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| **Section Cover Page** |
|  **Section 03 05 05****2019-06-05 Concrete Testing and Inspection** |

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1. **General**
	1. **SUMMARY**

.1 This section is included for the information of the concrete Contractor so that they can coordinate their activities with the Province’s inspection and testing agency. Costs for inspection and testing will be paid for by the Province directly. The Contractor shall include coordination costs only, do not include any costs for actual inspection and testing.

.2 Terms of reference for the inspection and testing services for concrete work include:

.1 Inspection and testing agency is responsible for the review of concrete work and reporting compliance with the specified requirements.

.2 Responsibility for quality of construction and compliance with Contract Documents rests solely with the Contractor.

* 1. **RELATED WORK SPECIFIED IN OTHER SECTIONS**

.1 Section 01 33 00 – Submittal Procedures

.2 Section 01 45 00 – Quality Control

.3 Section 03 20 00 – Concrete Reinforcement

.4 Section 03 30 00 – Cast-in-Place Concrete

.5 Section 03 30 10 – Cast-in-Place Concrete Short Form

.6 Section 04 20 00 – Masonry Units

.7 Section 04 23 00 – Glass Unit Masonry

.8 Section 31 62 13 – Cast-in-Place Concrete Piles

* 1. **REFERENCE DOCUMENTS**

*SPEC NOTE: Latest versions of the following standards to be used*

* + 1. American Society for Testing and Materials (ASTM):

|  |  |  |
| --- | --- | --- |
| .1 | ASTM C873/C873M-15 | Standard Test Method for Compressive Strength of Concrete Cylinders Cast in Place in Cylindrical Molds |

* + 1. Canadian Standards Association:
			1. CSA A23.1-14 Concrete Materials and Methods of Concrete

Construction.

* + - 1. CSA A23.2-14 Test Methods and Standard Practices for Concrete.
			2. CSA A283-06 (R2016) Qualification Code for Concrete Testing

Laboratories

* 1. **APPOINTMENT OF TESTING AGENCY**
		1. The Province may hire a CSA‑approved Testing Agency who shall test concrete, reinforcement, and grout as per this specification.
		2. Testing paid for by the Province:
			1. Review of initial mix designs.
			2. Testing as outlined in Section 3.0, except for testing required by the Contractor for stripping of formwork.
		3. Testing paid for by the Contractor:
			1. Review of Contractor requested changes in materials or concrete mix design.
			2. Any waiting time incurred by the Testing Agency in excess of thirty (30) minutes.
			3. Any additional costs due to overtime, shift work, holiday or weekend work, except that the Province will pay for holiday or weekend pickup when the concrete was placed on a regular workday.
			4. Costs for testing required by the Contractor for stripping of formwork, such as field cure cylinders etc.
			5. Cost for retesting or additional testing of concrete or reinforcement where tests have failed to meet the specified requirements.
	2. **QUALITY ASSURANCE**

.1 Regulatory Requirements: Determine compressive strength of concrete as prescribed in CSA A23.1 and A23.2 based on 28‑day test as required by Alberta Building Code.

.2 Qualifications: Provide proof of qualifications when requested by Consultant.

.1 Concrete testing laboratory and personnel shall be certified in accordance with CSA A283.

.2 Inspection and testing agency shall be experienced in all aspects of the required work described in this Section and as required by certification agency.

.3 Inspection and testing agency shall be independent of the Contractor.

* 1. **RESPONSIBILITY OF THE CONTRACTOR**
		1. The Contractor shall cooperate fully with the Province’s appointed Testing Agency. This includes providing access to the project site or to source of materials and assisting the Testing Agency in obtaining and handling samples at project site or at source of materials.
		2. The Contractor shall submit for review the concrete supplier’s quality control program to the Province and Consultant.
		3. The Contractor shall advise the Testing Agency at least twenty‑four (24) hours in advance of a concrete placement to allow for scheduling of quality assurance tests, review of project requirements, and assignment of personnel.
		4. Contractor shall provide a finished product that meets the specification. If initial tests indicate that the concrete failed to meet the specification, additional testing is necessary. This testing shall be done by a CSA‑approved Testing Agency, but need not be the Province’s agency.
		5. Core strengths must equal the specified strength if tested dry or 85% of specified if tested wet, with wet or dry tests as per the Standard.
	2. **RESPONSIBILITY AND DUTIES OF THE TESTING AGENCY APPOINTED BY THE PROVINCE**
		1. The Testing Agency is responsible to the Province and has the authority to, and is expected to reject any concrete not conforming to the Contract Documents.
		2. The Province’s testing agency will inspect, sample, and test materials and concrete production as required. If material furnished or Work performed by the Contractor fails to conform to the Contract Documents, the testing agency will report deficiency to the Consultant, Province, Contractor and concrete supplier.
		3. If the Testing Agency becomes aware that concrete is being placed without their notification, or if insufficient notice is received, then the Testing Agency shall notify the Province immediately.
		4. Low 7‑day, 28‑day and 56‑day strength tests shall be brought immediately to the attention of the Province.
1. **Products**
	1. **REPORTS: GENERAL**

.1 Provide inspection reports in accordance with Section 01 33 00 – Submittal Procedures and Section 01 45 00 – Quality Control.

.2 Prepare and submit certified written reports that include the following, except where otherwise specified:

 .1 Date of issue

 .2 Project title and number

 .3 Name, address, and telephone number of testing agency

 .4 Date, time, batch ticket number, and location of samples and tests or inspections

.5 Names of individuals making tests and inspections

.6 Description of the Work and test and inspection method

.7 Identification of product and Specification section

.8 Complete test or inspection data

.9 Test and inspection results and an interpretation of test results

.10 Ambient conditions at time of sample taking and testing and inspecting

.11 Comments or professional opinion on whether tested or inspected Work complies with the Contract Document requirements

.12 Recommendations on re-testing and re-inspecting

.3 All tests and test results shall be calculated, recorded and submitted on industry standard worksheets.

.4 All inspection reports and test results worksheets shall be signed and certified for correctness by the inspector or individual that carried out the test, respectively.

.5 All test and test result worksheets shall be reviewed and certified for correctness by a Professional Engineer employed by the Testing and Inspection firm, on a minimum weekly basis.

.6 Review and provide comments and recommendations regarding the Contractor’s mix designs when requested by Consultant.

.7 Notify the Consultant of noncompliant, or potentially noncompliant, workmanship or materials as soon as possible, but in any case, within one (1) day of discovery.

.8 Submit material test reports at regular intervals mutually agreed upon between the testing agency and the Consultant, [but no later than five (5) working days after completion of the test] [but not exceeding once every five (5) working days].

.9 Upon completion of the Work requiring concrete inspection and testing, submit a final report summarizing previous reports, signed by the agency’s inspector responsible for the testing and inspection program.

.10 Submit copies of reports to the following:

 .1 Contractor

 .2 Concrete Supplier

 .3 Consultant

 .4 Province

.11 Prepare detailed monthly invoices addressed and submitted to the Consultant for review.

* 1. **REPORTS: CYLINDER TESTING**

.1 All strength tests shall be numbered consecutively and cylinders marked as follows:

 .1 7‑Day Test: Marked “A”

 .2 28‑Day Test: Two (2) cylinders marked “B” and “C”

.3 56‑Day Test: Where these are required by the drawings and specifications, two (2) cylinders marked “D” and “E”

.4 Labelled with the suffix “L” for laboratory cured and “F” for field cured cylinders

.2 Report test results of one (1) batch per form.

.3 Include the following information for each report:

 .1 Project Name, Contractor, and Subcontractor

 .2 Concrete Supplier

 .3 Date and time of sampling

 .4 Air temperature at time of sampling

 .5 Concrete Mix Design Identification

 .6 Exact location on the structure where concrete is being placed

 .7 Specimen Number

 .8 Concrete Temperature

 .9 Specified concrete strength

 .10 Specified slump

.11 Slump, measured at point of discharge from the delivery vehicle, prior to addition of plasticizing agent

.12 Specified air content

.13 Measured air content

.14 Method of curing

.15 Test number

.16 Test date and age of cylinder

.17 Cylinder strength

.18 Running average of three consecutive strength tests as defined by A23.1 for the class of concrete being tested

.19 Remarks regarding compliance

.4 Store a carton of 12 cylinder moulds together with slump apparatus on site for use should a test be required when testing company inspector is not present; instruct Contractor on use of moulds and slump apparatus.

* 1. **REPORTS: ANALYSIS OF CONCRETE PRODUCTION**

.1 A summary table and associated strip charts shall be submitted to the Province for all classes of structural concrete placed on projects with 25 or more compressive strength tests.

.2 Summary tables are to indicate at least the following information:

.1 Classification of Concrete.

.2 Project name.

.3 Test number.

.4 Compressive strength of concrete.

.5 Supplier’s ticket number.

.6 Date concrete placed.

.7 Time batched.

.8 Time tested.

.9 Slump.

.10 Air entrainment.

.11 One (1) 7‑day and two (2) 28‑day compressive strength test results for each test.

.12 Average strength and within test variation for the two (2) 28‑day concrete test results for each test.

.13 Moving average of three (3) consecutive 28‑day concrete test results.

.14 Average and standard deviation of 28‑day concrete test results and an evaluation of conformance to CSA production guidelines.

.3 Charts shall plot concrete slump, air content, individual compressive strength tests, and the moving average of three (3) consecutive compressive strength tests.

.4 Tables and charts for each type or class of concrete are to be provided on a monthly basis for concrete supplied for the structure until completion of the concrete work.

.5 When 56‑day concrete testing is permitted by the Province, summary charts and tables shall be provided for concrete tested at 56 days.

1. **Execution**
	1. **INSPECTION: BATCH PLANT AND TRUCK MIXERS**

.1 Make occasional reviews of the concrete batching facility for inspection and reporting of the following:

 .1 Storage of materials

 .2 Batching equipment and operation

 .3 Condition and operation of truck mixers

* 1. **INSPECTION: FRESH CONCRETE AT SITE**

.1 Review delivery slips for appropriate mix for application and time expired between batching and beginning of placing the load.

.2 Addition of water to truck mixers after leaving the plant is governed by the limitations of CSA A23.1; notify the Contractor and Consultant about concrete that has had water added.

.3 Fresh concrete will be considered deficient for the following reasons:

 .1 Allowable time from mixing has been exceeded

 .2 Water has been added beyond the limits of CSA A23.1

 .3 Measured slump not within limits specified in mix design

 .4 Measured air content not within limits specified for mix design

 .5 Incorrect mix design for scheduled placement

.4 Notify the Contractor and Consultant verbally and follow up with a written report about concrete that is considered deficient and should not be placed.

.5 Notify the Consultant verbally and follow up with a written report about placed concrete considered deficient.

.6 Attend occasional site meetings as directed by the Consultant to review inspection reports regarding quality control of concrete as it relates to: mixing, delivery, conveying, depositing, consolidation, curing, installation and removal of formwork, re-shoring and protection.

* 1. **TESTING: GENERAL**

.1 Inspection and testing agency shall coordinate with the Contractor for notification requirements regarding the timing of testing and inspections.

.2 Inspection and testing agency shall coordinate their activities with the Contractor; be aware of the current work schedule and bring to the attention of the Consultant any testing or inspection requirement apparently being overlooked.

.3 Additional tests may be directed by the Consultant, or requested by the Contractor with reference to accelerated strength prediction, cold weather concreting and removal of forms:

 .1 Costs of tests requested by the Consultant will be paid for by the Province.

 .2 Costs of tests requested by the Contractor will be paid for by the Contractor.

.4 Immediately inform the Consultant where sufficient number of site visits is not clearly identified and make a recommendation for additional site visits as required to form an opinion as to the compliance of the work.

.5 Immediately inform the Consultant where site conditions are such that a reduced program of testing and inspection is deemed appropriate to form an opinion as to the compliance of the work.

.6 Re-Testing/Re-Inspecting:

.1 Provide quality control services, including re-testing and re-inspecting for construction that revised or replaced Work that failed to comply with requirements established by the Contract Documents.

.2 Payment for costs arising from re-testing and re-inspection are the responsibility of the Contractor.

* 1. **[TESTING: MATERIALS]**

.1 [Test and report on cement, fine and coarse aggregate, mixing water and admixtures, as directed by the Consultant.]

.2 [Conduct tensile and bend tests on reinforcing steel, as per Clause 3.7, as directed by the Consultant.]

* 1. **TESTING: CONCRETE – REGULAR**
		1. Perform a complete test set for each [50] [100] m3 of concrete or 500 m2 of surface area of slabs or walls, or fraction thereof, and in any event, not less than one test set for each type of concrete each day it is used.

.2 Each test set shall consist of a slump test, air content test, temperature measurement, and not less than three (3) [100 mm diameter x 200 mm] cylinders for compression testing, all in accordance with CSA A23.2-3C and as follows:

 .1 Test one (1) cylinder at seven (7) days, moist cured.

 .2 Test two (2) cylinders at twenty-eight (28) days.

.3 Test two (2) additional cylinders at fifty-six (56) if and when directed by Consultant.

.4 Contractor may elect to have testing agency make and test additional specimens at other ages to assist in determining timing of formwork removal; costs of this additional testing shall be borne by Contractor.

.3 Testing for concrete with SCM’s to reduce the cement content [greater than 30% cement reduction as defined in Section 03 30 00 Cast-in-Place Concrete] to conform to CSA A23.2, except each test shall consist of four (4) cylinders – one (1) for 7-day strength, one (1) for 28-day strength [, and two (2) for 56-day strength].

.4 For suspended structural floor slabs make two additional specimens for compression testing when the air temperature is below 0°C within 24 hours after a placement; additional specimens shall be standard concrete cylinders or concrete cylinders cast in place in cylindrical moulds and as follows:

.1 Site cure cylinders in a manner that simulates as closely as possible to the curing of the concrete sampled.

.2 Test cylinders prior to falsework removal.

.3 Test specimens cast-in-place in cylindrical moulds in accordance with ASTM C873/C873M.

.5 Field cure cylinders shall be stored on the floor right below the slab they represent and be protected against wind unless the floor below is heated, in which case they shall be stored on top of the slab but covered with a plywood box. The cylinders are to be undisturbed at this location until picked up by the Testing Agency.

.6 Chlorine ion tests shall be performed on the first set of compressive test cylinders taken from the first [parking slab] pour and the first [post-tensioned slab] pour, to show that the chloride ion content of these mixes satisfies the limits set out in CAN/CSA A23.1.

.7 Conduct additional tests for air content as required by CSA A23.2-4C or CSA A23.2-7C.

.8 Core tests, if required, shall be tested saturated, surface dry in accordance with CSA A23.1/A23.2; if core is taken from concrete that will remain dry during the life of the structure, the cores shall be tested air dry.

.9 Provide Contractor with criteria for maintaining facilities for temporary storage of concrete test cylinders, review site curing of test cylinders and provide guidance to the Contractor regarding curing and storage procedures.

.10 Regular testing applies to all elements not listed in Clause 3.6 - Full Time Testing.

* 1. **TESTING: CONCRETE – FULL-TIME**
		1. Full time testing shall apply to:
			1. Concrete above 40 MPa specified strength.
			2. Parking slab concrete in suspended slabs.
		2. Conform to CSA A23.2 and regular testing except:
			1. The Testing Agency shall have a representative on the job site at all times that the concrete requiring full time testing is being placed.
			2. Test the slump and air content from every truck and reject any concrete not within specification.
	2. **TESTING: MASS CONCRETE**

.1 Site testing for mass concrete is to be as above for concrete in general, plus temperature monitoring as below.

.2 Install and monitor temperature measuring devices within mass concrete elements as follows:

.1 Measuring devices shall be placed in each concrete pour where concrete thickness is 1000 mm or greater; provide devices in pairs, with a minimum of two (2) devices per [30] m3 of concrete in the mass concrete element.

.2 Devices shall be installed throughout thickness of mass concrete element. Locate 50% of the devices per element at the centre of the mass, and 50% near the surface of the element.

.3 Measuring devices shall be in accordance with Consultant’s written acceptance of the testing agency’s proposed locations.

.4 Take measurements every [##] [minutes] [hours] for the first [##] hours and every [##] hours for the next [##] hours.

* 1. **[TESTING REINFORCEMENT]**

***SPEC NOTE: delete entire section if not required***

* + 1. [The Testing Agency shall, at start of the project, perform at least one (1) tensile and bend test for each bar size used on the project. Such testing shall comply with the applicable CSA documents. Further testing may be requested at the Province’s discretion.]
		2. [The Testing Agency will select the bars to be tested from the reinforcing supplied to the construction site, not from the suppliers’ yard. The Contractor shall cut the bars to the required length and replace the shortened bars without cost to the Province.]
		3. [The Contractor shall supply mill certificates of chemical analysis in accordance with CAN/CSA G30.18R and G30.18W when requested.]
		4. [For epoxy coated reinforcing steel, the Testing Agency will visit the epoxy coating fabrication site, as required, to satisfy themselves that the fabrications and quality control process is in accordance with ASTM A775M. They shall report their findings to the Province.]
		5. [When bar fabrication occurs at temperatures less than 16 degrees Celsius, submit copies of bend tests indicating acceptability at the fabrication temperature.]
	1. **[TESTING: LEVELLING AND BEARING GROUT UNDER BASE PLATES, MACHINERY AND MISCELLANEOUS LOAD-BEARING APPLICATIONS]**

.1 For pre-packaged proprietary grout products, perform at least one (1) set of compression tests (6 cubes total) for each type of grout used by each Contractor.

.2 For grout proportioned and mixed on site, perform at least one (1) set of compression tests (6 cubes total) for each type of grout used by each Contractor.

* 1. **[TESTING: MORTAR]**

**SPEC NOTE**: delete entire section if not required

.1 Testing of mortar shall be in accordance with Section 15 of CSA S304.

.2 Testing Frequency:

.1 Masonry of concrete blocks or hollow clay units:

1. Mortar shall be tested at least once for each 500 m2 of masonry or portion thereof, for a project having more than 500 m2 of masonry; and
2. For each 250 m2 of masonry or portion thereof, for a project having less than 500 m2 of masonry.

.2 Masonry of solid brick units:

1. Mortar shall be tested at least once for each 250 m2 of masonry or portion thereof, for a project having more than 250 m2 of masonry; and
2. For each 125 m2 of masonry or portion thereof, for a project having less than 250 m2 of masonry.

.3 Each test set shall consist of an air content test, temperature measurement, and not less than six (6) 50 mm cubes for compression testing at the following intervals:

.1 Test three (3) cubes at seven (7) days.

.2 Test three (3) cubes at twenty‑eight (28) days.

.4 Acceptance:

1. Ratio of aggregate to cementitious material: The ratio of aggregate to cementitious material determined in accordance with CSA A179 shall be greater than 0.85 Rm and less than 1.15 Rm, where Rm is the control value for the ratio of aggregate to cementitious material for the mortar being tested, determined in accordance with the procedures set forth in CSA A179.
2. Compressive strength: The average mortar cube compressive strength determined from 7 day and 28 day field control tests, in accordance with CSA A179, shall satisfy the compressive strength criteria for the chosen mortar set forth for property specification mortars in CSA A179.
	1. [TESTING: MASONRY GROUT]

SPEC NOTE: delete entire section if not required

.1 Testing of masonry grout shall be in accordance with Section 15 of CSA S304.

.2 Grout shall be tested at least once:

1. For each 20 m3 of grout poured or portion thereof for a project having more than 20 m3 of grout; and
2. For each 10 m3 of grout poured or portion thereof for a project having less than 20 m3 of grout.

.3 Each test shall consist of a slump test, air content test, temperature measurement, and not less than three (3) 100 mm x 203 mm cylinders for compression testing at the following intervals:

 .1 Test one (1) cylinder at seven (7) days.

 .2 Test two (2) cylinders at twenty‑eight (28) days.

.4 Grout shall satisfy the compressive strength criteria set forth in CSA A179, as applicable for the grout specified under either the property specifications of the proportion specifications options.

end of section