CONSTRUCTION SPECIFICATION FOR PRECAST REINFORCED CONCRETE BOX CULVERTS WITH SPAN 3M OR LESS IN OPEN CUT

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422.01 SCOPE

This specification covers the requirements for the installation of precast reinforced concrete box culverts with span 3m or less (but including imperial sized spans of 3.048 m) in open cut and includes the requirements for concrete appurtenances, excavation, bedding, backfilling, and cover material.

422.02 REFERENCES

This specification refers to the following standards, specifications or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 209 Embankments Over Swamps
OPSS 404 Support Systems
OPSS 501 Compacting
OPSS 517 Dewatering
OPSS 539 Temporary Protection Systems
OPSS 902 Excavating and Backfilling - Structures
OPSS 904 Concrete Structures
OPSS 905 Steel Reinforcement for Concrete

Ontario Provincial Standard Specifications, Material

OPSS 1002	Aggregates - Concrete
OPSS 1004	Aggregates - Miscellaneous
OPSS 1010	Aggregates - Base, Subbase, Select Subgrade, and Backfill Material
OPSS 1205	Clay Seal
OPSS 1301	Cementing Materials
OPSS 1302	Water
OPSS 1350	Concrete - Materials and Production
OPSS 1440	Steel Reinforcement for Concrete
OPSS 1821	Precast Reinforced Concrete Box Culverts with Span 3m or Less
OPSS 1860	Geotextiles

MTO Laboratory Testing Manual

LS-706	Moisture - Density Relationship of Soils Using 2.5 kg Rammer and a 305 mm Drop

CSA Standards

A23.1-19/A23.2-19	Concrete Materials and Methods of Concrete Construction/Methods of Test for Concrete
A23.3-19	Design of Concrete Structures
S6-19	Canadian Highway Bridge Design Code

ASTM International

D2487 - 06	Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D2488 - 17	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
D3665 - 12(2017)	Standard Practice for Random Sampling of Construction Material
D6938 - 17a	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

422.03 DEFINITIONS

For the purpose of this specification the following definitions apply:

Backfill means earth, rock, or granular material used as fill within the excavation placed beyond the limits of bedding and cover below the subgrade elevation, including frost tapers.

Bedding means the material used to cushion and evenly distribute the soil reaction at the bottom of the structure.

Box Culvert means a culvert constructed of precast reinforced concrete box units rectangular in cross-section, with a span 3m or less (but including imperial sized spans of 3.048m).

Box Unit means a single precast reinforced concrete box unit of a box culvert.

Concrete Appurtenances means head walls, cut-off walls, aprons, collars, and any other concrete fixtures associated with the box culverts, excluding concrete bedding or concrete structures covered elsewhere in the Contract Documents and specified as such.

Cover means the material placed as a protective layer around the box unit to prevent damage to the box unit.

Distribution Slab means a reinforced concrete slab placed directly on the top slab of a box culvert when there is less than 600 mm of earth fill cover to improve load distribution on culvert.

Earth means earth as defined in OPSS 902.

Excavation, Earth and Rock means the excavation material classified as earth and rock according to OPSS 902.

Excavation, Swamp means swamp excavation as defined in OPSS 209.

Lot means lot as defined in OPSS 1821.

Native Material means the original material removed to form an excavation and which is acceptable to the Contract Administrator for return to the same or other excavation as backfill or cover.

Rock means rock as defined in OPSS 902.

Soil means soil as defined in OPSS 902.

422.04 DESIGN AND SUBMISSION REQUIREMENTS

All box units shall be designed according to CSA S6-19.

Electronic file of the fabrication and assembly drawings, including handling details, produced by the manufacturer shall be submitted to the Contract Administrator two weeks prior to delivery of the box units. All Working Drawings shall bear the seal and signature of an Engineer certifying they are according to the Contract Documents.

The design shall be according to CSA S6-19 and as specified in the Contract Documents.

Culverts shall be waterproofed as specified in the Contract Documents.

422.05 MATERIALS

422.05.01 Concrete

Concrete for appurtenances and distribution slab shall be according to OPSS 1350.

422.05.02 Granular

Granular shall be according to OPSS 1010.

422.05.03 Fine Aggregates for Levelling Course

Fine aggregate for levelling courses shall be according to OPSS 1002.

422.05.04 Precast Reinforced Concrete Box Units

Precast reinforced concrete box units shall be according to OPSS 1821.

422.05.05 Connector Plates

Connector plates shall be in accordance with ASTM A240/240M Type 304 and stainless steel threaded rods shall be in accordance with ASTM F593 Type 316 with nuts in accordance with ASTM F594.

422.05.06 Steel Reinforcement

Steel reinforcement for concrete appurtenances and concrete distribution slab shall be according to OPSS 1440.

422.05.07 Mortar

Mortar for joints shall be according to OPSS 904. The Portland cement type GU shall be according to OPSS 1301, mortar sand shall be according to OPSS 1004, and water shall be according to OPSS 1302.

422.05.08 Clay Seal

Clay seal shall be according to OPSS 1205

422.05.09 Preformed Gasket

Preformed gaskets shall be as specified by the manufacturer of the box units.

422.05.10 Joint Sealing Compound

Joint sealing compound shall be as specified by the manufacturer of the box units.

422.05.11 Grout

Grout shall be non-shrink and non-staining.

422.05.12 Geotextile

Geotextile type shall be as specified in the Contract Documents and according to OPSS 1860.

422.05.13 Native Material

Native material shall be classified according to the Unified Soil Classification System using the procedures prescribed in ASTM D2488. When precise classification of native material is required, ASTM D2487 shall be used.

422.05.14 Bedding

Bedding shall be as specified in the Contract Documents.

Earth bedding material shall be classified as Group I or Group II according to Table 1.

Granular aggregate materials shall be according to OPSS 1010.

422.05.15 Cover

Cover shall be as specified in the Contract Documents. Earth cover material shall be classified as Group I or Group II according to Table 1.

Cover shall be free of stones having a diameter greater than 75 mm, debris, or frozen materials.

422.05.16 Backfill

Backfill material shall be according to OPSS 902. Earth backfill shall be classified as Group I, Group II or Group III according to Table 1.

422.07 CONSTRUCTION

422.07.01 Selection of Box Units

The box units shall be in accordance with OPSS 1821 based on the dimensions and height of fill as specified in the Contract Documents.

422.07.02 Excavation

The excavation for the installation of the box units shall be according to OPSS 902.

422.07.03 Support Systems

Support systems shall be according to OPSS 404.

422.07.04 Dewatering

Dewatering shall be according to OPSS 517.

422.07.05 Temporary Protection Systems

Temporary protection systems shall be according to OPSS 539.

422.07.06 Foundations

The foundation shall be comprised of firm to hard in situ soil or compacted backfill, or as specified in Contract Documents

When unsuitable or unstable material is encountered during the excavation for the foundation, with approval of the Contract Administrator, the unsuitable or unstable material shall be removed to firm to hard in situ soil and replaced to the foundation grade with compacted backfill meeting the requirements of Group I or Group II, according to Table 1. The foundation on each side of the box unit, for a minimum distance equal to the inside width of the box unit shall be at least as stable as the foundation below the box unit.

The final founding elevations shall be as specified in the Contract Documents and approved by the Contract Administrator.

422.07.07 Bedding

Bedding shall be placed to the dimensions shown in the Contract Documents.

Bedding shall be placed in layers not exceeding 200 mm in thickness, loose measurement, and each layer shall be compacted according to OPSS 501.

When precast concrete box culvert is a substitute for cast-in-place concrete box culvert, the depth of the bedding under the precast culvert shall be as shown on the cast-in-place drawing, but no less than 300 mm. This layer shall form a bedding/levelling course for the substitute concrete box culvert.

Bedding shall not be placed on frozen earth grade.

422.07.08 Levelling

The surface prepared to support the box units shall have a 75 mm minimum thickness top levelling course of uncompacted Granular A or fine aggregates.

422.07.09 Installing Box Units

422.07.09.01 Box Units

Box units shall be installed to the alignment and grade specified in the Contract Documents.

Box units shall not be installed on bedding containing frozen material.

End units to accommodate concrete appurtenances shall be as specified in the Contract Documents. End two box units shall be a minimum of 2.44 m in length, all other units shall be a minimum of 0.914 m in length. All box units shall be less than 3.1m in length. The box units shall be installed to make a continuous line forming a box culvert.

The gap at box unit joints shall not exceed 15 mm. The gaps over 15 mm shall be addressed by removal and replacement of the box unit to achieve a joint not exceeding 15 mm.

For box units placed in parallel for multiple cell installations, a 60 mm ± 10 mm gap filled with grout between adjacent cells shall be provided.

Installation of the box units shall commence at the outlet end and proceed in the upstream direction with the bell ends of the box units facing upgrade. The box units shall be placed with the base of each box unit in uniform contact with the prepared bedding throughout its full length. The ends of the box units shall be joined so there is no unevenness along the inside. The box units and joint surfaces shall be kept clean as work progresses. Water shall not be allowed to flow through the box units during installation. The excavation shall be kept dry and the box units shall not be installed in water.

422.07.09.02 Connector Plates

Connector plates shall be used to connect the end culvert unit to the adjacent unit and at all other joint locations as specified in the Contract Documents.

422.07.09.03 Joint Treatment

Joints between box units shall be provided with a preformed seal. All joints, including the bottom side of culvert, shall be effectively covered to prevent influx of material from the backfill or native soil through the joints. Unless otherwise specified, material for the joint cover shall be geotextile.

The geotextile shall be according to OPSS 1860 and be free of defects, rips, holes, flaws, deterioration or damage incurred during manufacture, transportation or storage.

The geotextile cover layer shall have minimum overlaps of 500 mm and shall be pinned together or adhered to the concrete surface.

422.07.09.04 Mortared Joints

When mortared joints are specified in the Contract Documents, all joints shall be thoroughly cleaned and wetted. Mortar shall then be applied over the joint around the inner and outer perimeter. After the mortar joint is complete the joint inside shall be wiped clean and smooth.

422.07.09.05 Preformed Seal

Preformed seal shall be placed according to the manufacturer's recommendations.

422.07.09.06 Lift Holes

All lift holes shall be filled with mortar after installation of the box unit.

422.07.09.07 Inspection After the Installation of the Culvert and Prior to Waterproofing

After installation of all elements of a culvert within a construction stage, and prior to waterproofing, a Request to Proceed shall be submitted to the Contract Administrator. The next operation shall not proceed until a Notice to Proceed has been received from the Contract Administrator.

422.07.09.08 Waterproofing of the Culvert

When specified, waterproofing of the culvert shall be according to the Contract Documents.

422.07.10 Concrete in Culverts - Concrete Appurtenances and Distribution Slab

Concrete placement, curing, sampling and testing for cast-in-place concrete appurtenances, protection slabs or distribution slabs shall be according to OPSS 904. Reinforcing steel shall be placed according to OPSS 905.

When a protection slab or distribution slab is required, it shall be according to the Contract Documents. The protection slab or distribution slab shall be placed without any damage to or movement of the culvert.

422.07.11 Backfill

Backfill shall be placed in layers not exceeding 300 mm in thickness, loose measurement. Compaction shall be according to OPSS 501.

Backfilling on each side of the box units shall be completed simultaneously without any movement of the box culvert. At no time shall the levels on each side differ by more than 400 mm. When native material is specified as backfill in the Contract Documents, earth material may be substituted, if the substitute material is approved by the Contract Administrator. In areas within the roadway, for a depth equal to the frost treatment depth, earth backfill shall have frost susceptibility characteristics similar to the native material.

Rock may be used as backfill provided the installed box units are protected by a minimum thickness of cover material as specified in the Contract Documents.

Box unit installation and backfill shall be completed prior to the start of any subbase and base course construction over the box unit location.

Shoring and bracing shall be withdrawn and removed as the excavation is being backfilled.

422.07.12 Cover

Cover shall be placed in layers not exceeding 200 mm in thickness, loose measurement, and each layer shall be compacted according to OPSS 501.

Cover shall be placed without any damage to or movement of the box culvert.

Cover in trenches and in other locations where pavements require controlled differential settlement shall be of a type and compaction level to control pavement differential settlement within acceptable limits for the specified type of pavement.

422.07.13 Clay Seal

When a clay seal is specified in the Contract Documents, the clay seal shall be placed to the dimensions specified in the Contract Documents and compacted to a minimum of 95% of the maximum dry density (MDD). The MDD shall be determined from LS-706, carried out on a single representative sample. Field density and field moisture determinations shall be made according to ASTM D6938.

422.07.14 Management of Excess Materials

Management of excess material shall be as specified in the Contract Documents.

422.08 QUALITY ASSURANCE

422.08.01 General

The acceptance of culvert shall be according to the requirements of this specification, including satisfactory completion of any repairs.

All culvert installation alignments shall meet the following requirements:

a) Alignment of elements: ± 10 mm

b) Joint Gap: 20 mm maximum

c) Gap between adjacent side-by-side box (multi-cell culverts): ± 10 mm

d) Dimensional variation not otherwise specified: 1:800 or +/- 5mm, whichever is greater.

422.08.02 Access for Quality Assurance

Unhindered access for inspection and testing of all the work shall be provided to the Contract Administrator or Owner's representative.

Any debris and obstructions shall be removed to allow access for the purposes of covermeter and dimensional measurements or inspection.

422.09 MEASUREMENT FOR PAYMENT

422.09.01 Actual Measurement

422.09.01.01 Precast Concrete Box Culvert, Fabrication

Measurement for the fabrication of precast concrete culverts shall be by the horizontal length in metres along the centerline of the invert of the culvert.

422.09.01.02 Precast Concrete Box Culvert, Delivery and Installation

Measurement for the delivery and installation of precast concrete culverts shall be by the horizontal length in metres along the centerline of the invert of the culvert.

422.09.02 Plan Quantity Measurement

When measurement is by Plan Quantity, such measurement shall be based on the units shown in the clause under Actual Measurement.

422.10 BASIS OF PAYMENT

422.10.01 Precast Concrete Box Culvert, Fabrication (Span 1800 mm) - Item
Precast Concrete Box Culvert, Fabrication (Span 2400 mm) - Item
Precast Concrete Box Culvert, Fabrication (Span 3000 mm) - Item

Payment at the Contract price for the above tender items shall be full compensation for all labour, Equipment, and Material to do the work.

Payment for precast units used as a substitute for cast-in-place units shall be based on the tender quantities for construction of cast-in-place units including any concrete appurtenances.

422.10.01.01 Payment Adjustment for Air Void System in Hardened Concrete

The payment adjustment shall be calculated based on individual lots according to OPSS 1821 and applied as follows:

Payment reduction for a lot = Lot quantity/tender quantity x Price x ((100 - P)/100)

Where:

Lot quantity = volume of concrete in a lot (m^3) (calculated based on plan dimension)

Tender quantity = volume of concrete in tender (m^3) (calculated based on plan dimension)

Price = Contract price for the Fabrication tender item

P = pay factor for the lot according to the spacing factor specified below:

Spacing Factor, mm	Pay Factor (P)
> 0.200 but ≤ 0.220	90
> 0.220 but ≤ 0.240	80
> 0.240 but ≤ 0.250	70

422.10.01.02 Payment Adjustment for Rapid Chloride Permeability

The payment adjustment shall be calculated based on individual lots according to OPSS 1821 and applied as follows:

Payment adjustment = Lot quantity x (C-2500)/5

Where:

Payment adjustment = payment adjustment of a lot ($)

C = rapid chloride permeability of a lot (coulombs)

Lot quantity = volume of concrete in a lot (m^3) (calculated based on plan dimension)

The payment adjustment for concrete containing silica fume shall be calculated based on individual lots and applied as follows:

Payment adjustment = Lot quantity x (C-1000)/5

Where:

Payment adjustment = payment adjustment of a Lot ($)

C = rapid chloride permeability of a lot (coulombs)

Lot quantity = volume of concrete in a lot (m^3) (calculated based on plan dimension)

422.10.02 Precast Concrete Box Culvert, Delivery and Installation (Span 1800 mm) - Item
Precast Concrete Box Culvert, Delivery and Installation (Span 2400 mm) - Item
Precast Concrete Box Culvert, Delivery and Installation (Span 3000 mm) - Item

Payment at the Contract price for the above tender items shall be full compensation for all labour, Equipment, and Material to do the work.

Corrective work, including investigation of defects and deficiencies, design of repairs, site access, traffic staging and removal of existing work, shall be at no additional cost to the Owner.

422.10.03 Clay Seal

Payment for clay seal shall be according to OPSS 902.

422.10.04 Granular

Granular material used for bedding, backfill, cover, and frost tapers shall be paid for under the appropriate granular items specified in the Contract Documents.

Payment will not be made for granular used to fill any area excavated beyond the lines specified in the Contract Documents or used as cover when acceptable quality native material is available.

422.10.05 Steel Reinforcement in Concrete Appurtenances

Payment for steel reinforcement in concrete appurtenances shall be according to OPSS 905.

422.10.06 Concrete in Culverts

Payment for concrete in culverts shall be according to OPSS 904.

422.10.07 Excavation for Box Culverts

Payment for earth and rock excavation shall be according to OPSS 902.

Payment for excavation quantities for precast units used as a substitute for cast-in-place units shall be based on the tender quantities for excavation for cast-in-place units.

422.10.08 Swamp Excavation

Where swamp excavation is required to place precast concrete box culverts, payment for the swamp excavation shall be under the tender item covering the swamp excavation for earth embankment construction.

TABLE 1
Soil Gradation Requirements for Earth Bedding, Backfill and Cover Materials

Group	Grain Size	Description	Symbols
I	16-64 mm	Well-Graded Gravel, Gravel-Sand Mixtures, little or no fines	GW
	16-64 mm	Poorly-Graded Gravel, Gravel-Sand Mixtures, little or no fines	GP
	0.5-2 mm	Well-Graded Sand, Gravelly Sand, little or no fines	SW
	0.5-2 mm	Poorly-Graded Sand, Gravelly Sand, little or no fines	SP
II	4-16 mm	Clayey Gravel or Gravel-Sand-Clay Mixtures	GC
	0.25-0.5 mm	Clayey Sand or Sand-Clay Mixtures	SC
	0.25-0.5 mm	Silty Sand or Sand-Silt Mixtures	SM
	4-16 mm	Silty Gravels or Gravel-Sand-Silt Mixtures	GM
	0.06-0.25 mm	Inorganic Silts and Very Fine Sands, Silty or Clayey Fine Sands, Clayey Silts	ML
III	2-4 mm	Clayey Gravel or Gravel-Sand-Clay Mixtures	GC
	<0.06 mm	Clayey Sand or Sand-Clay Mixtures	SC
	<0.06 mm	Inorganic Clay, Gravelly Clay, Sandy Clay, Silty Clay, Lean Clay	CL
	<0.06 mm	Inorganic Silts, Micaceous or Diatomaceous Fine Sandy or Silty Soil	MH