BEST PRACTICE GUIDELINES FOR CONCRETE PLACEMENT PLANNING, FIELD TESTING, AND SAMPLE COLLECTION

A PUBLICATION JOINTLY PREPARED BY:

BC Ready-Mixed CONCRETE ASSOCIATION

CCIL
Canadian Council of Independent Laboratories

The guide is subject to ongoing review and edits. Comments and questions are welcome at ccil@magma.ca

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1 EXECUTIVE SUMMARY

Concrete is the most widely used construction material and can be used in almost any environment for a multitude of applications but successful concrete construction begins with careful planning.

This document was prepared by representatives of the ready-mixed concrete suppliers in British Columbia and testing agencies as a planning tool for field testing and sample collection of Portland cement concrete.

2 INTRODUCTION

The importance of good quality concrete to the construction industry cannot be over-stated. Many parties are involved to ensure that the quality of concrete meets the required contract specifications. This is not always a straightforward matter as many factors can affect the quality of the concrete and the ability of each party to carry out proper quality control and/or quality assurance activities during construction.

This document applies to parties involved in a construction project that requires the placement of concrete. This includes the ready mixed concrete supplier, owner, architect, structural engineer, general contractor, subcontractors especially for placing and finishing, testing agencies, and inspectors.

While the Canadian Standards Association's (CSA) Standard A23.1-14 *Concrete Materials and Methods of Concrete Construction* and Standard A23.2-14 *Test Methods and Standard Practices for Concrete* describes the standards and test methods respectively, this document is intended as a guideline to provide additional commentary regarding best practices which can be used for field testing and sample collection. Wherever applicable, the commentary is shown adjacent to the relevant CSA standard or test method. Reference is made in this guide to several tables in CSA Standard A23.1-14 and these are reproduced in **APPENDIX A** for convenience and further guidance.

3 PLACEMENT PLANNING

Commentary	**CSA Standard**
Prior to start of concrete placements, a preconstruction meeting should be held with all members of the team to establish the responsibilities of the ready mixed concrete supplier, owner, architect, structural engineer, general contractor, placing and finishing subcontractors, testing agencies, and inspectors. The purpose of the meeting is to encourage communication and establish protocols which prevent issues. In addition, the meeting should address what can be done to resolve issues quickly and cooperatively in the event there is a deviate from the plan. The meetings should be held in advance of the work to ensure there is sufficient time for all team members to gain consensus of the roles and responsibilities and plan according. Once the pre-construction meeting is complete, all parties should be clear on how they will work together and	***CSA A23.1-14 Annex J***** ***J.7.1.5 Pre-construction and pre-placement meetings*** *The owner's quality plan should specify pre-construction and pre-placement meetings, defining the* *(a) meetings schedule;* *(b) attendance list; and* *(c) agenda (checklist).* ***Note:** A typical checklist is found in "Best Practices Guidelines for Concrete Construction"; OGCA-RMCAO; Revision 1.0; 2005.* ** Note: The annexes of CSA Standard

communicate if there are issues. Minutes of the meeting should be distributed to all affected parties within three business days of the meeting. In addition to the pre-construction meeting, large or complex placements could warrant additional pre-placement meetings with the design and construction team to discuss and review the roles and responsibilities. On smaller projects, there may not be a formal preconstruction meeting. In such cases, the responsibilities of all members of the team should be documented in advance of the first placement and such documentation should be distributed to all members. An example of a pre-construction meeting checklist excerpted from the *"Best Practices Guidelines for Concrete Construction"; OGCA-RMCAO; Revision 1.0; 2005,* is attached in **APPENDIX B** for reference. The checklist is reproduced with permission from Ready Mixed Concrete Association of Ontario.	A23.1-14 are written in non-mandatory language and the information is provided for guidance in the standard.

4 ROLES AND RESPONSIBLITIES

4.1 Introduction

The following sections provide a list of parties and their typical roles and responsibilities. However, it is not intended to cover all possible scenarios and the specifications and other contracts may specify other roles and responsibilities. Although the actual contract documents will govern in areas of dispute, roles and responsibilities should be reviewed and confirmed at the pre-placement meeting. Paramount and prior to concrete delivery, the responsibility for acceptance or rejection of the plastic concrete must be clearly defined.

4.2 Owner and/or Owner's Representative

Commentary	**CSA Standard**
The owner is the person or company that requisitions the project. The owner may in turn engage an architect, an engineer and/or a general contractor to carry out various design and project management functions prior to and during the construction. The owner or agent of the owner (owner's representative) is responsible for: ▪ Ensuring that the contract documents define the roles and responsibilities of the parties. ▪ Ensuring (usually through the general contractor) that the construction meets the requirements to allow proper on-site testing along with proper curing and storage of concrete test specimens destined for laboratory testing. ▪ Specifying the quality requirements and test or inspection frequencies for the concrete (on the basis of advice from a structural engineer or architect in concert with the applicable requirements of CSA Standard	***A23.1-09, Annex J***** *J.5 Roles and Responsibilities* ***J.5.1 Performance specifications*** ***J.5.1.1 Owner*** *Prior to endorsing the use of a performance specification, the owner should have confidence that this approach will meet his or her objectives. This requires reliance on the design team to prepare an effective performance specification and on the implementation of a reliable quality assurance process that will verify that the performance criteria will be met.* *The owner is therefore responsible for appointing a competent design authority and implementing an appropriate quality*

A23.1-14). In addition, the owner is responsible for stipulating the methods to be used to evaluate the performance of the concrete and the acceptance criteria. The owner should specify one of the two alternatives in accordance with Table 5 of CSA Standard A23.1-14: 1) *Performance*; or 2) *Prescriptive*. Table 5 defines the role of the *owner*, *contractor* and *supplier* in each method. The *Prescription* method is not typically specified in commercial work as it is more suited to public or industrial infrastructure in remote locations. This document focuses on construction projects where concrete is specified by the *Performance* method	*assurance process. Often responsibility for quality assurance will be delegated to the design authority.* ***A23.1-14, Table 5*** *1) Performance: When the owner requires the concrete supplier to assume responsibility for performance of the concrete as delivered and the contractor to assume responsibility for the concrete in place.* *2) Prescription: When the owner assumes responsibility for the concrete.*

4.3 Owner's Consultants

Commentary	**CSA Standard**
The owner will normally have consultants engaged in specific roles on the project. These could include, but not limited to: ▪ Design Professional**:** The engineering or architectural firm that provides design drawings and specifications for concrete work. ▪ Materials Consultant: The agency responsible for the Materials Certificate of Compliance (Schedule C as required by the Structural Engineer of Record). ▪ Structural Engineer of Record (Engineer): The Professional Engineer(s) responsible for the structural design and issuing the Structural Certificate of Compliance (the terminology of this compliance certificate changes with the various provincial or territorial jurisdictions of Canada). The materials consultant and/or the engineer of record may also undertake a quality assurance (QA) function on behalf of the owner. For the purpose of this document this activity is referred to as QA testing. When the general contractor is required by his contract with the Owner to hire a testing agency on behalf of the Owner, it should be understood that the testing agency is providing QA testing function, even if the testing agency's service is coordinated by the general contractor and the testing agency's service is paid for by the general contractor. In such cases, the testing agency should report its test results as specified in the contract between the Owner and the general contractor, and as agreed to by the parties at the preconstruction meeting.	***A23.1-14, Annex J*** *J.5 Roles and Responsibilities* ***J.5.1 Performance specifications*** ***J.5.1.2 Design authority*** *The designer is responsible for* *(a) establishing the performance criteria, usually in consultation with the owner;* *(b) preparing the technical specification that states the performance criteria in appropriate terms; and* *(c) under the direction of the owner, conducting quality assurance and reviewing quality assurance reports, or both, to ascertain on the owner's behalf that the performance criteria have been met.*

4.4 General Contractor

Commentary	CSA Standard
The general contractor has the primary responsibility of all aspects of the project, including health, safety, quality and cost-control issues, and engages the majority or all of the sub-contractors. The general contractor is typically responsible for: ▪ Selecting a qualified ready-mixed concrete supplier; ▪ Developing Quality Control Plans with respect to concrete supply, placement and curing; ▪ Leading the pre-construction and/or pre-placement meetings; ▪ Making the final decision when there is an identified issue with the concrete at the time of placement (i.e. acceptance or rejection); ▪ Ensuring the proper site provisions are made to safely conduct the on-site sampling and testing, including the storage, curing, and collection of samples destined for the testing laboratory; and ▪ Coordinating with the testing agency with sufficient notice to schedule the concrete field testing technician (generally 24 hours prior to the time of the placement).	***A23.1-14, Annex J*** ***J.5 Roles and Responsibilities*** ***J.5.1 Performance specifications*** ***J.5.1.3 Contractor*** *The construction team is responsible for procuring concrete and related materials and incorporating them into the structure in a manner that meets the performance requirements.* *The contractor is also responsible for conducting appropriate and sufficient quality control to demonstrate and document that the performance requirements have been met. The quality control documents should be communicated to the design authority and owner in a manner, and according to a schedule, that will accommodate the quality assurance process.*

4.5 General Contractor Quality Control Representative

Commentary	CSA Standard
The general contractor quality control (CQC) representative is directly responsible for: ▪ The overall planning and implementation of quality control plan; and ▪ Coordination of quality control work by others on the project. These activities often include hiring a testing agency to provide concrete sampling and testing services. The role of the testing agency must be clearly stated in the quality control plan or written agreement and may involve testing at the ready-mixed concrete plant, on the project site, or both.	***A23.1-14, Annex J*** ***J.3 Definitions*** ***Quality control plan*** *— the planning of the quality control activities of the contractor by defining items, such as sampling and testing frequency, and alerting or rejecting criteria for non-conformance.*

4.6 Quality Control Personnel

Commentary	CSA Standard
The roles of quality control (QC) personnel and quality assurance (QA) personnel are often misunderstood. The titles are sometimes often used interchangeably, when, in fact, the responsibilities are different.	***A23.1-14, Annex J*** ***J.3 Definitions*** ***Quality control*** *— the activity of measuring (e.g., testing samples) and adjusting the*

Quality control personnel typically take actions for the producer or general contractor to control the materials, processes and quality of work so as to control the level of quality being produced in the end product . In the context of concrete strength requirements, it is a common situation that one testing agency will to be engaged by the producer or general contractor to cast and test strength specimens for quality control purposes, and for second independent testing agency be engaged by the owner to cast and test strength specimens for quality assurance purposes. On small projects, the quality assurance testing may be the only on-site testing. On larger projects, especially where the contractor uses sophisticated process controls, the contract documents may stipulate that the quality control test results also be used for quality assurance purposes.	*methods of production to meet the requirements of the quality plan.* ***Note**: Quality control can involve developing a system to ensure products or services are designed and produced to meet customer requirements. An objective of quality control can be to detect and prevent non-conformance through a management system for continuous improvement. With respect to concrete construction, the sampling, testing, and inspection of the concrete is performed by qualified personnel.*

4.7 Quality Assurance Personnel

Commentary	**CSA Standard**
Quality assurance personnel typically take actions on behalf of the owner, or the owner's representative, to provide confidence and document assurance that what is being done and what is being provided are in accordance with the applicable project specifications and standards of good practice for the Work.	***A23.1-14, Annex J*** ***J.3 Definitions*** ***Quality assurance** — the verification that the requirements of an accepted quality plan are being implemented and met.* ***Note:** Quality assurance activities should be performed by the owner.*

4.8 Ready-Mixed Concrete Supplier

Commentary	**CSA Standard**
The ready-mixed concrete supplier proportions and produces the concrete to ensure compliance with the contract specifications in terms of quality, quantity, and timing of delivery. The ready-mixed concrete supplier would normally be represented by the following personnel: Supplier Quality Control (SQC) representative who would be responsible for: ▪ The on-site quality of the ready mixed concrete; and ▪ Making decisions regarding implementing approved procedures in adjusting (tempering) delivered concrete, if required. **Note:** The SQC performing this role could be an employee of the ready-mixed concrete supplier or from an independent testing agency that has been retained by the ready-mixed concrete supplier.	***A23.1-14, Annex J*** ***J.5 Roles and Responsibilities*** ***J.5.1 Performance specifications*** ***J.5.1.4 Concrete supplier*** *The concrete supplier is responsible for procuring materials and producing concrete that will, in its plastic and hardened states, meet the performance requirements. This includes responsibility for implementing a quality control program to demonstrate and document that the product as delivered is of appropriate quality and will meet the performance requirements.* *Since in a typical construction project the custody of the concrete transfers from the supplier to the contractor while in its plastic*

Concrete Delivery Professional (CDP) who would be responsible for: ▪ Delivery of the ready mixed concrete to the jobsite; ▪ Acting as a liaison between the Field Technician and the SQC representative; and ▪ Implementation (if pre-authorized) of correct action as instructed by the SQC representative such as adjusting the plastic properties of non-conforming concrete. **Note**: The term Concrete Delivery Professional (CDP) is that derived from the training program for concrete delivery personnel sponsored by the Canadian Ready Mixed Concrete Association. The training program is delivered by CRMCA provincial member associations and was adapted from that developed by NRMCA.	*state, a high degree of coordination is required between supplier and contractor to ensure that the final product meets the performance criteria and that the quality control processes are compatible and demonstrate compliance.*

5 MONITORING AND ADJUSTMENTS OF SLUMP AND AIR CONTENT

This section provides an outline of the requirements of the CSA test methods and general best practices for control of slump and air content. These items should be reviewed as part of the pre-construction and/or pre-placement meetings and consensus obtained between all parties.

5.1 Time of Delivery

Commentary	**CSA Standard**
The maximum time limit from the initial mixing to complete discharge should be monitored and not exceed 120 minutes unless otherwise agreed upon by the owner and ready-mixed concrete supplier. In some cases, set retarders or hydration stabilizers may be acceptable by the owner to extend the discharge time beyond 120 minutes. The ready-mixed concrete supplier should be prepared to define the time limits beyond 120 minutes for the dosages of admixtures employed.	***A23.1-14 – Clause 5.2.5.3.1Time of delivery*** *A maximum time limit of 120 minutes from the time of initial mixing to complete discharge shall be observed. Exemptions to the maximum time limit, if required, shall be agreed upon by the owner and the concrete supplier prior to placement of the concrete. In some circumstances, set retarders or hydration stabilizers may be used to extend the discharge time as permitted by the owner.* *Note: The period during which concrete is workable is significantly affected by type and content of the cementing materials, the type and dosage of the admixture, other added materials, and ambient and concrete temperatures. This period can be extended or reduced by the use of set-retarding or accelerating admixtures. If specific time limitations are desired, they should be clearly identified and included in project specification.*

5.2 Addition of Water on the Job Site

Commentary	**CSA Standard**
When the measured slump is less than specified, water may be added by the ready-mixed concrete	***A23.1-14 – Clause 5.2.5.3.2 Addition of water on the job site***

supplier to increase the slump provided: 1. The specified water/cementing materials ratio is not exceeded; 2. No more than 60 minutes have elapsed from the time of batching; and 3. No more that the lesser of 16 L/m^3 or 10% of the mixing water is added. Water shall be added under the instruction of the: ▪ Ready-mixed concrete supplier when the concrete is supplied of Alternative 1 *Performance* method; or ▪ Owner when the concrete is supplied of Alternative 2 *Prescriptive* method. In either case, the amount of water added and by whose authority shall be recorded on the delivery ticket and the field test report. Refer to CSA A23.1-14, Table 5 for additional details regarding the alternative methods for specifying concrete. *TIP: increasing the air content of the concrete may increase the slump of the concrete. Similarly, increasing the slump may increase the total air content.* *TIP: high slump can often be reduced by means of additional mixing time on site.*	*The water shall be added on the instruction of the concrete supplier when the concrete is supplied on the basis of Alternative 1 (Performance Specification) in Table 5 and the water addition including quantity shall be recorded on the delivery ticket.* *The water shall be added on the instruction of the owner when the concrete is supplied on the basis of Alternative 2 (Prescription Specification) in Table 5 and the water addition including quantity shall be recorded on the ticket and signed for by the owner.* *When the measured slump or slump flow of the concrete is less than that designated, water may be added by the concrete supplier to achieve the designated slump or slump flow provided that the following criteria are met:* *(a)The specified water-to-cementing materials ratio is not exceeded.* *(b)No more than 60 minutes has elapsed from the time of batching. In some circumstances, set retarders or hydration stabilizers may be used to extend the elapsed time allowed for water addition as permitted by the owner.* *(c)Not more than the lesser of 16 L/m3 or 10% of the mixing water shall be added.* *In each case, the mixer drum shall be turned at mixing speed for at least 30 revolutions (or equivalent time limit) after the addition of water. The amount of water added and by whose authority shall be recorded on the delivery ticket*

5.3 Monitoring and Adjustments of Slump or Slump Flow of Superplasticized Concrete on the Job Site

Commentary	**CSA Standard**
Prior to discharge, concrete with superplasticizer may be retempered with water as noted above provided the water/cementing materials ratio is not exceeded. The addition of water shall be done by the ready-mixed concrete supplier. When concrete with superplasticizer falls below the designated slump after discharge has begun, it can only be retempered with superplasticizer, not water, and the addition of superplasticizer shall be done by the ready-mixed concrete supplier. In all cases, the amount of water and/or admixture added on site shall be recorded on the delivery ticket and the field test report.	***A23.1-09 – Clause 5.2.5.3.3Control of slump or slump flow of plasticized concrete on the job site*** *Prior to discharge, concrete incorporating ASTM C494 Type F or G water reducing admixture (i.e., plasticizer) may be retempered with water in accordance with Clause 5.2.5.3.2, provided the designed w/cm is not exceeded. When concrete incorporating ASTM C494 Type F or G water reducing admixture falls below the designated slump or slump flow after discharge has begun, it shall be retempered with those admixtures only, not water. The amount of additional admixture added shall be recorded on the delivery ticket. All retempering shall be done by the concrete supplier.*

	Notes: *(1)High-strength superplasticized mixes need extra care.* *(2)Variations in initial slump or slump flow, prior to the addition of superplasticizers, can affect performance. Initial slump or slump flow should be monitored where consistency of setting and finishing properties is of particular concern (e.g., flatwork).*

5.4 Monitoring and Adjustments of Air Content on the Job Site

Commentary	**CSA Standard**
See clause 5.2 above regarding adjustments for slump and slump flow. Air content shall, if necessary, be adjusted to within the specified range by the ready-mixed concrete supplier by the addition of air entraining admixture (AEA) in the field. The AEA is to be added in accordance with the manufacturer's recommended procedure and re-mixed (e.g. 70 revolutions at mixing speed), re-sampled and re-tested to confirm compliance to the contract requirements. In all cases, the amount of admixture added on site shall be recorded on the delivery ticket. If the concrete is supplied for Classes of Exposure C-XL, C-1, C-2, and F-1 (as defined in Table 1 of CSA Standard A23.1-14), the air content shall be retested if not discharged after 90 minutes. *TIP: increasing the air content of the concrete may increase the slump of the concrete. Similarly, increasing the slump may increase the total air content.* *TIP: a reduction in slump (with time) may also reduce the air content.*	***A23.1-14 – Clause 5.2.5.3.4 Control of slump or slump flow and air content on the job site*** *When the measured slump or slump flow of the concrete is less than designated it can be adjusted according to Clause 5.2.5.3.2. When the concrete slump or slump flow of the concrete is higher than that designated, concrete shall not be adjusted on-site with the addition of dry materials. The air content of the concrete shall, if necessary, be brought up to the specified range by the concrete supplier by the addition of an air-entraining agent in the field. Mixing shall follow to ensure proper dispersion. The air content shall be retested. When concrete is supplied for exposure classifications C-XL, C-1, C-2, and F-1 and the 120 min time limit is in effect, the concrete shall be retested for conformance to air content requirements when more than 90 minutes have elapsed since batching.* *The amount of air-entraining agent added and air content test results shall be recorded on the delivery ticket.*

6 TESTING METHODS AND BEST PRACTICES

This section provides an outline of test methods and general best practices for on site testing, initial curing, and/or the collection of samples for laboratory testing. These items should be reviewed as part of the pre-construction and/or pre-placement meeting and consensus obtained between all parties.

6.1 On-Site Testing – General

Commentary	CSA Standard
In accordance with CSA, field testing performed to assess concrete quality shall be conducted by certified personnel. Field technicians shall perform concrete tests in accordance with the project specifications and in accordance with the following test methods of CSA Standard A23.2-14: ▪ 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 of concrete; ▪ A23.2-6C – Density, yield and cementing materials factor of plastic concrete; ▪ A23.2.2-7C – Air content of plastic concrete by the volumetric method; ▪ A23.2-17C - Temperature of freshly mixed hydraulic cement concrete; and ▪ A23.2-19C – Slump flow of concrete (if applicable).	***A23.1-14 – Clause 4.4.1.5 Concrete test procedures*** ***4.4.1.5.1*** *Laboratory test procedures undertaken to assess concrete and concrete aggregate quality shall be carried out by a testing laboratory meeting the requirements of CSA A283 for the appropriate category or ISO 9001 with equivalent scope to CSA A283 or other equivalent certification approved by the owner.* ***Note:*** *The owner should be aware that equivalence means, as a minimum, competence to perform the required test procedures, establishment of traceability of all test records and results, and the assumption of responsibility for the program by a registered or licensed professional engineer in Canada.* ***4.4.1.5.2*** *Field sampling and test procedures undertaken to assess concrete quality shall be carried out in accordance with the requirements of CSA A23.2 by personnel certified under an industry-recognized program.* ***Note:*** *Such industry-recognized programs include* *(a) CSA A283 or ISO 9001 with equivalent scope to CSA A283; and* *(b) ACI Concrete Field Testing Technician Grade 1.*

6.2 On-Site Sampling

Commentary	CSA Standard
Unless otherwise written in the contract specifications or agreed upon at the pre-construction or pre-placement meetings, sampling for the purposes of acceptance shall be a grab sample obtained between 10% and 90% of the load at the point of discharge. This requirement is not applicable if the concrete is to be tested for slump prior to the addition of superplasticizer.	***A23.1-14 – Clause 4.4.2 Sampling concrete*** *Samples of concrete for testing purposes shall be secured in accordance with CSAA23.2-1C. When the owner elects to assess the quality of concrete at a location other than the point of discharge from the delivery equipment, the owner shall state the point from which the samples shall be taken.* *Note: The point at which the concrete is sampled will depend on the intended use of the test information. Where the test data are intended to give information on the properties of the concrete* *(a)as delivered to the site, the concrete should be sampled at the point of discharge from the delivery equipment; or* *(b) as incorporated into the structure, the concrete should be sampled as close to the point of final deposit in the form as is practicable.*

	A23.2-1C- 14 – Sampling Plastic Concrete ***7.2 Sampling from a truck agitator or mixer*** ***7.2.1*** *When sampling from a truck agitator or mixer, take the sample between the 10% and 90% points of the discharge.* ***7.2.2*** *Clause 7.2.1 shall not apply when it is required that concrete be tested for slump immediately prior to the addition of superplasticizer.* ***Clause 7.3 Sampling for evaluation of concrete quality*** *The sample for strength test specimens and the corresponding related plastic concrete properties shall be a grab sample from the designated place of sampling, as defined in Clause4.4.2 of CSA A23.1. Grab sampling is the operation of securing at one point the required representative material in as short a period of time as possible.* ***Note:*** *More than one container may be used to obtain a single grab sample.*

6.3 Test Frequencies for Slump or Slump Flow

Commentary	**CSA Standard**
The required frequency of slump or slump flow tests should be as described in the contract specifications and confirmed at the pre-placement meeting but as a minimum a slump or slump flow test is performed with every strength test.	***A23.1-14 – Clause 4.4.3 Slump or slump flow*** ***4.4.3.1 Frequency and number of tests****A sufficient number of tests shall be made to ensure uniform slump of the concrete. A slump test shall be made with every strength test and every second or third air test.*

6.4 Test Frequencies for Air Content

Commentary	**CSA Standard**
The required frequency of air content tests should be as described in the contract specification and confirmed at the pre-construction or pre-placement meetings but as a minimum an air content test is performed with every strength test.	***A23.1-09 – Clause 4.4.4 Air content of concrete*** ***4.4.4.1 Air content of plastic concrete*** ***4.4.4.1.1 Frequency and number of tests*** ***4.4.4.1.1.1*** *Where concrete will be subjected to frequent cycles of freezing and thawing in the presence of moisture or de-icing chemicals [i.e., Class F-1, Classes C-XL and C-1 when exposed to freezing and thawing, and ClassC-2 (see Table1)], every load or batch of concrete shall be tested until satisfactory control of the air content is established and fewer tests are required by the owner. Whenever a test falls outside the specified limits (see Table4), the testing frequency shall revert to one test per*

	load or batch until satisfactory control is re-established. ***Note:*** *Since it is essential to know whether the total air content of concrete is within specified limits, air content determinations should be made on samples taken from the first portion of the concrete prior to placement. The amount of entrained air for recording purposes, however, should be determined on samples taken in accordance with Clause4.4.2.* ***4.4.4.1.1.2*** *Where exposure is less severe [i.e., Class F-2, Class C-1 when not exposed to freezing and thawing, and ClassC-3 and C-4 exposures (see Table1)], air content determinations may, at the discretion of the owner, be less frequent than those specified in Clause4.4.4.1.1.1.* ***4.4.4.1.1.3*** *An air content determination shall be made with every strength test for all classes of concrete.*

6.5 Test Frequency for Strength Tests

Commentary	CSA Standard
The required frequency of strength tests should be as described in the contract specification and confirmed at the pre-construction or pre-placement meetings but as a minimum should be performed for each 100 m^3 of concrete placed per day for each mix design.	***A23.1-14 – Clause 4.4.6.3 Frequency and number of tests*** ***4.4.6.3.1*** *Not less than one strength test shall be made for each 100 m^3 (or part thereof) of concrete placed. A minimum of one test is required per day for concrete of a single mix design. When high-performance or high-strength concrete is involved, or where structural requirements are critical, the owner may require a higher frequency of testing, which shall be defined in the contract documents.*

6.6 Initial Curing of Strength Test Specimens

Commentary	CSA Standard
Unless otherwise agreed at the pre-construction or pre-placement meetings, the contractor is responsible to provide adequate facilities for the safe storage and proper initial curing of strength test specimens. Facilities are to include a rigid surface free from vibration and other disturbances and in an environment that maintains the temperature between 15°C and 25°C. In all cases, the minimum and maximum curing temperatures shall be recorded. Generally, the contractor is expected to provide a	***A23.1-14 – Clause 4.4.6.5.1.3 Storage and curing facilities****To facilitate testing, the contractor shall provide and maintain, for the sole use of the testing agency, adequate facilities for safe storage and proper curing of concrete test specimens on the project site for the initial curing period. Adequate facilities shall include a protected and temperature-controlled designated area to comply with CSAA23.2-3C.* ***A23.2-3C- 14 – Making and curing concrete compression and flexural test specimens*** ***Clause 9.3.2.1 Initial curing conditions in the mould*** *Place the moulds on a rigid horizontal surface free from vibration and other disturbances. During initial curing,*

heated facility with power allowing the testing agency to utilize temperature controlled curing boxes. *TIP: During hot weather conditions, it may be necessary to use an external cooling device, ice, cold water or other means to maintain initial temperatures between 15°C and 25°C.* *TIP: During cold weather conditions, it may be necessary to use an external heating device or other means to maintain initial temperatures between 15°C and 25°C*.	*store the test specimens in a controlled environment that maintains the temperature between 15°C and 25 °C immediately adjacent to the specimens. Prevent loss of moisture from the specimens by the requirements specified in Clause8.7.* *Report the records of the maximum and minimum temperature within the curing enclosure during the initial curing period.* *Note: These curing requirements necessitate an appropriate temperature- and moisture-controlled curing facility on a project site.*

6.7 Initial Curing of Field Cured Specimens

Commentary	CSA Standard
When tests are required to simulate field conditions, additional cylinders shall be cast and stored as close as practical to the actual structure being represented. Safe storage and access should be provided by the contractor.	***A23.1-14 – Clause 4.4.6.6.3 Field cured specimens – test procedure*** *When tests are required on specimens cured to simulate field conditions, additional specimens shall be made in accordance with CSAA23.2-3C. The test results of the field-cured specimens shall not be used as a basis for acceptance or rejection of the concrete.* *Note: Field-cured cylinders are subject to many types of variation and might not represent the strength of the structural element. In-place testing using CSAA23.2-15C is the preferred alternative when it is difficult to cure the specimens in conditions similar to the structure they represent.*

6.8 Demoulding Time of Test Specimens

Commentary	CSA Standard
Test specimens are to be demoulded at the end of 28 ± 8 hours. Demoulding time may be increased to 76 hours if the specified compressive strength of concrete is less than 35 MPa. **Note:** Determining and recording the mass of each test specimen immediately upon demoulding is a new requirement in the 2014 edition of the test method.	***A23.2-3C- 14 – Making and curing concrete compression and flexural test specimens*** ***Clause 9.3.3 Demoulding time of test specimens*** *Remove the specimens from the moulds at the end of 28 h ± 8 h if the test specimens were made for checking the adequacy of the laboratory mixture proportions for strength or as the basis for acceptance. Store the test specimens in accordance with Clause9.3.2.2.* *Demoulding time may be extended to a maximum of 76 h for cylinders representing concrete having a specified strength of less than 35 MPa, provided that the specimens are stored in an environmentally controlled facility at the project site that maintains the temperature between 15 °C and 25 °C immediately adjacent to the specimens and prevents loss of moisture from the specimens. Record the maximum and minimum temperatures when the initial*

	curing period is extended beyond 24 h. *Determine the mass of each test specimen, expressed to the nearest gram (g), immediately upon demoulding.*

6.9 Transportation of Test Specimens after Initial Curing Period

Commentary	CSA Standard
Test specimens may be transported to the laboratory only after a minimum of 20 hours of curing. The test specimens are to be protected from shocks or exposure to adverse conditions. The initial curing method and date received shall be reported.	***A23.2-3C- 14 – Making and curing concrete compression and flexural test specimens*** ***Clause 9.4 Transportation of concrete test samples during curing period*** *Transport the test specimens from the field to the laboratory only after curing for a minimum of 20 h under the curing condition required by Clause9.3.2.1. Protect the test specimens during transportation, from any shocks or exposure to adverse conditions. State the curing conditions and the date received in the laboratory in the test report.* *Note: When concrete specimens are to be transported under curing conditions other than those of Clause 9.3.2.1, the transportation should be delayed as long as possible to minimize the effect of adverse transportation conditions*

6.10 Reporting

Commentary	CSA Standard
The on-site reporting procedures should be described in the Quality Control Plan or reviewed and consensus obtained at the pre-construction or pre-placement meeting. Final reporting of test results shall be provided to the owner, contractor, and ready-mixed concrete supplier. The process of how the distribution of reporting will occur should be reviewed and consensus obtained at the pre-construction or pre-placement meeting. Note that there are significant changes to the reporting requirements for many of the test methods in the 2014 edition of the standard.	***A23.1-14 – Clause 4.4.1.7 Test Reports*** ***4.4.1.7.1 General*** *Unless otherwise agreed, test results shall be provided to the owner, contractor, and concrete supplier within five working days.* ***4.4.1.7.2 Field and laboratory test reports*** *Both field and laboratory test reports shall include all information required by the applicable test methods of CSA A23.2.* **Note:** *Annex B of A23.2 contains a sample report form for strength test results.* ***4.4.1.7.3 Non-compliant test specimens*** *If any test specimen shows distinct evidence of improper sampling, making, curing, transporting, moulding, handling, curing, or testing, the test specimen shall be disregarded and declared unacceptable.* *The strength of the remaining test specimen(s) shall be considered the test result.*

7 NON-CONFORMING CONCRETE – SUGGESTED ACTIONS

There will be occasions when the concrete delivered to the site does not comply with the specifications for one or more parameters. In these cases, it is important that all parties identified in the Quality Control Plan, contract, or as identified in the pre-construction or pre-placement meeting are notified as soon as possible.

In the event, a pre-established line of communication has not been established or Quality Control Plan has not been prepared, the following lines of communication and course of action regarding non-conforming concrete are suggested:

- The first notification of non-conforming concrete should be from the field technician to the Concrete Delivery Professional (CDP), the on-site Quality Control Representative (QCR) and/or general contractor. However, given the time constraints for delivery and placement of concrete, initial discussions with the CDP will be essential.
- In the event, concrete is determined to be non-compliant and there is no QCR and/or general contractor representative on site, the CDP may consult the Supplier Quality Control representative (SQC) for instructions on course of action.
- The CDP, after consultation with the SQC, may be requested to adjust the non-conforming concrete by the SQC provided the CSA production and delivery requirements are met.
- The Field Technician should retest the concrete to verify compliance and record the actions taken along with the follow up results.
- If attempts to bring the concrete into compliance are not successful, the Field Technician should notify the CDP, the QCR, and/or general contractor of the final test results of the non-conforming concrete and record that the non-conforming concrete was not placed.
- If the non-conforming concrete is placed, the Field Technician should record that the concrete was non-conforming and accepted (and by whom) and record the exact location where the concrete was placed.
- In situations where the contractor has accepted non-conforming concrete the owner's representative (typically in consultation with the Engineer of Record) shall make the final decision to accept/reject the hardened concrete. This may include providing recommendations for further testing, additional remedial measures, or instructions to remove the hardened concrete. Refer to clauses 4.4.6.6.1.3, 4.4.6.6.2, and 4.4.6.6.5 of CSA Standard A23.1-14 for further information.

8 NON-CONFORMING TESTING – SUGGESTED ACTIONS

All testing is to be conducted in accordance with the requirements of the test methods of CSA Standard A23.2-14. However, despite the best intentions of the testing agency's technicians and the contractor's personnel, situations occasionally arise on site which prevents sample collection, testing, or specimen curing from being carried out in strict accordance with the requirements of the applicable test methods. The purpose of this section is not to condone improper sampling and testing, but to offer suggestions to minimize the impact of improper procedures. Implementing these suggestions can only occur where there is good communication and constructive support among the people on site, regardless of whether they are employed by the owner, contractor, concrete supplier, or testing agency.

The following are examples of situations that can arise from time to time. The suggestions that are given presume that contract documents do not prevent such a course of action.

8.1 Field Technician is Not on Site When Concrete is Delivered

It is important that contact information be exchanged before the concrete placement is scheduled. The ideal time to do this is at the pre-construction or pre-placement meeting. The first step is to find out when he or she is expected. If the Technician is slightly delayed, it may be possible to wait until he or she arrives. If the Technician is not expected to arrive in a reasonable time, the contractor has to decide

whether to proceed with the concrete placement since the contractor is responsible for the consequences of the decision. The contractor's decision will likely be influenced by the criticality of the component, the consequences of delay, and the contractual relationship with the testing company. If the placement proceeds without the concrete being tested, it is essential that the placement of the batch is recorded.

8.2 Field Technician Arrives after Concrete Placement Begins

In the event the Field Technician arrives after the concrete placement begins, the Technician should sample the concrete as soon as possible and complete the tests for slump and air content as quickly as possible and advise the contractor immediately if the test results are outside of the specified limits.

8.3 The Sample Cannot be Collected from the Specified Point of Discharge

In the event a sample cannot be taken from the point of discharge of the delivery equipment, the sample should be collected from the nearest location to the specified point of discharge as it is safe to do so. The actual point of sampling, and the reason for not sampling at the specified point, shall be recorded.

8.4 Field Testing Equipment is Missing, Damaged, or Malfunctioning

In the event field testing equipment is missing, damaged, or malfunctioning, the Field Technician should not complete the relevant test and immediately communicate the situation to their office, the contractor and the CDP(s) and make alternate arrangements to correct the issue(s).

8.5 Deviations from the CSA Standard Test Methods

In the event that tests are performed which deviate from the CSA test methods, the deviations from the standard(s) shall be reported.

Some examples of deviations include but are not limited to:

- Tests on the plastic concrete are not completed within ten minutes of transporting and remixing the sample.
- Specimen moulds are damaged.
- A proper curing facility is not on site.
- The transportation of the test specimens to the laboratory is delayed.

9 TEST EQUIPMENT CALIBRATION AND MAINTENANCE

9.1 General

- The Field Technician shall keep the testing equipment clean, well maintained and in good working order.

9.2 Maintenance

- Spray the outside of the air meter with form oil, WD40™, or any other similar product to prevent concrete from sticking to the air meter. This also lubricates external moving parts.
- Daily place a small amount of oil on the central air release shaft of the air meter to keep the shaft and rubber "O" ring lubricated.
- Thoroughly wash all tools and equipment (e.g. air meter, slump cone, slump board, scoops, rods, strike off bars, etc.) with water using a brush or sponge after each test.
- When concrete begins to accumulate on equipment, soak equipment in a mild acid to remove concrete, then rinse thoroughly with water. Take proper safety precautions when using acid to protect skin and the environment.

9.3 Calibration

- Table 1 of CSA Standard A283 specifies the minimum calibration intervals for the various test equipment. Depending on the frequency of use, the frequency of calibration may have to be increased.
- Under normal use, air meter and thermometer calibration should be checked and adjusted once per month or whenever there is a question regarding the accuracy of the equipment.
- Calibration of air meters should be performed in accordance with the manufacturer's written instructions for the particular model of air meter.

10 SAFETY AND ENVIRONMENTAL CONSIDERATIONS

10.1 Safety Considerations

Concrete is a corrosive material and is a controlled product according to the Workplace Hazardous Material Information System (WHMIS). All employees should have WHMIS training prior to working with concrete.

Working with plastic (unhardened) concrete requires a number of precautions, primarily to protect the skin from the high alkalinity. Contact with plastic concrete, can cause skin irritation, severe chemical burns or serious eye damage. Appropriate garments that should be worn include: waterproof and lime resistant gloves, safety glasses, form fitting clothing that protects arms and legs from the corrosive properties of the concrete, and waterproof boots that are high enough to keep concrete from flowing into them. These recommendations are not meant to supersede more rigorous requirements established by legislation or employers' safe work practices.

Wash wet concrete, cement, or cement mixtures from the skin immediately. Flush eyes with clean water immediately after contact. Indirect contact through clothing can be as serious as direct contact, so promptly rinse out wet concrete cement or cement mixtures from clothing. Seek immediate medical attention for persistent or severe discomfort.

Once it has hardened, concrete is generally free from health concerns except that dust control measures are required if the concrete must be cut or drilled.

Refer to the *"Best Practices Guidelines for Concrete Construction"* found at the website for the Ready Mixed Concrete Association of Ontario (**www.rmcao.org**) for additional safety considerations.

10.2 Environmental Considerations

Environmental protection is an important and integral part of conducting business. The primary environmental safety risks are related to the potential for fresh concrete and concrete wash water to escape into watercourses and storm water drains. Cement, which represents about one eighth of the volume of typical residential grade concrete, mixes with water to form a very high pH solution that is highly toxic to fish and other aquatic life. Once concrete has cured, it is no longer a threat to the environment.

The following considerations are necessary:

- Protect the surrounding environment and do not discard unused concrete samples on the job site.
- Do not discard equipment wash water in an area which could adversely effect the environment.
- Establish a protocol for discarding of unused concrete and wash water with the Site Superintendent.

Any spill should be contained immediately and removed as quickly as possible. If concrete or concrete wash water is spilled, you are required to report the spill to the Federal Department of Environment and the appropriate provincial authority.

Refer to the *"Best Practices Guidelines for Concrete Construction"* found at the website for the Ready Mixed Concrete Association of Ontario (**www.rmcao.org**) for additional environmental considerations.

11 CLOSURE

This document was prepared as a planning tool for field testing and sample collection of Portland cement concrete. The key factor in its successful delivery will be effective communication between all parties involved in concrete construction to ensure the processes are efficiently implemented and effectively documented.

12 REFERENCES

- CSA A23.1-14 Concrete Materials and Methods of Concrete Construction
- CSA A23.2-14 Test Methods and Standard Practices for Concrete
- CSA A283-06 (R2011) Qualification Code for Concrete Testing Laboratories
- Best Practices Guidelines for Concrete Construction; OGCA-RMCAO; Revision 1.0; 2005

13 DEFINITIONS

The following definitions have been adapted primarily from documents published by the American Concrete Institute, Canadian Standards Association, and the Ontario Ministry of Transportation.

Air Entrainment: the incorporation of air in the form of microscopic bubbles (typically smaller than 1 mm) during the mixing of concrete.

Compressive Strength: the measured maximum resistance of a concrete specimen to axial compressive loading, expressed as force per unit cross-sectional area.

Concrete: a mixture of hydraulic cement, aggregates, and water, with or without admixtures, fibers, or other supplementary cementing materials.

Contractor: the person, partnership, or corporation undertaking the Work

Contract: the signed document between the Owner and the Contractor for the performance of the Work included in the Contract Documents

Contract Documents: the Tender, Specifications, Drawings, Special Provisions and Addenda, and subsequent amendments to any of these documents made pursuant to the provisions of the Contract.

Curing: actions taken to maintain moisture and temperature conditions in a freshly placed concrete to allow hydraulic cement hydration and (if applicable) pozzolanic reactions to occur.

Field-cured specimens: concrete test specimens cured as nearly as practicable in the same manner as the concrete in the structure.

Hydraulic Cement: a binding material that sets and hardens by chemical reaction with water and is capable of doing so under water.

Owner: the party to the Contract for whom the Work is being performed.

Placing: the handling, deposition, and consolidation of freshly mixed concrete in the place where it is to harden.

Quality Assurance: actions taken by the Owner or the Owner's representative , to provide and document assurance that what is being done and what is being provided are in accordance with the project specifications and standards of good practice for the Work.

Quality Control: actions taken by the Contractor, or the Contractor's representative, to provide control and documentation over what is being done and what is being provided so that the applicable standard of good practice and the project specifications for the Work are followed.

Ready-Mixed Concrete: concrete manufactured for delivery to a purchaser in a fresh state.

Slump: a measure of the consistency of freshly-mixed concrete equal to the subsidence of a moulded specimen immediately after the removal of a standard slump cone.

Subcontractor: a person, firm, or corporation undertaking the execution of a part of the Work by virtue of a contract with the Contractor.Work means the total construction and related services required by the Contract Documents.

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

Testing: The act of obtaining a representative sample of concrete and conducting the required test(s), all in accordance with CSA Standard A23.2-14, and reporting the test results.

APPENDIX A

Selected Tables from CSA Standard A23.1-14

Table 1
Definitions of C, F, N, A,S and R classes of exposure

(See Clauses 3, 4.1.1.1.1, 4.1.1.1.3, 4.1.1.5, 4.1.1.8.1, 4.1.2.3, 4.4.4.1.1.1, 4.4.4.1.1.2, 6.1.4, 6.6.7.5.1, 8.12.1, 9.1, L.3, and R.1, Tables 2, 3, and 17, and Annex L.)

C-XL	Structurally reinforced concrete exposed to chlorides or other severe environments with or without freezing and thawing conditions, with higher durability performance expectations than the C-1 classes.
C-1	Structurally reinforced concrete exposed to chlorides with or without freezing and thawing conditions. Examples: bridge decks, parking decks and ramps, portions of structures exposed to seawater located within the tidal and splash zones, concrete exposed to seawater spray, and salt water pools. For seawater or seawater-spray exposures the requirements for S-3 exposure also have to be met.
C-2	Non-structurally reinforced (i.e., plain) concrete exposed to chlorides and freezing and thawing. Examples: garage floors, porches, steps, pavements, sidewalks, curbs, and gutters.
C-3	Continuously submerged concrete exposed to chlorides, but not to freezing and thawing. Examples: underwater portions of structures exposed to seawater. For seawater or seawater-spray exposures the requirements for S-3 exposure also have to be met.
C-4	Non-structurally reinforced concrete exposed to chlorides, but not to freezing and thawing. Examples: underground parking slabs on grade.
F-1	Concrete exposed to freezing and thawing in a saturated condition, but not to chlorides. Examples: pool decks, patios, tennis courts, freshwater pools, and freshwater control structures.
F-2	Concrete in an unsaturated condition exposed to freezing and thawing, but not to chlorides. Examples: exterior walls and columns.
N	Concrete that when in service is neither exposed to chlorides nor to freezing and thawing nor to sulphates, either in a wet or dry environment. Examples: footings and interior slabs, walls, and columns.
N-CF	Interior concrete floors with a steel-trowel finish that are not exposed to chlorides, nor to sulphates either in a wet or dry environment. Examples: interior floors, surface covered applications (carpet, vinyl tile) and surface exposed applications (with or without floor hardener), ice-hockey rinks, freezer warehouse floors.
A-XL	Structurally reinforced concrete exposed to severe manure and/or silage gases, with or without freeze-thaw exposure. Concrete exposed to the vapour above municipal sewage or industrial effluent, where hydrogen sulphide gas might be generated, with higher durability performance expectations than A-1 class.
A-1	Structurally reinforced concrete exposed to severe manure and/or silage gases, with or without freeze-thaw exposure. Concrete exposed to the vapour above municipal sewage or industrial effluent, where hydrogen sulphide gas might be generated. Examples: reinforced beams, slabs, and columns over manure pits and silos, canals, and pig slats; and access holes, enclosed chambers, and pipes that are partially filled with effluents.
A-2	Structurally reinforced concrete exposed to moderate to severe manure and/or silage gases and liquids, with or without freeze-thaw exposure. Examples: reinforced walls in exterior manure tanks, silos and feed bunkers, and exterior slabs.
A-3	Structurally reinforced concrete exposed to moderate to severe manure and/or silage gases and liquids, with or without freeze-thaw exposure in a continuously submerged condition. Concrete continuously submerged in municipal or industrial effluents. Examples: interior gutter walls, beams, slabs, and columns; sewage pipes that are continuously full (e.g., forcemains); and submerged portions of sewage treatment structures.
A-4	Non-structurally reinforced concrete exposed to moderate manure and/or silage gases and liquids, without freeze-thaw exposure. Examples: interior slabs on grade.

(Continued)

Table 1 (Concluded)

S-1	Concrete subjected to very severe sulphate exposures (Tables 2 and 3).
S-2	Concrete subjected to severe sulphate exposure (Tables 2 and 3).
S-3	Concrete subjected to moderate sulphate exposure and to seawater or seawater spray (Tables 2 and 3).
R-1	Residential concrete for footings for walls, columns, fireplaces and chimneys.
R-2	Residential concrete for foundation walls, grade beams, piers, etc.
R-3	Residential concrete for interior slabs on ground not exposed to freezing and thawing or deicing salts.

Notes:

(1) *"C" classes pertain to chloride exposure.*

(2) *"F" classes pertain to freezing and thawing exposure without chlorides.*

(3) *"N" class is exposed to neither chlorides nor freezing and thawing.*

(4) *All classes of concrete exposed to sulphates shall comply with the minimum requirements of S class noted in Tables 2 and 3. In particular, Classes A-1 to A-4 and A-XL in municipal sewage elements could be subjected to sulphate exposure.*

(5) *No hydraulic cement concrete will be entirely resistant in severe acid exposures. The resistance of hydraulic cement concrete in such exposures is largely dependent on its resistance to penetration of fluids.*

(6) *Decision of exposure class should be based upon the service conditions of the structure or structural element, and not upon the conditions during construction.*

Table 2
Requirements for C, F, N, A, and S classes of exposure

(See Clauses 4.1.1.1.1, 4.1.1.1.3, 4.1.1.3, 4.1.1.4, 4.1.1.5, 4.1.1.6.2, 4.1.1.8.1, 4.1.1.10.1, 4.1.2.1, 4.3.1, 4.3.5.2.2, 4.3.7.2, 4.3.7.3, 7.4.1.1, 8.7.5.1, 8.12.1, 9.4, 9.5, L.1, L.3, and R.3 and Table 1.)

Class of exposure*	Maximum water-to-cementing materials ratio†	Minimum specified compressive strength (MPa) and age (d) at test†,***	Air content category as per Table 4	Curing type (see Table 19)			Chloride on penetrability requirements and age at test‡
				Normal concrete	HVSCMN-1	HVSCM-2	
C-XL or A-XL	0.40	50 within 56 d	1 or 2§	3	3	3	< 1000 coulombs within 91 d
C-1 or A-1	0.40	35 within 56 d	1 or 2§	2	3	2	< 1500 coulombs within 91 d
C-2 or A-2	0.45§§	32 at 28 d	1	2	2	2	—
C-3 or A-3	0.50	30 at 28 d	2	1	2	2	—
C-4** or A-4	0.55	25 at 28 d	2	1	2	2	—
F-1	0.50	30 at 28 d	1	2	3	2	—
F-2 or R-1 or R-2	0.55	25 at 28 d	2††	1	2	2	—
N	As per the mix design for the strength required	For structural design	None	1	2	2	—
N-CF or R-3	0.55	25 at 28 d	None	1	2	2	—
S-1	0.40	35 within 56 d	1 or 2§	2	3	2	—
S-2	0.45†††	32 within 56 d	1 or 2§	2	3	2	—
S-3	0.50†††	30 within 56 d	1 or 2§	1	2	2	—

**See Table 1 for a description of classes of exposure.*

†The minimum specified compressive strength may be adjusted to reflect proven relationships between strength and the water-to-cementing materials ratio provided that freezing and thawing and de-icer scaling resistance have been demonstrated to be satisfactory. The water-to-cementing materials ratio shall not be exceeded for a given class of exposure.

(Continued)

Table 2 (Concluded)

‡*In accordance with CSA A23.2-23C, an age different from that indicated may be specified by the owner. Accelerated moist curing in accordance with CSA A23.2-23C may be specified by the owner; in such cases, the age at test shall be* 28 d. *Where calcium nitrite corrosion inhibitor is to be used, the same concrete mixture, without calcium nitrite, shall be prequalified to meet the requirements for the permeability index in this Table. For field testing, the owner shall specify the type of specimen and location from which it is taken. If cores are required, the concrete cores shall be taken in accordance with CSA A23.2-23C.*

§*Air content category 1 shall be used for concrete exposed to freezing and thawing. Air content category 2 shall be used for concrete not exposed to freezing and thawing.*

***For class of exposure C-4, S-1, S-2, and S-3, the requirement for air-entrainment should be waived when a steel trowelled finish is required. The addition of supplementary cementing materials may be used to provide reduced permeability in the long term, if required.*

††*Interior ice rink slabs and freezer slabs with a steel trowelled finish have been found to perform satisfactorily without entrained air.*

‡‡*See Clause 8.12 for concrete mixes for concrete floors.*

§§*The maximum water-to cementing material ratio for HVSCM-1 concrete in a C-2 exposure shall not exceed 0.40.*

****A different age at test may be specified by the owner to meet structural or other requirements.*

†††*For concretes made with MSLb or HSLb blended cements or combinations of portland-limestone cement and supplementary cementing materials, the water to cementing materials ratio for S-2 and S-3 classes of exposure shall be no greater than 0.40. This maximum water to cementing materials ratio for all sulphate exposures, in addition to the high levels of SCMs required, will help ensure high resistance to sulphate penetration. This provides an additional safeguard until sufficient data on field performance of concrete with these binders can be generated.*

Table 4
Requirements for air content categories

(See Clauses 4.1.1.1.1, 4.1.1.3, 4.1.1.4, 4.1.1.5, 4.3.1, 4.3.3.1, 4.3.3.2, and 4.4.4.1.1.1 and Table 2.)

	Range in air content* for concretes with indicated nominal maximum sizes of coarse aggregate, %		
Air content category	**10 mm**	**14–20 mm**	**28–40 mm**
1†	6–9	5–8	4–7
2	5–8	4–7	3–6

*At the point of discharge from the delivery equipment, unless otherwise specified.

†For hardened concrete, see Clause 4.3.3.2.

Notes:

(1) The above difference in air contents has been established based upon the difference in mortar fraction volume required for specific coarse aggregate sizes.

(2) Air contents measured after pumping or slip forming may be significantly lower than those measured at the end of the chute.

Table 5
Alternative methods for specifying concrete

(See Clauses 4.1.2.1, 4.1.2.3, 4.4.1.2, 4.4.1.3, and 8.1.5 and Annex J.)

Alternative	The owner shall specify	The contractor shall	The supplier shall
(1) Performance: When the owner requires the concrete supplier to assume responsibility for performance of the concrete as delivered and the contractor to assume responsibility for the concrete in place.	(a) required structural criteria, including strength at age; (b) required durability criteria, including class of exposure; (c) additional criteria for durability, volume stability, architectural requirements, sustainability, and any additional owner performance, pre-qualification or verification criteria; (d) quality management requirements (see Annex J); (e) whether the concrete supplier shall meet certification requirements of concrete industry certification programs; and (f) any other properties that might be required to meet the owner's performance criteria.	(a) work with the supplier to establish the concrete mix properties to meet performance criteria for plastic and hardened concrete, considering the contractor's criteria for construction and placement and the owner's performance criteria; (b) submit documentation demonstrating the owner's pre-qualification performance requirements have been met; and (c) prepare and implement a quality control plan to ensure that the owner's performance criteria will be met and submit documentation demonstrating the owner's performance requirements have been met.	(a) certify that the plant, equipment, and all materials to be used in the concrete comply with the requirements of this Standard; (b) certify that the mix design satisfies the requirements of this Standard; (c) certify that production and delivery of concrete will meet the requirements of this Standard; (d) certify that the concrete complies with the performance criteria specified; (e) prepare and implement a quality control plan to ensure that the owner's and contractor's performance requirements will be met, if required; (f) provide documentation verifying that the concrete supplier meets industry certification requirements, if specified; and (g) submit documentation to the satisfaction of the owner, demonstrating that the proposed mix design will achieve the required strength, durability, and performance requirements.
(2) Prescription: When the owner assumes responsibility for the concrete.	(a) mix proportions, including the quantities of any or all materials (i.e., admixtures, aggregates, cementing materials, and water) by mass per m^3 of concrete; (b) the range of air content; (c) the slump range; (d) use of a concrete quality plan, if required; and (e) other requirements.	(a) plan the construction methods based on the owner's mix proportions and parameters; (b) obtain approval from the owner for any deviation from the specified mix design or parameters; and (c) identify to the owner any anticipated problems or deficiencies with the mix parameters related to construction.	(a) provide verification that the plant, equipment, and all materials to be used in the concrete comply with the requirements of this Standard; (b) demonstrate that the concrete complies with the prescriptive criteria as supplied by the owner; and (c) identify to the contractor any anticipated problems or deficiencies with the mix parameters related to construction.

Notes:

(1) *The owner may accept recognized concrete facility certification programs from British Colombia, Alberta, Saskatchewan, Manitoba, Ontario, Québec, or the Atlantic Concrete Association.*

(2) *Some of these specification performance requirements necessitate that performance be measured (pre-qualified) by test submissions that demonstrate conformance. If the requested performance characteristics cannot be demonstrated from a pre-existing concrete mix design, timing for developing the mix, testing, and reporting shall be accommodated in the job schedule and planning process.*

(3) *See Annex J for background information and guidance on the use of this Table.*

(4) *See Annex M for background information and guidance on sustainability and the use in specifications.*

Table 14
Permissible concrete temperatures at placing

(See Clauses 5.2.5.4.1, 7.1.2.1, 7.4.1.3, and 8.5.5.)

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

Notes:

(1) *In no case shall the placing temperature for high-performance concrete exceed* 25 °C.

(2) *The placing temperature should be kept as close as possible to the suggested minimum temperatures shown in this Table. Higher temperatures result in an increase of mixing water, increased slump loss, and an increase in thermal shrinkage.*

APPENDIX B

Example of a Pre-Construction Meeting Checklist

With permission of Ready Mixed Concrete Association of Ontario (www.rmcao.org), the material reproduced in the appendix is from Appendix F of *"Best Practices Guidelines for Concrete Construction"; OGCA-RMCAO; Revision 1.0; 2005.*

SAMPLE CHECKLIST FOR THE CONCRETE PRE-CONSTRUCTION CONFERENCE

A. Project Information

1. Project name _____
2. Location _____
3. Project start date _____
4. Project completion date _____
5. Project participants
   - Contact _____
   - Owner _____
   - Architect _____
   - Structural Engineer _____
   - Construction Manager/General Contractor _____
   - Concrete Contractor _____
   - Concrete Supplier _____
   - Concrete Pumping Contractor _____
   - Concrete Finisher _____
   - Testing Laboratory _____
   - Inspection Agency _____
   - Other _____
6. Background information about the project

   _____

   _____
7. Unique features of the project

   _____

   _____
8. Distribution of completed checklist
   - Project Participants _____
   - Others _____

B. Construction Process

1. Review notes and changes on drawings that may affect construction process

   _____

   _____

2. Sequence of construction and milestone dates

   Foundations _____

   Walls _____

   Structural slabs _____

   Slab-on-grade interior _____

   Slab-on-grade exterior _____

3. Construction/acceptance of base/subgrade, compaction, elevation. Responsibility for:

   Providing base and subgrade elevations to contractors

   _____

   _____

   Stability of the base and or subgrade under construction traffic

   _____

   _____

   Protecting the base and/or subgrade from water damage

   _____

   _____

   Compacting and final grading of the base and subgrade after all plumbing installations are complete

   _____

   _____

   Location of electrical lines (conduit)

   In subgrade trenched and backfilled with rock _____

   In rock subgrade_____

   Protection from truck traffic if required _____

4. Responsibility for site access roads and their maintenance

   _____

5. Responsibility for available space for pumping operations if required

   Access for two trucks to pump, one on each side _____

   Staging area for testing and slump adjustment _____

6. Person responsible for directing trucks to pump or placement area _____

7. Responsibility for directing/backing up trucks _____

8. Responsibility for power, lighting, water, and water pressure during placing and finishing

_____

9. Responsibility for controlling the ambient temperatures (subgrade, forms, and air)

_____

10. Forms

Form sizes, types _____

Lifting equipment required _____

Form materials, accessories _____

Review location of reinforcement, embedded items, waterstops, drains, openings, openings for frames, etc.

_____

Scheduling form erection and removal correlated to reinforcing and concreting operations

_____

Responsibility for installation and inspection

Reinforcement _____

Embedded items _____

Waterstops _____

Drains _____

Opening frames _____

Responsibility for form inspections

Preliminary – prior to rebar placement _____

Semifinal – with rebars, embedded items, waterstops and drains _____

Note: *Reinforcement inspection must include:*
Location and spacing to allow access for vibration equipment and proper coverage
Spacing of reinforcement in relation to aggregate size

Final – before placing concrete _____

11. Vapor retarder or vapor barrier membrane

Type of membrane _____

Location of membrane relative to subgrade _____

Effect on curling _____

Effect on bonding of applied floor coverings _____

Basis of acceptance for installation of moisture sensitive flooring materials (wood, carpet, tiles) on the slab

Moisture emission requirements for flooring materials to be installed

_____

Responsibility for

Testing and reporting of the test results _____

Acceptance of the slab _____

12. Placing concrete: equipment and procedures

Deposit from truck _____

_____

Buggy _____

_____

Belt conveyor _____

_____

Bucket placement _____

_____

Pumping _____

_____

Other _____

_____

13. Consolidation of concrete: equipment and procedures

Vibrators _____

_____

Vibratory screeds (surface vibrators) _____

_____

Back up equipment _____

_____

Power source _____

_____

Other _____

_____

14. Responsibility for inspection of placing and consolidation of concrete_____

15. Ventilation in enclosed spaces

Type of test required_____

Responsibility for ventilation:

During placement _____

During finishing _____

16. Strike off technique

Hand strike off _____

Vibratory screed _____

Laser screed _____

Other _____

17. Finishing

Types of finishes

- Area 1 _____
- Area 2 _____
- Area 3 _____
- Area 4 _____

Special materials for finishes _____

Dry-shake hardener

Rate of application _____

Procedure to install _____

Tools and equipment required _____

Back up tools and equipment required _____

18. Specified tolerances for

Vertical concrete surfaces:

Plumbness _____

Dimensions _____

Thickness _____

Texture _____

Colour _____

Acceptable variances _____

Surface defects _____

Others _____

Slabs-on-grade and floors

Flatness/levelness _____

Dimensions _____

Thickness _____

Texture _____

Colour _____

Acceptable variances _____

Surface defects _____

Joint spacing _____

Others _____

Elevated slabs

Flatness/levelness _____

Dimensions _____

Thickness _____

How it will be determined _____

Texture _____

Colour _____

Acceptable variances _____

Surface defects _____

Others _____

Procedures for measuring tolerances (when and how)

_____

Review specifications for possible conflict between the concrete installer and other trades

_____

_____

Review specifications for conflict between the surface profile provided by the concrete installer and the surface profile required by installer of finished material

_____

_____

Responsibility for

Reporting F-numbers to concrete contractor _____

Accepting floors _____

Measuring tolerances _____

Repairing "air or bug holes" in vertical surfaces _____

Removing curing compounds prior to application of sealers _____

19. Jointing

Review/verification of contraction, isolation, and construction joint layout plans

Structures (walls) ☐ Yes ☐ No

Comments (number, location, spacing, details) _____

Slabs-on-grade ☐ Yes ☐ No

Comments (number, location, spacing, details) _____

Type of joints ☐ contraction ☐ isolation ☐ construction

Formed joints _____

Tooled joints _____

Early entry saw-cut

Timing _____

Depth of cut _____

Joint spacing _____

Equipment _____

Conventional saw-cut

Timing _____

Depth of cut _____

Joint spacing _____

Equipment _____

20. Slabs-on-grade

Joints ☐ Yes ☐ No

Reinforcement ☐ Yes ☐ No

Position of reinforcement in slab _____

Method of supporting reinforcement at specified elevation _____

Termination at joints _____

Load transfer devices (e.g. dowel bars) _____

Type, size, and location _____

Check for specified alignment _____

Define unacceptable cracks (see surface defects in tolerances) _____

Method of repair of unacceptable cracks _____

Responsibility for repair of unacceptable cracks _____

Sealing (filling) joints ☐ Yes ☐ No

Epoxy joint filler ☐ Yes ☐ No

Elastomeric sealant ☐ Yes ☐ No

Timing (review product directions and ACI Guidelines) _____

_____

Depth of filling _____

Procedure (flush or slightly crowned for epoxy joint or concave for Elastomeric sealant)

_____

_____

Responsibility for future touch up _____

21. Curing and Sealing

Curing methods _____

Curing periods _____

Responsibility for curing floors placed prior to erection of roof, walls

_____

Temperature Control ☐ Yes ☐ No

Specify _____

If temporary heaters are used, responsibility for venting to prevent concrete dusting

_____

Excessive evaporation control

Specify _____

Evaporation retarder ☐ Yes ☐ No

Specify _____

Fogging ☐ Yes ☐ No

Specify _____

Other _____

Responsibility for inspection of curing operations/timing

_____

Responsibility for removing curing compounds

_____

Applying sealers

Types _____

Locations _____

22. Protection of concrete

Roof and walls ☐ Yes ☐ No

Specify _____

Floors coverings ☐ Yes ☐ No

Specify _____

Floor protection ☐ Yes ☐ No

Specify age/strength of floor prior to the use of floor by

Foot traffic _____

Pneumatic tire traffic _____

Hard wheel traffic _____

Construction traffic _____

Specify age/strength of floor when

Equipment is installed _____

Racks are erected _____

23. Responsibility for storage areas and site security

_____

_____

24. Form removal

What is the minimum strength requirement for form removal? _____ MPa

What formal report is required before form removal?

_____

Type of field or in-place strength tests (if used) and evaluation criteria?

_____

Name(s) of personnel authorized to approve form removal

_____

25. Procedures for hot weather concreting

_____

_____

26. Procedures for cold weather concreting

_____

_____

C. Concrete Requirements

1. Concrete mix designations

   All concrete materials and supply shall conform to CSA A23.1

2. Concrete mix designs submittal

Have mix submissions been received	☐ Yes	☐ No
Prescriptive requirements	☐ Yes	☐ No
Performance requirements	☐ Yes	☐ No

Comments: _____

_____

Copies of the mix submittal provided to

Owner	☐ Yes	☐ No
Architect	☐ Yes	☐ No
Structural engineer	☐ Yes	☐ No

Construction manager or general contractor	☐ Yes	☐ No
Concrete contractor	☐ Yes	☐ No
Concrete pumping contractor	☐ Yes	☐ No
Concrete finisher	☐ Yes	☐ No
Testing laboratory	☐ Yes	☐ No
Inspection agency	☐ Yes	☐ No

3. Additional mix designs required ☐ Yes ☐ No

   Specify _____

4. Consideration for aggregates other than CSA – prescriptive specification only

   Gradation _____

   Sand requirements ☐ Yes ☐ No

5. Pumped concrete ☐ Yes ☐ No

6. High early strength ☐ Yes ☐ No Strength required _____ MPa at age _____

7. Lightweight concrete ☐ Yes ☐ No

8. Other ☐ Yes ☐ No

   Comments _____

9. Concrete supply

   RMCAO Production Facility Certification receive ☐ Yes ☐ No – do not proceed with supply

   Primary Plant _____ Backup Plant _____

   Plant Contacts _____ Phone Number _____

   Revolutions or time limits for mixing concrete _____

   Note: *Refer to CSA A23.1*

10. Review project specifications for conflicts in performance requirements (compressive/flexural strength, durability, shrinkage, curling and water-cementitious materials ratio, water content, slump, air content)

    _____

    _____

11. Other performance ingredient materials required

Mid range water reducing admixture	☐ Yes	☐ No
High range water reducing admixture	☐ Yes	☐ No
Non-chloride accelerator	☐ Yes	☐ No
Corrosion inhibitors	☐ Yes	☐ No
Fly ash	☐ Yes	☐ No
GGBF slag	☐ Yes	☐ No

Silica fume	☐ Yes	☐ No
Fibres	☐ Yes	☐ No
Colour	☐ Yes	☐ No
Other	☐ Yes	☐ No

Note 1: *Batching all ingredient materials at the plant ensures best quality control of concrete. Jobsite modifications to mixture shall be documented on the delivery tickets.*

Note 2: *Add appendices with the approved concrete mix design submittals*

12. Project specification requirements for air content

Normal weight air-entrained concrete (not recommended if floors require a machine troweled finish, but recommended for all exterior work)

Comments _____

_____

Are adjustments to air content allowed on the jobsite ☐ Yes ☐ No

Comments _____

_____

Air-entrained lightweight concrete for interior slabs

Comments _____

_____

Other requirements

Comments _____

_____

13. Project specification requirements for slump limits

Conventional concrete Max. _____ Min. _____

Pumped concrete Max. _____ Min. _____

Comments _____

_____

Plasticized concrete Max. _____ Min. _____

Comments _____

_____

Other: Max. _____ Min. _____

Comments _____

_____

14. Jobsite slump adjustments

Responsibility for:

Making/permitting jobsite slump adjustments _____

Recording of adjusted batch _____

Materials permitted to adjust the slump:

☐ Water ☐ Mid-range water reducer ☐ High-range water reducer

Procedure to be followed and limitations that apply to jobsite slump adjustment (maximum amount, subsequent mixing, sampling of the load) _____

_____

15. Project specification requirements for temperature

Required temperature of concrete as delivered:

Max: _____ °C Min: _____ °C

Responsible person for requiring and approving special measures to meet concrete temperatures such as hot water, heated aggregate, cold water, ice, liquid nitrogen

_____

_____

Outline procedure to be followed and limitations that apply for measurement of concrete temperature and acceptance of concrete at the jobsite

_____

_____

16. Project specification requirements for concrete delivery time – 120 minutes as per CSA A23.1/.2

Other _____

17. Project specification requirements for lightweight concrete

Maximum unit weight _____

Slump _____

Air content _____

Pumping operations _____

18. Architectural concrete

Finish details	Location
Exposed aggregate	
Smooth finish	
Rubbed finish	
Colored	
Imprinted	

Details (grouted joints, textured)

Special materials

Cement _____

Aggregates _____

Water _____

Admixtures _____

Sealers _____

Release agents _____

Architectural samples or mockups

Location _____

Preservation _____

Responsibility for acceptance _____

Repair methods _____

_____

D. Ordering and Scheduling Concrete

1. Person(s) responsible for ordering concrete (concrete must be ordered by mix design code)

   _____

2. Minimum time notice required for most placements

   _____

3. Define large and specialty orders

   _____

4. Minimum notice required for large and specialty placements

   _____

5. Procedure for handling will call orders

   _____

6. Procedure for handling revised orders

   _____

7. Contact name(s) and phone number(s) for last-minute cancellations

   Supplier _____

   Concrete contractor _____

   Construction manager or general contractor _____

8. Person on jobsite responsible for reviewing delivery ticket prior to placement

   _____

9. Regular hours are between _____ am and _____ pm

   Regular workdays are _____ through _____ not including designated holidays

10. Are there any anticipated holiday and/or overtime placements? ☐ Yes ☐ No

    Comments _____

11. Delivery schedules

    Location of placement _____

    Anticipated placement sizes _____ cubic metres

    Minimum load size _____ cubic metres

    What are anticipated placement rates? _____ cubic metres/hour

    Approximate placements dates _____

    Inclement weather plant capability _____

12. Concrete delivery

    Acceptance/rejection responsibility _____

    Any traffic restrictions at or near the jobsite ☐ Yes ☐ No

    Comments _____

    Any restrictions on entrance to or exits from jobsite ☐ Yes ☐ No

    Comments _____

    Other Items

    Comments _____

13. Trucks:

    Number of trucks _____

    Interval schedule (turn around time) _____

E. Environmental Aspects

1. Environmentally sensitive areas around the project: ☐ Yes ☐ No

   Comments _____

2. Contractor identified concrete wash out area at the jobsite _____
3. Responsibility for clean up of the wash out areas _____
4. Person responsible for directing trucks to the wash out area _____
5. Are spill response kits available on site? ☐ Yes ☐ No

   Comments _____

6. On-site emergency contact person _____
7. Responsibility for disposal of curing compounds _____
8. Other items _____

F. Quality Control/Assurance

1. CSA Accreditation requirements for laboratory_____
2. Certification requirements for

   Laboratory testing technicians name(s)

   CSA Concrete Laboratory Testing Technician _____

   Field testing technicians name(s)

   ACI Grade I Certified _____

   CSA Certified Concrete Tester _____

   CCIL Type J Certified Concrete Tester_____
3. Procedures for verification of specified requirements

   Strength tests _____

   Other _____

F.1. Concrete Sampling and Testing Requirements

1. Sampling frequency _____
2. Sampling location

   Point of discharge _____

   Point of placement _____

   Comments (agreement on sampling location) _____
3. Tests performed on each sample

   Slump _____

   Temperature _____

   Density (unit weight) _____

   Air content _____

   Compressive strength _____

   Flexural strength _____

   Other _____
4. Cylinder size for compressive strength test

   ☐ 100X200 mm ☐ 150x300 mm
5. Beam size for flexural strength test

   ☐ 150X150 mm ☐ Length: refer to CSA A23.2 – 3C

   ☐ Other size _____

   Note: *If beam breaks are low, compare acceptable concrete with suspect concrete by coring*

6. Number of cylinders per sample _____
   (hardened cylinder weight must be recorded on concrete strength reports)
7. Number of beams per sample
8. Number of cylinders/beams to be cured _____ Field? _____ Lab? _____
9. At what ages are cylinders/beams to be tested? _____
10. Number of cylinders/beams per test (minimum 2)_____
11. Are reserve cylinders/beams required? ☐ Yes ☐ No How many? _____
12. Frequency of yield tests and compliance checks (three-load average of unit weight)

    _____

F.2. Test Cylinder Storage and Transportation

1. As per CSA A23.2

F.3. Acceptance/Rejection of Fresh Concrete

1. Who has the authority to accept/reject a concrete delivery?

   _____

   Note: *A second person may be designated as having the authority for FINAL rejection of a concrete delivery*
2. What criteria will be used to reject concrete?
   Slump _____
   Air content _____
   Unit weight _____
   Temperature _____
   Time limit _____
   Other _____
3. Are re-tests allowed before rejection? ☐ Yes ☐ No
   Procedure _____

F.4. Acceptance Criteria for Hardened Concrete

1. Review acceptance criteria
   Other _____

F.5. Distribution of Test Reports (to all participants)

1. CMATS™ shall be used for project

   Note: *Concrete supplier and concrete contractor must receive reports directly and immediately from the laboratory to allow timely response to any deficiencies.*

2. Early age test result strength requirements

   Anticipated concrete strength for earlier age breaks: _____/_____ (% specified strength/days)

F.6. Testing of Hardened In-Place Concrete

1. In what situations will additional (or referee) testing be required?

   Running average of three consecutive strength tests is less than specified – CSA A23.1

   Other _____

2. Procedure(s) to be followed for evaluation of low-strength tests

   Evaluation of test results and testing procedures – including laboratory operations

   Comments _____

   Non-destructive testing

   Penetration probe in accordance with ASTM C 803

   Rebound hammer in accordance with ASTM C 805

   Other (combined method) _____

   Note: *Refer to ACI 228.1R*

   Evaluation of structural adequacy of questionable sections by the structural engineer

   _____

   Core testing and evaluation in accordance with CSA A23.1

   Procedure for conditioning cores prior to testing _____

   Load testing in accordance with CSA A23.1

   Other _____

   Remove and replace

   Comments _____

3. How do the project specifications handle additional testing? _____

   _____

   If additional testing is required, _____ will notify the following parties

   _____

   _____

4. What investigative procedures will be used?

_____

_____

5. Who will be employed to conduct additional testing and who employs them?

_____

_____

6. How will the test results be evaluated?

_____

_____

7. Who will pay the costs of additional testing?

Specified strength confirmed _____

Specified strength not confirmed _____

G. Safety

1. Personal protective equipment required:

Hard hats	☐ Yes	☐ No
Safety boots	☐ Yes	☐ No
Eye protection	☐ Yes	☐ No
Safety vests	☐ Yes	☐ No
Specific protective clothing	☐ Yes	☐ No
Respirators	☐ Yes	☐ No

Other _____

2. Responsibility for

First aid supplies _____

Providing and maintaining information such as Material Safety Data Sheets (MSDS) and Spills Response Plans at the jobsite _____

Job site Ingress and Egress _____

Fall protection _____

Safety inspections _____

Signalers _____

Safety meetings _____

3. Emergency contacts _____