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**AMENDMENTS TO OPSS 1350 (JAN 95) – MATERIAL SPECIFICATION FOR  
CONCRETE – MATERIALS AND PRODUCTION**

**OPSS 1350.02** is amended by the addition of the following:

**TS 1350.02                      References**

**Ontario Provincial Standard Specifications, Materials**

- OPSS 1306 – Burlap **(Sept. 1996)**  
OPSS 1315 – White Pigmented Curing Compounds **(Sept. 1996)**

**Canadian Standards Association (CSA)**

- CAN/CSA-A23.1 – Concrete Materials and Methods of Concrete Construction **(Current Edition)**  
A283 –Qualification Code for Concrete Testing Laboratories **(Current Edition)**  
CAN/CSA-A362 – Blended Hydraulic Cement **(Current Edition)**  
CAN/CSA-A363 – Cementitious Hydraulic Slag **(Current Edition)**  
CAN/CSA-G30.3 – Cold Drawn Steel Wire for Concrete Reinforcement **(Current Edition)**  
CAN/CSA G30.5 – Welded Steel Wire Fabric for Concrete Reinforcement **(Current Edition)**  
CAN/CSA-G30.18 – Billet Steel Bars for Concrete Reinforcement **(Current Edition)**  
CAN/CSA-G40.21 – Structural Quality Steels **(Current Edition)**

**American Society for Testing and Materials (ASTM)**

- ASTM C 171 – Sheet Materials for Curing Concrete **(Current Edition)**  
ASTM C 174 – Measuring Length of Drilled Concrete Cores **(Current Edition)**  
ASTM C 309 – Liquid Membrane-Forming Compounds for Curing Concrete **(Current Edition)**  
ASTM C 457 – Microscopical Determination of Air-Void Content and the Parameters of the Air-Void System in Hardened Concrete **(Current Edition)**  
ASTM C 494 – Chemical Admixtures for Concrete **(Current Edition)**  
ASTM C 666 – Resistance of Concrete to Rapid Freezing and Thawing **(Current Edition)**

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ASTM D 1751 – Expansion Joint Filler for Concrete Paving and Structural Construction (Current Edition)

**City of Toronto Specifications**

TS 904 – Amendments to OPSS 904 – Construction Specification for Structural Concrete (December 2004)

TS 905 – Amendments to OPSS 905 – Construction Specification for Reinforcement for Concrete Structures (June 2001)

TS 1860 – Amendments to OPSS 1860 – Material Specification for Geotextiles (June 2001)

**Transportation Research Board**

NCHRP Report 244 – Concrete Sealers for Protection of Bridge Structures

**OPSS 1350.03** is amended by the addition of the following:

**TS 1350.03 Definitions**

**Admixtures:** means ingredients in concrete other than Portland cement, water and aggregates, that are added to the concrete mixture before or during mixing.

**Alkali-Aggregate Reactivity:** means a chemical reaction between the cementing material and certain minerals in the aggregates which cause expansive cracking in the hardened concrete.

**Cementing Material:** means Portland cement with or without the addition of supplementary cementing materials.

**Crushed Gravel:** means at least 2 crushed faces on 100 percent of gravel particles.

**Epoxy:** means a multi-component resin grout.

**Falsework:** means a temporary structure erected to support work in the process of construction - composed of shoring or vertical posting, formwork for beams and slabs, and lateral bracing.

**Formwork:** means a total system of support for freshly placed concrete including moulds or sheathing as well as all supporting membranes, hardware and bracing.

**Grout:** means a mixture of cementing materials, with or without admixtures, and water. The consistency varies from stiff to fluid.

**Mortar:** means a mixture of cementing materials, sand and water, with a butter-like consistency.

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**Non-Structural Concrete:** means concrete used for the construction of catch basins, maintenance holes, valve chambers, pipe support, road base, sidewalk, curb, curb and gutter and all other concrete that does not classify as structural concrete.

**Slurry:** means a pourable mixture of cementing materials, sand and water.

**Superplastized (Flowing) Concrete:** means normal slump concrete to which a high-range water reducing admixture has been added to produce a high-slump flowing concrete.

**Supplementary Cementing Materials:** means materials that, when used in conjunction with Portland cement, contribute to the properties of the hardened concrete through hydraulic or pozzolanic activity or both.

**Structural Concrete:** means any concrete used in the construction of bridges, culverts, tunnels, retaining walls, wharfs or guideways.

**Unshrinkable Fill:** means a mixture of aggregates, cementing material and water, with or without chemical admixtures, that hardens into a material with higher strength than soil but less than 0.4 MPa compressive strength at 28 days that can be removed with hand tools.

**Vitrified Clay Pipe:** means pipe made from various clays which are shaped, dried and fired to a point where glass-forming components fuse to form a bond between the crystalline grains.

OPSS 1350.04.01.01 is deleted and replaced with the following:

**TS 1350.04.01.01                      Concrete Mix Data**

**TS 1350.04.01.01.01                  General**

The Contractor shall provide a complete mix design submission to the City, for each specific concrete mix, prior to the placement of that mix on the contract. A complete mix design submission consists of:

- a)     Either a completed City of Toronto Concrete Mix Design Submission Form A; or
- b)     A completed City of Toronto Concrete Mix Design Submission Form B; and
- c)     Supporting documentation including all material quality test data, for the mix design and for component materials, required by the contract

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Concrete Mix Design Submission Forms A or B shall identify all materials to be used in the concrete; no material shall be used in the concrete without the knowledge of the Commissioner.

**TS 1350.04.01.01.02                      Submission of Form A**

The Contractor shall confirm with the concrete supplier and the owner the performance characteristics of the concrete through the submission of three copies of the Concrete Mix Design Submission (Form A) for each type of concrete as specified in the contract. The form shall be submitted to the Contract Administrator at least three (3) weeks prior to the delivery and placement of the concrete.

- The form shall be completed by the concrete supplier based on the requirements of the contract and those of the contractor. The form shall be signed by the contractor and the Contract Administrator on behalf of the owner to certify that performance characteristics of the concrete meet their respective requirements under the contract.
- The performance based mix design will be checked by the City's Contract Administrator to verify that the materials and sources are in compliance with the contract requirements. Concrete placement cannot proceed until the City's Contract Administrator has verified that the form meets the project requirements.
- The form shall then be returned to the supplier and shall form the basis of the detailed mix design.

The Contractor shall provide the following to the City on Form A:

- Concrete supplier
- Primary and back-up concrete plants supplying concrete
- Specified 7-day and/or 28-day strength of concrete
- Identification of all materials to be used in the concrete
- Sources of all materials to be used
- Intended use and location of the concrete on the contract
- Target air content of the mix and slump range for quality control purposes
- Nominal maximum size of coarse aggregate and fineness modulus of fine aggregate, and inventory numbers for the aggregates
- Unique mix design code for each mix
- Declarations from the concrete supplier that the concrete they supply will meet all concrete requirements as stated in Form A.
  - i. The proportions of all supplementary cementing materials meet the contract requirements.

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- ii. The dosages of all chemical admixtures are at least the minimum shown on the Designated Sources for Materials for that product.
  - iii. Mix proportions will be submitted to City prior to placement of concrete of that mix design on the contract.

Form A shall be accompanied by all material quality test data and other information, for the mix design and for component materials, required by the contract.

#### **TS 1350.04.01.01.03                      Submission of Form B**

Three weeks prior to the placing of the concrete, the City of Toronto and the concrete supplier shall execute a confidentiality agreement to cover the protection of proprietary mix proportion information which is to be released as part of the mix design submission process.

Upon receipt of the completed concrete mix submission form and the executed confidentiality agreement, the concrete producer shall formulate the detailed mix design. The details of the mix proportions will be documented in a way consistent with City of Toronto Concrete Mix Design Submission Form B.

The detailed mix design in Form B shall contain the material quantities for cement, supplementary cementing materials, water and admixtures ranges, consistent with the specified Designated Sources Material List (DSM), in addition to source information.

Form B will be submitted directly from the concrete producer to the Commissioner only, for all concrete supplied for engineering structures (current OPSS Division 9 items only). Form B will be submitted no later than two (2) weeks prior to the delivery and placement of the concrete. The Contract Administrator shall review the submission and satisfy itself of the appropriateness of the mix. The review of the proposed source of supply and proportions in no way relieves the supplier of their responsibility for producing concrete that achieves the performance requirements under the contract.

Under no circumstances shall the Contractor place concrete of a given mix in the work until the City has been provided with Form B for that mix design.

The information contained in Form B shall be treated in a confidential manner by the City of Toronto.

The Contractor shall provide the following on Form B, to be submitted to Contract Administrator prior to the placement of concrete:

- The information provided on Form A, with the exception of the supplier declarations.

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- Quantity of cement and supplementary cementing materials to be used in the mix.
  - Dosage or range of dosages of chemical admixtures to be used in the mix. The quantity of chemical admixtures shall be at least the minimum dosage given in the Designated Sources for Materials.
  - Quantity range of water to be used in the mix (total water).

#### **TS 1350.04.01.01.04                      Submission Requirements**

A complete mix design submission shall be provided for concrete of each specified compressive strength that will be placed on the contract. A separate mix design submission is also required within each strength level, for:

- a) Mixes where material proportions vary outside the tolerance identified below in this clause.
- b) Cast-in-place and slip-formed concrete.
- c) Mixes with different sources of materials.
- d) Mixes with different admixtures. (Where a mix will be used with variable dosages of retarder, supporting documentation for that mix design may be based on concrete with or without the retarder.)
- e) Special purpose or unique mixes.

If the same mix design (same materials, in the same proportions) is to be supplied by multiple plants, submission of separate mix designs and separate supporting documentation shall not be required.

A new, complete mix design submission shall be provided prior to:

- a) Changing sources of materials used in the concrete.
- b) Substituting a material or product for another from the same source.
- c) Adding a material to the concrete that was not on the original mix design (except retarder).
- d) Adjusting the quantities of the stated materials in the concrete, outside of the following tolerances:
  - i. Cement: +/- 5% of quantity stated on Form B
  - ii. Supplementary cementing materials: 95% to 100% of quantity stated on Form B
  - iii. Admixtures: Dosage or range of dosage, as stated on Form B
  - iv. Water: Range stated on Form B.

Material quantities may be varied within the tolerances identified above, without submission of a new mix design.

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Removal of a material from the mix requires submission of a new mix design, but does not require submission of supporting test data.

The submission process for new or modified mix designs is the same as for the original mix design.

**OPSS 1350.04.01.03** is amended by the addition of the following:

**TS 1350.04.01.03     Mix Design Materials**

Submissions required by the Commissioner regarding concrete mix designs and materials shall provide at least the following information:

- (i) The source of each material to be incorporated in the concrete and the name of the concrete supplier.
- (ii) Certification that all materials to be incorporated into the concrete mix are compatible in the mix and meet or exceed the requirements given above.
- (iii) The proportions of each material for each class of concrete to be incorporated into the work.
- (iv) The results of slump, total air content and compressive strength testing at 7-day, 28-day, and other ages if required in the specifications, for each class of concrete to be incorporated into the work, supplied by an independent laboratory certified to CSA A283 (Category I).
- (v) If blended hydraulic cements or supplementary cementing materials are proposed, documentation demonstrating satisfactory performance of similar concrete mixes incorporating the proposed cementing materials in similar applications. As a minimum, this satisfactory performance may be shown through the documented visual assessment of at least 5 projects, each at least 3 years old, for each mix incorporating blended hydraulic cement or supplementary cementing materials. Documentation for each visual assessment shall include, as a minimum, the type and source of the cementing material incorporated, concrete mix materials and proportions used, the application in which the concrete has been incorporated (eg. bridge deck, sidewalk, etc.) and the current condition, signed by a professional engineer.

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(vi) Alternative to (v)

If supplementary cementing materials are to be incorporated into the concrete mix, certification and documentation signed by a professional engineer, stating that the quality and durability of the concrete with supplementary cementing materials will equal or exceed the quality and durability of the concrete without supplementary cementing materials. Specific documentation relating to deicer chemical scaling resistance and rate of strength gain shall also be submitted.

(vii) The results of testing of the quality of the air voids system of the hardened concrete mix(es) to be incorporated into the work, as determined by ASTM C457, documenting conformance to CAN/CSA-A23.1.14.3.

**OPSS 1350.04.01** is amended by the addition of the following:

**TS 1350.04.01.05 Reinforcing Steel**

Submissions required by the Commissioner from the Contractor shall provide at least the following information:

- (i) The source of all reinforcing steel products, name of the reinforcing steel fabricator.
- (ii) Two copies of the mill certificate and two copies of the stress-strain curves representative of each lot of material to be used for reinforcing steel.

**TS 1350.04.01.06 Curing Media**

Submissions required by the Commissioner from the Contractor shall provide at least the following information:

- (i) The source of the curing medium, manufacturer's product installation and certification data.

**TS 1350.04.01.07 Joint Filler**

Submissions required by the Commissioner from the Contractor shall provide at least the following information:

- (i) The source of expansion joint filler material, manufacturer's product installation and certification data.



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**TS 1350.04.01.08 Concrete Sealer**

Submissions required by the Commissioner from the Contractor shall provide at least the following information:

- (i) The source of the concrete sealer and the manufacturer's installation guidelines and data.
- (ii) Certification that the sealer meets or exceeds the requirements of NCHRP 244, as stated above.

**TS 1350.04.01.09 Production of Concrete**

Submissions requested by the Commissioner regarding the production of concrete shall provide at least the following information:

- (i) Certification of the plant and equipment by the Ready Mix Concrete Association of Ontario.
- (ii) Certification that the plant and equipment meet or exceed the requirements of CAN/CSA-A23.1, Section 16, Table 11 for Alternate 1.

**OPSS 1350.05.01** is amended by the addition of the following

**TS 1350.05.01 Materials for Concrete**

Unless otherwise specified in the Contract, the Contractor shall supply all materials necessary for the execution and completion of the work.

**OPSS 1350.05.01.01** is amended by the addition of the following:

**TS 1350.05.01.01 Cementing Materials**

Unless otherwise specified, all cement shall be normal Portland cement (Type 10) or high-early strength Portland cement (Type 30) meeting the requirements of CAN/CSA-A5.

High-early strength Portland cement (Type 30) may be used only with the prior approval of the Commissioner.

Additional Type 10 Portland cement may not be used as a means of obtaining high early strength in the concrete.

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Blended hydraulic cements shall meet the requirements of CAN/CSA-A362 and CAN/CSA-A363. Blended hydraulic cements may be used only with the prior approval of the Commissioner.

**OPSS 1350.05.01.01 Supplementary Cementing Materials** is deleted and replaced with the following:

Unless otherwise specified, supplementary cementing materials (fly ash, silica fume and/or slag cement) may be used only with the prior approval of the Commissioner. Supplementary cementing materials shall meet the requirements of CAN/CSA-A23.1 and CAN/CSA-A363.

The supplementary cementing materials proportion restriction is amended as:

The supplementary cementing materials shall be restricted to the following proportions by mass of the total cementing materials:

- (i) Slag cement (ground granulated blast furnace slag) up to 50 percent.
- (ii) Fly ash up to 25 percent.
- (iii) Silica fume up to 10 percent
- (iv) A mixture of slag cement and fly ash up to 50 percent except that the amount of fly ash shall not exceed 25 percent by mass of the total cementing materials.

**OPSS 1350.05.01.02** is amended by the deletion of

“The maximum nominal size of aggregate shall not exceed 19.0 mm.”

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**OPSS 1350.05.01.02** is also amended by the addition of the following:

**TS 1350.05.01.02     Aggregates**

**TS 1350.05.01.02.01   General**

Aggregates from sources known to cause alkali-aggregate reactivity or D-cracking shall not be used. Aggregates shall be supplied from the MTO Concrete Aggregate Sources List and shall have documented, demonstrated, satisfactory performance for durability, resistance to alkali-aggregate activity (alkali-silicate or alkali-carbonate) and resistance to D-cracking for concrete in severe exposure conditions. As a minimum, this satisfactory performance may be shown through the documented visual assessment of at least 5 exposed concrete deck, slab or pavement projects, each at least 10 years old, for each aggregate source and type. The Contractor's documentation for each visual assessment shall include, as a minimum, the location, type and name of the installation, the aggregate source(s) and types incorporated, concrete materials and mix design used and the current condition, in a signed report by a professional engineer. Additional supporting information on the aggregates, such as CAN/CSA-A23.2-14A (potential expansivity of aggregate), CAN/CSA-A23.2-25A (detection of alkali-silica reactive aggregate) and ASTM D 666 Procedure A (D-cracking) test results, will be of assistance to the Commissioner during assessment of the concrete materials submission.

**TS 1350.05.01.02.02   Fine Aggregate**

Fine aggregate shall consist of clean particles of natural or manufactured sand or an approved combination thereof, free from soft, thin, elongated or laminated particles and shall meet the requirements of CAN/CSA-A23.1, OPSS 1001 and OPSS 1002, including the requirements of the latest revision to these documents.

**TS 1350.05.01.02.03   Coarse Aggregate**

Coarse aggregate shall consist of hard, strong, uncoated, durable particles of crushed stone or crushed gravel, meeting the requirements of CAN/CSA-A23.1, OPSS 1001 and OPSS 1002, including the requirements of the latest revisions to these documents.

Except where otherwise specified, the nominal maximum size of coarse aggregate shall be either 37.5 mm or 19.0 mm (normally, 37.5 mm aggregate is used in concrete road base only).

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**OPSS 1350.05.01.03** is amended by the addition of the following

**TS 1350.05.01.03      Water**

Water for use in concrete and for curing shall meet the requirements of CAN/CSA-A23.1

**OPSS 1350.05.01.04** is amended by the addition of the following

**TS 1350.05.01.04      Air Entraining and Chemical Admixtures**

All admixtures shall meet the requirements of ASTM C 494

**OPSS 1350.05.01** is amended by the addition of the following:

**TS 1350.05.01.05      Concrete**

This Specification covers the manufacture of either job mixed or ready mixed concrete for use in road base, pavements, curbs, gutters, sidewalks, catch basins and maintenance holes and all other non-structural items.

The Contractor shall be responsible for the collection and disposal of the remains of all concrete used for testing purposes. In order to simplify collection and handling, the Contractor shall set aside a designated location for the temporary piling of this discarded material close to the point of discharge from the delivery truck and shall provide assistance to transport the material into the designated location.

**TS 1350.05** is amended by the addition of the following:

**TS 1350.05.03      Other Materials**

**TS 1350.05.03.01      Reinforcing Steel**

**TS 1350.05.03.01.01      General**

Reinforcing steel, including reinforcing steel bars and welded wire steel fabric, shall be supplied from a source on the MTO Designated Sources for Materials List.

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#### **TS 1350.05.03.01.02 Reinforcing Steel Bars**

Deformed reinforcing steel bars shall meet the requirements of OPSS 1440. Unless otherwise specified, reinforcing steel for installation in culverts and head walls shall be grade 400 W.

#### **TS 1350.05.03.01.03 Welded Steel Wire Fabric**

Welded steel wire fabric shall meet the requirements of CAN/CSA-G30.5.

#### **TS 1350.05.03.01.04 Cold Drawn Steel Wire**

Cold drawn steel wire shall meet the requirements of CAN/CSA-G30.3.

#### **TS 1350.05.03.01.05 Supports**

Bar supports shall be made of precast concrete blocks, plastic or wire. Bar supports over 200 mm in height shall be made of bent or welded steel bar. Bar supports shall meet the requirements of CAN/CSA-A23.1, Section 12.7.2.

#### **TS 1350.05.03.01.06 Dowels**

Dowel bars for concrete road base shall be 450 mm x 32 mm plain round bars of grade 350 or better meeting the requirements of CSA-G30.18.

#### **TS 1350.05.03.01.07 Curing Media**

##### **TS 1350.05.03.01.07.01 Curing Compound**

White pigmented curing compound shall meet the requirements of ASTM C 309 and OPSS 1315.

##### **TS 1350.05.03.01.07.02 Polyethylene Film**

White opaque polyethylene film shall meet the requirements of ASTM C 171. A minimum thickness of 6 mils is required.

##### **TS 1350.05.03.01.07.03 Geotextile Fabric**

Geotextile fabric used as a curing medium shall be a synthetic, permeable textile meeting the requirements of TS 1860. A minimum thickness of 0.9 mm is required.

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**TS 1350.05.03.01.07.04 Burlap**

Burlap cloth used as a curing medium shall be made from jute or kenaf, and shall meet the requirements of OPSS 1306.

**TS 1350.05.03.01.08 Expansion (Isolation) Joint Filler**

Expansion joint filler material shall consist of preformed Type A - Non-Extruding and Resilient Bituminous, ASTM D 1751.

Unless otherwise specified or shown on the Standard Drawings, the thickness of the expansion joint filler shall be 12 mm.

**TS 1350.05.03.01.09 Concrete Sealer**

Unless otherwise specified, the sealer shall be a two-coat colourless solution of methyl methacrylate copolymer resins, a penetrating agent and fast evaporating solvent with a minimum solids content of 20 percent and containing no fillers. Application rates and solids content shall be in accordance with certified test results on the NCHRP 244 test series to be submitted prior to construction for approval. Acceptable materials shall meet the following NCHRP 244 performance criteria:

Four Inch Cube Tests: 75 percent effective in reducing water absorption when compared to an untreated control sample.

Southern Exposure Tests: 90 percent effective in reducing chloride ion content when compared to an untreated control sample.

The sealer shall be compatible with the surface over which it is to be applied. The resultant coating shall have the ability to breathe, be water resistant, durable, nonyellowing, and resistant to ultraviolet light and weathering.

**OPSS 1350.05.02** is replaced by the following:

The physical requirements for the concrete shall meet the concrete physical requirement specifications of the structure.

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OPSS 1350.07.06 heading is replaced by the following:

**1350.07.06                      Concrete Strengths 32 MPa (at 28 days) or Greater**

OPSS 1350.07.06.01 is superseded by the following:

**1350.07.06.01                  Trial Batch**

The concrete mix proportions for concrete with strengths of 32 MPa or greater shall be confirmed by means of test cylinders.

The testing of the field trial batch of concrete shall be the responsibility of the Contractor.

At least 30 d prior to placing concrete of 32 MPa strength, or greater, the concrete supplier shall mix a full size trial batch of concrete in the proportions designed.

When the concrete is mixed within a ready mixed truck, the volume of the trial batch shall be the volume of concrete normally mixed in the truck.

When the source of concrete is a ready mix plant a trial batch of concrete shall originate from each plant that will be used for the supply of the concrete and the trial batch shall be delivered to the site of the work or as directed by the contract administrator.

When an approved ready mixed concrete operation is currently supplying or has supplied a class of concrete to another of the City's contracts, within the last 12 months, that requires tests in conformance with this clause, permission may be given to use concrete from that operation without the need for full size field trial batches, providing that:

- a.     There is no change in the source of any material.
- b.     The quality and grading of the aggregates have not changed significantly.
- c.     The concrete mix designated and previously used meets the specified requirements.
- d.     Documentation of this prior approval is submitted to the concrete purchaser.

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**OPSS 1350.07** is amended by the addition of the following:

**TS 1350.07.09 Control of Slump and Air Content**

No water shall be added after the initial introduction of the mixing water for the batch, except at the start of discharge, when the measured slump of the concrete is less than that specified and no more than 60 minutes have elapsed from the time of batching to the start of discharge. In this case, water may be added by the producer to an amount not exceeding 16 l/m<sup>3</sup> or 10 percent of the mix design water. The drum or blades shall then be turned an additional 30 revolutions or more at mixing speed, until the uniformity of the concrete is sufficient. Water shall not be added to the batch at any later time. Concrete may be used as long as it is of such slump that, in the opinion of the Commissioner, it can be placed and properly consolidated without the addition of water to the batch. The Commissioner will determine the air content of the concrete at the point of discharge, in accordance with the provision of CAN/CSA A23.1. Concrete shall be retested for conformance to air content requirements when more than 90 minutes have elapsed since batching. Water added at the job site shall be recorded on the delivery slip.

The air content of the concrete shall, if necessary, be brought up to the specified range by the addition of an air-entraining admixture in the field. Mixing shall follow to ensure proper dispersion. The air content shall be retested. The amount of admixture shall be recorded on the delivery slip.

When superplasticized or flowing concrete is used and the measured slump falls below the specified slump due to delay, it shall be retempered with superplasticizing admixtures only, not water. The amount of admixture shall be recorded on the delivery slip.

**TS 1350.07.10 Placing Concrete**

Concrete shall be placed and consolidated in accordance with the requirements of Section 19 of CAN/CSA A23.1 and the requirements of this specification. The concrete delivering and spreading operations shall be coordinated as to provide a uniform rate of progress.

The concrete shall be placed to the specified thickness, line and grade. The concrete shall be consolidated by the use of 50mm vibrators to eliminate voids, honeycombing and entrapped air. Vibrators shall not be used to distribute the concrete.



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## **TS 1350.07.11 Concrete Curing**

### **TS 1350.07.11.01 General**

All exposed concrete surfaces shall have the curing process commence as soon as possible, and not more than 30 minutes after surface finishing or within one hour of form removal.

Acceptable methods of curing include one or more of the following:

- (i) Burlap
- (ii) Geotextile fabric and water.
- (iii) Polyethylene sheet.
- (iv) Curing membrane compound.

Each curing method may be used at ambient temperatures up to 27°C. At temperatures above 27°C, only the geotextile fabric and water procedure is permitted. In cold weather, as described in TS 904, curing compound shall not be used.

### **TS 1350.07.11.02 Curing with Burlap and Water**

Burlap mats shall be presoaked by immersion in water for at least 6 hours immediately prior to placing. The mats shall cover the entire width and edges of the exposed concrete. The mats shall overlap 300 mm and shall be held down to prevent displacement. The mats shall be maintained in place and kept saturated for a minimum period of 7 days. The Contractor may constantly water the mats or cover them with opaque polyethylene film, or a combination of both, in order to keep the mats saturated.

Alternatively, this method shall be used for a minimum period of 3 days following which the surface shall be cured with curing compound as specified in TS 1350.07.11.05 of this specification.

### **TS 1350.07.11.03 Curing with Geotextile Fabric and Water**

Geotextile fabric shall be presoaked by immersion in water for at least 6 hours immediately prior to placing. Two layers of fabric shall be applied to the surface of the concrete and shall cover the entire width and edges of the exposed concrete. Strips shall overlap 100 mm and shall be held down to prevent displacement. The fabric shall be maintained in place and kept saturated for a minimum period of 7 days. The Contractor may constantly water the mats or cover them with opaque polyethylene film, or a combination of both, in order to keep the mats saturated.

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Alternatively, this method shall be used for a minimum period of 3 days following which the surface shall be cured with curing compound as specified in TS 1350.07.11.05 of this specification.

#### **TS 1350.07.11.04 Curing with Polyethylene Film**

White, opaque polyethylene film (100 µm thick) shall be placed such that air flow between it and the concrete surface is prevented. The film shall be held down at the edges and laps, and shall be overlapped a minimum of 150 mm, to prevent displacement. The film shall be kept in place for a minimum period of 7 days.

Alternatively, this method shall be used for a minimum period of 3 days following which the surface shall be cured with curing compound as specified in TS 1350.07.11.05.

#### **TS 1350.07.11.05 Curing with Membrane Compound**

Immediately prior to application, the curing compound shall be agitated by mechanical means to provide a homogeneous mixture. Curing compound shall be spray applied in two coats to the concrete surface such that the membrane formed is uniform in thickness and colour and is free of breaks and pinholes. The surface shall be maintained in this condition for a minimum period of 7 days.

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

#### **TS 1350.07.12 Protection**

##### **TS 1350.07.12.01 Rain**

Concrete shall not be placed if rain is sufficiently intense to separate cement (paste) from the surface of the concrete mix or to hinder finishing operations. The surface of the concrete shall not be finished when water is present on the surface.

Concrete already placed shall be protected against the effects of rain until the concrete has sufficiently hardened to resist damage.

##### **TS 1350.07.12.02 Traffic**

The section of newly constructed concrete shall be closed to all vehicular traffic, including construction equipment, until such time as the concrete has attained at least 75 percent of the design compressive strength. Pedestrian traffic shall be kept off the newly constructed concrete for at least 8 hours.

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The Contractor shall provide adequate measures to protect the newly constructed concrete section from damage by vehicular or pedestrian traffic.

**TS 1350.07.12.03 Cold and Hot Weather Precautions**

When the air temperature is below 5°C or likely to fall below this limit, or when the air temperature is at or above 27°C or is likely to rise above this limit during concrete placing, the Contractor shall comply with the requirements of TS 904, sections 904.07.03.07 and 904.07.03.08.

**OPSS 1350.08.01.01** is amended by the addition of the following

Concrete compressive strength, concrete surface tolerance, concrete thickness and proper curing, as specified above, shall be the criteria for acceptance of non-structural concrete

**OPSS 1350.08.01.04 Strength Tests and Requirements, Compressive Strength** is amended to read as follows:

Compressive Strength

The concrete mix shall be sampled in accordance with CAN/CSA A23.2-1C, with compressive strength specimens made in accordance with CAN/CSA A23.2-3C and tested in accordance with CAN/CSA A23.2-9C. Slump (CAN/CSA A23.2-5C), air content (CAN/CSA A23.2-4C) and temperature (ASTM C 1064) tests shall also be determined each time the concrete is sampled for compressive strength.

To meet the specified nominal minimum 28 day strength requirements:

- (I) The average of all groups of three consecutive strength tests shall equal or exceed the specified strength.
- (ii) No individual strength test shall be more than 3.5 MPa below the specified strength.

A compressive strength test result is the average 28 day strength of two 100 x 200 mm or two 150 x 300 mm concrete cylinders shall be removed from a lot and tested. One cylinder shall be tested to determine the 7 day strength. The strength test of the 100 x 200 mm cylinders shall be multiplied by 0.95.

The 28-day strength criteria can be expected to be met 99% of the time if the concrete mix is proportioned to produce an average strength as follows:

- 
- A. 1.4 times the standard deviation (1.4s) above the specified strength when the standard deviation is not more than 3.5 MPa
  - B. 2.4 times the standard deviation minus 3.5 MPa above the specified strength when the standard deviation is more than 3.5 MPa

$$\sigma = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

Where: s is the standard deviation

x is the test strength

$\bar{x}$  is the mean strength

n is the number of tests

Concrete represented by compressive strength samples not meeting or exceeding the requirements shall be removed and replaced at the Contractor's expense.

**TS 1350.08.01.04** is amended by the addition of the following:

**TS 1350.08.01.04.01 Concrete Road Base**

The concrete road base shall be divided into lots of up to 1,000 m<sup>2</sup> or daily production (if less than 1,000 m<sup>2</sup>).

Compressive strength determination will be made on a lot basis. Each lot shall have 4 equal sublots, sampled on a stratified random basis in accordance with ASTM D 3665.

A compressive strength test for concrete road base shall be based on two 150 x 300 mm cylinder samples per sub lot.

**TS 1350.08.01.04.02 Concrete Curb and Curb and Gutter**

The concrete curb and curb and gutter shall be divided into lots of up to 200 m<sup>2</sup> or daily production (if less than 200 m<sup>2</sup>).

Compressive strength determination will be made on a lot basis. Each lot shall have 4 equal sublots, sampled on a stratified random basis in accordance with ASTM D 3665.

A compressive strength test for concrete curb and curb and gutter shall be based on two 150 x 300 mm cylinder samples per sub lot.

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**TS 1350.08.01.04.03 Concrete Sidewalk and Concrete Raised Median**

The concrete road base shall be divided into lots of up to 1,000 m<sup>2</sup> or daily production (if less than 1,000 m<sup>2</sup>).

Compressive strength determination will be made on a lot basis. Each lot shall have 4 equal sublots, sampled on a stratified random basis in accordance with ASTM D 3665.

A compressive strength test for concrete Sidewalk and Concrete Raised Median shall be based on two 150 x 300 mm cylinder samples per sub lot.

**TS 1350.08.01** is amended by the addition of the following:

**TS 1350.08.01.05 Concrete Thickness**

**TS 1350.08.01.05.01 General**

The Commissioner may make measurements to determine the thickness of the concrete.

The minimum acceptable thickness of the concrete shall be the specified thickness minus 5 percent. Concrete constructed to less than 95 percent (90 percent for concrete sidewalk only) of the specified thickness shall be removed and replaced at the Contractor's expense.

Thickness determinations shall be made on a lot basis. Each lot shall have 4 equal sublots represented by a concrete core.

The mean concrete thickness for a lot shall be calculated from the following formula:

$$T_x = \frac{T_1 + T_2 + T_3 + T_4}{4}$$

where:  $T_x$  is the mean concrete thickness for a lot, rounded off to the nearest mm.

$T_1 + T_2 + T_3 + T_4$  are the core lengths for Sublots 1, 2, 3 and 4.

If any individual (sublot) core length is more than 5 mm above the specified slab thickness, its length shall be assumed to be equal to the specified thickness plus 5 mm for the purpose of the calculation of  $T_x$ .

Concrete cores shall only be used for the purpose of measuring concrete thickness. Cores shall not be used the testing of compressive strength.

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#### **TS 1350.08.01.05.02 Concrete Road Base**

The concrete road base thickness shall be based on maximum 100 mm diameter cores. No core shall be taken within 250 mm of panel joints or edges. The length of each core shall be determined in accordance with ASTM C 174.

Cores which are obviously damaged shall not be considered and replacement cores shall be taken as necessary for the determination of slab thickness.

#### **TS 1350.08.01.05.03 Concrete Curb and Curb and Gutter**

The concrete curb and concrete curb and gutter thickness shall be based on the depth of the exposed face of the curb and/or gutter, measured in place.

#### **TS 1350.08.01.05.04 Concrete Sidewalk and Concrete Raised Median**

The concrete thickness shall be based on maximum 100 mm diameter cores. No core shall be taken within 250 mm of panel joints or edges. The length of each core shall be determined in accordance with ASTM C 174.

#### **TS 1350.08.01.06 Surface Tolerance**

##### **TS 1350.08.01.06.01 General**

The Contractor shall grind off or remove and replace panels with variations exceeding the specified surface tolerance. The placement of additional concrete or patching material will not be an acceptable method of achieving the desired surface tolerance.

##### **TS 1350.08.01.06.02 Concrete Road Base**

Except across the crown or drainage gutter, the surface of the concrete road base shall be such that, when tested with a 3 metre long straight edge placed anywhere, in any direction, on the surface, there shall not be a gap greater than 5 mm at any point between the bottom of the straight edge and the surface of the concrete.

Surface tolerance determinations will be made on a lot basis. Each lot shall have 4 equal sublots, sampled on a stratified random basis in accordance with ASTM D 3665.

The concrete road base shall be divided into lots of up to 1,000 m<sup>2</sup> or daily production (if less than 1,000 m<sup>2</sup>).

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### **TS 1350.08.01.06.03 Concrete Curb and Curb and Gutter**

Concrete curb and concrete curb and gutter shall be divided into lots of up to 200 m<sup>2</sup> or daily production (if less than 200 m<sup>2</sup>).

The surface of the concrete curb or the concrete curb and gutter shall be such that, when tested with a 3 metre long straight edge placed anywhere on the surface, longitudinal to the curb, there shall not be a gap greater than 3 mm at any point between the bottom of the straight edge and the surface of the concrete.

### **TS 1350.08.01.06.04 Concrete Sidewalk and Concrete Raised Median**

Concrete sidewalk and concrete raised median shall be divided into lots of up to 1,000 m<sup>2</sup> or daily production (if less than 1,000 m<sup>2</sup>).

The surface of the concrete sidewalk or the concrete raised median shall be such that, when tested with a 3 metre long straight edge placed anywhere, in any direction, on the surface, there shall not be a gap greater than 3 mm at any point between the bottom of the straight edge and the surface of the concrete.

### **TS 1350.08.01.07 Visibly Defective or Damaged Concrete**

Concrete that is visibly defective or damaged shall be removed and replaced as directed by the Commissioner. Concrete is visibly defective or damaged when:

- (i) The concrete is honeycombed.
- (ii) The concrete contains embedded debris.
- (iii) The concrete has been damaged by freezing.
- (iv) The concrete temperature at the time of placement exceeded the requirements of this Specification.
- (v) The concrete surface has been damaged by rain.
- (vi) The concrete contains footprints or other undesirable impressions.
- (vii) The concrete has been subjected to traffic before the concrete achieved 75 percent of the specified 28 day compressive strength.
- (viii) The concrete has cracked or separated.
- (ix) The concrete surface has spalled.

- 
- (x) Expansion and isolation joints are not vertical.
  - (xi) The concrete sections have heaved or sunk, from their original position.

OPSS 1350.10 is amended by the addition of the following

**TS 1350.10                      Payment for Unacceptable Concrete**

**TS 1350.10.01                  Warranty for Replaced Concrete**

All unacceptable concrete, required to be removed and replaced, shall have a warranty period of 24 months from the date of replacement. Unacceptable concrete is defined as concrete that does not meet the acceptable concrete requirements outlined in TS 1350.08. Concrete that is required to be removed and replace shall all be done at the contractor's expense.

**TS 1350.10.01                  Compressive Strength of Concrete**

**TS 1350.10.01.01          General**

An unacceptable lot is a lot in which at least one of its sub-lots is unacceptable. An unacceptable sub-lot is a sub-lot represented by one or two cores that fail to meet the compressive strength requirements. Unacceptable lots shall be removed and replaced at the Contractor's expense.

Where the Owner permits the work to remain in place, a price adjustment will be calculated in accordance with the clause TS 1350.10.01.02. Unacceptable lots will not be eligible for full payment.

All replacement lots shall be accepted on the same basis as the original lot.

For the purpose of calculating the price adjustment for an unacceptable lot, the Contract Administrator will determine the quantity of concrete in lot(s) using the dimensions in the Contract Documents. A price adjustment for an unacceptable lot will be applied if the requirements outlined in TS 1350.08.01.04 are not satisfied. The price adjustment factors and calculations are described in TS 1350.10.01.01.02.



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**1350.10.01.02 Price adjustment for Unacceptable Lot**

Payment for an unacceptable lot will be calculated if the average of all groups of the two consecutive 28 day strength test are less than the specified strength. Price adjustment will be calculated for each unacceptable lot, according to **Table 1**, based on the actual strength of the concrete.

*NOTE: If an individual strength test is more than 3.5 MPa below the specified strength, the contractor is required to remove and replace the corresponding lot at their expense.*

**TABLE 1**

<b>Average Tested Compressive Strength</b>	<b>Percent Payment Of Concrete</b>
Greater than or equal to 100 percent of specified compressive strength	100
Up to 3.5 MPa below Specified compressive strength	$\frac{(Actual\ Strength)^2}{(Specified\ Strength)^2} \times 100$
More than 3.5 MPa below specified compressive strength	remove and replace at contractor's expense

**TS 1350.10.02 Concrete Thickness**

**TS 1350.10.02.01 General**

An unacceptable lot is a lot represented by the mean concrete thickness for a lot that fails to meet the acceptable thickness requirements. Unacceptable lots shall be removed and replaced at the Contractor's expense.

Where the Owner permits the work to remain in place, a price adjustment will be calculated in accordance with the clause TS 1350.10.02.02. Unacceptable lots will not be eligible for full payment.

All replacement lots shall be accepted on the same basis as the original lot.

For the purpose of calculating the price adjustment for an unacceptable lot, the Contract Administrator will determine the quantity of concrete in lot(s) using the dimensions in the Contract Documents. A price adjustment for an unacceptable lot will be applied if the requirements outlined in TS 1350.08.01.05 are not satisfied. The price adjustment factors and calculations are described in TS 1350.10.01.02.02.

**1350.10.02.02 Price adjustment for Unacceptable Lot**

Payment for unacceptable lot will be calculated if the mean concrete thickness is less than the minimum acceptable thickness. Payment shall be adjusted for each lot, according to **Table 2**, based on the actual thickness of the concrete.

The cost of core tests shall be borne by the Commissioner unless the results indicate a thickness deficiency of 5 percent or more, in which case the Contractor shall bear all costs of testing.

**TABLE 2**

<b>Thickness Tx</b>	<b>Percent Payment Of Concrete</b>
Greater than or equal to 100 percent of specified thickness	100
100 percent of specified thickness to 95 percent of specified thickness (90% for sidewalks)	$\frac{(Actual\ Thickness)^2}{(Specified\ Thickness)^2} \times 100$
less than 95 percent of specified thickness (90% for sidewalks)	remove and replace at contractor's expense

# APPENDIX TO TS 1350

1. City of Toronto Concrete Mix Design Form (Form A)
2. City of Toronto Confidential Concrete Mix Design Form (Form B)

# CONCRETE MIX DESIGN SUBMISSION (FORM A)



Date: \_\_\_\_\_

Contract No.: \_\_\_\_\_ Contractor: \_\_\_\_\_

Location: \_\_\_\_\_ Concrete Supplier: \_\_\_\_\_

Primary Plant Name & Address : \_\_\_\_\_ Back-up Plant Name & Address: \_\_\_\_\_

**Mix Code**

**Application / Element / Location**

**Structural Requirements**

- CSA Exposure Class

- Maximum W/CM Ratio

- Minimum Specified Strength (MPa)

- Nominal Maximum Aggregate Size (mm)

- Maximum Slag Replacement (%)

- Maximum Fly Ash Replacement (%)

- Plastic Air Content (%)

- Slump Range (mm)

**Durability Requirements**

- Alkali Aggregate Reactivity

**Architectural Requirements**

- Other

**Rate (m<sup>3</sup>/h)**

**Quantity (m<sup>3</sup>)**

**Slump Range (mm)**

**Strength @ Age (MPa)**

**Other**

**Specialty Information**

- Concrete Set (Delay, Normal, Accelerated)

**Method of Placement**

Material	Quantity	Type / Name & Source	Inventory No.
Cement (kg/m <sup>3</sup> )	-----		-----
SCM - Slag (kg/m <sup>3</sup> )	-----		-----
SCM - Fly Ash (kg/m <sup>3</sup> )	-----		-----
Water (l/m <sup>3</sup> )	-----		-----

Cement (kg/m<sup>3</sup>)

SCM - Slag (kg/m<sup>3</sup>)

SCM - Fly Ash (kg/m<sup>3</sup>)

Water (l/m<sup>3</sup>)

Fine Aggregate

Coarse Aggregate

A.E.A. (mL/100 kg)

W.R. (mL/100 kg)

S.P. (mL/100 kg)

**Contractor's Representative submitting Form A:**

Print Name: \_\_\_\_\_ Signature: \_\_\_\_\_ Date: \_\_\_\_\_

**Concrete Supplier's declaration to meet the above contract requirements:**

Print Name: \_\_\_\_\_ Signature: \_\_\_\_\_ Date: \_\_\_\_\_

**Form A Reviewed by Contract Administrator:**

Print Name: \_\_\_\_\_ Signature: \_\_\_\_\_ Date: \_\_\_\_\_

**Notes:**

- 1) The "Concrete Supplier" provides to the contractor, a valid "Certificate of Concrete Production Facilities" as issued by the RMCAO (copy available upon request). Check [www.rmcao.org](http://www.rmcao.org) for an updated list of certified concrete plants.
- 2) The "Concrete Supplier" certifies that all materials incorporated in the mix designs meet current CSA A23.1 requirements.
- 3) Concrete testing shall incorporate [www.cmats.com](http://www.cmats.com) and shall be used by the testing company.
- 4) Concrete tests not done according to CSA Standards shall not be accepted for any basis of measurement.
- 5) The Owner shall be responsible for performance "off the chute" if the owner specifies any material proportion(s).

**CONFIDENTIAL**

**CONCRETE MIX DESIGN SUBMISSION (FORM B)**

Project: \_\_\_\_\_ Date: \_\_\_\_\_  
 Contract No.: \_\_\_\_\_ Contractor: \_\_\_\_\_  
 Location: \_\_\_\_\_ Concrete Supplier: \_\_\_\_\_  
 Primary Plant Back-up Plant  
 Name & Address: \_\_\_\_\_ Name & Address: \_\_\_\_\_

	<b>Mix Code</b>			
	<b>Application / Element / Location</b>			
<b>SPECIFICATIONS</b>	<b>Structural Requirements</b>			
	- CSA Exposure Class			
	- Maximum W/CM Ratio			
	- Minimum Specified Strength (MPa)			
	- Nominal Maximum Aggregate Size (mm)			
	- Maximum Slag Replacement (%)			
	- Maximum Fly Ash Replacement (%)			
	- Plastic Air Content (%)			
	- Slump Range (mm)			
		<b>Durability Requirements</b>		
	- Alkali Aggregate Reactivity			
	<b>Architectural Requirements</b>			
	- Other			
<b>CONTRACTOR REQUIREMENTS</b>	<b>Rate (m<sup>3</sup>/h)</b>			
	<b>Quantity (m<sup>3</sup>)</b>			
	<b>Slump Range (mm)</b>			
	<b>Strength @ Age (MPa)</b>			
	<b>Other</b>			
	<b>Specialty Information</b>			
	- Concrete Set (Delay, Normal, Accelerated)			
	<b>Method of Placement</b>			
<b>MATERIALS SECTION</b> <small>(Material quantity information is confidential and is for internal use only)</small>	<b>Material</b>	<b>Quantity</b>	<b>Type / Name &amp; Source</b>	<b>Inventory No.</b>
	Cement (kg/m <sup>3</sup> )			-----
	SCM - Slag (kg/m <sup>3</sup> )			-----
	SCM - Fly Ash (kg/m <sup>3</sup> )			-----
	Water (l/m <sup>3</sup> )			-----
	Fine Aggregate			
	Coarse Aggregate			
	A.E.A. (mL/100 kg)			-----
	W.R. (mL/100 kg)			-----
	S.P. (mL/100 kg)			-----

Form B submitted by: \_\_\_\_\_

Print Name: \_\_\_\_\_ Signature: \_\_\_\_\_

Date: \_\_\_\_\_

Form Reviewed by Contract Administrator:

Print Name: \_\_\_\_\_ Signature: \_\_\_\_\_

Date: \_\_\_\_\_

**Notes:**

- 1) The "Concrete Supplier" provides to the contractor, a valid "Certificate of Concrete Production Facilities" as issued by the RMCAO (copy available upon request). Check [www.rmcao.org](http://www.rmcao.org) for an updated list of certified concrete plants.
- 2) The "Concrete Supplier" certifies that all materials incorporated in the mix designs meet current CSA A23.1 requirements.
- 3) Concrete testing shall incorporate [www.cmats.com](http://www.cmats.com) and shall be used by the testing company.
- 4) Concrete tests not done according to CSA Standards shall not be accepted for any basis of measurement.
- 5) The Owner shall be responsible for performance "off the chute" if the owner specifies any material proportion(s).