# Amendment to OPSS.MUNI 1350 (Nov 2014) – Material Specification for Concrete – Materials and Production

This specification shall be read in conjunction with OPSS.MUNI 1350 (Nov 2014). OPSS.MUNI 1350 (Nov 2014) shall form a normative part of this specification as a completed document. All requirements of OPSS.MUNI 1350 (Nov 2014) Appendix 1350-A shall apply in this specification.

## TS 1350.01 SCOPE

Section 1350.01 of OPSS.MUNI 1350 is amended by the addition of the following paragraph:

This specification also covers the requirements for acceptance of concrete material for the construction of road base, curb and gutter, sidewalk, crosswalk, streetcar track and other concrete items.

## TS 1350.02 REFERENCES

Section 1350.02 of OPSS.MUNI 1350 is amended by the addition of the following paragraphs:

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

### City of Toronto Standard Specifications

| | |
|---|---|
| TS 3.40 | Construction Specification for Concrete Road Base |
| TS 3.45 | Construction Specification for the Repair of Concrete Pavement and Base |
| TS 3.50 | Construction Specification for Concrete Curb and Concrete Curb and Gutter |
| TS 3.65 | Construction Specification for Concrete Crosswalk |
| TS 3.70 | Construction Specification for Concrete Sidewalk and Concrete Raised Median |
| TS 3.75 | Construction Specification for Streetcar Track Pavement and Foundation Slab |

### Ontario Provincial Standard Specifications

| | |
|---|---|
| OPSS.MUNI 904 | Construction Specification for Structural Concrete |
| OPSS 1306 | Material Specification for Burlap |
| OPSS 1315 | Material Specification for White Pigmented Curing Compounds |
| OPSS.MUNI 1440 | Material Specification for Steel Reinforcement for Concrete |
| OPSS 1860 | Material Specification for Geotextiles |

### Canadian Standards Association

| | |
|---|---|
| A3000 | Cementitious Materials Compendium |
| A23.1 | Concrete Materials and Methods of Concrete Construction |
| A23.2 | Test Methods and Standard Practices for Concrete |
| A23.2-1C | Sampling Plastic Concrete |
| A23.2-4C | Air Content of Plastic Concrete by the Pressure Method |

| | |
|---|---|
| A23.2-5C | Slump of Concrete |
| A23.2-17C | Temperature of Freshly Mixed Hydraulic Cement Concrete |

**American Society of Testing and Materials**

| | |
|---|---|
| C 109 | Standard Test Method for Compressive Strength of Hydraulic Cement Mortars |
| C 171 | Standard Specification for Sheet Materials for Curing Concrete |
| C 174 | Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores |
| C 309 | Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete |
| C457 | Standard Test Method for Microscopical Determination of Parameters of the Air Void System in Hardened Concrete |
| C 666 | Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing |
| D 1751 | Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction |

**Transportation Research Report**

| | |
|---|---|
| NCHRP Report 244 | Concrete Sealers for Protection of Bridge Structures |

## TS 1350.03 DEFINITIONS

Section 1350.03 of OPSS.MUNI 1350 is amended by the addition of the following sentences:

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

**Admixtures** means a material other water, aggregate, cementing material, and fibre reinforcement used as an ingredient in concrete, mortar, or neat cement grout and added to the batch immediately before or during its mixing in order to purposely modify its usual characteristics and behavior.

**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.

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

**Crushed Material** means aggregate particles having at least one well-defined face resulting from fracture. Particles with smooth faces and rounded edges or with only small chips removed are not considered crushed.

**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.

**Form A** means a complete City of Toronto concrete mix design submission form for performance specification alternative. OPSS.MUNI 1350 (Nov 2014) OPSF 1350-1 is replaced by Form A.

**Form B** means a complete City of Toronto concrete mix design submission form to be submitted by the concrete supplier after executing a confidentially agreement. OPSS.MUNI 1350 (Nov 2014) OPSF 1350-2 is replaced by Form B.

**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.

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

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

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

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

## TS 1350.04 DESIGN AND SUBMISSION REQUIREMENTS

Subsection 1350.04.01 of OPSS.MUNI 1350 is amended by the addition of the following paragraphs:

### TS 1350.04.01 Design Requirements

Concrete mix design shall be one of the following alternatives chosen by the City:

- performance specification alternative; or
- prescriptive specification alternative.

The Contractor shall submit a mix design for each type of concrete specified in the Contract Documents. A complete mix design should consist of the following:

1) Either a completed City concrete mix design submission Form A; or

2) A completed City concrete mix design submission Form B; and

3) Supporting documentation including all material quality test data for the mix design and component materials required by the contract.

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 Contract Administrator.

Under the performance specification alternative, the Contractor shall provide a complete mix design submission on Form A to the Contract Administrator for each specific concrete mix.

At the sole discretion of the City, the City and the concrete supplier may enter to 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 on Form B.

## TS 1350.04.02 Submission Requirements

Subsection 1350.04.02 of OPSS.MUNI 1350 is amended by the addition of the following paragraphs:

A complete mix design submission shall be provided for concrete of each specified compressive strength according to CSA A23.1. A separate mix design submission is also required within each strength level for:

- Mixes where material proportions vary outside the tolerance identified below in this clause.
- Cast-in-place and slip-formed concrete.
- Mixes with different sources of materials.
- Mixes with different admixtures.
- Special purpose or unique mixes.

Submission of separate mix designs and separate supporting documentation is not required if concrete with the same mix design is to be supplied by multiple plants with the same sources of materials in the same proportions, however it must be supported in writing prior to use.

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

- Changing sources of materials used in the concrete.
- Substituting a material or product for another from the same source.
- Adding a material to the concrete that was not on the original mix design (except retarder).
- Adjusting the quantities of the stated materials in the concrete, outside of the following tolerances stated on Form B:

    a) Cement: ± 5% of quantity
    b) Supplementary cementing materials: 95% to 100% of quantity
    c) Admixtures: Dosage or range of dosage
    d) Water: Range

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

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.

## **TS 1350.04.02.01.01** *Performance Based Concrete Mix Data*

Clause 1350.04.02.01.01 of OPSS.MUNI 1350 is amended by the addition of the following paragraphs:

**Form A**

Form A shall be completed by the concrete supplier based on the requirements of the Contract. The Contractor shall confirm with the concrete supplier and the Contract Administrator the performance characteristics of the concrete through the submission of Form A for each type of concrete as specified in the Contract Documents. The form shall be signed by the Contractor to certify that performance characteristics of the concrete have met their respective requirements under the contract.

The performance based mix design as detailed in Form A will be checked by the Contract Administrator to verify that the materials and sources are in compliance with the Contract Documents. Concrete placement cannot proceed until the Contract Administrator has verified that the form meets the project requirements. The form shall then form the basis of the detailed mix design.

The Contractor shall provide the following on submission of Form A:

1) Concrete exposure requirements shall be according to CSA A23.1, Table 2.

2) Primary concrete plant(s) supplying concrete.

3) Specified strength of concrete, for example 24-hour, 7-day, 28-day, or other specified ages.

4) Identification of all materials to be used in the concrete.

5) Concrete supplier and sources of all materials to be used.

6) Intended use and location of the concrete on the contract.

7) Target air content of the mix and slump range for quality control purposes.

8) Nominal maximum size of coarse aggregate and fine aggregate, and inventory numbers for the aggregates.

9) Declarations from the concrete supplier that the concrete they supply will meet all concrete requirements as specified in the Contract Documents.

10) The percentage of all supplementary cementing materials meet the contract requirements.

11) The dosage ranges of all chemical admixtures meet the requirements shown in subsection TS 1350.05.01, herein.

Form A shall be accompanied by all material quality test data of all materials used in the mix design, if requested.

**Form B**

Upon the execution of a confidentiality agreement between the City and the concrete supplier to cover the protection of proprietary mix proportion information which is to be released as part of the mix design submission process, the concrete supplier shall forward a completed Form B to the City.

The detailed mix design in Form B shall, in addition to material source information, contain the material quantities for cement, supplementary cementing materials, water and admixtures ranges, consistent with the specified Designated Sources for Materials List, and the requirements shown in TS 1350.05.01, herein.

The concrete supplier shall provide the following to the City on submission of Form B:

1) The information provided on Form A.

2) Quantity of cement and supplementary cementing materials to be used in the mix.

3) Dosage range of chemical admixtures to be used in the mix shall be according to subsection TS 1350.05.01, herein.

4) Quantity range of water to be used in the mix (total water).

Form B shall be signed by the concrete supplier to certify that performance characteristics of the concrete meet their respective requirements under the contract.

Form B shall be checked by the City to verify that the materials and sources are in compliance with the contract requirements. Concrete placement cannot proceed until the Contract Administrator has verified that the form meets the contract requirements.

## TS 1350.05 MATERIALS

Section 1350.05 of OPSS.MUNI 1350 is amended by the addition of the following paragraphs:

Concrete materials submission shall provide the following information:

1) The source of each material to be incorporated in the concrete and the name of the concrete supplier.

2) Certification that all materials to be incorporated into the concrete mix are compatible in the mix and meet or exceed the requirements given in subsection TS 1350.05.01, herein.

3) The proportions of materials for each class of concrete to be incorporated into the work as per the confidentiality agreement in a confidential manner by the City.

4) The results of slump, total air content and compressive strength testing at 7-day, 28-day, and other ages if required in the contract, for each class of concrete supplied.

5) If blended hydraulic cements or supplementary cementing materials are proposed, the Contract Administrator may request for documentation demonstrating satisfactory performance of similar concrete mixes incorporating the proposed cementing materials and proportions used in similar

applications such as bridge deck, sidewalk, and so on, and the current condition. The satisfactory performance may be shown through the documented visual assessment of at least five projects, each at least three years old, for each mix incorporating blended hydraulic cement or supplementary cementing materials.

6) If supplementary cementing materials are to be incorporated into the concrete mix, the Contract Administrator may request certification and documentation, 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 de-icer chemical scaling resistance and rate of strength gain, if required, shall also be submitted.

7) At the request of the Contract Administrator, the results of testing of the quality of the air voids system of the hardened concrete mix(es) shall be incorporated into the Work, as determined by ASTM C 457, documenting conformance to CSA A23.1, clause 4.3.3.

## TS 1350.05.01 Materials for Concrete

Subsection 1350.05.01 of OPSS.MUNI 1350 is amended by the addition of the following Table A:

**Table A: Materials for concrete**

| Specification | TS 3.40<br>TS 3.45 | TS 3.50<br>TS 3.70 | TS 3.75 |
|---|---|---|---|
| **concrete for** | road base | curb and gutter<br>sidewalk and median | streetcar track |
| **cement type** | Portland and Portland limestone cement GU/GUL | Portland and Portland limestone cement GU/GUL | Portland and Portland limestone cement GU/GUL |
| **min 28-day compressive strength** | 32 MPa | 32 MPa | 32 MPa |
| **class of exposure** | C-2 | C-2 | C-2 |
| **max size of aggregate** | 37.5[a] or 19 mm | 19 mm | 19 mm |
| **slump at plant** | - - - | - - - | max 50 mm |
| **slump at discharge no plasticizer** | 80 ± 30 mm | 80 ± 30 mm | max 20 mm |
| **slump at discharge with plasticizer** | - - - | - - - | 150 ± 30 mm |
| **air content for max size of aggregate** | 5.5 ±1.5% (37.5 mm)<br>6.5 ±1.5% (19 mm) | 6.5 ±1.5% | 6.5 ±1.5% |
| **water/cementing materials ratio** | max 0.45 | max 0.45 | max 0.45 |
| **lot size** | per day or as directed by the City | per day or as directed by the City | per day or as directed by the City |

Note [a]: The 37.5 mm nominal aggregate may only be used for concrete slabs 250 mm thick or greater.

### TS 1350.05.01.01 *Cementing Materials*

Clause 1350.05.01.01 of OPSS.MUNI 1350 is amended by the addition of the following paragraphs:

All cement shall be general use Portland cement (GU) and Portland-limestone cement (GUL) according to CSA A3000 or high-early-strength Portland cement (HE) and Portland-limestone cement (HEL) meeting the requirements of CSA A3000.

High-early-strength Portland cement (HE) and Portland-limestone cement (HEL) may be used only with the prior approval of the Contract Administrator.

Portland cement (GU) and Portland-limestone cement (GUL) may not be used as a means of obtaining high early strength in the concrete unless prior approval has been obtained from the Contract Administrator.

Blended hydraulic cements shall be according to CSA A3000. Blended hydraulic cements may be used only with the prior approval of the Contract Administrator.

Supplementary cementing materials such as fly ash, silica fume and/or slag cement may be used by meeting the requirements of this specification.

Except when the cementing materials are supplied blended, the supplementary cementing material shall be weighed separately from the cement. In the concrete materials weighing process the cement shall be weighed prior to the supplementary cementing material. Supplementary cementing materials may be weighed on the same scale with the cement.

### TS 1350.05.01.02 *Aggregates*

Clause 1350.05.01.02 of OPSS.MUNI 1350 is amended by the deletion of the following:

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

### TS 1350.05.02.04 *Air Content*

Clause 1350.05.02.04 of OPSS.MUNI 1350 is amended by the addition of the following paragraphs:

Air content on the job site shall be controlled according to CSA A23.1, clause 5.2.5.3.4.

### TS 1350.05.02.05 *Slump or Slump Flow*

Clause 1350.05.02.05 of OPSS.MUNI 1350 is amended by the addition of the following paragraphs:

Under the performance specification alternative, addition of water on the job site according to CSA A23.1, clause 5.2.5.3.2 is at the discretion of the Contractor.

Under the prescriptive specification alternative, addition of water on the job site according to CSA A23.1, clause 5.2.5.3.2 is at the discretion of the City.

Section 1350.05 of OPSS.MUNI 1350 is amended by the addition of the following subsection:

### TS 1350.05.03 Other Materials

### TS 1350.05.03.01 *Steel Reinforcement for Concrete*

Steel reinforcement for concrete shall be according to OPSS 1440.

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

1) The source of all reinforcing steel products and name of the reinforcing steel fabricator.

2) Three copies of the mill certificate and three copies of the stress-strain curves representative of each lot of material to be used for reinforcing steel.

### TS 1350.05.03.02 *Curing Media*

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

1) Curing plan requirements.

2) Allowable curing regimes according to CSA A23.1, Table 19.

3) Three copies of the manufacturer's product installation and certification data.

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:

- Burlap cloth shall be made from jute or kenaf, and shall be according to OPSS 1306.
- Geotextile fabric shall be a synthetic, permeable textile shall be according to OPSS 1860. A minimum thickness of 0.9 mm is required geotextile fabric and water.
- White opaque polyethylene film shall be according to ASTM C 171. A minimum thickness of 6 mils is required.
- White pigmented curing compound shall be according to ASTM C 309 and OPSS 1315.

Each curing method may be used at ambient temperatures up to 28°C. At temperatures above 28°C, only the geotextile fabric and water procedure is recommended. At temperature below 5°C, curing compound is not recommended.

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.

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 20 MPa. Pedestrian traffic shall be kept off the newly constructed concrete for at least eight hours. The Contractor shall provide adequate measures to protect the newly constructed concrete section from damage by vehicular or pedestrian traffic.

### TS 1350.05.03.03 *Joint Filler*

Expansion joint filler material shall be according to ASTM D 1751.

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

1) The source of the expansion filler material.

2) Three copies of the manufacturer's product installation and certification data.

### TS 1350.05.03.04 *Concrete Sealer*

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 per cent and containing no fillers. Application rates and solids content shall be according to 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:

1) Four Inch Cube Tests: 75 per cent effective in reducing water absorption when compared to an untreated control sample.

2) Southern Exposure Tests: 90 per cent effective in reducing chloride ion content when compared to an untreated control sample.

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

1) The source of the expansion concrete sealer.

2) Three copies of the manufacturer's product installation and certification data.

3) Certification that the sealer meets or exceeds the requirements of NCHRP 244.

## TS 1350.07 PRODUCTION

### TS 1350.07.02 Temperature Control

Subsection 1350.07.02 of OPSS.MUNI 1350 is amended by the addition of the following paragraph:

When the air temperature is below 5°C or likely to fall below this limit within 24 hours of placing, 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 OPSS 904.

## TS 1350.08 QUALITY ASSURANCE

### TS 1350.08.02.01 *General*

Clause 1350.08.02.01 of OPSS.MUNI 1350 is amended by the addition of the following paragraph:

Concrete compressive strength and proper curing, as specified in this specification, shall be the criteria for acceptance of non-structural concrete.

As requested by the City, the Contractor shall submit to the owner prior to the start of the project verification that the foreman, lead hand or the supervisor of the concrete placing crew has ACI Flatwork Certification or equivalent.

### **TS 1350.08.02.01.02** *Quality Assurance Test Reporting*

Sub-clause 1350.08.02.01.02 of OPSS.MUNI 1350 is amended by the addition of the following paragraph:

The concrete mix shall be sampled according to CSA A23.2–1C; the slump of the concrete shall be tested in accordance with CSA A23.2–5C; the air content of the concrete shall be tested according to CSA A23.2–4C; and the temperature of the concrete shall be tested in accordance with CSA A23.2-17C.

Concrete test reports shall be distributed immediately to the Owner, Contractor and concrete supplier by electronic files when available.

### **TS 1350.08.02.04.01** *Compressive Strength*

Sub-clause 1350.08.02.04.01 of OPSS.MUNI 1350 is amended by the addition of the following paragraph:

The compressive strength requirements for standard-cured cylinders shall be according to CSA A23.1 clause 4.4.6.6.1.2. The strength determination of test result shall be according to CSA A23.1 clause 4.4.6.4.1.

Section 1350.08 of OPSS.MUNI 1350 is amended by the addition of the following subsections:

## **TS 1350.08.03 Field Sampling and Testing of Concrete**

Concrete field sampling for cylinders and testing of air, slump and temperature of plastic concrete shall be obtained directly from the load of concrete and tested according to CSA A23.2.

### **TS 1350.08.03.01** ***Frequency of Field Sampling and Testing***

The concrete supplied shall be sampled for acceptance tests according to Table B and Table C.

**Table B: Frequency of field sampling and testing of concrete**

| Concrete for | Quantity $m^3$ | 28-day cylinder | Field testing |
|---|---|---|---|
| abutments, catch basins, maintenance holes, columns, culverts, slabs, footings, foundations, piers, walls, curb and gutter, sidewalk, and forms | < 100 | 3 sets /day | Air, slump and temperature tests shall be carried out when cylinders are cast, or as directed by the City. |
| | 100 - 500 | 2 sets/100 $m^3$ | |
| | > 500 | 1set/100 $m^3$ | |
| decks | < 100 | 3 sets /day | |
| | 100 - 500 | 2 sets/100 $m^3$ | |
| | > 500 | 1set/100 $m^3$ | |
| decks overlay | - - - | 3 sets /day | |
| volume overlay | - - - | 1 set /load | |

The following lot sizes for small quantity work relating to catch basins, maintenance holes, slabs, foundations, curb and gutter, sidewalk and fixed forms:

**Table C: Small quantity lots frequency of field sampling and testing of concrete**

| If quantity is . . . | Then sets per day required is . . . |
|---|---|
| less than 65 ($m^3$) | 2 |
| less than 30 ($m^3$) | 1 |

OPSS.MUNI 1350 is amended by the addition of the following section:

## TS 1350.10 ACCEPTANCE

### TS 1350.10.01 Compressive Strength Acceptance

Concrete used in this Contract shall be according to TS 1350, except that the acceptance requirements shall apply to all types of concrete and not just for 28-day strengths. For example, if 7-day concrete is requested, the acceptance of the appropriate item or Extra Work shall be based on amending TS 1350 and all other relative specifications to replace all instances of 28-day with 7-day.

Acceptance of concrete strength for a lot shall be based on the compressive strength test results of a lot defined in subsection TS 1350.05.01 or as specified in the Contract Documents.

The Contract Administrator may determine the lot size after discussion with the Contractor before any concrete is placed, or according to the lot size as shown in subsection TS 1350.05.01, herein.

A concrete lot is deemed unacceptable if the concrete compressive strength does not meet all of the following:

1) The average of all groups of three consecutive compressive strength tests shall be equal to or greater than the specified strength.

2) No individual strength test shall be more than 3.5 MPa below the specified strength.

The Contractor is required to remove and replace all unacceptable lots at no extra cost to the City. All replacement lots shall be accepted on the same basis as the original lot.

### TS 1350.10.02 Small Lot Acceptance

A single cylinder test may be used to represent a sub lot under the following conditions:

- the second cylinder was damaged or determined to be unrepresentative;
- the second cylinder was broken early or later; either in error or at the discretion of the Contract Administrator; or
- the cylinder is used to determine compliance with TS 1350.11.10.

#### TS 1350.10.02.01 *Track Allowance*

For the purposed of acceptance, the concrete within the TTC track allowance shall be divided into lots of up to 100 linear metres or daily production, whichever is less.

### TS 1350.10.03 High Early Strength

Concrete used in this Contract shall be according to TS 1350, except that the acceptance requirements shall apply to all types of concrete and not just for 28-day strengths. For example, if 7-day concrete is requested, the acceptance of the appropriate item or Extra Work shall be based on amending TS 1350 and all other relative specifications to replace all instances of 28-day with 7-day or 24 hour, respectively.

The number of cylinders cast for each set shall be revised as follows:

1) 7 day strength – minimum 4 cylinders cast

    - 1 break at 3 days
    - 2 breaks at 7 days
    - 2 breaks at 28 days

2) 24 hour strength – minimum 5 cylinders cast

    - 1 break at 10 hours
    - 1 break at 13 hours
    - 2 breaks at 24 hours
    - 2 breaks at 7 days

The timing for the second 24 hour break may be altered by the Contract Administrator depending on the results of the 10 hour or previous break(s). The Contract Administrator may request additional cylinders for critical work. The spare cylinders can be cast away if the previous results are favourable.

The concrete strength shall meet the requirements of TS 1350.10.01, herein, at the required strength interval, that is to say 7 day or 24 hour.

OPSS.MUNI 1350 is amended by the addition of the following section:

## TS 1350.11 PAYMENT AND WARRANTY

### TS 1350.11.01 Small Lot Price Adjustment

Price adjustments for 28-day concrete will be based on following:

**Table D: Price adjustment for compressive strength 28-day concrete**

| Average tested compressive strength | Per cent payment of concrete |
|---|---|
| up to 3.5 MPa below specified compressive strength | $\frac{(Actual\ Strength)^{2.5}}{(Specified\ Strength)^{2.5}} \times 100$ |
| greater than 3.5 MPa below specified compressive strength | remove and replace at no extra cost to the City |

Price adjustments for high early strength concrete will be non-payment for any and all premium costs or based on the following, whichever is greater:

**Table E: Price adjustment for high early strength concrete**

| Average tested high early compressive strength | Per cent payment of concrete |
|---|---|
| up to 3.5 MPa below specified high early strength | $\frac{(Actual\ Strength)^{2.5}}{(Specified\ Strength)^{2.5}} \times 100$ |
| between 3.5 MPa and 7.0 MPa below specified high early strength | $\frac{(Actual\ Strength)^{3}}{(Specified\ Strength)^{3}} \times 100$ |
| greater than 7.0 MPa below specified high early strength | remove and replace at no extra cost to the City |

Concrete that is to be removed and replaced at no extra cost to the City may be deemed usable if all of the following conditions are met:

- High early strength concrete meets the specified compressive strength within the next time constraint, for example 24 hour within 7 days, and 7 day within 28 days;

- The contract schedule did not incur any delays;
- The major interim schedules did not incur any delays, such as delays in opening the intersection to full operation;
- The public did not incur any delays, for instance delayed access to private property; and
- The concrete passes all other requirements.

In lieu of removing and replacing concrete that does not meet the compressive strength requirements, the Contract Administrator has the option to allow the usable concrete to be left in place. However, payment for the appropriate item or extra work related to the usable concrete shall be at 40 per cent of the bid cost for the entire contract item or no payment will be made for the concrete portion of the extra work performed, including all labour and Equipment that was used in the supply or placement of the concrete or both.

## Attachments

The following two concrete mix design submissions form part of this specification:

1) Concrete Mix Design Submission Form A for Performance Specification Alternative

2) Concrete Mix Design Submission Form B for Prescriptive Specification Alternative

TORONTO

# CONCRETE MIX DESIGN SUBMISSION (FORM A)

**Project:** _____ **Date:** _____

**Contract No.:** _____ **Contractor:** _____

**Location:** _____ **Concrete Supplier:** _____

**Primary Plant**
**Name & Address :** _____

**Back-up Plant**
**Name & Address:** _____

| | | | | |
|---|---|---|---|---|
| | **Mix Code** | | | |
| | **Application / Element / Location** | | | |
| SPECIFICATIONS | **Structural Requirements** | | | |
| | - CSA Exposure Class | | | |
| | - Maximum W/CM Ratio | | | |
| | - Minimum Specified Strength, Mpa @ Days | | | |
| | - Nominal Maximum Aggregate Size, mm | | | |
| | - HVSCM Type 1 or 2 | | | |
| | - Maximum Slag Replacement, % | | | |
| | - Maximum Fly Ash Replacement, % | | | |
| | - Plastic Air Content, % | | | |
| | - Slump Range, mm | | | |
| | **Durability Requirements** | | | |
| | - Exposure to Sulphate Attack | | | |
| | - Alkali Aggregate Reactivity | | | |
| | **Architectural Requirements** | | | |
| | -Colour / Texture | | | |
| | - Other | | | |
| CONTRACTOR REQUIREMENTS | **Rate ($m^3$/h)** | | | |
| | **Quantity ($m^3$)** | | | |
| | **Slump Range (mm)** | | | |
| | **Strength @ Age (MPa)** | | | |
| | **Other** | | | |
| | **Specialty Information** | | | |
| | - Concrete Set (**D**elay, **N**ormal, **A**ccelerated) | | | |
| | **Method of Placement** | | | |
| MATERIALS SECTION | **Material** | **Quantity** | **Type / Name & Source** | **Inventory No.** |
| | Cement (kg/$m^3$) | -------- | | ------- |
| | SCM - Slag (kg/$m^3$) | -------- | | ------- |
| | SCM - Fly Ash (kg/$m^3$) | -------- | | ------- |
| | Water (l/$m^3$) | -------- | | ------- |
| | 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 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 tests not done according to CSA Standards shall not be accepted for any basis of measurement.
4) The **Owner** shall be responsible for performance "off the chute" if the owner specifies any material proportion(s).

TORONTO

# CONFIDENTIAL

# CONCRETE MIX DESIGN SUBMISSION (FORM B)

**Project:** _____ **Date:** _____

**Contract No.:** _____ **Contractor:** _____

**Location:** _____ **Concrete Supplier:** _____

**Primary Plant**
**Name & Address:** _____

**Back-up Plant**
**Name & Address:** _____

| | | | | |
|---|---|---|---|---|
| | **Mix Code** | | | |
| | **Application / Element / Location** | | | |
| SPECIFICATIONS | **Structural Requirements** | | | |
| | - CSA Exposure Class | | | |
| | - Maximum W/CM Ratio | | | |
| | - Minimum Specified Strength, Mpa @ Days | | | |
| | - Nominal Maximum Aggregate Size, mm | | | |
| | - HVSCM Type 1 or 2 | | | |
| | - Maximum Slag Replacement, % | | | |
| | - Maximum Fly Ash Replacement, % | | | |
| | - Plastic Air Content, % | | | |
| | - Slump Range, mm | | | |
| | **Durability Requirements** | | | |
| | - Exposure to Sulphate Attack | | | |
| | - Alkali Aggregate Reactivity | | | |
| | **Architectural Requirements** | | | |
| | -Colour / Texture | | | |
| | - Other | | | |
| CONTRACTOR REQUIREMENTS | **Rate, $m^3/h$** | | | |
| | **Quantity, $m^3$** | | | |
| | **Slump Range, mm** | | | |
| | **Strength @ Age, MPa @ Days** | | | |
| | **Other** | | | |
| | **Specialty Information** | | | |
| | - Concrete Set (**D**elay, **N**ormal, **A**ccelerated) | | | |
| | **Method of Placement** | | | |
| MATERIALS SECTION (Material quantity information is confidential and is for internal use only) | **Material** | | **Quantity** | **Type / Name & Source** | **Inventory No.** |
| | Cement | ($kg/m^3$) | | | ------ |
| | SCM - Slag | ($kg/m^3$) | | | ------ |
| | SCM - Fly Ash | ($kg/m^3$) | | | ------ |
| | Water | ($l/m^3$) | | | ------ |
| | 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 Reviewd 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 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 tests not done according to CSA Standards shall not be accepted for any basis of measurement.
4) The **Owner** shall be responsible for performance "off the chute" if the owner specifies any material proportion(s).

# MATERIAL SPECIFICATION FOR CONCRETE - MATERIALS AND PRODUCTION

## TABLE OF CONTENTS



## 1350.01 SCOPE

This specification covers the requirements for Materials; product supply pre-qualification; and mixing, transporting, and delivering concrete.

### 1350.01.01 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.

**1350.01.02 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.

**1350.02 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 904 Concrete Structures

**Ontario Provincial Standard Specifications, Material**

OPSS 1001 Aggregates - General
OPSS 1002 Aggregates - Concrete
OPSS 1302 Water

**CSA Standards**

A23.1-09 Concrete Materials and Methods of Concrete Construction *
A23.2-3C Making and Curing Concrete Compression and Flexural Test Specimens *
A23.2-4C Air Content of Plastic Concrete by the Pressure Method *
A23.2-5C Slump and Slump Flow of Concrete *
A23.2-6C Density, Yield, and Cementing Materials Factor of Plastic Concrete *
A23.2-8C Flexural Strength of Concrete (Using a Simple Beam with Third-Point Loading) *
A23.2-9C Compressive Strength of Cylindrical Concrete Specimens *
A23.2-10C Accelerating the Curing of Concrete Cylinders and Determining Their Compressive Strength *
A23.2-13C Splitting Tensile Strength of Cylindrical Concrete Specimens *
A283-00 (R2004) Qualification Code for Concrete Testing Laboratories
A3000-08 Cementitious Materials Compendium
* [Part of A23.1-09/A23.2-09 - Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete]

**ASTM International**

| | |
|---|---|
| C 157/C 157M-04 | Standard Test Method for Length Change of Hardened Hydraulic-Cement, Mortar, and Concrete |
| C 260-01 | Standard Specification for Air-Entraining Admixtures for Concrete |
| C 457-06 | Standard Test Method for Microscopical Determination of Air Void Content and Parameters of the Air Void System in Hardened Concrete |
| C 494/C 494M-05a | Standard Specification for Chemical Admixtures for Concrete |
| C 1017/C 1017M-03 | Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete |
| C 1202-05 | Standard Test Method for Electrical Indication of Concretes Ability to Resist Chloride Ion Penetration |

**Ready Mixed Concrete Association of Ontario Publications (RMCAO)**

| | |
|---|---|
| R1025 | Certificate of Ready Mixed Concrete Production Facilities |
| R1026 | Certificate of Mobile Mix Concrete Production Facilities |

## 1350.03 DEFINITIONS

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

**Agitator Truck** means a vehicle in which freshly mixed concrete can be conveyed from the mixing site to the Work Area while being agitated. The containment vessel can either be stationary with an agitator or it can be mobile with a drum rotated continuously so as to agitate the concrete.

**Cementing Material** means hydraulic cement with or without a supplementary cementing material.

**Confidentiality and Indemnity Agreement** means a legal agreement between an Owner and the concrete supplier as obtained from the Municipal Engineers Association (MEA) or the Ready Mixed Concrete Association of Ontario (RMCAO).

**Curing** means the maintenance of a satisfactory moisture content and temperature in concrete for a period of time immediately following placing and finishing so that the desired concrete properties may develop.

**High Volume Supplementary Cementing Materials (HVSCM) Concrete** means concrete that contains a level of supplementary cementing materials above that typically used in construction.

**Hot Weather** means those conditions when the air temperature is at or above 28 °C. It is also considered to exist when the air temperature is likely to rise above 28 °C within 24 hours. Temperature refers to shade temperature.

**Inspector** means a representative of the Owner to which the concrete is being supplied.

**Mobile Mix Concrete** means concrete that is completely batched and mixed by a mobile mixer truck at the site.

**Performance Criteria** means requirements to be met as specified in the Contract Documents and as shown in form OPSF 1350-1 or OPSF 1350-2.

**Portland Cement** means the product obtained by pulverizing clinker consisting essentially of hydraulic calcium silicates to which calcium sulphate, limestone, water, and processing additions may be added at the option of the cement manufacturer.

**Pre-Qualification Performance Criteria** means requirements to be met as specified in the Contract Documents and as shown in form OPSF 1350-1 or OPSF 1350-2 and have been demonstrated through trial batches or concrete test data from a similar class of concrete as specified in the Trail Batch clause.

**Ready Mixed Concrete** means concrete that is completely batched at the plant and completely mixed at the plant or while in transit.

**Self-Consolidating Concrete (SCC)** means a highly flowable, yet stable concrete that can spread readily into place, fill the formwork, and, if applicable, encapsulate the reinforcement without any mechanical consolidation and without undergoing any significant separation of material constituents.

**Stationary Mixer** means a non-mobile mixer installed at a plant for the purpose of mixing concrete.

**Supplementary Cementing Material (SCM)** means material that, when used in conjunction with hydraulic cement, contributes to the properties of the hardened concrete through hydraulic or pozzolanic activity or both.

**Truck Mixer** means a concrete mixer mounted on a truck or other vehicle used for the complete mixing of concrete materials after they have been batched at the plant.

**Water-to-Cementing Materials Ratio (W/CM)** means the ratio by mass of the amount of water to the total amount of cementing material in a freshly mixed batch of concrete or mortar, stated as a decimal. The amount of water does not include that absorbed by the aggregate.

## 1350.04 DESIGN AND SUBMISSION REQUIREMENTS

### 1350.04.01 Design Requirements

#### 1350.04.01.01 Mix Design Alterations

The Contractor may make minor alternations to the stated mix proportions in order to maintain compliance with the overall performance requirements as specified in the Contract Documents. Such deviations shall be according to CSA A23.1.

A minimum of 24 hours notice of deviations in the mix design that alter the sources of supply or the fundamental characteristics of the mix shall be given to the Owner by the Contractor. Resubmission of form OPSF 1350-1 and, if applicable, form OPSF 1350-2, shall be made for such deviations.

### 1350.04.02 Submission Requirements

Submissions for the performance or prescriptive specification alternative requirements shall be made based on the specification alternative as specified in the Contract Documents.

#### 1350.04.02.01 Performance Specification Alternative

In the case of the performance specification alternative, the Contractor shall be solely responsible for the design of the concrete and to ensure that the requirements of CSA A23.1 and this specification have been met.

At least 14 Days prior to placing any concrete, the Contractor, in concert with the concrete supplier, shall:

a) Establish the concrete mix properties to meet performance criteria for plastic and hardened concrete, after considering the Contractor's criteria for construction and placement and the Owner's performance criteria.

b) Submit documentation demonstrating the Owner's pre-qualification performance criteria can be met.

c) Prepare, submit, and implement a quality control plan to ensure that the Owner's performance criteria can be met. When specified in the Contract Documents, submit documentation demonstrating that the Owner's performance requirements have been met.

d) Ensure that the concrete supplier submits the following to the Contractor to forward to the Owner.

   i. Certification that the plant, equipment, and all materials to be used in the concrete comply with the requirements of this specification.
   ii. Certification that the mix design satisfies the requirements of this specification.
   iii. Certification that the production and delivery of concrete will meet the requirements of this specification.
   iv. Certification that the concrete complies with the specified performance criteria.

e) Provide documentation verifying that the concrete supplier's plant and equipment meet the plant certification requirements of the RMCAO Approved Quality Program.

**1350.04.02.01.01 Performance Based Concrete Mix Data**

At least 2 weeks prior to the delivery of concrete, the Contractor shall submit to the Owner the attached form OPSF 1350-1 detailing the material and sources of materials to be used for each class of concrete. The form shall be completed for all concrete supplied to the project.

The quantity of chemical admixtures shall be at least the minimum dose specified in the Contract Documents. The Contractor may deviate from the specified minimum dose due to weather conditions and changes in materials. However, written notification of this change shall be provided to the Contract Administrator at least 24 hours prior to the delivery of the concrete by the Contractor.

**1350.04.02.01.02 Mix Design Confidentiality and Indemnity Agreement**

The Contractor shall ensure that the concrete supplier submits a confidential concrete mix design for the Contract to the Owner on the attached form OPSF 1350-2, when requested by the Contract Administrator, and only after a confidentiality agreement has been signed between the Owner and the concrete supplier.

At least 2 weeks prior to the placing of any concrete, the Owner and the concrete supplier shall execute a confidentiality agreement to cover the protection of proprietary mix proportion information that is to be released as part of form OPSF 1350-2.

**1350.04.02.02 Prescriptive Specification Alternative**

In the case of the prescriptive specification alternative, the Owner shall be solely responsible for the concrete mix design and to ensure that the requirements of CSA A23.1 and this specification have been met.

The Contractor, in concert with the concrete supplier, shall:

a) Plan the construction methods based on the Owner's mix proportions and parameters.

b) Obtain approval from the Owner for any deviations from the specified mix design or parameters.

c) Identify to the Owner any anticipated problems or deficiencies with the mix parameters related to construction.

d) Provide verification that the plant, equipment, and materials to be used in the concrete comply with the requirements of this standard.

e) Demonstrate that the concrete complies with the prescriptive criteria as supplied by the Owner.

**1350.04.02.03 Ready Mixed Concrete Operation or Mobile Mix Concrete Operation**

At least 1 week prior to the delivery of concrete to the Work Area, the Contractor shall submit to the Owner a current valid Certificate of Ready Mixed Concrete Production Facilities or a current valid Certificate of Mobile Mix Concrete Production Facilities for the plant being used to produce ready mixed concrete, issued under the Approved Quality Program as outlined in the publications, Certificate of Ready Mixed Concrete Production Facilities and Certificate of Mobile Mix Concrete Production Facilities.

**1350.04.02.04 Concrete Delivery Ticket**

The concrete supplier shall provide 2 copies of the delivery ticket to the Contractor immediately following unloading at the Work Area. The Contractor shall provide one copy of each delivery ticket to the Owner within 1 Business Day of completion of the placement. The concrete delivery ticket shall include:

a) Name and location of plant.

b) Date and serial number of the ticket.

c) Name of Contractor.

d) Specific designation of the job by name and location.

e) Specified class or designation of the concrete.

f) Volume of concrete.

g) Truck number and cumulative total or load number.

h) Time stamped when mixing of cement and aggregates commences.

i) Ordered slump or slump flow.

j) Time that the discharge of load was completed.

k) Amount of water added after batching, authorization, and units used.

l) Amount and type of admixtures added after batching.

## 1350.05 MATERIALS

### 1350.05.01 Materials for Concrete

**1350.05.01.01 Cementing Materials**

Cementing materials shall be according to CAN/CSA A3000.

Portland cement shall be used; however, a portion of it may be replaced by SCM. The SCM shall be ground granulated blast furnace slag, fly ash, or silica fume or any combination of two or all of the materials.

The mass of Portland cement and all SCMs contained in a concrete mix shall be specified on form OPSF 1350-2, if applicable. Furthermore, the Contractor shall disclose on form OPSF 1350-1 and, if applicable, form OPSF 1350-2, when the mix design is classified as a HVSCM as specified in CSA A23.1.

HVSCM 1 concrete shall only be used with prior written approval of the Owner.

Neither slag nor fly ash shall be used for lean concrete base, unless trial mix tests are performed and the results show that the performance requirements of the Owner have been met.

**1350.05.01.02 Aggregates**

Aggregates shall be according to OPSS 1001 and OPSS 1002.

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

**1350.05.01.03 Water**

Water for concrete shall be according to OPSS 1302 and CSA A23.1, clause 4.2.2.

**1350.05.01.04 Air Entraining and Chemical Admixtures**

Air entraining chemical admixtures shall be according to the ASTM C 260.

Chemical admixtures shall be according to ASTM C 494M or when flowing concrete is specified, it shall be according to ASTM C 1017M.

The Contractor shall ensure that the chemical admixtures to be used are compatible with each other and that the performance of the concrete will not be negatively affected.

The Contractor shall use only chemical admixtures specified in the Contract Documents. Specialty chemical admixtures may be used when approved by the Owner.

**1350.05.02 Performance Requirements for Concrete**

**1350.05.02.01 General**

In instances where there are conflicts between this specification and other standards, the most stringent performance requirements shall apply.

**1350.05.02.02 Exposure Classes of Concrete**

Concrete having various exposure classifications shall meet the most stringent requirements of CSA A23.1, Tables 1, 2, and 3.

Classification A exposures do not apply to this specification.

**1350.05.02.03 Compressive Strength**

The concrete compressive strength shall be according to CSA A23.1, Tables 1, 2, and 3, and as specified in the Contract Documents.

**1350.05.02.04 Air Content**

The total air content of the concrete, measured with an air meter immediately prior to placing, shall be as shown in CSA A23.1, Table 4. Nominal maximum sizes of coarse aggregate shall be according to CSA A23.1, Table 4 (i.e., 10 mm, 14-20 mm, and 28-40 mm shall be 9.5 mm, 13.2-19.0 mm, and 28-40 mm, respectively).

Air content in hardened concrete shall meet the requirements of CSA A23.1, clauses 4.3.3.2 and 4.3.3.3, and the requirements as shown in Table 3 of this specification.

**1350.05.02.05 Slump or Slump Flow**

Slump or slump flow shall be consistent with the placement and consolidation methods, equipment, and site conditions.

Slump requirements shall be identified and reviewed by the Contractor and concrete supplier prior to construction. The tolerances for concrete slump acceptance and rejection in the Work Area shall be as follows:

a) Slumps less than 80 mm - the maximum allowable variation shall be ± 20 mm.

b) Slumps between 80 to 180 mm - the maximum allowable variation shall be ± 30 mm.

c) Slumps greater than 180 mm - the maximum allowable variation shall be ± 40 mm.

d) For SCC, the maximum allowable variation shall be ± 70 mm from the slump specified in the mix design.

Slump or slump flow shall be measured according to CSA A23.2-5C. Maximum slump for non-self-consolidating concrete shall be 240 mm, provided no segregation of the concrete occurs.

**1350.05.02.06 Within Batch Uniformity of Concrete**

If, in the opinion of the Contract Administrator, there is evidence of non-uniformity of the mixed concrete from a particular mixer, tests shall be carried out by the Contractor on 3 samples of concrete obtained from widely separate portions of the batch while the mixer is being completely emptied at normal operating rate to evaluate the mixing equipment.

Samples shall not be taken prior to 10% or after 90% of the batch has been discharged.

The minimum size of sample shall be 30 litres.

Between samples, the mixer shall not be allowed to turn in the mixing direction. Water shall not be added to the batch at any time after sampling has started.

The following criteria and that of CSA A23.1, Table 13, shall be used to judge whether or not the equipment under test is producing uniform concrete:

a) Where the result of each test is equal to or less than the acceptance limit, the concrete shall be considered uniform.

b) Where the result of any single test is greater than the rejection limit, the concrete shall be considered non-uniform.

c) If a test result falls between acceptance limit and rejection limit, additional tests shall be made on the next consecutive batch or load delivered by that unit.

If, after testing one additional batch or load, the test falls outside the acceptance limit, the equipment shall be rejected.

## 1350.06 EQUIPMENT

### 1350.06.01 Batching Plant

The batching plant and equipment shall be according to the certification requirements of the RMCAO.

The batching plant shall have direct communication with the placement operation.

### 1350.06.02 Mixing Equipment

All mixers shall be according to the certification requirements of RMCAO and shall be capable of discharging the concrete so that the uniformity requirements of CSA A23.1, Table 13, are met.

### 1350.06.03 Non-Agitating Delivery Equipment

The concrete containment area of non-agitating delivery equipment shall be a smooth watertight steel container equipped with gates that will permit control of the concrete discharge.

## 1350.07 PRODUCTION

### 1350.07.01 General

A manufacturer producing ready mixed concrete shall possess a current valid Certificate of Ready Mixed Concrete Production Facilities or a current valid Certificate of Mobile Mix Concrete Production Facilities for the plant being used to produce ready mixed concrete, issued under the Approved Quality Program as outlined in the publications, Certificate of Ready Mixed Concrete Production Facilities and Certificate of Mobile Mix Concrete Production Facilities.

The entire contents of the truck mixer shall be discharged prior to recharging. When any ingredient is added after initial batching, the volume of material in the drum shall not exceed the mixing capacity of the drum.

Proper facilities shall be provided to enable inspection of the quality of the materials used in the production of the concrete. The inspector shall be provided with all reasonable facilities for securing samples to determine whether the concrete and its materials are being supplied according to this specification. Owners wishing to obtain samples of the various raw materials from the concrete supplier shall provide advance notice to the concrete supplier and comply with all concrete supplier health and safety policies.

Where test results fail to meet the minimum requirements of this specification and the Owner and the concrete supplier have already executed a confidentially agreement, the Contractor shall ensure that the batch records retained by the concrete supplier under the Approved Quality Program shall be made available to the Owner within 5 Business Days of a written request. The Owner shall treat these records in the same manner as form OPSF 1350-2 and they shall remain the confidential information of the concrete supplier.

### 1350.07.02 Temperature Control

The concrete temperature at the time of discharge from the truck shall be between 10 and 28 °C.

### 1350.07.03 Records and Reporting

In addition to the batch records required to conform to the Approved Quality Program, the Contractor shall record the following information on the concrete delivery tickets, when applicable:

a) The method used to control the temperature of the concrete during hot weather conditions.

b) The method used to extend the discharge time of the concrete beyond 1.5 hours after introduction of the mix water during hot weather conditions.

c) The type and quantity of any materials added to the concrete after leaving the batch plan, and the time that each material was added.

### 1350.07.04 Concrete Strengths 35 MPa or Greater

#### 1350.07.04.01 Trial Batch

The mix properties for concrete with strengths of 35 MPa or greater shall be confirmed by the performance of a trial batch. The trial batch shall confirm all the performance properties identified for a particular class of concrete in CSA A23.1, Table 2, through the following tests:

a) Slump.

b) Plastic air content.

c) Compressive strength.

d) Hardened Air Void System (AVS).

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

At least 30 Days prior to placing concrete with strengths of 35 MPa or greater, the Contractor shall mix a full size trial batch of concrete in the proportions stated in the mix design.

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

When the source of concrete is a ready mixed concrete plant, the trial batch of concrete shall originate from the primary plant to be used for the supply of the concrete and be delivered to the Work Area.

When the approved ready mixed concrete operation is currently supplying or has supplied a similar class of concrete within the last 6 months, permission may be given by the Owner to use concrete test data from that operation without the need for full size field trial batch, providing:

a) There is no change in the source of any material.

b) The performance characteristics of the aggregates have not changed significantly.

c) The concrete mix designated and previously used meets the specified performance requirements.

d) Documentation of this prior approval is submitted to the Owner.

#### 1350.07.04.02 Early Compressive Strength Determination of Mix Design

When approved by the Owner, accelerated compressive strengths shown in Table 1 may be used to predict the 28-Day compressive strength of the proposed concrete mix.

The cylinders shall be tested according to CSA A23.2-10C using the autogenous curing test procedure.

**1350.07.05 Ready Mixed Concrete**

**1350.07.05.01 Delivery of Ready Mixed Concrete**

**1350.07.05.01.01 General**

The concrete shall be delivered to the Work Area without segregation in a thoroughly mixed and uniform mass and be discharged with the uniformity required in CSA A23.1, Table 13.

**1350.07.05.01.02 Delivery by Non-Agitating Equipment**

Concrete that is completely mixed in a stationary mixer may be transported in non-agitating equipment.

Covers shall be used to provide protection to the concrete during inclement weather.

Discharge of concrete shall be completed within 30 minutes of the introduction of the mixing water to the cement and aggregates.

**1350.07.05.01.03 Delivery by Agitator or Mixer Trucks**

After completion of mixing, concrete shall be transported to the Work Area by means of agitator trucks or truck mixers. The equipment shall be operated at the agitation speed of rotation designated by the manufacturers of the truck.

Discharge of the concrete shall be completed within 90 minutes after the introduction of mixing water to the cement and aggregates. This time may be extended using a set retarder, provided the Owner approves such use.

**1350.07.05.01.03.01 Site Addition of Materials**

When a truck mixer is used at agitating capacity, no adjustment shall be made to the load of concrete.

In the case of the performance specification alternative, only the concrete supplier, in concert with the Contractor, shall undertake the site addition of materials to the mixer.

When the measured slump or slump flow of the concrete is less than that specified in the mix design, water may be added by the concrete supplier, in concert with the Contractor, to bring the concrete up to the designated slump or slump flow, provided the following criteria are met:

a) The specified water-to-cementing materials ratio is not exceeded.

b) No more than 60 minutes has elapsed from the time of batching.

c) Addition of water is only at the start of discharge (i.e., not more than 10% of the concrete has been discharged).

d) Not more than the lesser of 16 $L/m^3$ or 10% of the mixing water shall be added.

Air entraining admixture may be added to the load of concrete by the concrete supplier, in concert with the Contractor, prior to discharge, to increase the air content to that specified in the mix design. The use of detraining admixtures to lower the air content of concrete is prohibited.

When any material is added to the concrete, the concrete supplier shall thoroughly mix the load of concrete to meet the uniformity requirements of CSA A23.1, Table 13.

## 1350.08 QUALITY ASSURANCE

### 1350.08.01 General

The Owner shall be allowed access to all sampling locations and reserves the right to request a quality assurance (QA) sample at any time from the Contractor. The Contract Administrator may elect to carry out testing of the QA sample to ensure that material used in the Work is according to the requirements of this specification. Testing shall be carried out at a laboratory designated by the Owner. The Owner shall be responsible for all costs associated with QA testing.

Samples of aggregates, cementing materials, water, chemical admixtures, and air entraining admixtures representative of the materials to be used in the work shall be provided, when requested by the Owner.

### 1350.08.02 Sampling and Testing

#### 1350.08.02.01 General

##### 1350.08.02.01.01 Quality Assurance Testing Staff and Laboratory Requirements

Field sampling and testing of concrete shall be performed by a person holding either of the following certifications:

a) CSA Certified Concrete Testing Technician, Concrete Testing and Sampling Certificate, or

b) ACI Concrete Field Testing Technician - Grade 1.

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

Laboratory tests shall be completed by a laboratory certified according to CSA A283 for the category appropriate to the test required by CSA.

##### 1350.08.02.01.02 Quality Assurance Test Reporting

Concrete test reports shall be immediately distributed electronically to the Owner, Contractor, and concrete supplier using CMATS™. The test results shall include the following information for each individual mix design:

a) Project identification.

b) A graphical representation of the specified and actual compressive strength data.

c) The average strength value for each age that the concrete is tested.

d) Average slump value for the mix design.

e) Average plastic air content for the mix design.

Testing shall be completed as shown in Table 2.

#### 1350.08.02.02 Air Content in Hardened Concrete

The air void system in the hardened concrete may be performed on cast cylinder specimens. The air void system shall be tested according to ASTM C 457.

### 1350.08.02.03 Testing for Uniformity of Mixed Concrete

When required by the Owner, tests to determine the within-batch uniformity of mixed concrete shall be according to the Within Batch Uniformity of Concrete clause, except the acceptance and rejection limits for uniformity shall be according to CSA A23.1, Table 13.

### 1350.08.02.04 Strength Tests and Requirements

#### 1350.08.02.04.01 Compressive Strength

For the purpose of concrete acceptance on the basis of concrete strength, cylinders shall be made and cured according to CSA A23.2-3C, under standard moisture and temperature conditions, and tested according to CSA A23.2-9C.

A compressive strength test result is the average strength of two standard 100 x 200 mm or 150 x 300 mm concrete cylinders that are representative of concrete taken from one batch of concrete.

To conform to the specified nominal minimum 28-Day compressive strength requirements:

a) The average of all groups of 3 consecutive strength tests shall be equal to or greater than the specified strength.

b) No individual strength test shall be more than 3.5 MPa below the specified strength.

#### 1350.08.02.04.02 Flexural Strength

Concrete for pavement and base shall meet the requirements for compressive strength and also flexural strength as stated here. The minimum flexural strength shall be 3.8 MPa at 10 Days.

A flexural strength test is the average of 2 breaks on a standard beam test specimen that is representative of concrete taken from one batch of concrete.

Flexural strength test beams shall be made and cured according to CSA A23.2-3C, depending on the particular circumstances. The method of testing shall be according to CSA A23.2-8C.

Alternatively, a splitting tensile test may be carried out instead of the flexural strength test. One splitting tensile test shall be considered to be the average of 2 standard cylinders that are representative of concrete taken from one batch of concrete. The splitting tensile test cylinders shall be according to CSA A23.2-3C. The method of testing shall be according to CSA A23.2-13C. The minimum splitting tensile strength shall be 2.8 MPa at 10 Days.

To conform to the specified nominal minimum 10-Day strength requirements, the average of all sets of 3 consecutive strength tests shall be equal to or greater than the specified strength.

**TABLE 1**
**2-Day Accelerated Compressive Strengths**

| Minimum 28-Day Compressive Strengths MPa | Corresponding 2-Day Accelerated Compressive Strengths MPa |
|---|---|
| 20 | 8.4 |
| 25 | 12.9 |
| 30 | 17.4 |
| 35 | 21.9 |
| 40 | 26.4 |

**TABLE 2**
**Quality Assurance Tests**

| Required Test | Test Method |
|---|---|
| Slump and Slump Flow of Concrete | CSA A23.2-5C |
| Air Content | CSA A23.2-4C |
| Compressive Strength | CSA A23.2-3C and CSA A23.2-9C |
| Accelerating the Cure of Concrete Cylinders and Determining Their Compressive Strength (Accelerated Cured) | CSA A23.2-10C |
| Yield | CSA A23.2-6C |
| Chloride Ion Penetrability Test | ASTM C 1202 |
| Linear Shrinkage Test | ASTM C 157M (Note 1) |
| Note:<br>1. Drying shall commence after 7 Days of wet curing. | |

**TABLE 3**
**Hardened Concrete Air Void System Requirements**

| Class of Exposure | Total Air Content % | Spacing Factor mm |
|---|---|---|
| C-XL, C1, C2, and F1 | 3.0 minimum | 0.230 maximum mean<br>0.260 maximum individual |
| Concrete with water/cementing ratios of 0.36 or less | 3.0 minimum | 0.250 maximum mean<br>0.300 maximum individual |

## Concrete Mix Design Submission

Contract _____ Date Submitted _____

Location _____ Submitted To _____

Contractor _____ Contact _____

Batch Plants: Primary _____ Secondary _____

Concrete Supplier: Name _____

Address _____

City/Province _____

Telephone _____ Fax _____ Email _____

| | | | | | |
|---|---|---|---|---|---|
| | **MIX CODE** | | | | |
| | **Application / Element / Location** | | | | |
| **SPECIFICATION** | **Structural Requirements** | | | | |
| | - CSA Exposure Class | | | | |
| | - Maximum W/CM | | | | |
| | - Minimum Specified Strength, MPa @ Days | | | | |
| | - Nominal Maximum Aggregate Size, mm | | | | |
| | - HVSCM Type 1 or 2 | | | | |
| | - Plastic Air Content, % | | | | |
| | **Durability Requirements** | | | | |
| | - Exposure to Sulphate Attack | | | | |
| | - Alkali Aggregate Reactivity | | | | |
| | **Architectural Requirements** | | | | |
| | - Colour / Texture | | | | |
| | - Other | | | | |
| **CONTRACTOR REQUIREMENTS** | **Rate, $m^3/h$** | | | | |
| | **Quantity, $m^3$** | | | | |
| | **Slump Range, mm** | | | | |
| | **Strength @ Age, MPa @ Days** | | | | |
| | **Other** | | | | |
| | **Specialty Information** | | | | |
| | - Concrete Set, **D**elay, **N**ormal, **A**ccelerated | | | | |
| | | | | | |
| | **Method of Placement** | | | | |

| **MATERIALS SECTION** | **Material** | **Source** |
|---|---|---|
| | Cement | |
| | SCM - Slag | |
| | SCM - _____ | |
| | Water | |
| | Fine Agg. | |
| | Coarse Agg. | |
| | A.E.A. | |
| | W.R. | |
| | S.P. | |
| | | |

**Form Submitted By:**

**Print Name:** _____ **Signature:** _____ **Date:** _____

**Contractor's Representative Receiving Form:**

**Print Name:** _____ **Signature:** _____ **Date:** _____

## CONFIDENTIAL - Concrete Mix Design Submission

Contract _____ Date Submitted _____

Location _____ Submitted To _____

Contractor _____ Contact _____

Batch Plants: Primary _____ Secondary _____

Concrete Supplier: Name _____

Address _____

City/Province _____

Telephone _____ Fax _____ Email _____

| | | | | | | |
|---|---|---|---|---|---|---|
| | **MIX CODE** | | | | | |
| | **Application / Element / Location** | | | | | |
| **SPECIFICATION** | **Structural Requirements** | | | | | |
| | - CSA Exposure Class | | | | | |
| | - Maximum W/CM | | | | | |
| | - Minimum Specified Strength, MPa @ Days | | | | | |
| | - Nominal Maximum Aggregate Size, mm | | | | | |
| | - HVSCM Type 1 or 2 | | | | | |
| | - Plastic Air Content, % | | | | | |
| | **Durability Requirements** | | | | | |
| | - Exposure to Sulphate Attack | | | | | |
| | - Alkali Aggregate Reactivity | | | | | |
| | **Architectural Requirements** | | | | | |
| | - Colour / Texture | | | | | |
| | - Other | | | | | |
| **CONTRACTOR REQUIREMENTS** | **Rate, $m^3/h$** | | | | | |
| | **Quantity, $m^3$** | | | | | |
| | **Slump Range, mm** | | | | | |
| | **Strength @ Age, MPa @ Days** | | | | | |
| | **Other** | | | | | |
| | **Specialty Information** | | | | | |
| | - Concrete Set, **D**elay, **N**ormal, **A**ccelerated | | | | | |
| | | | | | | |
| | **Method of Placement** | | | | | |

| | **Material** | **Source** | **Unit** | **Quantity** | | | |
|---|---|---|---|---|---|---|---|
| **MATERIALS SECTION** | Cement | | $kg/m^3$ | | | | |
| | SCM - Slag | | $kg/m^3$ | | | | |
| | SCM - _____ | | $kg/m^3$ | | | | |
| | Water | | $L/m^3$ | | | | |
| | Fine Agg. | | | | | | |
| | Coarse Agg. | | | | | | |
| | A.E.A. | | mL/100 kg | | | | |
| | W.R. | | mL/100 kg | | | | |
| | S.P. | | mL/100 kg | | | | |
| | | | | | | | |

**Form Submitted By:**

**Print Name:** _____ **Signature:** _____ **Date:** _____

**Municipal Representative Receiving Form:**

**Print Name:** _____ **Signature:** _____ **Date:** _____

**Appendix 1350-A, November 2014**
**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

This specification is intended for use by municipalities requiring ready mixed concrete.

The designer should specify the following in the Contract Documents:

- The Owner's choice of concrete specification alternatives, either Performance Specifications or Prescriptive Specifications. (1350.04.02)

- Minimum dose of chemical admixtures. (1350.04.02.01.01)

- Chemical admixtures. (1350.05.01.04)

The designer should determine if a quality control program is to be prepared and implemented. If so, the requirement for it should be specified in the Contract Documents. (1350.04.02.01)

The designer may consider the following and specify this requirement for air content in hardened concrete in the Contract Documents:

When the approved ready mixed concrete operation is currently supplying or has supplied a similar class of concrete within the last 6 months, permission may be given to waive this testing requirement, providing that:

a) There is no change in the source of any material.

b) The concrete mix designated and used previously meets the specified performance requirements.

c) Documentation of this prior approval is submitted to the Owner.

CSA A23.1, Table 5, lists the alternative methods for specifying concrete. The designer should review this table when determining which concrete specification alternative is to be used in the Contract. CSA A23.1, Annex J, discusses the selection of alternatives for specifying concrete requirements. These alternatives include:

**Performance** - When the Owner requires the concrete supplier to assume the responsibility for performance of the concrete as delivered and the Contractor to assume responsibility for the concrete in place.

For this alternative, the Owner should specify the following in the Contract Documents:

a) Required structural criteria including strength at age.

b) Required durability criteria including class of exposure.

c) Additional criteria for durability, volume stability, architectural requirements, sustainability, and any additional Owner performance, pre-qualification or verification criteria.

d) Quality management requirements.

e) Certification of the concrete supplier through the Approved Quality Program.

f) Any other properties that may be required to meet the Owner's performance requirements.

**Prescriptive** - When the Owner assumes responsibility for the performance of the concrete.

For this alternative, the Owner should specify the following in the Contract Documents:

a) Mix proportions, including the quantities of any or all materials (admixtures, aggregates, cementing materials, and water) by mass per cubic metre of concrete;

b) The range of air content;

c) The slump range;

d) Use of a concrete quality plan, if required;

e) Other requirements.

CSA A23.1, Annex K, discusses concrete made with a high volume of supplementary concreting materials (HVSCM).

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 Standards Drawings**

No information provided here.