



**MATERIAL SPECIFICATION FOR
CONCRETE - MATERIALS AND PRODUCTION**

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1350.01 SCOPE

This specification covers the requirements for materials and methods for proportioning, mixing, transporting, field testing, acceptance, and payment adjustments of concrete material, including provisions for referee testing of compressive strength, air void system parameters, and rapid chloride permeability of high performance concrete and silica fume overlays.

1350.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

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

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

Ontario Provincial Standard Specifications, Material

OPSS 1002	Aggregates - Concrete
OPSS 1301	Cementing Materials
OPSS 1302	Water
OPSS 1303	Air Entraining and Chemical Admixtures for Concrete

Ontario Ministry of Transportation Publications

Designated Sources for Materials (DSM)

Laboratory Testing Manual:

LS-100	Method of Rounding-off Data and Other Numbers
LS-101	Method for Calculation of Per Cent Within Limits
LS-407	Method of Test for Compressive Strength of Moulded Cylinders
LS-413	Method of Test for Non-Volatile Content of Chemical Admixtures, Latex Admixtures and Curing Compounds
LS-414	Method of Test for Relative Density of Chemical Admixtures, Air Entraining Admixtures, Latex Admixtures and Curing Compounds
LS-415	Method of Test for pH of Aqueous Solutions by Glass Electrode
LS-426	Method of Testing Compressive Strength of High Performance Concrete Cylinders
LS-431	Method of Test for Microscopical Determination of Air Void System Parameters in Hardened Concrete, for Conformance Testing
LS-432	Method of Test for Microscopical Determination of Air Void System Parameters in Hardened Concrete

- LS-433 Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
- LS-435 Method of Test for Linear Shrinkage of Concrete

MTO Forms:

- PH-CC-322 Concrete Construction Report
- PH-CC-340 Field Sample Data Sheet - Concrete
- PH-CC-433A Concrete Mix Design Submission Form A
- PH-CC-433B Concrete Mix Design Submission Form B
- PH-CC-434 Sample Letter to Contractor - Concrete Mix Design

CSA Standards

- A23.2-1C Sampling Plastic Concrete*
 - 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*
 - A23.2-14C Obtaining and Testing Drilled Cores for Compressive Strength Testing*
 - A23.2-17C Temperature of Freshly Mixed Hydraulic Cement Concrete*
 - A23.2-1D Moulds for Forming Concrete Test Cylinders Vertically*
 - A3004-B6 Physical Test Methods for Cementitious Materials for Use in Concrete and Masonry **
 - A3001 Cementitious Materials for Use in Concrete**
- * [Part of A23.1-14/A23.2-14 - Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete]
- ** [Part of A3000-13 - Cementitious Materials Compendium]

1350.03 DEFINITIONS

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

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

High Strength Concrete means concrete with a minimum specified 28-Day compressive strength of 40 MPa or greater.

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

Steel Reinforcement means all types of steel reinforcement for concrete, including reinforcing steel bars, stainless steel reinforcing bars, splice bars, welded steel wire fabric, and prestressing strands and bars.

Tremie Concrete means a concrete mix specifically designed to be placed under water by means of a tremie.

1350.04 DESIGN AND SUBMISSION REQUIREMENTS

1350.04.01 Design Requirements

1350.04.01.01 General

The concrete mix shall be designed to provide adequate strength and durability for the intended use and to meet the requirements as specified in the Contract Documents.

1350.04.01.01.01 Use of Admixtures

Water reducer Type A or D according to OPSS 1303 shall be used in all concrete, except in applications where plant addition of superplasticizer is permitted, in which case water reducer may be used at the Contractor's option.

Retarding of concrete set shall be provided when specified in the Contract Documents. If no retarding of set is specified, retarders may be used at the Contractor's option to delay setting of concrete for a maximum of 3 hours. Longer periods of set retardation shall be used only when specified in the Contract Documents.

Accelerators shall be used only when specified in the Contract Documents.

Superplasticizers shall be used in concrete containing silica fume and concrete in expansion joint end dams as specified in the Contract Documents. Superplasticizers may be used in other applications at the Contractor's option providing the superplasticized concrete meets the contract requirements and there is no evidence of segregation or inadequate consolidation.

Where rapid chloride permeability is an acceptance requirement, superplasticizers may be added at the Contractor's option to the concrete at the plant or at the site. In all other applications superplasticizer shall be added to the concrete at the site.

Type S admixtures listed on the DSM may be used and concrete containing Type S admixture shall meet all requirements of this specification.

1350.04.02 Submission Requirements

1350.04.02.01 Mix Design

1350.04.02.01.01 General

A complete mix design submission shall be provided for concrete of each specified compressive strength that is to be placed in the work, for each of the following:

- a) Cast-in-place concrete.
- b) Slip formed concrete.
- c) Mixes with different sources of materials.
- d) Mixes with different admixtures.
- e) Precast concrete.
- f) Special purpose or unique mixes.

A complete mix design submission shall be provided for each specific concrete mix prior to the placement of that mix in the work. A complete mix design submission consists of the following:

- a) A completed MTO form PH-CC-433A (Form A).
- b) A completed MTO form PH-CC-433B (Form B).
- c) Mix design-supporting documentation.

Form A and Form B shall identify all materials to be used in the concrete. No material shall be used in the concrete without the knowledge of the Owner.

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

The mix shall not be placed until the Contract Administrator provides written confirmation that Form A and the mix design supporting information meet the requirements as specified in the Contract Documents. Within 4 Business Days following the delivery of all required documentation by the Contractor, the Contract Administrator shall provide the Contractor with a completed MTO form PH-CC-434 indicating the above confirmation or advising the Contractor of any requirements that have not been met.

1350.04.02.01.02 Changes to Mix Design Submission

The following adjustments to the submitted mix design may be made without having to submit a new mix design or supporting data:

- a) Total cementing material content: $\pm 5\%$ of quantity stated on Form B.
- b) Supplementary cementing materials: $+0/-5\%$ of quantity stated on Form B.
- c) Admixtures: Variation within range of dosage stated on Form B.
- d) Water: Variation within range stated on Form B.

Removal of a material from the mix or addition of retarding admixture Type B or D according to OPSS 1303 requires submission of a new mix design, but does not require submission of supporting test data.

A new mix design, including supporting documentation, shall be provided prior to placing concrete, if the Contractor proposes to change the mix in any of the following ways:

- a) Changing sources of materials used in the concrete.
- b) Substituting a material or product for another from the same source.
- c) Adding any material to the concrete that was not on the original mix design, except retarding admixture Type B or D according to OPSS 1303.
- d) Adjusting the quantities of the stated materials in the concrete outside of the ranges provided above.

The submission process for new or modified mix designs is the same as for the original mix design, except that when supporting documentation is not required, the confirmation by the Contract Administrator shall be provided within 1 Business Day.

1350.04.02.01.03 Submission of Form A

At least 7 Business Days prior to the placement of concrete, an accurately completed Form A shall be submitted to the Contract Administrator.

Each mix design submitted shall be identified by the Contractor with a mix design number consisting of the following:

- a) 8-digit Contract number, followed by
- b) 2 digits indicating the specified compressive strength of concrete, followed by

- c) 2 digits indicating the number of the submission for that Contract (e.g., 01 for the first mix design of a specified strength, 02 for the second, and so on) followed, if applicable, by
- d) 1 digit indicating the number of revisions of a mix design submitted previously (e.g., 1 for first revision, 2 for second revision, and so on).

1350.04.02.01.04 Submission of Form B

Prior to the placement of concrete of a given mix design, the Contractor shall ensure that for each Form A submitted, a corresponding Form B is accurately completed by the concrete supplier and submitted directly to the Regional Head of Quality Assurance with a copy to the MTO Concrete Section electronic mix design depository.

The Form B shall bear the mix design number assigned by the Contractor to the corresponding Form A.

1350.04.02.01.05 Mix Design Supporting Documentation

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 Documents. All required supporting test data and certificates shall be less than 12 months old at the time the concrete mix design is submitted.

Supporting documentation shall include the following:

- a) A currently valid Certificate of Ready Mixed Concrete Production Facilities as issued by the Ready Mixed Concrete Association of Ontario (RMCAO) for any plant to be used on the Contract.
- b) The range of concrete production rates required for the work.
- c) A certificate or letter verifying the compatibility of the admixtures to be used in the concrete, if admixtures are supplied from different manufacturers.
- d) Water test results, if water other than municipal drinking water is used, demonstrating compliance with the requirements as specified in the Contract Documents.
- e) A certificate verifying the cement is free from early stiffening tendencies when tested according to CAN/CSA A3004-B6, if non-agitating trucks are used.
- f) Any other requirements specified elsewhere in the Contract Documents.

Documentation applicable to multiple mix designs need only be submitted once for a Contract.

1350.04.02.02 Certification of Ready Mixed Concrete Production Facilities

For multi-year Contracts, the Contractor shall submit annually for all plants supplying concrete to the work, verification that the plant continues to hold a valid Certificate of Ready Mixed Concrete Production Facilities, as issued by the RMCAO.

1350.05 MATERIALS

1350.05.01 Cementing Materials

Cementing materials shall be according to OPSS 1301 and CAN/CSA A3001, except:

- a) For all concrete other than silica fume overlays and HPC, Portland cement shall be used. A portion of it may be replaced by supplementary cementing material; however, silica fume or blended cement containing silica fume shall not be used.
- b) For silica fume overlays and HPC, blended hydraulic cement containing silica fume shall be used. A portion of it may be replaced by Portland cement Type GU or supplementary cementing materials or both.

Supplementary cementing material shall be ground granulated blast furnace slag or fly ash or a combination of the two materials and shall be restricted to the following proportions by mass of the total cementing material:

- a) Slag up to 25%.
- b) Fly ash up to 10%, except for silica fume overlays and HPC where up to 25% is permitted.
- c) A mixture of slag and fly ash up to 25%, except the amount of fly ash shall not exceed 10% by mass of the total cementing materials, in concrete other than silica fume overlays and HPC.

For tremie concrete, the minimum cementing material content shall be 415 kg per cubic metre of concrete.

1350.05.02 Aggregates

Aggregates shall be according to OPSS 1002.

1350.05.03 Water

Water used for production shall be according to OPSS 1302.

1350.05.04 Admixtures for Concrete

Air entraining, chemical, and superplasticizing admixtures for concrete shall be according to OPSS 1303.

1350.05.05 Concrete

Target values for air content and slump shall be identified for all plastic concrete on mix design Forms A and B.

The plastic concrete shall meet the following requirements:

- a) Concrete shall be free of lumps and segregation and shall have consistent air content and slump throughout each load.
- b) Plastic air content shall meet the requirements as shown in Table 1.
- c) Slump shall meet the requirements of Table 1. The maximum allowable slump, including tolerance, shall be 100 mm, except for tremie concrete, which shall be 180 mm.

When superplasticizer is to be added to the concrete according to the Use of Admixtures clause, the following shall apply:

- i. For superplasticizers added at the plant, the Contractor shall identify target slump for the concrete after the addition of superplasticizer. The tolerance on measurement of concrete slump after addition of superplasticizer shall be ± 30 mm and the maximum slump including tolerance shall not exceed 230 mm.

- ii. For superplasticizers added at the site, the Contractor shall identify target slumps for the concrete both prior to and after the addition of superplasticizer. The tolerance on measurement of concrete slump prior to the addition of superplasticizer shall be ± 20 mm and the maximum slump including tolerance shall not exceed 100 mm. The tolerance on measurement of concrete slump after addition of superplasticizer shall be ± 30 mm and the maximum slump, including tolerance, shall not exceed 230 mm.
- d) The concrete temperature at the time of discharge from the truck shall be at or between 10 and 28 °C, with the exception of HPC and silica fume overlays, which shall be at or between 10 and 25 °C.

The hardened concrete shall meet the following requirements:

- a) Concrete compressive strength shall be as specified in the Contract Documents.
- b) Rapid chloride permeability of HPC and silica fume overlays at 28 to 32 Days shall be less than or equal to 1,000 coulombs.
- c) Air void system parameters as determined on the hardened concrete shall meet the following requirements:
 - i. Each core shall have a minimum air content of 3.0 %.
 - ii. Each core shall have a maximum spacing factor of 0.230 mm, except for HPC and silica fume overlays for which each core shall have a maximum spacing factor of 0.250 mm.

Self-Consolidating Concrete (SCC) will be considered on an individual basis subject to the Owner's approval. If permitted for use, SCC shall be according to the Owner's current specification for SCC. A copy of the specification can be obtained from:

Ontario Ministry of Transportation,
Materials Engineering and Research Office,
145 Sir William Hearst Avenue,
Downsview, Ontario M3M 0B6.

1350.06 EQUIPMENT

1350.06.01 Batching Plant

The batching plant and equipment shall be certified by the RMCAO prior to producing concrete for the work, including concrete for any trial batches, and shall meet the requirements for certification throughout the production of concrete.

1350.06.02 Delivery Equipment

Delivery equipment shall be truck mixers, agitator trucks, or non-agitating equipment. Use of non-agitating equipment shall be restricted to delivery for placement of concrete base or concrete pavement.

Truck mixers shall consist of concrete mixers mounted on a truck or other vehicle used for the complete mixing of concrete ingredients after they have been batched at the plant. All truck mixers shall be certified by RMCAO and shall display valid certification stickers.

Agitator trucks shall consist of drums or containers mounted on trucks or other vehicles in which completely mixed concrete is kept sufficiently agitated during delivery to prevent segregation.

Non-agitating equipment shall consist of containers mounted on trucks for delivering completely mixed concrete. The body of the container shall be smooth, watertight, made of steel, and equipped with gates that permit control of the discharge of the concrete.

1350.07 PRODUCTION

1350.07.01 General

Concrete shall be produced at a batching plant. Use of mobile mixers is not permitted. A back-up plant shall be identified for all post-tensioned deck placements.

When multiple plants supply concrete for the same component, all plants, including primary and back-up, shall produce the same mix design using the same aggregates, cementing materials, and admixtures.

The supplementary cementing material shall be weighed separately from the cement, except when the cement and supplementary cementing materials are supplied in blended form.

The entire contents of the mixer shall be discharged and the mixer completely emptied of wash water prior to loading of a new concrete batch. When a truck mixer is used for complete mixing, it shall not be loaded beyond its maximum mixing capacity.

Cementing materials shall not be added by bags or sacks or from a storage facility remote from the ready mix plant.

1350.07.02 Temperature Control

Any method of heating aggregates shall be such as to produce uniform conditions, without local hot spots.

Frozen lumps of aggregate shall not be added to the concrete.

When ice is used as part of mixing water, the ice shall be measured by mass and shall be completely melted by the time concrete mixing is completed.

1350.07.03 Mixing Time and Mixing Rate

The minimum mixing time for concrete shall be as recommended by the equipment manufacturer or the minimum time required to produce concrete meeting the requirements of this specification, whichever is greater.

When a stationary mixer is used for partial mixing of concrete prior to transferring to a truck mixer, the mixing time shall be no more than is required to intermingle the ingredients. After transfer to a truck mixer, further mixing at the designated mixing speed shall be carried out.

After completion of mixing, the truck mixer drum shall be rotated at the designed agitating speed until discharge of concrete commences.

1350.07.04 Delivery

1350.07.04.01 General

Concrete that is transported in non-agitating equipment shall be covered. Concrete delivered by means of agitator trucks or truck mixers shall be transported after completion of mixing.

1350.07.04.02 Discharge Time

When concrete is transported to the site by means of agitating or mixing equipment, discharge of the concrete shall be completed within 1.5 hours after introduction of the mixing water to the cement and aggregates, except when the air temperature exceeds 28 °C and the concrete temperature exceeds 25 °C, the concrete shall be discharged within 1 hour after the introduction of the mixing water.

When concrete is transported by means of non-agitating equipment, discharge shall be completed within 30 minutes after introduction of the mixing water to the cement and aggregates.

Use of retarders or other admixtures does not change the specified concrete discharge time.

1350.07.04.03 Delivery Ticket

Each load shall be accompanied by a delivery ticket. The following information shall be printed on each ticket at the plant using an automated printing device:

- a) Name and location of plant.
- b) Date, including year, month, and day.
- c) Contract number.
- d) Truck number.
- e) Time of batching concrete. Where an electronic ticketing system is not used, time shall be stamped by a time clock within 5 minutes of batching.
- f) Mix design number assigned by the Contractor or the supplier's unique mix design number verified to correspond to the mix design number assigned by the Contractor.
- g) Specified minimum 28-Day compressive strength of concrete.

In addition, the following shall be recorded in writing on the delivery ticket:

- a) The amount of any material added after batching.
- b) Rejection of a load or part thereof, if applicable.
- c) Time truck arrived at the job site.
- d) The time the truck finished discharging..

1350.07.05 Material Sampling and Testing

1350.07.05.01 Contractor Sampling for Quality Control Purposes

The Contractor may obtain samples of plastic concrete for quality control purposes. The Contractor shall not carry out sampling or destructive testing of hardened concrete in the work for quality control purposes without obtaining the written permission of the Owner in advance. The Owner's denial of permission shall not relieve the Contractor of responsibility for the quality of concrete placed or to be placed in the work.

1350.07.05.02 Sampling of Water, Admixtures, and Cementing Materials

The Contractor shall obtain samples of all cementing materials, admixtures, and water (when other than municipal drinking water is used) according to the frequencies as shown in Table 8, for testing by the Owner.

The Contractor shall deliver samples of admixtures and water to the Regional Quality Assurance laboratory.

The Contractor shall deliver samples of cementing materials to:

Head, Concrete Section
Ontario Ministry of Transportation
Room 15,
145 Sir William Hearst Avenue,
Downsview, ON M3M 0B6

Samples of admixtures and water shall be protected from freezing and high temperatures. Cementing materials samples shall be protected from moisture.

1350.07.05.03 Testing of Plastic Concrete

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

- a) CCIL Certified Concrete Testing Technician, or
- b) ACI Concrete Field Testing Technician, Grade 1.

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

Samples for determining acceptance of concrete for air and slump shall be grab samples taken according to CSA A23.2-1C after approximately 10% of the load has been discharged. The discharge shall be stopped and no additional concrete shall be discharged or placed into the work until samples have been tested and found acceptable. If the test results indicate that the concrete does not meet the specified requirements and adjustments permitted in the Acceptance and Field Adjustments of Plastic Concrete clause cannot produce acceptable concrete, the remainder of the load shall be rejected.

Temperature shall be measured according to CSA A23.2-17C. Slump shall be measured according to CSA A23.2-5C. Air content shall be measured according to CSA A23.2-4C. The air meter shall be calibrated at least once a year according to CSA A23.2-4C and a copy of the calibration certificate shall be with the air meter and available for review when requested by the Contract Administrator.

1350.07.05.04 Frequency of Testing Slump, Air Content, and Temperature

For all concrete, quality control testing consisting of slump, air content, and temperature determinations shall be carried out on each load or batch of concrete until satisfactory control is established. Satisfactory control shall be established each Day. It is established when concrete from 5 consecutive loads or batches is within the specified requirements without field adjustments as defined in the Acceptance and Field Adjustments of Plastic Concrete clause. If any field adjustments are required, testing on each load shall be continued until 5 consecutive loads or batches meet the requirements with no field adjustment. After satisfactory control has been established, testing shall be carried out on every third load. If testing indicates that a load does not meet the requirements, testing shall resume on each load until satisfactory control is established.

If multiple plants supply concrete, satisfactory control shall be established for each plant.

In addition to the above, air content, slump, and temperature tests shall be carried out whenever compressive test cylinders are cast.

1350.07.05.05 Acceptance and Field Adjustments of Plastic Concrete

The Contractor shall be responsible for all quality control inspection and testing required to ensure that plastic concrete included in the work is according to the submitted mix design and meets the specified requirements for air content, slump, temperature, delivery time, and uniformity.

Concrete which does not meet the specified requirements for air content, slump, temperature, delivery time or uniformity shall be rejected and not used in work.

Slump of concrete shall be measured prior to and after the addition of superplasticizer. When superplasticizer is permitted to be added at the plant according to the Use of Admixtures clause, the slump shall be measured after the addition of superplasticizer. Air content shall be measured after any addition of superplasticizer.

For non-superplasticized concrete, when the measured slump is higher than that specified and there is time available to discharge the concrete within the specified time limit, the Contractor shall be permitted to retest the slump once using the unused portion of the same concrete sample. Slump shall be retested within 5 minutes of the completion of the original test.

For superplasticized concrete, when the measured slump is higher than that specified and there is time available to discharge the concrete within the specified time limit, the Contractor shall be permitted to wait and retest the slump using a new sample of concrete when superplasticizer is plant added and rapid chloride permeability is an acceptance requirement, or superplasticizer is added on site and the measured slump prior to addition of superplasticizer is within specified limits.

When the measured plastic air content exceeds the upper test limit and there is time available within the discharge time limit specified, the Contractor shall be permitted to rotate the load at agitation speed and re-test the air content. The use of additives to reduce the air content shall not be permitted.

When a truck mixer is used, the following field adjustments may be carried out prior to acceptance of the load:

1. When the measured air content is low, air-entraining admixture may be added.
2. When the measured or estimated slump is low, the following adjustments may be made:
 - a) For concrete mixes that do not include superplasticizer, water may be added:
 - i. Prior to discharge of concrete from the truck has started, or
 - ii. When the measured slump of concrete is lower than the maximum targeted range.
 - b) For concrete mixes with site-added superplasticizer:
 - i. Water may be added before superplasticizer is added at the site. Water additions may be done prior to discharge of concrete from the truck has started or when the measured slump of concrete is lower than the maximum targeted range,
 - ii. No water shall be added after the addition of a superplasticizer. Additional doses of superplasticizer may be added.
 - c) For concrete mixes with plant added superplasticizer:
 - i. No water shall be added.

- ii. Superplasticizer may be added.

No field adjustments shall be carried out after concrete has been accepted, with the exception of superplasticized concrete. For superplasticized concrete, addition of a superplasticizer to increase the slump to assist in placing shall be permitted.

When any material is added to the concrete, the load of concrete shall be mixed for 30 revolutions or more at the designated mixing speed to ensure that the concrete is uniformly mixed. The load shall be re-tested for acceptance.

1350.07.05.06 Visual Acceptance of Plastic Concrete

The Contractor shall visually inspect plastic concrete during discharge and placement to identify the presence of any segregation or lumps.

If any segregation is identified, the Contractor shall immediately reject the entire load of concrete.

Any visible lumps present in the concrete shall be removed before concrete is placed in the work. If more than 3 visible lumps are present in a load of concrete, the remainder of the load shall be immediately rejected and no further concrete from that truckload shall be placed in the work.

If more than three truckloads during the day's work are observed to contain more than 3 lumps per truck, concrete placement shall be stopped at the end of the Day or at the end of the placement of the specific structure component, whichever comes first.

No further concrete shall be placed until all of the following occur:

- a) The Contractor has provided an explanation of the reasons for the lumps and identified the steps that shall be taken to eliminate the reoccurrence of lumps in future work.
- b) A trial batch has been carried out in the presence of the Contract Administrator and the Contract Administrator has verified that the concrete is free of lumps.
- c) The Contract Administrator has granted written approval for placement to proceed.

1350.07.05.07 Within-Batch Uniformity of Plastic Concrete

When required by the Contract Administrator, determination of the within-batch uniformity of the plastic concrete shall be carried out by testing air content, slump, and density according to CSA A23.2-4C, 5C, and 6C, respectively. The Contractor shall be granted 24 hours' notice when density testing is required as part of within-batch uniformity determination. No advance notice shall be granted for carrying out the slump and air portion of the uniformity testing.

Tests shall be carried out on samples of concrete obtained when approximately 10%, 50%, and 90% of the batch has been discharged while the mixer is being emptied at normal operating rate. The minimum size of sample shall be 30 litres. Between samples, the mixer shall not be allowed to turn in the mixing direction.

The acceptance and rejection limits for uniformity shall be as shown in Table 2. When the result of each test is equal to or less than the acceptance limit, the concrete is uniform. When the result of any single test is greater than the rejection limit, the concrete is considered to be non-uniform.

If the result of any single test exceeds the acceptance limit and is not greater than the rejection limit, all tests shall be made on the next consecutive batch or load delivered by that mixing equipment.

If, after testing one additional batch or load, the test result is greater than the acceptance limit, the concrete is non-uniform.

When the concrete is non-uniform and the mixing equipment is a stationary mixer, no more concrete shall be produced in it until within batch uniformity has been demonstrated. If the unit is a truck mixer, the truck mixer shall not be used again.

1350.07.05.08 Submission of Plastic Concrete Test Results

After each Day's work, a copy of the delivery ticket for each load of concrete and a daily summary shall be submitted to the Contract Administrator. The daily summary shall include air contents, slumps prior to and after any additions, concrete temperature, and all adjustments made to each load of concrete, including volume of any water or superplasticizer added, and shall identify rejected material.

1350.07.05.09 Compressive Strength

1350.07.05.09.01 General

Prior to placing concrete, an estimate of concrete volumes for each minimum specified 28-Day compressive strength shall be provided to the Contract Administrator. Acceptance method A shall be used when the quantity of concrete of a specified minimum strength is 100 m³ or more. Acceptance method B shall be used for concrete in expansion joints, tremie concrete, or when the quantity of concrete of a specified minimum strength is less than 100 m³. The Contract Administrator shall confirm the method(s) to be used.

1350.07.05.09.02 Acceptance Method A

The Contract Administrator shall determine the lot and subplot size after discussion with the Contractor and before any concrete is placed. Each lot shall contain concrete of one specified minimum 28-Day strength. There shall be only one lot of each specified strength of concrete; however, if the quantity of concrete of one specified strength is greater than 5,000 m³, the Contract Administrator shall consider requests to divide the concrete into two lots based on placement in separate structures or in different construction seasons.

Each lot shall be divided into sublots of approximately 10 m³ to a maximum of 100 m³. Sublot sizes shall be established based on the estimated concrete quantity such that each lot contains a minimum of 10 sublots. One set of acceptance and one set of referee cylinders shall be made from each subplot. The loads of concrete to be sampled shall be selected by the Contract Administrator on a random basis.

In addition to acceptance cylinders cast on a random basis, the Contractor shall also cast test cylinders as required by the Contract Administrator. The results from these cylinders shall be used for assessment of structural adequacy, for information purposes, or for other uses by the Owner.

1350.07.05.09.03 Acceptance Method B

One set of acceptance and referee cylinders, each shall be cast for every 20 m³ of concrete placed or one set per day, whichever is more frequent.

1350.07.05.09.04 Test Cylinders

The Contractor shall cast, cure, and transport cylinders for compressive strength testing by the Owner.

Every time a set of acceptance cylinders is cast, a second set of cylinders shall be cast for referee testing purposes, unless otherwise specified in the Contract Documents.

Concrete test cylinders for compressive strength testing for acceptance and for referee testing purposes, where required, shall be cast, cured, and transported according to CSA A23.2-3C. Referee cylinders shall be cured and transported to the Regional Quality Assurance Laboratory, along with the acceptance cylinders. A set of cylinders for concrete made with aggregate of nominal maximum size larger than 19 mm shall consist of two 150 mm diameter x 300 mm long cylinders. For all other concrete, a set of cylinders shall consist of three 100 mm diameter x 200 mm long cylinders.

Concrete test cylinders for early strength determination shall be cast, cured, and transported as specified in the Contract Documents.

No referee cylinders shall be cast when cylinders are prepared for determination of early strength or are requested by the Owner, for information purposes.

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

Test information shall be recorded on MTO form PH-CC 322, a copy of which shall be submitted with each set of the concrete cylinders.

The Contractor shall continuously record and monitor temperature immediately adjacent to the cylinders during the field-curing period. The maximum time interval for recording the temperature shall be every 15 minutes.

1350.07.05.09.05 Submission of Cylinder Curing Records

Cylinder curing temperature records shall be submitted to the Contract Administrator at the completion of the field-curing period.

1350.07.05.10 Air Void System Parameters

Cores for evaluation of air void system parameters shall be required for the categories of concrete shown in Table 3.

The Contractor shall remove cores from the hardened concrete for testing by the Owner. Cores shall be taken at random locations specified by the Contract Administrator. All cores shall be removed when the concrete is between 7 to 10 Days of age, and cores from bridge decks shall be removed prior to application of any waterproofing membrane.

The lot sizes, core size, and number of cores shall be as shown in Table 3. When two cores are required for a lot, the lot shall be divided into two, and one core shall be removed at a random location within each half of the lot. For concrete barriers and barrier walls on structures, the cores shall be removed from the lower sloped portion of the wall at the designated locations. For parapet walls, the cores shall be removed from the lower one-third of the wall at the designated locations. Steel reinforcement and other embedded material shall be avoided when possible while coring and the Contractor shall use a covermeter to establish reinforcement location, prior to coring.

For concrete patches and refacing where the total area of patches or refacing on a structure is less than 20 m², no cores shall be required, but one 100 x 200 mm cylinder shall be cast and tested.

The Contract number, lot number, and exact location of each individual core shall be marked legibly on the core with durable ink. The cores shall be delivered to the Regional Quality Assurance laboratory with a transmittal form and Form A of the concrete mix design for the component.

1350.07.05.11 Rapid Chloride Permeability

Cores for evaluation of rapid chloride permeability shall be required for HPC and silica fume overlays as shown in Table 4. Cores for evaluation of rapid chloride permeability may also be required for other concrete as specified in the Contract Documents.

The Contractor shall remove cores from the hardened concrete for testing by the Owner.

One core shall be removed at the random location specified by the Contract Administrator and the second core shall be removed at a location no more than 1 m from the location of the first core. Cores shall not contain steel reinforcement or other embedded material. All cores shall be removed when the concrete is between 7 to 10 Days of age and cores from bridge decks shall be removed prior to application of any waterproofing membrane.

The lot sizes, core sizes, and number of cores shall be as shown in Table 4. If the total quantity of a component is less than shown in the Table 4, the minimum number of cores specified in Table 4 shall be removed.

Each core shall be placed in a plastic bag, sealed to prevent loss of moisture, and delivered to the Regional Quality Assurance laboratory within 24 hours of coring with a transmittal form and Form A of the concrete mix design for the component.

1350.07.06 Filling of Core Holes

Each core hole shall be filled immediately after coring with a proprietary patching material from the Owner's pre-qualified product list. The patching material shall be comparable to the surrounding concrete in terms of strength and permeability. The patching material shall be mixed, handled, and cured according to the manufacturer's instructions. Immediately prior to filling, the inside surface of each core hole shall be cleaned of the paste left from the coring operation by nylon brushing and all free water shall be removed. The patch shall be finished flush with the surface of the surrounding concrete. All excess material shall be removed from the surface of the concrete.

1350.08 QUALITY ASSURANCE

1350.08.01 Acceptance of Concrete Compressive Strength

1350.08.01.01 General

Lots for compressive strength shall be as identified in the Acceptance Method A or Acceptance Method B clause, as applicable.

Compressive strength shall be determined according to LS-407 and LS-426.

The compressive strength result of a subplot shall be the average of the set of 3 acceptance cylinders made from the subplot, rounded to one decimal place, except for concrete made with aggregate of nominal maximum size larger than 19 mm where the subplot result shall be the average of 2 cylinders.

The individual test results shall be forwarded to the Contractor, as they become available. The Contractor shall forward individual test results and monthly summaries to the concrete supplier.

When any individual strength test result falls below the specified minimum 28-Day strength by more than 4.0 MPa, the Contract Administrator may require the Contractor to take and test 100 mm diameter concrete cores to determine whether individual sections of concrete are structurally adequate and whether remedial work or removal is required. When required, cores shall be removed in groups of 3 at

locations specified by the Contract Administrator. Cores shall be removed, moisture conditioned, and tested for compressive strength according to CSA A23.2-14C.

Where required, determination of structural adequacy is independent of and in addition to any payment reduction. Core results shall not replace cylinder results in any bonus or penalty calculations. Where extensive design calculation is required in order to confirm structural adequacy, the Contractor shall reimburse the Owner for all costs incurred up to a maximum of \$2,000.00 per occurrence.

1350.08.01.02 Acceptance Method A

Acceptance of concrete compressive strength for each lot shall be based on the mean and standard deviation of the compressive strength results of all sublots contained in the lot.

The mean and standard deviation of the results and forecast potential bonus or penalty, if any, shall be submitted to the Contractor at monthly intervals.

The Contract Administrator shall calculate the percent within limits (PWL) according to LS 101, using the specified compressive strength as the lower limit.

When the lot PWL is greater than 95%, the Contractor shall receive a bonus, in $\$/m^3$, as calculated by the following:

$$\text{Bonus} = \text{PWL} - 95$$

When the lot PWL is greater than or equal to 90% and less than or equal to 95%, there shall be no bonus or penalty due to concrete compressive strength.

When the lot PWL is less than 90% and greater than or equal to 50%, the Contractor shall be assessed a penalty, in $\$/m^3$, as calculated by the following:

$$\text{Penalty} = 90 - \text{PWL}$$

When the lot PWL is less than 50%, the lot is unacceptable and is subject to removal and replacement. The Contractor may submit an alternative in writing for the Owner's consideration for unacceptable lots. If the Contract Administrator determines that an unacceptable lot may remain in the work, it shall be subject to the calculated penalty.

For the purpose of penalty or bonus, the quantity of concrete in each lot shall be calculated by the Contract Administrator as the sum of the following:

- a) The payment quantity for items paid by unit price per cubic metre of concrete.
- b) The theoretical quantity indicated in the Contract Documents for items paid by lump sum, provided the actual quantity is within $\pm 3\%$ of the theoretical quantity.
- c) The quantity of concrete in each lot shall be calculated from the quantities indicated in the Contract Drawings for items, where these quantities are listed.
- d) The quantity based on the neat lines called for in the Contract Drawings, where none of the above methods are applicable.

1350.08.01.03 Acceptance Method B

Concrete compressive strength shall be considered acceptable when it meets all of the following:

- a) The average of all groups of 3 consecutive compressive strength tests shall be equal to or greater than the specified strength.
- b) No individual strength test shall be more than 4.0 MPa below the specified strength.

Unacceptable concrete shall be subject to removal and replacement.

The Contractor may submit an alternative in writing for the Owner's consideration for unacceptable concrete.

1350.08.01.04 Referee Testing Based on Duplicate Cylinders

The referee testing process for concrete compressive strength is based on duplicate cylinders cast at the same time as the acceptance cylinders.

Referee testing of compressive strength for a subplot may only be invoked by the Contractor within 5 Business Days of receiving the test results for that subplot.

The referee laboratory shall be designated by the Owner based on the applicable roster. Referee test results shall be forwarded to the Contractor, as they become available.

If the difference between the referee test result and the acceptance test result is less than the confirmation value, the acceptance test result is then confirmed and the acceptance test result shall be used in the determination of acceptance and payment for the concrete. If the difference between the referee test result and the acceptance test result is greater than the confirmation value, the acceptance test result is then not confirmed and the acceptance test result shall be disregarded and not used in the determination of acceptance and payment. The confirmation value for confirming the acceptance test result shall be the greater of 10% of the specified strength or 10% of the strength of the acceptance cylinders, expressed to one decimal place.

If the referee test result is more than 4.0 MPa below the specified strength, the result shall be reviewed to determine if structural adequacy is in question and, if so, the relevant provisions of this specification shall be followed.

When acceptance results are eliminated from the analysis as a result of referee process, the concrete shall be assessed based on the available strength results for the lot.

If acceptance test results from multiple sublots are eliminated such that there are fewer than 4 acceptance test results available for the lot, Acceptance Method B shall be used for acceptance of the concrete.

1350.08.01.04.01 Referee Testing Cost

The cost of compressive strength referee testing shall be as specified in the Contract Documents.

When the referee result confirms the acceptance test result, the Contractor shall be charged the cost of compressive strength referee testing. When the referee result does not confirm the acceptance test result, the Owner shall bear the cost.

1350.08.02 Acceptance of Air Void System in Hardened Concrete

1350.08.02.01 General

The lots for air void system shall be as shown in Table 3.

One half of each core shall be tested to determine the acceptability of concrete. The core shall be tested according to LS-432. The other half of each core shall be retained by the Owner for audit purposes.

Individual test results shall be forwarded to the Contractor, as they become available.

1350.08.02.02 Basis of Acceptance

For a lot to be considered acceptable, each core shall have air content of 3.0% or more and spacing factor of 0.230 mm or less in all concrete, except for silica fume overlays and HPC where the spacing factor shall be 0.250 mm or less. Acceptable lots shall be subject to full payment or bonus payment.

An unacceptable lot is a lot represented by one or two cores that fail to meet the air void system parameters. Unacceptable lots shall be removed and replaced except where the Owner permits the work to remain in place. The removal and replacement of unacceptable lots shall be at no additional cost to the Owner. The replacement lots shall be evaluated for acceptance on the same basis as the original lot. When the Owner permits the work to remain in place, it shall be subject to the calculated penalty and shall not be eligible for bonus.

For the purpose of calculating a bonus or penalty, the Contract Administrator shall round-off spacing factor test data to two decimal places and air content test data to one decimal place according to LS-100 and shall determine the quantity of concrete in lots using the dimensions as specified in the Contract Documents.

When two cores are tested per lot, the bonus payment for an acceptable lot shall be calculated by averaging bonus values corresponding to individual core results. When one core is tested per lot, the bonus payment for an acceptable lot shall be the bonus value corresponding to the core.

Bonus payment for a lot represented by 2 cores shall be calculated according to the following:

$$B = (B1 + B2)/2$$

Where: B = bonus in $\$/m^3$ of concrete in the lot
B1 and B2 = bonus for cores 1 and 2 in $\$/m^3$ of concrete in the lot from Table 5

Bonus for acceptable lot = lot quantity (m^3) x B

Payment for unacceptable lots shall be calculated by averaging the pay factors corresponding to individual core results. Where one core in an unacceptable lot meets the specified requirements for air void system, the core shall be assigned a pay factor of 100%. When only one core is tested per lot, the payment for an unacceptable lot shall be the pay factors corresponding to the individual core result.

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

$$P = (P1+P2)/2$$

Where: P = pay factor for the lot (%)
P1 and P2 = pay factor for cores 1 and 2 in % as shown in Table 6 or 7, as applicable

Payment reduction for a lot = lot quantity/tender quantity x tender lump sum price x ((100-P)/100)

Where: Lot quantity and tender quantity are in cubic metres

1350.08.02.03 Referee Testing

Referee testing of air void system parameters may only be invoked by the Contractor within 5 Business Days of receiving the test result.

When referee testing is invoked, all core samples representing a lot shall be referee tested and the acceptance test results discarded. The lot referee test results shall replace the acceptance test result in the acceptance requirements of this specification.

Referee testing shall be carried out on the same half of the core sample that was tested for acceptance.

Cores shall be tested according to LS-431. Referee test results shall be forwarded to the Contractor, as they become available.

1350.08.02.03.01 Referee Testing Cost

The cost of air void system referee testing shall be as specified in the Contract Documents.

When the referee results indicate that the refereed lot is acceptable, the Owner shall bear the cost. When the referee results indicate that the refereed lot is not acceptable, the Contractor shall be charged the cost of the air void system referee testing.

1350.08.03 Acceptance of Rapid Chloride Permeability

1350.08.03.01 General

The lots for rapid chloride permeability shall be as shown in Table 4.

Cores shall be tested according to LS-433. Acceptance testing shall be carried out at 28 to 32 Days. For HPC, two 50 mm long samples shall be cut from one of the cores representing a lot and tested to determine the acceptance of the lot. The other core shall be retained for referee testing.

For silica fume overlays, one 50 mm sample shall be cut from each of 2 cores. Two samples for the lot shall be tested to determine the acceptance of the lot. The remaining 2 cores shall be retained for referee testing.

Individual test results shall be forwarded to the Contractor, as they become available.

1350.08.03.02 Basis of Acceptance

Acceptance of rapid chloride permeability shall be based on the average of results obtained on cores representing a lot. Lots with an average value of rapid chloride permeability exceeding 1,000 coulombs and less than or equal to 2,000 coulombs shall be accepted with a price reduction. Lots with rapid chloride permeability value exceeding 2,000 coulombs shall be considered unacceptable. Unacceptable concrete shall be removed and replaced at the Contractor's expense.

For the purpose of calculating penalty, the Contract Administrator shall determine the quantity of concrete in the lots using the dimensions as specified in the Contract Documents.

The payment reduction shall be calculated and applied as follows:

$$Pa = (C-1000)/5$$

Where: Pa = payment reduction in \$/m³
C = average rapid chloride permeability of a lot

$$\text{Payment reduction per lot} = \text{lot quantity (m}^3\text{)} \times Pa$$

1350.08.03.03 Referee Testing

Referee testing of rapid chloride permeability may only be invoked by the Contractor within 5 Business Days of receipt of the acceptance test result.

For HPC, referee testing shall be carried out on two 50 mm samples obtained from the reserved core representing the lot for which referee testing was invoked and the results shall be averaged to obtain the test result for the lot. For silica fume overlay, referee testing shall be carried out on two 50 mm samples cut from the two reserved cores representing the lot for which referee testing was invoked and the results shall be averaged to obtain the test result for the lot.

Cores shall be tested according to LS-433.

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

When the referee result is greater than the acceptance test result or no more than 200 Coulombs below the acceptance test result, the acceptance test result is then confirmed and shall remain valid. When the referee test result for the lot is more than 200 Coulombs below the acceptance test result, the acceptance test result is then not confirmed and the referee test result shall replace the acceptance test result in the acceptance requirements of this specification.

1350.08.03.03.01 Referee Testing Cost

The cost of referee testing shall be as specified in the Contract Documents.

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

1350.08.04 Acceptance of Admixtures, Water and Cementing Materials

1350.08.04.01 Admixtures

1350.08.04.01.01 General

Air entraining admixtures shall be tested by the Owner for pH and relative density. Chemical and superplasticizing admixtures shall be tested by the Owner for relative density and non-volatile content. Testing shall be according to LS-413, LS-414, and LS-415, as applicable.

One 750 ml admixture sample shall be used for acceptance testing. The other 750 ml admixture sample shall be reserved for referee testing.

Individual test results shall be forwarded to the Contractor, as they become available.

1350.08.04.01.02 Basis of Acceptance

Relative density, pH and non-volatile content shall be according to OPSS 1303. Admixtures represented by sample test results that fail to fall within the specified tolerances for pH, relative density, or non-volatile content shall be deemed unacceptable and no further concrete shall be produced with that supply of admixture.

For each admixture represented by sample test results that exceed the tolerances specified by OPSS 1303 and before any additional concrete can be placed, the Contractor shall remove and replace the admixture with a new supply of admixture meeting the requirements of OPSS 1303.

For each sample of air-entraining admixture that exceeds the tolerances for relative density, or pH, or both, as shown in Table 9, in addition to the removal and replacement of the admixture represented by the sample, a payment reduction of \$5000 shall be assessed.

For each chemical admixture sample that exceeds the tolerances for relative density, or non-volatile content or both, as shown in Table 9, in addition to the removal and replacement of the admixture represented by the sample, a payment reduction of \$5000 shall be assessed.

For each superplasticizing admixture sample that exceeds the tolerances for relative density, or non-volatile content or both, as shown in Table 9, in addition to the removal and replacement of the admixture represented by the sample, a payment reduction of \$5000 shall be assessed.

Notwithstanding the above, concrete made with admixtures that do not meet the specified requirement may be subject to additional financial penalty or removal if the deficiency has the capacity to adversely impact the short or long term performance of the concrete.

1350.08.04.01.03 Referee Testing

Referee testing of admixtures may only be invoked by the Contractor within 5 Business Days of receiving the test results. Referee testing shall be carried out on the reserved referee sample.

The referee laboratory shall be designated by the Owner based on the applicable roster. Referee samples shall be transported from the Regional Quality Assurance laboratory to the Referee Laboratory by the Owner, and testing shall be carried out according to LS-413, LS-414, and LS-415, as applicable.

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

The referee test results shall replace the original results.

The cost of referee testing shall be as specified in the Contract Documents.

When the referee results indicate that the refereed sample is acceptable, the Owner shall bear the cost. When the referee results indicate that the refereed sample is not acceptable, the Contractor shall be charged the cost of the admixture referee testing.

1350.08.04.02 Water Other than Municipal Drinking Water

1350.08.04.02.01 General

Samples of water, other than municipal water, shall be tested by the Owner according to OPSS 1302.

One 1-litre water sample shall be used for acceptance testing. The other 1-litre water sample shall be reserved for referee testing.

Individual test results shall be forwarded to the Contractor, as they become available.

1350.08.04.02.02 Basis of Acceptance

Water that fails the requirements of OPSS 1302 shall be deemed unacceptable and the source of water represented by the failed samples shall not be used for making of concrete.

Concrete made with water that does not meet the specified requirements is unacceptable and may be subject to financial penalty or removal if there is potential for the short-term or long-term performance of the concrete to be adversely affected.

1350.08.04.02.03 Referee Testing

Referee testing of water may only be invoked by the Contractor within 5 Business Days of receiving the test results. Referee testing shall be carried out on the reserved referee sample.

The referee laboratory shall be designated by the Owner based upon the applicable roster. Referee samples shall be transported from the Regional Quality Assurance laboratory to the Referee Laboratory by the Owner, and testing shall be carried out according to OPSS 1302.

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

The referee test results shall replace the original result.

The cost of referee testing shall be as specified in the Contract Documents.

When the referee results indicate that the refereed sample is acceptable, the Owner shall bear the cost. When the referee results indicate that the refereed sample is not acceptable, the Contractor shall be charged the cost of the water referee testing.

1350.08.04.03 Cementing Materials

1350.08.04.03.01 General

Cementing materials shall be tested by the Owner for fineness, soundness by autoclave, initial time of set, compressive strength, and slag activity index or pozzolanic strength activity index, as applicable, according to CSA A 3000.

One 10-kilogram sample shall be taken and divided into two 5-kilogram samples. One 5-kilogram sample shall be used for acceptance testing. The second 5-kilogram sample shall be reserved for referee testing.

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

1350.08.04.03.02 Basis of Acceptance

Cementing materials that do not comply with the requirements of OPSS 1301 and CAN/CSA A3001 shall not be used for making of concrete.

Concrete made with cementing materials that do not meet the specified requirements is unacceptable and may be subject to financial penalty or removal if there is potential for the short-term or long-term performance of the concrete to be adversely affected.

1350.08.04.03.03 Referee Testing

Referee testing of cementing materials may only be invoked by the Contractor within 5 Business Days of receiving the test results. Referee testing shall be carried out on the reserved referee sample.

Referee testing shall be carried out according to CSA A 3000 by the Owner's laboratory or an independent laboratory acceptable to the Contractor and the Owner in the presence of the Contractor or his designate.

Referee results shall be reported to the Contractor, as they are available.

The referee test results shall replace the original result.

The cost of referee testing shall be as specified in the Contract Documents.

When the referee results indicate that the refereed sample is acceptable, the Owner shall bear the cost. When the referee results indicate that the refereed sample is not acceptable, the Contractor shall be charged the cost of the cementing material referee testing.

TABLE 1
Slump and Air Content of Plastic Concrete

Component	Slump mm (Note 1)	Air Content in Plastic Concrete %
Cast-In-Place, Slip formed Concrete Barriers	Target slump \pm 10	Target air \pm 1.5
Tremie Concrete	Target slump \pm 30	When required 5.0 \pm 1.5
All Other Concrete	Target slump \pm 20	Target air \pm 1.5
<p>Note:</p> <p>1. When the use of superplasticizer is permitted, requirements shall be as specified in the Concrete clause.</p>		

TABLE 2
Determination of Within-Batch Uniformity of the Concrete

Test	Range Between Highest and Lowest Values of 3 Test Samples	
	Acceptable If Equal to or Less Than	Rejectable If More Than
Density, kg/m ³	32	50
Air Content in Plastic Concrete,%	0.7	1.0
Slump, mm	30	50

TABLE 3
Cores for Air Void System Determination

Category	Lot Size	Core Size	Number of Cores Per Lot
Sidewalk on Structure and Curb on Structure	500 lineal metres per stage.	100 mm diameter and 200 mm long.	2
Median on Structure	500 lineal metres per stage.		
Parapet or Barrier Wall on Structure	500 lineal metres per structure per stage.		
Toe Wall	500 lineal metres per stage.		
Bridge Deck-Thin Slab Deck	500 m ² per stage.		
Bridge Deck-Post-Tensioned Deck	300 m ² per stage.		
Abutment, Wingwall, Cast-In-Place Retaining Wall	1 abutment, wingwall, cast-in-place retaining wall or a stage thereof.		
Pier	1 pier. (Note 1)		
Arches and Spandrels	Between piers or between pier and abutment.		
Culvert	1,000 m ² of floor area of cast-in-place concrete culvert. (Note 2)		
	All cast-in-place concrete associated with a precast culvert.		
Approach Slab	500 m ² per stage.		
Sidewalk and Curb With Gutter	500 lineal metres. (Note 3)	100 mm diameter and a minimum of 125 mm long.	2
Concrete Barrier	Cast-in-place, slip formed: 1,000 lineal metres. (Note 3)	100 mm diameter and 200 mm long.	2
	Cast-in-place, formed, including transitions: 250 lineal metres. (Note 3)		
Concrete Patches and Refacing	Approximately equal in size and not greater than 100 m ² for each individual structure.	150 mm diameter and 100 mm long.	1
Overlays	300 m ² per placement per individual structure.	150 mm diameter and 100 mm long.	1
Concrete Pavement and Concrete Base	Covered by OPSS 350		
<p>Notes: 1. A pier consists of columns and a pier cap. 2. The total floor area of a component shall be added together and then divided into lots of specified size. Where a culvert has no floor, the area of the upper surface shall be used as the basis of determining lots. 3. The total length of a component shall be added together and then divided into lots of specified size.</p>			

**TABLE 4
Cores for Rapid Chloride Permeability Determination**

Category	Lot Size	Core Size	Number of Cores Per Lot
Sidewalk on Structure and Curb on Structure	500 lineal metres per stage.	100 mm diameter and a minimum 125 mm long.	2
Median on Structure	500 lineal metres per stage.		
Parapet or Barrier Wall on Structure	500 lineal metres per stage.		
Bridge Deck	500 m ² per stage.		
Abutment, Wingwall, Cast-In-Place Retaining Wall	1 abutment, wingwall, cast-in-place retaining wall or a stage thereof.		
Pier	1 pier. (Note 1)		
Arches and Spandrels	Between piers or between pier and abutment.		
Overlays	300 m ² per placement for each individual structure.	100 mm diameter and 70 mm long. (Note 2)	4
<p>Notes:</p> <ol style="list-style-type: none"> 1. A pier consists of columns and a pier cap. 2. Where overlay thickness is less than 70 mm, the Contractor shall make cylinders for testing of rapid chloride permeability. 			

TABLE 5
Bonuses for Air Void System Parameters in All Hardened Concrete
\$/m³

		Air Content, %																																	
		3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	
Spacing Factor, mm	<0.100	0	1	2	3	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	3	2	1	0	
	0.100	0	1	2	3	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	3	2	1	0	
	0.110	0	1	2	3	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	3	2	1	0	
	0.120	0	1	2	3	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	3	2	1	0	
	0.130	0	1	2	3	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	3	2	1	0	
	0.140	0	1	2	3	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	3	2	1	0	
	0.150	0	1	2	3	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	3	2	1	0	
	0.160	0	1	2	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	2	1	0
	0.170	0	1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	1	0	
	0.180	0	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	0
	0.190	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
0.200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Notes:

- A. For silica fume overlays and HPC, when a core has an air content of 3% or higher and a spacing factor of 0.250 mm or lower, but its air void system parameters are outside the range shown in Table 5, it shall be assigned a value of 0 \$/m³ for the purpose of calculating a bonus.
- B. For all other concrete, when a core has an air content of 3% or higher and a spacing factor of 0.230 mm or lower, but its air void system parameters are outside the range shown in Table 5, it shall be assigned a value of 0 \$/m³ for the purpose of calculating a bonus.

TABLE 6
Pay Factor for Air Void System Parameters of Hardened Concrete for Concrete Other Than Silica Fume Overlays and HPC
Pay Factor in % of Tender Item Price Per Lot

	Air Content, %																				
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	>2.9
<0.100	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.100	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.110	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.120	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.130	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.140	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.150	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.160	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.170	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.180	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.190	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.200	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.210	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.220	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.230	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.240	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95
0.250	48	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95
0.260	45	48	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93
0.270	43	45	48	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90
0.280	40	43	45	48	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88
0.290	38	40	43	45	48	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86
0.300	36	38	40	43	45	48	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83
0.310	33	36	38	40	43	45	48	50	52	55	57	59	62	64	67	69	71	74	76	79	81
0.320	31	33	36	38	40	43	45	48	50	52	55	57	59	62	64	67	69	71	74	76	79
0.330	29	31	33	36	38	40	43	45	48	50	52	55	57	59	62	64	67	69	71	74	76
0.340	26	29	31	33	36	38	40	43	45	48	50	52	55	57	59	62	64	67	69	71	74
0.350	24	26	29	31	33	36	38	40	43	45	48	50	52	55	57	59	62	64	67	69	71
0.360	21	24	26	29	31	33	36	38	40	43	45	48	50	52	55	57	59	62	64	67	69
0.370	19	21	24	26	29	31	33	36	38	40	43	45	48	50	52	55	57	59	62	64	67
0.380	17	19	21	24	26	29	31	33	36	38	40	43	45	48	50	52	55	57	59	62	64
0.390	14	17	19	21	24	26	29	31	33	36	38	40	43	45	48	50	52	55	57	59	62
0.400	12	14	17	19	21	24	26	29	31	33	36	38	40	43	45	48	50	52	55	57	59
0.410	9	12	14	17	19	21	24	26	29	31	33	36	38	40	43	45	48	50	52	55	57
0.420	7	9	12	14	17	19	21	24	26	29	31	33	36	38	40	43	45	48	50	52	55
0.430	5	7	9	12	14	17	19	21	24	26	29	31	33	36	38	40	43	45	48	50	52
0.440	2	5	7	9	12	14	17	19	21	24	26	29	31	33	36	38	40	43	45	48	50
0.450	0	2	5	7	9	12	14	17	19	21	24	26	29	31	33	36	38	40	43	45	48
>0.450	0	0	2	5	7	9	12	14	17	19	21	24	26	29	31	33	36	38	40	43	45

Note:

- A. When a core in an unacceptable lot has an air content of 3% or higher and a spacing factor of 0.230 mm or lower, the core shall be assigned a value of 100% for the purpose of calculating a penalty.
- B. Thick line between 0.230 and 0.240 mm spacing factor indicates maximum acceptable spacing factor.

TABLE 7
Pay Factor for Air Void System Parameters of Hardened Concrete for HPC and Silica Fume Overlays
Pay Factor in % of Tender Item Price Per Lot

	Air Content, %																				
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	>2.9
<0.100	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.100	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.110	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.120	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.130	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.140	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.150	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.160	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.170	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.180	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.190	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.200	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.210	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.220	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.230	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.240	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.250	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95	100
0.260	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95	95
0.270	47	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93	95
0.280	45	47	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90	93
0.290	42	45	47	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88	90
0.300	39	42	45	47	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86	88
0.310	36	39	42	45	47	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83	86
0.320	33	36	39	42	45	47	50	52	55	57	59	62	64	67	69	71	74	76	79	81	83
0.330	30	33	36	39	42	45	47	50	52	55	57	59	62	64	67	69	71	74	76	79	81
0.340	27	30	33	36	39	42	45	47	50	52	55	57	59	62	64	67	69	71	74	76	79
0.350	24	27	30	33	36	39	42	45	47	50	52	55	57	59	62	64	67	69	71	74	76
0.360	21	24	27	30	33	36	39	42	45	47	50	52	55	57	59	62	64	67	69	71	74
0.370	19	21	24	27	30	33	36	39	42	45	47	50	52	55	57	59	62	64	67	69	71
0.380	16	19	21	24	27	30	33	36	39	42	45	47	50	52	55	57	59	62	64	67	69
0.390	13	16	19	21	24	27	30	33	36	39	42	45	47	50	52	55	57	59	62	64	67
0.400	10	13	16	19	21	24	27	30	33	36	39	42	45	47	50	52	55	57	59	62	64
0.410	7	10	13	16	19	21	24	27	30	33	36	39	42	45	47	50	52	55	57	59	62
0.420	5	7	10	13	16	19	21	24	27	30	33	36	39	42	45	47	50	52	55	57	59
0.430	3	5	7	10	13	16	19	21	24	27	30	33	36	39	42	45	47	50	52	55	57
0.440	0	3	5	7	10	13	16	19	21	24	27	30	33	36	39	42	45	47	50	52	55
0.450	0	0	3	5	7	10	13	16	19	21	24	27	30	33	36	39	42	45	47	50	52
>0.450	0	0	0	3	5	7	10	13	16	19	21	24	27	30	33	36	39	42	45	47	50

Notes:

- A. When a core in an unacceptable lot has an air content of 3% or higher and a spacing factor of 0.250 mm or lower, the core shall be assigned a value of 100% for the purpose of calculating a penalty.
- B. Thick line between 0.250 and 0.260 mm spacing factor indicates maximum acceptable spacing factor.

TABLE 8
Admixtures, Water, and Cementing Materials - Minimum
Frequencies for Sampling and Testing

Material	Use or Type of Construction	Minimum Sampling Frequency (Note 1)	Minimum Sample Size (Note 2)
Air Entraining and Chemical and Superplasticizing Admixtures	All concrete.	One sample shall be taken at the beginning of concrete placement in each calendar year, no more than 30 Days prior to concrete placement.	Two samples shall be taken. Each shall be at least 750 ml.
Water Other Than Municipal Drinking Water	All concrete.	One additional sample shall be taken during the calendar year.	Two samples shall be taken. Each shall be at least 1 litre.
Cementing Materials: Portland Cement, Ground Granulated Blast Furnace Slag, Fly Ash, and Blended Silica Fume Cement	Concrete pavement and base.	One sample per Contract or one sample per each 10, 000 m ³ of concrete, whichever is more frequent.	10 kg of each cementing material used.
	Precast components.	One sample per calendar year.	
	All other concrete.	One sample per Contract or one sample per each 5,000 m ³ of concrete, whichever is more frequent.	

Notes:

1. Additional samples shall be taken every time there is a change in material source.
2. Admixture and water samples shall be contained in a 1 litre bottle of a suitable plastic with a lid. Cementing material samples shall be contained in a canvas bag with plastic insert, accompanied by MTO form PH-CC-340.

TABLE 9
Admixture Test Result Tolerances for Acceptance Purposes

Test Result	Air Entraining Admixtures	Chemical and Superplasticizing Admixtures
Relative Density	a) ± 0.010 where the value of relative density shown on DSM is 1.050 or less b) $\pm X$ where the value of relative density shown on DSM is greater than 1.050; Where $X = (\text{relative density shown on DSM} - 1.000) / 5$	
Non-volatile Content	Not required	$\pm 3.0\%$ of the value shown on DSM *
pH	± 2.0 of the value shown on DSM	Not required
* Example: If value shown on DSM is 10.0 %, no payment reduction will be applied if the result is between 7.0% and 13.0 %.		

**Appendix 1350-A, November 2016
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

No information provided here.

Related Ontario Provincial Standard Drawings

No information provided here

