



**CONSTRUCTION SPECIFICATION FOR INSTALLATION OF
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 3 m or less (including imperial sized spans of 3.048 m) in open cut and includes the requirements for concrete appurtenances, excavation, bedding, backfilling, granular cover and protection layer.

422.02 REFERENCES

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

Ontario Provincial Standard Specifications, Construction

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 1303	Admixtures for Concrete
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

Ontario Ministry of Transportation Publications

MTO Laboratory Testing Manual:

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

MTO Forms:

PH-CC-701 Request to Proceed

PH-CC-702 Notice to Proceed

CSA Standards

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

ASTM International

A240/A240M-22	Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels for General Applications
D2487-17	Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D2488-17	Practice for Description and Identification of Soils (Visual-Manual Procedure)
D6938-17a	Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
F593-17	Specification for Stainless Steel Bolts, Hex Cap Screws and Studs
F594-09(2020)	Specification for Stainless Steel Nuts

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 as defined in OPSS 1821.

Box Unit means as defined in OPSS 1821.

Competent Native Material means rock, or soil with a density of compact or greater or a consistency of firm or greater, or otherwise determined by the Contract Administrator to be suitable as a foundation material.

Concrete Appurtenances means head walls, cut-off walls, aprons, collars, and any other concrete fixtures associated with the box culverts.

Protection Layer means the material placed 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 206.

Granular Cover means the material placed as a protection layer above the culvert to prevent damage to the culvert.

Lot means lot as defined in OPSS 1821.

Native Material means the original material removed to form an excavation.

Protection Slab means a reinforced concrete slab that may be placed on the top of the culvert in an area exposed to chlorides. See also distribution slab.

Rock means rock as defined in OPSS 206.

Soil means soil as defined in OPSS 902.

422.04 DESIGN AND SUBMISSION REQUIREMENTS

422.04.01 Design Requirements

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

422.04.02 Submission Requirements

422.04.02.01 Working Drawings

Electronic file of the fabrication and assembly drawings, including handling details, joint sealing compound, preformed gaskets material, placement of preformed seal produced by the manufacturer shall be submitted to the Contract Administrator 2 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.

422.04.02.02 Concrete Mix Designs

The concrete mix for concrete appurtenances, protection and distribution slabs shall be designed to provide adequate strength and durability for the intended use and to meet the requirements as specified in the Contract Documents. The concrete mix design shall be submitted according to the Mix Design clause of OPSS 1350.

422.05 MATERIALS

422.05.01 Backfill

Granular backfill material shall be according to OPSS 1010.

Earth backfill shall be classified as Group I, Group II according to Table 1. Within the areas of the Roadway, earth backfill shall have frost susceptibility characteristics similar to the native material for a depth equal to the frost treatment depth.

Rock backfill shall be according to the Rock Backfill to Structure subsection of OPSS 206.

422.05.02 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.

422.05.03 Clay Seal

Clay seal shall be according to OPSS 1205

422.05.04 Concrete

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

422.05.05 Connector Plates

Connector plates shall be according to ASTM 240M Type 304. Stainless steel threaded rods shall be according to ASTM F593 Type 316 with nuts according to ASTM F594.

422.05.06 Protection Layer

Protection layer shall be as specified in the Contract Documents.

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

422.05.07 Geotextile

Geotextile shall be according to OPSS 1860. Geotextile type shall be as specified in the Contract Documents and free of defects, rips, holes, flaws, and deterioration.

422.05.08 Granular Cover

Granular cover shall be one of the following, or as specified in the Contract Documents:

- a) Granular A, according to OPSS 1010.
- b) Granular B, Type I or II, with 100% passing the 26.5 mm sieve, according to OPSS 1010.

422.05.09 Grout

Grout shall be non-shrink.

Cementing materials for grout shall be according to OPSS 1301. Sand for grout shall be mortar sand according to OPSS 1004. Water for grout shall be according to OPSS 1302. Admixtures for grout shall be according to OPSS 1303.

The workability of the grout mix shall be suitable for the application.

422.05.10 Joint Sealing Compound

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

422.05.11 Leveling Course

Leveling course shall be fine aggregate according to OPSS 1002.

422.05.12 Mortar

Mortar for joints shall be according to OPSS 904.

422.05.13 Native Material

Classification of native material shall be according to ASTM D2487. The Contract Administrator shall determine if the native material is acceptable for use in the work.

422.05.14 Precast Reinforced Concrete Box Units

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

422.05.15 Preformed Gasket

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

422.05.16 Steel Reinforcement

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

422.07 CONSTRUCTION

422.07.01 Selection of Box Units

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

422.07.02 Delivery and Storage

The Contract Administrator shall be notified in writing a minimum of 3 Business Days prior to delivery of the box units.

Delivery shall include transportation, loading and unloading, and storage of the box units. Transportation and storage of the box units shall be according to CSA A23.4.

Box unit shall be loaded for shipping in such a manner that they can be transported and unloaded at their destination without being damaged or exposed to stresses for which they were not designed. Box unit, when stored, shall be stored in such a manner to avoid damage or excessive stress.

Storage includes, but is not limited to, storage while awaiting delivery in temporary locations or, at the job site.

Lifting, storing, and transporting shall be as specified in the Working Drawings.

Advertising by means of removable signing shall be permitted on box unit only while in transit to the site. Any permanent markings on a surface that would be visible after installation shall not be permitted.

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 Foundation

The foundation shall be as specified in the Contract Documents.

The excavation shall not disturb the material beyond the excavation limits.

When directed by the Contract Administrator, native material encountered at the excavation limits that is not considered to be competent shall be:

- a) subexcavated to competent native soil or rock, in the presence of the Contract Administrator; and
- b) the subexcavation backfilled with material acceptable to the Contract Administrator and compacted according to OPSS 501.

422.07.07 Bedding

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

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

Bedding shall not be placed on frozen earth grade.

422.07.08 Levelling Course

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

422.07.09 Installing Box Units

422.07.09.01 General

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.

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

End units to accommodate concrete appurtenances shall be as specified in the Contract Documents. End box units shall be a minimum of 2.0 m in length, all other units shall be a minimum of 0.914 m in length. All box units shall be less than 3.1 m in length. The box units shall be installed to make a continuous line forming a box culvert.

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.

The gap at box unit joints shall not exceed 20 mm.

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

422.07.09.02 Connector Plates

Connector plates shall be installed 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 the requirements of 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, the joints shall be thoroughly cleaned and wetted. Mortar shall then be applied around the inner and outer perimeter over the joint. 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 box units of a culvert within a construction stage, and prior to waterproofing or installation of distribution slab when specified in the Contract Documents, MTO form PH-CC-701, Request to Proceed shall be submitted to the Contract Administrator. The next operation shall not proceed until MTO form PH-CC-702, Notice to Proceed has been received from the Contract Administrator.

422.07.09.08 Waterproofing of the Culvert

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

422.07.10 Concrete Appurtenances, Protection and Concrete Distribution Slabs

Concrete placement, curing, and quality assurance for cast-in-place concrete appurtenances, protection slabs or distribution slabs shall be according to OPSS 904. Steel reinforcing steel shall be placed according to OPSS 905.

When a protection slab or distribution slab is specified, 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, uncompacted 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 or any damage to it. At no time shall the levels on each side differ by more than 400 mm. Within the areas of the Roadway, earth backfill shall have frost susceptibility characteristics similar to the native material for a depth equal to the frost treatment depth.

Rock may be used as backfill provided the installed box units are protected by a protection layer having a minimum thickness as specified in the Contract Documents.

422.07.12 Granular Cover

Granular cover shall be placed in layers not exceeding 200 mm in thickness, loose measurement, and each layer shall be compacted according to OPSS 501. The granular cover shall be placed without any damage to or movement of the culvert.

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 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 dimensional measurements or inspection.

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

422.08.02 Installation Deficiencies

The Contract Administrator shall carry out an inspection of the box culvert to determine if the completed work contains any installation deficiencies. An installed culvert not meeting the following tolerances, shall be deemed rejectable:

- a) Alignment of box units: ± 10 mm
- b) Joint Gap: 20 mm maximum
- c) Gap between adjacent side-by-side box (multi-cell) culverts: ± 10 mm

Where the installation is rejectable, a proposal for remediation signed and sealed by an Engineer shall be submitted to the Contract Administrator for acceptance.

422.08.03 Defects

The Contract Administrator shall carry out an inspection of the box culvert to determine if the completed work contains cracks, spalls or delaminations. Any box unit with a crack width > 0.3 mm, or any delamination, or spalls shall be deemed rejectable.

Where the crack width is between 0.3 mm and 1.0 mm, or where a spall or delamination is $< 0.1\text{m}^2$, a proposal for repair or remediation signed and sealed by an Engineer may be submitted to the Contract Administrator for acceptance.

422.08.04 Repair Proposal and Assessment of Repairs

If the repair proposal is deemed acceptable by the Owner, the culvert or element shall be repaired according to the proposal. Repairs shall not be carried out without the prior written acceptance of the proposal by the Contract Administrator. If the repair proposal is not acceptable to the Owner, the element or culvert shall be replaced.

The Contract Administrator shall inspect the repaired work. This inspection may include covermeter surveys, coring, and any other testing deemed necessary to assess the effectiveness and acceptability of the repair.

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 box 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, subject to payment adjustments.

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 (m³) (calculated based on plan dimension)

Tender quantity = volume of concrete in tender (m³) (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 (m³) (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 (m³) (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.

Payment at the Contract price for the above tender items shall also include Support Systems.

422.10.03 Clay Seal - Item

Payment shall be at the Contract price for the tender item "Clay Seal" according to OPSS 902.

422.10.04 Granular - Item

Granular material used for bedding, backfill, granular 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 backfill when acceptable quality native material is available.

422.10.05 Steel Reinforcement in Concrete Appurtenances

Payment shall be at the Contract price for the tender items "Reinforcing Steel Bar", "Stainless Steel Reinforcing Bar", "Mechanical Connectors" and "Stainless Steel Mechanical Connectors" according to OPSS 905.

422.10.06 Concrete in Appurtenances

Payment shall be at the Contract price for the tender item "Concrete in Culverts", according to OPSS 904.

422.10.07 Excavation for Box Culverts

Payment for earth and rock excavation shall be at the Contract price for the tender items "Earth Excavation for Structure" and "Rock Excavation for Structure", according to OPSS 902.

When material not considered to be competent native material is encountered at the excavation limits, any subexcavation and backfill work directed by the Contract Administrator shall be administered as a Change in the Work.

422.10.08 Swamp Excavation

Payment for swamp excavation shall be at the Contract price for the tender item Earth Excavation, Grading, according to OPSS 206.

Payment shall not be made for the removal of materials that slide or slough inside the excavation limits.

TABLE 1
Soil Gradation Requirements for Earth Bedding, Backfill and Protection Layer

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