Roller wheels shall be kept slightly moistened by water or oil to prevent picking up the mixture, but an excess of either water or oil will not be permitted.

In cases where the asphaltic mixture is placed under weather and temperature conditions which may be considered less than ideal, the Contractor shall modify normal operations and provide special attention to these situations such that specified compaction results are achieved.

17.7.5.4 Hot-Applied Rubberized Asphalt Waterproofing Membrane System Paving

The ACP wearing surface shall be placed and compacted in two nominal 40 mm lifts.

The first lift of ACP shall be spread by the asphalt paver in the direction of the protection board

laps (downhill). In the event that paving cannot be carried out in the direction of the protection board laps, the Contractor shall submit a procedure for review, identifying measures that will be taken to ensure that the protection board and waterproofing membrane will not be damaged during paving. To avoid damaging the waterproofing membrane the paver shall not exceed the placing rate or push the delivery trucks, all equipment shall perform all turning movements off the bridge deck, and the asphalt mixture shall not be dumped onto the protection board ahead of the paver.

The allowable temperature range for compaction of ACP lifts on the hot-rubberized asphalt waterproofing membrane system shall be as follows:

ASPHALT GRADE	COMPACTION TEMPERATURE RANGE	
	FIRST LIFT	SECOND LIFT
150 - 200 (A) or PG58-28	MAX. 105°C	128°C - 138°C
200 - 300 (A) or PG52-34	MAX. 105°C	123°C - 133°C

The minimum average Marshall density of the first lift shall be 95% with no individual test less than 93%. The remainder of the first lift shall have a minimum Marshall density of the 95%. The minimum average Marshall density of the second lift shall be 97% with no individual density less than 95%.

17.7.5.5 Polymer Waterproofing Membrane Paving

The ACP wearing surface shall be placed in one lift of 50 mm nominal thickness. Dumping of the asphalt mixture onto the polymer waterproofing membrane ahead of the paver will not be permitted.

The temperature of the asphalt mixture shall be between 123°C and 138°C at the start of compaction.

17.7.5.6 Transition and Approach Road Paving

The ACP shall be placed as shown on the drawings and as determined by the Consultant. Lifts of ACP shall not exceed 70 mm.

The temperature of the asphalt mixture shall be between 123°C and 138°C at the start of compaction.

17.7.6 Surface Defects and Material Tolerances

The completed pavement and all intermediate lifts shall be smooth, true to established

cross-section and grade, thoroughly compacted and free from ruts, humps, depressions, or other irregularities. Any ridges, indentations or other objectionable marks left in the surface of the asphalt concrete pavement shall be eliminated by rolling or by other means. The Contractor shall be responsible for all costs including materials associated with the repair of Surface Defects.

17.7.6.1 Smoothness

Except across the crown, the surface shall be such that when tested with a 3 m long straight edge placed anywhere in any direction on the surface, there shall not be a gap greater than 3 mm between the bottom of the straight edge and the surface of the deck anywhere below the straight edge. The surface shall be checked by the Contractor, as described above, immediately after the final rolling.

Any final lift pavement surface which does not meet the smoothness requirements given above shall be repaired by the Contractor to meet the requirements using methods acceptable to the Consultant.

Material removed by cold milling shall be hauled and disposed of by the Contractor, at his expense.

17.7.6.2 Segregation

Pavement segregation shall be classified in accordance with section 3.50.4.7.2 "Classifying Pavement Segregation" of the Alberta Transportation Standard Specifications for Highway Construction. The Departments manual for "Paving Guidelines and Segregation Rating Manual" shall be used as reference in classifying segregation severity.
(<http://www.transportation.alberta.ca/Content/docType233/Production/pavsegman.pdf>)

During paving operations, the Contractor shall make every effort to achieve a finished surface that has a uniform closed texture and is free of segregated areas. At the end of paving each day or completion of a paving lift, the Consultant will perform an inspection of the paving to identify areas of pavement segregation. If segregation is present, the Contractor shall take immediate corrective action to the paving process to prevent any further occurrence of segregation. The Contractor shall repair segregated areas of all severities as follows:

- (a) When slight segregation is identified in the bottom lift, the Contractor shall identify and correct the cause of the segregation to prevent segregation in the top lift.
- (b) When any moderate or severe segregation or centre of paver streak is identified in the bottom lift, the top 20 mm of the lift shall be removed and replaced. Subsequent lift(s) shall be modified to meet the specification requirements and approved by the Consultant.
- (c) When any moderate or severe segregation or centre of paver streak is identified in the top lift, the entire lift shall be removed and replaced.
- (d) When slight segregation is identified in the top lift and the total area of slight segregation does not exceed 0.5% of the total paved area, the areas identified shall be repaired with a slurry patch.
- (e) When slight segregation is identified in the top lift and the total area of slight segregation exceeds 0.5% of the total paved area, the entire lift shall be removed and replaced.

Methods of repair, removal and replacement shall be reviewed and accepted by the Consultant.

17.7.6.3 Obvious Defects

The finished surface of any lift shall have a uniform closed texture and be free of visible signs of poor workmanship. Any obvious defects as determined by the Consultant such as, but not limited to the following, shall be promptly repaired in a manner acceptable to the Consultant.

- (a) Areas of excess or insufficient asphalt
- (b) improper matching of longitudinal and transverse joints
- (c) roller or tire marks
- (d) cracking or tearing
- (e) sampling locations not properly reinstated
- (f) improperly constructed patches

17.7.6.4 Asphalt Content

For top lift material the average asphalt content shall not be greater than $\pm 0.50\%$ from the accepted mix design asphalt content.

For bottom lift material the average asphalt content shall not be greater than $\pm 0.65\%$ from the accepted mix design asphalt content.

17.7.6.5 Aggregate Gradation

For each lift of placement the difference between the average gradation and the Job Mix Formula gradation shall not exceed the amounts shown in the following table:

Table 17.6
Aggregate Gradation Variation

Sieve Designation	Maximum Permissible Variation* Percent by Weight Passing
5000	± 6
1250	± 4
630	± 3
315	± 3
160	± 2.5
80	± 2.0
*In any case the Average Gradation must meet the gradation requirements of Specification 3.2 Aggregate Production and Stockpiling	

17.8 Measurement and Payment

17.8.1 By Lump Sum Price Bid

Payment for **Asphalt Concrete Pavement** will be made on the basis of the lump sum price bid for the Asphalt Concrete Pavement acceptably placed on the bridge deck, approach slabs and approach roadways (as specified) and remaining in the completed work, which price shall include full compensation for the cost of furnishing all labour, equipment, tools, materials, milling, hauling and placing the mix, quality control testing and incidentals necessary to complete the work.

17.8.2 By Unit Price Bid

Payment for **Asphalt Concrete Pavement** will be made on the basis of the unit price bid per tonne for the Asphalt Concrete Pavement acceptably placed on the bridge deck, approach slabs and approach roadways (as specified) and remaining in the completed work, which price shall include full compensation for the cost of furnishing all labour, equipment, tools, materials, milling, hauling and placing the mix, quality control testing and incidentals necessary to complete the work. The number of tonnes to be paid for will be calculated based on the field measurement. The conversion factor for Asphalt Concrete Pavement from cubic metre to tonne shall be 2.3

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 18

CSP AND SPCSP STRUCTURES

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REFERENCE TABLES

Table No.

Details of Standard 2:1 Sloped End Sections for CSP Round Culverts A

Details of Standard 2:1 Sloped End Sections for CSP Arch Culverts B

Details of Standard 2:1 Sloped End Sections for SPCSP Round Culverts..... C

18.1 General

This section describes the supply, fabrication, delivery and installation of Corrugated Steel Pipe and Structural Plate Corrugated Steel Pipe with an equivalent diameter of 1500 mm or greater.

Abbreviations for the various types of metal pipe are as follows:

CSP	Corrugated Steel Pipe
CSP Arch	Corrugated Steel Pipe Arch
SPCSP	Structural plate Corrugated Steel Pipe
SPCSP Arch	Structural plate Corrugated Steel Pipe Arch

18.2 Supply and Fabrication

18.2.1 Standards

The supply and fabrication of all galvanized, polymer coated and aluminum coated Corrugated Steel Pipe including couplers and appurtenances and Structural Plate Corrugated Steel Pipe shall be in accordance with the current edition of CSA Standard G401 with additions and exceptions as described in this specification.

18.2.2 Engineering Data

18.2.2.1 Shop Drawings

Five copies of the shop drawings for SPCSP structures and any non-standard materials (e.g. elbows, bottomless arch details, horizontal ellipses, etc.) as well as bevel end details shall be submitted to the Consultant for review prior to fabrication.

18.2.2.2 Plate Arrangement

The arrangement of the plates for SPCSP structures shall be shown on the shop drawings. The drawings shall also indicate that the bolts in the valley of each longitudinal seam are nearer to the visible edge of the plate than the bolts in the crest. With the exception of "change of radii" locations, all longitudinal seams shall be staggered a minimum of 2N.

The Contractor shall use the shop drawings at the site to facilitate the assembly of the pipe.

18.2.3 Materials

Previously installed pipe shall not be used. All pipe supplied shall be clearly marked with the following information at intervals of not more than 3 m.

- Manufacturer's Name or Trade Mark
- Nominal Thickness and Type of Metal
- Plate/Metal Coating (for non standard coating)
- Specification Designation
- Plant Designation Code
- Date of Manufacture

18.2.4 Fabrication

18.2.4.1 Fabrication of CSP

Sloped Ends

Sloped end sections are required for each culvert unless otherwise noted on the drawing or the culvert order. When 2:1 sloped end sections are specified by the order, the attached Tables A and B will apply unless stated otherwise.

Termination of Lockseams

On pipes 1000 mm diameter or larger all lockseams terminating at the cut edges of a sloped or square end section shall have a 75 mm length of fillet weld run along both sides of the lockseam (staggered 300 mm apart) at each cut edge. The weld and surrounding area shall be zinc coated in accordance with CSA G401.

Cut Ends

All cut edges of a sloped or square end section shall be made smooth by grinding so that all the burrs are removed. Any damaged protective coating shall be recoated with appropriate material in accordance with CSA G401.

Recorrugated Ends

All corrugated steel pipes shall have ends recorrugated to provide annular corrugations for couplers.

Couplers

Only annular corrugated couplers will be accepted unless specified otherwise on the order. The couplers for pipes 1600 mm and over in diameter shall be a minimum of 600 mm width. There shall be a minimum of five bolts per coupler.

18.2.4.2 Fabrication of SPCSP

Sloped Ends

Sloped end sections are required for each culvert unless otherwise noted on the drawing or the order. When 2:1 sloped end sections are specified by the order the attached Table C will apply unless stated otherwise.

18.2.5 Shop Inspection

18.2.5.1 Inspection, Sampling and Testing

All materials shall be subject to inspection, sampling and quality assurance testing by the Consultant. The Contractor shall provide safe, convenient access acceptable to the Consultant for inspection and sampling of the materials, and shall cooperate in the inspection and sampling process when requested to do so.

Any material found unacceptable by the Consultant shall be replaced with acceptable material by the Contractor at the Contractor's expense.

Reinspection required due to faulty work shall be paid by the Contractor.

18.2.5.2 Notification

The Contractor shall contact the Consultant at least 72 hours prior to shipment. This is to facilitate inspection of the materials at the plant.

18.2.5.3 Failure to Notify for Inspection

Material that has not been inspected in the plant by the Consultant will not be passed for payment until such material has been inspected. The Contractor may be charged with all expenses incurred for the material to be inspected at the site.

18.2.6 Storage of Material

18.2.6.1 Stockpiles

All material shall be unloaded and stockpiled in a neat and orderly manner, so as to facilitate inspection and inventory, and in such a manner as to insure preservation of their quality and fitness for the work. Stockpiled materials, accepted on delivery as to quantity and observed condition, shall be subject to test, and shall meet requirements of the specifications at the time they are to be used in the work.

18.2.6.2 Storage Stains

In addition to CSA G401, when noted on the order, SPCSP material is to be stored concave down. This requirement is to reduce the occurrence of storage stain damage on plates that are not going to be assembled immediately.

18.2.7 Handling of Material

All culvert material shall be handled carefully and in such manner as to prevent bruising, scaling or breaking of the galvanized coating. Culvert material shall also be handled and unloaded without undue stress and in such a manner that the radii or dimensions of the pipes remain true. Coupling bands shall be shipped with all necessary hardware and fittings attached thereto, or in suitable shipping containers. All SPCSP bolts are to be shipped with plates. Where the material supplied is damaged, the Contractor shall immediately separate nested sections of plate or pipe to facilitate more detailed inspection. Culvert material designated by the Consultant as unacceptable, due to failure to meet specified requirements, shall be immediately repaired or replaced by the Contractor.

Where the Contractor's failure to satisfactorily stockpile, or to satisfactorily expedite repairs to damaged material, necessitates that the Consultant require this to be done separately, the cost of such work will be charged to the Contractor.

18.3 Installation

Metal pipes are flexible, and their resistance to deformation depends on careful bedding and backfilling. As they deflect under vertical load they must build up wide support and therefore, to obtain maximum load bearing capacity, it is essential that the material under and beside the pipe be of good quality, carefully placed and properly shaped and compacted as specified on the drawings. It is essential that the structure be kept dewatered to the bottom of the excavation until all backfilling is complete.

18.3.1 Care of Water

The Contractor shall be responsible to make adequate provisions for handling water in and around the construction site. Care of water will be considered incidental to the work and no separate or additional payment will be made.

18.3.2 Excavation

Excavation shall be done to the lines and grades shown on the drawings, or as determined by the Department and Consultant, and in accordance with the appropriate sections of Section 1 "Excavation" of the Specifications for Bridge Construction, to permit placing of the bedding material.

18.3.3 Bedding

Where the bottom of the excavation lies at 600 mm or less below the pipe invert the fill material shall be compact by the Contractor to a minimum of 95% of Standard Proctor Density at optimum moisture content. Where the bottom of the excavation extends more than 600 mm below the pipe invert, the fill material shall be compacted at the 600 mm level to a minimum of 95% of Standard Proctor Density at optimum moisture content. The structural fill shall be placed in lifts not exceeding 150 mm when compacted. The Contractor shall use whatever materials, labour, equipment and incidentals necessary to achieve a stable bed.

When in the opinion of the Department and Consultant foundation conditions are considered soft and unstable, the Contractor shall supply and place woven geotextile filter fabric at the base of the excavation between the clay seals as shown on standard drawing S-1418. The woven geotextile filter fabric shall be in accordance with the following table:

Woven Geotextile Filter Fabric	
Specifications and Physical Properties	
Grab Strength	1275N
Elongation (Failure)	15%
Puncture Strength	275 N
Burst Strength	3.6 MPa
Trapezoidal Tear	475 N
Minimum Fabric Lap to be 1000 mm	

The granular material within 150 mm of the bottom of pipe shall be placed in a loose uncompacted state. All other structural fill, including the clay seepage cutoffs, shall be compacted to a minimum of 95% of Standard Proctor Density at optimum moisture content.

The top of the bedding is that portion of the structural fill in contact with the bottom of the pipe and shall be constructed to the exact grade established by the Consultant. Where camber is specified, the top of the bedding shall be constructed on a gradual crest curve with no sudden breaks in the grade. Where preshaping is specified, the top of the bedding shall be constructed to the exact curvature of the bottom plates. The top of the preshaping shall be 200 mm to 300 mm below the horizontal seam which joins the sidewall to the bottom plates, or as shown on the drawings.

18.3.4 Assembly

Placing and assembly of the pipe may proceed only after the excavation, foundation and bottom bedding material and shape have been inspected and accepted by the Consultant.

Assembly of CSP

CSP sections shall be laid so that the ends are in close contact. Couplers shall be well fitted and evenly tightened all around the pipe. Where required, joints shall be sealed using sealing materials supplied by the Contractor and approved by the Consultant.

Assembly of SPCSP

SPCSP shall be assembled as shown on the drawings which will be provided by the pipe supplier and as outlined below:

- (a) The pipe shall be assembled on the invert bed as detailed on the drawings and reviewed by the Consultant.
- (b) All bolted seams shall be properly lapped and plates shall be in contact for the full width and length of the lap. The bolts in the valley of each longitudinal seam shall be nearer to the visible edge of the plate than the bolts in the crest.
- (c) Assembly and loose bolting of the side arc and top arc plates may then proceed to starting from the upstream end of the structure and progressing towards the downstream end.
- (d) After two complete rings have been loosely assembled, the vertical dimensions shall be checked and where necessary adjusted with horizontal cables and/or supports to obtain design rise dimensions.
- (e) Each adjacent ring shall then be assembled and adjusted in a similar manner until the entire structure is loosely assembled and conforms to design geometry with nested plates.
- (f) The vertical axis shall be upright and the longitudinal seams shall be straight. Rotation of the pipe and/or spiralling of the longitudinal seams shall not be permitted.
- (g) Adjustments shall be made to produce design dimensions with fully nested laps. When horizontal tie cables are used for shape adjustment, adequate means shall be taken to ensure distribution of concentrated forces at the pipe walls. Distortion of the pipe side walls at the cable points will not be tolerated.
- (h) Bolts shall be torqued to not less than 200 Nm and not more than 340 Nm. This includes bolts which connect special features to the pipe. Where the supplier's specification for torque differs from this range the Contractor shall contact the Consultant for direction.
- (i) Distortion of bolt holes caused by over-torquing, or poor assembly methods will not be permitted. Where additional holes are required they shall be drilled. Torch cutting of holes or welding on the pipe will not be permitted.
- (j) The shape of the pipe shall be maintained within 2% of design dimensions. This includes the rise, the span, and any chords or chord offsets identified by the Consultant. Where required, the Contractor shall supply and install devices and/or use methods to maintain the shape of the structure. These devices shall not cause local distortions of the pipe or other signs of distress. Horizontal strutting shall not be used unless the Contractor obtains written acceptance from the Consultant. Restraining devices shall be left in place until the structural fill reaches the top of the sidewall or as determined by the Consultant. When determined by the Consultant, the Contractor shall supply and install devices to monitor the shape of the pipe.

18.3.5 Backfilling

When the assembly of the structure has been accepted by the Consultant, backfilling with Granular and or Non-Granular materials as specified on the drawings may proceed. Backfilling shall be in accordance with the current version of standard drawing S-1418 and Section 2 "Backfill" of the Specifications for Bridge Construction. In addition, the following requirements shall be met.

When the air temperature is below 0°C, no backfilling is allowed unless otherwise accepted by the Department and Consultant. When acceptance is granted, all backfill materials shall be in a thawed state when placed and compacted. No backfill material will be permitted to be placed on frozen substrate.

The backfilling under the haunches shall be compacted in thin layers filling all corrugations and ensuring firm contact with the entire bottom surface of the pipe.

The backfilling shall fill each corrugation, be free of voids and provide uniform support to the pipe. The backfill shall be placed such that the level of fill on one side of the pipe does not exceed the level of fill on the other side of the pipe by more than 300 mm.

The backfill shall be placed and compacted by equipment moving parallel to the pipe with simultaneous handwork along the pipe. Large earth moving equipment and large compaction equipment shall not be permitted within 1.0 m of the pipe.

The first 300 mm of the backfill over the pipe shall be placed, levelled and compacted without vibration. Subsequent fill over the pipe shall be placed and compacted by equipment moving perpendicular to the longitudinal axis of the pipe. The Contractor shall obtain the Consultant's acceptance before using any equipment above the pipe.

The Contractor shall supply suitable material for the Compacted Non-Granular Backfill. Generally the material shall consist of clay or till materials. Highly plastic clay material or material with high silt content will not be permitted. The quality of the material, and the methods of placing and compacting, shall be accepted by the Consultant before commencement of this stage of construction.

18.3.6 Strutting for Composite Concrete/SPCSP Structure

For composite concrete/SPCSP structures strutting and scaffolding shall be supplied and installed as shown on the drawing.

18.4 Concrete Work

Where detailed and specified, the concrete work shall be constructed as shown on the drawings and in accordance with the Specifications for Bridge Construction:

Section 4 - Cast-In-Place Concrete

Section 5 - Reinforcing Steel

18.5 Fish Baffles

Fish baffles shall be constructed as shown on the drawings and be fabricated in accordance with the applicable Specifications for Bridge Construction sections.

18.6 Rock Riprap

Rock riprap shall be placed as shown on the drawings and shall conform to the Specifications for Bridge Construction: Section 10 "Heavy Rock Riprap".

18.7 Measurement and Payment

Unless otherwise specified on the drawings or in the "Special Provisions" payment for the following items:

- Detour Road - Construct and Maintain
- Salvage or Disposal of Existing Structure
- Excavation
- SPCSP - Supply
- CSP with couplers - Supply
- Granular Backfill - Des 6 Class 80
- Crushed Granular Backfill - Des 2 Class 40
- Non-Granular Backfill
- SPCSP Assembly
- CSP Assembly
- Concrete End Treatment
- Fish Baffles
- Miscellaneous Iron
- Guardrail
- Roadway Work

will be on the basis of the unit price or lump sum prices bid for each of these items of work, acceptably completed. The prices bid shall include full compensation for the cost of furnishing all labour, materials, equipment, tools and incidentals necessary to complete the work.

When specified, payment for the supply and assembly of SPCSP or CSP with couplers can be made on the basis of the unit price bid per metre in place. The price bid shall be full compensation of the cost of furnishing all labour, materials, equipment, tools and incidentals necessary to complete the work.

When materials are delivered to the worksite, payments for: **"SPCSP – Supply" and "CSP with Couplers – Supply"** will be made to a maximum of 90% of the cost of the materials based upon the applicable supplier's invoices. Payments will not be initiated until the Contractor submits the invoices to the Consultant upon receipt and acceptance of the material at the site. The remaining payment will be made after the structure is backfilled and accepted by the Consultant.

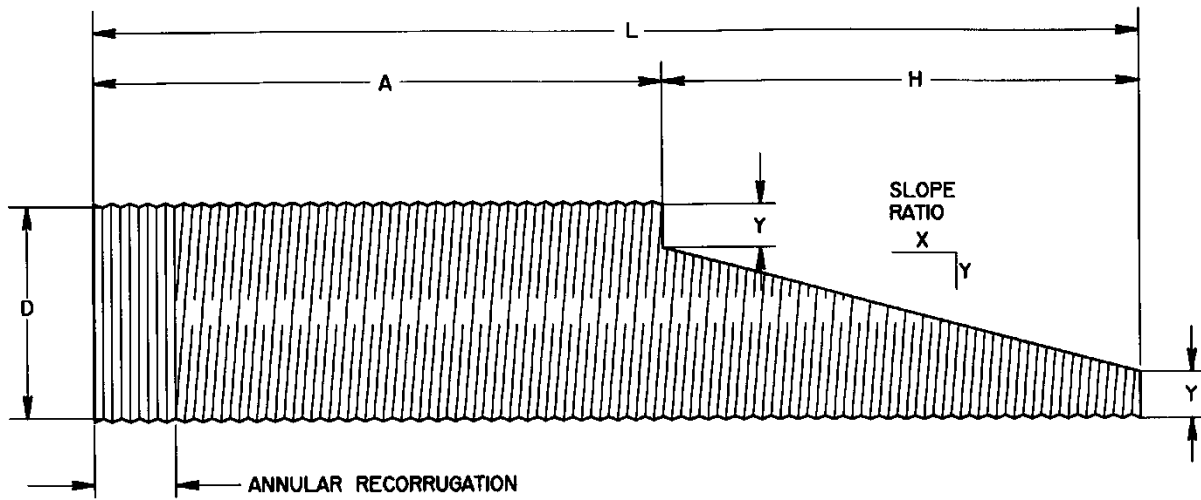
When woven geotextile filter fabric is specified, the supply, placing, equipment and tools necessary to acceptably complete this work will be considered incidental and no separate or additional payment for this incidental work will be made.

When woven geotextile filter fabric is not specified but deemed necessary as determined by the Consultant due to unsuitable foundation conditions, the supply, placing and the related work will be paid for by a negotiated lump sum price or in accordance with 1.2.25 "Extra Work" of the General Specification as determined by the Consultant.

Payment for Concrete, Reinforcing Steel and Rock Riprap will be made on the basis of the unit price bids or lump sum bid for these items of work. These prices shall include full compensation for the cost of supplying all labour, materials, equipment, tools and incidentals necessary to complete the work.

The quantity to be paid for will be the actual number of units of materials and work satisfactorily completed and remaining in the structure.

TABLE A
 DETAILS OF STANDARD 2:1 SLOPED END SECTIONS
 FOR CSP ROUND CULVERTS



INSIDE DIAMETER "D" mm	SLOPE RATIO X:Y	"Y" mm	"A" m	"H" m	INVERT LENGTH OF SLOPED END SECTION "L" m
1200	2:1	150	4.2	1.800	6.0
1400	2:1	200	4.0	2.000	6.0
1600	2:1	200	3.6	2.400	6.0
1800	2:1	300	3.6	2.400	6.0
2000	2:1	300	5.2	2.800	8.0
2200	2:1	300	4.8	3.200	8.0
2400	2:1	400	4.8	3.200	8.0
2700	2:1	400	6.2	3.800	10.0
3000	2:1	500	6.0	4.000	10.0
3300	2:1	500	5.4	4.600	10.0
3600	2:1	600	5.2	4.800	10.0

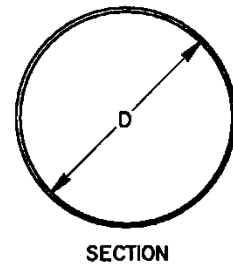
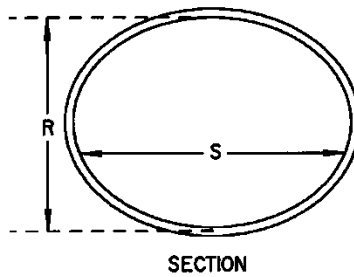
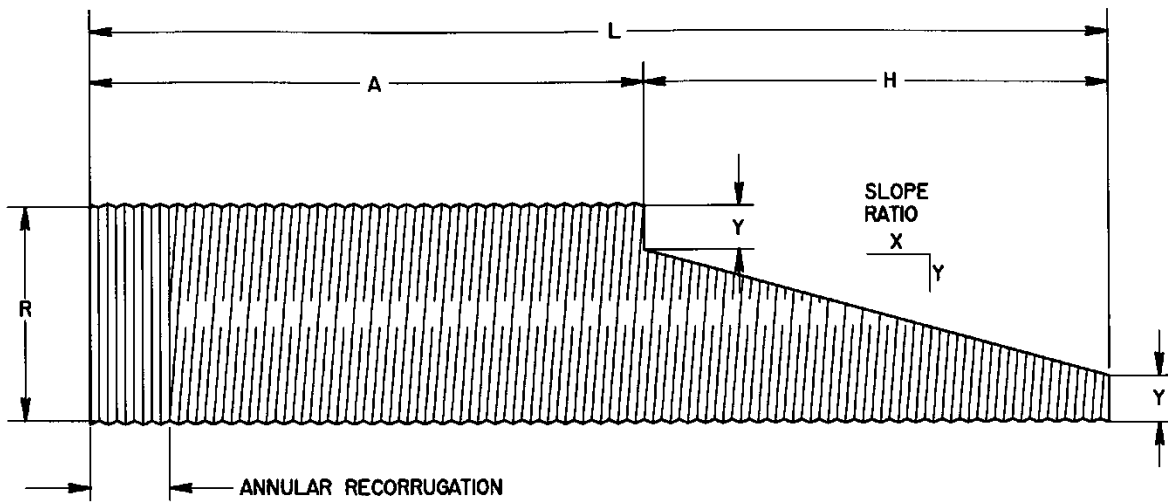
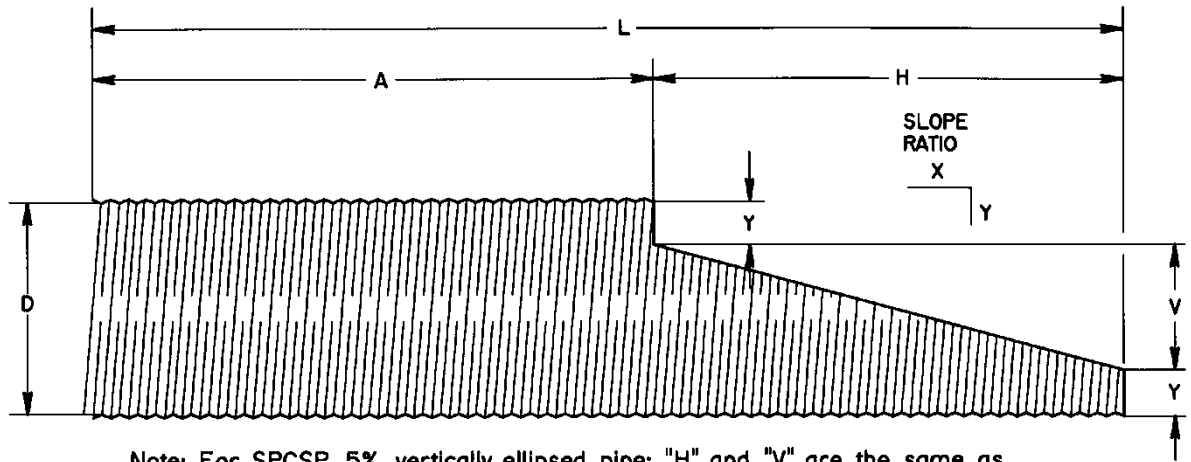


TABLE B
 DETAILS OF STANDARD 2:1 SLOPED END SECTIONS
 FOR CSP ARCH CULVERTS



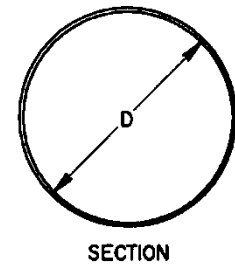
EQUIVALENT INSIDE DIAMETER "D" mm	SPAN "S" mm	RISE "R" mm	SLOPE RATIO x:y	"Y" mm	"A" m	"H" m	INVERT LENGTH OF SLOPED END SECTION "L" m
1200	1390	970	2:1	150	4.660	1.340	6.0
1400	1630	1120	2:1	200	4.560	1.440	6.0
1600	1880	1260	2:1	250	4.480	1.520	6.0
1800	2130	1400	2:1	300	4.400	1.600	6.0

TABLE C
DETAILS OF STANDARD 2:1 SLOPED END SECTIONS
FOR SPCSP ROUND CULVERTS



Note: For SPCSP 5% vertically ellipsed pipe: "H" and "V" are the same as for a round pipe of equivalent diameter; "Y" is variable with the increase in rise.

INSIDE DIAMETER "D" mm	SLOPE RATIO X:Y	"Y" mm	"H" m
1500	2:1	293	1.828
1660	2:1	373	1.828
1810	2:1	295	2.440
1970	2:1	375	2.440
2120	2:1	298	3.048
2280	2:1	378	3.048
2430	2:1	453	3.048
2590	2:1	533	3.048
2740	2:1	455	3.658
3050	2:1	610	3.658
3360	2:1	765	3.658
3670	2:1	920	3.658
3990	2:1	1080	3.658
4300	2:1	1235	3.658
4610	2:1	1390	3.658
4920	2:1	936	6.096
5230	2:1	1091	6.096
5540	2:1	1246	6.096
5850	2:1	1095	7.320
6160	2:1	1250	7.320
6470	2:1	1405	7.320
6780	2:1	1560	7.320
7090	2:1	1715	7.320
7400	2:1	1870	7.320
7710	2:1	2025	7.320
8020	2:1	2180	7.320



SECTION

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 19

PAINTED ROADWAY MARKINGS

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19.1 General

This Specification is for the supply of all painting materials and the painting of roadway markings on bridge decks and approach roadways.

19.2 Materials

Paint and Glass Beads

The Contractor shall supply paint and glass bead materials that are on the Department's Approved Products List. The Contractor shall submit written confirmation from the manufacturer that the materials supplied shall meet all specified requirements.

The Contractor shall provide the Consultant with the following information prior to commencing the Work:

- Names and mailing addresses of the suppliers and manufacturers
- Paint formulation

The Contractor shall advise the Consultant of any change in paint formulation. No paint formulation shall be diluted or mixed with a different formulation or with any other material without the specific acceptance of the Department.

The Contractor shall take all necessary steps to prevent contamination of the materials. Paint shall be protected from freezing.

19.3 Protection of Bridge Structure

The Contractor shall take due precautions against damaging or disfiguring any portion of the structure. He shall guard against spatters, overspray, splashes or smirches of paint or associated paint materials, and damages caused by fuel or lubricants used with his equipment.

19.4 Application

The Contractor shall paint lane lines, continuity lines, edge lines and directional arrows or dividing lines on the roadway and bridge deck to restore the painted markings as existed prior to the construction work, or as shown on the drawings, or as specified. Centrelines and shoulder lines shall be 100 mm wide. Broken centrelines shall be 3 m in length followed by a 6 m space. The Contractor shall ensure that painted lines match the existing lines exactly, unless otherwise determined by the Consultant.

The substrate surface shall be clean, dry and at least 10°C in temperature during the paint application. All painted messages and lines shall be applied at the rate of 0.4 l/m² of actual painted area. Glass beads shall be applied immediately following the paint application at a uniform application rate of 600 g/l of paint. Messages and lines initially applied at less than the specified rate, as determined by the Consultant shall be repainted at the expense of the Contractor.

All painted markings shall be uniform in thickness with no spatter, excessive overspray, or other

defects.

Construction and public traffic shall not be permitted to travel on the painted markings until after the paint has sufficiently cured.

19.5 Payment

Unless otherwise specified, Painted Roadway Markings including the cost of furnishing all labour, materials, equipment and tools necessary to acceptably complete the work, will be considered incidental and no separate or additional payment for this incidental work will be made.

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 20

DECK OVERLAY AND CONCRETE REHABILITATION

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20.1 General

Deck overlay and concrete rehabilitation work may consist of, but not be limited to, surface removal, concrete repair, surface preparation, and/or deck overlay.

20.2 Traffic Accommodation

Unless otherwise approved by the Consultant, all rehabilitation projects which include either a concrete or ACP overlay shall be carried out in stages and shall have a minimum of one undisturbed travel lane available for the accommodation of public traffic at all times during construction.

Traffic accommodation shall be in accordance with the requirements of Specification 7.1, "Traffic Accommodation and Temporary Signing", of the Standard Specifications for Highway Construction and as described in the Special Provisions.

20.3 Surface Preparation for Concrete Overlay

20.3.1 General

Surface preparation includes all work necessary to prepare the bridge for deck overlay concrete placement. This work includes, but is not limited to, the following:

- Surface removal
- Removal and disposal of existing concrete paving lips
- Partial depth repair
- Full depth repair
- Sandblasting of concrete surfaces to be overlaid
- Removal and reinstallation of bridgerail, as required, to accommodate screed rails

Jack hammers heavier than nominal 14 kg class and chipping hammers heavier than nominal 7 kg class shall not be used for concrete removal.

20.3.2 Surface Removal

Surface removal shall be carried out in stages. The Contractor shall complete surface removal operations to the depth(s) shown on the Drawings or as described in the Special Provisions. The Contractor shall submit details of his proposed surface removal methods to the Consultant for review and acceptance a minimum of 1 week prior to the scheduled commencement of this work.

Surface removal shall be carried out as close as possible to all curbs, medians, barriers, drains, deck joints, and other bridge components without causing damage. Chipping equipment shall be used in these areas to complete removal operations. Concrete curb and deck joint paving lips within the limits of the surface removal area shall be removed, including the reinforcing steel projecting into these components. For bridges that do not have formal deck joints at the abutments, the Contractor shall saw cut through the full depth and width of the wearing surface

at both ends of the bridge or at the transition paving limits prior to commencing removal operations.

When the specified removal depth includes more than 5 mm of concrete removal and cold-milling methods are proposed by the Contractor, small milling machines having a maximum removal width of 1.2 m shall be used. Adjustments to the removal depth shall be carried out on an ongoing, as required basis to ensure an accurate depth of material removal is maintained throughout milling operations. If the Contractor removes material in excess of 5 mm from that specified without prior approval from the Consultant, the costs associated with the additional material replacement quantities shall be at the Contractor's expense.

The Contractor shall remove milling debris from behind the cold-milling machine and clean the milled surface on a continuous basis, as close to the milling machine as is safely practicable. Debris removal and surface cleaning details shall be included in the Contractor's proposed surface removal method submission. The Contractor shall dispose of all debris resulting from surface removal operations at an approved location.

Reinforcing steel or other bridge components damaged as a result of the Contractor's surface removal operations shall be repaired or replaced by the Contractor at his expense.

Upon completion of surface removal operations, including thorough cleaning and drying of the deck surface and removal of all equipment, the Consultant will inspect the deck surface and identify areas of unsound concrete to be repaired. Repairs shall be carried out in accordance with Subsection 20.4, Concrete Repair.

20.3.3 Deck Surface Sandblasting

Prior to deck overlay concrete placement, the Contractor shall sandblast the entire deck surface and the vertical faces of the curb, median and parapet up to a height equal to the overlay thickness. Adequate shielding shall be provided to protect any repaired epoxy coated reinforcing steel or galvanic anodes. Sandblasting shall be carried out to the extent necessary to uniformly expose fine aggregate.

Following sandblasting, the Contractor shall clean the deck surface so that it is free of all sand, dust and other contaminants to the satisfaction of the Consultant. Debris from the cleaning operations shall be disposed of at an approved location.

Once accepted by the Consultant, the Contractor shall be responsible for maintaining the cleaned deck in satisfactory condition until placement of deck overlay concrete. Additional preparation or cleaning, including sandblasting, that may become necessary during this period shall be carried out by the Contractor at his expense.

20.4 Concrete Repair

20.4.1 General

At repair areas other than the deck substrate, the limits of concrete removal will be determined

by the Consultant. The perimeters of repair areas shall be sawcut with neat, perpendicular, 25 mm deep cuts.

The Contractor shall remove the areas of unsound concrete by chipping, scabbling or other means approved by the Consultant. Removal operations at each location shall result in a sound surface suitable for bonding to the deck overlay concrete or repair material.

The Contractor shall contain all debris resulting from concrete removal operations and dispose of the material at an approved location. Methods of containment shall not result in damage to the existing bridge or surrounding areas, and are subject to acceptance by the Consultant.

20.4.2 Partial Depth Repair

Partially exposed reinforcing steel shall be entirely exposed by removal of the concrete to a depth of 25 mm below the bars.

Exposed reinforcing steel and bonding surfaces shall be sandblasted and the areas blown clean with oil-free compressed air. Reinforcing steel shall be sandblasted to a white metal finish.

For repair areas where epoxy coated reinforcing steel is exposed, the epoxy coating shall be completely removed by sandblasting. The exposed reinforcing bar shall then be protected by the installation of discrete galvanic anodes installed at a minimum of 1 anode per 300 mm of perimeter of the patch area, or the epoxy coating repaired in accordance with the requirements of Section 5, Reinforcing Steel. Galvanic anodes shall be a product selected from those listed on the Alberta Transportation Product List for Galvanic Corrosion Protection. Anodes shall be embedded in a low resistivity mortar and shall have the concrete cover specified on the Drawings, or as determined by the Consultant.

Additional reinforcing steel shall be installed at all locations where the existing reinforcing steel has suffered sectional loss greater than 20%, or as determined by the Consultant. Additional reinforcing steel shall be of the same type used in the original construction or a corrosion resistant reinforcing steel type acceptable to the Consultant. Splicing and/or development requirements will be determined by the Consultant.

Once a prepared area has been accepted by the Consultant and prior to placement of repair material, bonding surfaces shall be saturated with clean water for a minimum of 30 minutes. The area shall be blown free of any surface water immediately prior to placement of the repair material. Repairs shall be trowelled smooth, leveled flush to adjacent surfaces, and given the appropriate concrete finish if applicable.

Unless otherwise shown on the Drawings or directed by the Consultant, the Contractor shall re-establish the original design concrete cover at each repair location.

All partial depth repair areas located on the deck surface shall be poured monolithically with placement of deck overlay concrete. Other partial depth repair areas shall be formed and recast with an appropriate Alberta Transportation approved concrete patching product, extended with

aggregates that meet the requirements of CAN/CSA 23.1 or ASTM C33.

Where the volume of approved concrete patching product required for an individual partial depth repair area exceeds the volume produced by three 25 kg bags, a rubber paddled mortar mixer of adequate size shall be used for mixing the product. The use of free fall mixers will not be permitted.

Where the repair area is large enough such that placement of an approved concrete patching product becomes impractical, concrete shall be used. Class C concrete shall be used for substructure elements and Class HPC for all other elements. Repair procedures shall be in accordance with Subsection 20.4.3, Full Depth Repair, and the product Manufacturer's recommendations. In the case of conflict, the more stringent requirements shall apply.

20.4.3 Full Depth Repair

Where concrete deterioration extends completely through the deck, curbs, or other elements as determined by the Consultant, all unsound concrete shall be removed and replaced with new concrete.

Exposed reinforcing steel and bonding surfaces shall be sandblasted and the areas blown clean with oil-free compressed air. Reinforcing steel shall be sandblasted to a white metal finish.

For repair areas where epoxy coated reinforcing steel is exposed, the epoxy coating shall be completely removed by sandblasting. The exposed reinforcing bar shall then be protected by the installation of discrete galvanic anodes installed at a minimum of 1 anode per 300 mm of perimeter of the repair area, or the epoxy coating repaired in accordance with the requirements of Section 5, Reinforcing Steel. Galvanic anodes shall be a product selected from those listed on the Alberta Transportation Product List for Galvanic Corrosion Protection. Anodes shall be embedded in a low resistivity mortar and shall have the concrete cover specified on the Drawings, or as determined by the Consultant.

Additional reinforcing steel shall be installed at all locations where the existing reinforcing steel has suffered sectional loss greater than 20%, or as determined by the Consultant. Additional reinforcing steel shall be of the same type used in the original construction or a corrosion resistant reinforcing steel type acceptable to the Consultant. Splicing and/or development requirements will be determined by the Consultant.

The underside of the deck, curbs, and other areas requiring full depth repair shall be formed to neatly restore the original lines of the concrete. Forms shall not be hung or suspended from existing deck reinforcing steel.

Once a prepared area has been accepted by the Consultant and prior to concrete placement, bonding surfaces shall be saturated with clean water for a minimum of 30 minutes. The area shall be blown free of any surface water immediately prior to concrete placement. Repairs shall be adequately vibrated, trowelled smooth, leveled flush to adjacent surfaces, and given the applicable concrete finish. Concrete shall be cured in accordance with Subsection 4.23 of

Section 4, Cast-In-Place Concrete.

Full depth repairs located on the deck surface shall be recast monolithically with placement of deck overlay concrete. When conditions do not permit a monolithic pour with the deck overlay concrete, full depth repair concrete shall be placed to a depth such that, once the subsequent overlay concrete has been placed, the specified design overlay thickness is achieved.

Full depth repair concrete not poured monolithically with the overlay concrete shall be wet cured for a minimum of 7 days or until it has attained sufficient strength so it is not adversely affected by subsequent placement of the deck overlay as determined by the Consultant.

Class C concrete shall be used to repair substructure elements and Class HPC for all other elements.

Compressive strength tests shall be completed on each batch of concrete placed in accordance with Subsection 4.9.1 of Section 4, Cast-In-Place Concrete. Concrete shall have 28 day minimum compressive strengths meeting the requirements of Subsection 4.27 of Section 4, Cast-In-Place Concrete, for the applicable Class. The Department reserves the right to reject any concrete that fails to meet the full strength requirements of the Specifications.

In the event that the strength of any respective concrete batch fails to meet full strength requirements, the Consultant may, in consultation with the Department, accept that batch at reduced payment rates according to the following schedule:

28 Day Minimum Compressive Strength	Amount of Payment
Specified strength and over	Full bid price
up to 2 MPa less than the specified strength	Bid price less \$25.00 per square metre
between 2 MPa and 4 MPa less than the specified strength	Bid price less \$50.00 per square metre
between 4 MPa and 5 MPa less than the specified strength	Bid price less \$100.00 per square metre

All concrete showing a 28 day minimum compressive strength 5 MPa or greater below that specified will be rejected.

20.5 Deck Overlay

20.5.1 General

Deck overlay concrete shall be placed as shown on the Drawings; in accordance with the requirements of this specification and Section 4, Cast-in-place Concrete; and as directed by the Consultant.

20.5.2 Concrete

Deck overlay concrete shall be Class HPC or Class HPC with steel fibres, as specified.

20.5.3 Gradeline Profiles/Dry Run

The gradeline will be designed by the Consultant to provide a smooth riding surface for the finished overlay and transition ACP. The Contractor shall assist the Consultant with profiling of the bridge and approaches prior to and after surface removal. When developing the gradeline profiles, the Consultant will consider such items as rideability, concrete/ACP thickness/quantity, dead load deflection and deck drainage. The design gradeline will be used to determine the overlay thickness and the height of the screed above the existing concrete at each control point.

Gradeline profiles will be produced by the Consultant using the following guidelines:

- Two parallel profile lines the entire length of the bridge for each construction stage will be provided as follows:
 - Line No. 1 will be located 1.0 m from curb face.
 - Line No. 2 will be located 0.3 m in from the opposite edge of proposed pour.

The Stations of Line No. 1 and Line No. 2 will be square to each other.

Additional profile lines will be produced when determined by the Consultant.

- Stations will be established at 3.0 m intervals; and at the edges of existing deck joints to be retained and/or at new deck joint locations.
- Profiles will include 30 m of approach at each end of the bridge at 3.0 m intervals.
- Profile plots will be to the following scales:
 - Horizontal: 10 mm = 1 000 mm
 - Vertical: 1 mm (normal) or 1 mm = 5 mm (minimum)
- The proposed design gradeline will be a smooth line achieving a nominal overlay thickness as shown on the Drawings.

Fluorescent paint shall be used to mark profile locations on the existing deck surface, curbs and approaches. The markings shall be approximately 40 mm in diameter. The Contractor shall remove all exposed markings remaining after the deck overlay work is complete.

The Consultant will provide the summary of the proposed overlay thickness, to the nearest mm, at each control point prior to the Contractor setting the screed guide rails. The Contractor is

responsible for properly setting the screed rails to match the gradeline provided by the Consultant.

Emphasis shall be placed on providing positive longitudinal and transverse drainage from the bridge deck. Depressions in the concrete surface resulting from deficient finishing procedures which may result in ponding water shall be repaired by the Contractor at his expense.

Screed guide rails shall be placed outside the area of concrete placement. The guide rails shall be horizontally and vertically stable. Hold down devices shot into the concrete will not be permitted. The finishing machine and guide rails shall be adjusted so that the height of the screed above the existing concrete at each point conforms to the profile requirements. Guide rails sufficient for the entire contemplated pour shall be set out, adjusted for height, and accepted by the Consultant prior to concrete placement.

To confirm proper adjustment of the machine and guide rails, the screed shall be "dry-run" prior to the pour; and clearance measurements taken at each control point and provided to the Consultant for review and acceptance. Re-setting of the machine and/or guide rails shall be done as necessary, to provide an acceptable dry-run. Adjustments to the machine or the rails will not be permitted after an acceptable dry-run has been made.

Proposed longitudinal overlay construction joint locations shall be approved by the Consultant prior to commencement of overlay construction. Typically, joints shall be located as close to the crown as possible. Where the crown is located at or near a connection joint between two adjacent girders, the longitudinal overlay construction joint shall be offset by a minimum of 300 mm. Longitudinal bulkheads shall be provided at overlay construction joint locations.

20.5.4 Cement/Silica Fume Slurry Grout

After all deck preparation has been completed and accepted by the Consultant, surfaces to be overlaid shall be continuously saturated with clean water for a minimum of 3 hours prior to concrete placement. Immediately prior to the commencement of concrete placement operations, surfaces shall be blown free of all excess water, and a cement/silica fume slurry grout applied to enhance the bond between the prepared surfaces and the overlay concrete.

Slurry grout shall consist of 4% silica fume, 46% Type GU hydraulic cement and 50% sand (maximum 2.5 mm aggregate size) by weight, mixed with sufficient water to form a slurry. Slurry grout shall be mixed in a rubber paddled mortar mixer. The consistency of the mixed slurry grout shall be such that it can be applied with a stiff brush or broom to the existing concrete surface without running, or puddling in low spots.

The slurry grout shall be applied in a thin, even coat with no puddling. The rate of application shall be controlled to keep pace with the rate of concrete placement, and be limited such that slurry grout is applied immediately ahead of concrete placement. In no case shall the slurry grout be permitted to dry before concrete placement.

Slurry grout shall be continuously mixed to prevent segregation, and applied within 45 minutes

of initial mixing. Slurry grout in excess of 45 minutes old will be rejected. The Contractor shall have a minimum of two grout mixers on site during overlay placement.

20.5.5 Conveyance of Concrete on Deck

Generally, vehicles and equipment will not be permitted directly on the prepared bridge deck surface. However, unless otherwise determined by the Consultant and provided the deck surface is continually protected, concrete mixer trucks will be permitted onto the deck to discharge directly ahead of the finishing machine. Deck protection shall consist of plywood, heavy tarps or other protective devices accepted for use by the Consultant.

Deck protection shall be sufficient to protect the saturated surface from becoming contaminated with water, oil, spilled concrete and/or other substances. The protection shall remain in place for as long as practicable prior to air blasting and slurry grouting.

All costs associated with the provision of deck protection necessary for mixer truck access will be considered incidental to the Work, and no separate or additional payment will be made.

20.5.6 Mixing Overlay Concrete

Deck overlay concrete shall be mixed at an acceptable concrete batch plant or at the bridge site in mixer trucks. Site batching shall be in accordance with the following requirements:

Pre-bagging for Site Batching

Fine and coarse aggregates; cement; steel fibres, if applicable; and silica fume shall be measured and pre-mixed together in the approved proportions before being packaged into suitable bags. Each bag delivered to the site shall be in good condition, free of holes or tears, and with all seams fully sealed. The bags shall be constructed of moisture proof material, and shall be securely closed after filling. The bags shall have adequate lifting hooks or straps attached to the tops, and shall be designed to suitably discharge the material from the bottom of the bag through a discharge opening with a minimum diameter of 460 mm. Each bag shall have a minimum nominal 1 100 kg capacity. Partially filled bags will not be accepted for use on the site.

Materials shall be proportioned by weight. The accuracy of all weighing devices shall be such that successive quantities can be measured to within one percent of the desired amount. As a minimum quantity, 1 100 kg of dry materials, in the correct proportions, shall be mixed together until the materials are fully dispersed before being placed in a bag.

The Department and Consultant shall be given full access to inspect all aspects of the mixing operation; including supply of materials, drying of aggregates, proportioning the constituents, mixing, bagging and storage. The Contractor shall take all precautions necessary to protect the bagged pre-mix from exposure to the elements during hauling and storage at the site.

Mixer Trucks and Water Supply for Site Batching

Deck overlay concrete shall be mixed at the bridge site in mixer trucks.

The Contractor shall employ adequate equipment in order to mix concrete at a rate sufficient to ensure continuous concrete placement. A minimum of three mixer trucks shall be brought to the site prior to each overlay pour, and utilized in mixing operations. Mixer trucks shall be revolving drum type, watertight, and constructed so that concrete can be mixed to ensure uniform distribution of materials. Materials for the concrete shall be loaded into the drum at the bridge site.

The Contractor shall provide a suitable water source or tank for the dedicated purpose of batching concrete. The water supply shall have sufficient capacity for each pour. The water supply shall be equipped with an accurate water measuring device calibrated in 0.1 L increments.

Mixing of Deck Overlay Concrete for Site Batching

Initially, approximately two thirds of the required mixing water shall be released into the drum, after which the air entraining agent, superplasticizer and other admixtures shall be added. The remaining required water shall continue to flow into the drum as the solid materials are being loaded into the mixer. The mixing time shall be as specified in the concrete mix design.

The water supply pipe shall be adequate to ensure that all remaining water addition into the mixer is completed within the first quarter of the mixing time and the outlet situated at a location within the mixer where the water will quickly mix with the entire batch.

The Contractor shall take all steps necessary to ensure that the full content of each pre-mix bag enters the mixer in an even and uniformly proportioned manner. Segregation, spillage and/or other loss of material will not be tolerated. Particular care shall be taken to avoid the loss of cement and silica fume. Batch constituent materials shall be accurately proportioned. Increases in water-cement ratio will not be permitted.

The Contractor shall maintain the mixers in good condition at all times while the work is being carried out. Inner surfaces of the mixer shall be kept free of hardened concrete and mortar. Mixer blades which are bent or worn to the point that mixing efficiency is affected shall be replaced or refurbished. Mixers leaking mortar or causing waste of materials through faulty charging shall be removed from service until the equipment has been repaired to the satisfaction of the Consultant.

The Contractor shall not load mixers with more than 3 m³ of concrete or in excess of 85% of its rated capacity, whichever is less. The Contractor shall provide the Manufacturer's certification of the mixing capacity for each machine upon request. Mixers shall only be operated at the speeds recommended by the Manufacturer.

The Contractor shall record the bag production dates/numbers and test the air content, slump,

and temperature of each batch at the mixing site. Results of all tests shall be provided to the Consultant. In the case of an unacceptable result, the Contractor will only be allowed to adjust the quantities of superplasticizer and air entraining agent. Adding additional water to the batch will not be permitted. All batch adjustments shall be completed at the batching site and will not be permitted on the deck or at the discharge area. The Department reserves the right to reject any batch in the event of confirmed unacceptability, and to require immediate removal of any concrete from a rejected batch that may have already been placed.

Concrete shall be discharged within 70 minutes after initial introduction of water to the pre-mixed material.

Discharge chutes shall be kept clean, free from hardened concrete, and wetted down prior to use. After each batch is discharged, the drum shall be thoroughly cleaned and excess water removed before a subsequent batch is mixed.

20.5.7 Concrete Placement

20.5.7.1 General

Concrete placement shall be carried out in accordance with Section 4, Cast-In-Place Concrete, and the following requirements.

The Contractor shall carry out his concrete placement operations in such a manner that a smooth riding surface within the tolerances specified in Section 4, Cast-In-Place Concrete, are achieved.

Adequate lighting shall be provided in front and behind the finishing machine. Additional tower lights satisfactory to the Consultant shall be placed at each end of the bridge and at the sampling and testing area.

Concrete shall be placed in such a manner that segregation of materials does not occur. The concrete finishing machine shall meet the requirements of Subsection 4.16.1 of Section 4, Cast-In-Place Concrete. Concrete placement shall be carried out in a continuous operation for the duration of the pour. No more than 5 minutes shall be allowed to elapse between individual truck mixer discharges. The width of the initial overlay section placed shall extend to the approved construction joint location. Subsequent overlay pours shall not be placed until the initial pour has cured a minimum of 72 hours or as determined by the Consultant.

In the event of equipment breakdown and concrete placement for a respective section of bridge is suspended for a period of 60 minutes or more, further concrete placement for the affected section shall be discontinued and shall not resume for a minimum of 12 hours. Notwithstanding this restriction, concrete placement may continue on a subsequent section of the bridge provided a gap sufficient in length for the finishing machine to clear the previously placed concrete is left between the two sections. Prior to continuing concrete placement at a discontinued overlay section, the Contractor shall sawcut a clean, straight vertical edge satisfactory to the Consultant. Material beyond the saw cut shall be removed and disposed of at

an approved location. Concrete shall be placed in a gap section between 12 hour and 36 hours after suspension of the pour at the affected section.

20.5.7.2 Surface Texture

Deck overlay concrete shall receive a Class 6 finish when the overlay concrete is the final wearing surface or a Class 4 finish where a waterproofing membrane will be applied. Following surface texturing, a 400 mm wide strip of overlay adjacent to the curb shall be trowelled smooth and the surface left closed.

At locations where, in the opinion of the Consultant, a satisfactory finish has not been achieved, the Contractor shall saw cut transverse grooves at his expense. Grooves shall be cut to the dimensions described in the Subsection 4.25.7 of Section 4, Cast-In-Place Concrete.

20.5.7.3 End of Overlay

Generally, concrete overlays will terminate at a deck joint. At locations where an overlay does not terminate at a deck joint, such as on roof slabs, the overlay shall be extended for a distance of 150 mm beyond the required end of the overlay to a bulkhead. After adequate curing time, the 150 mm over pour shall be saw cut, and the material removed and disposed of at an approved location.

All costs associated with installation of the bulkhead; saw cutting; and removal and disposal of over pour areas will be considered incidental to the Work, and no separate or additional payment will be made.

20.5.7.4 Longitudinal and Transverse Overlay Construction Joints

The Contractor shall construct an acceptable bulkhead at each construction joint location to maintain horizontal and vertical alignments during concrete placing and finishing. The resulting vertical faces of concrete shall be sandblasted as described in Subsection 20.3.3.

For longitudinal and transverse construction joints, the top edge of the overlay concrete at the faces of curbs, barriers, medians, previously placed overlay concrete, and/or existing concrete shall be tooled to a depth of 12 mm and a width of 6 mm. Tooled grooves shall be filled with a proven epoxy resin type gravity flow concrete crack filler listed on the Alberta Transportation Product List.

Prior to epoxy application, the grooves shall be blown clean to remove all deleterious materials and the concrete contact surfaces prepared in accordance with the epoxy Manufacturer's recommendations. Tooled grooves shall be completely filled with epoxy material to a level equal to the adjacent concrete; multiple applications of epoxy may be required.

All costs associated with constructing longitudinal and transverse overlay construction joints including sandblasting, groove tooling, and application of gravity flow epoxy crack filler will be considered incidental to the Work, and no separate or additional payment will be made.

20.5.7.5 Curing Concrete

Curing of overlay concrete shall be in accordance with Subsection 4.23.3 of Section 4, Cast-In-Place Concrete.

If, in the opinion of the Consultant, the Contractor's wet curing procedures are deemed deficient in any way and/or any portion of the overlay becomes surface dry during the curing period, the overlay may be rejected.

20.5.7.6 Application of Sealer

The Contractor shall supply and apply a Type 1c sealer to all areas where a Class 6 surface finish has been applied and along trowelled gutter areas. Sealer shall be applied once the concrete has cured for a minimum of 14 days.

Sealer shall be applied in accordance with Subsection 4.26 of Section 4, Cast-In-Place Concrete. In the event the deck overlay concrete surface becomes contaminated with dirt, debris or other deleterious material prior to sealer application, the Contractor shall clean the affected areas to the satisfaction of the Consultant.

All costs associated with the supply and application of sealer to deck overlay areas, including cleaning as required, will be considered incidental to the Work, and no separate or additional payment will be made.

20.5.7.7 Opening to Traffic

The concrete overlay shall not be opened to traffic until the concrete has been cured in accordance with Subsection 20.5.7.5 and has reached a minimum strength of 35 MPa.

20.6 Measurement and Payment

20.6.1 Surface Removal

Measurement of surface removal will be by the square metre of surface acceptably removed, measured to the nearest 0.1 m².

Payment will be made at the unit price bid for "Surface Removal", and will be full compensation for removal of the existing wearing surface and concrete to the depths specified; deck surface cleaning; disposal of debris; and all labour, equipment, tools and incidentals necessary to complete the Work to the satisfaction of the Consultant.

20.6.2 Partial and Full Depth Repairs

Measurement of partial and full depth repair areas will be by the square metre of concrete acceptably repaired, regardless of depth, measured to the nearest 0.1 m².

Payment will be made at the unit prices bid for "Partial Depth Repair" or "Full Depth Repair", as applicable, for the locations identified. Payments will be full compensation for the containment

and removal of unsound concrete; sandblasting; disposal of debris; the supply and installation of additional reinforcing steel where required; epoxy coated reinforcing steel coating repair and/or the supply and installation of galvanic anodes as required; provision and removal of all forming, scaffolding and falsework; repair material placement; and all labour, materials, equipment, tools and incidentals to complete the Work to the satisfaction of the Consultant.

Where concrete is used for repairs, it will be subject to strength requirement testing and penalty assessment described in Subsection 20.4.3, Full Depth Repair.

20.6.3 Deck Sandblasting

Measurement of deck surface sandblasting will be by the square metre of horizontal bridge deck surface acceptably treated, measured to the nearest 0.1 m². No allowance will be made for required sandblasting of the vertical faces of curbs, medians and barriers.

Payment will be made at the unit price bid for "Sandblasting - Bridge Deck", and will be full compensation for sandblasting; cleaning of the sandblasted area, including disposal of debris; and all labour, materials, equipment, tools and incidentals necessary to complete the Work to the satisfaction of the Consultant.

20.6.4 Deck Overlay Concrete

Measurement for the supply of deck overlay concrete will be by the cubic metre of acceptable overlay concrete remaining in the completed work, calculated to the nearest 0.1 m³. The cubic metre quantity will be calculated by the Consultant from the final "dry-run" values and the area overlaid. Concrete overpour will not be included in the quantity calculation.

Payment will be made at the unit price bid for "Deck Overlay Concrete - Supply", and will be full compensation for supplying the concrete to the bridge site from batch plants or by site batching; including all labour, materials, equipment, tools and incidentals necessary to complete the Work to the satisfaction of the Consultant.

Measurement for placement of deck overlay concrete will be by the square metre of concrete acceptably placed and remaining in the structure, measured to the nearest 0.1 m².

Payment will be made at the unit price bid for "Deck Overlay Concrete - Place", and will be full compensation for the supply and application of water for surface saturation; the supply and application of slurry grout; concrete placement, finishing and curing; and all labour, equipment, tools and incidentals to complete the Work to the satisfaction of the Consultant.

Concrete overlay failing to meet the 28 day minimum compressive strength requirement of 45 MPa is subject to payment adjustment as described in Subsection 4.26 of Section 4, Cast-In-Place Concrete.

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 21

REMOVAL AND SALVAGE OF BRIDGE STRUCTURES

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21.1 General

This specification covers materials and related works for the removal of bridge structures and bridge culverts. This includes salvage and disposal of materials from these bridge structures.

Work shall be completed in accordance with this specification or as determined by the Department and Consultant.

All materials in bridge structures are the property of the Department. Prior to removal of bridge structures the Contractor shall obtain, from the Consultant, a list of materials to be salvaged and permission to proceed. Treated timber, structural steel, corrugated steel pipes and precast concrete units may be considered for salvage and when required will be specified in the Special Provision of the contract.

21.2 Workmanship and Handling of Materials

The Contractor shall perform his work in a manner that prevents damage to or loss of materials listed for salvage. Where the Contractor causes damage to or loss of materials listed for salvage, the Contractor shall repair or replace these materials at his expense and to the acceptance of the Consultant.

21.3 Excavation for Removal

Excavation shall conform to Section 1 - Excavation.

For culverts, the excavation shall extend to the invert elevation and the width at this level shall be the culvert width plus 3.0 m. For bridge abutments, the excavation shall extend to the ground level at the front of the abutment. The sides of all excavations shall be excavated at one horizontal to one vertical or as required for stability.

21.4 Removal

21.4.1 General

Removal shall mean removing bridge structures, salvaging the materials listed by the Consultant, stockpiling the salvaged materials at the bridge site or the Contractor's storage area, disposing of the remainder of the bridge structure and leaving all work areas in a tidy and safe condition.

The Contractor shall provide the Consultant with a list of all materials that were salvaged.

21.4.2 Salvage

Materials listed by the Consultant for salvage shall be dismantled piece by piece removing all nails, bolts, drift pins and other hardware. Torch cutting to remove hardware or to dismantle these materials will not be permitted.

Structural Plate Corrugated Steel Pipes shall be dismantled to yield lengths not exceeding eight metres. Corrugated Steel Pipes shall be dismantled by removing the couplers to achieve the original fabricated lengths.

Precast concrete units shall be individually removed after disconnecting the units by removing the grout from shear keys and connector pockets, and by removing connector bolts, drift pins and other hardware. Precast concrete units shall be lifted only at the designed lifting points, with the top of each unit up at all times, and shall be allowed to rest only on the designed bearing areas.

21.4.3 Disposal

Materials in bridge structures not listed for salvage shall be disposed of in a manner and location acceptable to the Consultant. The Contractor shall provide written acceptance from the owners of the disposal site(s) and evidence of their acceptance of the disposal site clean up, prior to receiving full payment.

In general, the portion of bridge abutments and piers located above natural ground level shall be completely removed, and the portion 1 metre below the natural ground level may remain in place.

21.5 Haul of Bridge Material

When determined by the Consultant, the Contractor shall haul salvaged materials. The haul of salvaged materials shall include loading, unloading, stockpiling and all associated handling of the materials.

21.6 Measurement and Payment

Payment for **Removal of Bridge Structures** will be made at the lump sum bid for the particular bridge structure removed. This payment will be full compensation for completing the work as described in section 21.4 including excavation and for the use of all equipment, tools, labour and incidentals necessary to complete the work.

21.6.1 Haul of Bridge Material

Haul of Bridge Material will be made only where the Consultant directs the Contractor to undertake the haul of salvaged material to a point outside the limits of the contract and only when the Consultant accepts the condition of the salvaged material at the final location. The haul of salvaged material to the Contractor's storage area, and haul of material to a disposal site will not be paid for separately but will be considered incidental to the removal of the bridge structures.

Where applicable, payment for the **Haul of Bridge Material** outside the limits of the contract will be at the lump sum price bid which price shall include full compensation for loading, hauling, unloading, stockpiling and for providing all labour, equipment, tools and incidentals necessary to complete the Work.

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 22

PAINTING

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22.1 General

This specification is for field painting of structural steel bridges and for shop painting of newly fabricated structural steel for bridges.

Where Standards and Standard Specifications are referenced, the version current at the time of tendering shall govern, unless a specific date is described. Metric versions are inferred, when available and relevant.

This specification describes requirements for several different methods of preparation and for several different approved coating systems which may be applied to bridge structures. Each painting contract shall have Special Provisions and/or Drawings which delineate the applicable area of the structure and the coating system to be applied to it.

22.2 Standards

- Society for Protective Coatings (SSPC) "Standard Procedure for Evaluating the Qualifications of Painting Contractors" SSPC-QP1.
- SSPC "Standard Procedure for Evaluating the Qualifications of Painting Contractors to Remove Hazardous Paint" SSPC-QP2
- SSPC Guide 6-Guide for Containing Debris Generated During Paint Removal Operations.
- SSPC SP 1 Solvent Cleaning.
- SSPC SP 2 Hand Tool Cleaning.
- SSPC SP 3 Power Tool Cleaning.
- SSPC SP 5 White Metal Blast Cleaning.
- SSPC SP 6 Commercial Blast Cleaning.
- SSPC SP 7 Brush-Off Blast Cleaning.
- SSPC SP 10 Near-White Blast Cleaning.
- SSPC SP 12 Surface Preparation and Cleaning of Steel and Other Hard Materials by High- and Ultrahigh-Pressure Water Jetting Prior to Re-coating.
- SSPC AB1 Mineral and Slag Abrasives.
- SSPC AB2 Cleanliness of Recycled Ferrous Metallic Abrasives.
- SSPC AB3 Newly Manufactured or Re-Manufactured Steel Abrasives.
- SSPC PA Guide No.11 Protecting Edges, Crevices, and Irregular Steel Surfaces by Stripe Coating
- SSPC PA 2 Measurement of Dry Coating Thickness with Magnetic Gauges

- Alberta Transportation "Fish Habitat Manual"

SSPC specifications are available at <http://www.sspc.org>

Alberta Transportation Product List – Approved Products "Bridge Coating Systems – Paint" available on the Department's website at:

<http://www.transportation.alberta.ca/Content/docType253/Production/paintlist.pdf>

22.3 Contractor Qualifications

One of the following four competency levels will be specified in the Special Provisions of the Contract.

- CQ1** The Contractor or painting subcontractor must have certification in good standing with the Society for Protective Coatings (SSPC) under SSPC-QP2.
- CQ2** The Contractor or painting subcontractor must have certification in good standing with the Society for Protective Coatings (SSPC) under SSPC-QP1.
- CQ3** The Contractor or painting subcontractor acceptance will be based on submission of documented experience which should include but not be limited to: the names of owners, projects and dates of previous bridge painting projects where containment and disposal of blasting spoil was practised, copies of any relevant environmental permits and any citations for failure to comply. A list of qualified personnel responsible for the actual paint removal and application will be required. Once accepted no personnel changes shall be made without the Consultant's written acceptance. Permission for the Consultant to interview the owners, environmental departments and personnel listed above. Falsifying information in the submission will be grounds for disqualification of the bid.
- CQ4** No specific pre-qualification requirements.

Only Contractors having the specified level of competency, at the time of closing tenders will be considered acceptable.

22.4 Materials

22.4.1 Supply

The Contractor or painting subcontractor shall supply all materials to satisfactorily complete the work.

22.4.2 Blasting Media

Contractors may choose the type of abrasive intended for use, taking into consideration the abrasive disposal and worker's health implications of each type. The abrasive selected shall comply with the applicable Society for Protective Coatings (SSPC) standard.

Blasting grit shall be free of corrosion producing contaminants and shall be free of any moisture, oils, greases or other elements which will reduce the adhesion of paint coatings. The blast cleaning abrasive used shall produce the minimum surface profile required by the paint manufacturer.

The use of pre-treatment coatings, blasting media additives or treatment of blasting spoil prior to, or subsequent to, disposal must be reviewed and accepted by the Department and

Consultant.

22.4.3 Paint

The Contractor shall select an approved product from the Alberta Transportation Product List – Approved Products “Bridge Coating Systems – Paint”. The paint system shall be from the category specified in the Special Provisions. The material data sheets and material safety data sheets of the chosen paint system shall be submitted with the Contractor’s work proposal. A single paint system shall be used throughout the entire project unless specified otherwise. The Contractor shall not change to another paint system once the initial paint system has been applied to any portion of the structure.

The paint shall be delivered in sealed, original, labelled containers bearing the Manufacturer’s name, type of paint, brand name, colour designation, batch number and instructions for mixing and/or reducing.

For each batch of paint used on the project, the Contractor shall have an independent laboratory carry out quality control tests for colour, gloss and formulation. The results shall be submitted to the Consultant for review and acceptance a minimum two weeks prior to the anticipated commencement of painting operations. No paint shall be applied to the structure prior to acceptance of the test results by the Consultant and Department.

Colour testing for the mixed top coat shall be carried out in accordance with ASTM D2244 with a CIE 1976 L*A*B, 2 degree observer, and a D65 illuminate.

Gloss testing for the mixed top coat shall be carried out in accordance with ASTM D523 at 60 degrees.

Infrared Spectroscopy (IR) shall be conducted on all individual components of the paint system prior to mixing, to confirm that the formulation conforms to that which was originally approved. A minimum 32 scans shall be taken with a Fourier transform infrared spectrometer between 4000 and 400 wave-numbers (CM-1) using the salt plate sandwich technique. The salt plate may be made from potassium bromide for non-aqueous paints. If the formulation contains water; appropriate, non-water soluble plates shall be used. Plate material shall be reported with each individual spectrum. The spectra shall be taken of vehicle portion of the coating without the pigment. For single component materials, a representative sample of the material shall be centrifuged to remove pigment and then analyzed. For plural component materials, each of the individual components shall be centrifuged to remove pigment and then analyzed separately. IR analysis of the mixed components is not required. The IR plots shall be completed with transmittance (0 – 100%) on the y-axis and Wave-numbers (4000 – 400; non-linear) on the x-axis. All peaks shall be labelled with the corresponding wave-number. The spectra shall be taken such that the largest peaks are at 50 – 0%T and the baseline is greater than 80%T. Materials with IR plots indicating a change in formulation from that which was originally approved will be rejected.

Each batch of paint may be subjected to additional testing by the Department or Consultant.

If requested, the Contractor shall provide four – 250 ml samples of paint from a pail or barrel chosen by the Department or Consultant. Samples shall be placed in suitable new, clean, metal containers; and sealed to avoid contamination of the paint.

22.5 Environmental Considerations

22.5.1 Emission Levels

The percentage of blasting spoil that must be recovered and the Class of containment required shall be as specified in the contract Special Provisions and detailed in the SSPC-Guide 6.

Monitoring and acceptance criteria described in section 5.5 of the SSPC-Guide 6, methods A to F, to monitor the quantity of emissions escaping the enclosure shall be specified in the contract Special Provisions.

22.5.2 Environmental Regulations

The Contractor shall ensure that existing paint being removed, and any abrasive material used to accomplish the removal, is contained and properly and safely disposed of in accordance with the applicable laws and regulations.

The Contractor shall comply with all Federal, Provincial, and Municipal, air, soil and water pollution control regulations, when cleaning and repainting the structural steel and when disposing of any waste generated. These specifications set forth minimum requirements necessary to protect the environment. The Contractor shall perform additional work to modify containment or disposal procedures to ensure compliance with all applicable laws and regulations.

22.5.3 Fish Habitat

When working on structures over water inhabited by fish the Contractor shall conform to the requirements of the Alberta Transportation “Fish Habitat Manual”. This manual is available on the internet at:

http://www.transportation.alberta.ca/Content/docType245/Production/Complete_Fish_Habitat_Manual.pdf

22.5.4 Blasting Spoil Recovery

The containment system for the blast cleaning and painting shall be installed such that the minimum specified percentage of the blast spoil and paint removed, as listed in the Special Provisions, is contained.

22.5.5 Protection of Property

During cleaning and painting procedures, the Contractor shall take necessary precautions to fully protect the environment, the workers, traffic, parked vehicles, adjacent property, and other portions of the structures from damage caused by cleaning debris, blast cleaning materials, dirt, dust, equipment oils, solvents, acids, burning matter and paint drifts, drops, or spray and

spatter.

22.5.6 Quality Assurance

An Environmental Auditor may be retained by the Consultant to assure compliance with the requirements of the Environmental Permits and/or Screening Report and to monitor the performance of the containment system in particular and that of the Contractor in general.

22.5.7 Background Contamination Levels

Pollution of the environment shall be minimized at all times during the Work. The Contractor's operations may also be monitored by other agencies.

The Contractor shall identify locations in which to establish background soil, water/snow, and air contamination levels in his work proposal. After the Contractor's work proposal has been reviewed and accepted by the Consultant and prior to commencement of the work, the Contractor shall collect soil, water/snow, and air samples from the project site for analysis. Samples shall be collected in the presence of the Consultant and at locations most likely affected by the work, such as at the dust collector, recycling unit, key points along the spoil material transfer lines, and spoil material storage areas. As a minimum, three samples shall be collected at each location and sent to an accredited laboratory approved by the Consultant for analysis. Analysis shall be consistent with regulatory reporting requirements and results submitted to the Consultant.

The Consultant may require the Contractor to collect additional soil, water/snow, and air samples at the site for analysis during the course of the work if contamination is suspected. If requested, the Contractor shall immediately collect samples and have them analyzed at the approved laboratory. Results shall be forwarded to the Consultant within one week of collecting the samples.

The Contractor shall collect samples at all established background locations once painting operations are completed and equipment is removed from the site. As a minimum, two post construction composition tests shall be completed at each background location and results submitted to the Consultant for review and acceptance. Analysis shall be performed at the approved laboratory using the same test methods used for initial background analysis. If post construction analyses show that the Contractor's work has adversely affected the environment, site remediation will be required and shall be carried out to the full satisfaction of the Department and the Consultant.

All cost associated with soil, water/snow, and air sampling including any subsequent site remediation requirements will be considered incidental to the Work and no separate or additional payment will be made.

22.6 Permits, Licences and Approvals

The Contractor shall obtain the necessary permits, licences and approvals, and conform to all requirements of Environmental Screening Reports, Municipal bylaws, Provincial and Federal

Environmental Protection laws, for all work carried out. The Contractor shall be familiar with and comply with all regulations, such as, but not limited to, Environmental permits, the Worker's Compensation Act, the Occupational Health and Safety Act, Regulation and Code which control the exposure of workers to chemical hazards.

22.7 Work Proposal

The Contractor shall submit his work proposal to the Consultant for review and acceptance a minimum of two weeks prior to the pre-construction meeting. The work proposal shall include, but not be limited to:

- Schedule
- Sequence of operations
- Traffic accommodation strategy
- Site lay down plan including placement of equipment
- Proposed sampling locations for establishment of background contamination levels
- Bridge washing strategy
- Storage, handling and disposal of new and contaminated blasting material
- Methods of weighing blasting material on and off the project
- Method of separating hazardous and non hazardous blasting spoil
- Sample documentation for tracking the disposal of hazardous waste
- The final destination of hazardous waste
- Chosen coating system from the Alberta Transportation Product List - Approved Products "Bridge Coating Systems (Paint)"
- Bridge load evaluation report

The Contractor shall submit drawings signed and sealed by a Professional Engineer registered in the Province of Alberta detailing his containment structure, scaffolding, platforms, swing stages, and attachments for the Consultant's review. All scaffolding, platforms, swing stages and material collection equipment shall be designed and operated in accordance with the authority having jurisdiction.

22.8 Work Site Health and Safety

The Contractor is fully responsible for the protection of his employees and any sub-contractor's personnel, from exposure to lead. The Contractor shall develop and implement a Lead Health and Safety Program (LHASP) that meets all the requirements of the Occupational Health and Safety Act and Regulations (Attention is drawn to OH&S Bulletin MSB-06 and in particular the chemical requirements) and all other Municipal, Provincial and Federal Regulations that may apply when working in a hazardous environment.

The Contractor shall provide shower and change facilities for the work force in accordance with governing regulations and ordinances. The facilities shall be freely available for use by all personnel associated with the Contract.

Respirators shall be furnished by the Contractor and used when such equipment is necessary to protect the health of employees. Respirators shall be donned before entering the work area and

shall not be removed until the worker has left the work area or has entered a decontamination area. Selection of the respirator type shall be based on the ability of the respirator to adequately filter air which is at the maximum air-lead level monitored in the locations where the worker may be exposed.

Extra protective clothing and clean respirators shall be available for use by visitors to the work site.

The Contractor shall supply employees, who are potentially exposed to lead, with clean, dry, protective work clothing and equipment, and with appropriate changing facilities. Appropriate protective work clothing can include coveralls or similar full body work clothing, gloves, hats, shoes or disposable shoe coverlets, face shields or vented goggles and, if applicable, blasting helmets.

The Contractor shall designate a Health and Safety officer, to act as the primary on site monitor of the program and to ensure that the LHASP is implemented on a daily basis and that all work on the site is in compliance with the LHASP.

22.9 Bridge Load Evaluation Report

The Contractor shall engage a Professional Engineer registered in the Province of Alberta to prepare and submit a bridge load evaluation report. In the bridge evaluation report the Contractor's Engineer shall identify all loadings imposed on the bridge during the Work or staging of the Work, determine where to transfer the loads to the bridge, and evaluate the ability of the bridge to accommodate the loads in accordance with the Canadian Highway Bridge Design Code CAN/CSA-S6 and the following provisions:

- Dead loads and dead load factors shall be in accordance with Section 14;
- Vehicle live loads and vehicle live load factors shall be in accordance with Section 14. The load rating evaluation vehicles shall be the Alberta Transportation single unit vehicle (CS-28t), two-unit vehicle (CS2-49t) and vehicle train (CS3-63.5t).
- Notwithstanding Clause 14.9.5.3, winds loads shall be considered when the Contractor's containment system results in an increased wind loading on the bridge. Wind loads shall be incorporated in the evaluation with load combinations ULS3 and ULS4 as per Section 3. Design wind loads may be adjusted if a written work procedure for removing the screens/containment system at projected wind speeds is developed by the Contractor's Professional Engineer, adequately demonstrated, and reviewed and accepted by the Consultant and the Department.
- All other construction live loads and live load factors shall be in accordance with Section 3;

Components of the bridge that shall be evaluated and rated include, but are not limited to, the bridge superstructure and bridge bearings. Bridge bearings shall be evaluated and rated in cases where the Contractor's containment system results in an increased wind loading on the

bridge in any direction or alternate means of load transfer are imposed on the bridge. Bridge substructure components are typically not included in the evaluation and rating, but may be required at some bridge sites. When required, rating of the bridge substructure will be specified in the Special Provisions of the Contract.

When containment systems include temporary structural elements to strengthen bridge components, details of the fabrication, installation and removal of the temporary structural elements shall be clearly detailed in the bridge load evaluation report.

The bridge load evaluation report shall also provide Live Load Rating Factors, as described in Clause 14.15, for all three load evaluation vehicles under the ultimate limit state ULS1 and shall demonstrate that the bridge capacity is adequate under the ultimate limit states of ULS3 and ULS4. The capacity of the bridge will be considered acceptable if the Live Load Rating Factors are greater than 1.0 and if the factored resistances exceed the factored load effects.

The bridge load evaluation report shall be stamped by the Contractor's Engineer, and shall clearly identify the magnitude and direction of the imposed loads, where the loads from the containment system will be transferred to the bridge, and the Engineer's assessment in the ability of the bridge to accommodate these loads. The report shall be submitted to the Consultant for review and acceptance as part of the Contractor's work proposal.

All costs associated with the preparation of the load evaluation report will be considered incidental to the Work and no separate or additional payment will be made.

22.10 Protection of Surfaces

The Contractor shall protect and maintain the painted surfaces until acceptance of the entire project.

The Contractor shall take due precaution against damaging or disfiguring any portion of the bridge with blast media, spatter, spray fog, splashes, smirches of paint or associated painting materials including the fuel and lubricants used with his equipment.

Tarps, polyethylene or other covering material shall be used to protect deck, sidewalks, piers, abutments, slope protection and other portions of the structure adjacent to areas being painted and subject to paint or other damage.

Any inadvertent damage or disfigurement which may occur by reason of the Contractor's operations shall immediately be repaired to the satisfaction of the Consultant at the Contractor's expense.

22.11 Areas Not To Be Painted

The following surfaces shall not be painted unless noted in the Special Provisions of the Contract:

- Surfaces which will be cast into concrete such as the top and sides of the top flange of

girders or the side of expansion joints in contact with concrete.

- Sliding metal to metal contact bearing surfaces and mating surfaces of spherical bearings.
- Galvanized surfaces.
- Concrete surfaces adjacent to painted steel surfaces such as sidewalks and the underside of bridge decks. Where painted items such as girder flanges are cast into concrete the paint applied to the flange may overlap the concrete by up to 25 mm on condition that this shall be a uniform straight line as produced by masking the remainder of the concrete surface. Any paint inadvertently applied to the concrete shall be removed immediately.

22.12 Work Execution

22.12.1 Temporary Attachments

To reduce the possibility of damaging the existing bridge components and painted surfaces, any clamps or other devices attached to the structure shall be padded or designed such that they do not mark or damage the surface to which they are attached.

No welding or tack welding to the structure will be permitted.

The removal and replacement of any bolts from the structure must be acceptable to the Consultant. No holes may be placed in the structure.

22.12.2 Containment System

The containment system's purpose is to prevent the debris generated during surface preparation from entering into the environment and to facilitate the controlled collection of debris for disposal.

The containment system and its operation shall meet or exceed the class of containment specified in the Special Provisions. When abrasive blast cleaning is used to clean and prepare the steel surfaces, the Contractor shall contain the paint chips, abrasive particles, and debris resulting from the operation. The containment system includes but is not limited to, such articles as cover panels, screens, tarps, scaffolds, supports, shrouds and ground sheets used to enclose the entire work area, and equipment to clean, transport, collect, and store blast media. .

The materials used for screens shall be of a commercial brand designed specifically for the purpose of containing and facilitating collection of blasting and painting debris. If woven screens are used, the material shall contain not more than 15% voids with a mesh opening not exceeding 20 mils (500 microns). If monitoring detects leakage of dust through the woven screens, exceeding the allowable, then the screens shall be replaced with ones of a tighter weave which will meet the recovery requirements. All materials used for screens shall be adequately reinforced to prevent tearing or displacement when subjected to construction, wind

or other environmental loads and their related conditions. The Contractor shall supply auxiliary lighting to improve visibility where necessary within enclosures.

22.12.3 Containment System Monitoring

(1) Abrasive Blasting

The containment system shall provide emission control effectiveness such that random escapes to the environment do not exceed 3% of the work day (e.g. 15 minutes over an 8 hour work shift). Operations shall cease immediately if the limits of emission control are exceeded. An enclosure which does not meet the specified criteria shall be modified at the Contractor's expense. Blasting shall not resume until the Contractor has modified his containment system and the modifications have been reviewed and accepted by the Consultant.

The Contractor shall maintain a documented reporting system to provide gross weights, tare of containers and the calculated weight of the material provided to and removed from the structure. The blasting spoil shall be protected from absorbing any moisture. Contaminated blasting spoil shall be in a dry condition prior to making the recovery calculation.

If the wind velocity is too excessive to effectively contain the blast debris within the enclosure, the Contractor shall suspend blast cleaning operations and protect the existing blasting spoil from the wind.

The Contractor shall take whatever measures are necessary to prevent the release of dust or spent material from the ground tarpaulins and other components of the containment enclosure during moving or removal. Debris collected on temporary work platforms, ground cloths, or walls of the containment structure, shall be removed each workday with a vacuum system equipped with high efficiency particulate air (HEPA) filters adequately sized to collect all spent material.

The Contractor shall contain all debris and waste materials as described herein and shall also provide a temporary platform located directly underneath the area enclosed for surface preparation cleaning, power tool cleaning, or blast cleaning and paint application. The platform shall be adequately sized to contain and/or filter debris, wash water and paint during the cleaning or application operation. The containment enclosure shall extend down to the level of the platform and shall be secured to prevent release of other than filtered material. The surface of the platform shall be constructed to ensure collection and filtration of spent waste materials or shall be designed to collect, funnel and discharge the spent waste materials into waste containers.

For bridges located over a navigable waterway the location of platforms, scaffolding, floating booms or other equipment shall not interfere with navigation.

The containment system must be properly maintained while work is in progress and shall not deviate from the approved working drawings without prior acceptance of the Consultant. If, at any time during execution of the work, the containment system fails to function properly,

the Contractor shall immediately suspend surface preparation until modifications can be made to correct the deficiency.

Containment meeting these requirements may not necessarily provide adequate emission control or abrasive recovery rate. The Contractor may have to provide a higher containment standard to meet these other requirements.

(2) Water Blasting

When High or Ultra High Pressure Water Jetting is specified the filtration or collection and treatment of water used in the cleaning shall be as specified in the Special Provisions. The recovery of a certain volume of spoil will not be specified, but the waste water may have to be filtered through a cloth system of specified porosity and when the cleaning is completed the cloth filters shall be carefully folded to contain the debris collected and shall be disposed of as outlined in section 22.16 of this specification. The Contractor is responsible to perform additional work or to otherwise modify containment or disposal procedures to ensure compliance with all applicable laws and regulations.

22.12.4 Ventilation System

The ventilation system used shall be as specified in the Special Provisions and described in the SSPC-Guide 6. The use of the minimum ventilation system as described herein does not assure control of emissions to the required level nor will it assure worker safety. Revisions to the ventilating system may be necessary and will be required to meet the health and emission requirements.

The minimum air movement specified in the Special Provisions, for inside the Containment system may not be adequate for visibility of the work surface and may or may not be adequate for protection of the workers from health hazards such as lead. The Contractor may have to provide a higher standard of air movement to meet these requirements.

22.12.5 Assessing Emissions

Methods for Assessing the Quantity of Emissions shall be as specified in the Special Provisions and as described in the SSPC-Guide 6.

The Contractor shall have monitoring equipment to ensure that the containment is performing to the required level.

22.13 Surface Cleaning

Prior to the commencement of any surface preparation operations, the Contractor shall carry out surface cleaning on all steel designated to receive a coating system and adjacent surfaces that could contaminate surfaces to be prepared. Surface cleaning shall consist of the hand removal of organic materials such as bird droppings and nests and other non-structural items adhered to the steel, and bridge washing.

Oil, grease and road tar shall be removed manually by solvent cleaning in accordance with

SSPC Specification SP1. Remaining area contaminated with residual oil or grease shall be cleaned with an approved biodegradable detergent. The detergent shall be environmentally friendly and non-toxic. The Contractor shall supply copies of the MSDS sheets for the proposed cleaning products to the Consultant for review and acceptance prior to using these materials.

All areas to be coated shall be washed clean of road spatter, chlorides and other contaminants using water of sufficient pressure and volume to flush the contaminants from the structure.

Areas of cleaned steel shall be tested for chloride contaminants, soluble ferrous ions and sulphate contaminants. Chloride contamination shall be tested using Quantab Method or by Kitagawa Tube. Soluble ferrous ion contaminants shall be tested using ferrous ion test strips. Sulphate contaminants shall be tested using a barium chloride optical comparator or an alternative method accepted by the Consultant.

Cleaning shall result in surfaces with less than $7 \mu\text{g}/\text{cm}^2$ of chloride ion contaminants; less than $10 \mu\text{g}/\text{cm}^2$ of soluble ferrous ion contaminants; and less than $17 \mu\text{g}/\text{cm}^2$ of sulphate contaminants. All testing shall be carried out by the Contractor and the results submitted to the Consultant for review and acceptance prior to commencing surface preparation operations.

Wash water shall be captured, filtered and disposed of in compliance with all applicable laws and regulations.

22.14 Surface Preparation

22.14.1 Abrasive Blast Cleaning

All compressed air sources shall have oil and moisture separators, attached and functional, properly designed and sized to allow delivered air at the blasting or painting nozzle to be free of oil and moisture and of sufficient pressure to accomplish the associated work efficiently and effectively. The tanks on the air compressors and the moisture separators shall, as a minimum, be drained at the end of each working shift. Prior to abrasive blast cleaning, the Contractor shall demonstrate to the Consultant that the air is moisture free. Air driven power tools shall be properly lubricated in accordance with the respective Manufacturer's instructions, but in such a manner that lubrication is not deposited onto the surface being prepared.

Blast cleaning of steel surfaces in preparation for painting, shall be in accordance with the SSPC Surface Preparation Standards specified in the Special Provisions.

Surface Preparation Standard SSPC-SP6 requires that the cleaned surface be free of all visible oil, grease, dirt, dust, mill scale, rust and paint.

Surface Preparation Standard SSPC-SP7 requires the removal of all loose coating, loose rust and loose mill scale. Mill scale, rust and paint are considered to be tightly adhered if they cannot be lifted with a dull putty knife.

The anchor pattern in the blasted steel shall be that specified by the manufacturer of the coating.

As work progresses a 150 mm wide strip of uncoated blasted steel shall be left between the newly coated surface and the non blasted surfaces of the structure.

The Contractor shall grind all burs and sharp edges to the satisfaction of the Consultant. This requirement shall be measured using an "L" shaped metal gauge with a $\frac{1}{32}$ " (1.0 mm) radius at the point of intersection of the two 90° arms. The member will require grinding if the radius touches the member when both arms are in tight contact with the surfaces of the member.

The Contractor shall prepare only as much surface as can be coated with primer the same day. If unusual circumstances occur which prevent all prepared surfaces from being primed the same day, a light blast cleaning will be required over all un-primed surfaces prior to recommencement of painting.

Care shall be exercised to prevent contamination of blast-cleaned or coated surfaces prior to over coating. Compressed air cleaning of the members before coating application will generally be accepted. At the discretion of the Consultant, this operation may be requested in any area before the application of any coat of paint. The degree of surface preparation specified shall exist immediately prior to the coating material being applied. Paint shall be protected from contamination by blasting debris until it has cured sufficiently. Paint contaminated with blasting grit shall be removed and re-applied.

Prepared surfaces shall be kept clean at all times, before coating and between coats.

22.15 Pack Rust

Pack rust is the term used for the condition where two areas of steel have been held tightly together by rivets or bolts, and subsequent crevice corrosion has forced these areas apart with a build-up of corrosion products between them. Pack rust that forces plates or structural sections apart to form a gap of 2 mm or greater shall be cleaned to a depth of one half of the gap width, to a maximum depth of 6.0 mm, treated with an approved penetrant and caulked to form a water tight seal along the top edge and the two sides of plate involved. The bottom edge or lowest edge of the plate or member shall not be caulked.

The type of penetrant and caulking used must be compatible with the paint system used and shall be applied according to the Manufacturer's instructions. No penetrant or caulking shall be used which has not been accepted by the Consultant. When only one plate edge is exposed, a fillet of caulking shall be applied when the pack rust gap is greater than or equal to 3 mm. The fillet is not required where there is no separation of the plates due to pack rust.

Regardless of whether pack rust is evident or not, all connection plates shall be treated with an approved penetrant and caulked as described. All costs associated with the penetrant treatment and caulking will be considered incidental to the Work and no separate or additional payment will be made.

22.16 Disposal of Blasting Spoil

The collection, storage and disposal of blasting residue shall be carried out in compliance with

federal, provincial and municipal laws.

All waste residue collected during the surface preparation process shall be stored at the site in containers acceptable to the Consultant. The waste containers shall be stored in an acceptable area and shall be protected at all times with water-proof covers. Waste residues collected and stored in the waste containers will be sampled and tested by the Contractor in accordance with the Toxic Characteristic Leachate Procedure (TCLP) test. The test results will characterize the waste residue as a hazardous or non-hazardous material and the Contractor shall dispose of the blast residue accordingly. The representative test results, for each batch of blasting residue collected shall be provided to both the Consultant and the Department before disposal of waste can be undertaken.

It is the Contractor's responsibility to provide documentation to the Consultant that all hazardous waste was disposed of in conformance with all applicable regulations governing the disposal of such materials. Acceptable documentation shall consist of a certificate of disposal that will provide information such as the quantity of material, truck manifests, way bills, and other information necessary to clearly document the transportation of, and the final disposal method and disposal site used.

22.17 Priming and Painting

22.17.1 Stripe Painting

Stripe painting is a process whereby an additional layer of paint is applied to all sharp edges of the structure being painted to increase the thickness of the coating around the sharp edge. The Contractor shall apply stripe paint along all sharp changes in steel surfaces, including but not limited to, edges of flanges, stiffeners, bracing, plates, bolts, nuts, washers, rivets, plates, and sections with sharp profile. Stripe painting may be applied prior to the prime coat or after the prime coat to aid in preservation of the blast cleaned surface. Drying times and recoat conditions must be compatible with all other coats of the paint system. Paint systems using an intermediate coat shall also be stripe painted after each intermediate coat, but not after the top coat. Stripe coats when applied over the primer or intermediate coat shall be tinted to contrast the underlying coat.

22.17.2 Paint Application

- (1) Paint shall be applied in accordance with the Manufacturer's instructions. When required the coating Manufacturer's representative shall be available at the site, to provide guidance and solve problems.
- (2) Paint shall not be applied when the air and/or steel temperatures are at or below 4°C, nor when the metal has absorbed sufficient heat (above 50°C) to cause the paint to blister and produce a porous paint film, nor when it is possible the air temperature may drop below 0°C before the paint is dry. Variances from these requirements, due to paint supplier's recommendations or requirements, require the Consultants acceptance prior to usage.
- (3) Paint shall not be applied to damp or frosty surfaces, nor applied to surfaces when there is a

risk of dew. Painting shall not commence unless the dry bulb temperature exceeds the wet bulb temperature by more than 5°C and the ambient temperature is rising.

- (4) Only the anticipated quantity of paint required for one day's work is to be opened on that day. Left over paint shall not be left exposed to air. Any paint that becomes oxidized, thickened, ropy, lumpy or dirty shall be discarded.
- (5) The paint shall be mixed in a manner which will ensure breaking up of all lumps, complete dispersion of settled pigment, and provide a uniform composition. The paint shall be agitated often enough during application to keep the pigment in suspension.
- (6) Paint shall not remain in spray pots, painter's buckets, etc., overnight. Multi component paints which have been mixed for the duration of the Manufacturer's recommended pot life shall be discarded in a safe manner.
- (7) Paint shall be safely stored by the Contractor, in a location which keeps its temperature between 10°C to 25°C.
- (8) Paint shall be applied by spraying, brushing, rolling or a combination of these methods. On all surfaces which are inaccessible for brushes or rollers and where spraying cannot be employed, the paint may be applied with sheepskin mitts specifically manufactured for this purpose.
- (9) Finish coat paint shall not be applied over wet touched up primer.
- (10) All portions of the paint system shall be within the range of film thickness(es) in which it was originally approved. Bolts, rivets, edges of members and other changes in surface contour shall also receive the required film thickness(es).
- (11) To ensure that the proper dry film thickness is obtained, the wet film thickness shall be checked at the time the paint is applied. The minimum wet film thickness shall be equal to the dry film thickness divided by the percentage (expressed as a decimal) of solids in the paint used, with the result rounded up to the next full mil. Each painter shall have his own wet film thickness gauge and do frequent checks of the paint film as it is applied.

Dry film thickness shall be verified with a Type 2 constant pressure probe magnetic gauge as defined by SSPC-PA 2. The magnetic gauge shall be calibrated in accordance with SSPC-PA 2.

22.18 Quality Control

To ensure that the work done meets the requirements of this specification, the Contractor shall have an experienced quality control person solely dedicated to actively monitoring and correcting the work of his employees whenever cleaning, surface preparation and coating application is taking place. The Consultant will provide a NACE certified quality assurance inspector to monitor and accept the work. The Contractor shall provide him and all other

representatives of the Consultant and Alberta Transportation, at their request, safe free access to all areas of the work in all stages of completion.

There shall be no application of coating materials until the cleaning, and surface preparation have been inspected and accepted by the Consultant. Failure to follow this requirement will necessitate the complete removal, by blast cleaning, of all coating placed over surfaces not inspected and accepted by the Consultant. Each coat must be thoroughly dry and the mil thickness of each coat accepted by the Consultant prior to applying an additional coat.

22.19 Authority of the Consultant

Non-compliance with any portion of this specification may result in the Consultant suspending the work until the infraction has been corrected. There will be no alteration to the completion date, lane charge dates and site occupancy as applicable due to this suspension of work.

22.20 Acceptance

Painted surfaces will be rejected, if any of the following defects are identified:

- (1) Runs, sags, holidays or shadowing.
- (2) Evidence of poor coverage at bolts, plate edges, lap joints, crevices, pockets, corners and re-entrant angles.
- (3) Surfaces which have been struck, scraped, spotted by rain or otherwise damaged.
- (4) Surfaces which exhibit an objectionable texture such as orange peel, mud cracking, fish eyes, etc.
- (5) Surfaces damaged by over spray.

22.21 Repair

Areas requiring repair, shall be cleaned of all damaged paint and the system re-applied using all coats typical to the original paint system. Each coat shall be thoroughly dry before applying subsequent coats. The Contractor shall carry out all repairs to the satisfaction of the Consultant at no additional cost to the Department.

Support points for work platforms or containment structures shall be painted with the accepted paint system. Work platform designs shall consider the potential to adjust touch points so coatings can be applied as work progresses. The Contractor may submit proposed alternate paint systems and application procedures for the painting of touch points, however, any proposed alternate paint systems shall be equivalent in the protection provided, expected durability and the manner in which the system ages so visual uniformity is preserved over the life of the coating. The use of alternate materials and methods will be at the sole discretion of the Department and Consultant.

22.22 Site Clean-Up

The Contractor shall leave the entire site in a neat and tidy condition with all paint cans, masking materials and other debris removed from the site and disposed of in manner acceptable to the Consultant and the Department.

22.23 5 Year Bridge Painting Warranty

The Contractor shall warranty the Work against all defects in material and workmanship for a period of five years. The warranty period will commence on the date of the final acceptance of the Work.

The Contractor shall execute the form entitled, "5 Year Bridge Painting Warranty", a sample copy of which is contained in this Specification.

During the warranty period, the Consultant and/or the Department will conduct yearly inspections of the coating system. A final inspection of the coating system will be carried out a minimum of sixty days prior to the expiration of the warranty period.

Failure of the coating system shall include, but not be limited to: Any de-bonding or failure of adhesion of the coating either to the structural steel or lack of inter-coat adhesion; the appearance of any rust stains on the structure due to loss of paint or due to leaking from joints between structural members; any loss of normal gloss or rapid change of colour of the coating. Damage to the coating due to vehicle impact or snow removal equipment will not constitute failure of the system.

Repair under warranty shall include, but is not limited to, all permitting, approvals, traffic accommodation, containment systems, labour, materials, equipment, tools and incidentals necessary to restore the coating to a condition acceptable to the Department at no cost to the Department.

Warranty repairs shall be completed within 60 days of notification or, in the event this would place the repair work period in winter weather conditions, by the following June 30 .

5 YEAR BRIDGE PAINTING WARRANTY

(Name of Contractor)

(Contract Number)

(Bridge File Number and Name)

(Name of Paint Manufacturer)

(Paint System Name)

The undersigned party agrees to provide a 5 year warranty for the Work. The warranty period will commence upon final acceptance by the Department of the work; and shall include all labour, materials, equipment, tools and incidentals necessary to repair all defects and restore the coating to a condition acceptable to the Department, at no cost to the Department.

CONTRACTOR:

(Name of Company Officer)

(Corporate Position)

(Signature of Company Officer)

(Name of Witness)

(Signature of Witness)

(Date)

22.24 Shop Coating of Structural Steel for Bridges

22.24.1 Fabrication Paint Shop

Paint shops or areas of fabrication shops where painting is performed shall be well lit, free of dust and drafts and maintained at the correct temperature and relative humidity for the coating being applied.

Compressed air for cleaning and painting shall be free of moisture and oil contamination.

22.24.2 Pre-Surface Preparation

Surfaces to be coated shall free of weld spatter, welding flux and cutting slag. All sharp corners and edges shall be lightly ground to a 1.0 mm chamfer to break the sharp edge and all holes shall be free of burrs and cutting chips. Oil and grease shall be solvent cleaned to meet the requirements of SSPC SP1 specification for solvent cleaning, prior to blast cleaning in preparation for coating.

22.24.3 Abrasives

Abrasives used in shop cleaning shall be free of chlorides and other contaminants which could affect the coating being applied, and shall produce the anchor pattern required by the coating system.

22.24.4 Blast Cleaning

Unless noted otherwise noted all fabricated surfaces shall be blast cleaned to meet the requirements of SSPC-SP10 Near White Blast Cleaning, which is a surface free of all visible oil, grease, dust, dirt, mill scale, rust, coating, oxides, corrosion products, and other foreign matter. The surface roughness of the cleaned surface shall be from 5 to 15 μm . No paint shall be applied until the Consultant has inspected and accepted the cleaned surface. Surfaces which have been painted without acceptance of the cleaning shall have the paint removed by blast cleaning and must be accepted by the Consultant before the paint can be applied again.

22.24.5 Masking

All areas not to be painted shall be masked prior to applying paint. This includes portions of members within 100 mm of field weld locations. Unless noted otherwise, all faying surfaces and within 75 mm of open holes shall be masked to prevent application of coating. All clip angles and other detail material shall be applied after blast cleaning to assure a cleaned faying surface.

22.24.6 Paint

Unless noted otherwise, shop primer shall be an inorganic zinc rich primer from the Alberta Transportation Product List – Approved Products “Bridge Coating Systems – Paint”.

22.24.7 Paint Application

Paint shall be applied to the specified Dry Film Thickness (DFT) of 35 to 45 μm (100 -120 μm wet film thickness). Painters shall be equipped with wet film thickness gauges to assure proper application thickness. DFT shall be checked and accepted by the Consultant prior to shipping the work.

22.24.8 Intercoat Cleanliness

The initial blast cleaned surface and subsequent coats of paint shall be kept free of dust, dry spray, overspray, oil and grease prior to application of subsequent coats or shipping.

22.24.9 Recoat Time

The maximum and minimum recoat time for the coating system being applied shall be observed and required conditioning agents or surface roughing between coats shall be done.

22.24.10 Shipping Inspection

No product is to be shipped until the Consultant has inspected and accepted the coating. Section 22.20 shall apply. Material shipped without inspection by the Consultant, may be inspected at the receiving point with all costs of this inspection charged to the Fabricator.

22.24.11 Shipping

The coating shall be protected from damage during shipping.

22.25 Estimated Areas

The estimate of painted areas contained in the Special Provisions is presented as a convenience to the Contractor bidding the work. The areas shown will be used in pro-rating the value of work completed to date, during the course of the project. While it is believed that the areas are a good representation of the actual painted area of the structure, the Consultant makes no claim as to the accuracy of the values and in no way can be held responsible for the use of these values for any purpose whatsoever.

22.26 Payment

22.26.1 Surface Preparation and Painting

Payment for **Surface Preparation and Painting** will be made on the basis of the lump sum price bid, which shall include full compensation for the cost of furnishing all labour, materials, equipment, tools and incidentals necessary to complete the work.

Progress payments will be made on a monthly basis and will be based on the percentage of the total estimated area satisfactorily cleaned, prepared and coated as determined by the Consultant. Payment will not be made for areas which do not have the specified number of

coats for the paint system used nor for surfaces that require repair as per Section 22.21.

22.26.2 Protection of the Environment

22.26.2.1 General

Payment for **Protection of the Environment** will be made by either unit price per span or lump sum price bid as applicable. Payment will not be made for work related to shop coating projects. Payment will be full compensation for all labour, materials, equipment, tools and incidentals necessary to complete the Work to the satisfaction of the Consultant.

22.26.2.2 Unit Price per Span Price Bid

When the Unit Price Schedule contains unit price bid for this work, each payment will be made in stages as follows:

- An initial payment of 60% of the unit price bid will be made once the containment structure and equipment for a respective span have been acceptably installed; and the Contractor is prepared to commence surface preparation and painting operations.
- The final 40% of the unit price bid will be paid when the work on the respective span has been acceptably completed; all blasting spoil has been accounted for; the blasting spoil has been removed from the bridge site and the Contractor has provided the Consultant with written acceptance of the materials from the owners of the disposal site(s); the containment structure and equipment has been removed; and the area is returned to a condition acceptable to the Consultant.

22.26.2.3 Lump Sum Price Bid

When the Unit Price Schedule contains lump sum price bid for this work, payment will be made in stages as follows:

- An initial payment of 60% of the lump sum price bid will be made once the complete containment structure and equipment have been acceptably installed; and the Contractor is prepared to commence surface preparation and painting operations.
- The final 40% of the lump sum price bid will be paid once the work has been acceptably completed; all blasting spoil has been accounted for; the blasting spoil has been removed from the bridge site and the Contractor has provided the Consultant with written acceptance of the materials from the owners of the disposal site(s); the containment structures and equipment has been removed; and the area is returned to a condition acceptable to the Consultant.

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 23

STRUCTURAL LUMBER AND PILING

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23.1 General

This specification is for the supply and treatment of dimensional structural lumber and round timber piles. Dimensions are metric, imperial dimensions are shown in parentheses.

23.2 Standards

The grading shall be as per National Lumber Grading Authority (NLGA) -1999 Standard Grading Rules for Canadian Lumber and CAN/CSA O141-91 - Softwood Lumber.

The round wood piles shall be as per CAN3-056-M79.

The treatment shall conform to CSA-080-97 Wood Preservation, CSA-080.2-97 Preservative Treatment of Lumber, Bridge Ties, and Mine Ties by Pressure Process; CSA-080.3-97 Preservative Treatment of Piles by Pressure Process and American Wood Preservers Association (AWPA) Standard C1, C2, M4 and Supplementary Requirements to M4.

23.3 Material Specification

All material shall be full sawn unless otherwise noted in the Special Provisions.

23.3.1 Planking (S1S1E Strip Deck)

The material shall be Species Group HEM-FIR conforming to the stress grade "No. 1 Structural Joists and Planks" (NLGA paragraph 124 b), allowing a maximum of 20% of the Board Measure (BM) to conform to the stress grade "No. 2" of each size length supplied.

23.3.2 Sheeting, Retainers, Nailers and S1S1E Subdeck

The material shall be Coast Douglas Fir or Pacific Coast Hemlock species conforming to the stress grade "No. 1 Structural Joists and Planks" (NLGA paragraph 124 b), allowing a maximum of 15% of the Board Measure (BM) to conform to the stress grade "No. 2 Structural Joists and Planks", (NLGA paragraph 124 c).

23.3.3 Rough Caps

The material shall be Coast Douglas Fir species, conforming to the stress grade "Select Structural Posts and Timbers" (NLGA paragraph 131 a).

23.3.4 Framed Subcaps

The material shall be Coast Douglas Fir species, conforming to the stress grade "Select Structural Posts and Timbers" (NLGA paragraph 131 a). The 305 mm x 355 mm (12" x 14") cap has a length of 4.6 m (15'). From the center of the 4.6 m (15') length in both directions along the length, for the 355 mm (14") depth, the cap is cut on a continuous 2% slope which results in an end depth of 310 mm (12¼"). The 305 mm (12") width remains constant.

23.3.5 Wheelguards

The material shall be Coast Douglas Fir or Pacific Coast Hemlock species conforming to the stress grade "No. 1 Structural Beams and Stringers" (NLGA paragraph 130 b), allowing a maximum of 15% of the BM to conform to the stress grade "No. 2 Structural Beams and Stringers" (NLGA paragraph 130 c).

23.3.6 Rough Stringers

The material shall be Coast Douglas Fir species conforming to the stress grade "Select Structural Beams and Stringers" (NLGA paragraph 130 a), allowing a maximum of 10% of the BM to conform to the stress grade "No. 1 Structural Beams and Stringers" (NLGA paragraph 130 b).

23.3.7 Struts and Handrails Posts

The material shall be Coast Douglas Fir or Pacific Coast Hemlock species, conforming to the stress grade "Select Structural Post and Timbers" (NLGA paragraph 131 a) allowing a maximum of 15% of the BM conforming to the stress grade "No. 1 Structural Post and Timbers" (NLGA paragraph 131 b).

23.3.8 S1S1E Cleats

The material shall be Coast Douglas Fir or Pacific Coast Hemlock species, conforming to the stress grade "No. 2 Structural Joists and Planks" (NLGA paragraph 124 c).

23.3.9 Railing

The material shall be S4S and is to be of the Coast Douglas Fir or Pacific Coast Hemlock species conforming to the stress grade "No. 1 Structural Joists and Planks" (NLGA paragraph 124 b).

23.3.10 Piling

All piles shall be cut from sound trees of Douglas Fir or Pine. The piles shall be clean peeled soon after being felled. All bark shall be thoroughly removed and no pile shall be considered thoroughly peeled unless all the rough bark and all the inner bark have been removed. When a portion of pile is rough and convoluted, the inner bark may remain in the depressions, provided that any such depression is not more than 20 mm ($\frac{3}{4}$ " in width and 205 mm (8") in length.

(a) Dimensions

Unless otherwise specified, the minimum diameter after the outer and inner bark has been removed and after seasoning, will be as follows:

SIZES OF TIMBER PILES

Length (m)	Tip Diameter (mm)	Butt Diameter (mm)
Up to 6.1 (20')	230 (9")	305 (12")
6.2 to 12.2 (20.25' to 40')	205 (8")	305 (12")
12.3 to 18.3 (40.25' to 60')	180 (7")	330 (13")

However, a pile may be 12 mm ($\frac{1}{2}$ ") smaller in either or both tip and butt diameters in one axis provided that the minimum circumferences are as follows:

Diameter (mm)	Circumference (mm)
180 (7")	535 (21")
205 (8")	610 (24")
230 (9")	685 (27")
305 (12")	940 (37")
330 (13")	1015 (40")

The maximum butt diameter shall not exceed 405 mm (16").

(b) Sapwood

The minimum thickness of the sapwood shall be 12 mm ($\frac{1}{2}$ ") as measured on the small end of the pile. However, no pile will be rejected where the thickness of the sapwood falls below 12 mm ($\frac{1}{2}$ "), but not lower than 10 mm ($\frac{3}{8}$ ") for a distance of 150 mm (6") as measured around the circumference, provided it is of the minimum thickness around the balance of the circumference.

(c) Knots

Single knots will not be considered a defect unless they are loose or show signs of decay. A "knot cluster" that is the grouping of two or more knots together as a unit, with the fibres of the wood deflected around the entire unit, shall be reason for rejection of the pile. All knots shall be trimmed close to the body of the pile.

(d) Straightness

A line drawn from the centre of the butt and to the centre of the tip shall lie within the body of the pile. Piles shall be free from short bends in which the distance from the centre of the pile to a line stretched from the centre of the pile above the bend to the centre of the pile below the bend exceeds 4 per cent of the length of the bend, or 65 mm ($2\frac{1}{2}$ ").

(e) Pitch Streaks

Pitch streaks that extend through the length of the pile shall be cause for rejection.

23.4 Air Seasoning

Air seasoning shall be as per Clause 1.7 of CSA 080.M1-97 (Guide for Purchasers and Specifiers of Treated Wood). Moisture content shall not be more than 19% prior to treatment.

23.5 Kiln Drying

The material may be kiln dried in lieu of air seasoning as per Clause 1.10 of CSA 080.M1-97 (Guide for Purchasers and Specifiers of Treated Wood). The moisture content shall not exceed 19% prior to treatment. The supplier shall ensure that the material is stacked to allow maximum ventilation between lumber and reduce any warping or checking.

23.6 Incising

The material shall be incised on all four sides and all around for round piles prior to treatment by a method that will provide at least the minimum penetration specified without any damage and with the least loss of strength.

23.7 Creosote Treatment

- (1) The material seasoned and incised as per Clauses 4.0 or 5.0 and 6.0 shall be pressure treated using 100% creosote treatment.
- (2) Treatment shall conform to CSA-080.2-97 - Preservative Treatment of Lumber, Bridge Ties, and Mine Ties by Pressure Process and AWWA Standard C1 and C2.

The retention shall be 96 kg/m³ (6 lb/ft³) by gauge, 128 kg/m³ (8 lb/ft³) by assay.

23.8 Chromate Copper Arsenate (CCA) Treatment

- (1) When noted in the Special Provisions the planking material (strip deck) and guardrail posts seasoned and incised as per Clauses 4.0 or 5.0 and 6.0 shall be pressure treated using a waterborne preservative Chromate Copper Arsenate (CCA).
- (2) Treatment shall conform to CSA-080.2-97 - Preservative Treatment of Lumber, Bridge Ties, and Mine Ties by Pressure Process and AWWA Standard C1 and C2.
- (3) The retention and penetration shall be 6.4 kg/m³ (0.4 lb/ft³) and 10 mm (0.4"), respectively by assay.

23.9 Handling, Storage and Care of Wood

Wood shall be kept free of dirt and shall be stored in a location which will not create an excessive increase in temperature (green house effect) resulting in rapid drying of the material.

Wood shall be stored in a manner, which will prevent ponding or trapping of excess moisture between surfaces where it cannot dry readily.

Where oil treatment is used, the wood shall be given three coats of creosote oil to repair all cuts, abrasions and holes made after the pressure preservative treatment. Each coat shall be allowed to dry before the next coat is applied.

Repair of cuts, abrasions and holes in material treated with water-borne preservative shall conform to CSA 080 and AWPAs.

23.10 Inspection

The supplier shall provide for inspection of the material by an independent inspector who is qualified and has a minimum of 10 years of experience for this type of inspection. All material shall be inspected prior to and after the treatment. All material shall be stamped by the inspector identifying the inspection date and that the material meets or exceeds the required specifications. The stamp shall be placed at the end of each member in a location that is clearly visible even when the material is in a large stockpile. A written report from the inspector along with his experience and qualifications indicating the material meets the specifications with a "Certificate of Compliance" shall be forwarded to the Consultant and Owner.

23.11 Acceptance

- (1) All materials shall be subject to inspection by the Consultant/Owner prior to usage.
- (2) Where S1S1E or S4S Size is specified the material shall be not more than 6 mm ($\frac{1}{4}$ ") scant per side.
- (3) When for example 15% "No. 1" or 15% "No. 2" grade is allowed, this shall mean 85% must be the specified grade and not more than 5% of the 15% is below "No. 1" or "No. 2" grade or there will be grounds for reinspection.

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 24

SIGN STRUCTURES AND PANELS

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24.1 General

This specification is for the design, supply, fabrication, erection and all associated work pertaining to overhead and cantilevered sign structures and panels.

The underground utilities located on the drawings are approximate and are to be confirmed by the Contractor in the field.

Prior to design and construction, the Contractor shall confirm underground and overhead utility conflicts with the sign bases and support structure and immediately inform the Consultant of these conflicts. Any costs associated with addressing these underground utility conflicts shall be included in the bid price of the foundation.

24.2 Sign Structures**24.2.1 Design****24.2.1.1 Design Standards**

The design shall be carried out by the Contractor, using the general layout information prepared by the Consultant. The Contractor's design engineer shall be a Professional Engineer registered to practice in the Province of Alberta under the APEGGA Act.

The design shall be in accordance with the requirements of AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, latest Edition and Interims, unless noted otherwise in these specifications.

AASHTO equation 3-1, Clause 3.8.1, shall be modified as follows:

$$P_z = 2.5 q K_z C_d$$

where q shall be taken from CAN/CSA S6-06, Table A3.1.1 for a return period of 50 years.

The design ice thickness for ice accretion shall be the value given in CAN/CSA S6-06 Figure A3.1.4.

For the design of all cantilevered sign structures, the Fatigue Importance Factors in Table 11-1 shall be based on Fatigue Category I.

Further to AASHTO Standard Specifications section 11.7 "Fatigue Design Loads", a dynamic analysis of the structure will not be accepted in lieu of using the equivalent static pressures provided in the specifications;

Further to AASHTO Standard Specifications section 11.7.1 "Galloping", the Department will not approve the use of vibration mitigation devices in lieu of designing to resist periodic galloping forces. Furthermore, the Department requires that the galloping loads be part of the fatigue design of all overhead cantilevered sign support structures regardless of their configuration;

Further to AASHTO Standard Specifications section 11.8 "Deflection", the vertical deflection for sign structures shall not exceed 200 mm regardless of their configuration;

Design sign panel area shall be taken as the largest of:

- (a) Actual sign panels shown on the drawings.
- (b) Future sign panels shown on the drawings.
- (c) Area of 3.5 m x 60% of horizontal span length (span length includes portion of arm over clear zone), placed in any position along the span that will produce the most critical loading conditions in the structure.

Sign structures shall have a minimum permanent vertical camber of $L/200$ under a loaded condition, where L is the span of the horizontal arm of the sign structure.

Cantilever arm lengths shall not exceed 20m

The top of the concrete foundations shall project from 700 mm to 850 mm above the adjacent ground surface on the traffic side. The exposed portion of the concrete foundation shall be of circular cross-section.

The minimum vertical clearance measured to the bottom edge of sign panel of overhead sign structures shall be 6.0 metres. The bottom edge of the structural framing for the sign shall be at least 0.6 m higher than the bottom edge of the sign panels.

24.2.1.2 Design Notes and Drawings

All design notes and shop drawings, shall be stamped, signed, and sealed by the Contractor's design engineer.

Two copies of the design notes and five copies of the shop drawings shall be submitted to the Consultant for review and acceptance at least three weeks in advance of scheduled fabrication.

The Contractor shall incorporate as-built conditions and re-submit all design notes and shop drawings, at the completion of construction.

(1) Design Notes

Design notes shall be presented in a legible and logical format and shall be sufficiently detailed to allow a technical review of the design concepts and assumptions used in the design. The design notes shall include, as a minimum, calculations for the following:

- (a) Design moment, shear and axial force envelopes for serviceability and fatigue criteria.
- (b) Columns
- (c) Horizontal arm or truss
- (d) Column or arm flange bolted connections
- (e) All welded connections, stiffeners, etc.
- (f) Anchor rods
- (g) Foundation

(2) Shop Drawings

The shop drawings shall be legible and of adequate quality to be reproduced and microfilmed. All drawings shall be done on standard 11 x 17 or 22 x 34 sheet sizes.

The shop drawings shall include the following:

- (a) Alberta Transportation Bridge File numbers, A-Ident numbers and project title, as provided by the Consultant, shall be shown on all the shop drawings.
- (b) Design criteria meeting the requirements of section 24.2.1.1, for each individual sign structure, including:
 - AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals latest Edition and Interims
 - Initial sign panel area and/or minimum design sign panel area
 - Design wind pressure
 - Fatigue category and fatigue loadings
 - Design ice thickness
 - Other dead loads
 - Design temperature range
 - Foundation soils parameters
 - Critical anchor rod forces
- (c) Each individual shop fabricated section or assembly shall be shown separately with complete and clearly identified welded or bolted details.
- (d) Weld procedure identification shall be shown on the shop drawings in the tail of the weld symbols.
- (e) All material splice locations shall be shown on the drawings.
- (f) Complete material list.
- (g) Erection procedure including any temporary supports, grouting and tightening procedure for anchor rod nuts.

24.2.1.3 Consultant Review

The design notes and drawings will be reviewed by the Consultant solely to ascertain conformance with codes and specifications. Responsibility of the final design remains solely with the Contractor. The Consultant's acceptance of the shop drawings shall not be construed as relieving the Contractor from his responsibility for errors or omissions in the calculations and drawings or for proper completion of the work in accordance with the contract.

After the Consultant review, the Contractor shall revise the drawings and calculations as required to the satisfaction of the Consultant without any additional cost to the Department.

Prior to commencing fabrication, all shop drawings shall be clearly signed by the Department's Consultant as verification that the Consultant has completed his review and accepted the Shop Drawings. The Consultant's review and acceptance of the Shop Drawings will apply to general arrangements and details of design but not to figured dimensions or details of fabrication, and will be subject to the requirements of specifications and to such corrections as may be marked here on.

24.2.2 Supply and Fabrication

24.2.2.1 Standards

Fabrication of sign structures shall conform to AASHTO LRFD Bridge Construction Specifications and the American Welding Society (AWS) - Bridge Welding Code D1.5.

Where imperial/metric conversions are necessary, The National Standard of Canada, CAN3-Z234.1-79 shall be used as the basis of conversion.

All welding, cutting and preparation shall be in accordance with the American Welding Society (AWS) - Bridge Welding Code D1.5 and D1.1.

24.2.2.2 Qualification

(1) Certification

The fabricator shall operate a recognized steel fabricating shop accepted by the Consultant.

The Fabricator shall be fully approved by the Canadian Welding Bureau (CWB) as per CSA Standard W47.1 in Divisions 1 or 2.

The Contractor shall notify the Department and Consultant of any subcontractors in his employ. The Contractor shall remain responsible for the work of the subcontractors. All terms of the contract, such as CWB approval and right of access shall apply to the subcontractor.

Only welders, welding operators and tackers approved by the Canadian Welding Bureau in the particular category shall be permitted to perform weldments. Their qualifications shall be current and available for examination by the Consultant.

(2) Contractor's Quality System

The Contractor shall maintain acceptable quality management system throughout the contract. The purpose of the quality management system is to ensure that the product meets the quality requirements of the contract and is delivered on time. The Contractor's quality management system shall apply to all stages of the design, procurement, manufacturing, testing and delivery of the product.

24.2.2.3 Engineering Data

(1) Welding Procedures

Welding procedures including Welding Procedure Datasheets shall be submitted for each type of weld used in the structure. The procedures shall bear the approval of the Canadian Welding Bureau and shall also be reviewed by the Department and Consultant prior to use on the structure.

(2) Proposed Fabrication Sequence

Prior to commencement of fabrication, the Contractor shall present for review and acceptance an outline of the fabrication sequence that clearly describes the order of make-up and assembly of all the component parts, as well as shop assembly, inspection stations.

(3) Mill Certificates

Mill certificates shall be provided for all material before fabrication commences.

Where mill test certificates originate from a mill outside Canada or the United States of America, the Contractor shall have the material tested and the mill test certificate verified by a Canadian laboratory. This laboratory shall be certified by an organization accredited by the Standards Council of Canada to comply with the requirements of ISO/IEC 17025 for the specific tests or type of tests required by the material standard specified on the mill test certificate. The mill test certificates shall be stamped with the name of the Canadian laboratory and the signature of an authorized officer. It shall state that the material is in conformance with the specified Contract requirements.

(4) Schedules

The Contractor shall provide and keep current a complete fabrication schedule in a form satisfactory to the Consultant.

24.2.2.4 Materials

- (a) All materials shall be new.
- (b) The use of aluminum and aluminum alloy are not acceptable, unless specifically stated otherwise by the Consultant.
- (c) Structural steel plate material shall conform to either CSA G40.21M grade 300W* or 350W* or ASTM A572 GR. 50*. However, the yield strength of the steel plate shall be limited to 300 MPa when designing for fatigue regardless of the material used.

*Silicon content shall be less than 0.04% for the shafts, whereas for flanges and base plates the silicon content shall be either less than 0.04% or 0.15 to 0.25% inclusive.

All other structural shapes except HSS incorporated in the design shall conform to CSA G40.20M grade 300W or 350W with silicon content less than 0.04%.

- (d) HSS members shall conform to CSA G40.20M 350W Class H with silicon content less than 0.04%.
- (e) All bolts shall conform to American Society for Testing and Materials (ASTM) Standard A325 or shall meet property class 8.8 of the Industrial Fasteners Institute for metric high strength structural bolts. The nuts shall be conform to ASTM A563 and harden washers shall conform to ASTM F436. Metric bolts shall be marked with the symbol A325M and those of "weathering" steel shall have the A325M symbol underlined. Weathering steel nuts shall be marked with three circumferential lines or shall be marked with a symbol "3". Weathering steel washers shall be identified by a symbol "3". Certified mill test reports for the fastener material shall be provided.

- (f) Anchor rods shall be manufactured from smooth rods conforming to the requirements of ASTM F1554 Grade 55 ($F_y=380$ MPa). The anchor rod assembly shall consist of, but not limited to: anchor rods complete with nuts and washers, top temporary templates c/w clamping nuts, bottom anchor plates c/w anchor nuts and clamping nuts.
- (g) All steel materials including all hardware and anchor rod assemblies shall be hot-dip galvanized

24.2.2.5 Welding

(1) Filler Metals

Low hydrogen filler, fluxes and low hydrogen welding practices shall be used throughout. Filler metal with AWS designation of hydrogen level of H4 will only be permitted. The low hydrogen covering and flux shall be protected and stored as specified by AWS Standard D1.5. Flux cored welding or use of cored filler wires in the submerged arc process or shielding gas processes are not considered as conforming to low hydrogen practice. These methods will not be permitted. However metal core welding process utilizing low hydrogen electrodes will be allowed. The deposited weld metal shall provide strength, durability, impact toughness and corrosion resistance equivalent to base metal.

Field application of metal core arc welding is not allowed.

(2) Cleaning Prior to Welding

Weld areas must be clean, free of mill scale, dirt, grease, and other contaminants prior to welding.

(3) Longitudinal Seams

All longitudinal seams shall be made by an approved semi or fully automatic submerged arc or metal core welding processes.

(4) Weld Penetration

The column to base plate and flange to horizontal arm full penetration welds shall be completed using backing bars. All other full penetration welds shall be made by using backing bars or backgouged to sound metal. The longitudinal seams shall have a minimum 60% penetration. Backing bars will not be allowed for longitudinal seam welds.

The following welds shall have 100% penetration:

- (a) Column to base plate
- (b) Horizontal arm to flange plate
- (c) Longitudinal seam welds within 150 mm of circumferential welds and 150 mm beyond hand holes (when provided) shall be full penetration groove welds. Transition between full and partial penetration welds shall be ground smooth.
- (d) Backing bar splices
Backing bars shall be minimum dimensions of 8 x 30 mm for full penetration welds. These shall be properly fitted and welded all around top and bottom of the member. The groove weld shall be placed in a minimum of two passes. A reinforcing fillet weld shall be placed all around the joint.

- (5) Preheat and Interpass Temperatures
Preheat and interpass temperatures shall be as per AWS D1.5. All full penetration welds shall be preheated and interpass temperature maintained to a minimum of 100°C unless a higher temperature is required by AWS D1.5 Table 12.3 for the material thickness. The preheat temperature shall be measured 75 mm from the point of welding.
- (6) Tack and Temporary Welds
Tack and temporary welds shall not be allowed unless they are to be incorporated in the final weld. Tack welds, where allowed, shall be of a minimum length of four times the nominal size of the weld, and shall be subject to the same quality requirements as the final welds. Cracked tack welds shall be completely removed prior to re-welding.
- (7) Run-off Tabs
Run-off tabs shall be used at the ends of all welds that terminate at the edge of a member. The tabs shall be a minimum of 100 mm long unless greater length is required for satisfactory work. They shall be tack welded only to that portion of the material that will not remain a part of the structure, or where the tack will be welded over and fused into the final joint. After welding, the tabs are to be removed by flame cutting, not by breaking off.
- (8) Methods of Weldment Repair
Repair procedures for unsatisfactory weldments shall be submitted for review and acceptance by the Department and Consultant prior to repair work commencing.
- (9) Arc Strikes
Arc strikes will not be permitted. In the event of accidental arc strikes, the Contractor shall submit to the Department and Consultant for review and acceptance a proposed repair procedure. The repair procedure shall include the complete grinding out of the crater produced by the arc strike. These areas will be examined by the Consultant to ensure complete removal of the metal in the affected area.
- (10) Plug and Slot Welds
Plug welds or slot welds shall not be permitted.

24.2.2.6 Fabrication

Fabrication shall be performed in a fully enclosed area which is adequately heated. The shop temperature shall be at least 10°C. Field welding will not be allowed.

- (1) Pre-job Meeting
A pre-fabrication meeting is required prior to commencement of fabrication of sign structures. The meeting will be held at fabricator's plant and the Contractor shall ensure the plant superintendent and plant manager responsible for the work and any manufacturer's representatives directly involved in the specialized work are in attendance. The Department/Consultant will conduct this meeting after the shop drawings and welding procedures have been reviewed. The Contractor shall provide two weeks notice to the Department/Consultant prior to the meeting.

(2) Cutting of Plate

All plate material for main members and any plate material welded to the main member shall be flame cut using an automatic cutting machine. Shearing is not allowed.

Corners of plates and structural sections shall be ground to a 1 mm chamfer.

(3) Material Splices

Additional splices, other than those shown on the shop drawings, will require acceptance of the Department and Consultant. The Contractor shall bear the cost of inspection of these splices.

(4) Additional Requirements

- (a) Each column, arm, extension, clamp and bracket shall be fabricated from one piece of sheet steel with a maximum of 2 longitudinal seam welds unless accepted otherwise. Laminating of plates shall not be allowed
- (b) Intermediate circumferential butt welds will not be allowed however horizontal members greater than 12 m span may have a bolted splice.
- (c) Columns, arms, extensions and clamps shall be brake press formed or roll formed. The brake press knife shall have a radius suitable for the thickness of the material and nature of the bend. The minimum bend radius for all cold formed sections shall be 100mm.
- (d) All plates and structural sections shall be free of notches and gouges.
- (e) The depth or projection of any imperfections on the inner or outer surfaces shall not exceed 15% of wall thickness. Any depth or projection up to 33% of wall thickness may be repaired by welding. Any excessive projecting weld metal shall be removed.
- (f) The diameter of bolt holes in base plates shall be sized in accordance with CAN/CSA S6-06 Clause 10.18.4.2(a). Further, the nominal diameter of all other bolt holes shall be 2mm greater than the nominal bolt size.
- (g) Punching of full size holes will not be permitted. The holes shall be circular and perpendicular to the member and shall be deburred to ensure a proper faying surface.
- (h) Hand holes with cover plates on top and bottom of columns are to be provided for illuminated sign structures or when required as per special provisions.
- (i) Hand hole (when required) shall be stiffened by providing a reinforcing rim with semi-circular ends. The rim shall be welded to the member with a full penetration groove weld supplemented with an all around fillet weld.
- (j) Only low stress stamps shall be used for identification marks. The stamps and specific location shall be shown on the shop drawings and accepted by the Consultant.
- (k) Stiffeners are not allowed on column to base plate and horizontal arm to flange plate connections.

(5) Dimensional Tolerances

All fabrication shall meet the tolerances described below:

(a) Straightness

The straightness of any item shall not exceed the overall length divided by 300 from the surface at any point. This shall be measured with a straight line joining the surface at both ends. The difference between the straight line and the surface shall then be measured to determine the straightness.

(b) Twisting

The twist in the overall length of any column, arm, or extension shall not exceed 7°.

(c) Length

The specified length of any item shall be within 0 to 60 mm or 0 to +5% (whichever is less) with the exception of sign bridge spans which shall be within 5 mm of the specified dimensions in unloaded condition. The tolerance for height shall be – 0 to +60 mm.

(d) Across the Flat Dimensions

- i. Regular Polygonal Cross-sections: The average of all across the flats dimensions from a given cross section shall be within 1% of the specified dimension. In addition, the ratio of the maximum to minimum across the flats dimensions shall be less than or equal to 1.05.
- ii. Irregular Polygonal Cross-sections: The across the flats of the minor and major axis shall be within 2% of the specified dimensions and the sum of the minor and major axis across the flats must be within 1% of the specified dimensions.

(e) Tolerance for Flatness of Base Plates and Flange Plates

Surfaces of column base plates shall be flat to within 3 mm tolerance in 305 mm, and to within 5 mm tolerance overall. Faying surfaces of flange plates shall be flat to within 2 mm tolerance for each surface.

(f) Arm Rise

Arm rises apply to unloaded structure in the standing position.

(6) Pre-Assembly

After welding and fabrication, but prior to galvanizing, the Contractor shall pre assemble all structures complete with welded sign clamps to check the fit and geometry. Pre-assembled structures shall be inspected by the Consultant.

Following inspection by the Consultant, the structures shall be disassembled for galvanizing.

(7) Galvanizing

Factors contributing to galvanization-induced cracking shall be minimized. Galvanizing shall be by the hot dip method, after fabrication, in accordance with the current edition of ASTM A123/A123M Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products and ASTM F2329 Standard Specification for Zinc Coating Hot-Dip Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners with additions and exceptions as described in this specification. The Fabricator shall provide a smooth finish on all edges and surfaces, and remove all weld spatter and all welding flux residue from the steel components prior to galvanizing. Lumps, globules or heavy deposits of zinc will not be permitted. All threaded holes or threaded couplings shall be retapped after galvanizing.

Repair of galvanizing shall only be done if bare areas are infrequent, small, and suitable for repair. A detailed repair procedure shall be submitted and accepted prior to its use. It should be noted that repairs may require complete removal of the galvanized coating and re-galvanizing. Repair shall be in compliance with ASTM A780, Method A3 "Metallizing". However repair for areas not exceeding 100 mm² may be done in accordance with ASTM Method A1 "Repair Using Zinc-Based Alloy" The thickness of the coating for both methods shall be 180 µm, and the repair tested for adhesion. The finished appearance shall be similar to the adjacent galvanizing. The Consultant will determine the acceptability of repaired areas.

(8) Base Plate Corrosion Protection

The bottom face of each base plate shall be protected by a medium grey colour barrier coating accepted by the Consultant, to prevent contact between the zinc and the grout. The galvanized surface must be roughened prior to application of barrier coating. The surface preparation of the galvanized surface and the dry film thickness (DFT) of the coating shall be in accordance with the coating manufacturer's recommendations. The Consultant will test the adhesion of fully cured coating as per ASTM D3359 Standard Test Methods for Measuring Adhesion by Tape Test. The method selected for testing (Method A or B) shall depend on the dry film thickness of the coating. The coating manufacturer's product data sheets shall be provided to the Consultant prior to the application of the coating. The adhesion test result shall meet a minimum of "4B" classification (a maximum allowable flaking of 5%).

24.2.2.7 Testing and Inspection

(1) Access

The Contractor shall provide full facilities for the inspection of material and workmanship. Free access shall be allowed to the Consultant to all parts of the works. When required by the Consultant, the Contractor shall provide needed manpower for assistance in checking layout and performing inspection duties.

(2) Testing by the Contractor

The Contractor shall provide quality control throughout the course of fabrication. All test records made by the fabricating shop in the course of normal quality control shall be open to the Consultant for inspection. Testing and inspection made necessary by the repair of faulty work shall be paid for by the Contractor.

The Contractor shall arrange to have all full penetration welds inspected either by ultrasonic testing or radiographic inspection methods. Partial penetration seam welds shall be inspected by ultrasonic testing. The frequency of partial penetration weld inspections shall be three random locations per weld and the length of weld for ultrasonic inspection at each location shall be 200 mm. Calibration blocks for each thickness shall be prepared for ultrasonic testing to establish sensitivity levels and acceptance criteria. The NDT shall be done by a company certified to CAN/CSA W178.1. Ultrasonic and radiographic testing technicians shall be certified to Level II of CGSB. Ultrasonic testing procedure shall be submitted to the Consultant for review and acceptance prior to commencement of fabrication. A copy of test results shall be provided to the Consultant indicating the percentage of penetration. The Contractor shall not proceed to the next stage of fabrication until all the seam welds have passed the Quality Control and the results have been reviewed by the Consultant.

All costs associated with non-destructive inspection of partial and full penetration welds, preparation of calibration blocks, establishing sensitivity levels and acceptance criteria shall be the responsibility of the Contractor.

The Contractor shall be responsible for all travel, boarding and lodging costs for a Department's representative to attend the prejob meeting and two additional trips during the course of fabrication when the sign structures are being fabricated outside the Province of Alberta.

(3) Testing by the Consultant

The Consultant will perform visual inspection. Any additional NDT; such as radiographic, ultrasonic, magnetic particle and any other inspection that may be specified or required will be performed by the Consultant or by his testing agencies at the Consultant's expense.

(4) Inspection Station

To insure that each stage of inspection is performed in an orderly manner, during the fabrication, Inspection Stations will be set up at specific points. Certain items of the work will then be checked, and deficiencies shall be corrected, prior to the work being sent to the next stage of fabrication. These check points are to be agreed to by the Department and Consultant and the Fabricator prior to commencement of fabrication. The Department and Consultant reserve the right to stop detrimental fabrication between check points if deemed necessary.

(5) Non-destructive Methods of Examination

The methods of non-destructive examination shall be in accordance with the following standards:

- Radiography - AWS Standard D1.5
- Ultrasonic - AWS Standard D1.5
- Magnetic Particle - ASTM Standard E-709

(6) Inspection Schedule

All welds will be visually inspected.

Ultrasonic or radiographic inspection will be performed on full penetration welds.

24.2.2.8 Identification Tag

The Contractor shall supply and install an identification tag on one column of each structure at 2.4 m above base plate. The column shall be drilled and tapped for 2 - 10 mm diameter attachment bolts. The Identification Tag shall be fabricated as per the standard drawing S-1682.

24.2.3 Erection

Any product damaged in shipping or during erection shall be replaced at no extra cost to the Department.

The Contractor shall not erect the structural steel until the substructure concrete has been cured a minimum of three days and achieved 80% of the 28 day specified concrete strength requirement.

All components shall be handled with care to prevent stress to the components through bending or twisting. The use of steel chains as slings shall not be permitted. Any damage to the components through overstress, scratching or denting shall be repaired or replaced at the Contractor's expense to the satisfaction of the Consultant.

The Contractor shall be responsible for any additional supports to maintain stability until the anchor rod nuts are fully tightened.

After the top temporary template for the anchor rod assembly and clamping nuts are completely removed, the structure shall be set accurately on galvanized shims on top of the concrete foundation. The shim plates must be located so that a minimum of 75 mm of distance is provided from shims to grout edge. The method of forming and pouring the grout shall be submitted to the Consultant for review and acceptance. Base plates shall be grouted with Sika 212 flowable grout or equivalent. Dry pack methods of constructing grout pads will not be accepted. The top of the finished grout elevation shall not be higher than the underside of the column base plate.

Hand hole bolts shall be coated with anti-seize lubricant.

(1) High Tensile Strength Bolted Connections

Bolted parts shall fit solidly together when assembled. Contact surfaces shall be free of dirt, grease, burrs, pits and other defects that would prevent solid seating of the parts. Connections shall be assembled with a hardened washer under the bolt head or nut, whichever is the element turned in tightening. Surfaces of bolted parts in contact with the bolt head and nut shall be parallel.

(2) Bolt Tension

Each bolt shall be tightened so as to provide, when all bolts in the joint are tight, at least the minimum bolt tension shown in the following table for the size of bolt used:

Table 1 Bolt Tension

Specified Bolt Size (A325M Bolts)	Minimum Bolt Tension		Commonly Supplied Equivalent Imperial Size (A325 Bolts)	Minimum Bolt Tension	
	Kilonewtons	pounds-force		Kilonewtons	pounds-force
M16X2	94	21,180	5/8	85	19,200
M20X2.5	147	33,050	3/4	126	28,400
M22X2.5	181	40,700	7/8	175	39,250
M24X3	212	47,660	1	227	51,500
--	--	--	1 1/8	251	56,450
M30X3.5	337	75,760	1 1/4	319	71,700
--	--	--	1 3/8	380	85,450
M36X4	490	110,160	1 1/2	463	104,000

All structural bolts shall be tightened by using turn of nut method to provide bolt tension specified in Table 1. There shall first be enough bolts brought to a "snug tight" condition to ensure that the parts of the joint are brought into full contact with each other. Snug tight is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Following this initial operation, bolts shall be placed in any remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be tightened additionally by the applicable amount of nut rotation specified below, with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation there shall be no rotation of the part not turned by the wrench.

Amount of rotation of nut relative to bolt, regardless of which is turned:

- 1/3 turn where bolt length is 4 bolt diameters or less
- 1/2 turn where bolt length is over 4 bolt diameters and not exceeding 8 bolt diameters
- 2/3 turn where bolt length exceeds 8 bolt diameters

Notes

- tolerance 1/6 turn (60°) over, nothing under
- length of bolt measured from underside of head

24.2.4 Foundation

The following sections of Alberta Transportation 'Specifications for Bridge Construction' shall apply:

Section 3 'Bearing Piles'
Section 4 'Cast-In-Place Concrete'
Section 5 'Reinforcing Steel'

(1) General

The Contractor is to undertake geotechnical work at his own cost where necessary to ensure proper performance of the sign structure.

Any adjustments to the locations of sign structures will be subject to the acceptance of the Consultant.

The Contractor shall co-ordinate placement of the street light cable and conduit around the sign support foundation to avoid any conflicts.

Foundations shall be designed to allow for local frost conditions.

(2) Material

(a) All reinforcing steel shall conform to CSA G30.18-M92 Grade 400.

(b) All concrete shall be Class C - 35 MPa, with Type HS sulphate resistance cement.

(3) Anchor Rod Installation

Anchor rods shall be installed true and plumb in one complete assembly. The assembly shall be accurately positioned and secured to prevent movement or displacement during concreting procedures. No welding of any component is allowed.

The top anchor nuts shall have beveled washers if necessary to ensure full contact with the top of the column base plate. Anchor rod nuts shall be tightened an additional 1/3 turn of the nut past the snug-tight condition after the grout has attained sufficient strength. No nuts shall be allowed under the base plate. All voids including the slots and annular space around anchor rods in the base plate shall be filled with an approved corrosion inhibiting paste.

(4) Grout Pockets and Grout Pads

The Contractor shall fill the grout pockets and construct the grout pads using Sika 212 flowable grout or approved equivalent. Filling of grout pockets and construction of grout pads shall be done by workers competent in this work. The grout pocket shall be 25 mm deep and the total grout thickness shall not be less than 75 mm.

Grout shall be packaged in waterproof containers with the production date and shelf life of the material shown. It shall be mixed, placed, and cured in strict accordance with the Manufacturer's recommendations.

The method of forming and pouring the grout shall be submitted to the Consultant for acceptance. Dry pack methods of constructing grout pads will not be accepted.

(5) Protection of Sign Structures

The Contractor shall erect the sign structure in a manner that addresses all safety issues including the interim period between erection grouting and final tightening of anchor rod nuts.

After erection of the sign structures, the Contractor shall place grout pockets and pads and tighten anchor rod nuts as soon as possible after grout has achieved sufficient strength. However the Contractor shall provide adequate safe traffic accommodation until tightening and grouting is complete.

(6) Grouting in Cold Weather

When the daily minimum air temperature or the temperature of the girders, bearings or substructure concrete in the immediate area of the grouting is, or is expected to be below 5°C during the placing and curing period, the following provisions for cold weather grouting shall be applied:

(a) Before grouting, adequate preheat shall be provided to raise the temperature of the adjacent areas of the girders, bearings and substructure concrete to at least 15°C.

(b) Temperature of the grout during placing shall be between 10°C and 25°C.

(c) The grout pads shall be enclosed and kept at 15°C to 25°C for a minimum of five days. The enclosure shall meet the requirements of Section 4 of the Specifications for Bridge Construction for concreting in cold weather.

(7) Clean-Up

All steel shall be left clean and free of oil, grease, mud, dust, road spray or other foreign matter.

24.3 Sign Panels

The Contractor shall supply and install overhead sign panels as shown on the plans and in accordance with the requirements specified herein.

24.3.1 Shop Drawings

The Contractor shall provide the Consultant with three copies of the shop drawings showing the number, spacing and locations of the aluminum T-section required for each sign panel(s), assembly and mounting details. These drawings shall also detail the required method of attaching the sign panels to the sign support arms.

The Consultant's review of the shop drawings shall not be construed as relieving the Contractor from his responsibility for errors or omissions in the calculations and drawings or for proper completion of the work in accordance with the Contract.

After the Consultant review, the Contractor shall revise the drawings and calculations as required to the satisfaction of the Consultant without any additional cost to the Department.

Fabrication shall not commence prior to the review of the shop drawings.

24.3.2 Materials

Extruded aluminum panels shall be manufactured in accordance with Specification 5.18, Supply of Permanent Highway Signs, Posts and Bases of the Standard Specifications for Highway Construction, except as noted herein.

24.3.2.1 Sheeting Materials

Reflective sheeting materials used on all overhead sign and cantilever sign structures shall be in accordance with Specification 5.18.2.8.2 of the Standard Specifications for Highway Construction.

24.3.2.2 Backing

Each panel shall be fabricated from a number of rows of extruded aluminum sections bolted together. Each row of a panel shall be fabricated from a single piece of extruded aluminum up to a maximum length of 6 metres. Sign panels with a length in excess of 6 m can be split into multiple sections with a vertical joint that runs the vertical distance of the panel. The location of the vertical joint shall be chosen to minimize the number of letters/symbols split between the two sections. The number of sections for a panel shall be minimized.

A 1.0 cm wide x 2.5 cm long slotting shall be located on both edges of the extruded aluminum panels. The slotting shall be centered on the identification groove running longitudinally with the first slot centered 76 mm from the end of the section. The slotting shall be spaced on 152 mm centres for the entire length of the section.

24.3.2.3 Extruded Aluminum Preparation

The extruded aluminum panels shall be clean of dust, dirt and/or grease. The method used for cleaning must not damage the anodized finish of the extruded aluminum panels or prevent the adhesion of the sheeting material to the extruded aluminum sections.

The ends of the extruded aluminum sections shall be checked to ensure that they are cut square to ensure flush joints between both panels and sections of a panel. The maximum allowable gap between two adjacent sections or panels shall be 5 mm. All excess material found along the slots and edges of the panels shall be removed.

The joint between two sections of a single panel shall be connected together with a T-stiffener when installed on the sign support structure. Care should be taken in choosing the vertical joint location to avoid conflicts between the joint T-stiffeners and the T-stiffeners used to attach the sign panels to the sign support structure.

Adjacent sign panels shall not be connected together by a joint T-stiffener or the T-stiffener used to attach the sign panel to the sign support structure.

24.3.2.4 Application of Sheeting Materials

The sheeting material (lettering, symbols, borders, background, etc.) shall be applied to the extruded aluminum sections as required by the sheeting manufacturer and as shown on the Plans. The horizontal line of lettering/copy across a joint between panels, or sections of a sign panel, shall be less than 8 mm.

Each panel, as shown on the Plans, shall be fabricated as an individual piece to facilitate future modifications. Large individual panels may be fabricated in multiple pieces as noted herein.

For sign panels where the background sheeting material is green and/or yellow, the sheeting is to be wrapped securely around the top and bottom horizontal edges of each extruded aluminum sub panel section. The outer edges of sheeting are to be neatly trimmed flush with the vertical edges of the sign panel.

24.3.3 Construction

Signs shall be shipped, stored and installed in a manner to prevent damage to the sign panels. Any damaged signs shall be repaired or replaced at no cost to the Department.

The Contractor shall erect the sign panels onto the sign structures as shown on the Plans to ensure that the signs are located correctly over the indicated lanes and that the correct vertical clearance is maintained.

The Contractor shall provide the T-stiffeners, J-clips, bolts, flat washers, nylon insert lock nuts, slip arresting bolts and all of the necessary hardware to securely assemble the sign and connect the sign panels to the sign structure as detailed on Alberta Transportation drawing TCS-A4-335A and shown on the accepted shop drawings.

Individual extruded aluminum sign sub panels shall be fastened together using stainless steel 10 mm diameter x 25 mm long bolts, nylon insert lock nuts, and with a washer under both the bolt head and the nut. The last slot of each joint between sections shall be bolted.

The bolting of the joint between the extruded aluminum sections shall be staggered between the rows of slots, except for the last slots at either end of the section or panel.

Sign panels shall be attached to the T-stiffeners using J-clip assemblies. The J-clip assembly consists of a J-clip bolt whose square head fits into the channels that run along either edge of an extruded aluminum section, a J-clip, a washer and a nylon insert lock nut. J-clip assemblies shall be placed where the edge/joint of the extruded aluminum sections meets a T-stiffener. The J-clip assemblies shall alternate sides of the T-stiffeners.

19mm diameter x 38 mm long Stainless Steel slip arresting bolts shall be provided with each sign as follows:

Number of Standard Height Sub Panels In Sign	Overall Maximum Sign Height (mm)	Number of Slip Arresting Bolts Per Each End of Each Sign
≤ 9	2745	2
10-13	3965	4
14-17	5185	6

Stainless steel slip arresting bolts and nuts shall meet the requirements of Type 316 ASTM F593H and Type 316 ASTM F594H respectively with a minimum yield strength of 310 MPa and a minimum tensile strength of 585 MPa. A stainless steel washer shall be provided under the nut side of the bolt. Slip arresting bolts shall have nuts tightened to a torque of 181 Nm.

All joiner bolts and J-clip nuts must be tightened to a torque to 26.5 Nm within a tolerance of ± 0.5 Nm.

The face of the sign panels shall be cleaned prior to acceptance.

24.4 Measurement and Payment

24.4.1 Sign Structure

Payment for Supply and Install Sign Structures will be made at the lump sum price bid for the specified structure. Such payment will be considered full compensation for the design and construction of the foundation and sign structure, fabrication, erection and the furnishing of all materials, labour, equipment, tools, and incidentals necessary to complete the Work to the satisfaction of the Consultant.

24.4.2 Sign Panels

Sign panels for overhead sign structures will be measured in square metres based on surface area for the extruded aluminum sign panels acceptably supplied and installed.

Payment for Supply and Install Sign Panels - Extruded Aluminum will be made at the unit price bid per square metre. Such payment will be full compensation for all materials, labour, equipment, tools, and incidentals necessary to complete the Work to the satisfaction of the Consultant.

24.5 Warranty

The Contractor shall warrant that sign structures and panels are free from defect (material and workmanship) for a two year period in accordance with Specification 1.2.54 of the General Specifications.

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 25

MECHANICALLY STABILIZED EARTH WALLS

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25.1 General

This specification is for the design, supply, fabrication and construction of mechanically stabilized earth (MSE) retaining walls with precast concrete fascia panels. MSE retaining walls shall include, but not be limited to, excavation for the wall, concrete leveling pads, precast concrete fascia panels, compacted granular backfill, soil reinforcement, inspection wires, perforated drain pipe complete with filter fabric sock, geotextiles, geomembranes, surface drains, cast-in-place concrete wall coping, traffic barrier, pedestrian railing, permanent safety railing, hardware and all associated materials.

MSE retaining walls shall be designed and constructed in accordance with the provisions contained herein and as determined by the Department and the Consultant.

The Contractor shall supply all necessary materials. All components of the MSE wall system shall be supplied from one MSE supplier.

25.2 Design

25.2.1 General

Location, layout, geometry control, short and long term global stability, allowable rate of fill placement, and allowable bearing capacity requirements shall be as specified in the contract documents. The Contractor's design responsibility shall include internal and external stability (sliding and overturning), tensile resistance, pullout resistances, and all other elements for a complete MSE wall system. The Contractor shall check the global stability design using actual soil properties upon confirmation of the source of backfill.

If the wall system selected by the Contractor requires modification to any component of the project, the Contractor will be solely responsible for all costs required to complete the change. Proposed changes to the project shall be submitted to the Consultant and the Department for review and acceptance 3 weeks prior to commencement of detailed design.

The most stringent requirements of the following standards shall be met:

- Alberta Transportation Bridge Structures Design Criteria
- Alberta Transportation Roadside Design Guide
- CAN/CSA S6 – Canadian Highway Bridge Design Code (CHBDC)
- AASHTO LRFD Bridge Design Specifications

The design life for all MSE wall system components shall be 100 years.

Typical detail drawings illustrating some of the design requirements outlined in the following sections are available in the Alberta Transportation Bridge Structures Design Criteria Appendix D, SK16 through SK19.

25.2.2 Drainage

Water carrying appurtenances, such as catch basins, drainage inlets/outlets, culverts etc., shall

be placed away from, or beyond the ends of the soil reinforcement zone, and provisions shall be made to mitigate the detrimental effects of potential leakage.

All galvanized steel soil reinforcement shall be protected from exposure to roadway de-icing salt by an impermeable geomembrane placed above the top layer of soil reinforcement. The membrane shall be sealed to prevent leakage, sloped to drain away from the bridge or wall and be connected to an outlet beyond the MSE soil mass. A non-woven geotextile filter fabric layer shall be placed below and above the membrane to prevent puncture. Weep drains consisting of flexible perforated 150 mm diameter pipe complete with filter sock shall be provided near the front and the back bottom corner of the MSE soil mass. Weep drains shall be day lighted or connected to an outlet to establish positive drainage.

Downspouts shall be provided for deck joint and deck wick drain drainage. Downspouts shall be rigid PVC type DB2 conduit meeting the requirements of CSA C22.2 No. 211.1. Couplers shall be solvent bell ends (SBE). Downspouts shall have a vertical slip joint with a dished top drain inlet cast into the wall coping. Downspouts shall not be directed through the mechanically stabilized earth mass. Down spouts shall be recessed full height in a chase formed into the front of precast concrete fascia panels or by using special fascia panels and covered with a 10 gauge or 2.6 mm thick steel plate. The plate shall be shop painted with a system selected from the SS1 or SS2 category of the Department's list of approved coating systems. Surface preparation shall be in accordance with the selected coating systems published product data sheet.

The run of MSE walls shall slope away from bridge abutments. Grassed swales with a non-degradable erosion control mat shall be provided behind the top of MSE cast-in-place concrete wall coping, beyond the footprint of the bridge deck, and shall have a minimum width of 600 mm and a minimum depth of 150 mm. Concrete swales of the same dimension shall be provided behind the top of MSE cast-in-place concrete wall coping within the footprint of the bridge deck. Closed cell foam of adequate thickness to accommodate thermal movements shall be provided between the concrete swale and integral concrete bridge abutments. A 10 mm thick asphalt impregnated fibre board shall be placed between the concrete swale and semi-integral or conventional concrete bridge abutments. Swales shall have a bottom liner of impervious geomembrane.

When a headslope is provided between the bridge abutment and concrete swale it shall be protected with concrete slope protection. Isolation with closed cell foam or asphalt impregnated fibre board shall be provided between the top of the concrete slope protection and abutment concrete as described above.

25.2.3 Barriers/Railings

In locations where traffic runs adjacent to the top of, and nominally parallel to a MSE wall, a rigid bridge barrier shall be provided that meets the appropriate Performance Level requirements of the CAN/CSA-S6 CODE Section 12 – Barriers and Highway Accessory Supports. Flexible guardrail systems shall not be used. The MSE wall shall be designed to fully resist the collision loads applied to the barrier, and loads from any attachments such as sign supports and lamp posts. All obstacles, such as sign supports and lamp posts, shall meet set-back and clearance

requirements specified in the Alberta Transportation Roadside Design Guide. The barriers shall be located on top of the MSE wall, and supported on a moment slab to resist sliding and overturning. Approach rail transitions shall be provided at either end of the rigid bridge barrier as outlined in the Alberta Transportation Roadside Design Guide. Details for the Department's standard PL-2 Barrier System on top of MSE walls can be found on standard drawing S-1798.

In locations where a sidewalk or a combined pedestrian/cyclist use pathway runs adjacent to the top of, and nominally parallel to a MSE wall, a pedestrian/cyclist railing shall be provided that meets the requirements of the Alberta Transportation Bridge Structures Design Criteria Section 21.2 – Pedestrian/Cyclist Railing. The MSE wall shall be designed to fully resist the loads applied to the railing, and loads from any attachments such as sign supports and lamp posts. The railing shall be mounted on the top surface of the concrete coping of the MSE wall.

Unless a traffic barrier or a pedestrian/cyclist railing is mounted directly on top of a MSE wall, a safety railing shall be mounted on the top surface of the concrete coping of the MSE wall and shall be designed as a "guard" in accordance with the Alberta Building Code, Part 9. Safety railings shall have a minimum height of 1070 mm and shall consist of vertical posts with not less than two horizontal rails. Chain link fence shall not be used. Safety railing anchorage assemblies shall be cast within concrete coping and not field drilled. The MSE wall shall be designed to fully resist the loads applied to the railing.

In locations where traffic is running adjacent to the bottom of, and nominally parallel to a MSE Wall, and where thriebeam approach rail transitions are anchored to one or both ends of the MSE wall, anchor blocks with sufficient strength shall be provided for anchoring of the thriebeam transitions where they connect to the ends of the MSE wall.

25.2.4 Miscellaneous Details

Obstructions such as foundation piles and associated casings, or casings for future pile installations in the soil reinforcement zone, shall be accommodated with appropriate arrangement of soil reinforcement around such obstructions. For those MSE wall systems that lend themselves to splaying of the soil reinforcement, the splay angle shall not exceed 20° from perpendicular to the facing panel. For other MSE wall systems, coverage ratios of soil reinforcement shall be specifically developed for each project.

Concrete leveling pads shall be used and project a minimum of 75 mm either side of the precast concrete fascia panels. Precast concrete fascia panels shall be centered on the concrete leveling pad. For stepped leveling pads, the maximum elevation difference between adjacent steps shall not exceed 1250 mm. The minimum length of each stepped section shall be 1500 mm.

All MSE walls shall be battered back 50 to 1. MSE wall panels shall be fully supported by compacted backfill without voids on the non-exposed side.

All MSE walls shall have a cast-in-place concrete wall coping running the full length of the top of the wall. The top of the coping shall be smooth, have no steps or abrupt changes in height, and a 3% wash slope towards the back of the wall. Copings shall have a drip groove located in the soffit and control joints. Drip groove and control joints shall be detailed in accordance with

Standard Drawing S-1680 "Standard Curb Details". Control joints shall be located at precast concrete fascia panel joints, perpendicular to the wall direction and in no case exceed 4 m spacing. At control joints, longitudinal reinforcing shall be discontinuous and have a 50 mm concrete cover measured from the center of the joint.

Precast concrete fascia panels shall have a minimum thickness of 140 mm, excluding any additional thickness required for aesthetic surface treatments. The minimum cover to reinforcing steel shall be 50 mm from all faces. Joints between panels shall have a lip and recess (ship lap) configuration. Butt joints may be used if a precast HPC concrete backing block with filter fabric is designed and installed along the joint to prevent soil infiltration. Backing blocks shall overlap adjacent panels a minimum of 200 mm and have a minimum thickness of 140 mm.

Precast concrete fascia panels shall be designed to accommodate a differential settlement of 100 mm in 10 metres of length along the wall. The spacing between adjacent panels shall be designed to be 20 mm nominal. Where staged construction is required, and large differential settlement is expected between stages, appropriately located full height vertical slip joints shall be provided.

To facilitate construction of the cast-in-place concrete wall coping pre-formed holes in precast concrete fascia panels are permitted provided the holes are located a minimum of 100 mm above the wall coping soffit.

Acute wall corners less than 70° (measured between backfill sides of panels) shall not be used. Special corner panels shall be used to maintain the 20 mm nominal design joint gap along the front face of panels on either side of the bend line.

A minimum 300 mm wide strip of filter fabric shall be installed behind all precast concrete fascia panel joints. An adhesive shall be used to hold the fabric securely against the panels centered on the vertical and horizontal joints. At MSE wall corners, the fabric shall be installed in one piece.

25.2.5 Inspection Components

An inspection access walkway shall be provided full width of the bridge superstructure in front of the abutment seat and on top of MSE abutment walls. The inspection access walkway shall have a minimum vertical clearance of 1200 mm under the girders and a minimum clear width of 1000 mm.

Galvanized steel inspection wires shall be provided in all MSE wall systems in addition to the soil reinforcement design requirements. One inspection wire shall be provided for each 25 m² of wall area. Inspection wires shall be placed in vertically distributed sets of 2 or 3 depending on the wall height. Two locations shall be provided where the wall height is less than 6 m and 3 locations provided where the wall height is greater than 6 m. Vertical distribution shall be such that a single inspection wire is placed within the center of the bottom wall panel, center of the top wall panel, and in the center wall panel when 3 locations are required. Sets of inspection wires shall be evenly distributed along the length of the wall.

Inspection access ports, wire removal and centering devices shall be detailed in accordance with the California Department of Transportation standard bridge detail sheet XS13-020-3. Inspection access ports shall be cast as voids in the panels at the panel manufacturing facility and the remaining cavity placed and filled with an approved type OH-V patching product in accordance with the manufacturer's recommendations. All inspection access ports shall be marked with a 25 mm diameter galvanized survey target anchored into the patching material and flush with the wall surface. Survey targets shall not receive pigmented sealer when specified.

25.2.6 Submissions and Consultant Review

Design notes and shop drawings shall be stamped, signed and sealed by a Professional Engineer, registered to practice in the Province of Alberta.

Design notes shall be presented in a legible and logical format, and shall be sufficiently detailed to allow a technical review of design concepts and assumptions used in the design. Where necessary, the design package shall be accompanied by properties of materials used together with the appropriate test certificates.

Shop drawings shall be legible and of adequate quality to be reproduced and microfilmed. Each drawing shall have sufficient blank space for the Consultant's acceptance stamp.

As a minimum, shop drawings shall contain:

- Alberta Transportation bridge file number and project name on each drawing.
- Design criteria and material lists.
- Backfill properties.
- Wall layout plan and elevation complete with dimensions and elevations, and typical wall cross-sections.
- All component and connection details.
- Site drainage and drainage details.

Two copies of the design notes and five copies of the shop drawings shall be submitted to the Consultant for review and acceptance a minimum of 3 weeks in advance of scheduled fabrication.

The design notes and shop drawings will be reviewed by the Consultant solely to ascertain conformance with codes and specifications. Responsibility of the final design remains solely with the Contractor. The Consultant's acceptance of the shop drawings shall not be construed as relieving the Contractor from his responsibility for errors or omissions in the calculations and drawings or for the proper completion of the work in accordance with the Contract.

After the Consultant's review, the Contractor shall revise the drawings and calculations as required to the satisfaction of the Consultant without any additional cost to the Department. Prior to commencing fabrication, all shop drawings shall be clearly signed by the Department's Consultant as verification that the Consultant has completed his review and accepted the Shop Drawings.

The Contractor shall incorporate as-built conditions and submit revised design notes and shop drawings for records at the completion of construction. One paper copy and one electronic copy (PDF format) of as constructed shop drawings, design notes, and supplier inspection construction records shall be submitted to the Consultant within three weeks of wall completion.

25.3 Materials

25.3.1 Concrete

Concrete for leveling pads shall be Class C. Concrete for precast concrete fascia panels, anchor blocks, backing blocks, cast-in-place concrete wall copings, and all other concrete components shall be Class HPC. Concrete shall conform to the requirements of Section 4 “Cast-In-Place Concrete” of the Specifications for Bridge Construction. The maximum aggregate size for HPC concrete used in panel production shall suit the panel design and the requirements of CAN/CSA S6 and CAN/CSA 23.1.

25.3.2 Concrete Reinforcing Steel

Reinforcing steel shall be in accordance with the requirements of Section 5 “Reinforcing Steel” of the Specifications for Bridge Construction.

25.3.3 Soil Reinforcement

Steel reinforcement, including inspection wires, shall meet the requirements of ASTM A1064 and be galvanized in accordance with ASTM Standard A123/A123M and ASTM A153/A153M.

Geosynthetic reinforcing shall meet AASHTO LRFD Bridge Design Specifications Clause 11.10.6.4.3b. The requirements “for applications involving severe consequences of poor performance or failure” shall apply. Results of product specific durability studies carried out to determine the product-specific long term strength reduction factor (RF) shall be submitted for the Consultant’s review and approval. These studies shall be used to estimate the short term and long term effects of the environment factors on the strength and deformational characteristics of the geosynthetic reinforcement throughout the specified design life.

Geosynthetic reinforcing materials shall satisfy the requirements of the following tests with the understanding that the test methods are current at the time of construction:

- GG 1 “Standard Test Method for Geogrid Rib Tensile Strength”
- GG 2 “Standard Test Method for Geogrid Rib Junction Strength”
- GG 3 “Standard Test Method for Tensile Creep Testing of Geogrids”
- GG 4 “Standard Practice for Determination of the Long Term Creep Design Strengths of Geogrids”

Geosynthetic reinforcing materials shall contain stabilizers or inhibitors to prevent degradation of properties due to ultraviolet light exposure.

The nominal long-term reinforcement material design strength (T_{al}) values for specific products

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shall be determined by third party agencies such that as the Highway Innovative Technology Evaluation Centre (HITEC) or AASHTO National transportation Product Evaluation Program (NTPEP), and product lines shall be re-tested every 3 years at a minimum.

25.3.4 Barriers/Railings

All steel components of traffic barriers, pedestrian/cyclist railings, and safety railings shall conform to CSA G40.21M-Grade 300W, and shall be galvanized in accordance ASTM Standard A123/A123M and ASTM A153/A153M. Steel components of traffic barriers, pedestrian/cyclist railings, and safety railings shall be fabricated in accordance with Section 12 "Bridgerail" of the Specifications for Bridge Construction.

25.3.5 Backfill

Backfill for construction of MSE walls shall be crushed aggregate material conforming to the gradation requirements listed in the following table:

Metric Sieve Size (CGSB 8-GP-2M)	Designation/Class		
	Crushed Aggregate Material Des 2 Class 20	Crushed Aggregate Material Des 2 Class 25	Crushed Aggregate Material Des 2 Class 40
	Sieve Size µm	Percent Passing	Percent Passing
125 000			
80 000			
50 000			
40 000			100
25 000		100	70 - 94
20 000	100	82 - 97	----
16 000	84 - 94	70 - 94	55 - 85
10 000	63 - 86	52 - 79	44 - 74
5 000	40 - 67	35 - 64	32 - 62
1 250	22 - 43	18 - 43	17 - 43
630	14 - 34	12 - 34	12 - 34
315	9 - 26	8 - 26	8 - 26
160	5 - 18	5 - 18	5 - 18
80	2 - 10	2 - 10	2 - 10
% fractures by weight (2 faces)	60+	60+	50+

Standard Specifications for Bridge Construction Section 25, Mechanically Stabilized Earth Walls

Metric Sieve Size (CGSB 8-GP-2M)	Crushed Aggregate Material Des 2 Class 20	Crushed Aggregate Material Des 2 Class 25	Crushed Aggregate Material Des 2 Class 40
Plasticity Index		NP - 6	NP - 6
L.A. Abrasion Loss Percent Maximum		50	50

The MSE wall supplier shall use the physical properties of the backfill selected by the Contractor shall in his design. In no case shall any backfill placed within 2.0 m of the face panels have more than 5% passing the 80 µm sieve size. Soil filters between soil zones shall be designed based on the properties of the adjacent materials.

The selected backfill shall also meet the following parameters based on soil reinforcement type used in the MSE wall system:

BACKFILL REQUIREMENTS FOR GALVANIZED STEEL REINFORCING

Backfill Requirement		Test Method (ASTM)	Test Method (AASHTO)
Resistivity	≥ 3000 ohm-cm	G57	T 288
pH	5 - 10	G51	T 289
Chlorides	≤ 100 ppm	D512	T 291
Sulphates	≤ 200 ppm	D516	T 290
Organic Content	≤ 1.0%	D2974	T 267

BACKFILL REQUIREMENTS FOR GEOSYNTHETIC REINFORCING

Backfill Requirements		Test Method (ASTM)	Test Method (AASHTO)
pH	3 - 12	G51	T 289
Organic Content	≤ 1.0%	D2974	N/A
Design Temperature at Site	≤ 30°C	N/A	N/A

Collection of samples for testing shall be from proposed stockpiles at the top, middle and bottom portions, approximately 0.6 m in from the face of the stockpile. Resistivity testing shall be completed on 6 samples (2 top, 2 middle, 2 bottom). PH, chloride, sulphate, and organic content testing shall be completed on 9 samples (3 top, 3 middle, 3 bottom).

25.3.6 Geotextile Filter Fabric

Non-woven geotextile filter fabric shall comply with the following minimum physical properties:

NON-WOVEN GEOTEXTILE FILTER FABRIC REQUIREMENTS

Fabric Requirements		Test Method (ASTM)
Grab Strength	≥ 650 N	D4632
Elongation - Failure	≥ 50%	D4632
CBR Puncture Strength	≥ 275 N	D6241
Trapezoidal Tear	≥ 250 N	D4533

The minimum fabric lap length shall be 300 mm.

25.3.7 Impermeable Geomembrane

Impermeable geomembrane shall be PVC, HDPE or LLDPE with a minimum thickness of 0.75 mm, and comply with the following minimum physical properties:

IMPERMEABLE GEOMEMBRANE REQUIREMENTS

Impermeable Geomembrane Requirements		Test Method (ASTM)
Tear Strength	≥ 45 N	D1004
CBR Puncture Strength	≥ 140 N	D6241

Specific designs may warrant the use of roughened surface geomembranes. The membrane shall be installed in accordance with the manufacturer's recommendations. All seams in the membrane shall be welded or bonded to prevent leakage.

25.3.8 Concrete Sealer

Sealer shall be applied to exposed concrete surfaces in accordance with Section 4 of the Specifications for Bridge Construction.

25.4 Precast Concrete Fascia Panel Fabrication

The fabrication of precast concrete fascia panels shall be in accordance with Section 7 "Precast Concrete Units" of the Specifications for Bridge Construction, CAN/CSA A23.4, and as modified by this Section.

All edges of precast concrete fascia panels shall be chamfered.

Geosynthetic reinforcing embedded into precast concrete fascia panels shall exit perpendicular.

Concrete shall have a minimum strength of 18 MPa prior to formwork removal.

Exposed precast concrete fascia panels shall be finished in accordance with Section 4 of the Specifications for Bridge Construction with the exception that all required surface cavities shall be filled with a Department approved concrete patching material. The entire exposed panel fascia finish texture shall be a form finish and not a washed or rubbed finish.

Panels with the following defects shall be rejected, and new panels provided:

1. Units with variation in panel face trueness for any line across a panel face from a straight edge exceeding 2 mm over 1 m;
2. Units with honeycombing, cracks, spalls or broken corners;
3. Units with more than 10 surface cavities per square metre with cavity diameters from 2 mm up to 5 mm;
4. Units with more than three surface cavity per square metre with cavity diameter from 5 mm up to 10 mm; and
5. Units with any surface cavities greater than 10 mm in diameter.

Inspection and assessment of surface cavities shall be carried out by the Contractor immediately after stripping of forms. Surface cavities of 5 mm or less on panels meeting the above acceptance criteria will not require further repair.

Repair of surface cavities shall be completed in a sheltered environment and with a minimum ambient temperature of 10°C. Saturation of the face of the panels in preparation for the repair of surface cavities shall begin immediately after stripping. During repair of surface cavities, and up to the start of elevated temperature curing or moist curing, panel faces shall be kept in a continuously wet condition. As an alternative to moist curing with filter fabric, panels may be moist cured in an enclosure with controlled temperature and humidity such that all exposed concrete surfaces remain saturated for the duration of the curing period. If stacked during curing, sufficient space shall be maintained between panels to permit airflow and inspection of surfaces.

25.5 Construction

25.5.1 General

The Contractor shall employ qualified personnel experienced in constructing MSE walls to supervise and perform the work. Construction of the MSE wall system shall conform to the shop drawings, supplier's recommendations, and these specifications.

The Contractor shall also require the supplier of the MSE wall system provide a full-time qualified representative on site during construction to advise the Contractor's personnel regarding construction procedures and to monitor that construction is being completed in accordance with the shop drawings and the supplier's recommendations. The suppliers on site representative shall provide the Consultant with a weekly summary report detailing daily construction activities and compliance. Work that is not in compliance with the shop drawings or supplier's recommendations shall be reported to the Consultant immediately.

MSE wall components that are damaged during any construction operation shall be removed and replaced at the Contractor's expense.

25.5.2 Conformance Criteria

The Contractor shall provide formalized documentation, sealed and signed by the Professional Engineer registered in the Province of Alberta, for each of the following construction phases:

- Foundation base preparation
- On-site delivery of all components
- Alignment of precast wall panels
- Backfill requirements

25.5.3 Excavation

The Contractor shall establish the locations and extents of all underground services in the work area prior to commencement of work. All underground service locations shall be clearly marked and protected during the course of construction. Damages to existing services resulting from the Contractor's operations shall be repaired at the Contractor's expense.

Excavation for the MSE wall shall be carried out in conformance with Section 1 "Excavation" of the Specifications for Bridge Construction and these specifications. Excavation shall be completed to the design grades shown on the design drawings, shop drawings, and as determined by the Consultant. The Contractor shall proof roll the foundation subgrade after excavation to identify any soft spots. Soft material, as determined by the Consultant, shall be removed and replaced with compacted granular material to the satisfaction of the Consultant. Any temporary excavation support required shall be the full responsibility of the Contractor and no separate or additional payment will be made.

25.5.4 Concrete Leveling Pads

Construction of concrete leveling pads shall conform to the requirements of Section 4 "Cast-In-Place Concrete" of the Specifications for Bridge Construction. Concrete leveling pad elevations shall be set by instrument. Tolerance from design profile shall be 3 mm over a 3 m length and panels shall be centered on the leveling pad.

25.5.5 Backfill

Backfill shall include the supply, placing and compaction required for construction of the MSE wall systems and be in accordance with Section 2 "Backfill" of the Specifications for Bridge Construction and these specifications. 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 disturbances of the wall materials or misalignment of the precast concrete fascia panels. Any MSE wall components that are damaged during backfill placement shall be removed and replaced at the Contractor's expense. Any misalignment or distortion of the precast concrete fascia panels due to placement of backfill shall be corrected by the Contractor at his expense.

Where geosynthetic reinforcement is used, overlap of geosynthetic reinforcement can occur in walls with curves or acute angle corners. For any wall layout where overlap of geosynthetic reinforcement occurs, a minimum 75 mm of compacted backfill shall be placed between geosynthetic reinforcement layers.

No equipment shall be allowed to run directly on soil reinforcement. Backfill compaction shall be performed such that equipment moves parallel to the wall panels and away from the precast concrete fascia panels toward the end of the soil reinforcement. Only hand operated power tampers and vibrators shall be used for compaction within 1000 mm of the wall panels. The Contractor shall slope the last level of backfill away from the wall panels, at the completion of each day's work to direct potential surface run-off away from the wall face. In addition, the Contractor shall not permit any surface run-off from adjacent areas to enter the wall construction site.

Backfill compaction testing of the reinforced backfill shall be done at a minimum frequency of one test per lift for every 45 m of wall or part thereof with no less than one test per day. Backfill compaction shall be measured in accordance with Alberta Transportation Test Method ATT-58A, "DENSITY TEST, Control Strip Method". The density of compacted backfill shall be a minimum of 98% of the control strip density.

The Contractor shall also complete the following sampling and testing of the backfill during construction to demonstrate continued compliance:

SAMPLING AND TESTING OF BACKFILL PROPERTIES DURING CONSTRUCTION

Range of Resistivity (ohm-cm)	Sample Interval for Resistivity Testing (m ³)	Sample Interval for PH, Chlorides, Sulphates, Organic Testing (m ³)
>5000	3000	1500
<5000	1500	750

Test results shall be submitted to the Consultant within 3 days of completion. If any test result does not meet specification requirements, the Contractor shall stop backfilling operations immediately and resample and test the backfill. Additional testing of material already placed may be required and will be determined by the Consultant. Backfilling operations shall not recommence until all additional sampling and testing is completed and any non-compliant backfill removed and replaced. All costs associated with sampling and testing, including removal and replacement of non-compliant backfill will be at the Contractor's expense.

25.5.6 Precast Concrete Fascia Panel Installation Tolerances

Installation tolerances of precast concrete fascia panels shall be:

1. Flatness of wall surfaces measured in any direction shall not exceed 25 mm under a 3 m straight edge.

2. Offset of adjacent panel edges at joints shall not exceed 10 mm.
3. Overall vertical alignment of the completed wall shall not exceed 4 mm/m of the total wall height.
4. Joint width shall be between 10 mm and 30 mm.

Should any panels be out of tolerance, the backfill shall be removed and the panels reset to the specified tolerance.

All precast concrete fascia panel lifting hook pockets shall be patched with an approved type NH or HEH concrete patching material.

25.5.7 Cast-in-Place Concrete Wall Copings

Construction of cast-in-place concrete wall copings and surface finishes shall conform to the requirements of Section 4 "Cast-In-Place Concrete" of the Specifications for Bridge Construction. Cast-in-place concrete wall coping elevations shall be set by instrument. Tolerance from design profile shall be 3 mm over a 3 m length.

Galvanized anchor bolt assemblies for railings shall be cast into the concrete.

Cast-in-place concrete wall coping sections at corners shall be isolated from contact with other concrete components with 12 mm thick closed cell foam.

25.5.8 Impermeable Geomembrane

Seams of impermeable geomembranes shall be placed parallel to the MSE wall and lapped in the direction of positive drainage to produce a shingling effect. Seams shall be welded in accordance with the manufacturer's recommendations and in weather conditions acceptable to the Consultant.

25.5.9 Barrier/Railings

All steel components of traffic barriers, pedestrian/cyclist railings, and safety railings shall be constructed in accordance with Section 12 "Bridgerail" of the Specifications for Bridge Construction.

25.5.10 Material Storage

The Contractor's lay-down area shall be graded level to ensure panels are safely and uniformly supported on timber bearing blocks with plastic separators. Precast concrete fascia panels shall be stacked on timber planks or pallets and separated by timber blocks with dimpled plastic separators designed by the precast supplier's engineer. Soil reinforcement and connectors shall be stored above ground. All materials shall be covered and protected from rain, snow, dirt, ultraviolet light, and damage. Precast concrete fascia panels shall be stored such that the uniform color of the panels is maintained and protected from staining or discoloration. Panels with stained, discoloured, or damaged front faces shall not be incorporated into the wall.

25.6 Payment

Measurement for payment of mechanically stabilized earth walls will be based on the square metre of installed precast concrete fascia panels in place.

Payment will be made at the unit price bid for “**Mechanically Stabilized Earth Wall**”, and will be full compensation for design, construction, and submission of as-built shop drawings, design notes and construction records. Payment will also include, but not be limited to, excavation, backfill and compaction below the MSE walls where required; all excavation, concrete leveling pad construction, backfill material and compaction within and beyond the MSE wall zone necessary for construction of the MSE wall; the supply and installation of precast concrete fascia panels complete with epoxy coated reinforcing steel; cast-in-place concrete wall coping complete with epoxy coated reinforcing steel; soil reinforcement and inspection wires; sealer; drains; traffic barriers and anchor blocks; the supply and installation of galvanized steel safety railing including anchor bolts and swales at the top of the MSE wall; and all labour, material, equipment, tools and incidentals necessary to complete the Work.

STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 26

RCP AND PBC STRUCTURES

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Drawing No.

Installation of Large Steel Pipes S-1418

26.1 General

This specification describes the supply, manufacture, delivery and installation of Reinforced Concrete Pipes and Precast Box Culvert structures.

Abbreviations for the various types of pipe and box culvert are as follows:

RCP	Reinforced Concrete Pipe
PBC	Precast Box Culvert

26.2 Supply and Manufacture

26.2.1 Standards

26.2.1.1 Reinforced Concrete Pipe

The supply and manufacture of all indirect designed Reinforced Concrete Pipe including any maintenance holes (manholes), and flared end pipe sections shall be in accordance with the current edition of CSA A257 or ASTM C 76. For pipe sizes of 1050 mm or larger direct design pipe in accordance with the current edition of ASTM 1417M "Standard Specification for Manufacture of Reinforced Concrete Sewer, Storm Drain, and Culvert Pipe for Direct Design (Metric)" may be used by the engineer, following the design procedure in the American Society for Civil Engineers (ASCE) "Standard Practice for Direct Design of Buried Precast Concrete Pipe using Standard Installations (SIDDD) No.15".

26.2.1.2 Precast Box Culvert

The supply and manufacture of all Precast Box Culverts shall be in accordance with the current edition of ASTM 1433M "Standard Specification for Precast Reinforced Concrete monolithic Box Sections for Culverts, Storm Drains, and Sewers (Metric)" following the design procedure in the American Society for Civil Engineers (ASCE) "Standard Practice for Direct Design of Buried Precast Concrete Box Sections".

26.2.2 Engineering Data

26.2.2.1 Shop Drawings and Design Reports

(a) Reinforced Concrete Pipe

Shop drawings and design reports shall be provided to the Consultant illustrating that the Reinforced Concrete Pipe has been designed by the direct design methods in accordance with ASCE SIDDD No.15. Design factors outlined in the CAN/CSA S6 Canadian Highway Bridge Design Code (CHBDC) shall govern over the ASCE and the ASTM documents.

Shop drawings and design reports submitted to the Consultant shall include the Alberta Transportation bridge file number and project name.

(b) Precast Box Culvert

Shop drawings and design reports shall be provided to the Consultant illustrating that the Reinforced Concrete Box has been designed by direct design methods in accordance with ASCE 28. Design factors contained in the CAN/CSA S6 Canadian Highway Bridge Design Code (CHBDC) shall govern over the ASCE and the ASTM documents.

Shop drawings and design reports submitted to the Consultant shall include the Alberta Transportation bridge file number and project name.

26.2.3 Materials

26.2.3.1 Cement

All reinforced concrete pipes and precast box culverts shall be manufactured from sulphate resistant Type HS or HSb cement in accordance with CSA A3001.

26.2.3.2 Reinforcing Steel

Reinforcing steel shall conform to the Specifications for Bridge Construction, Section 5 - Reinforcing Steel.

26.2.3.3 Gaskets

All gaskets supplied for reinforced concrete pipe projects shall meet the requirements of CSA 257.3.

The precast box culvert sections shall be joined with preformed flexible joint sealants in accordance with ASTM C990 or rubber gaskets compliant with ASTM C1619.

26.2.4 Qualification

The prime Contractor shall notify the Department and Consultant of any subcontractors in his employ. The Contractor shall remain responsible for the work of the subcontractor.

The manufacturer shall operate a recognized precast concrete manufacturing plant and be fully certified by the Ontario Concrete Pipe Association (OCPA) Prequalification Program.

26.2.5 Identification

26.2.5.1 Pipe

All pipes supplied shall be marked in accordance with ASTM 1417M standards:

- The pipe designation shall be indicated as follows:
 - Di _____ , T _____ , H _____ - _____ where,
 - Di = designated pipe nominal inside diameter, mm,
 - T = type
 - H = minimum-maximum fill height, m
- The date of manufacture,
- The manufacture's name or trademark
- The plant identification
- For pipe with elliptical reinforcement or otherwise requiring special placement, appropriate marking to indicate the correct installed orientation.
- Plant Prequalification Symbol

26.2.5.2 Box Sections

All boxes supplied shall be marked in accordance with ASTM 1433M standards:

- The box designation shall be indicated as follows:
 - S _____ , R _____ , H _____ - _____ where,
 - S = designated box section span, mm,
 - R = designated section rise, mm,
 - H = minimum-maximum fill height, m
- The date of manufacture,
- The manufacture's name or trademark
- The plant identification (Box Id)
- One end of each box section designed to be installed with the top slab up shall be legibly marked during the process of manufacturing or immediately thereafter on the inside and outside of the top slab, or shall have the top identified by the location of one or more lift holes or devices
- Plant Prequalification Symbol

26.2.6 Shop Inspection

All terms of the contract shall apply to the subcontractor. The Department and Consultant shall have rights to access the subcontractor's plant to perform quality assurance inspection, as deemed necessary.

26.2.6.1 Notification

The Contractor shall notify the Consultant a minimum of 72 hours prior to the start of manufacture to facilitate inspection of the materials at the plant. Material that has not been inspected and accepted by the Consultant at the manufacturer's plant will not be passed for payment until such material has been inspected and accepted. The Contractor will be responsible for all expenses incurred for the material to be inspected by the Consultant at the site.

26.2.6.2 Inspection, Sampling and Testing

All materials shall be subject to inspection, sampling and quality assurance testing by the Consultant. The Contractor shall provide safe, convenient access acceptable to the Consultant for inspection and sampling of the materials, and shall cooperate in the inspection and sampling process when requested to do so. Any material found unacceptable by the Consultant shall be replaced or repaired with acceptable material by the Contractor at the Contractor's expense.

All costs associated with the re-inspection required by the Consultant due to faulty work shall be paid for by the Contractor.

26.2.6.3 Crack Identification/Repairs

Cracks in RCP or PBC identified either at the manufacturer's plant or at the project site will require action as follows:

- Cracks equal to or less than 0.2 mm, in width are considered minor and shall be documented on the inspection report.
- Cracks greater than 0.2 mm and less 0.3 mm in width shall be assessed by the manufacturer and a repair or replacement strategy developed. The repair or replacement strategy shall be submitted to the Department and Consultant for review and acceptance prior to the commencement of the repair or replacement work. The Consultant shall be present for all repair work undertaken by the manufacturer or Contractor.
- Sections with cracks 0.3 mm in width or greater shall be rejected.

26.2.7 Stockpiles

All material shall be unloaded and stockpiled in a neat and orderly manner, to facilitate inspection and inventory, and in such a manner as to ensure suitability for the work. Stockpiled materials, accepted on delivery as to quantity and observed condition, shall be subject to further testing, and shall meet the specified requirements at the time they are to be used in the work. Reinforced concrete pipe should be stockpiled at ground height rather than stacking two or more pipes in height.

26.2.8 Handling of Material

All RCP and PBC material shall be handled carefully and in such a manner as to prevent cracking, gouging or chipping the concrete surfaces. All rubber gaskets shall be kept warm at room temperature prior to installation during winter months. Culvert material designated by the Consultant as unacceptable, due to failure to meet the specified requirements, shall be immediately repaired or replaced by the Contractor at his expense.

26.3 Installation

The installation of RCP and PBC shall be carried out in a professional manner meeting all the requirements of the preparation of bedding and haunch gravel as specified on the drawings. It is essential that the structure be kept dewatered to the bottom of the excavation until all backfilling is complete.

Installation of RCP and PBC shall follow both ASTM C1479M and CAN/CSA S6 Canadian Highway Bridge Design Code respectively.

The Contractor shall submit documentation of lifting procedures for the Consultant's review, two weeks prior to installation of RCP or PBC.

26.3.1 Excavation

Excavation shall be done to the lines and grades shown on the drawings, or as determined by the Consultant, and in accordance with the appropriate sections of Section 1 "Excavation" of the Specifications for Bridge Construction.

26.3.2 Bedding/Backfill

26.3.2.1 Reinforced Concrete Pipe

Excavation and backfill shall conform to Figure 3 “Standard Trench Installation” from ASTM C1479M and Section 7.8 from CAN/CSA S6 Canadian Highway Bridge Design Code.

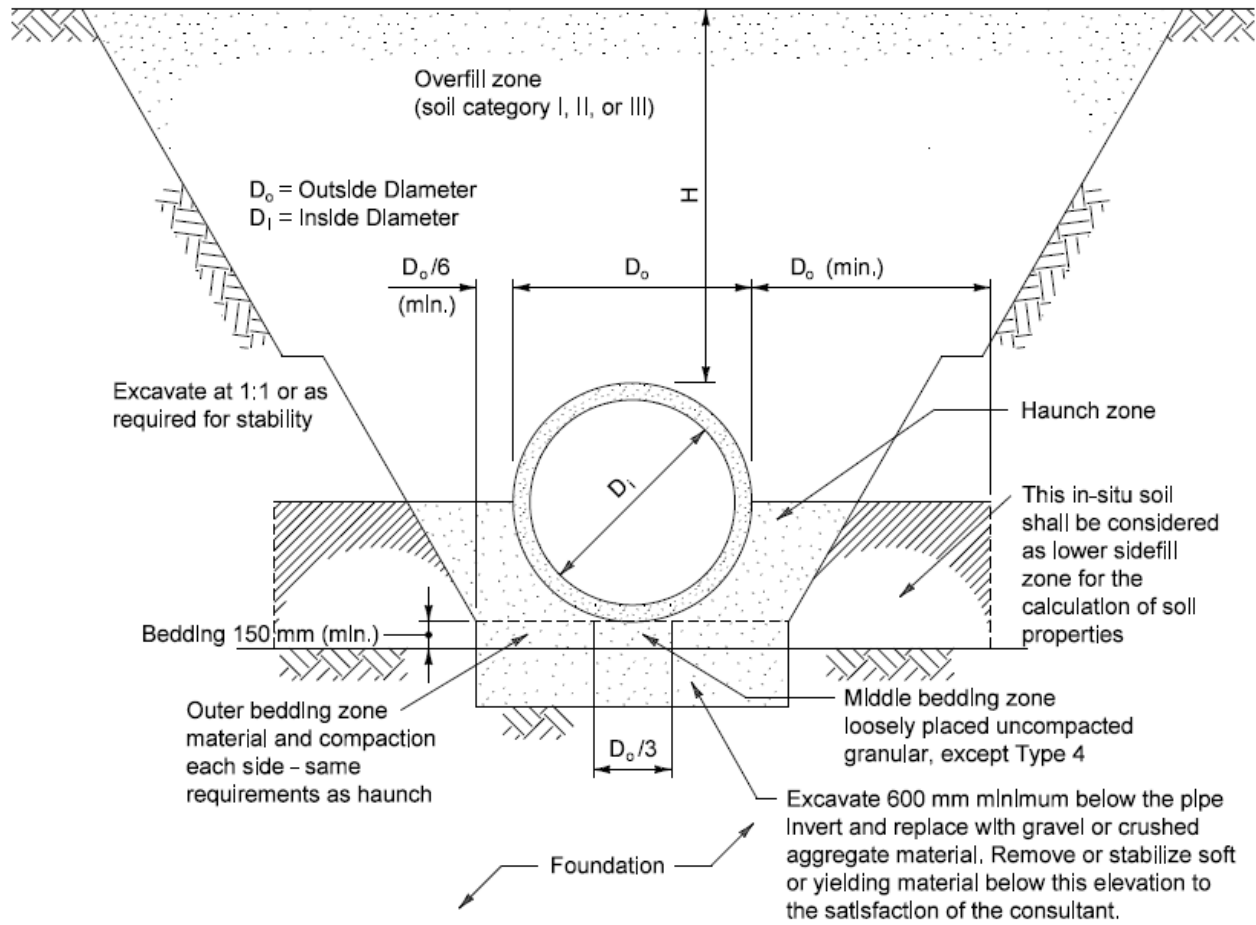


Figure 3 Standard Trench Installations

Bedding and haunch criteria for reinforced concrete pipe shall follow one of the following bedding types based on the Consultant's design:

Installation Type	Bedding Thickness	Haunch and outer bedding	Lower side
Type 1	$D_o/24$ minimum; Not less than 75mm If rock foundation, use $D_o/12$ minimum; Not less than 150 mm	95% Category I	90% Category I 95% Category II or 100% Category III
Type 2	$D_o/24$ minimum: Not less than 75mm If rock foundation, use $D_o/12$ minimum; Not less than 150 mm	90% Category I or 95% Category II	85% Category I 90% Category II or 95% Category III
Type 3	$D_o/24$ minimum: Not less than 75mm If rock foundation, use $D_o/12$ minimum; Not less than 150 mm	85% Category I 90% Category II or 95% Category III	85% Category I 90% Category II or 95% Category III
Type 4	No bedding required, except if rock foundation, use $D_o/12$ minimum; Not less than 150 mm	No Compaction required, except If Category III, use 85% Category III	No Compaction required, except If Category III, use 85% Category III

D_o denotes the outside diameter

Categories of soil for haunch and bedding material shall be defined by the following table as per ASTM 1479M:

Soil	Representative Soil Types		% Compaction	
	USCS ASTM Practice D 2487	ASSHTO M145	Standard Proctor	Modified Proctor
Category I	Clean, coarse grained soils: SW, SP, GW, GP or any soil beginning with one of these symbols with 12% or less passing a 75 µm sieve	A-1, A-3	100	95
			95	90
			90	85
			85	80
Category II	Coarse grained soils with fines: GM, GC, SM, SC or any soil beginning with one of these symbols, containing more than 12% passing a 75 µm sieve Sandy or gravelly fine-grained soils: CL, ML, (or CL-ML, CL/ML, ML/CL) with 30% or more retained on a 75 µm sieve	A-2-4, A-2-5, A-2-6; OR A-4 OR A-6 soils with 30% or more retained on a 75 µm sieve	100	95
			95	90
			90	85
			85	80
Category III	Fine-grained soils: CL, ML, (or CL-ML, CL/ML, ML/CL) with less than 30% retained on a 75 µm sieve	A-2-7; or A-4 or A-6 with less than 30% retained on a 75 µm sieve	100	90
			95	85
			90	80
			85	75
Category IV but not allowed for haunch and bedding	MH, CH, OL, OH, PT	A-5, A-7	100	90
			95	85
			90	80

Compaction Specifications:

Standard proctor density – AASHTO T 99, T 310, or Test Methods D 698

Modified proctor density – AASHTO T 180 or Test Methods D 1557

When the bottom of the excavation lies below the pipe invert, the fill material shall be compacted by the Contractor to a minimum of 95% of Standard Proctor Density at optimum moisture content up to the bedding material.

The thickness of the bedding material shall be according to that previously stated and shall be placed in a loose, un-compacted state under the middle third of the pipe. The bedding elevation shall be constructed as per the thickness of the pipe and the Consultant's proposed invert elevation.

Haunch material need only extend to the 'springline' of the pipe. Clean material void of rocks and sharp objects shall be used in the overfill zone from the springline of the pipe to the road surface.

26.3.2.2 Precast Box Culvert

Figure 7.11 illustrates the excavation and backfill requirements.

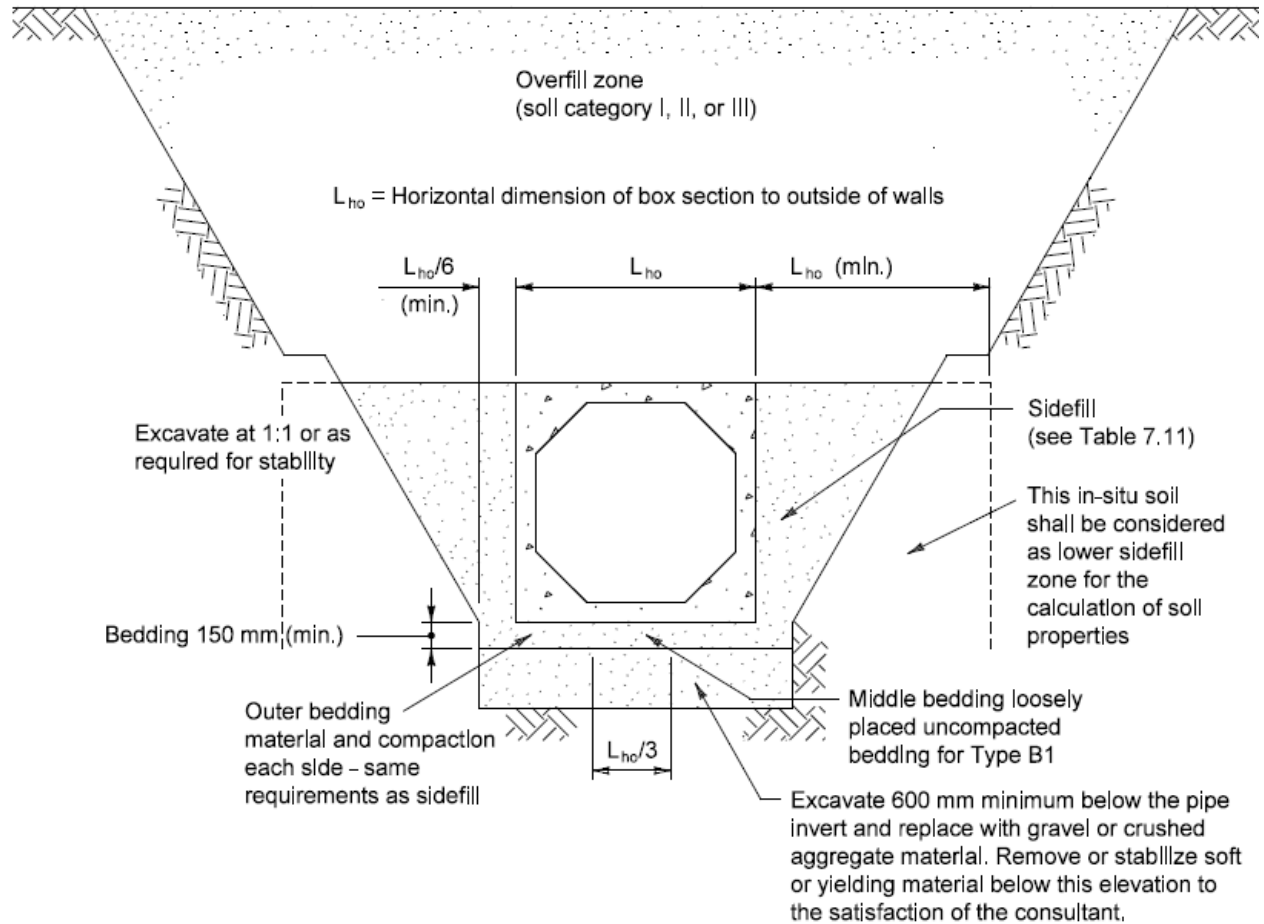


Figure 7.11
Standard Installations for Concrete Box Sections in Trenches

Bedding and haunch criteria for precast box culverts shall conform to one of the following installation types from the CHBDC:

Table 7.11
Soils and compaction requirements for standard installation for concrete boxes
(See Clauses 7.8.3.6.1 and Figures 7.10 and 7.11)

Installation type	Soil group	Equivalent minimum Standard Proctor compaction in side fill and outer bedding zones
B1	I	90%
	II	95%
	III	Not permitted
B2	I	80%
	II	85%
	III	95%

Soil group categories for bedding material shall be defined by the following table as per CHBDC:

Soil group ¹	Description	Unified Soil Classification symbols ²
I	Sand and gravel	SW, SP, GW, GP
II	Sandy silt	GM, SM, GC and SC with less than 20% passing #200 sieve
III	Sandy clay	CL, MH, GC and SC with more than 20% passing #200 sieve

¹ See Table 7.4

² According to ASTM D 2487

When the bottom of the excavation lies below the culvert invert, the fill material shall be compacted by the Contractor to a minimum of 95% Standard Proctor Density at optimum moisture content.

The thickness of the bedding material under the middle 1/3 of the culvert, referenced in the previous table, shall be placed in a loose, un-compacted state. The bedding elevation shall be constructed as per the thickness of the box and at the Consultant's proposed invert elevation.

26.3.3 Installation

26.3.3.1 Reinforced Concrete Pipe (RCP)

Placing and assembly of the pipe may proceed only after excavation, foundation and bottom bedding material have been inspected and accepted by the Consultant.

Assembly of RCP shall include a rubber gasket at each joint conforming to CSA 257.3. The Contractor shall implement proper installation methods and conformance to the manufacturer's recommendations for the rubber gaskets for the particular type of gasket being installed.

Allowable joint gap spacing between two joined pipe sections shall not exceed 13 mm.

Contractor shall:

- Install and join pipe sections in accordance with the manufacturer's recommendations.
- Install the reinforced concrete pipe from the lowest elevation to the highest elevation with the bell end upstream.
- Clean both inside of the bell end and outside of the spigot end prior to installation.
- Keep all rubber gaskets at room temperature and out of direct sunlight. Gaskets shall be free of dirt, oil and grease.
- Where pipe sections are supplied with a protruding bell, excavate at each bell section ensuring uniform support underneath the pipe as per Figure 4 below (ASTM 1479M).
- If the installed pipe section is not on an acceptable grade, the pipe section shall be completely unjoined, the grade corrected, and the pipe then rejoined.
- Use lifting clutches with a 3-legged chain sling (wire or link) for pipe diameter 1050 mm or larger.

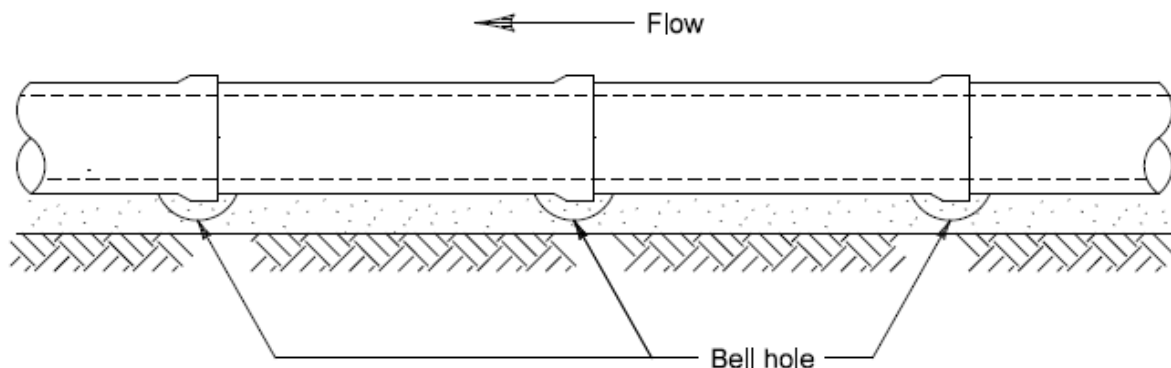


Figure 4 Uniform Pipe Support

Under no circumstances shall the Contractor:

- Use an excavator, or any other mechanical device to push, pound, drop, or rock the pipe to achieve the proper grade.
- Drag pipe along the ground to either stockpile or install the pipe.
- Unload pipe by rolling off a truck and dropping onto the ground.

26.3.3.2 Precast Box Culvert (PBC)

Placing and installation of the box may proceed only after the excavation, foundation and bottom bedding material and shape have been inspected and accepted by the Consultant.

Installation of the PBC shall include a rubber gasket and/or coil sealants such as Kent Seal or Con Seal at each joint conforming to CSA 257.3. The Contractor shall implement proper installation methods for the rubber gaskets for the particular type of gasket being installed.

Allowable joint gap spacing between joined box sections shall not exceed 13 mm.

Contractor shall:

- Install and join sections in accordance with the manufacturer's recommendations.
- Install the precast box culvert from the lowest elevation to the highest elevation.
- Clean the inside of both ends prior to joint installation.
- Keep all rubber gaskets at room temperature and out of direct sunlight. Gaskets shall be free of dirt, oil and grease.
- Use lifting clutches in conjunction with the embedded lifting pins (anchors).
- If the installed section is not on an acceptable grade, the section shall be completely unjoined, the grade corrected, and the box section then rejoined.

Under no circumstances shall the Contractor:

- Use an excavator, or any other mechanical device to push, pound, or rock the culvert to achieve the proper grade.
- Drag boxes along the ground to either stockpile or install the section.

26.3.4 Backfilling

When installation of the structure has been accepted by the Consultant, backfilling with granular and/or non-granular materials as specified on the drawings and in Section 26.3.2 may proceed. Backfilling shall be in accordance with the current version of the standard drawing S-1418 "Installation of Large Steel Pipes" and Section 2 "Backfill" of the Specifications for Bridge Construction. In addition, the following requirements shall be met:

- When the ambient air temperature is below 0°C, no backfilling is allowed unless otherwise accepted by the Department and the Consultant. When acceptance is granted, all backfill material shall be in a thawed state when placed and compacted. Backfill material shall not be placed on frozen substrate.
- Backfilling under the haunches shall be compacted to achieve density as per Section 26.3.2 "Bedding/Backfill".
- Backfilling shall be free of voids and provide uniform support to the structure. The backfill shall be placed such that the level of fill on one side does not exceed the level of fill on the other side of the structure by more than 300 mm.
- Should vibratory equipment be required, the backfill shall be placed and compacted by equipment moving parallel to the structure with simultaneous handwork along the structure.

- Clean material void of rocks and sharp objects shall be used from the springline of the structure to the road surface.
- Should in situ material be used in place of granular material, the in situ material shall also extend to the springline of the structure as per the compaction required by the Consultant. The Consultant shall confirm the in situ material conforms to the type and compaction level as specified on the drawings.
- The Contractor shall supply suitable material for the compacted non-granular backfill. Generally the material shall consist of clay or till materials. Highly plastic clay material or material with high silt content will not be permitted. The quality of the material, and the methods of placing and compacting, requires acceptance by the Consultant before commencement of this stage of construction.

26.4 Fish Passage Infrastructure

Fish passage infrastructure shall be constructed as shown on the drawings and be fabricated in accordance with the applicable specifications.

26.5 Rock Riprap

Rock riprap shall be placed as shown on the drawings and shall conform to the Specifications for Bridge Construction Section 10 "Heavy Rock Riprap".

26.6 Measurement and Payment

Unless otherwise specified on the drawings or in the "Special Provisions" payment for the following items:

- Detour Road - Construct and Maintain
- Salvage or Disposal of Existing Structure
- Excavation
- Reinforced Concrete Pipe or Precast Box Culvert - Supply
- Granular Backfill - Des 6 Class 80
- Crushed Granular Backfill - Des 2 Class 40
- Non-Granular Backfill
- Reinforced Concrete Pipe or Precast Box Culvert Installation
- Fish Passage Infrastructure
- Guardrail
- Roadway Work
- Heavy Rock Riprap

will be on the basis of the unit price or lump sum prices bid for each of these items of work, acceptably completed. Payment for the supply and installation of Reinforced Concrete Pipe or Precast Box Culvert will be based on the unit price bid per metre in place. The prices bid shall include full compensation for the cost of furnishing all labour, materials, equipment, tools and incidentals necessary to complete the work.

When materials are delivered to the worksite, payments for: "Reinforced Concrete Pipe or Precast Box Culvert – Supply" will be made to a maximum of 90% of the cost of the materials based upon the applicable supplier's invoices. Payments will not be initiated until the Contractor submits the invoices to the Consultant upon receipt and acceptance of the material at the site. The remaining payment will be made after the structure is backfilled and accepted by the Consultant.

When woven geotextile filter fabric is specified, the supply, placing, equipment and tools necessary to acceptably complete this work will be considered incidental and no separate or additional payment for this incidental work will be made.

When woven geotextile filter fabric is not specified but deemed necessary as determined by the Consultant due to unsuitable foundation conditions, the supply, placing and the related work will be paid for by a negotiated lump sum price or in accordance with 1.2.25 "Extra Work" of the General Specification as determined by the Consultant.