CONSTRUCTION SPECIFICATION FOR PRECAST CONCRETE CULVERTS WITH SPANS GREATER THAN 3.0 M

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912.01 SCOPE

This specification covers the material and construction requirements of single and adjacent side-by-side (multi-cell) precast concrete box culverts with spans greater than 3.0 m, and associated precast concrete appurtenances, in open cut, for both new culverts and replacement of existing culverts. This specification includes requirements for excavation, bedding, backfilling, and cover material.

912.02 REFERENCES

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

Ontario Provincial Standard Specifications, Construction

OPSS 206 Grading
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 902 Excavating and Backfilling – Structures~~
OPSS 905 Steel Reinforcement for Concrete
~~OPSS 909 Prestressed Concrete – Precast Girders~~
~~OPSS 919 Formwork and Falsework~~
~~OPSS 929 Abrasive Blast Cleaning – Concrete Construction~~
~~OPSS 930 Structure Rehabilitation – Concrete Patches, Refacing, and Overlays~~
~~OPSS 932 Crack Repair - Concrete~~

Ontario Provincial Standards 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 Material
OPSS 1302- Water
OPSS ~~1306 Burlap~~1303 Admixtures for Concrete
OPSS 1350 Concrete –- Materials and Production
OPSS ~~1440 Steel Reinforcement for~~1355 Precast Concrete - Materials and Production
OPSS 1860 Geotextiles

MTO Publications

Structural Manual

MTO Laboratory Testing Manual:
~~LS-410 Method of Test for Compressive Strength of Concrete Cores~~
~~LS-432 Method of Test for Microscopical Determination of Air-Void System Parameters in Hardened Concrete~~
~~LS-433 Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration~~
LS-706 Moisture - Density Relationship of Soils Using 2.5 kg Rammer and a 305 mm Drop ~~Structural Manual~~

MTO Forms:
~~PH-CC-322 Concrete Construction Report~~
~~PH-CC-433A Concrete Mix Design Form A~~
PH-CC-701 Request to Proceed
PH-CC-702 Notice to Proceed

CSA Standards

A23.4-16 (R2021) Precast Concrete Materials and Construction
S6:25 Canadian Highway Bridge Design Code

ASTM International

~~A153-16a Zinc Coating (Hot-Dip) on Iron and Steel Hardware~~
~~B633-15 Electrodeposited Coatings of Zinc on Iron and Steel~~
~~C171-16 Sheet Materials for Curing Concrete~~
C990~~-09 (R2014)~~/C990M-24 Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
D6938-~~17a~~23 Standard Test Methods for In-Place Density and Water Content of Soil and ~~Soil-~~Aggregate by Nuclear Methods (Shallow Depth)

~~**CSA Standards**~~

~~A23.4-16 Precast Concrete Materials and Construction~~
~~S6-19 Canadian Highway Bridge Design Code~~
~~W47.1-09 (R2019) Certification of Companies for Fusion Welding of Steel~~
~~W59-13 Welded Steel Construction (metal arc welding)~~
~~W186 Welding of Reinforcing Bars in Reinforced Concrete Construction~~
~~A23.2-14C Obtaining and Testing Drilled Cores for Compressive Strength Testing*~~
~~* [Part of A23.1-19/A23.2-19 – Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete]~~

912.03 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 ~~support~~cushion and evenly distribute the soil reaction at the bottom of the ~~culvert~~structure.

~~**Bughole** means a small regular or irregular cavity resulting from entrapment of air bubbles in the surface of formed concrete during placement or consolidation.~~

~~**Cold Joint** means a joint or discontinuity resulting from a delay in placement of sufficient duration to preclude intermingling and bonding of the concrete.~~

~~**Cold Weather** means when the air temperature to which the element is exposed is at or below 5 ºC, or when the air temperature to which the element is exposed is at or is likely to fall below 5 ºC within 96 hours after completion of concrete placement. Temperature refers to shade temperature.~~

Culvert means a structure constructed of precast concrete box units with a span greater than 3.0 m that is typically embedded in fill, and is used to convey water, pedestrians, vehicles, cyclists, or animals.

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 culvert, ~~excluding~~and excludes concrete bedding or concrete structures covered elsewhere in the Contract Documents.

Distribution Slab means a reinforced concrete slab placed directly on top of the culvert ~~that may be specified~~ when the earth cover is less than ~~600mm~~600 mm to improve load distribution on a culvert.

Element means an individual precast concrete culvert unit.

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

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

~~**Honeycombing** means rough and stony concrete surface with voids where the mortar did not fill the spaces between the coarse aggregate particles.~~

Indoor Precast Concrete Plant means a building, which is a permanent structure, providing protection from sun, wind, and rain and which is temperature controlled, such that the temperature does not fall below 15 °C or exceed 30 °C.

Length of the culvert means the distance measured between the ends of the assembled elements, measured along the longitudinal axis.

Lot consists of all elements of the same span and concrete mix design, produced over seven consecutive Days.

Native Material means the original soil that is naturally occurring, formed by normal geologic and biological processes.

Protection Layer means the material removed placed around the culvert to form an excavation and which is acceptable to the Contract Administrator for return to the same or other excavation as backfill beyond the structureprovide protection from damage.

Pour Line means a visible delineation between two placements of concrete where the concrete from each placement is well-bonded to the other.

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

Segregation means visible separation of the mortar and coarse aggregate particles in the plastic concrete resulting in concrete that is not uniform in appearance or proportions.

Soil means all loose or moderately cohesive organic or inorganic deposits of the earth's crust such as silt, sand, gravel, or clay or any of their mixtures.
Rock means as defined in OPSS 206.

Soil means as defined in OPSS 902.

Span means the horizontal distance measured perpendicular to the inside faces of the walls of the culvert.

912.04 DESIGN AND SUBMISSION REQUIREMENTS

912.04.01 Design Requirements

912.04.01.01 Culvert

The design shall be according to CSA S6, the Structural Manual Division 1, and as specified in the Contract Documents.

Culverts shall be waterproofed as specified in the Contract Documents.

912.04.02 Submission Requirements

912.04.02.01 Working Drawings

Three sets ofOne electronic copy in PDF format of the Working Drawings, including supporting documentation, shall be submitted to the Contract Administrator at least seven7 Days prior to the commencement of fabrication of the elements, for information purposes. The only. All Working Drawings shall be:bear the seal and signature of an Engineer certifying they are as specified in the Contract Documents.

~~a) signed and sealed by an Engineer, where Working Drawings show the same reinforcement sizes, spacing, and layouts from Contract Drawings, or,~~

~~b) signed and sealed by a design Engineer and a design-checking Engineer, where Working Drawings have been modified from Contract Drawings.~~

When other authorities are involved in the approval of the design or construction of the culvert, the submission of Working Drawings shall be made at least 35 Days prior to commencement of fabrication of the elements and one additional copy of the submission shall be provided for each authority. The requirements of each authority and the requirements of the Owner ~~as~~ specified in the Contract Documents shall be satisfied prior to commencement of the Work.

The Working Drawings shall include as a minimum the following information:

a) Element details.

b) Steel reinforcement details.

c) Lifting point locations.

d) Details and location of any temporary supports.

e) Stripping strength for formwork removal and requirements for handling of components immediately after stripping.

f) Design calculations, of any components not specified on, or altered from, the Contract ~~Drawings~~Documents.

g) ~~Waterproofing details, provided by Owner.~~
~~h)~~ Connection details.

~~i~~h) Details for invert, obvert, depth of embedment, and substrate materials.

~~j~~i) Details for inlet and outlet control structures, and any associated retaining structures.

~~k~~j) Details of any openings required in the walls or slabs for connection of storm drainage.

~~l~~k) Details of any features required to facilitate fish passage, up-welling or any other environmental requirements.

~~m~~l) Any other applicable details.

The supporting documents shall include, as a minimum, the following information:

a) Handling and installation procedures including calculations.

b) Details of any bracing required to provide stability to the elements during transportation and construction.

912.04.02.02 ~~Concrete Mix Designs~~ Preformed Joint Seal

The ~~concrete mix 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.~~

912.04.02.03 Precast Plant Certification Submissions

The certificate, verifying the precast plant is certified according to the Precast Plant Certification clause, shall be submitted with the concrete mix design submission.

Copies of precast plant certification audit reports of Canadian Precast Concrete Quality Assurance Program (CPCQA), Canadian Standards Association (CSA), or both as applicable, and related documentation, shall be submitted to the Owner upon request.

If concrete is supplied by a ready-mix concrete supplier, a currently valid Certificate of Ready Mixed Concrete Production Facilities as issued by the Ready Mixed Concrete Association of Ontario (RMCAO), shall be submitted with the concrete mix design submission.

For multi-year contracts, for all plants supplying the work, documentation verifying that the precast plant, and ready-mix plant(s) if used, continue to hold valid certification shall be submitted annually.
manufacturer's recommended installation procedures for the preformed joint seal

912.04.02.04 Control of Concrete Temperature

Seven Days prior to the commencement of fabrication of the elements, a description of the method for monitoring and effectively controlling the temperature of the concrete shall be submitted to the Contract Administrator, for information purposes. The description shall include the method of controlling and recording the concrete temperature during the curing and protection period.

912.04.02.05 Notification of Placement

The Contract Administrator shall be notified in writing at least seven Days prior to commencement of fabrication. Any changes in the fabrication schedule shall be provided to the Contract Administrator in writing.
a
912.04.02.06 Mill Certificates

Mill certificates shall be submitted according to OPSS 1440. The mill certificates shall be submitted as part of the precast report.

912.04.02.07 Manufacturer's Certificate of Conformance and Precast Report

A manufacturer's Certificate of Conformance and precast report shall be submitted to the Contract Administrator for each shipment of elements at least five Business Days prior to shipping the elements from the precast plant.

The precast report shall contain the following information:

a) List of elements including their identification number, lot number and description.

b) Mill certificates for the steel reinforcement used in the elements.

c) Summary of all measurements and inspections carried out prior to concrete placement to verify compliance with the Contract Documents including reinforcement placement, and other pre-pour checks.

d) Temperature records for formwork and steel at the time of concrete placement.

e) Temperature records for the concrete, including location of thermocouple wires, and graphical plots verifying that the requirements for maximum and minimum temperature, maximum allowable temperature difference, and maximum cooling rate, have been met. The format of the temperature plots shall be acceptable to the Ownerof 5 Days prior to the installation.

f) Record of inspection of moist curing.

g) Summary of material test results for plastic concrete: air content, slump and concrete temperature.

h) Summary of material test results for hardened concrete: stripping strength, confirmation of the projected 28-Day compressive strength. If test results are not available at the time of shipping, they may be submitted within four Business Days following completion of testing.

i) Summary of all measurements and inspections required by this specification, including the concrete cover over steel reinforcement, crack measurement summary, and dimensional verification.

j) Documentation, including colour photographs (labelled and dated), confirming that any defects repairable by standard methods have been identified, evaluated, and repaired as detailed in the Repair of Defects and Deficiencies Repairable by Standard Methods clause.

k) When steam curing is used, test results showing that time of initial set was determined, unless standard delay periods are used, according to the Steam Curing and Other Application of Heat clause of OPSS 909.

A Request to Proceed shall be submitted to the Contract Administrator before each shipment of elements to the site.

The elements shall not be delivered to the site until the Contract Administrator has received the manufacturer's Certificate of Conformance, the precast report, and Request to Proceed, and the Contractor has received a Notice to Proceed.

912.05 MATERIALS

912.05.01 Backfill

912.05.01.01 Backfill to Structure

Backfill to the structure shall be one of the following, or as specified in the Contract Documents:.

a) When Granular A, is specified in the Contract Documents, the Granular A shall be according to OPSS 1010.

b) When Granular B, is specified in the Contract Documents, the Granular B shall be Type I or II, with 100% passing the 26.5 mm sieve, according to OPSS 1010.

When rock backfill is specified in the Contract Documents, it shall be according to the Rock Backfill to Structure subsection of OPSS 206.

The 19.0 mm clear stone for wall drains shall be according to OPSS 1004.

Protection layer shall be as specified in the Contract Documents.

912.05.01.02 Backfill Beyond Structure

Backfill beyond the structure shall be one of the following, or as specified in the Contract Documents:.

a) When Granular A, is specified in the Contract Documents, the Granular A shall be according to OPSS 1010.

b) When Granular B, is specified in the Contract Documents, the Granular B shall be Type I or II, with 100% passing the 26.5 mm sieve, according to OPSS 1010.

c) Native material.
When rock backfill is specified in the Contract Documents, it shall be according to the Rock Backfill to Structure subsection of OPSS 206.

When native material is specified in the Contract Documents, the native material shall be as specified in the Native Material subsection.

912.05.02 Bedding

Bedding shall be as specified in the Contract Documents. The nominal maximum aggregate size for bedding shall not exceed 26.5 mm in diameter, unless the bedding layer has a thickness of 150 mm or greater, in which case the nominal maximum aggregate size shall not exceed 37.5 mm in diameter.

912.05.03 Burlap

Burlap Granular aggregate materials shall be according to OPSS 1306.1010.

912.05.0403 Clay Seal

Clay seal, if required, shall be according to OPSS 1205.

912.05.0504 Concrete

912.05.04.01 General

Concrete materials for precast components shall be according to the Materials section of OPSS 1350 with the following additions and amendments:

a) Compressive strength shall beappurtenances shall be precast or cast-in-place, as specified in the Contract Documents.

b) The air void system spacing factor, when tested according to LS-432, shall be 0.200 mm maximum.

c) The nominal maximum size of coarse aggregate shall be 19.0 mm, except when a smaller nominal size is required in order to meet the requirements of CSA S6.

d) Air-cooled blast furnace slag shall not be used as aggregate.

912.05.04.02 Cast-in-Place Concrete

Cast for cast-in-place concrete shall be according to OPSS 1350.

912.appurtenances, protections slabs and distribution slabs **05.04.03 Precast Concrete Culverts and Appurtenances**

Precast concrete shall be according to OPSS 1350. Compressive strength for cast-in-place concrete appurtenances, protections slabs and distribution slabs shall be as specified in the Contract Documents.1355.

~~**912.05.06 Concrete Sealers**~~

~~Concrete sealers, if required, shall be from the Owner's list of acceptable sealers. The list shall be obtained from the Contract Administrator.~~

912.05.~~07~~ ~~Formwork~~

~~All formwork shall be according to OPSS 919 and CSA A23.4. Formwork shall be fabricated to meet the dimensional tolerances and finishes as specified in the Contract Documents. Textile form liners shall not be used.~~

~~912.~~05.~~08~~ Geotextile

Geotextiles shall be non-woven according to OPSS 1860 and shall be of the type, class and filtration opening size (FOS) specified in the Contract Documents. The minimum width of the geotextile roll shall be 900 mm. Geotextile shall be free of folds, tears, holes and wrinkles.

912.05.~~09~~06 Granular Cover

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

~~a)~~ When Granular A~~,~~ is specified in the Contract Documents, the Granular A shall be according to OPSS 1010.

~~b)~~ When Granular B~~,~~ is specified in the Contract Documents, the Granular B shall be Type I or II, with 100% passing the 26.5 mm sieve, according to OPSS 1010.

912.05.~~10 Hardware~~07 Grout

~~Hardware~~Grout shall be ~~made of stainless steel~~non-shrink.

Cementing materials for grout shall be according to OPSS ~~1440 or be galvanized~~1301. Sand for grout shall be a mortar sand according to ~~ASTM A153, except that galvanized hardware located within 50 mm of the concrete surface shall be chromate coated over an electro-deposited coating of zinc~~ OPSS 1004. Water for grout shall be according to ~~ASTM B633.~~
OPSS 1302. Admixtures for grout shall be

~~**912.05.11 Moisture Vapour Barrier**~~

~~The moisture vapour barrier shall be white opaque polyethylene film~~ according to ~~ASTM C171 and shall not be less than 100 µm thick.~~OPSS 1303.

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

912.05.~~12~~08 Levelling Course

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

912.05.09 Native Material

Native ~~and imported~~ material shall be ~~approved by~~acceptable to the Contract Administrator prior to use in the work. All material shall be free from frozen lumps, cinders, ashes, refuse, vegetable or organic matter, rocks and boulders over 150 mm in any dimension, and other deleterious material.

912.05.~~13~~10 Preformed Joint Seal

Preformed joint seals ~~shall be used~~, for sealing ~~the joint~~ between elements~~. Preformed joint seals~~, shall be butyl rubber according to ASTM C990. The primer for the preformed joint seal, shall be as recommended by the preformed joint seal manufacturer.

912.05.~~14~~11 Proprietary Patching Materials

Proprietary patching materials shall be from the Owner's List of Acceptable Concrete Patching Materials. The list of proprietary patching materials shall be obtained from the Contract Administrator. Water used for proprietary patching materials shall be according to OPSS 1302.

~~**912.05.15 Steel Reinforcement**~~

~~Steel reinforcement shall be according to OPSS 1440.~~

~~**912.05.16 Water**~~

~~Water used for curing, including steam curing and pre-soaking of burlap, and water used in proprietary patching materials shall be according to OPSS 1302.~~

~~**912.06 EQUIPMENT**~~

~~**912.06.01 General**~~

~~Equipment made of aluminum, including tools, shall not come in contact with the plastic concrete.~~

~~**912.06.02 Temperature Monitoring and Recording System**~~

~~The temperature monitoring and recording system shall provide unalterable records of temperature during the recording period. Prior to use on the Contract, the temperature monitoring and recording system shall be confirmed by the Owner, in writing, to be acceptable.~~

~~Thermocouples and associated instrumentation shall have an accuracy of ± 1.5 °C and shall record temperatures at time intervals not exceeding 15 minutes and shall digitally display the temperature.~~

~~**912.06.03 Chipping Hammers**~~

~~Chipping hammers shall have a maximum weight of 9.0 kg and a maximum piston stroke of 102 mm. All hammers shall have the manufacturer's name and model number legibly engraved on them by the manufacturer.~~

912.07 CONSTRUCTION

912.07.01 ~~Production of Precast Concrete Culverts~~ Foundation

912.07.01.01 ~~Precast Plant Certification~~ General

~~Precast culverts shall be fabricated by a plant certified according to one of the following:~~

~~a) Canadian Precast Concrete Quality Assurance (CPCQA) Certification Program, Group B, Precast Bridge Products (B1 minimum), or~~

b) Canadian Standards Association (CSA) Pre-cast Concrete Products Certification Program, Group B, Bridge Products (B1 minimum).

If concrete is supplied by a ready-mix concrete plant, the concrete production facility shall be certified by the Ready Mixed Concrete Association of Ontario (RMCAO).

912.07.01.02 Markings

As a minimum, the following information shall be embossed using numbers and letters 30 mm wide, 35 mm high and 5 mm deep on an upper top haunch of each element in the following order, readily visible for inspection:

a) Prequalification stamp in accordance with the published requirements of the CPCQA or CSA Certification Program.

b) Name or trademark of the manufacturer.

c) Identification of plant if manufacturer has more than one plant.

d) Date of manufacture (yyyy-mm-dd).

e) Unique Number.

f) Specification designation.

g) MTO Site Number on end pieces.

In addition, the word "top" shall be lettered with waterproof paint on the top surface. This requirement shall be waived if the manufacturer installs lifting devices in the top slab only.The

912.07.01.03 Steel Reinforcement, Mechanical Connectors, and Associated Hardware

912.07.01.03.01 Placement of Reinforcement

The placement of steel reinforcement shall be according to OPSS 905.

Under no circumstances shall reinforcement be inserted into plastic concrete.

912.07.01.03.02 Welding

Welding of steel hardware shall be according to CSA W59 and shall be performed by a welder qualified by the Canadian Welding Bureau (CWB) working for a company certified in accordance with CSA W47.1, Division 1 or 2.

Welding of reinforcing steel bars shall be according to OPSS 905. The reinforcing steel welding shall be performed by a welder qualified by the CWB working for a company certified in accordance with CSA W186.

912.07.01.04 Production of Concrete

Production of concrete shall be according to the General, Temperature Control, Mixing Time and Mixing Rate, and Delivery subsections of OPSS 1350.

When there are multiple batches of concrete in a single ready-mix truck, hopper or other container, discharge times shall be measured from the time of introduction of water to cement for the first batch of concrete in the truck, hopper or other container. Discharge of all concrete in the truck, hopper or other container shall be completed within 1.5 hours, except when the air temperature exceeds 28 °C and the concrete temperature exceeds 25 °C, the discharge shall be completed within 1 hour.

912.07.01.05 Sampling and Testing of Plastic Concrete

Sampling and testing of the plastic concrete for slump, air content, and temperature shall be according to OPSS 1350. The results of these tests shall be recorded. The minimum frequency of testing shall be as follows:

a) For concrete supplied by an external concrete supplier and delivered by a ready-mix truck, once for each of the first three trucks, until satisfactory control is established, and then once every third truck.
b) For batches of concrete produced at the precast plant and transported by a ready-mix truck, once for each of the first three trucks, until satisfactory control is established, and then once every third truck.

c) For batches of concrete produced at the precast plant, and not delivered by a truck, once for each of the first five batches of concrete, until satisfactory control is established, and then once every fifth batch.

d) For batches of concrete produced at a precast plant with an integrated mixing and delivery system (e.g. Autocor), once for every second batch for the first six batches, until satisfactory control is established, and then once every 7 m^3 of concrete.

Satisfactory control is established when three or five consecutive tests of concrete, as specified above, are within the specified requirements, without adjustments. If any adjustments are required or conducted, testing shall continue until three or five consecutive tests, as specified above, meet the requirements with no adjustments. Satisfactory control shall be established each Day or when there is a break in production longer than 1.5 hours.

Testing of plastic concrete shall be carried out as close as possible to the location of discharge of concrete into the formwork.

Sampling and testing of slump, air content and temperature of plastic concrete shall be carried out by a technician holding either of the following certifications:

a) CCIL Certified Field Testing Technician; or

b) ACI Concrete Field Testing Technician - Grade 1.

This technician shall have a valid, original card issued by the certifying agency in his or her possession at all times.

912.07.01.06 Verification Cylinders for 28-Day Compressive Strength Testing

One set of three 100 mm diameter x 200 mm long cylinders shall be cast per lot for 28-Day compressive strength testing by the Owner. Cylinders shall be cast by a certified technician. Cylinders shall be cast with an element selected randomly from the lot by the Contract Administrator.

All concrete test cylinders shall be cast in new, single-use moulds conforming to the requirements of CSA A23.2-1D and made of plastic, with a lid. The lids shall be chemically and physically compatible with the concrete and shall provide watertight closure for the moulds.

Concrete test cylinders shall be cast, cured, and transported to the designated laboratory according to CSA A23.2-3C with the exception that cylinders shall be cured with the element with which they were made, prior to delivery to the laboratory. Cylinders shall be delivered to the laboratory for demoulding.

Test information shall be recorded on MTO form PH-CC 322. A copy of the form shall be submitted with each set of the concrete cylinders along with a transmittal form and PH-CC-433A (Form A) of the concrete mix design for the culvert. No referee cylinders are required for this testing.

Cylinder test results will be used by the ministry to verify compliance with the requirements of CSA S6.

912.07.01.07 Placing of Concrete

912.07.01.07.01 General

The method of transporting, placing, and consolidating the concrete shall be such as to prevent segregation. Concrete placing and transporting devices shall not be supported by the steel reinforcement.

Concrete shall be deposited within 0.5 m of the top of the reinforcement and 2.5 m horizontally of its final position.

Concrete shall be placed at a steady rate such that a monolithic concrete is obtained without on the formation of cold jointsleveling course and bedding, or pour lines.

When there is an interruption in placing concrete greater than 20 minutes, the top of the formwork shall be covered with wet burlap to maintain 100% relative humidity above the concrete. The Contract Administrator shall be notified of any interruption resulting in a cold joint.

912.07.01.07.02 Concrete Placing Restrictions

All surfaces against which concrete is to be placed shall be free of standing water. Fresh concrete shall be protected from contact with rain or snow. Deicing chemicals shall not be used.

All debris shall be removed from the area where concrete is to be placed.

Any surface against where concrete is placed, including existing concrete, steel reinforcement, structural steel, forms, or other surfaces, shall be at a minimum temperature of 5 °C immediately prior to commencement of placing concrete.

The temperature of the formwork, steel reinforcement or any other material against which concrete is to be placed shall not exceed 30 °C.

Temperature measurements shall be taken no more than 10 minutes prior to concrete placement, for each element. Temperature measurements shall be made with a contact thermometer with an accuracy of ± 0.5 °C.

912.07.01.07.03 Consolidation

Internal or external vibrators or both shall be used to thoroughly consolidate the concrete, as it is placed. Concrete shall be thoroughly consolidated around all steel reinforcement.

Each layer of concrete shall be vibrated. Vibrators shall extend into the previous layer to produce a homogenous mixture at the layer interface and prevent the formation of pour lines or cold joints.

Vibration shall not be used to make the concrete flow or to spread the concrete more than 1.5 m from the point of deposit.

The requirements of this clause do not apply to self-consolidating concrete (SCC), where accepted for use by the Owner.

912.07.01.07.04 Concrete Finishing

Finishing of the concrete surface shall be done immediately following placement. No material shall be applied to the concrete surface or the finishing tools to aid in the finishing.

Except as indicated below, finished surfaces shall be smooth, free from open texturing, undulations, projections, and ridges. The concrete shall be struck off to the required dimensions and cross-section and shall be hand finished with a float.

Concrete surfaces against which new concrete is to be placed shall be:

a) Left with a rough surface finish (so that the depth of the indentations is at least 5 mm and the spacing is not greater than 15 mm), except for concrete surfaces against which protection slabs or distribution slabs shall be placed, and

b) Abrasive blast cleaned according to OPSS 929, prior to placing any additional concrete.

The requirement to hand finish the concrete with a float does not apply to SCC, where accepted for use by the Owner.

912.07.01.08 Control of Temperature

912.07.01.08.01 General

For all concrete, all necessary actions shall be taken to maintain temperatures within the specified limits. During production, moist curing and the cold weather protection period, the following temperature requirements shall be met:

a) The concrete temperature shall not exceed 60 °C, except if the concrete has a maximum thickness greater than 500 mm, then the concrete temperature shall not exceed 65 °C.

b) The concrete temperature shall not fall below 10 °C before the end of moist curing.

c) The concrete temperature shall not fall below 0 °C before the end of the cold weather protection period.

d) The temperature difference, as measured between thermocouples at the following locations, shall not exceed 20 °C:

i. Internal concrete temperature and the corresponding surface concrete temperatures.
ii. Internal concrete temperatures at different locations within the element.

e) The maximum cooling rate of concrete shall not exceed 15.0 °C per hour until the concrete is not more than 20.0 °C above the air temperature. Air temperature is temperature next to the concrete, within the curing enclosure.

912.07.01.08.02 Temperature Monitoring and Records

The concrete and air temperatures during the curing period and, if applicable, the cold weather protection period shall be monitored and recorded. The concrete temperature shall be measured and recorded for each element.

Thermocouples shall be placed in the following locations at a minimum:

a) Ambient air temperature adjacent to the concrete.

b) The expected point of maximum internal temperature, located centrally within the concrete at the maximum section thickness, typically a haunch.

c) Corresponding surface concrete temperature, with the thermocouple imbedded in the concrete within 5 mm of the surface, at the maximum section thickness.

d) Centrally at mid-span and mid-depth of the longest span, typically the top or bottom of the element.

A set of a) to d) thermocouples shall be placed in each element at mid-length.
For culverts with a span greater than 6 m, an additional set of b) and c) thermocouples shall be imbedded in each element in another location of maximum section thickness so that temperatures are monitored in both halves of the span.

Recording of concrete and air temperatures shall begin at the start of concrete placement. The temperature shall be recorded automatically at time intervals not exceeding 15 minutes until the end of the curing period and, if applicable, the end of the cold weather protection period. The temperature monitoring system shall be left in place until the end of the monitoring period.

When requested, the Contract Administrator and any other Owner's representatives shall be provided access to verify temperature readings and thermocouple function.

Temperature records shall be submitted for the duration of the temperature monitoring period.

Temperature records, including a graphical plot of temperature versus time, shall be submitted to the Contract Administrator in the precast report.

912.07.01.09 Curing

912.07.01.09.01 General

Concrete shall be moist cured for four Days except for concrete containing silica fume which shall be moist cured for seven Days. Curing in cold weather conditions shall be according to the Cold Weather Protection Period section of this specification.

Moist curing of exposed surfaces shall commence immediately after concrete finishing, except for culverts produced in an indoor precast concrete plant and not containing silica fume; for such culverts, exposed surfaces may be covered with moisture vapour barrier between concrete placement and concrete finishing, for the shortest practical time period and in no cases exceeding 40 minutes.

912.07.01.09.02 Moist Curing

Moist curing shall be sufficient to keep all surfaces of the concrete in a continuously wet condition, with no dry areas, by applying one or a combination of the following methods:

a) Curing according to the Curing with Burlap and Water clause.

b) Curing by means of continuous water application, e.g. mist.

c) Curing according to the Steam Curing and Other Application of Heat clause.

d) Curing by means of immersion in water.

Records of moist curing shall be maintained and submitted according to the requirements of this specification.

The records shall provide verification that curing is in accordance with this specification. As a minimum, records of moist curing shall include the identification of the person checking the moist curing system, the time that it was verified and photo documentation of the curing chamber in operation during the curing period as follows:

a) Photographs shall be taken every 8 hours for the first 24 hours of the curing period.

b) Photographs shall be taken every 24 hours as a minimum for the remainder of the curing period.

c) Each photo shall include a date and time stamp of when the photo was taken.
Elements whose surfaces have not been kept in a continuously wet condition shall be deemed rejectable.

Formwork shall be removed within four Days of concrete placement and the concrete shall be moist cured for the remainder of the minimum curing period and no less than 24 hours.

Concrete may be exposed to ambient conditions, during the moist curing period, according to the Exposure clause of this specification.

912.07.01.09.03 Curing with Burlap and Water

Curing with burlap and water shall be done according to the Curing with Burlap and Water clause of OPSS 909 with the addition of the following:

a) Burlap shall be held in place without marring the surface of the concrete.

912.07.01.09.04 Steam Curing and Other Application of Heat

Steam curing and application of heat, if used, shall be according to the requirements of the Steam Curing and Other Application of Heat section of OPSS 909.

912.07.01.10 Exposure

During moist curing and cold weather protection periods, the element may be exposed for a maximum total period of one hour per day for the purposes of formwork removal, inspection or relocation within the plant, except for indoor precast concrete plants, where the exposure period shall not exceed two hours per day.

During the exposure period:

a) The requirements in the Control of Temperature clause do not apply.

b) There shall be no more than three consecutive thermocouple measurements of surface temperature below 10.0 °C, and none below 5.0 °C, when measured at 15 minute intervals at locations according to the Temperature Monitoring and Records clause.

On the day formwork is removed, the moist curing may be suspended during the 1-hour exposure period, or 2-hour exposure period for indoor plants, except for concrete containing silica fume. For concrete containing silica fume, continuous moist curing shall be applied throughout the exposure period.

912.07.01.11 Cold Weather Protection Period

If cold weather conditions are present at the end of the curing period, the elements shall be provided with protection from cold weather and moisture loss for an additional 24 hours, prior to exposure to cold weather conditions. Protection shall be extended if required to meet the requirements in the Control of Temperature clause.

~~**912.07.01.12 Stripping Strength**~~

~~For each element, it shall be demonstrated that the stripping strength as specified in the Working Drawings has been achieved prior to stripping the formwork. The Contractor, when requested by the Owner, shall participate in standard cylinder correlation strength testing programs conducted by the Owner.~~

~~**912.07.01.13 Concrete Cover**~~

~~The Contractor shall carry out, at the precasting facility, a covermeter survey on all elements until satisfactory control is established. For each design and size of element, satisfactory control shall be established when three consecutive elements of the same design are within the specified tolerances. After satisfactory control has been established, testing shall be carried out on every fifth element. If testing indicates that cover measurements for an element do not meet the tolerances specified in Table 1, testing shall resume on each element until satisfactory control is re-established.~~

~~Concrete cover readings shall be taken evenly spaced across the surface of the concrete at grid points, along the longitudinal and transverse axes, at a spacing of 1 to 3 m, providing a minimum of 20 measurement points per element.~~

~~**912.07.01.14 Dimensional Tolerances**~~

~~The Contractor shall carry out measurements on each element prior to shipping and on each culvert, after installation, to determine compliance with tolerance requirements. Elements and culverts shall meet the tolerances specified~~ in the Contract Documents~~ and Table 1 of this specification.~~.

~~For dimensional tolerances not specified, the maximum allowable dimensional variation shall be 1:800 or ± 5 mm, whichever is greater.~~

~~**912.07.01.15 Surface Finish**~~

~~**912.07.01.15.01 General**~~

~~Concrete surfaces shall not be treated with cement slurry or paste.~~

~~Surface defects and deficiencies with dimensions according to Table 2 are repairable by standard methods according to Table 2.~~

~~A repair proposal shall be submitted to the Contract Administrator to repair surface defects and deficiencies not listed in Table 2.~~

~~**912.07.01.15.02 Exposed Surfaces**~~

~~The appearance of the concrete and repairs shall be uniform in colour, pattern, and texture when viewed from a distance of 15 m. Material, including all patching materials, shall be selected to achieve uniformity of colour and appearance.~~

~~All projections, such as fins and bulges, and all blemishes, such as stains, shall be removed.~~

~~**912.07.01.15.03 Surface Tolerance**~~

~~Formed and unformed surfaces shall be such that when tested with a 3 m long straight edge placed anywhere in any direction on the surface, there shall be no gap greater than 6 mm between the bottom of the straight edge and the surface of the concrete.~~

~~912.07.02 Installation~~

~~912.07.02.01 Foundations – General~~

~~The culvert shall be placed on competent in situ soil or compacted backfill, or as specified in the Contract Documents.~~

When unsuitable material is encountered during excavation for the culvert foundation, the unsuitable material shall be removed to competent stratum and replaced to the foundation grade with compacted ~~granular material~~Granular A, to according to OPSS 1010 , as specified in the Contract Documents.

The ~~final founding elevations~~elevation of the top of the levelling course shall be as specified in the Contract Documents ~~or an elevation approved~~, unless otherwise stated, in writing, by the ~~Contract Administrator~~Owner.

912.07.~~02.~~01.~~01~~02 Support Systems

Support systems shall be according to OPSS 404.

912.07.~~02.~~01.~~02~~03 Temporary Protection Systems

Temporary protection systems shall be according to OPSS 539.

912.07.~~02.~~01.~~03~~04 Excavation

The excavation for the installation of the culvert shall be according to OPSS 902, including frost tapers and culvert end treatments.

Swamp excavation shall be according to OPSS 209.

912.07.~~02.~~01.~~04~~05 Dewatering

Dewatering shall be according to OPSS 517.

912.07.~~02.~~01.~~05~~06 Bedding

Bedding shall not be placed on frozen material.

Bedding shall be placed as specified in the Contract Documents.

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

Bedding shall ensure uniform support under the full width and length of the culvert. The length of the culvert shall be the distance measured between the ends of the assembled elements, measured along the longitudinal axis

~~The bedding shall be placed in uniform lifts not exceeding 200 mm in thickness. Bedding shall not be placed on frozen material.~~

Bedding and subgrade material shall be protected from disturbance during construction.

912.07.~~02.~~01.~~06~~07 Levelling Course

~~When a leveling~~ The levelling course ~~is specified, it~~ shall consist of a 75 mm minimum thickness of fine aggregate. ~~Fine aggregate for levelling courses~~

912.07.02 Placement of Geotextile at Joints Prior to Installation of Elements

Prior to installation of the elements, geotextile shall be ~~according to OPSS 1002~~placed under the location of the bottom slab of the culvert elements, centered at the joints, as specified in the Contract Document. A sufficient length of geotextile shall be placed such that the entire culvert joint can be wrapped. The geotextile shall be protected from damage prior to final installation.

For side-by-side culverts, geotextile shall wrap both culverts together and omit covering the portion of the joints between the two culverts that is filled with grout.

912.07.~~912.07.02.02 Delivery~~

03 Inspection of Elements Prior to Installation

Prior to commencing installation, the Contractor shall inspect all the elements on site for any defects or deficiencies. The Contract Administrator shall be notified immediately in writing ~~a minimum of three Business Days prior to delivery~~if any of the culvert elements contain defects or deficiencies.

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

~~Elements 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. Elements, 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 elements only while in transit to the site. Any permanent markings on a surface that would be visible after installation shall not be permitted.~~

A MTO form PH-CC-701, Request to Proceed shall be submitted to the Contract Administrator prior to installation. The culvert elements shall be inspected on site by the Contract Administrator for any defects and deficiencies prior to installation. The Contract Administrator will notify the Contractor immediately in writing if any of the culvert elements contain defects or deficiencies.

Any defects or deficiencies identified shall be addressed prior to installation according to the Defects and Deficiencies subsection of OPSS 1355, as applicable.

Installation of elements shall not proceed until a MTO form PH-CC-702, Notice to Proceed has been received from the Contract Administrator.

912.07.~~02.03~~04 Installation of ~~Precast Concrete Culvert~~Elements

912.07.04.01 General

The Contract Administrator shall be notified in writing of the installation date a minimum of ~~three~~3 Business Days prior to the commencement of installation.

Installation shall be according to CSA A23.4, Working Drawings and as specified in the Contract Documents. A copy of the Working Drawings shall be kept on the site during the installation of the culvert elements.

~~The Work shall consist of installation and stabilization of the elements.~~ Elements shall be lifted and placed in a manner to ensure they are not overstressed, unstable, or unsafe at any time.

After installation of the elements, concrete patching material, from the Ministry's list of acceptable patching materials, shall be used to provide required concrete cover over lifting devices.

A copy of the Working Drawings shall be kept on the site during installation of the elements.

The Contractor shall inspect the elements for defects before installation.

912.07.02.04 Cast-in-Place Concrete Appurtenances, Protection Slabs and Distribution Slabs

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

Installation of the elements shall commence at the outlet end and proceed in the upstream direction with the bell ends of the culvert elements facing up grade. The elements 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.

Cast in-place concrete appurtenances, protection slabs and 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 as specified Contract Documents. The protection slab or distribution slab shall be placed without any damage to or movement of the culvert.

912.07.02.05 Joints Between Elements

912.07.02.05.01 General

All joints between elements of the culvert shall be constructed and treated to prevent leakage and infiltration.

All elements shall be provided with bell and spigot ends. The ends shall be of such design that when the elements are laid together they will make a continuous culvert with a smooth interior free of irregularities in the flow line. The gap at the joints shall not exceed the maximum value provided in Table 1. The gap between adjacent side-by-side (multi-cell) box culverts shall be 60 mm, with a tolerance specified in Table 1. Joint treatment shall be as shown in the Contract Documents.

912.07.02.05.02 Preformed Seals

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

912.07.02.06 Alignment

The position of the inner and outer top edges of elements shall be set true to the elevations and alignment according to the Working Drawings and as specified in the Contract Documents. Culverts shall be constructed to the specified geometry, plumbness, and alignment and shall not exceed the tolerances outlinedspecified in Table 1.

The ends of each culvert element when laid together shall make a continuous culvert with a smooth interior, free of irregularities in the flow line.

After the installation, the Contractor shall inspect the elements for any defects or deficiencies and for geometery, plumbness, and alignment, to ensure that the culvert is as specified in the Contract Documents. The Contract Administrator shall be notified, in writing, of any requirements that are not met.

Repairs to erected elements, according to OPSS 1355, shall only be carried out after the Contract Administrator has accepted the repair proposal.

912.07.04.02 Joints Between Elements

Joint treatment shall be as specified in the Contract Documents.

All joints between elements of the culvert shall be constructed to prevent leakage and infiltration.

All elements shall be provided with bell and spigot ends.

Preformed joint seals shall be used for sealing the joint between elements. Preformed joint seals shall be placed according to the preformed joint seal manufacturer's recommendations and the following:

a) The concrete surface to receive the preformed joint seal shall be cleaned with a stiff bristle brush immediately prior to placing the preformed joint seal. All dirt and debris shall be removed from the concrete surface prior to placing the preformed joint seal.

b) The concrete surface shall be dry prior to placing the preformed joint seal.

c) If recommended by the preformed joint seal manufacturer, primer shall be applied to the concrete surface to receive the preformed joint seal, according to the manufacturer's recommendations. The primer shall be allowed to dry prior to placement of the preformed joint seal.

d) Preformed joint seal shall be clean and free of dirt and debris when placed.

e) Preformed joint seal shall be placed at the locations specified in the Contract Documents. Preformed joint seal shall be placed around the entire circumference of the culvert and shall be pressed into place. The preformed joint seal shall be placed such that the end of the length of the seal is located on the top portion of the element. The preformed joint sealant shall not be stretched.

f) Treatment at the ends of the preformed joint seal shall be as recommended by the manufacturer. There shall be no gap between the ends of the length of the preformed joint seal.

g) After placement, remove any protective backing paper from the preformed joint seal, if present. The placed preformed joint seal shall be protected from dirt and debris prior to installation of the next culvert element.

h) The preformed joint seal shall be compressed to the degree recommended by the manufacturer.

The gap at the joints shall not exceed the maximum value specified in Table 1.

912.07.04.03 Additional Requirements for Side-By-Side Culverts

For culverts placed in parallel, side-by-side, the gap between the adjacent culverts shall be 60 mm, within the tolerance specified in Table 1.

The 60 mm gap shall be filled with grout. The vertical surfaces to receive the grout shall not be waterproofed on the inside vertical face between the two culvert.

912.07.05 Filling of Holes for Lifting Devices

After installation of the elements, a proprietary patching material shall be used to fill holes for lifting devices. The proprietary patching material shall be comparable to the surrounding concrete in terms of strength and permeability. The patching material shall be mixed, handled, and cured according to the manufacturer's instructions. Immediately prior to filling, the inside surface of each lifting device hole shall be cleaned with nylon brushing and all free water shall be removed. The patch shall be finished flush with the surface of the surrounding concrete. All excess material shall be removed from the surface of the concrete. When filling lifting device holes, the proprietary patching material shall be cured with curing compound according to OPSS 904, or shall be cured as recommended by the manufacturer of the proprietary patching material.

912.07.06 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 placement of a protection slab or distribution slab and prior to waterproofing, a MTO form PH-CC-701, Request to Proceed shall be submitted to the Contract Administrator. The next operation shall not proceed until a MTO form PH-CC-702, Notice to Proceed has been received from the Contract Administrator.

912.07.07 Cast-in-Place Concrete Appurtenances, Protection Slabs and Distribution Slabs

Cast-in-place concrete appurtenances, protection slabs and distribution slabs shall be according to OPSS 904.

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

912.07.~~02.~~08 Waterproofing of the Culvert

Waterproofing of the culvert shall be as specified in the Contract Documents.

912.07.~~02.~~09 ~~Geotextile at Joints~~

~~After completion of waterproofing, including placement of protection board, the joints shall be covered with a minimum 600 mm wide geotextile, unless otherwise specified, to prevent influx of material from the backfill or native soil or both. The 600 mm wide strip of geotextile shall be placed to form a continuous barrier centered on the exterior of all buried joints, including on top of areas of the joint that are waterproofed.~~

~~The geotextile and the seam requirements at the joints shall be according to OPSS 1860.~~

~~Geotextile shall be free of folds, tears, and wrinkles. The geotextile shall be joined so that the material laps a minimum of 500 mm, and shall be pinned together.~~

~~**912.07.02.10 Inspection After the Waterproofing of the Culvert and Prior to Backfilling**~~

After waterproofing of all elements of a culvert within a construction stage, and prior to backfilling, a MTO form PH-CC-701, Request to Proceed shall be submitted to the Contract Administrator. The next operation shall not proceed until a MTO form PH-CC-702, Notice to Proceed has been received from the Contract Administrator.

912.07.10 Placement of Geotextile at Joints After Waterproofing

After completion of waterproofing, including placement of protection board, the joints shall be covered with geotextile. The geotextile shall be placed to form a continuous barrier centered on the exterior of all buried joints, including on top of areas of the joint that are waterproofed.

The geotextile shall be joined so that the geotextile laps a minimum of 500 mm, and shall be pinned together. When the lap is on the vertical face of the culvert, the geotextile from the top surface shall overlap the geotextile from the bottom of the culverts.

912.07~~02~~.11 Backfilling

Backfilling shall be according to OPSS 902~~.~~ with the addition that the maximum uncompacted lift thickness shall be 300 mm. Backfill shall be placed without any damage to or movement of the elements.

912.07~~.02~~.12 Granular Cover

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

912.07.~~02~~.13 Clay Seals

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 according to LS-706, and carried out on a single representative sample~~.~~, selected by the Contract Administrator. Field density and field moisture determinations shall be made according to ASTM- D6938.

~~**912.07.03 Repair of Defects and Deficiencies Repairable by Standard Methods**~~

~~**912.07.03.01 General**~~

~~All concrete shall be routinely inspected for any defects and deficiencies up to the date of Completion of the work. Defects and deficiencies shall be identified and documented including their location, size, and frequency.~~

~~Areas requiring repair or replacement shall be based on the criteria shown in Table 2. The limits of repair and replacement for each area shall be identified.~~

~~Any element having one or more of the defects and deficiencies identified in Table 2 shall be repaired according to the repair method specified. Such repairs do not require proposals or Owner approval prior to repair.~~

~~Where more than one of the defects or deficiencies listed in Table 2, excluding bugholes, is located in the same area in the element, a repair proposal shall be submitted to the Contract Administrator. The repair proposal shall be according to the Quality Assurance section.~~

~~All causes, preventative actions, and corrective actions, including repair methods and materials used, shall be documented and submitted in the precast report.~~

~~**912.07.03.02 Assessment of Repair**~~

~~At the discretion of the Owner, additional visual inspection or other investigative measures, including the removal of cores, may be required to assess the effectiveness of the repair. The filling of core holes shall be according to the Filling of Core Holes subsection in OPSS 1350.~~

~~**912.07.04 Material Sampling for Acceptance Testing**~~

~~**912.07.04.01 Sampling of Steel Reinforcement**~~

~~Samples of steel reinforcement shall be provided to the Owner according to OPSS 905.~~

~~**912.07.04.02 Sampling of Water, Admixtures, and Cementing Materials**~~

~~Samples of all water, admixtures, and cementing materials shall be provided to the Owner for testing, according to OPSS 1350.~~

~~**912.07.04.03 Sampling of Hardened Concrete for Acceptance Testing**~~

~~**912.07.04.03.01 General**~~

~~Hardened concrete shall be sampled on a lot basis according to the Coring clause and Lot Size subsection of this specification. Test specimens shall consist of cores removed from the hardened concrete for testing by the Owner of compressive strength, air void system parameters and rapid chloride permeability.~~

~~**912.07.04.03.02 Notification**~~

~~A list of elements and their identification numbers shall be submitted to the Contract Administrator within 24 hours of the completion of a lot, to facilitate selection by the Contract Administrator of elements for acceptance testing.~~

~~**912.07.04.03.03 Coring**~~

~~One set of cores shall be obtained from each lot for quality assurance testing. Locations of core removal shall be randomly selected from each lot by the Contract Administrator. A set of cores shall consist of five cores, 100 mm in diameter and 220 mm in length. If the element is less than 220 mm thick, the full depth of the element shall be cored.~~

~~Cores shall be removed when the concrete is between 7 to 10 Days of age, and prior to application of waterproofing membrane. Cores shall be removed in the presence of the Contract Administrator or Owner's representative. No core shall be taken within 250 mm of any joint or edge or within a distance 500 mm from another core. No core shall be taken through the waterproofing system. All cores of the same set shall be removed at a location no more than 3 m from the location of the first core for that set. Cores shall be removed from the sides or haunch of the elements.~~

~~Coring shall be carried out according to CSA A23.2-14C. Cores shall not contain reinforcement or other embedded material. A covermeter capable of detecting the type(s) of reinforcing materials in the element shall be used to establish the location of reinforcement and other embedded material prior to coring.~~

~~The contract number, lot number, and element identification number shall be marked legibly on each core with durable ink. Each core shall be placed in a plastic bag, sealed to prevent loss of moisture, and fitted with a security tag by the Contract Administrator. All acceptance cores shall immediately be given to the Contract Administrator, with the transmittal form and PH-CC-433A (Form A) of the concrete mix design, for transportation to the designated laboratory.~~

~~The core holes shall be filled, within three Days, according to the Filling of Core Holes subsection of OPSS 1350.~~

~~912.07.05~~912.07.14 Access for Quality Assurance

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

Any debris and obstructions shall be removed to allow access for the purposes of covermeter and dimensional measurements or inspection. The Contract Administrator shall be notified in writing when the culvert is ready for the verification measurements and inspection.

912.07.~~06~~15 Management of Excess Materials

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

912.08 QUALITY ASSURANCE

912.08.01 General

The acceptance of culverts shall be ~~according to the requirements of~~ as specified in this specification and the Contract Documents, including satisfactory completion of any repairs.

~~Acceptance of compressive strength, air void system parameters, and rapid chloride permeability shall be on a lot basis.~~

~~Lots not meeting the requirements of the Contract Documents shall be deemed rejectable.~~

~~**912.08.02 Lot Size**~~

912.08.02 Acceptance of Installation Tolerances

The Contract Administrator shall ~~determine the limits of each lot prior to commencing production, based on the lot size definition, and shall confirm the specific~~be notified in writing when the bridge elements ~~to be included in each lot prior to commencing production of that lot.~~are ready for the verification measurements.

~~**912.08.03 Acceptance of Compressive Strength of Concrete in Place**~~

~~Testing of compressive strength shall be according to LS-410.~~

~~Three cores shall be tested to determine the acceptability of compressive strength of the lot.~~ The ~~28-Day concrete compressive strength of a lot shall be considered acceptable when:~~

~~a) The average of the three individual compressive strength cores is equal to or greater than the specified strength, and~~

~~b) No individual core result is more than 10% below the specified 28-Day compressive strength.~~

~~Unacceptable lots shall be deemed rejectable, but may, at the discretion of the Owner, be permitted to stay in the work. When the Owner permits the work to remain in place, it shall be subject to a payment adjustment calculated according to the Basis of Payment section.~~
~~Test results shall be forwarded to the Contractor as they become available.~~

~~**912.08.03.01 Referee Testing of Compressive Strength of Concrete In Place**~~

~~Referee testing of compressive strength may only be invoked by the Contractor within five Business Days of receipt of the acceptance test result.~~

~~Referee testing of compressive strength shall be carried out on a set of three cores taken, within three Business Days of invoking referee testing, by the Contractor from the same element which the acceptance cores were taken, in accordance with the Coring clause. Referee cores shall immediately be given to the~~ Contract Administrator ~~for transportation to the designated laboratory.~~

~~The referee laboratory shall be designated by the Owner based on the applicable roster and cores shall be tested according to LS-410.~~

~~Referee test results shall be forwarded to the Contractor as they become available.~~

~~The confirmation value for confirming the acceptance test result shall be the greater of 10% of the specified strength or 10% of the strength of the acceptance cores, expressed to one decimal place.~~

~~If the difference between the referee test result and the acceptance test result is less than the confirmation value, the acceptance test result is confirmed, and the acceptance test result shall be used in the determination of acceptance of the lot. If the difference between the referee test result and the acceptance test result is greater than the confirmation value, the acceptance test result is not confirmed, and the acceptance test result shall be disregarded~~

~~The cost of referee testing of compressive strength shall be according to OPSS 1350.~~

912.08.04 Acceptance of Air Void System in Hardened Concrete

Testing of air void system shall be according to LS-432. One half of a core shall be tested to determine the acceptability of the lot. The other half of the core shall be retained by the Owner for audit purposes.

Test results shall be forwarded to the Contractor as they become available.

For the lot to be considered acceptable, the sample shall have a minimum air content of 3.0% and a spacing factor of 0.200 mm or less. Acceptable lots shall be subject to full payment.

Lots with a sample with a spacing factor greater than 0.200 mm and less than or equal to 0.250 mm are unacceptable. If the Owner permits the work to remain in place, lots with a spacing factor greater than 0.200 mm and less than or equal to 0.250 mm shall be subject to a payment adjustment calculated according to the Basis of Payment section.

Lots with a sample with a spacing factor more than 0.250 mm or air content less than 3.0% shall be deemed rejectable.

912.08.04.01 Referee Testing of Air Void System in Hardened Concrete

Referee testing of air void system parameters shall be according to OPSS 1350.

The cost of air void system referee testing shall be according to OPSS 1350.

912.08.05 Acceptance of Rapid Chloride Permeability

912.08.05.01 General

Acceptance of rapid chloride permeability shall be based on the result of the core representing the lot, tested according to LS-433 at 28-32 Days of age.

Two samples 50 mm long shall be cut from the core, tested, and the results averaged to determine the acceptance of the lot.

Test results shall be forwarded to the Contractor as they become available.

912.08.05.02 Concrete Without Silica Fume

Lots with rapid chloride permeability less than or equal to 2,500 coulombs are considered acceptable. Acceptable lots shall be subject to full payment.

Lots with a rapid chloride permeability result greater than 2,500 coulombs are unacceptable. If the Owner permits the work to remain in place, lots with an average value of rapid chloride permeability exceeding 2,500 coulombs and less than 3,500 coulombs shall be subject to a payment adjustment calculated according to the Basis of Payment section.

Lots with rapid chloride permeability results exceeding 3,500 coulombs shall be deemed rejectable.

912.08.05.03 Concrete Containing Silica Fume

Lots with rapid chloride permeability less than or equal to 1,000 coulombs are considered acceptable. Acceptable lots shall be subject to full payment.

~~Lots with a rapid chloride permeability result greater than 1,000 coulombs are unacceptable. If the Owner permits the work to remain in place, lots with an average value of rapid chloride permeability exceeding 1,000 coulombs and less than 2,000 coulombs shall be subject to a payment adjustment calculated according to the Basis of Payment section.~~

~~Lots with rapid chloride permeability results exceeding 2,000 coulombs shall be deemed rejectable.~~

~~912.08.05.04 Referee Testing of Rapid Chloride Permeability~~

~~912.08.05.04.01 General~~

~~Referee testing of rapid chloride permeability may only be invoked by the Contractor within five Business Days of receipt of the acceptance test result.~~

~~Referee testing shall be carried out on a core taken, within three Business Days of invoking referee testing, by the Contractor from the same element which the acceptance core was taken, in accordance with the Coring clause. The referee core shall immediately be given to the Contract Administrator for transportation to the designated laboratory.~~

~~Referee testing shall be done on two-50 mm samples obtained from the core representing the lot for which referee testing was invoked, and the results shall be averaged to obtain the test result for the lot.~~

~~Cores shall be tested according to LS-433.~~

~~The referee laboratory shall be designated by the Owner based on the applicable roster and cores shall be tested by that laboratory.~~

~~Referee test results shall be forwarded to the Contractor as they become available.~~

~~The cost of referee testing of rapid chloride permeability for all concrete shall be according to the Referee Testing Cost clause in the Acceptance of Rapid Chloride Permeability subsection in OPSS 1350.~~

~~912.08.05.04.02 Concrete Without Silica Fume~~

~~When the referee result is greater than the acceptance test result or no more than 500 coulombs below the acceptance test result, the acceptance test result is then confirmed and shall remain valid. When the referee test result for the lot is more than 500 coulombs below the acceptance test result, the acceptance test result is then not confirmed, and the referee test result shall be used for determining acceptability of the lot.~~

~~912.08.05.04.03 Concrete Containing Silica Fume~~

~~When the referee result is greater than the acceptance test result or no more than 300 coulombs below the acceptance test result, the acceptance test result is then confirmed and shall remain valid. When the referee test result for the lot is more than 300 coulombs below the acceptance test result, the acceptance test result is then not confirmed, and the referee test result shall be used for determining acceptability of the lot.~~

~~912.08.05.04.04 Cost of Referee Testing for Rapid Chloride Permeability~~

~~The cost of rapid chloride permeability referee testing shall be as specified in the Contract Documents.~~

~~When the referee result confirms the acceptance test result, the Contractor shall be charged the cost of rapid chloride permeability referee testing. When the referee result does not confirm the acceptance test result, the Owner shall bear the cost.~~

~~**912.08.06 Acceptance of Water, Admixtures, and Cementing Materials**~~

~~Acceptance of water, admixtures and cementing materials shall be according to OPSS 1350.~~

~~**912.08.07 Acceptance of Concrete Temperature**~~

~~Elements that meet the temperature requirements of this specification during production, the curing period, and, if applicable, the cold weather protection period, shall be considered acceptable. Elements that do not meet one or more of the temperature requirements of this specification are deemed rejectable.~~

~~**912.08.08 Acceptance of Surface Finish**~~

~~All elements meeting the surface finish requirements of this specification shall be considered acceptable. For elements that do not meet the surface finish requirements of this specification, a proposal for repair or remediation may be submitted by the Contractor, according to the All Other Defects and Deficiencies clause.~~

~~**912.08.09 Dimensional Verification and Concrete Cover Measurements**~~

~~The Contract Administrator shall~~will carry out measurements on ~~interior and exterior surfaces on at least one element per lot,~~the installed culvert prior to any waterproofing or backfilling operations, to confirm ~~compliance with~~the installation tolerances meet the requirements ~~of~~specified in Table 1~~. The~~ and the Contract ~~Administrator~~Documents. Culverts that do not meet the installation tolerances specified in Table 1 shall be ~~notified in writing when the test area is ready for the concrete covermeter survey and dimensional verification~~deemed rejectable.

~~If an element fails to meet the dimensional or cover tolerances specified in Table 1,~~

~~a) It shall be deemed rejectable and,~~

~~b) A consultant shall be retained by the Owner, at the Contractor's expense, to verify that all the other elements in the lot are within the tolerances of Table 1.~~

912.08.~~10~~03 Dowels

When dowels are specified in the Contract Documents, they shall be according to the visual acceptance criteria and pull testing criteria requirements ~~as~~ specified in the Contract Documents.

912.08.~~11~~04 Field Inspection

The Contract Administrator will inspect the installed culverts to determine if the completed work contains any defects and deficiencies.

For precast concrete, any defects and deficiencies identified shall be addressed according to the Defects and Deficiencies subsection of OPSS 1355, as applicable.

~~**912.08.11.01 Defects and Deficiencies Repairable by Standard Methods**~~

~~Any individual element having one or more of the defects and deficiencies listed in Table 2 shall be deemed unacceptable and shall be repaired according to Table 2.~~

~~**912.08.11.02 Defects and Deficiencies Causing Rejection**~~

~~An element having one or more of the following defects and deficiencies shall be deemed rejectable:~~

a) If concrete temperature of an element less than 500 mm in thickness exceeds 60 °C, or if the concrete has a maximum thickness greater than 500 mm and the concrete temperature exceeds 65 °C, at any time during the curing period.

b) If concrete temperature of an element falls below 10 °C during the moist curing period or 0 °C during the cold weather protection period.

c) If an element has honeycombing, voids, cavities, spalls, delaminations, or cracks, in the concrete that exceed the conditions described in Table 2.

d) If an element has a crack that is greater than 1.0 mm in width or if there is a crack of any width that extends through to the opposite face of the element.

e) If an element contains a cold joint.

912.08.11.03 All Other Defects and Deficiencies

A repair proposal for repair or remediation signed and sealed by an Engineer may be submitted to the Contract Administrator for acceptance when,

a) Failure to maintain moist curing has occurred; or

b) An element has defects or deficiencies that are not identified as rejectable or included in Table 2 in the list of defects and deficiencies repairable by standard methods; or

c) More than one of the defects or deficiencies listed in Table 2, except for bugholes, are located in the same area in the element; or

d) Three occurrences of the same defect are present in the element; or

e) Surface finish is unacceptable; or

f) Dimensional tolerances of the element or culvert do not meet the requirements of this specification.

912.08.11.03.01 Repair Proposal

The repair proposal shall include as a minimum:

a) Identification of the culvert or element and description of the defects or deficiencies.

b) High resolution photographs and detailed sketches showing the width, length, depth, location, nature and frequency of any defects.

c) An assessment of any impact of the repaired defect(s) on durability, structural adequacy and integrity of the element or on the culvert.

d) A detailed repair plan including materials, method, and equipment to be used.

e) Verification that the repair plan complies with the applicable Standards for the type of work.

f) All relevant supporting information, including material test results, field measurements and observations, production records, photographs, and structural analysis calculations, used for determining that the performance and function originally expected from the element or culvert shall be met.

g) Cause(s) of the defect and corrective action to be taken to prevent recurrence of the defect in future production, delivery, or installation.

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.

912.08.11.04 Assessment of Repairs

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.

912.09 MEASUREMENT FOR PAYMENT

912.09.01 Actual Measurement

912.09.01.01 Precast Concrete Box Culvert, Fabrication
Precast Concrete Box Culvert, Delivery
Precast Concrete Box Culvert, Installation

Measurement for the fabrication, and 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.

Each side-by-side culvert shall be measured separately.

912.09.01.02 Plan Quantity Measurement

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

912.10 BASIS OF PAYMENT

912.10.01 Precast Concrete Box Culvert, Fabrication (Span ≥ 3.0 to < 4.0 m) - Item
Precast Concrete Box Culvert, Fabrication (Span ≥ 4.0 to < 5.0 m) - Item
Precast Concrete Box Culvert, Fabrication (Span ≥ 5.0 to ≤ 6.1 m) - Item
Precast Concrete Appurtances, Fabrication - 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 according to OPSS 1355.

For side-by-side culverts, the work includes supply and placement of grout between the culverts, as specified in the Contract Documents.
Elements deemed rejectable shall be replaced at no additional cost to the ownerOwner.

912.10.01.01 Payment Adjustment for Compressive Strength of Concrete in Place

Payment adjustment for an unacceptable lot represented by cores shall be calculated according to the following:

Payment Adjustment = lot quantity/tender quantity x Price x ((100 – P)/100)

Where:

Payment Adjustment = payment reduction for a lot ($)
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 table below:

Average of the three individual compressive strength cores, as percentage of specified strength	Lowest of the three individual compressive strength cores, as percentage of specified strength	**Pay Factor (P)**
≥ 90%	≥ 80%	100
< 90% but ≥ 85%	≥ 80%	95
< 85% but ≥ 80%	≥ 75%	85
< 80%	Not Applicable	Reject

912.10.01.02 Payment Adjustment for Air Void System in Hardened Concrete

Payment adjustment for an unacceptable lot represented by cores shall be calculated according to the following:

Payment Adjustment = lot quantity/tender quantity x Price x ((100 – P)/100)

Where:

Payment Adjustment = payment reduction for a lot ($)
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 table 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

912.10.01.03 Payment Adjustment for Rapid Chloride Permeability

The payment adjustment shall be calculated based on individual lots and applied as follows:

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

Where:

Payment adjustment = payment reduction for 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 reduction for 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)~~

Culvert elements that requires no further fabrication and that is stored at the fabricator's premises in Ontario or some other location in Ontario away from the Working Area shall be eligible to be paid for when the Contractor obtains a lease from the property owner that names the Owner as the tenant. The Owner shall provide the form of lease for this purpose that specifies payment of $1.00 for the term of the lease. The Contractor shall retain full responsibility for the Work.

912.10.02 **Precast Concrete Box Culvert, Delivery ~~and Install~~(Span ≥ 3.0 to < 4.0 m) - Item**
Precast Concrete Box Culvert, Delivery (Span ≥ 4.0 to < 5.0 m) - Item
Precast Concrete Box Culvert, Delivery (Span ≥ 5.0 to ≤ 6.1 m) - Item
Precast Concrete Appurtances, Delivery - Item
Precast Concrete Box Culvert, Installation (Span ≥ 3.0 to < 4.0 m) - Item
Precast Concrete Box Culvert, ~~Delivery and Install~~Installation (Span ≥ 4.0 to < 5.0 m) - Item
Precast Concrete Box Culvert, ~~Delivery and Install~~Installation (Span ≥ 5.0 to ≤ 6.1 m) - Item
Precast Concrete Appurtances, Installation - Item

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

Payment for removal of unsuitable material encountered below the predetermined elevations shall be administered as a Change in the Work. The replacement to competent stratum to the foundation grade with compacted granular material shall be administered as a Change in the Work.

912.10.03 Excavation for 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.

912.10.04 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.

912.10.05 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.

912.10.06 Concrete in Cast-in-Place Appurtenances, Protection Slabs and Distribution Slabs

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

912.10.07 Steel Reinforcement in Cast-in-Place Concrete Appurtenances, Protection Slabs and Distribution Slabs

Payment shall be at the Contract price for the tender items " "Carbon Steel Reinforcing ~~Steel~~ Bar, Grade 500W", "Stainless Steel Reinforcing Bar", "Carbon Steel Mechanical Connectors" and "Stainless Steel Mechanical Connectors" according to OPSS 905.

912.10.08 Clay Seal - Item

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

TABLE 1
Installation Tolerances

Item	Tolerances
~~Span~~ ~~(Straight-line measurement taken horizontally at the mid-height of element perpendicular to the centre line of the culvert.)~~Alignment of elements	± ~~15~~10 mm ~~from design drawings~~
~~Height~~	~~± 15 mm from design drawings~~
~~Length~~	~~+ 15 / - 5 mm~~
~~Wall and Slab Thickness~~	~~+ 10 mm, - 5 mm~~
~~Haunch~~	~~± 10 mm~~
~~End Squareness or Skew (Note 1)~~	~~< 15 mm along its length~~
Plumbness	1 in 300 maximum
~~Location of Blockouts~~	~~± 15 mm~~
~~Location of Inserts~~	~~± 10 mm~~
~~Concrete Cover~~	~~Concrete cover shall be 50 mm, tolerances for cover and placement accuracy shall be according to OPSS 905, or as specified in the Contract Documents.~~
~~Alignment of elements~~	~~± 10 mm~~
Joint Gap	20 mm maximum
Gap between adjacent side-by-side ~~box~~ culverts (multi-cell culverts)	± 10 mm

~~Notes:~~

~~1. Variations in the lengths of two opposite surfaces of the element. The ends of the element shall be normal to the wall and centreline of the element within the tolerances specified elsewhere in this Table except where special culvert elements, e.g. end walls, toe walls, etc. are specified.~~

TABLE 2
Defects and Deficiencies Repairable by Standard Methods

Repairable Defects and Deficiencies	Condition	Repair Method
Bugholes	a) Bugholes with depth > 5 mm and all dimensions at the surface not exceeding 25 mm, b) Bugholes with a depth ≤ 5 mm and any dimension at the surface greater than 50 mm and not exceeding 100 mm.	i. Blast surfaces with high pressure water to remove any weak or loose material. ii. Fill Bugholes with a proprietary patching material placed and cured according to the manufacturer's instructions. Patching materials shall be from the Ministry's list of acceptable patching materials.
Honeycombing, Voids, Cavities, Spalls, and Delaminations	Any area less than an equivalent area of 300 mm x 300 mm with no steel reinforcement exposed. Cumulative total area of this type of repair shall not exceed 2% of any face of the culvert.	a) Square all sides of the repair area. b) Sawcut perimeter of removal area to a depth of 10 mm or to the depth of the steel reinforcement, whichever is less. c) Remove all unsound concrete using a chipping hammer or hand tools. d) Insert corrosion resistant wires and anchors, according to OPSS 930 and OPSS 1440. e) Abrasive blast clean all concrete surfaces to be patched according to OPSS 929. f) Remove all dust and loose material from the prepared surface by using compressed air. h) Moisten area to be repaired. i) Fill repair area with concrete and cure concrete according to this specification. j) An acceptable concrete patching material may be used. Patching materials shall be from the Ministry's list of acceptable patching materials and shall be placed and cured according to the manufacturer's recommendations.
Cracks	For width of crack ≥ 0.30 mm and ≤ 1.0 mm, total linear measurement of crack per m^2 is < 2 m and the crack does not extend through to the opposite face of the element.	Repair according to OPSS 932.