Note: The MUNI published in November 2021 replaces OPSS 1821 COMMON, November 2015 with no technical content changes.

MATERIAL SPECIFICATION FOR PRECAST REINFORCED CONCRETE BOX CULVERTS

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1821.01 SCOPE

This specification covers the requirements for materials, design and fabrication of single-cell precast reinforced concrete box culverts not exceeding 3 m in span.

1821.01.01 Specification Significance and Use

This specification is written as a municipal-oriented specification. Municipal-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of many municipalities in Ontario.

Use of this specification or any other specification shall be according to the Contract Documents.

1821.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

1821.02 REFERENCES

When the Contract Documents indicate that municipal-oriented specifications are to be used and there is a municipal-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.MUNI, unless use of a provincial-oriented specification is specified in the Contract Documents. When there is not a corresponding municipal-oriented specification, the references below shall be considered to be the OPSS listed, unless use of a provincial-oriented specification is specified in the Contract Documents.

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

Ontario Provincial Standard Specifications, Construction

OPSS 422 Precast Reinforced Concrete Box Culverts In Open Cut
OPSS 904 Concrete Structures

Ontario Provincial Standard Specifications, Materials

OPSS 1002 Aggregates - Concrete
OPSS 1350 Concrete - Materials and Production
OPSS 1440 Steel Reinforcement for Concrete

Ontario Ministry of Transportation Publications

Structural Manual, Division 1, Exceptions to the Canadian Highway Bridge Design Code

MTO Laboratory Testing Manual:

LS-412 Scaling Resistance of Concrete Surfaces Exposed to De-icing Chemicals

CSA Standards

A23.1/A23.2-00 Concrete Materials and Methods of Concrete Construction/Methods of Test for Concrete
S6-14 Canadian Highway Bridge Design Code

ASTM International

C457-98 Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete

Ontario Concrete Pipe Association

Prequalification Requirements for Precast Concrete Drainage Products

1821.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Box Unit means as defined in OPSS 422.

Distribution Slab means as defined in OPSS 422.

Dry Cast Concrete means concrete with a slump equal to or less than 20 mm at the time of placing.

Engineer means a professional engineer, licensed by the Professional Engineers of Ontario to practice in the Province of Ontario.

Height of Fill means the smallest elevation difference, between the top slab of a box culvert and the top of pavement or finished grade, from edge of shoulder to edge of shoulder.

Joint Annular Space means the design clearance between the tapered surface of the bell and spigot ends of adjacent box units.

Longitudinal Steel means steel reinforcement aligned parallel to the longitudinal axis of the box unit.

Perimeter Steel means steel reinforcement aligned perpendicular to the longitudinal axis of the box unit.

Wet Cast Concrete means concrete with a slump greater than 20 mm at the time of placing.

1821.04 DESIGN AND SUBMISSION REQUIREMENTS

1821.04.01 Design Requirements

All box units shall be designed according to CSA S6 and the Structural Manual, Division 1. For box units reinforced with welded wire fabric (WWF), the manufacturer's Working Drawings shall be according to Table 1 and the Contract Documents.

Box culverts with a height of fill less than 0.60 m require additional reinforcing and shall include a distribution slab. When a distribution slab is required it shall cover the entire top of box unit. The distribution slab shall be as specified in the Contract Documents.

1821.04.02 Submission Requirements

The box unit manufacturer's Working Drawings shall be submitted to the Owner upon request. All Working Drawings shall bear the seal and signature of an Engineer certifying they are according to the Contract Documents.

1821.05 MATERIALS

1821.05.01 Concrete

1821.05.01.01 General

Concrete shall be according to OPSS 1350 except as specified herein.

1821.05.01.02 Strength

The concrete shall have a nominal 28-Day compressive strength of 35 MPa.

1821.05.01.03 Water-Cement Ratio

All concrete shall have a water-cement ratio not exceeding 0.40 by mass.

1821.05.01.04 Wet Cast Concrete

For wet cast concrete, the air void system of the hardened concrete, when tested according to ASTM C 457, shall be as follows:

a) Air Content 3.0 % Minimum

b) Spacing Factor 0.200 mm Maximum

1821.05.01.05 Dry Cast Concrete

For dry cast concrete, the salt scaling resistance when tested according to laboratory method LS-412 and this specification shall have a mass loss of not more than 0.8 kg/m^2.

1821.05.02 Aggregates

Aggregates shall be according to OPSS 1002.

1821.05.03 Steel Reinforcement

Steel reinforcement shall be according to OPSS 1440.

In addition, WWF shall achieve minimum 4% elongation at ultimate strength measured over a 100 mm gauge length that includes at least one cross wire.

1821.05.04 Associated Hardware

All support systems shall be capable of withstanding the loads to be placed on them. All embedded hardware within 35 mm of exposed faces shall be coated with an acceptable material or be of an acceptable non-metallic material.

Tie wire shall be 1.5 mm diameter annealed wire.

1821.07 PRODUCTION

1821.07.01 Prequalification Requirements for Box Units

Manufacturers producing box units must possess a current Prequalification Certificate, issued under the Plant Prequalification Program as outlined in the publication, Prequalification Requirements for Precast Concrete Drainage Products.

1821.07.02 Box Units

1821.07.02.01 Placement of Reinforcement

The concrete cover to the WWF shall be 40 mm $\pm$ 5 mm, and the cover to reinforcing bars shall be 50 mm $\pm$ 15 mm.

The clear distance of the end perimeter reinforcement shall not be less than 35 mm or greater than 50 mm from the ends of the box unit. Box units reinforced with WWF may be assembled using any combination of single or double layers of the fabric. Box units using reinforcing steel bars shall be assembled with single layers of reinforcement in each face in each direction.

The areas of steel reinforcement shall be the steel areas as shown in Table 1. Steel areas greater than those required, shall not be cause for rejection.

1821.07.02.02 Laps, Welds, and Spacing of Reinforcement

Splices in the perimeter reinforcement shall be made by lapping. Reinforcement shall not be lapped in tension zones. Sheets of the WWF shall be tack welded at lap locations. The overlap measured between the outermost longitudinal wires of each WWF sheet, shall not be less than the spacing of the longitudinal wires plus 50 mm or 250 mm, whichever is greater. The centre to centre spacing of the perimeter wires shall not be less than 50 mm or more than 105 mm. The centre to centre spacing of the longitudinal wires shall not be more than 205 mm.

1821.07.02.03 Joints

The box units shall be produced with bell and spigot ends. The ends shall be of such design that when the box units are laid together they will make a continuous box culvert with a smooth interior, free of irregularities in the flow line.

1821.07.03 Curing

Except for exposed ends, wet cast box units shall be cured by leaving the box units in the form or by low pressure steam. Dry cast box units and the exposed ends of the wet cast box units shall be covered and cured by low pressure steam or other system that will maintain a moist atmosphere. Curing compounds are not an acceptable method of curing. Box units shall be cured until a minimum strength of 25 MPa is achieved or for four days, whichever occurs first**.**

1821.07.04 Forms

The forms used in the production process shall be sufficiently rigid and accurate to maintain the specified box unit dimensions. All casting surfaces shall be of smooth, nonporous, and non-staining material. Insulated forms shall not be used.

1821.07.05 Handling

Devices or holes will be permitted in each box unit for the purpose of handling and installing.

1821.07.06 Marking

The following information in the order listed, shall be embossed on the top haunch of each box unit using numbers and letters 3 mm wide, 35 mm high, and 5 mm deep:

a) Name or trademark of the manufacturer.

b) Identification of plant, if manufacturer has more than one plant.

c) Date of manufacture.

d) Specification designation.

e) Minimum and maximum height of fill over box units.

The word “Top” shall be lettered with waterproof paint on the top surface of each box unit.

Each box unit shall also be marked with the Prequalification Stamp as outlined in the publication, Prequalification Requirements for Precast Concrete Drainage Products.

1821.07.07 Surface Finish for Formed Surfaces

All surfaces shall be finished according to the Surface Finish sub-section in OPSS 904.

1821.07.08 Repairs

Box units may be repaired, provided the repaired box unit meets the requirements of this specification.

1821.07.09 Tolerances

1821.07.09.01 Dimensions

The span and rise dimensions shall not vary by more than 20 mm from the manufacturer's design dimensions.

The haunch dimensions shall not vary by more than 8 mm from the manufacturer's design dimensions.

1821.07.09.02 Slab and Wall Thickness

The slab and wall thickness shall not vary by more than 5 mm from the manufacturer's design dimensions.

1821.07.09.03 Squareness

Variations in the lengths of two opposite surfaces of the box unit shall not exceed 10 mm in each box unit along its length, except where special box units are specified by the Owner. The ends of the box units shall be perpendicular to the wall and centreline of the box unit within the tolerances specified elsewhere in this subsection, except where special box units are specified by the Owner.

1821.07.09.04 Length of Box Unit

The underrun in length of each box unit shall not exceed 15 mm.

1821.07.09.05 Straightness of Joints

The joint edge shall not deviate from straight, when measured around the perimeter of the box unit by more than the manufacturer's design joint annular space.

1821.07.10 Quality Control

1821.07.10.01 General

A production run shall be considered continual provided any interruption is not more than three consecutive Days and there is no change in materials, material proportions, source of materials, production or curing methods, or equipment.

Tests on concrete for compressive strength, box unit dimensions, and concrete cover over reinforcement shall be performed for each group of 15 box units or fraction thereof, for each continual production run of a single size.

Tests for air void system parameters of wet cast concrete and salt scaling resistance of dry cast concrete shall be performed on box units representing a lot size of 1,000 m^2 of box unit floor area or two months of production, whichever is more frequent. In addition, when there is a change in materials, source of materials, production or curing methods, or equipment, the concrete shall be tested for air void system or salt scaling resistance as specified herein.

All results shall be retained by the manufacturer for a period of two years from the date of manufacture and shall be provided to the Owner upon request.

1821.07.10.02 Concrete Compressive Strength

A set of two cylinders shall be made for determining the 28-Day strength of the concrete. The cylinders shall be made, cured, sampled, and tested according to OPSS 1350, except both cylinders shall be either 150 x 300 mm or 100 x 200 mm in size.

The cylinders shall be made by a:

a) concrete testing technician employed by a laboratory certified according to the requirements of CSA A283, or

b) ACI Concrete Field Testing Technician-Grade 1.

Compressive strength testing shall be carried out by a laboratory certified according to the requirements of CSA A283. In addition, the laboratory shall meet any pre-qualification requirements specified by the Owner.

The compressive strength result shall be the average of a set.

If the specified requirements of the concrete have not been reached after 28 Days, three cores shall be taken from a member at locations approved by the Contract Administrator. Cores shall be moisture conditioned and tested according to test method CAN/CSA A23.2-14C and evaluated according to CAN/CSA A23.1. The cores shall be tested no later than 35 days after manufacture of the box units represented by the failed results.

1821.07.10.03 Dimensional Verification

The box unit dimensions shall be verified by measuring one box unit for wet cast concrete or two box units for dry cast concrete selected at random from each group of box units.

1821.07.10.04 Concrete Cover Measurement

Concrete cover measurements shall be made on two box units, selected at random from each group of box units.

The measurements shall be obtained on a one metre grid on all interior and exterior surfaces of the box units, including the ends of the unit.

Cover measurements shall be carried out by a method acceptable to the Contract Administrator and shall be reported in writing to the Contract Administrator prior to installation of the box units.

1821.07.10.05 Testing of Air Void System of Hardened Concrete in Wet Cast Concrete

For evaluation of the air void system parameters, the manufacturer shall remove cores from hardened concrete and test the cores according to ASTM C 457, except that a magnification of 100 to 125 times shall be used. Testing shall be carried out by a laboratory and operators that are acceptable to the Owner.

As a minimum, two 100 x 200 mm cores from each lot of box units shall be removed and tested. All cores shall be taken when the concrete is a minimum of 7 Days of age. Cores shall be cut lengthwise into two halves with one half to be tested by the manufacturer and the other half to be forwarded to the Owner. Both halves shall be marked with a unique identification number. The half core forwarded to the Owner shall have an information sheet securely attached to it detailing the Contract number and concrete mix design for the box units. It shall also clearly identify which lot of box units it represents.

Air void samples shall be retained by the manufacturer for a period of one year from the date of testing and shall be provided to the Contract Administrator on request.

1821.07.10.06 Salt Scaling Resistance in Dry Cast Concrete

For evaluation of the salt scaling resistance of the dry cast concrete, the manufacturer shall cut a set of two specimens, each measuring 300 x 300 mm from each lot of the finished and cured box units. The specimens shall be tested according to LS-412 without further curing.

The salt scaling result shall be the average of a set.

1821.07.10.07 Plugging Core Holes

Core holes shall be plugged full depth with concrete by the manufacturer in a manner such that the box unit will be according to this specification.

1821.08 QUALITY ASSURANCE

1821.08.01 Acceptance

The latest test results of the manufacturer's quality control procedures specified in the subsection for Quality Control shall be submitted to the Owner.

Acceptance of the compressive strength shall be based on the average 28-Day compressive strength of the cylinders or, when required, from the compressive strength of the cores taken from the finished product.

Acceptance of air void system parameters shall be based on individual core results for air content and the average of each pair of cores for spacing factor.

Acceptance of salt scaling resistance shall be based on the average of a set.

The Owner may request submission of samples for testing.

The Owner shall be provided access to the manufacturer's plant, at times and locations determined by the Owner, to perform independent inspection, sampling, and testing.

1821.08.02 Rejection

A group of box units represented by failed compressive strength or failed air void system or failed salt scaling resistance results shall be rejected.

Individual box units may also be rejected for any of the following:

a) Inadequate concrete cover to reinforcement.

b) Defects resulting from incorrect proportioning, mixing, and forming.

c) Cracks greater than 0.3 mm or full depth cracks.

d) Honeycombed or open surface texture.

e) Damaged ends, where such damage would prevent making a satisfactory joint.

f) Out of tolerance.

1821.09 OWNER PURCHASE OF MATERIAL

1821.09.01 Inspection

The quality of materials, the process of manufacture, and the finished box units shall be subject to inspection by the Owner.

1821.09.02 Measurement for Payment

Box units shall be measured in metres along the centerline of the invert of the box unit. Payment at the price specified in the purchasing order shall be full compensation for the supply and delivery of the box units and jointing devices, to the destination at the times specified.

The cost of all testing, except that performed in the Owner's laboratory shall be included in the price.

TABLE 1
Welded Wire Fabric Reinforcement Areas

Height of Fill m	As1 mm^2/m	As2 mm^2/m	As3 mm^2/m	As4 mm^2/m	As5 mm^2/m	As6 mm^2/m
SPAN 1800(1829) X RISE 900(914) WALLS AND SLABS 200(203)mm Thick						
<0.6	552	980	480	400	300	402
0.6	400	400	400	400	63	-
0.9	400	400	400	400	63	-
1.2	400	400	400	400	63	-
1.5	400	400	400	400	63	-
1.8	400	400	400	400	63	-
2.4	400	400	400	400	63	-
3.0	400	400	400	400	63	-
3.6	386	407	418	400	63	-
4.3	445	469	480	400	63	-
4.9	498	524	535	400	63	-
5.5	552	580	591	400	63	-
SPAN 1800(1829) X RISE 1200(1219) WALLS AND SLABS 200(203)mm Thick						
<0.6	456	1040	480	400	300	426
0.6	400	440	457	400	63	-
0.9	400	400	400	400	63	-
1.2	400	400	400	400	63	-
1.5	400	400	400	400	63	-
1.8	400	400	400	400	63	-
2.4	400	400	400	400	63	-
3.0	400	403	420	400	63	-
3.6	400	459	476	400	63	-
4.3	400	527	545	400	63	-
4.9	422	589	607	400	63	-
5.5	467	652	670	400	63	-
SPAN 2400(2438) X RISE 1200(1219) WALLS AND SLABS 200(203)mm Thick						
<0.6	741	1280	567	400	300	448
0.6	663	690	712	400	63	-
0.9	488	509	530	400	63	-
1.2	448	467	488	400	63	-
1.5	455	475	497	400	63	-
1.8	476	499	520	400	63	-
2.4	536	564	586	400	63	-
3.0	614	648	670	400	63	-
3.6	702	741	763	400	63	-

Height of Fill m	As1 mm^2/m	As2 mm^2/m	As3 mm^2/m	As4 mm^2/m	As5 mm^2/m	As6 mm^2/m
SPAN 2400(2438) X RISE 1500(1524) WALLS AND SLABS 200(203)mm Thick						
<0.6	677	1315	630	400	300	460
0.6	603	762	793	400	63	-
0.9	446	560	591	400	63	-
1.2	410	514	544	400	63	-
1.5	415	522	552	400	63	-
1.8	434	546	577	400	63	-
2.4	487	617	648	400	63	-
3.0	556	707	738	400	63	-
3.6	633	808	839	400	63	-
SPAN 2400(2438) X RISE 1800(1829) WALLS AND SLABS 200(203)mm Thick						
<0.6	677	1445	677	400	300	506
0.6	552	825	867	400	63	-
0.9	412	606	647	400	63	-
1.2	400	554	595	400	63	-
1.5	400	564	602	400	63	-
1.8	400	587	628	400	63	-
2.4	448	660	702	400	63	-
3.0	510	755	797	400	63	-
3.6	579	861	904	400	63	-
SPAN 3000(3048) X RISE 1500(1524) WALLS AND SLABS 250(254) mm Thick						
<0.6	738	1250	620	500	300	400
0.6	797	825	858	500	79	-
0.9	592	612	664	500	79	-
1.2	544	564	595	500	79	-
1.5	552	573	604	500	79	-
1.8	577	600	632	500	79	-
2.4	648	678	709	500	79	-
3.0	739	775	807	500	79	-
3.6	841	884	917	500	79	-
SPAN 3000(3048) X 1800(1829) WALLS AND SLABS 250(254)mm Thick						
<0.6	777	1280	643	500	300	410
0.6	740	896	939	500	79	-
0.9	552	664	706	500	79	-
1.2	508	610	652	500	79	-
1.5	515	620	661	500	79	-
1.8	537	648	690	500	79	-
2.4	602	730	772	500	79	-
3.0	684	834	877	500	79	-
3.6	776	950	994	500	79	-

Height of Fill m	As1 mm^2/m	As2 mm^2/m	As3 mm^2/m	As4 mm^2/m	As5 mm^2/m	As6 mm^2/m
SPAN 3000(3048) X RISE 2100(2133) WALLS AND SLABS 250(254)mm Thick						
<0.6	639	1340	686	500	300	429
0.6	691	959	1014	500	79	-
0.9	519	711	764	500	79	-
1.2	478	652	705	500	79	-
1.5	485	661	715	500	79	-
1.8	505	691	744	500	79	-
2.4	563	776	830	500	79	-
3.0	638	884	939	500	79	-
3.6	723	1006	1062	500	79	-
SPAN 3000(3048) X RISE 2400(2438) WALLS AND SLABS 250(254)mm Thick						
<0.6	769	1380	744	500	300	442
0.6	648	1018	1087	500	79	-
0.9	490	754	821	500	79	-
1.2	453	691	757	500	79	-
1.5	456	699	766	500	79	-
1.8	479	729	796	500	79	-
2.4	531	816	884	500	79	-
3.0	601	928	997	500	79	-
3.6	678	1054	1124	500	79	-

Notes:

1. The dimensions in brackets are soft metric conversions of the actual imperial dimensions.
2. Yield strength of WWF is Fy = 500 MPa.
3. Area of steel reinforcement is per metre length of box unit.
4. Area of steel As5 minimum longitudinal reinforcement is per face.
5. Area of steel As6 is required when height of fill over box unit is less than 600 mm.
6. Reinforcement was proportioned using the loading, load factors, and resistance factors.
7. This design is according to CSA S6 and the Structural Manual, Division 1 for installation B-1 only.

Appendix 1821-A, November 2021
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

The designer should ensure that the General Conditions of Contract and the 100 Series General Specifications are included in the Contract Documents.

Related Ontario Provincial Standard Drawings

OPSD 3920.100	Precast Reinforced Concrete Box Culvert With Height Of Fill ≥ 0.6m
OPSD 3920.110	Precast Reinforced Concrete Box Culvert With Height Of Fill < 0.6m