INDEX TO CLAUSES

LIST OF TABLES

PART 1 - GENERAL

1.1 Work Included

.1 This section specifies requirements for constructing cast-in-place concrete. Work includes supply and installation of formwork, reinforcement, concrete, and accessories.

1.2 Reference Standards

The latest editions of all the following references shall apply to this specification.

.1 Joint Committee on Contract Documents Standard Specification for Municipal Services.

.2 AASHTO M182-05 (R2012), Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats.

.3 ASTM C1610/C1610M, Standard Test Method for Static Segregation of Self-Consolidating Concrete Using Column Technique.

.4 ASTM A933-14, Standard Specification for Vinyl Coated Steel Wire and Welded Wire Reinforcement.

.5 ASTM C260-10A (R2016), Standard Specification for Air-Entraining Admixtures for Concrete.

.6 ASTM C309-19, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.

.7 ASTM C457/C457-16, Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete.

.8 ASTM C494/C494M-19, Standard Specification for Chemical Admixtures for Concrete.

.9 ASTM C597-22, Standard Test Method for Ultrasonic Pulse Velocity Through Concrete.

.10 ASTM C805/C805M-2018, Standard Test Method for Rebound Number of Hardened Concrete.

.11 ASTM C1017-13E1, Standard Specification for Chemical Admixtures for Use in Producing Flooring Concrete.

.12 ASTM C1383-15, Standard Test Method for Measuring the P-Wave Speed and the Thickness of Concrete Plates Using the Impact-Echo Method

.13 CSA A3000-23, Cementitious materials compendium.

.14 CSA A23.1:24/A23.2:24, Concrete materials and methods of concrete construction/methods of test and standard practices for concrete.

.15 CSA A23.4-16, Precast concrete – materials and construction.

.16 CSA A283:124 Qualification code for concrete testing laboratories.

.17 CSA G30.18-09 (R2019), Billet-steel bars for concrete reinforcement.

.18 CSA S269.1-16, Falsework and formwork.

.19 ISO 10005:2018, Quality Management – Guidelines for quality plans.

1.3 Related Sections

.1	Precast Manholes, Catch Basins, and Structures	Section 33 39 00
.2	Walks, Curbs, and Gutters	Section S-11, Part B
.3	Interlocking Concrete Pavers	Section S-12

1.4 Submittals

Submittals pertain to Part A – Concrete and Part B – Walks, Curbs and Gutters, where applicable.

.1 A Quality Management Plan (QMP) shall include information regarding hot and cold weather concrete and applies to HRM flatwork projects including (but not limited to) Street Recapitalization projects, hereafter referred to as the project(s).

A QMP shall be submitted to the Engineer (TPW.TIM@halifax.ca) for review, a minimum of 15 working days prior to commencement of any concrete work as part of the project(s). The Engineer will provide written approval of the Contractor's QMP (Contractor QMP Approval Letter) in a timely manner, prior to commencement of this work.

The Contractor has the option to submit a comprehensive QMP to the Engineer (TPW.TIM@halifax.ca) for review, prior to the construction season and commencement of any concrete work as part of the project(s). This QMP shall be applicable for the entire construction season (ends December 30th of the calendar year) and pertains to all concrete work expected for that season, by the

Contractor. The Engineer will provide a Contractor QMP Approval Letter prior to the start of the construction season, which shall be submitted by the Contractor for each project as part of the preconstruction documents identified in HRM Construction's *Contractor Required Pre Construction Information* list.

If the Engineer deems the Contractor's QMP submission unacceptable, the Contractor shall provide iterations in a timely manner until the QMP is considered adequate by the Engineer. Construction of any concrete work as part of a project(s) shall not commence without submission of the Contractor QMP Approval Letter for the project. At the Engineer's discretion, a project specific QMP may be requested at any time to fit the criteria of a unique project. This request will be identified in contract specifications during the tendering process.

Note, if deemed necessary by the Contractor, an amended QMP can be submitted to the Engineer for review and approval at any point throughout the construction season (ends December 30th of the calendar year).

.2 The QMP shall include:

.1 All mix design summaries (properties) for mixes to be used on the project, including respective qualification testing as detailed in Section 2.1.

.2 Proposed frequency of testing for plastic and hardened concrete (slump, air content, mass density, temperature, and compressive strength) and method for reporting of results to HRM. Proposed frequency at a minimum to follow CSA A23.2:24-25C Clause 7.1.4.

.3 Complete procedures for proposed finishing, curing, and storage.

.4 Description of non-conformance processes for identifying and addressing non-conformant defects or issues in the concrete work.

.5 Description of communication methods when addressing non-conformant defects or issues in the concrete work, and escalation process for HRM to follow when an issue needs to be resolved.

An outline for a QMP, based on ISO 10005, is provided for reference in Attachment A.

.3 Submit shop drawings in accordance with Section 01 10 00 Clause

1.7.1 from latest edition of the Joint Committee on Contract Documents Standard Specification for Municipal Services. Shop drawings are required for structural elements only. At a minimum, shop drawings for each structural element shall include (but is not limited to) dimensions, tolerances, and concrete cover if applicable. Unless specified in project documentation, shop drawings are not required for non-structural elements such as sidewalks and curbs.

.4 Submit to the Engineer for acceptance all required documentation as outlined in CSA A23.1:24 – Table 5 Alternative 1 "Performance", along with CSA A23.2:24-24C Clause 7.2 demonstrating that each proposed concrete mix design will meet their respective performance requirements.

.5 For exposure classes C-XL, C-1, C-2, C-3, C-4, and F-1, submit test data for any proposed aggregate sources following CSA A23.2:24-27A Clause 5.3 from a testing laboratory certified by the Canadian Council of Independent Laboratories that shows measures taken to mitigate alkali silica reaction. The data shall be submitted with the QMP. Further submissions are required for any change in the quality, quantity, or proportion of materials used in any proposed concrete mixture, with a tolerance of +/- 5% or as defined in Project Documentation.

.6 For bridge structures and cold weather concrete work constructed for walks, curbs, and gutters, non-reactive coarse and fine aggregate, as defined in CSA A23.1:24 Clause 4.2.3, shall be used. Submit non-reactive alkali aggregate reaction (AAR) performance documentation for aggregates used in the mix design, consisting of at least five (5) consecutive tests performed in accordance with CSA A23.2:24-14A or CSA A23.2:24-25A over a period of at least five (5) years, while not exceeding ten (10) years.

.7 Unless noted otherwise, all test results used for qualification purposes shall be from tests completed within one (1) calendar year.

.8 Certification and Membership

.1 The Ready Mixed Concrete Supplier (hereafter concrete producer) shall provide current plant certification and membership certificates issued by the Atlantic Concrete Association (ACA) to comply with CSA A23.1:24 Clause 5.2.1.

.2 Upon written request from HRM, the Contractor shall

coordinate with the concrete producer(s) to allow for HRM (or its representative) to perform an inspection at the concrete producer's location (facility) for any concrete being produced for the project, *if requested* by HRM to perform forensic analysis. For clarity, it is the responsibility of the Contractor, and not HRM, to coordinate this inspection and such inspection is to occur during the period set forth in the written notification or during another period agreed to by HRM in writing. The inspection conducted by HRM (or its representative) may include any of the following:

- Production record review
- Batch tolerances
- Material storage
- Calibration records
- Quality control procedures
- Equipment condition
- Environmental and safety procedures

.9 Prior to use of any proposed self-consolidating concrete (SCC) mixture, a trial batch must be produced and tested to demonstrate mix design meets the performance requirements following CSA A23-1:24 Table 22 for Flow, T- 50 cm time and VSI value. If component has reinforcement, a J-ring test shall be performed. ASTM C1610/C1610M Column Segregation shall be used for pre-qualification of mix design.

.10 If requested by HRM, the concrete supplier, within 10 working days, shall provide documentation that the facility, materials, and products selected for use on a project address any of the following:

.1 Compliance with latest Nova Scotia Environment Act and regulations pertaining to Industrial facilities. All facilities shall comply with water taking permits, air and noise pollution, discharge of process water and waste generation regulations.

.2 For each mix design proposed, an Environmental Product Declaration (EPD) verified by a CSA-recognized verifier is required. Relevant EPDs published by the Atlantic Concrete Association are satisfactory. If a mix design lacks an approved EPD, a new EPD must be conducted and verified by a CSA-recognized verifier. Recognized verifiers can be found online at https://www.csaregistries.ca/GHG_VR_Listing/EPD_Verifier_Page

PART 2 - PRODUCTS

2.1 Materials

.1 Portland Cement: to CSA Standard A3001:23, Table 1 for Portland cement chemical requirements, Table 4 for physical requirements, and CSA A23.1:24 Table 6.

.2 Blended Hydraulic Cement: CSA Standard A3001:23 Table 2 for Portland cement chemical requirements, Table 5 for physical requirements, and CSA A23.1:24 Table 7.

.3 Where supplementary cementing materials are employed to mitigate potentially deleterious expansions due to AAR, the minimum level of supplementary material shall be in accordance with Table 7 of CSA Standard Practice A23.2:24-27A. Concrete curb and gutter, pavers, and sidewalks shall be classified as St3 and retaining walls as St4 according to Table 5 of the standard practice.

.4 Non-reactive coarse and fine aggregate, as defined in CSA A23.1:24 Clause 4.2.3, shall be used for bridge structures and for cold weather concrete work constructed for walks, curbs, and gutter. Frozen lumps of aggregate shall always be excluded from concrete mix. Prior to the start of any project using non-reactive aggregate, the ready-mix concrete supplier shall have at the place of production, enough aggregate to complete the entire concrete section scheduled for that day.

.5 Returned Hardened Concrete (RHC) further defined in CSA A23.1:24 Annex 0.1.3 Point C and Reclaimed Concrete Material (RCM) further defined in CSA A23.1:24 Annex 0.1.3 Point B shall follow CSA A23.1:23 Clause 4.2.3.4.1, along with the following requirements:

1. The concrete producer shall ensure the amount of RCM and/or RHC does not compromise the performance of the mix.

2. RCM and/or RHC aggregates, whether individually sourced or blended, shall follow CSA A23.1:24 Clause 4.2.3.2.2.

3. HRM shall be notified 10 working days prior to the use of RCM or RHC stockpiled material. HRM reserves the right to inspect the RCM or RHC stockpiles for contamination of materials other than concrete or natural aggregates. If contaminants are found, the stockpile will be rejected for use.

.6 Upon acceptance of the aggregates, the source and method of manufacture shall not be altered for the duration of the contract.

Aggregates shall be stored and maintained in such a manner to avoid the inclusion of foreign materials in the concrete and such that no equipment will be operated on the stockpiles. The stockpiles shall be constructed to prevent segregation or contamination.

.7 Fine aggregate shall be washed and classified to conform to the gradation limits specified in CSA Standard A23.1:24 Clause 4.2.3.3.2.1. Coarse aggregates shall consist of washed stone and conform to the gradation limits specified in CSA A23.1:24 Clause 4.2.3.4.2. The maximum combination of flat, elongated, and flat and elongated particles, as defined in CSA A23.2:24-13A, shall not exceed 10% of the mass.

.8 Water must be in accordance with CSA-A23.1:24, Table 9. Aggregates and water combined are not to exceed 35 ºC when in contact with cementitious materials.

.9 Admixtures:

.1 Air Entraining according to ASTM C260.

.2 Chemical according to ASTM C494/C494M or C1017 for flowing concrete.

.10 Adhere to CSA A3000:23 for the inclusion of supplementary cementing materials, considering potential ASR effects.

.11 Reinforcement:

.1 Bars according to CSA G30.18, billet steel, grade 400, deformed.

.2 Welded Steel Wire Fabric according to ASTM A933.

.3 Bar Supports and Spacers according to CSA A23.1:24 Clause 6.6.7.

.4 Tolerance for location of reinforcement according to CSA A23.1:24 Clause 6.6.8.

.12 Formwork:

.1 Form materials shall comply according to CSA S269-16 Clause 4.

.2 Form Ties according to CSA A23.1:24 Clause 6.6.4, removable or snap-off metal ties, fixed or adjustable length. Form ties, tie wire, other embedded fixtures susceptible to

corrosion shall not be positioned within the minimum cover distance. Form ties and tie wires shall be bent down to ensure minimum cover is maintained. For severe environments, dimension to be shown on the Project Drawings.

.3 Release Agent shall be non-staining natural organic chemicals of sprayable consistency which prevent adhesion of concrete to forms.

.4 Design according to CSA S269.3.

.13 Curing compound according to CSA A23.1:24 Clause 7.8, white pigmented. Refer to AASHTO M182 and ASTM A309.

.14 Waterstops:

.1 Ribbed or flexible strip, extruded PVC waterstops of type and size indicated.

.2 Bentonite shall be NSF certified, expandable strip composed of sodium bentonite, complete with adhesive if product is not self-adhering.

.15 Non-shrink grout pre-mixed, dry pack or pourable, containing non-metallic aggregate, plasticizing agents and cement, minimum compressive strength of 45 MPa at 28 days.

2.2 Concrete Mix

.1 Provide in accordance with CSA A23.1, Table 5, Alternate (1) "Performance."

.1 Performance requirements as outlined in Project Documentation or within respective Municipal Specifications.

.2 Mix proportions to provide workable concrete having required durability and strength.

.3 Air entraining admixtures: to obtain Air Content Category as defined in CSA A23.1, Tables 2, 3, and 4.

.4 Slump: to CAN/CSA A23.1:24, Clause 4.3.2.3.

.5 Compressive strength shall meet minimum strength requirements and specified age as per CSA A23.1:24 Table 2.

.6 Water to cementing materials ratio shall be according to CSA A23.1, Tables 2, 3, and 4 as required for exposure conditions.

.7 Cold weather concreting shall meet limits specified in CSA A23.2:24-Clause 7.2.2

.8 Hot weather concreting shall meet limits specified in CSA A23.2:24 Clause 7.2.1.

.9 Concrete temperature at placement shall meet limits of CSA A23.1:24 Table 14, within tolerance of specified minimum dimension of section.

Table 1: Permissible Concrete Temperatures at Placing (CSA A23.1:24 Table 14)

Temperatures, °C		
Thickness of section, m	Minimum	Maximum
< 0.3	10	32
≥ 0.3 - < 1	10	30
≥ 1 - < 2	5	25
≥ 2	5	20

.10 On site water addition for Portland cement concrete to comply with CSA A23.1:24 Clause 5.2.5.3.2 “Addition of Water on the job site”.

2.3 Advanced Concrete Testing

.1 Advanced concrete testing in this section shall refer to Air Void Analysis of Hardened Concrete (ASTM C457) and Resistance to Chloride Ion Penetration (A23.2:24-23C), tested in accordance with CSA A23.2:24.

.2 Price adjustment tables apply whenever advanced concrete testing is conducted, as defined by Clause 2.3.4 for Air Void Analysis of Hardened Concrete and Clause 2.3.5 for Resistance to Chloride Ion Penetration and shall apply to the concrete unit price.

.3 Advanced concrete testing to be conducted by Owner’s Consultant and any resultant payment adjustment shall apply solely to the Contractor. It is the responsibility of the Contractor and concrete producer to form their own agreement on price adjustment distribution.

.4 Concrete with an air content specified as Category 1, as described by CSA A23.1:24 Table 4, shall follow CSA A23.1:24 Clause 4.3.3.3.

.1 Total air content of hardened concrete shall be greater than or equal to 3.0 percent.

.2 Hardened concrete of the same mix shall have an average spacing factor less than 230 µm, with no single value greater than 260 µm.

.1 For mixes with a water to cementing material ratio equal or less than 0.36, the average spacing factor shall not exceed 250 µm, with no single value greater than 300 µm.

.3 Dependent upon the average spacing factor for the air-void system as well as the total air content measured within the hardened concrete, the following price adjustments shall apply to the unit price supplied for concrete with a water to cementing material ratio:

.1 w/cm greater than 0.36.

Table 2: Price Adjustments for Hardened Air Void Content (ASTM C457), w/cm > 0.36

Spacing Factor (mm)	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	≥3.0
<0.200	Reject	0.52	0.55	0.57	0.60	0.62	0.65	0.69	0.71	0.74	0.76	0.79	0.81	0.83	0.86	0.88	0.90	0.93	0.95	0.95	1.00
0.200	Reject		0.52	0.54	0.56	0.58	0.60	0.62	0.65	0.69	0.71	0.74	0.76	0.79	0.81	0.83	0.86	0.88	0.90	0.93	1.00
0.210	Reject			0.52	0.54	0.56	0.58	0.60	0.62	0.65	0.69	0.71	0.74	0.76	0.79	0.81	0.83	0.86	0.88	0.91	1.00
0.220	Reject						0.56	0.58	0.60	0.62	0.65	0.69	0.71	0.74	0.76	0.79	0.81	0.83	0.86	0.89	1.00
0.230	Reject										0.50	0.53	0.57	0.60	0.62	0.65	0.70	0.75	0.77	0.80	1.00
0.240	Reject															0.50	0.52	0.54	0.56	0.58	0.60
≥0.250	Reject																				

.2 w/cm equal or less than 0.36.

Table 3: Price Adjustments for Hardened Air Void Content (ASTM C457), w/cm < 0.36

Spacing Factor (mm)	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	≥3.0
<0.200	Reject	0.52	0.55	0.57	0.60	0.62	0.65	0.69	0.71	0.74	0.76	0.79	0.81	0.83	0.86	0.88	0.90	0.93	0.95	0.95	1.00
0.200	Reject		0.52	0.54	0.56	0.58	0.60	0.62	0.65	0.69	0.71	0.74	0.76	0.79	0.81	0.83	0.86	0.88	0.90	0.93	1.00
0.210	Reject			0.52	0.54	0.56	0.58	0.60	0.62	0.65	0.69	0.71	0.74	0.76	0.79	0.81	0.83	0.86	0.88	0.91	1.00
0.220	Reject						0.56	0.58	0.60	0.62	0.65	0.69	0.71	0.74	0.76	0.79	0.81	0.83	0.86	0.89	1.00
0.230	Reject										0.50	0.53	0.57	0.60	0.62	0.65	0.70	0.75	0.77	0.80	1.00
0.240	Reject													0.50	0.54	0.57	0.63	0.67	0.69	0.72	1.00
0.250	Reject																	0.50	0.52	0.65	1.00
≥0.250	Reject																				

.5 Concrete described as C-1 or C-XL according to CSA A23.1:24 Table 2, shall be tested via chloride ion penetrability in accordance with A23.2:24-23C.

.1 For C-XL, the chloride ion penetrability shall be measured as less than 1000 coulombs and tested within 91 days of placement. The following price adjustment shall apply for C-

XL concrete dependent upon the average chloride ion penetrability result and applied to the unit price for concrete.

Table 4: Price Adjustments for Resistance to Chloride Ion Penetration (A23.2:24-23C), Class C-XL

High Performance Concrete (Class C-XL)					
Resistance level to Chloride Ion Penetration	Great	Good	Below Standard	Poor	Extremely Poor
Coulombs*	0-500	500-1000	1000-1500	1500-2000	>2000
Unit Price Adjustment Factor	1.1	1.0	0.80	0.50	0.10 or full removal, as determined by the Engineer

* After corrosion inhibitor correction if applicable

.2 For C-1, the chloride ion penetrability shall be measured as less than 1500 coulombs and tested within 91 days of placement. The following price adjustment shall apply for C- 1 concrete dependent upon the average chloride ion penetrability result and applied to the unit price for concrete.

Table 5: Price Adjustments for Resistance to Chloride Ion Penetration (A23.2:24-23C), Class C-1

C-1 Exposure Concrete					
Resistance level to Chloride Ion Penetration	Great	Good	Adequate	Poor	Very Poor
Coulombs*	0-500	500-1000	1000-1500	1500-2000	>2000
Unit Price Adjustment Factor	1.1	1.0	1.0	0.80	0.10 or Full Removal, as Determined by the Engineer

* After corrosion inhibitor correction if applicable

PART 3 - EXECUTION

3.1 General

.1 Unless stated otherwise in Project Documentation or directed by the Engineer, plastic properties to be checked at a rate of one (1) test per load until satisfactory control is established. Typically, to demonstrate satisfactory control it is advised to test the first three to five loads to ensure consistency. If a test falls outside of any specified range from either quality control (QC) testing or via the Owner's Consultant, immediate notification shall be provided to the Engineer or HRM representative. Upon notification, the

Engineer or representative may request increased QC testing frequency until consistency is re-established. Once consistency is established, the plastic properties shall then be checked once every tenth load.

.2 Use ready-mixed concrete unless on-site mixings approved by the Engineer.

.1 Equipment for on-site mixing to be capable of accurately proportioning ingredients to produce required concrete.

.3 The Engineer (TPW.TIM@halifax.ca) shall be notified of concrete mix design changes. Changes in material supply will require submission of a new mix design as well as relevant qualification documentation for review by the Engineer, at least 1 working day prior to anticipated use.

3.2 Formwork and Falsework

.1 Formwork design and the proposed method of construction shall meet all necessary requirements in terms of strength and properties of material, rigidity, and erection tolerances as presented in Section 3.2 of this specification. Formwork shall also be compliant with the requirements of CSA S269.1 as well as other requirements described in CSA A23.1:25 Clause 6.5 “Formwork”.

.2 Formwork shall be built with sufficient strength and rigidity to carry the mass or fluid pressure of the Portland cement concrete (PCC) as well as all construction loads including wind, equipment, and runways which might be placed upon them. The fluid pressure on forms shall be correlated to the capacity and type of placing equipment, the rate of placing, slump, and temperature of the PCC.

.3 Formwork shall be supported by stiff members in two directions at right angles which are sufficiently rigid to hold the unit in line and in proper position and shape. Formwork shall be accurately located, rigidly tied, or braced to resist vertical or horizontal movements, and adequately supported. However, they shall be so arranged to allow for easy stripping to prevent damage of the PCC during removal.

.4 Formwork for SCC shall meet the requirements of CSA A23.1:24 Clause 6.5.3.1 and be designed to prevent paste loss. Design of the formwork shall assume that a full liquid head will be developed once placing is completed. Areas of focus include, but are not limited to, joints, holes for ties, and sill plates on foundation

footings or slab surfaces.

.5 Construct formwork to produce finished concrete to required shape, dimensions and levels indicated within tolerances required by CSA A23.1:24 Clause 6.5.3.1. Provide close fitting joints to prevent leakage of mortar and form ties and bracing sufficient to withstand pressure of plastic concrete without deflection.

.6 The Contractor shall construct the falsework and formwork in accordance with the approved drawings. Variations from the drawings shall not be permitted unless such variations are approved by the Engineer. Both the falsework and formwork shall be designed and constructed to provide the necessary rigidity and to support the loads without settlement or deflection.

.7 All falsework and formwork used to support fresh concrete during construction of the following components shall be designed by a Nova Scotia Registered Professional Engineer in accordance with CSA S269.1:16.

- Bridge decks and pier caps;
- Columns over 3 m in height;
- Retaining walls over 3 m in height;
- Roofs of structures under which persons are required to work; and,
- As required on the contract drawings.

.8 Use commercially available formwork release agent that will prevent the formwork absorption of moisture, prevent bond with concrete and not stain the concrete surface. Environmentally friendly form release materials shall be considered.

.9 Complete formwork removal in accordance with CSA A23.1:24 Clause 6.5.3.5.

.10 Fill form tie holes with non-shrink mortar and finish to texture of adjacent concrete.

.11 Under adverse weather conditions the Contractor shall be prepared to provide suitable protection to prevent damage to Portland cement concrete as per CSA A23.1:24 Clause 7.6 with methods subject to the approval of the Engineer.

3.3 Reinforcement and Embedded Items

.1 Surface condition of reinforcing to be in accordance with CSA A23.1:24 clause 6.1.6.

.2 Bend bars cold to measurements required.

.3 Confirm reinforcement and inserts are not disturbed during concrete placement.

.4 Place and support reinforcing using bar supports and side form spacers to obtain cover, spacing and location indicated.

.5 Reinforcing steel mesh to be positioned at appropriate height using non-reactive chairs.

3.4 Waterstops

.1 Install waterstops as specified in the Project Documents and in accordance with manufacturer's written instructions.

.2 Do not pierce or distort waterstops or displace reinforcement except near edges as required for securing.

3.5 Placing

.1 Place concrete to CSA A23.1:24 Clause 7.5.

.2 When cold weather concreting does not apply, place concrete on dampened base.

.3 Convey concrete from mixer to forms by methods that will maintain specified slump and prevent segregation.

.4 Do not drop concrete more than 1.5 metres vertically unless it can be shown that the concrete will not segregate. Deposit concrete in final position in forms to avoid lateral movement.

.5 Place concrete in continuous operation, starting from lowest point in form, in lifts not greater than 500mm.

.6 Internally consolidate each layer to obtain dense homogeneous structure free of cold joints, fill planes, voids, and honeycombing.

.7 For vertical installation vibrate at least 150mm into previously placed layers. Concrete to be well bonded to all reinforcing steel, anchors, waterstops and other embedded parts.

3.6 Joint Sealants

.1 Use of joint sealants to be directed by the Engineer.

3.7 Finishing

.1 Finish concrete in accordance with CSA A23.1:24 Clause 7.7 or

as specified in Project Documentation.

3.8 Curing and Protection

.1 Provide curing and protection to CSA A23.1:24 Clause 7.6. Keep the temperature of the concrete within the limits of Table 14 unless stated otherwise within Project Documentation.

.2 Protection during hot weather concreting according to CSA A23.1:24 Clause 7.2.1.

.3 Do not place concrete on frozen base. Remove all snow, ice, and frost from area prior to placing concrete. Do not place concrete on, or against, any surface that will lower the temperature of the concrete in place below the minimum value shown in CSA A23.1:24 Table 14.

.4 When air temperature may drop below 5 ºC or when there is a probability that it will drop below 5 ºC within 24 hours of placing, raise temperature of base, reinforcing steel, embedded parts, and forms above 5 ºC prior to placing concrete. In addition, before placement have available all materials and equipment needed for adequate protection and curing.

.5 Curing or sealing of concrete shall be carried out as per CSA A23.1:24 Clause 7.1.2.2, or as directed by the Engineer.

.6 After placing is completed, maintain minimum curing conditions for the concrete in accordance with CSA A23.1:24 Clause 7.8.

3.9 Concrete Quality

.1 Contractor shall bear full responsibility for ensuring the quality of the concrete product. Additionally, the Owner reserves the right for their independent Consultant to perform quality assurance (QA) testing for verification purposes. Contractor shall facilitate the Owner's Consultant's sampling and casting of test specimens as per CSA A23.1:24 Clause 4.4, as requested by the Owner.

.1 Unless otherwise noted in Project Documentation, the Owner's Consultant shall at a minimum, cast one set of three (3) compressive strength test specimens for testing at 7 days (1 sample) and 28 days (2 samples); as well as an appeal test (1 sample) at 56 days if required, for every 50 m^3 or fraction of thereafter for each mix during each site visit.

.2 For advanced concrete testing, the Owner's Consultant shall cast an additional test specimen for a minimum of once per concrete mix used for the project for Air Void Analysis of

Hardened Concrete. For Concrete described as C-1 or C-XL a second additional test specimen shall be cast and be tested via chloride ion penetrability in accordance with A23.2:24-23C. For larger projects, the Owner's Consultant shall cast their first additional specimens within the first 50 m^3 placed per mix, and another set for every 150 m^3 or fraction of thereafter.

.3 The Engineer reserves the right to reject concrete that is not in compliance with clause 5.2.5 of CSA A23.1:24. When both QC and QA tests are conducted, the contractor should consider all results prior to adjustment or placement of loads.

.2 Concrete shall be produced at a stationary or portable plant. Concrete shall not be supplied to any HRM project unless the concrete producer has completed all required submittals and are approved for use by the Engineer.

.3 Test concrete in accordance with CSA A23.1:24 Clause 4.4 and self-consolidating concrete in accordance with CSA A23.1:24 Table 22, using a testing laboratory certified to CSA A283:24 by Canadian Council of Independent Laboratories to the appropriate category for the tests performed.

3.10 Cold Weather Concrete

.1 Cold weather concreting shall apply whenever the air temperature is below 5 ºC or is expected to fall below 5 ºC within 24 hours of placing of concrete. When cold weather concrete applies, the concrete shall meet the requirements as specified herein.

.2 Contractor to follow CSA A23.1:24 Clause 7.2.2.1 regarding site preparation.

.3 Granular base for sidewalk shall be dry and free of ice or frost at the time of concrete placement. Base courses below 5 ºC shall be preheated prior to placement of concrete.

.4 Immediately after placing, consolidation, and strike off, the concrete shall be covered with either insulation blankets or 6 mil polyethylene plastic film to retain heat until final finishing. Plastic film may only be used if the ambient temperature is forecast to remain above 10 ºC. If plastic film is used, the Contractor shall monitor the temperature within the film, and the Contractor shall place insulation blankets prior to the temperature falling below 10 ºC. The Contractor shall always maintain at site sufficient insulation blankets to cover the entirety of the new concrete.

.5 Protective covers in accordance with CSA A23.1:24 Clause 7.2.2.4. The covers shall be temporarily removed for final finishing and replaced immediately after finishing is complete. Covers shall remain in place until the concrete reaches a compressive strength of 20 MPa. Compressive strength tests of field cured samples shall be used (cured in same environment as concrete structure) to determine removal time of concrete protective covers. Complete cover removal to follow requirements of CSA A23.1:24 Clause 7.2.2.5.

.1 Compressive strength test results of field cured samples shall be provided to the Engineer prior to removal of protective covers.

.6 MasterProtect H 400 or Engineer approved alternative to be applied when concrete achieves 80% design strength and only when ambient and expected 12-hour temperatures remain within 4 ºC to 43 ºC. Application shall not proceed during rain, or when rain is expected to occur within 12 hours of application. The Contractor shall notify the Engineer prior to application. Application shall be applied as per manufacturer's instructions.

.1 When temperatures are expected to remain below 4 ºC during application window, Sikagard SN-100 or Engineer approved alternative shall be applied instead. Application of Sikagard SN-100 can occur down to a minimum temperature of -10 ºC. Application shall be as per manufacturer's instructions.

.7 Verification that the concrete supplied meets the cold weather protection requirements, shall be provided to the Engineer or their direct representative (HRM Construction Inspector onsite or electronically) for each supplied load.

.8 HRM may conduct and record the results of random temperature readings under the insulation blankets during the curing period.

3.11 Defective Work

.1 Compressive strength evaluation shall follow CSA A23.1:24 Clause 4.4.2.2. Compressive strength of concrete shall be adequate if it meets the following two criteria:

.1 An acceptable test result (ATR) is defined as the specified strength minus 3.5 MPa, when the specified strength is 35 MPa or less. If specified strength is higher than 35 MPa then the ATR is determined to be 90% of the design strength. Each individual strength test shall meet or exceed the ATR where a strength test is defined as the average between two same

day (28-day) compressive strength tests.

.2 The moving average of three (3) consecutive test results of the same concrete mixture shall meet or exceed the specified strength. If less than three results are available, the average of available results shall meet or exceed the specified strength.

.3 A defect fee of $500 shall apply for each incident where concrete fails to meet the acceptance criteria. An incident shall be identified as one or more failures within a single day, for each project, and each mix. The defect fee shall compensate for the Engineer's time required to inspect the defects, manage the appeal process, and compile necessary documentation.

.2 When evaluation results are deemed to be inadequate, the following shall occur:

.1 The appeal test specimen cast by the Owner's Consultant will be assessed using the criteria of CSA A23.1:24 Clause 4.4.2.2.

.2 If the appeal test specimen fails to meet an ATR, the Contractor may elect to core the area which did not achieve an ATR for the purposes of appealing. CSA A23.1:24 Clause 4.4.2.3.2 shall be followed, as described below. If core samples meet these requirements, the Contractor shall fill all core holes with a material approved by the Engineer and make efforts to blend the filled areas seamlessly with the existing surface.

.1 The average of each set of three (3) cores from the portion of the structure in question is equal to at least 85% of the specified strength.

.2 No single core is less than 75% of the specified strength.

.3 Cores should be retrieved with a length to diameter ratio of 2.0. The minimum permitted length to diameter ratio is 1.0. Cores with length to diameter ratios greater than 1.0 and less than 2.0 shall have correction factors applied in accordance with CSA Test Method A23.2:24-14C:24.

.4 The Engineer may also request additional uniformity testing via Schmidt Hammer (ASTM C805), Impact-Echo (ASTM C1383), Ultrasonic (ASTM C597), or

acceptable alternative, in conjunction with testing core samples.

.3 If appeal processes yield inadequate strengths, then the infrastructure in question shall be replaced as directed by the Engineer.

.4 All additional costs for appeals, replacement, and/or other remediation processes due to inadequate strength results are to be absorbed by the Contractor. Any contractor concerns over Owner's Consultant's conformance to CSA methods must be immediately communicated to the Engineer upon occurrence. Otherwise, will be given no consideration as a means of waiving additional costs associated with inadequate testing results.

.5 Any additional costs incurred for appeals, replacements, and/or other remediation resulting from Consultant's findings shall be the responsibility of the Contractor. It is incumbent upon the Contractor to address any concerns regarding sample integrity or testing methodology at the time of placement. No concerns raised after the review of testing results shall be considered.

.3 Replace all structural defects in concrete such as spalling, moderate to severe honeycombing, high points, low points, cracking, and delamination as deemed necessary by the Engineer.

.1 High and low points denoted as points outside of the surface tolerances outlined in CSA A23.1:24 clause 6.4, with a specific tolerance limit of 8mm.

.4 Replace all aesthetic defects in exposed concrete as deemed necessary by the Engineer. Aesthetic defects include minor honeycombing, ravelling, joint chipping, blemishes, embedded debris from tie holes, surface cracks, discolouration, formwork impressions, segregation, laitance, scaling, and general surface voids.

.5 Submit method and obtain approval of the Engineer prior to proceeding with remediation of all structural and aesthetic defects.

.6 Defective concrete work shall be evaluated for spalling via depth gauges and calipers, or via visual assessment, as necessary during the 2-year warranty period. Overall assessment shall be based on the following criteria:

Table 6: Criteria for Assessment of Defective Concrete

Condition	Depth of Spalling	Area (%) of Panel
1R	≤ 3 mm (⅛")	> 15%
2R	> 3 mm (⅛") & ≤ 6 mm (¼")	> 10%
3R	> 6 mm (¼")	> 5%
Legend:	R: Removal and replacement of the slab/panel	

.7 If requested by HRM to perform forensic analysis, complete mix design information including precise weights of all substituents, shall be submitted to the Engineer (TPW.TIM@halifax.ca)

3.12 Emissions Reduction

.1 Concrete production and construction must take into consideration the Canadian Treasury Board's aim to reduce greenhouse gas emissions for ready-mix concrete by at least 10% below the Regional Industry Average EPD. An outcome-based approach will allow various methods of reaching these targets.

PART 4 - MEASUREMENT & PAYMENT

4.1 General

.1 Payment for all works carried out in accordance with this specification will be paid for per the payment items detailed in Section 01 22 00 – Measurement and Payment, of the Contract.

****** END PART A ******

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