



## **CONSTRUCTION SPECIFICATION FOR CONCRETE STRUCTURES**

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### **TABLE OF CONTENTS**

<b>904.01</b>	<b>SCOPE</b>
<b>904.02</b>	<b>REFERENCES</b>
<b>904.03</b>	<b>DEFINITIONS</b>
<b>904.04</b>	<b>DESIGN AND SUBMISSION REQUIREMENTS</b>
<b>904.05</b>	<b>MATERIALS</b>
<b>904.06</b>	<b>EQUIPMENT</b>
<b>904.07</b>	<b>CONSTRUCTION</b>
<b>904.08</b>	<b>QUALITY ASSURANCE</b>
<b>904.09</b>	<b>MEASUREMENT FOR PAYMENT</b>
<b>904.10</b>	<b>BASIS OF PAYMENT</b>

### **APPENDICES**

<b>904-A</b>	<b>Commentary</b>
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<b>904.01</b>	<b>SCOPE</b>
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This specification covers the requirements for the construction of concrete structures.

#### **904.01.01 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.

## **904.01.02 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.

## **904.02 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, or publications:

### **Ontario Provincial Standard Specifications, Construction**

OPSS 501	Compacting
OPSS 905	Concrete Reinforcement
OPSS 908	Metal Traffic Barriers and Metal Railings for Structures
OPSS 919	Formwork and Falsework
OPSS 920	Deck Joint Assemblies, Waterstops, Joint Fillers, Joint Seals and Joint Sealing Compounds - Structures
OPSS 928	Structure Rehabilitation - Concrete Removal
OPSS 929	Abrasive Blast Cleaning - Concrete Construction
OPSS 930	Structure Rehabilitation - Concrete Patches and Overlays
OPSS 932	Crack Repair - Concrete

### **Ontario Provincial Standard Specifications, Material**

OPSS 1002	Aggregates - Concrete
OPSS 1202	Bearings - Elastomeric Plain and Steel Laminated
OPSS 1301	Cementing Materials
OPSS 1302	Water
OPSS 1315	White Pigmented Curing Compounds for Concrete
OPSS 1350	Concrete - Materials and Production

## Ontario Ministry of Transportation Publications

Laboratory Testing Manual:

- LS-413 Method of Test for Non-Volatile Content of Chemical Admixtures, Latex Admixtures and Curing Compounds
- LS-414 Method of Test for Relative Density of Chemical Admixtures, Air Entraining Admixtures, Latex Admixtures and Curing Compounds
- LS-416 Method of Test for Settling Rate - Curing Compound

## ASTM International

- C 171-92 Sheet Materials for Curing Concrete

## American Association of State Highway and Transportation Officials (AASHTO)

- M182-89 Standard Specification for Burlap Cloth made from Jute or Kenaf

### 904.03 DEFINITIONS

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

**Bridge** means a structure that is greater than 3 m in span that provides a roadway, carriageway, or walkway for the passage of vehicles or pedestrians or both across an obstruction or gap or facility.

**Coated Reinforcing Steel Bars** means reinforcing steel bars coated with epoxy.

**Cold Joint** means the interface surface other than at a formed joint that occurs when plastic concrete is placed against concrete that has taken its initial set.

**Cold Weather** means those conditions when the ambient air temperature is at or below 5 °C. It is also considered to exist when the ambient air temperature is at or is likely to fall below 5 °C within 96 hours after completion of concrete placement. Temperature refers to shade temperature.

**Concrete Toe Wall** means a low unreinforced concrete gravity type retaining wall no greater than 2 m in height.

**Construction Joint** means the surface where two successive placements of concrete meet or where new concrete is placed against old concrete across which it is desirable to achieve bond between the two concrete placements and through which steel reinforcement may be continuous.

**Culvert** means a structure which provides an opening through an embankment and in which roadway loads are distributed to the structure through fill or that is designated as a culvert in the Contract Documents.

**Designated Limits** means the dimensions of the component as shown on the Contract Drawings or the limits of the component as revised in the field in writing by the Contract Administrator.

**Dowel** means deformed coated reinforcing steel bar, reinforcing steel bar or stainless steel reinforcing bar placed into a hole of specified dimensions drilled into a concrete structure and bonded to the concrete by dowel adhesive.

**Dowel Type** means a dowel differentiated by bar size, embedment length, orientation of embedment and by bar material, such as 15M stainless steel reinforcing bar and 20M reinforcing steel bar.

**High Performance Concrete (HPC)** means concrete with a minimum specified 28-Day compressive strength of at least 50 MPa, that shall include silica fume and may include other supplementary cementing materials having a specified rapid chloride permeability at 28-32 Days of 1,000 coulombs or less.

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

**Pull Test** means an in situ test consisting of the application of a specified tensile axial load for a specified time period to installed dowels selected for testing.

**Reinforcing Steel Bars** means plain or deformed steel bars, or welded wire fabric, with no epoxy coating, used for the reinforcement of concrete.

**R Value** means the metric thermal resistance value that is a measurement of the resistance to heat transfer of insulation.

**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.

**Stainless Steel Reinforcing Bar** means plain or deformed stainless steel bars.

**Steel Reinforcement** means a general term for steel bars, which includes reinforcing steel bars, splice bars, coated reinforcing steel bars, stainless steel reinforcing bars, and welded wire fabric.

**Structure** means any bridge, culvert, tunnel, retaining wall, wharf, dock, or guideway, or any part thereof, or other reinforced concrete component designed to carry loads, including high mast pole footings and sign support footings.

**Tremie** means a hopper with a vertical pipe extending from the bottom of the hopper to the lowest point of concrete deposit, used to place concrete under water.

## **904.04 DESIGN AND SUBMISSION REQUIREMENTS**

### **904.04.01 Submission Requirements**

#### **904.04.01.01 Notification of Placement of Structural Concrete**

At least 72 hours prior to each placing operation, the Contractor shall notify the Contract Administrator in writing of the scope and scheduling of the proposed placing operation.

#### **904.04.01.02 Bridge Deck Placement Plan**

A work plan shall be submitted to the Contract Administrator a minimum of one week prior to commencement of placing concrete in bridge decks for information purposes. The work plan shall include:

- a) The proposed methods and sequence of placing operations to be used.
- b) Complete details of all equipment to be used during the concrete placement.

### **904.04.01.03 Temperature Control Plans**

A temperature control plan shall be submitted to the Contract Administrator a minimum of one week prior to commencement of placing any concrete that requires temperature control, for review of compliance with the contract requirements.

The plan shall include methods for monitoring and controlling concrete temperature and the temperature difference before, during, and after placement for:

- a) Concrete subject to cold weather.
- b) HPC.
- c) Bridge decks.
- d) Large concrete components where the smallest dimension is 1.5 m.

The temperature control plan shall include, as a minimum, the following:

- a) Concrete element for which the plan applies.
- b) Temperature monitoring system, including the locations and depths, number of thermocouples, and frequencies of recordings to be used in each placement.
- c) Method of ensuring concrete temperature and temperature difference are maintained for the duration of the protection period.
- d) Any alterations to work schedule, production, delivery schedule, and time of placement for temperature control purposes.
- e) Any modification to mix design for temperature control purposes.
- f) Any other specific measures to be taken.
- g) Method of withdrawal of protection.

In addition, for concrete subject to cold weather, the temperature control plan shall also include the following:

- a) Type of insulation, R value and number of layers, including test data verifying the R value. The submission for cold weather protective measures shall be accompanied by samples of insulation, if requested by the Contract Administrator.
- b) Type and layout of heaters and type and extent of housing.

### **904.04.01.04 Temperature Records**

Datalogger temperature records and a record of any actions taken to maintain control of temperature and temperature difference shall be forwarded to the Contract Administrator at the end of each working day during the temperature monitoring period. At the end of the temperature monitoring period, the Contractor shall submit to the Contract Administrator a complete temperature record, including graphical plot of temperature versus time.

**904.04.01.05 Curing Compound**

A minimum of one week prior to the application of the curing compound, the following shall be submitted to the Contract Administrator for information purposes:

- a) Literature stating the manufacturer's recommended rate of application.
- b) Description of the equipment to be used.
- c) A statement from the manufacturer of the curing compound approving the equipment.

Test results for curing compounds shall be submitted to the Contract Administrator within 7 Days of sampling.

**904.05 MATERIALS**

**904.05.01 Concrete**

Concrete shall be according to OPSS 1350.

**904.05.02 Portland Cement**

Portland cement shall be according to OPSS 1301.

**904.05.03 Sand**

Sand shall be according to OPSS 1002.

**904.05.04 Bonding Agents**

Bonding agent shall consist of Portland cement, Type GU, and sand in the ratio of 1:1 by volume and water sufficient water to produce a consistency such that it can be applied with a stiff brush to the existing concrete in a thin even coating that shall not run or puddle.

**904.05.05 Mortar**

Mortar shall be a 2:1 mixture by volume of sand and Portland cement, Type GU, and shall contain 12% entrained air with water sufficient to make a stiff mix.

**904.05.06 Proprietary Patching Materials**

Proprietary patching materials shall be from the ministry's list of concrete patching materials.

**904.05.07 Burlap**

The burlap shall be according to AASHTO M182, Class 4, and shall be free from substances that are deleterious to concrete. The burlap shall have no tears or holes.

**904.05.08 Water**

Water used for curing and fog misting of concrete, including pre-soaking of burlap, and for making bonding agents and mortar and mixing proprietary patching materials, shall be according to OPSS 1302.

**904.05.09                      Moisture Vapour Barrier**

The material shall be a white opaque polyethylene film according to ASTM C 171, at least 100 µm thick.

**904.05.10                      Curing Compound**

Curing compound shall be according to OPSS 1315.

**904.05.11                      Approach Slab Seat Elastomer**

The elastomer delivered to the site shall exceed the required length to allow for a 600 mm test sample to be taken from each structure.

The elastomer shall be according to the plain bearing requirements of OPSS 1202, except that the hardness of the elastomer shall be a minimum of 50 Shore A, and the elastomer shall have a minimum tensile strength of 15 MPa.

**904.05.12                      Insulation Material**

Insulation material shall be mineral wool, glass fibre, plastic foam or other suitable material, having an R value not less than 0.02 m<sup>2</sup> C/W per 1 mm thickness.

Straw insulation shall not be used. Loose or absorbent insulation material shall not be used unless it is completely contained within waterproof wrapping.

**904.05.13                      Dowels**

Dowels shall be as specified in the Contract Documents. Dowels shall be capable of sustaining the pull test loads specified in Table 1 without displacement for a time period of not less than 1 minute.

**904.05.14                      Dowel Adhesive**

Dowel adhesive shall be an approved epoxy or acrylic resin.

**904.06                              EQUIPMENT**

**904.06.01                      General**

Equipment made of aluminium material shall not come in contact with the plastic concrete.

**904.06.02                      Concrete Pump**

The concrete pump shall be a reciprocating pump equipped to fit a pipeline at least 100 mm in diameter.

**904.06.03                      Consolidating Equipment**

Internal vibrators shall be of the high frequency type with 8,000 minimum to 12,000 maximum vibrations per minute when immersed in concrete.

Internal vibrators used to consolidate concrete components containing epoxy coated steel reinforcement shall have a resilient covering that shall not damage the epoxy-coated reinforcement during use.

External vibrators shall have a minimum frequency of 3,600 vibrations per minute.

#### **904.06.04 Mixer for Bonding Agents**

The mixer for the bonding agent shall be a stationary mixer, power driven, and capable of uniformly mixing the materials.

#### **904.06.05 Finishing Machine**

The finishing machine shall:

- a) Be self-propelled and capable of forward and reverse movement under positive control.
- b) Be fitted with wheels that travel on adjustable screed rails.
- c) Be fitted with a reversing rotating cylinder screed capable of finishing the concrete without subsequent hand finishing.
- d) Be fitted with a reversing power screw auger.
- e) Be capable of externally vibrating the surface of the concrete by means of a plate or roller.
- f) Be fitted with a means to raise all screeds to clear the screeded surface and to accurately reposition them without adjusting the legs.
- g) Have adjustable legs fitted with locking devices.

#### **904.06.06 Screed Rails**

The rails shall be made of metal and be straight to within 3 mm in a 3 m length. Screed rail chairs shall be adjustable in height, made of metal, and spaced at a maximum of 1.2 m and be placed under all rail joints. Maximum deflection of the screed rails under load shall be 2 mm in a 1.2 m length.

#### **904.06.07 Work Bridges**

Work bridges shall be provided to facilitate surface finishing of unscreeded areas, corrections to surface finish, concrete inspection, and placing of curing materials.

Work bridges shall ride on the screed rails and the top surface of a work bridge shall not be higher than 1.0 m above the finished surface.

#### **904.06.08 Hand Finishing Tools**

Floats shall be made of magnesium or wood. Magnesium bull floats shall be commercially made.

#### **904.06.09 Straight Edges**

Two straight edges commercially made of metal, one 3 m and one 500 mm long, shall be used.

#### **904.06.10 Tremie**

The tremie shall be equipped with a foot valve at the bottom of the pipe. The pipe shall have a 300 mm  $\pm$  50 mm inside diameter and shall be long enough to extend to the lowest point of concrete deposit.

#### **904.06.11 Spray Equipment for Curing Compound**

The curing compound shall be applied to the concrete surface by means of motorized spraying equipment approved by the manufacturer of the curing compound. The equipment shall include mechanical agitator.



#### **904.06.12 Compressor - Air Blasting**

The compressor for air blasting shall have a minimum capacity of 3.5 m<sup>3</sup>/minute. The compressed air shall be free of oil or other contaminants.

### **904.07 CONSTRUCTION**

#### **904.07.01 Formwork and Falsework**

Formwork and falsework shall be according to OPSS 919. Textile form liners shall not be used.

#### **904.07.02 Steel Reinforcement, Mechanical Connectors, and Associated Hardware**

Steel reinforcement, mechanical connectors, and associated hardware shall be according to OPSS 905.

Where the superstructure is continuous over a support, all of the deck steel reinforcement shall be placed in the entire deck before any concrete is placed. This requirement does not apply to the bottom slab of post-tensioned box voided decks.

#### **904.07.03 Deck Joint Assemblies and Joint Material**

Deck joint assemblies, joint fillers, joint seals, joint sealing compounds, and external waterstops shall be according to OPSS 920.

#### **904.07.04 Preparation for Concrete Placement**

##### **904.07.04.01 General**

All concrete surfaces against which new concrete is to be placed, including formed and sawcut surfaces, shall be clean, solid, and free from loose or unsound fragments, coatings, and any other foreign substances or debris and shall be sufficiently rough to ensure that a full bond is developed with the new concrete. The concrete surface shall be uniformly roughened to a surface profile of 5 mm ± 2 mm by means of methods such as scabbling, chipping, or bushhammering to expose the aggregates across the entire surface. Roughening is not required for the vertical faces of slope paving or for new concrete substrate with a roughened finish, imparted at the time of placement, meeting the profile requirement.

##### **904.07.04.02 Abrasive Blast Cleaning**

The following surfaces shall be abrasive blast cleaned according to OPSS 929:

- a) All existing steel reinforcement that shall be incorporated into the rehabilitation of a concrete structure component.
- b) All surfaces of existing structural steel against which new concrete shall be placed for the rehabilitation of a concrete structure component.
- c) All new or existing concrete surfaces against which new concrete shall be placed.

##### **904.07.04.03 Pre-wetting**

All concrete surfaces to receive concrete shall be maintained in a wet condition for a period of 1 hour prior to placing any new concrete.

Immediately prior to wetting the concrete surface, all dust and loose material shall be removed from the prepared surface by using compressed air.

Prior to placing concrete, excess water shall be removed from the surface using compressed air.

#### **904.07.04.04                    Bonding Agent**

A bonding agent shall be used for:

- a) Vertical surfaces of concrete against which new concrete is to be placed.
- b) Blockouts in concrete for installation and modification of deck joint assemblies.
- c) Stressing tendon anchorage recesses.

A thin uniform coating of bonding agent shall be brushed onto the prepared surface immediately before placing fresh concrete. Bonding agents shall be mixed by means of a mixer. Any bonding agent not used within 30 minutes of mixing shall be discarded. Bonding agent that has dried shall be removed and replaced prior to placing concrete against it.

#### **904.07.04.05                    Element-Specific Preparation**

For concrete in footings, when it is specified in the Contract that the concrete is to be placed against undisturbed soil or set in rock, any over-excavation shall be filled with concrete of the same strength as the footing concrete.

For parapet and barrier walls and curbs on structures, all anchorages shall be fastened in place accurately and securely before proceeding with concrete placement. The railing anchorage inserts shall be fastened in place according to OPSS 908.

For concrete in approach slabs, the approach slab seat elastomer, polystyrene, and joint filler shall be installed and the subgrade thoroughly wetted down prior to placing the concrete in the approach slab, including the adjacent sidewalk slab.

For concrete in slope paving, the slope face shall be shaped; excavation completed; granular A placed and compacted; and the crushed rock, moisture vapour barrier, wood strips, and joint filler shall be placed as required prior to placing the concrete. Sealant shall be installed as specified in the Contract Documents.

The granular A shall be compacted according to OPSS 501.

#### **904.07.05                        Dowels into Concrete**

##### **904.07.05.01                    General**

The Contractor shall carry out pull testing of dowels in the trial installations and during production. Pull test loads shall be according to Table 1. The Contractor shall notify the Contract Administrator in writing when the trial installation or a lot, as defined in the Lot Size clause, is ready for testing. The Contractor shall allow 3 Business Days for the Contract Administrator to witness the testing.

The Contractor shall provide documentation of equipment calibration to the Contract Administrator a minimum of 14 Days prior to any pull testing of the dowels.

##### **904.07.05.02                    Trial Installation**

Prior to installing each dowel type specified in the Contract Documents, the Contractor shall carry out a trial installation of that dowel type at locations selected by the Contract Administrator.

Each trial installation shall consist of a set of three dowels. If the Contractor changes the installation procedure for a dowel type from that used in the associated trial installation, the Contractor shall repeat the trial installation prior to incorporating dowels installed using the changed installation procedure into the work.

Each of the three dowels in the set shall be capable of achieving the specified test load and times, without any movement of the dowels, for the trial installation to be considered acceptable.

If the trial installation is not acceptable, installation of that dowel type in the work shall not be permitted until the following have been carried out by the Contractor to the satisfaction of the Contract Administrator:

- a) A written explanation for the failure has been submitted.
- b) Corrective action to be taken has been identified.
- c) The trial installation has been repeated with acceptable results.

If a dowel is not capable of achieving the test load and time due to failure of the surrounding concrete, the Contractor shall not be permitted to install any additional dowels of that type in the work until further advised by the Contract Administrator.

#### **904.07.05.03                      Installation**

The Contractor shall drill holes to the required dimensions, clean holes, place dowel adhesive, and properly position the dowels as specified in the Contract Documents. Core drilling of the dowel holes shall not be permitted.

Steel reinforcement and other existing embedments shall not be cut or damaged by the drilling process. Prior to drilling holes, the Contractor shall locate existing steel reinforcement using a covermeter, Utility ducts, post tensioning hardware, and any unsound concrete in the vicinity of the dowel locations. If any of the above is encountered during drilling operations, the Contract Administrator shall be notified immediately.

The Contractor's operations shall not cause spalling, cracking, or other damage to the surrounding concrete. Concrete spalled or otherwise damaged by the Contractor's operations shall be repaired in a manner acceptable to the Contract Administrator.

The Contractor shall clean the holes using compressed air to remove all deleterious material, including dust and debris, and shall dry them prior to placing the dowel adhesive. Holes that are started but not completed shall be cleaned and filled with a proprietary patching material.

The handling and placement of the dowel adhesive shall conform to the manufacturer's written instructions. All excess dowel adhesive shall be struck-off flush with the concrete surface and removed from the surrounding concrete surface area.

Dowels shall be clean and free of deleterious material.

The Contractor shall maintain dowels in the proper position during the setting of the dowel adhesive and shall prevent the loss of dowel adhesive from the holes.

**904.07.05.04 Pull Test**

**904.07.05.04.01 General**

The Contractor shall not install formwork or attach anything to the dowels such as steel reinforcement and Utility ducts until the pull tests have been completed and the dowels are accepted into the work.

**904.07.05.04.02 Lot Size**

A lot shall consist of dowels of the same dowel type installed on a given day, in a single stage. Where a given day's production is less than 50 dowels, the day's work may be combined with the next day's production to form a single lot.

**904.07.05.04.03 Pull Test Procedure**

The Contractor shall conduct pull testing for the trial installation and each lot within 3 Business Days of installation. The Contract Administrator shall be present during the testing procedure. The Contract Administrator shall randomly select 5% of the dowels in each lot or 10 dowels, whichever is greater, for testing. The applicable pull test load shown in Table 1 must be sustained by the dowel, without displacement, for a time period of no less than one minute.

**904.07.05.05 Replacement of Failed Dowels**

All dowels failing the pull test requirement, including trial installation dowels, shall be replaced by the Contractor by installing a new dowel in an adjacent location approved by the Contract Administrator.

Dowels failing the pull test requirement, including trial installation dowels, shall be removed and the hole filled with proprietary patching material.

**904.07.06 Placing of Concrete**

**904.07.06.01 General**

The method of transporting, placing, and consolidating the concrete shall be such as to prevent segregation.

Concrete shall be deposited within 1.5 m of its final position. When concrete is to be dropped more than 1.5 m, fully enclosed vertical drop chutes extending to the point of deposit shall be used. Drop chutes are not required for placing concrete in steel tube piles of 0.6 m diameter or less. Concrete shall be placed at a steady rate, such that a monolithic concrete is obtained without the formation of cold joints.

When there is an interruption in placing concrete greater than 20 minutes, the surface of the concrete shall be covered with wet burlap. The Contractor shall notify the Contract Administrator immediately of any interruption resulting in a cold joint and shall submit a proposal for remedial action for approval.

**904.07.06.02 Concrete Placing Restrictions**

No concrete shall be placed until all curing material and, in cold weather, all cold weather protection material, have been delivered to the site.

Barrier and parapet walls on structures shall not be slipformed.

When concrete is to be placed on a surface that has a slope greater than 3%, the placing operation shall begin at the lower end of the slope and progress upwards.

All surfaces against which concrete are to be placed shall be free of standing water, except for tremie concrete. Fresh concrete shall be protected from contact with rain or snow.

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

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

Ice and snow shall be removed from the area where concrete is to be placed. Deicing chemicals shall not be used. Concrete shall not be placed on or against frozen ground. Excavations prepared for concreting and any existing concrete, steel reinforcement, structural steel, forms, or other surfaces against which concrete shall be placed shall be at a minimum temperature of 5 °C for a period of 12 hours prior to commencement of placing concrete.

#### **904.07.06.03 Concrete in Structure and in Deck**

Concrete diaphragms shall be placed monolithically with the deck.

All bridge deck placements 3 m or wider shall be finished using a finishing machine and a work bridge. Where placements are longer than 40 m or wider than 10 m, a second work bridge shall be used. For deck placements narrower than 3 metres, the Contractor shall submit a proposal detailing a method of finishing to the Contract Administrator for approval. Small, localized areas may be hand finished subject to approval by the Contract Administrator.

Where the superstructure is continuous over a support, the screed rails shall be placed for the entire length of the structure before any concrete is placed.

A dry run shall be carried out to ensure that the specified camber, crown, slab thickness, and concrete cover are achieved. In those areas of the deck where a finishing machine will be used to finish the concrete, the dry run shall be carried out by means of the finishing machine fitted with an attachment suitable for checking the required cover, securely fastened to the finishing machine strike-off, with the strike-off set in its lowest position. This operation shall be repeated to cover the entire area to be concreted.

For HPC and silica fume overlay, at the time of the dry run the Contractor shall demonstrate that the performance of the fog misting equipment meets the specified requirements.

Screed rails and the supports for the screed rails shall not be removed until the concrete has hardened sufficiently to withstand the weight of workers and equipment used to remove them without marring the surface of the concrete. Any part of the screed rail supports that remain in the deck shall have 100 mm of concrete cover. Chairs used to support screed rails shall not be welded to structural steel but may be welded to shear connectors.

The holes in the deck resulting from removal of the screed rail supports shall be thoroughly cleaned of all deleterious material and abrasive blast cleaned immediately prior to filling with proprietary patching material. The work of cleaning and filling the holes shall be completed within 96 hours after the end of the deck curing period.

#### **904.07.06.04 Tremie Concrete**

Concrete shall be placed using a tremie or concrete pump. No air or water pockets shall be introduced into the tremie concrete by the placing equipment.

Pipe of a tremie or hose of a concrete pump shall be positioned vertical and shall be long enough to reach the lowest point of concrete deposit. A continuous flow of concrete at a minimum rate of 15 m<sup>3</sup>/h shall be maintained through the pipe or hose. The concrete shall be placed in its final position and to its full depth in a continuous placing operation without interruption. The top under water surface of the concrete shall be kept level during concrete placement. After placement, the concrete shall not be disturbed, puddled, or vibrated. Tremies or concrete pumps shall be located a maximum distance of 5 m apart and a maximum of 2.5 m from forms.

Concrete shall only be placed in water that has a temperature 2 °C or greater. The velocity of water flow inside the forms shall not be more than 3 m/min.

When placing the tremie pipe or concrete pump hose and at the start of the concreting operation, the pipe or hose shall be sealed at the bottom to prevent ingress of water. Once concrete is flowing through the pipe or hose, the discharge end shall be kept continuously immersed in the freshly placed concrete. If the seal is lost, thereby allowing the pipe or hose to fill with water, the pipe or hose shall be withdrawn, the seal re-established, and the starting operation repeated. Separate cranes shall be used to deliver the tremie concrete and to move and position the tremie or concrete pump.

Tremie concrete shall not be placed above the existing water level.

When a placement operation is interrupted below water level, the surface laitance shall be removed to expose the coarse aggregate within 36 hours after the interruption and before continuation of the operation.

When a placement operation is completed and work is to continue in the dry, the Contractor shall prepare the construction joint by removing surface laitance to expose the coarse aggregate.

Unwatering shall not be permitted until at least 24 hours after the concrete placement is completed.

#### **904.07.07 On-Site Transportation**

Runways for buggies shall be of sufficient strength to prevent shaking and jarring of the buggies and steel reinforcement.

Concrete placing and transporting devices shall not be supported by the steel reinforcement.

Chutes shall have sufficient slope to deliver concrete of the approved consistency and shall have a maximum length of 15 m.

#### **904.07.08 Consolidation**

Internal or external vibrators or both shall be used to thoroughly consolidate concrete at the point of deposit within 15 minutes of placing.

Each layer of concrete shall be vibrated. Vibrators shall extend into the previous layer to produce a homogenous mixture at the layer interface.

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.

#### **904.07.09 Concrete Finishing**

Finishing of the concrete surface shall be done while it is sufficiently plastic to achieve the desired grades, elevations, and texture. The Contractor shall ensure that excessive fines and water are not drawn to the surface.

No material shall be applied to the concrete surface or the finishing tools to aid in the finishing.

The surface shall be smooth, free from open texturing, undulations, projections, and ridges and shall be struck off true to grade and cross-section and, except as specified for bridge deck placements, shall be hand finished with a float.

Bearing seats and expansion joint dams shall receive a wood float finish. The top surface of sidewalks and curbs shall be given a broomed finish. Bridge decks shall be finished according to the Concrete in Structure and in Deck clause. In addition, for bridge decks where the concrete forms the wearing surface, the surface shall be textured. Texturing shall be done with a wire broom or comb having a single row of tines after a tight, uniform surface has been achieved. The required texture shall be transverse grooves that may vary from 1.5 mm width at 15 mm centres to 4.5 mm width at 20 mm centres with a groove depth varying from 3.0 mm to 4.5 mm. The texture shall extend uniformly to within 150 to 300 mm of the curb. Concrete surfaces against which new concrete shall be placed shall be left with a rough surface finish.

#### **904.07.10 Curing**

##### **904.07.10.01 General**

The curing period shall be a minimum of 7 Days for concrete subject to cold weather, concrete cured with curing compound, and HPC. For all other concrete, the curing period shall be a minimum of 4 Days.

When the ambient air temperature is 0 °C or higher at the time of placing, components of structures shall be cured with burlap and water except as specified in the Curing Formed Surfaces clause. When the ambient air temperature is below 0 °C at the time of placing, components shall be cured with moisture vapour barrier, except for HPC, which shall be moist cured with burlap and water regardless of ambient air temperature. During cold weather, burlap shall be prevented from freezing.

Curing compound shall only be permitted for non-structural elements such as slope paving.

##### **904.07.10.02 Fog Misting of High Performance Concrete**

The Contractor shall provide fog misting by hand held fogging wands and may also employ a fogging system mounted on the finishing machine.

Fog mist shall be applied from the time HPC is deposited in the deck, approach slab, median, curb, or sidewalk until it is covered with burlap.

Fog mist shall be applied using misting nozzle in such a way as to maintain a fog mist above the concrete surface to maintain high relative humidity above the concrete and prevent drying of the concrete. No accumulation of water shall be permitted on the concrete surface. Water from fog misting nozzles shall not be worked into the concrete surface or used as a finishing aid.

##### **904.07.10.03 Curing with Burlap and Water**

Burlap shall be pre-soaked by immersing it in water for a period of at least 24 hours immediately prior to placing. Two layers of burlap shall be applied to the surface of the concrete. The burlap shall be applied immediately after finishing the concrete surface. For continuing operations, such as barrier wall or sidewalk, the burlap shall be applied within 2 to 4 m of the finishing operation, and for bridge decks, within 2 to 4 m of the pan or screed of the finishing machine. Burlap strips shall overlap 150 mm and shall be held in place without marring the surface of the concrete.

The burlap shall be maintained in a continuously wet condition throughout the curing period by means of a soaker hose. The burlap shall be covered with a layer of moisture vapour barrier, within 12 hours of placing of the concrete, in a manner that shall prevent deformation of the surface of the concrete.

Air flow in the space between the moisture vapour barrier and the burlap shall be prevented.

Water shall not be allowed to drip, flow, or puddle on the concrete surface when placing the burlap or at any time before the concrete has achieved final set.

Where waterproofing is to be applied to a structure deck following curing with burlap and water, the deck shall be air dried for at least 72 hours prior to the application of waterproofing.

#### **904.07.10.04 Curing with Moisture Vapour Barrier**

A moisture vapour barrier shall be placed immediately after finishing the concrete surface, within 2 to 4 m of the finishing operation. Air flow in the space between the moisture vapour barrier and the concrete surface shall be prevented. The moisture vapour barrier strips shall overlap 150 mm and shall be held in place at the edges and laps to prevent displacement, without marring the surface of the concrete.

#### **904.07.10.05 Curing with Curing Compound**

Immediately prior to application, the curing compound shall be agitated by mechanical means to provide a homogeneous mixture. It shall be applied immediately after finishing of the concrete surface, within 2 to 4 m of the finishing operation, completely covering the surface of the concrete. A second application of curing compound shall be applied within 30 to 60 minutes after the first application. Each application shall be such that the membrane formed is uniform in thickness and colour and free of breaks and pinholes.

The rate of each application shall not be less than the rate specified by the manufacturer of the compound.

#### **904.07.10.05.01 Curing Compound Sampling and Testing**

The Contractor shall be responsible for sampling and testing curing compounds. Curing compounds shall be sampled at the site, from the spray nozzle, in the presence of the Contract Administrator. Samples shall be taken at a frequency of one sample per contract or one sample per 1,000 lineal meters, whichever provides the greater number of samples. Testing shall be carried out by a laboratory on the ministry's list of laboratories qualified for this testing. Testing for relative density, non-volatile content, and settlement shall be carried out according to LS-413, LS-414, and LS-416.

#### **904.07.10.06 Curing Formed Surfaces**

Forms for structure barrier wall, parapet wall, and curb on deck shall be removed no later than 24 hours after concrete placement, and the concrete shall be cured according to the Curing with Burlap and Water clause for the remainder of the minimum curing period.

Other formed surfaces shall require no additional curing where the formwork is left in place for the minimum specified curing period. Where the formwork is removed before the curing period is completed, formed surfaces shall be cured with burlap and water according to the Curing with Burlap and Water clause for the remainder of the minimum curing period.

For all concrete other than HPC, when ambient air temperatures are 5 °C or less, forms for concrete barrier wall, parapet wall, and curb on deck may be left in place for the duration of the curing period. When forms are left in place, exposed concrete surfaces of these components shall be cured with vapour barrier.



## **904.07.11 Control of Temperature and Temperature Difference**

### **904.07.11.01 General**

The Contractor shall ensure that during the curing period the concrete temperature does not fall below 10 °C or exceed 70 °C. The Contractor shall also ensure that the temperature difference between the centre of the concrete component at a location where the concrete is expected to reach the highest temperature and the surface does not exceed 20 °C, for:

- a) Any concrete subject to cold weather.
- b) HPC.
- c) Large concrete components where the smallest dimension is 1.5 metres.
- d) All bridge decks.

### **904.07.11.02 Monitoring**

The Contractor shall monitor the concrete and ambient air temperature for:

- a) Any concrete subject to cold weather.
- b) HPC.
- c) Large concrete components where the smallest dimension is 1.5 metres.
- d) All bridge decks.

The Contractor shall supply and install thermocouple wires and associated instrumentation with a combined accuracy of  $\pm 1$  °C capable of recording and displaying temperature. The instrumentation shall include data loggers capable of recording at hourly intervals or less and shall allow direct reading of temperature.

The thermocouples for concrete temperature measurement shall be installed according to Table 2 prior to placing concrete. Thermocouples for monitoring ambient air temperature shall be installed in the shade close to the surface of the concrete at a frequency of 1 thermocouple per stage.

Recording of concrete temperatures shall begin at the start of placement. The temperature shall be recorded automatically at intervals no greater than 1 hour until the end of the monitoring period. The monitoring period shall be 7 Days or longer when necessary in order to meet the requirements of the Withdrawal of Protection clause.

The Contractor shall also monitor and verify concrete and ambient air temperature every 6 hours, or more frequently, for the first 3 Days and every 12 hours for the remainder of the monitoring period. The Contractor shall take necessary action to maintain the temperature within the specified limits.

The Contract Administrator shall be provided access to verify temperature readings. The digital temperature indicators shall be left in place until the end of the monitoring period. If the datalogger does not have a digital display that allows the Contract Administrator to verify temperature, the Contractor shall provide the Contract Administrator with the necessary instruments to allow the Contract Administrator to verify thermocouple function and readings.

### **904.07.11.03 Concrete Subject to Cold Weather**

The Contractor shall design the protection system for the worst conditions that can be reasonably anticipated from local weather records, forecasts, site conditions, and past experience for the time period during which the protection is required. The Contractor shall monitor the conditions and modify the protection system as required.

For cold weather conditions, minimum protection of concrete shall be according to Table 3 and shall be maintained for the duration of curing period. This period may need to be extended in order to meet the requirement of the Withdrawal of Protection clause.

#### **904.07.11.03.01 Housing and Heating**

The design of the protective housing shall take into account the effects of construction activities such as placing concrete, stressing, and grouting. Heating equipment of sufficient capacity to establish and maintain the specified curing conditions shall be used throughout the curing period and for such time thereafter as is necessary for the completion of the work. Heating equipment used within the housing shall be vented outside the housing. Heating equipment having an open flame shall not be permitted.

The ambient air temperature adjacent to the concrete or formwork within the housing shall not be permitted to vary by more than 8 °C.

#### **904.07.11.04 Withdrawal of Protection**

For concrete subject to cold weather and for large concrete components where the smallest dimension is 1.5 metres, the protection shall be gradually removed or reduced in such a manner that the maximum allowable drop of concrete temperature, as specified in Table 4, for each 24-hour period is not exceeded.

The protection shall not be totally removed nor shall the concrete be fully exposed to the air until the average concrete temperature is within 10 °C of the ambient air temperature.

### **904.07.12 Removal of Formwork and Falsework**

The removal of formwork and falsework shall be according to OPSS 919 and the Contract Documents.

#### **904.07.13 Construction Joints**

The Contractor shall form construction joints at the locations shown on the Contract Documents.

In addition, construction joints can be formed where control joints are specified in barrier walls and parapet walls. No other construction joints shall be permitted unless approved in advance by the Contract Administrator.

A straight 20 mm V-groove shall be formed at the exposed face of the concrete at all construction joints. V-grooves shall not be used on bridge deck surfaces, except for the bottom slab of post tensioned box voided slabs.

A bulkhead shall be used to form vertical or inclined construction joints.

### **904.07.14 Surface Finish**

#### **904.07.14.01 General**

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

Within 3 Days following the removal of forms or curing materials, all holes left in the concrete surface with dimension greater than 15 mm and less than 50 mm shall be filled with mortar or a proprietary patching material. The holes shall be moist at the time of filling. Mortar shall be tamped into place. Proprietary patching materials shall be placed according to manufacturer's instructions.

Surfaces with cavities greater than 50 mm or with honeycombing are considered deficient and shall be repaired. The Contractor shall submit a repair proposal to the Contract Administrator for approval.

#### **904.07.14.02 Exposed Surfaces**

The appearance of the concrete shall be uniform in colour, pattern, and texture when viewed from a distance of 15 m. Where a patch is exposed to view, white Portland cement shall be blended with the normal cement to achieve a uniformity of colour. To ensure this uniformity, trial mixes shall be made beforehand and sample panels compared with the main body of the concrete.

The Contractor shall remove all projections, such as fins and bulges, and all blemishes, such as stains and rust marks.

Proprietary patching materials shall be selected to achieve uniformity of colour and appearance.

#### **904.07.14.03 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. When the straight edge is placed across a construction joint the gap between the straight edge and the surface of the concrete shall not be greater than 3 mm.

All unformed construction joint surfaces against which sidewalks, curbs, medians, and barrier walls are to be placed shall be such that, when tested with a 500 mm straight edge placed anywhere in any direction on the surface, there is no gap greater than 20 mm between the bottom of the straight edge and the surface of the concrete.

#### **904.07.14.04 Contamination of Surface**

Contamination by oil or other deleterious substances shall be prevented. Contaminated concrete in bridge decks or against which new concrete is to be placed shall be removed according to OPSS 928, procedure for Concrete Removal-Partial Depth-Type A, B, and C.

#### **904.07.15 Alignment of Components**

The position of the inner and outer top edges of structural components shall be set true to the elevations, alignment, and camber specified in the Contract Documents without visible deviation from one end of the structure to the other. All concrete items or structural components shall be constructed to the specified geometry.

Variations from plumb or a specified slope shall not exceed 1H:400V. Departure from specified alignment shall not exceed  $\pm 25$  mm.

#### **904.07.16 Testing for Early Strength**

The Contractor may, at their option, prepare sets of cylinders for early strength determination in addition to the cylinders required for determination of strength at 28 Days.

The Contractor shall be responsible for all aspects of the preparation, storing, and transportation of cylinders for early strength determination. Curing of cylinders for early strength determination shall consist of storing the cylinders in or on the structure as near as possible to the component that they

represent. The cylinders shall receive the same protection from the elements on all surfaces as is given to the portions of the structure that they represent. The Contractor shall identify the time of testing for early-break cylinders and provide the Contract Administrator with 1 Business Day advance notice to arrange testing. The Contractor shall deliver cylinders for early strength determination immediately prior to the time of testing. The Owner shall test a reasonable number of cylinders for early strength determination at the laboratory designated in the Contract.

Early strength determination of concrete in post-tensioned structures shall be carried out on a minimum of four sets of cylinders representative of the concrete placed in the structure. At least one set of cylinders from the start, middle, and end of the deck section being placed, shall be cast. All cylinder test results must reach the minimum stressing strength specified in the Contract Documents before stressing can commence.

#### **904.07.17 Cracks in Formed and Unformed Surfaces**

The Contractor shall inspect all concrete to identify and document any cracks including, their location, width, and density. The results of the inspection shall be reported to the Contract Administrator. The Contractor shall continue to inspect and monitor cracks up to the date of Completion of the Work.

Based on criteria in Table 5, the Contractor shall identify areas requiring repair or replacement, and shall identify the limits of such repair or replacement. This information shall be provided to the Contract Administrator along with a proposal for remedial action to be taken. No repairs shall proceed until the proposal has been accepted by the Contract Administrator in writing.

Repairs shall be according to OPSS 932. Where removal is required, the removals and preparation of concrete shall be according to OPSS 928 and OPSS 930.

For bridge decks to be waterproofed, the inspection of the surface to be waterproofed shall be carried out after completion of curing and before application of tack coat for waterproofing. For all other concrete, the inspection shall be carried out in a timely manner but no later than one month following completion of curing. The Contractor shall not proceed with waterproofing of a bridge deck until repairs have been completed and permission to waterproof has been given by the Contract Administrator.

#### **904.07.18 Concrete Cover**

The Contractor shall clear all debris and obstructions and provide unhindered access to allow the Contract Administrator to carry out the concrete covermeter survey as specified in the Concrete Cover subsection of the Quality Assurance section. The Contractor shall notify the Contract Administrator in writing when the test area is ready for the concrete covermeter survey.

The Contractor shall allow the Contract Administrator a time period of 3 Business Days to complete the survey, including review of the survey by the Owner. This time period shall commence upon receipt of the Contractor's written notification to carry out the survey. The time period required to complete the concrete survey shall be extended if inclement weather or the ambient air temperatures below 5 °C fall within that time period.

Where the cover does not meet the Contract requirements, the Contractor shall submit a proposal for remedial action for approval by the Contract Administrator.

The Contractor shall not proceed with waterproofing of a bridge deck until the survey has been completed and permission to waterproof has been given by the Contract Administrator.

For all other components, the inspection of the surface shall be carried out in a timely manner, no more than one month after removal of curing.

**904.07.19 Management of Excess Material**

Management of excess material shall be according to the Contract Documents.

**904.08 QUALITY ASSURANCE**

**904.08.01 Acceptance**

Acceptance shall be according to OPSS 1350 and this specification, including satisfactory completion of all remedial action associated with surface tolerance, surface finish, concrete cover, alignment, cracks, and dowel bars and any other deficiencies.

**904.08.02 Concrete Cover**

The concrete cover shall meet the Contract requirements. Concrete cover determination shall be carried out by the Contract Administrator on the front faces of barrier or parapet walls, and the top surface of decks, including medians and sidewalks. The Contract Administrator shall provide the survey report to the Contractor.

**904.08.03 Approach Slab Seat Elastomer**

The Contract Administrator shall select a random sample of the approach slab seat elastomer, 600 mm in length, from each structure for testing.

The Contractor shall allow 60 Days from the time of submission of the sample for the Owner's testing program.

The approach slab seat elastomer samples shall be delivered by the Contractor to the Contract Administrator.

Approach slab seat elastomer that does not meet the Contract requirements shall be considered unacceptable.

**904.08.04 Dowels into Concrete**

**904.08.04.01 Acceptance of Dowels into Concrete**

If more than one dowel fails, the lot of dowels shall be considered unacceptable and the Contractor shall complete the following:

- a) Conduct pull tests on all remaining untested dowels of the lot.
- b) On the subsequent lot, conduct pull tests on 10% of dowels or 20 dowels, whichever is greater. If more than one dowel fails, all remaining untested dowels of that lot shall be tested.
- c) The subsequent lot shall be tested at the higher frequency until no more than one tested dowel fails.

The Contractor shall pull test all replacement dowels in the presence of the Contract Administrator. Each replacement dowel shall be accepted individually.

Dowels shall not be subjected to more than one pull test.

**904.09 MEASUREMENT FOR PAYMENT**

**904.09.01 General**

No deductions from the volume of concrete shall be made for any of the following:

- a) Drainage openings, load reducing devices, embedded timbers, and Utility and prestressing steel ducts, each of which has a cross-sectional area of less than 0.1 m<sup>2</sup>.
- b) Timber, steel, concrete, or concrete filled tubular piles.
- c) Steel reinforcement, miscellaneous hardware, and structural steel.

**904.09.02 Actual Measurement**

**904.09.02.01 Concrete in Culverts  
Mass Concrete  
Tremie Concrete  
Concrete in Footings  
Concrete in Barrier Wall Footings**

Measurement of concrete shall be by volume in cubic metres.

Measurement shall be made within the designated limits of the work.

Tremie concrete volume may be measured using the concrete delivery tickets, when so designated by the Contract Administrator.

**904.09.02.02 Dowels into Concrete**

For measurement purposes, a count shall be made of the number of dowels installed.

**904.09.03 Plan Quantity Measurement**

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

**904.10 BASIS OF PAYMENT**

**904.10.01 Concrete in Culverts - Item  
Mass Concrete - Item  
Tremie Concrete - Item  
Concrete in Footings - Item  
Concrete in Barrier Wall Footings - Item  
Concrete in Structure - Item  
Concrete in Substructure - Item  
Concrete in Substructure and Retaining Walls - Item  
Concrete in Deck - Item  
Concrete in Barrier Walls - Item  
Concrete in Parapet Walls - Item  
Concrete in Approach Slab - Item  
Concrete in Slope Paving - Item  
Concrete in Toe Wall - Item  
Prestressed Concrete Bridge Deck - Item  
High Performance Concrete in Substructure - Item  
High Performance Concrete in Structure - Item  
High Performance Concrete in Approach Slab - Item  
High Performance Concrete in Deck - Item**

**High Performance Concrete in Barrier Walls - Item**  
**High Performance Concrete in Parapet Walls - Item**  
**High Performance Concrete in Substructure and Retaining Walls - Item**

Payment at the Contract price for the concrete tender items shall be full compensation for all labour, Equipment, and Material to do the work, subject to payment adjustments specified in the Contract Documents.

Surface cavities greater than 50 mm and honeycombing shall be repaired at no cost to the Owner.

**904.10.02 Dowels into Concrete - Item**

Payment at the Contract price for the tender items shall be full compensation for all labour, Equipment, and Material to do the work, except that payment for the reinforcing steel bars or coated reinforcing steel bars or stainless steel reinforcing bars used as the dowels shall be according to OPSS 905.

No payment shall be made for dowels that fail the pull test, except where the failure is due to concrete breakout.

Repair to the concrete required due to Contractor's operations shall be made at no cost to the Owner.

For any dowels that fail the pull test as a result of concrete breakout failure and not by bond failure, payment for repairs to concrete resulting from concrete breakout failure during the pull test and the cost of the replacement dowel shall be made as Extra Work.

The cost of additional testing according to the Acceptance of Dowels into Concrete clause shall be at the Contractor's expense and shall be a lump sum of \$1,000 with additional cost of \$50 per dowel.

**904.10.03 Formwork and Falsework**

Payment for formwork and falsework shall be included in the work in which it is used.

Where formwork is required for the work under a concrete tender item, it shall be deemed for progress payment purposes that the formwork, together with its supporting falsework, when installed, constitutes 35% of the work to be carried out under the tender item.

Partial payment for construction of the formwork and falsework shall be made on a prorated basis.

**904.10.04 Working Slabs**

When a concrete working slab is required by the Contract Administrator, payment shall be made as Extra Work at the unit price of the concrete in the footing to be placed on it.

**904.10.05 Deck Joint Assemblies, Bearings, and Deck Drains**

When the Contract does not contain a separate tender items for deck joint assemblies, bearings, and deck drains, the Contract price for the concrete tender items in which the deck joint assemblies, bearings, and deck drains are incorporated shall include full compensation for all labour, Equipment, and Material required to place the deck joint assemblies, bearings, and deck drains.

**904.10.06 Reinforcing Steel Bars, Coated Reinforcing Steel Bars, or Stainless Steel Reinforcing Bars**

When the Contract does not contain a separate tender item for reinforcing steel bar, coated reinforcing steel bar or stainless steel reinforcing bar, the Contract price for the concrete tender item in which the steel reinforcement is incorporated shall include full compensation for all labour, Equipment, and Material required to place the reinforcing steel bars, coated reinforcing steel bars or stainless steel reinforcing bars.

**TABLE 1  
Pull Test Loads**

<b>Dowel Size</b>	<b>Test Loads kN</b>	
	<b>Embedment depth less than 200 mm</b>	<b>Embedment depth 200 mm or greater</b>
10M	20	35
15M	40	70
20M	60	110
25M	100	180
30M	140	250
35M	190	340



**TABLE 2**  
**Minimum Number of Thermocouple Sets for Concrete Temperature Measurement**

	<b>Concrete Elements Requiring Temperature Monitoring</b>	<b>Number of Thermocouple Sets in Each Element</b>	<b>Number of Thermocouples in Each Set</b>	<b>Thermocouple Set Locations</b>
Cold weather protection	Each concrete element	Minimum of 3 per element or stages thereof	2	In locations where the concrete is expected to reach the highest temperature and at the surface of concrete.
Bridge Decks	All	1) Minimum of 3 per stage, or per deck if deck is not placed in stages.  2) When diaphragm is cast together with a deck a minimum of 4 per stage.	3	The beginning, middle, and final portion of the deck placement and in the diaphragm. In locations where the concrete is expected to reach the highest temperature and at the surfaces of concrete. (Note 1)
HPC	Substructure elements: abutments, pier columns, and pier caps	Minimum of 3 per element or stages thereof	2	In locations where the concrete is expected to reach the highest temperature and at the surface of concrete.
Large concrete components where the smallest dimension is 1.5 metres	Elements with smallest dimension of 1.5 m or more	Minimum of 3 per element or stages thereof	2	In locations where the concrete is expected to reach the highest temperature and at the surface of concrete.

**Notes:**

1. For bridge decks, thermocouples shall be installed in sets of three consisting of one mid-depth thermocouple and two surface thermocouples. The surface thermocouples shall be placed immediately above or the shortest distance from the corresponding mid-depth thermocouple. The surface thermocouples shall be installed beneath the burlap, in contact with the surface concrete or imbedded in the concrete within 5 mm of the surface and, for bridge decks, the second surface thermocouple shall be placed inside the bottom form.

**TABLE 3  
Minimum Cold Weather Protective Measures**

<b>Footings and Slabs on the Ground</b>				
<b>Anticipated Minimum Ambient Air Temperature °C</b>	<b>Thickness</b>			
	<b>&gt; 1.0 m</b>	<b>1.0 - 0.5 m</b>	<b>&lt; 0.5 - 0.25 m</b>	<b>&lt; 0.25 m</b>
+5 to 0	PM1	PM1	PM1	PM2
-1 to -10	PM2	PM2	PM2	PM3
-11 to -20	PM3	PM3	PM4	PM5
less than -20	PM3	PM4	PM5	PM5
<b>All Other Components</b>				
+5 to 0	PM1	PM1	PM1	PM2
-1 to -10	PM2	PM2	PM3	PM4
-11 to -20	PM3	PM3	PM4	PM5
less than -20	PM4	PM5	PM5	PM5
<p>Notes:</p> <p>A. Protective Measures</p> <p>PM1 - Cover components with a moisture vapour barrier as specified for curing with moisture vapour barrier.</p> <p>PM2 - Cover components as for PM1, then cover the moisture vapour barrier with insulation having an R-Value of 0.67.</p> <p>PM3 - Cover components as for PM1, then cover the moisture vapour barrier with insulation having an R-Value of 1.33.</p> <p>PM4 - Cover components as for PM1, then cover the moisture vapour barrier with insulation having an R-Value of 2.00.</p> <p>PM5 - Housing and heating.</p> <p>B. All R-Values are metric</p> <p>C. The conversion factor from metric to imperial units is:</p> <p>Metric R-Value x 5.678 = Imperial R-Value.</p>				

**TABLE 4  
Maximum Allowable Drop in Concrete Temperature**

<b>Thickness</b>	<b>&gt; 2.0 m</b>	<b>1.0 - 1.99 m</b>	<b>&lt; 1.0 m</b>
Maximum Allowable Drop in Concrete Temperature per 24 hours	10 °C	15 °C	20 °C

**TABLE 5**  
**Criteria for Treatment of Cracks**

<b>Components</b>	<b>Width of Crack at Widest Point mm</b>	<b>Treatment of Cracked Areas</b>
Decks to be waterproofed and paved	$\geq 0.50$	Repair
Exposed decks	$> 0.30$	a) Repair cracks in the areas where total linear measurement of crack per m <sup>2</sup> is $< 5$ m. b) Remove and replace the cracked areas where total linear measurement of crack per m <sup>2</sup> is $\geq 5$ m.
Barrier wall, parapet wall, sidewalk, and median on a structure	$> 0.30$	a) Repair cracks in the areas where the total linear measurement of crack per linear meter of the wall, sidewalk or median measured along the side facing traffic is $< 5$ m. b) Remove and replace the cracked areas where the total linear measurement of crack per lineal meter of the wall, sidewalk, or median measured along the side facing traffic is $\geq 5$ m.
	$\leq 0.30$	Apply sealer acceptable to the ministry to cracked areas where total linear measurement of crack per m <sup>2</sup> is $\geq 5$ m.
Curb on a structure	$> 0.30$	a) Repair cracks in the areas where the total linear measurement of crack per linear meter of the curb is $< 1.5$ m. b) Remove and replace the cracked areas where the total linear measurement of crack per linear meter of the curb is $\geq 1.5$ m.
Piers, pier caps, abutments, and other structural components within 3 m of roadway	$> 0.30$	Repair
	$\leq 0.30$	Apply sealer acceptable to the ministry to cracked areas where total linear measurement of crack per m <sup>2</sup> is $\geq 5$ m.
All other components	$\geq 1.00$	Repair

**Appendix 904-A, November 2023  
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 specify the following in the Contract Documents:

- Dowels. (904.05.13)
- Slope paving sealant installation. (904.07.04.05)
- Dowel type. (904.07.05.01)
- Installation of dowels. (904.07.05.02)
- Removal of formwork and falsework. (904.07.12)
- Location of construction joints. (904.07.13)
- Alignment of components. (904.07.15)
- Stressing strength for concrete. (904.07.16)
- Management of excess materials. (904.07.19)
- Payment adjustments for concrete. (904.10.01)

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**

No information provided here.