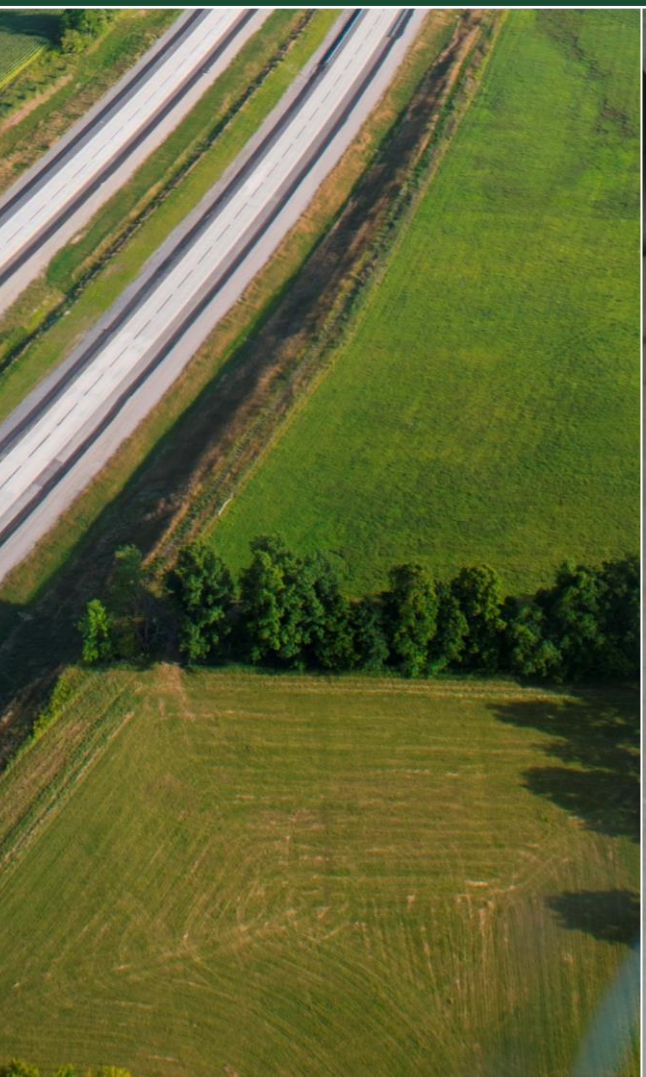
Concrete Producer Guidelines for MTO Concrete Projects



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Introduction

The Concrete Producer Guidelines for Ministry of Transportation Ontario (MTO) Concrete Projects has been developed by the Ready Mixed Concrete Association of Ontario's (RMCAO) Technical Committee. The purpose of this document is to identify key differences between MTO projects and Industrial, Commercial and Institutional (ICI) Sector projects. The document is intended for use by the concrete producer supplying concrete to an MTO project.

This document attempts to identify what concrete producers may specifically encounter when supplying concrete to MTO projects, with the primary objective being to ensure that the concrete producer is aware of the potential benefits (and risks) associated with this type of work. The comments included in this document relate to MTO projects only and while Ontario municipalities use the OPSS documents as well, the MTO concrete *acceptance methods* are specific to MTO projects.

While there are many concrete performance requirements on an MTO project, the concrete producer must always remember that it is only the general contractor who has a direct relationship with the MTO through the contract. The concrete producer must also remember that while the contract documents typically define the concrete performance requirements for the completed elements, it is the general contractor and not the concrete producer that is responsible for the *final* concrete performance.

Note: *This document is a guide and should in no way be viewed as an all-inclusive overview of MTO concrete or contract practice or requirements. It should be used as a starting point for RMCAO members that wish to supply concrete to MTO projects. It is important to remember that what really matters is the exact wording of the MTO contract documents for the specific project. Contract documents can change from one project to another, therefore one cannot assume that they are the same as the previous project. As with any contract proper due diligence and risk management assessment by the RMCAO member must be carried out.*

General Overview of MTO Concrete Projects

- **Unique Contract Structure** – The specifications used on MTO projects often utilize Standards that are prepared by the Owner (MTO), rather than being developed by the project consultant on a project-by-project basis as is more common in the Industrial/Commercial/ Institutional construction sectors. The actual MTO construction contracts may be administered by a consulting engineering firm (referred to as contract administrator or CA). The CA is normally not implementing their own contract specifications, but that of their client's (MTO) contract requirements. While working with consulting engineering firms on construction projects isn't a new idea, the significant difference relates to the fact that the Owner may often take an active role in the management of the contracts and in addressing any technical issues that might arise during the project (effectively an additional layer of management structure of the construction project that is not typically seen in commercial work). The end result may be a significant change in communication between the various construction team members, and the potential may exist for significant time lags in dealing with critical jobsite construction issues.

- **Material Performance Requirements** – MTO contracts have some of the most stringent prequalification and in-project concrete evaluation systems that you will see on any contracts. Concrete test methods such as Hardened Air Void Systems (AVS), Rapid Chloride Permeability (RCP) testing and Linear Shrinkage limits are examples of the concrete test methods that are often performed on these contracts. It is important to have a good understanding of these test methods, and of your mix design's performance characteristics under each test method.

- **Material Acceptance** – Concrete acceptance on an MTO project is measured on an end result basis on the in-place elements, which reflects the contractor's ability to place, consolidate, finish, and cure the actual cast-in-place concrete elements. As the concrete supplier does not have a contract with the MTO, the concrete supplier must be sure that the "purchaser" (i.e. the contractor) understands that the concrete supplier is only responsible to the "purchaser" to supply concrete that meets the purchaser's order requirements. This represents the largest challenge and source of potential risk for the concrete producer. The contractor's responsibility is to also understand and be accountable for ordering concrete including sampling and testing of the plastic concrete, job site acceptance, concrete placement methods, consolidation, finishing, curing and protection of the final concrete element, and making specimens for testing of hardened concrete by the Owner.

- **Significant Focus on Formal Construction Processes and Standardized Reporting Requirements** – The documentation requirements on an MTO project follow standardized forms and formats that each concrete producer must conform to. There can therefore be a significant learning curve that has to be overcome on your first few projects when it comes to preparing mix design submissions and performing any pre-qualification testing required by the contract documents.

OPS Standards, MTO Special Provisions and MTO Non-Standard Special Provisions

To supply an MTO project the supplier must understand how the contract documents are organized. There are a number of different types of documents that you need to be aware of. Always make sure to review the entire contract package.

- **Ontario Provincial Standards and Specifications (OPSS) –** These documents are developed by both the Municipal Engineers Association and the MTO with input from the various provincial associations (ORBA, RMCAO, etc.) with the objective of providing (where possible) standardized details and drawings that relate to infrastructure construction. All of these documents are available for download in PDF format from the MTO website. (http://www.raqsb.mto.gov.on.ca/techpubs/OPS.nsf/OPSHomepage)

  The primary types of OPS documents include:
  - **Provincial Oriented Standards –** Standards just used by the MTO (designated "**PROV**")
  - **Municipal & Provincial Common Standards** – Standards used by both municipalities and the MTO
  - **Municipal Standards** – Standards just used by the Municipalities (designated "**MUNI**")
  - **Drawings**
  - **Special Provisions**

- **MTO Special Provisions** – Since a number of OPSS standards are "Common" standards shared by both the Municipalities and the MTO, in order to modify the base requirements of the standards to address specification issues that are particular to MTO contracts, the MTO uses their own "Special Provisions". While you may be aware of the normal OPSS specification for a particular item, you must also be aware if the MTO has modified the OPSS common document through the use of a "Special Provision". Special Provisions are also included on the MTO website for downloading in PDF format. The location of these documents will also be shown in the Table of Contents of the contract documents. (http://www.raqsb.mto.gov.on.ca/techpubs/cdedsp.nsf/cdedwv?openview&count=1000)

- **MTO Non-Standard Special Provisions (NSSP's)** – Some projects have unique challenges that require specific modifications to the standard contract documents in order to address these issues. When this occurs the MTO creates an NNSP to address this specific issue. As the name implies, these specifications address non-standard issues and they may only be used on a single contract. If their use increases, then the MTO may convert them into a Special Provision when they wish to have these requirements applied to all future contracts. These documents are found in the tender package of the contract and are listed in the Table of Contents. Therefore, it is critical that you read all the contract documents prior to bidding on the work.

There are multiple types of specifications used and the concrete producer first must have a basic understanding of the contract requirements of an MTO project before moving on to the bidding stage of the project. While it is important that the concrete producer has a strong understanding of all the specification requirements, the OPSS items that most commonly involve concrete elements include the following:

- OPSS 350 – Concrete Pavement and Concrete Base
- OPSS 351 – Concrete Sidewalk
- OPSS 353 – Concrete Curb & Gutter Systems
- OPSS 360 – Full Depth Repair of Concrete Pavement or Concrete Base
- OPSS 364 – Partial Depth Repairs in Concrete Pavement

- OPSS 366 – Repairing Concrete Pavement and Concrete Base
- OPSS 553 – Concrete Barriers
- OPSS 578 – Material Specification for Unshrinkable Fill
- OPSS 904 – Concrete Structures
- OPSS 930 – Concrete Patches and Overlays on Structures
- OPSS 1002 – Material Specifications for Concrete Aggregates
- OPSS 1301 – Material Specifications for Cementing Materials
- OPSS 1302 – Material Specification for Mixing Water
- OPSS 1303 – Material Specification for Concrete Admixtures
- OPSS 1350 – Material Specification for Concrete

Note: This list is by no means fully inclusive of all the documents; however, it represents a good starting point for most projects. All the documents can be accessed at the following website: http://www.raqsb.mto.gov.on.ca/techpubs/OPS.nsf/OPSHomepage.

The various OPSS standards undergo updates as required by the MTO or MEA. Updated standards are typically published in April or November of each year. While not every standard can be updated every year, it is important to keep up to date on the current specifications being used.

Concrete suppliers must be aware of which standard is actually in effect on each of your contracts. From a legal standpoint it doesn't matter if there is a new OPSS specification produced to address an issue. It is important to identify which version of the Standard is included in the actual contract documents since that Standard is the only one that matters given the fact that MTO projects can span over multiple years.

Roles of the Key Construction Team Members

Ready mixed concrete is a unique material that is supplied in a plastic state to the jobsite and can be shaped into any form imaginable via the use of concrete formwork and proper structural design.

Since concrete is a plastic product early in its life, there is interaction between the contractor and the concrete producer as both parties must work together in order to meet the overall objectives of the owner.

The primary roles of each of the key players in the construction phase of the project can be as follows:

MTO Head Offices / Regional Offices

- Responsible for either completing the project design or sub-contracting the design work out to a qualified consulting firm
- Implement prequalification systems for contracting firms and contract administration firms
- Prepare the tender documents, receive the bids and award the contracts to the successful contractors
- Either manage the construction project directly or sub-contract the project management out to a consulting firm who will act as the contract administrator
- Supervises the work of contract administrators and responds to any clarification requests that the CA's may raise
- Administer the Designated Source Materials list (DSM)
- Develop contract standards and specifications
- Liaise with stakeholders such as the RMCAO and ORBA via liaison committees

Contract Administrator

- Organize formal pre-construction meeting
- Participate in a pre-construction meeting
- Responsible for managing the contract on behalf of MTO
- Is the direct connection between the contractor and the owner and represents the owner in dealings with the contractor
- Ensures that the specification requirements of the contract are followed and determines acceptability of the contractor's work based upon stated contract requirements
- Processes contractor progress claims and determines any contractual penalties or bonuses that might apply to the concrete elements

General Contractor

- Fully understand the scope and requirements of all aspects of the project
- Identify the work that will be completed by their own forces and the work that will be handed off to specialty sub-contractors and trades
- Identify the selected sub-contractors and concrete producers
- Determine the construction schedule and construction methods that will be employed for this project
- Request feedback from sub-contractors and material suppliers regarding specification requirements and the proposed scheduling of the work
- Clarify with the owner any questions raised during the tender period
- Organize a pre-construction meeting with suppliers and sub-contractors
- Determine where and when specialty concrete performance enhancement and protection allowances will be required (i.e. performance admixtures and special concrete performance needs)
- Provides necessary personnel (e.g. signaler) to direct trucks onto and off of the site
- Verify that all construction and specification issues have been addressed
- Order the correct concrete
- Accept concrete on project site

- Responsible for concrete in-place performance while the material is in their care and control
- Responsible for arranging concrete field testing and ensuring proper testing practices are done in accordance to CSA A23.1/.2 and MTO contract documents
- Identify and verify all project safety practices and protocols

Concrete Producer:

- Review all project specific contract documents
- Identify conflicting or confusing concrete specification requirements prior to tender closing. Forward any clarifications that are required to the Contractor who can make a bid inquiry prior to tender closing
- Participate in a pre-construction meeting
- Identify the concrete mixtures required for the project
- Comply with required contract submissions and pre-qualification requirements
- Ensure RMCAO plant certification is in good standing
- Provide options for concrete performance enhancement
- Assume responsibility for the performance properties of the concrete while the material is in their care and control (as discharged off the chute)
- Identify all project safety practices and protocols
- Deliver concrete as ordered by purchaser
- Monitor concrete field sampling and testing processes (as applicable)
- Confirm that the contractor will forward all applicable concrete test results to the concrete producer (as applicable)

Concrete Sub-Contractor:

- Participate in a pre-construction meeting
- Identify specification issues that will adversely affect their portions of the work
- Identify maximum placement rates of concrete
- Identify the concrete performance requirements for the completion of the work as specified
- Assume responsibility for the performance of the concrete while the material is in their care and control (after the end of the chute)
- Identify all project safety practices and protocols

Concrete Mix Design Submission Process

The starting point is to define which version of OPSS 1350 is being used when it comes to the mix design submittal process. Since there have been some significant modifications this year to the main MTO concrete standard regarding the addition of referee testing procedures, this document will use the most current version: **OPSS PROV 1350 – November, 2016**, for this discussion.

Concrete Mix Designs
On MTO contracts the concrete industry uses a two-part mix submission process. These forms can be found in Appendix B.

1. **Form A** - The concrete producer fills out MTO Form "**PH-CC-433A**", which is the performance-based mix design form for each of the concrete mix designs used on the project (doesn't contain the actual mix proportions of the mix design). This form is developed in consultation with the contractor and is submitted to the contractor for submission to the CA and through the CA to the MTO. This form is submitted at least 7 business days prior to the placement of concrete.

2. **Form B** - The concrete producer fills out MTO Form "**PH-CC-433B**", which includes some proprietary mix design information for each of the mixes. Since this document is confidential and a signed confidentiality agreement exists between the RMCAO and MTO, this "Form B" is submitted directly to the **Head of Quality Assurance** for the MTO region where the project is taking place. It is not submitted to the contractor or the CA on the project since they are not covered in the confidentiality agreement. This form is submitted prior to concrete supply to the project.

There are five MTO regional contract offices, each with its own Quality Assurance section:
- Central Region
- West Region
- Northwestern Region
- Northeastern Region
- East Region

Contact information for all government of Ontario employees can be found at the following website: http://www.infogo.gov.on.ca/infogo/searchDirectory.do?actionType=changeLocale&locale=en and the current list of the Heads of Quality Assurance is updated annually and posted on the RMCAO website so that you know where to send the Form B information package.

Concrete Mix Design Submission Process
The following is a quick overview of the supporting documentation required to be included with **Form A** mix design submissions:
- Copy of your up-to-date RMCAO Certificate of Ready Mixed Concrete Production Facilities for the plant(s) supplying concrete to the project
- The range of concrete production rates required for the work (as determined by the contractor)
- A certificate or letter from your admixture supplier confirming compatibility between the admixtures being used (only if you are using admixtures from multiple suppliers in the same mix design)
- Copy of your batch water test results (only if you are not using municipal drinking water)
- A certificate verifying cements to be free from early stiffening tendencies (only if non-agitating trucks will be used to deliver the concrete)
- Any other requirements specified elsewhere in the Contract Documents.

All supporting documentation included with the mix design submissions should be less than 12 months old at the time of submission in order to be acceptable and must be from the same raw material sources and similar proportions.

Designated Source Materials List
OPSS requires certain types of materials to be used in the production of the concrete to be listed on the Designated Source Materials List (DSM). What this typically means for concrete is that the major raw materials used to make the concrete (aggregates, admixtures and cements) must be prequalified by the MTO and listed on the DSM in order to be used on their contracts.

The list of approved concrete admixtures and cements can be found on the Road Authority website: http://applications.roadauthority.com/mpl/mpl.asp?MPlShortName=MTO+DSM. Just select "structural" and "concrete" in section 9.25 to see the list of currently approved products.

Note: For concrete admixtures the products may also identify a minimum dosage level for the product. This can create "issues" since the minimum dosage level may not take into account any potential for the synergistic effects of other admixtures or materials in the mix, and there may be a need to use less than the minimum amount specified on the DSM List. RMCAO is working with MTO on these issues; however, the specifications currently require the minimum dosages to be followed so you should raise this issue with the contractor during the mix design submission process.

There is not a formal list of acceptable aggregate sources for all concrete aggregates. However, the MTO does maintain a list of approved aggregate sources for concrete pavement projects on their RAQS website: https://www.raqsa.mto.gov.on.ca/login/raqs.nsf/English/Graphic/ViewconcretePavementAggregateLists?OpenForm.

Aggregate suppliers wishing to prequalify their materials for use on MTO projects should contact the appropriate section of the MTO for additional information on the prequalification requirements.

Mix Design Modifications
While the concrete mix design submission process is typically completed at the start of the project, the MTO mix design process does allow for modification to be made to the mix designs throughout the project, at the concrete producer's discretion.

The following changes can be made to the mix designs on an MTO project without requiring a new mix design submission and submission of supporting documentation:

- Total cement content can be varied by ± 5%
- Supplementary cementing materials can be reduced by up to 5%
- Concrete admixtures can be varied within the dosage range stated on Form B
- Water quantity can be varied by the dosage range stated on Form B

Removal of a material from a mix design or the addition of a retarder requires the submission of a new mix design, however does not require the submission of the supporting test data.

A new mix design and submission of new supporting documentation is required for the following conditions:

- Changing the source of materials used in the concrete
- Substituting a material or product for another from the same source
- Adding a material to the mix design (exception for retarder addition)
- Adjusting the quantities of the materials outside the initial ranges submitted on Form B

Plastic Concrete Evaluation Methods

The workability of the concrete is a significant issue for the concrete placement contractor and has a significant impact on the placement methods and placement rates that the contractor can achieve on the project.

The MTO does not directly specify the plastic properties of the concrete; they do require the contractor and the concrete producer to identify plastic properties on the mix design submission, their plastic targets for both slump and plastic air content for jobsite acceptance testing purposes.

Jobsite Testing

Unlike commercial concrete projects, there isn't a direct connection between the jobsite plastic concrete testing and sample casting, and the laboratory concrete testing work. In the MTO model, all the laboratory testing is performed by an MTO designated concrete testing laboratory that has the "Area Laboratory Contract" for that region or is sub-contracted to another laboratory by the Area Lab if they don't have the necessary equipment or certifications to perform the testing. The field testing component of the work is left in the control of the contractor who must use either ACI or CSA/CCIL Certified Concrete Field Testing Technicians to perform the work. The use of non-certified personnel for concrete field testing is not permitted.

For a list of all MTO prequalified concrete testing labs and operators please visit:

https://www.raqsa.mto.gov.on.ca/login/raqs.nsf/English/Graphic/ViewQualifiedLaboratories?OpenForm

In commercial sector projects, the concrete testing firm typically performs both the field testing and the laboratory testing. This allows them to maintain control of the testing quality and to be responsible for all aspects of proper testing.

It is RMCAO's opinion, because the field and laboratory testing services are separated for MTO projects, that there isn't a single source or company that is responsible for all aspects of the testing process. MTO has no formal mechanism to address improper field testing issues other than referee testing; the test results often remain in the material evaluation calculations. From a concrete producer's standpoint, this protocol represents a significant potential risk to supplying concrete.

The following steps can be taken:

- The first is the development of "referee testing procedures" that allow for the re-evaluation of the concrete samples, if the contractor wishes, to challenge the accuracy of the original test results.

- Second, the concrete producer has the ability to do both the acceptance and/or referee cylinder casting for compressive strength or subcontract this portion of the work out to a firm that you employ. While this approach still doesn't address the fact that improper concrete testing can be used in penalty/bonus calculations, it does, at a minimum, offer some direct control over the quality of the work. The arrangements and costs for completing the concrete field testing are ultimately the responsibility of the general contractor so the final selection of the field testing system to be employed remains their choice.
- When improper field testing is witnessed, immediately raise this issue with the contractor and request corrective actions be taken to address the issue. Remember, referee testing mechanisms are of limited value if the referee sample is also obtained through improper testing practices.
- Consider implementing your own QC testing program. While the MTO contract documents will not formally recognize your testing program, the test results themselves still indicate the quality of your concrete and can be very important later on in the project if there is a dispute with your customer regarding the quality of the concrete you supplied to the project.

Concrete Slump Testing

Contrary to the requirements of CSA A23.1, the contractor on an MTO project only has limited control over the workability of the concrete supplied to the project. While the MTO will allow the contractor to select the target slump value, the maximum allowable slump for normal concrete is 100 mm.

Exceptions:

- The maximum slump of conventional concrete with superplastizer added at the site is 230 mm (Note: site added SP generally reduces the effectiveness of cement dispersion in the mix and requires the need for a jobsite technician to dispense the product)
- HPC, silica fume overlays, concrete patches, refacing, and prestressed concrete members have a maximum slump of 230 mm and superplasticizer can be added at the plant
- Tremie concrete placements have a maximum slump of 180 mm
- Self Consolidating Concrete (SCC) is not evaluated using the conventional slump test method (see SCC non-standard special provision requirements for exact testing methods)

Slump acceptance ranges:

MTO slump requirements are not consistent with the CSA A23.1. The MTO slump ranges are as follows:

- Slipformed Concrete = Target Slump ± 10 mm
- Tremie Concrete = Target Slump ± 30 mm
- Precast Concrete Barriers = ± 20 mm
- All other Concrete = Target Slump ± 20 mm

Plastic Air Content

Since the MTO typically evaluates and accepts concrete based upon the hardened air void content of the concrete, the MTO allows the contractor and concrete producer to select any plastic air content that they feel is most appropriate for achieving the hardened air void content of the specifications.

The acceptable plastic air content ranges are as follows:

- Slipformed Concrete ± 1.5%
- Tremie Concrete - when required 5.0% ± 1.5%
- Precast Concrete Barriers 6% ± 1.5%
- All other Concrete ± 1.5%

Concrete Placement Window

MTO time requirements are not consistent with the CSA A23.1. While the standard time for concrete placement on commercial projects following CSA A23.1 is 120 minutes, the timelines for MTO projects are as follows:

- **30 minutes** for non-agitating delivery units (dump trucks)
- **90 minutes** for truck mixers and agitating units

The delivery window for truck mixers and agitating units is further reduced to only **60 minutes** when the concrete is placed under "hot weather conditions", which are defined as "Ambient (Air) temperatures in excess of 28°C and concrete temperatures in excess of 25°C."

While CSA A23.1 allows for an extension to the delivery times for the concrete when retarders or hydration stabilizers have been utilized in the mix design, the MTO version of OPSS 1350 does not.

Plastic Concrete Temperature

The temperature of the plastic concrete is determined whenever concrete samples are obtained for determination of slump, plastic air or for the casting of concrete strength cylinders. The actual concrete temperature requirements for the concrete at the time of discharge are as follows:

- For conventional concrete – 10 °C and 28 °C
- For silica fume overlays and HPC – 10 °C and 25 °C

Concrete that does not fall within these temperature ranges is rejected and cannot be used in the project. Secondly, conventional concrete with temperatures in the 25 - 28 °C range may result in a reduction in the concrete placement window when the air temperature is in excess of 28 °C (see Concrete Placement Window section).

Hardened Concrete Evaluation Methods

It is important to note that the owner evaluates the final product that the contractor actually placed, not the "as-delivered concrete from the end of the chute" as the concrete industry is typically used to. This is achieved by using coring as the concrete sampling method from the structure rather than obtaining the plastic concrete sample from the chute of the truck.

This difference in sampling dramatically changes the potential performance variables of the concrete and can significantly increase the risk.

This creates a unique situation from the standpoint that the contractor and concrete producer must now have clearly defined roles and responsibilities when it comes to concrete supply and performance. The concrete producer must identify their responsibility for the concrete "as delivered" via their quotation forms and general concrete supply Terms and Conditions to the contractor prior to the tender closing so that there is no confusion regarding this issue (See Appendix A for sample Terms & Conditions).

Compressive Strength Determinations

With the exception of concrete pavement projects where cores are utilized, field cast cylinders made from the end of the chute of the ready mix truck are used to determine the compressive strength of the concrete. MTO uses an End Result Specification (ERS) which includes a penalty/bonus system for compressive strength. Specifically, the MTO statistically analyzes the compressive strength results for each strength of concrete specified on the contract to determine the "Percent Within Limits" (PWL) and the resulting strength bonus or penalty. (Note: this system is only used when there is sufficient concrete on the project to allow for its use – typically more than 100 m^3 and consists of a minimum of 10 individual strength test results in a lot of concrete.)

Percent Within Limits calculation - use LS 101 to complete the calculations and keep in mind the following information (the link to the LS documents is included in the references section):

- This test method is an estimate of the percentage of the population (concrete lot) that is within the specified strength limit
- It is a statistical calculation that is determined from analyzing the concrete strength results using the following information:
    - Total number of test results
    - Mean strength value (average strength result)
    - Standard deviation of the test data collected
    - Lower specification limit (typically the minimum specified compressive strength)
- What is important to have a good "PWL" is that your average be above the specified strength and the variability from test result to test result be low since higher variability increases the standard deviation value for the data set
- Bonuses of $1 to $5 per m^3 are available for PWL values in the 96% to 100% range
- Penalties of $1 to $40 per m^3 are available for PWL values in the 90% to 50% range
- PWL values less than 50% result in complete removal and replacement of all the concrete
- Be aware that you can receive a penalty for compressive strength even though every test result on the project is above the specified strength. What matters is the **average strength** and the **standard deviation**

Issues to consider:

- The concrete is grouped by compressive strength. All the 30 MPa concrete strength results are used in the calculations regardless of the fact that there may be different 30 MPa concrete mix designs (e.g. 30 MPa, slipformed 20 mm slump concrete curb mix strength results are combined with the 30 MPa bridge deck 180 mm slump superplasticized concrete mix). Combining "30 MPa" mixes with different mean strengths creates additional variability in the test results and directly affects the PWL calculations.
- The MTO PWL program does not account for the fact that concrete can be supplied by multiple concrete producers. If there are two or more concrete producers on a project, all the test data gets combined together regardless of the fact that each producer has different mix designs and even different raw material sources. This can also result in significant variation in the statistical calculations and creates the potential for an extremely difficult jobsite challenge as how to determine who is responsible for the fact that there is no bonus on the project, and which party is assessed any strength penalty due to high test result variability. For this reason, many concrete producers prefer to be the only concrete producer for the project.
- If a company does its own compressive strength testing program as part of your company's internal quality assurance procedures, the results of your testing program will not be formally recognized by the CA or MTO. This doesn't mean that your own testing program doesn't have value as it still provides you with excellent information that you can use to determine when or if the contractor should invoke referee testing.
- The CA forwards the individual test results to the contractor as they become available. For each lot, the CA calculates the mean and standard deviation of the results and forecasts the potential bonus or penalty, if any. Analysis of the test results is given to the contractor monthly. The concrete producer needs to ensure that test results and monthly summaries are forwarded to them by the contractor as soon as they are received.

The new 2010 edition of OPSS PROV 1350 now includes provisions for referee testing of compressive strength results. Under this new system, the contractor is required to cast both acceptance cylinders and referee cylinders at the time of concrete placing. The contractor then has the ability to invoke referee testing once they receive the initial test results and have the referee samples broken at a second laboratory selected from a roster.

Referee testing**:**

- The contractor has 5 business days to invoke referee testing from the date of receipt of the original test results. The concrete producer must ensure that the contractor immediately forwards the test results and that you retain the right to invoke referee testing at your discretion (via the terms of your concrete supply agreement)
- The contractor is responsible for casting both the quality assurance samples and the referee samples, and transporting them to the area lab. Since a major component of concrete test variability can be the actual sample casting, storage and transportation component of the work, the first question that comes to mind is "so who is looking after the referee samples?". The MTO specifications leaves these arrangements and costs up to the contractor with the only requirement being that the field testing technician must be either ACI or CSA/CCIL certified. This leaves the concrete producer with multiple options. The concrete producer may choose to include in their quotation to the contractor the cost associated with your firm performing some or all of the referee or QA concrete field testing (or subcontract out the work to an appropriate testing company). At a minimum, you need to discuss who will be casting the referee samples since this is a critical issue
- Once the field samples are transported to the area lab, both the acceptance and the referee cylinders will likely be stored in the same curing facilities. While the MTO has indicated they will be conducting the appropriate level of inspections of the curing facilities, the referee samples will be cured at the

same facility as the acceptance cylinders so the referee samples will not likely indicate any variability associated with sample laboratory curing

- When referee testing is invoked, the referee samples will be transferred to a different concrete testing laboratory for cylinder breaking (laboratory selected from a roster list). The referee test results will only be considered valid if they are significantly different than the original test results. How this is determined is by comparing the original QA results to new referee test results. If the difference between the results is bigger than the larger of 10% of the specified strength or 10% of the original QA result, then the referee result will be considered significantly different and the original QA result will be removed from the statistical calculations (NOTE: The referee result does not replace the QA result for the determination of the PWL value)
- The costs associated with referee testing will be paid for by the "losing" party. If the contractor invokes referee testing and the referee test results are not significantly different, the original result stands and the contractor pays for the extra testing costs. Conversely, if the referee results are significantly different and the original strength results are removed from the calculations, then the owner pays for the testing costs
- The owner cannot invoke referee testing on their own. This decision remains solely with the contractor and concrete producer (assuming you have made the necessary arrangements with the contractor to have the ability to invoke the testing as well, via your concrete supply agreement)

Rapid Chloride Permeability (RCP)

RCP testing is currently specified on MTO contracts for all High Performance Concrete (HPC) elements and Silica Fume Concrete Overlay projects. RCP testing is also specified for some specialty concrete applications such as Self Consolidating Concrete (SCC).

RCP evaluation of ready mixed concrete is typically evaluated in the following ways:

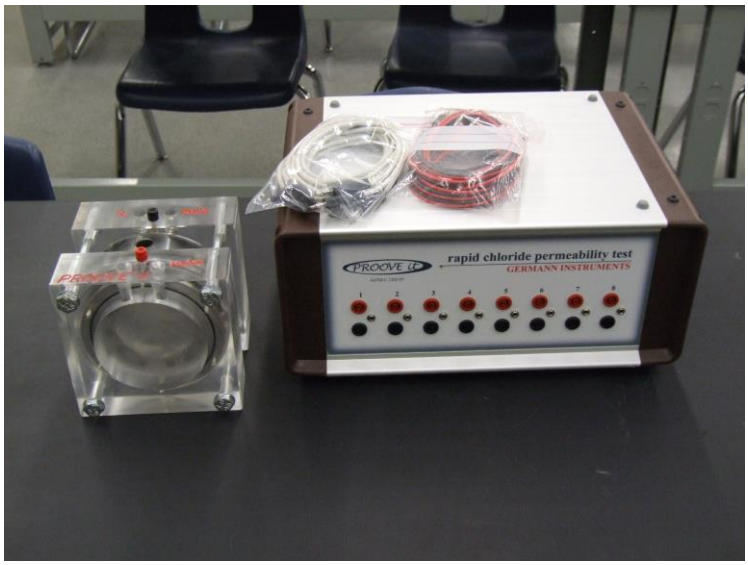
- On ICI sector construction projects and for prequalification testing purposes on MTO contracts (if required) – from cylinders cast as part of a trial batch or from plastic concrete obtained from the end of the chute and tested at the lab
- For MTO contract acceptance – from cores extracted 7 – 10 days after the concrete placement from the concrete element

A commercial sector prequalification process just looks at the ability of the mix design to meet the performance requirements, where as the actual MTO acceptance test methods measure End Result on in-place concrete only.

RCP testing:

- The contractor places and field cures the concrete
- 7 – 10 days after the concrete placement the CA randomly selects a location for the contractor to extract concrete cores for RCP testing from each lot
- The contractor extracts two sets of cores, one for quality assurance testing and a second core for referee testing (Cores shall be removed no more than 1m apart)
- Each core shall be placed in a plastic bag and shall be sealed to prevent loss of moisture
- The cores are transported to the area lab within 24 hours and are placed in the curing room until they are tested at 28 – 32 days as per the requirements of LS-433

A penalty system exists for RCP test results which is typically a 1,000 Coulomb target value for the test method (there is no bonus system). Full payment is received when the RCP value is below the specified value. A penalty is assessed to the contractor when the RCP result is 1,000 to 2,000 Coulombs (calculated using this formula: Penalty = (RCP Value – 1,000)/5) $/m^3. Concrete with an RCP value higher than 2,000 Coulombs is removed and replaced at the contractor's expense.



What's different about RCP testing on MTO projects?

- **Age of concrete at testing** – On commercial projects the concrete sample is typically tested at 56 or 91 days versus the 28-32 days for the MTO test method. Since the SCM's in the concrete have less time to fully react in the mix, the 28-day old samples can have RCP values 20-30% higher than standard 56 day samples in the case of slag usage
- **Sample curing conditions** – On commercial projects 35 MPa test cylinders are cured under laboratory conditions for all but the first 24 hours. MTO project samples are cured on the jobsite for 7 – 10 days. This can also increase the RCP results due to the potential for less than ideal site curing conditions
- **Concrete placement and site condition effects** – Since the concrete samples are obtained by coring the concrete 7 – 10 days after concrete placement, the added variables of concrete placement, consolidation and curing conditions are added into the evaluation. Therefore it is so important that proper placement, curing and protection procedures are in place on the jobsite

Referee testing for RCP was invoked in the 2010 edition of OPSS.PROV 1350. Using this system, the contractor extracts both the quality assurance sample and the referee sample at the time of coring. Both samples are then transported to the area lab and cured under laboratory curing conditions until the samples are tested at 28 – 32 days. The contractor then has the ability to invoke referee testing once they receive the initial test results and have the referee samples tested at a referee laboratory selected from a roster.

Referee testing:

- The contractor has 5 business days to invoke referee testing from the date of receipt of the original test results. This means that you need to ensure that **the contractor immediately forwards the test results to you** and that you retain the right to invoke referee testing at your discretion (via the terms of your concrete supply agreement)
- If the issues regarding the RCP results relate to concrete placement and/or initial site curing conditions, the referee testing process will not address those issues since both the quality assurance and referee samples are obtained at the same time and under the same curing conditions
- If the issues regarding the RCP results relate to the actual testing procedures, sending the referee samples to a second laboratory may address these issues
- If referee testing is invoked, the referee results must be significantly different than the original quality assurance test results. For the purpose of this testing program, significantly different is considered to be a 200 coulomb improvement in the RCP result
- If referee testing is invoked and found to be significantly different, the new RCP referee result is used in the penalty calculations

Hardened Air Void System (AVS)

AVS testing is currently specified for almost all MTO ready mixed concrete applications. The AVS testing procedure consists of obtaining a hardened concrete sample, cutting it in half, polishing the surface and using a microscope to visually inspect the surface of the concrete to determine the actual hardened air void structure of the concrete. The primary objective of this test method is to ensure that the concrete has the necessary properties to provide freeze thaw protection for the concrete element. The actual test method for performing the AVS testing is specified in LS-432.

From a performance standpoint, the test method is used to determine two critical factors, the total air content of the concrete sample and the average spacing factor between the air entrainment in the concrete sample. From a specification standpoint, the AVS requirements for conventional concrete in its hardened state are as follows:

- Air Content ≥ 3%
- Spacing Factor ≤ 0.230 mm

For HPC and Silica Fume concrete elements the AVS requirements are:

- Air Content ≥ 3%
- Spacing Factor ≤ 0.250 mm

While the CSA A23.1 standard specifies hardened air void system requirements for C-XL, C-1, C-2, A-1 & A-2 Exposure Classes of concrete on commercial projects, the big difference is the fact that the samples are obtained from the end of the concrete chute versus cores extracted from the completed structure. The location of sampling makes a big difference, since the MTO is not just evaluating the mix design itself, but the end product which reflects the contractor's ability to place, consolidate and finish the actual concrete element. Care must be taken to ensure proper placing, consolidating and pumping procedures are followed to ensure satisfactory maintenance of the air voids.

AVS evaluation:

- **Variability of the Test Method** – The AVS test method is a time-consuming, operator-driven test. It consists of a single operator performing visual observations on a concrete sample for extended periods of time. RMCAO has conducted blind AVS testing programs in the past and found significant test result variations from operator to operator.
- **Effects of Concrete Placement** – The air void structure can be significantly impacted by the contractor's choice of concrete placement method. In particular, concrete pumping with or without significant line configuration changes can negatively impact both the total air content and/or the average spacing factor significantly
- **Effects of Contractor Consolidation Efforts** – Most concrete requires some level of consolidation to remove any entrapped air that might be present in the concrete. The removal of entrapped air can be completed by either internal or external forces on the concrete, however the consolidation of the concrete results in changes to the air void structure of the concrete. Continued consolidation of the concrete tends to reduce the total air content and increase the spacing factor of the concrete being consolidated
- **AVS Testing is Non-Destructive** – The concrete sample is not damaged during the testing process and the sample can be retested by the same or a different AVS operator
- **Sample Preparation Can Have an Impact on the Test Results** – MTO completes an annual test correlation program to prequalify AVS operators in Ontario. Note that quantifying the proper level of sample preparation and polishing required to accurately complete the test is not addressed.

AVS penalty/bonus system:

- Bonuses for the AVS system are awarded based upon a combination of the hardened air content (must be between 3.9 – 7.1%) and the spacing factor (must be less than 0.200 mm). The bonus can be between $1 – $5 per m^3
- Penalties are calculated based upon a **percentage of the contractor's tendered price** for the element. **The significance of this difference (contractor tendered price versus $/m3) can't be overstated!** Contractor tendered price for the element can include items such as: concrete, formwork, rebar, site access, mobilization, overhead, profit, etc. The end result can be massive penalties that are multiples of the supply price of the concrete
- The concrete producer is responsible for supplying concrete to the project with the proper Air Void System structure. The contractor is responsible for placing, consolidating, finishing and curing the concrete in the actual element. Placement, consolidation and finishing operations can all have significant negative impacts on the final AVS properties of the concrete. Because of this, RMCAO recommends that the concrete producer needs to obtain their own samples of the concrete in order to show that they supplied concrete to the project in conformance with the contract specifications (RMCAO recommends that the terms of your concrete supply agreement clearly identify your rights to obtain your own concrete samples, and that you discuss the sampling frequency with your customer prior to the supply of concrete to the project)

OPSS.PROV 1350 includes provisions for referee testing of AVS results. Under this system, the contractor is required to extract the acceptance core within 7 – 10 days of concrete placement and transport to the area laboratory performing the testing work for the contract.

Referee testing:

- The contractor has 5 business days to invoke referee testing from the date of receipt of the original test results. This means that you need to ensure that the contractor immediately forwards the test results to you and that you retain the right to invoke referee testing at your discretion
- If referee testing is invoked, the samples will be sent to a referee testing laboratory selected from a roster
- When referee testing is performed, the AVS test method is modified to require the operator to take additional data points during the testing process. The intent is that the additional data points, while extending the length of the testing process, should reduce the potential variability in the test method
- When referee testing is invoked, the referee test result replaces the original AVS test results for the determination of any penalties or bonuses. Since this testing is non-destructive and there is no potential for sample improvement with time, there is no "significance difference" required between the original and referee test results for the test method. The new AVS results are accepted regardless of the change in air content or spacing factor

Linear Shrinkage

There has been an increase in the specification of linear shrinkage performance requirements for concrete on both commercial and MTO contracts over the last five years. Low-shrinkage concrete is defined in CSA A23.1 as a concrete type in which the use of special mixture proportions, materials, and/or shrinkage-reducing admixtures results in drying shrinkage less than that of normal concrete.

The 2009 version of CSA A23.1/.2 introduced a formal Canadian test method for concrete shrinkage properties (CSA A23.2 – 21 C Test Method for length change of hardened concrete) which is based largely on the

ASTM C157 testing protocols. The MTO also have a specific test method for measuring the linear shrinkage of concrete samples on MTO projects (LS-435).

General comments regarding linear shrinkage testing on any type of project (ICI or MTO):

- The CSA A3.1 definition of low shrinkage concrete is based upon the concrete producer conducting laboratory pre-qualifications of their concrete mix designs performed within the last 24 months. This test method is not a field test method, but many specifiers are attempting to impose the controlled laboratory prequalification requirements on highly variable field conditions. This is not appropriate in our view
- We are not aware of any laboratory prequalification procedures that are in place for CSA laboratory certifications or the development of an MTO prequalification system for this test method at this time
- There are only a limited number of testing companies that actually have the necessary equipment to perform the laboratory tests, therefore access to the testing equipment is an issue in many parts of the province
- Formal field testing protocols are not in-place and there has been no determination as to the appropriate field qualification limits for this test method (the 0.04% limit for "Low Shrinkage Concrete" in CSA A23.1 is for laboratory cast samples only)
- There are numerous factors that can affect the shrinkage properties of the concrete (total cement content, total water content, aggregate size, types of concrete admixtures, etc.) and some of these properties are directly specified by the owner. Because of this, there is the potential for the owner to specify or the contractor to request conflicting performance requirements
- The concrete industry does not support the field testing of linear shrinkage. This is due to the fact that there is the potential for a significant increase in test result variability when you moved from a strictly controlled laboratory environment to an actual project jobsite (sample casting conditions, vibration sources, initial curing conditions, sample transportation, etc.)

The MTO currently requires linear shrinkage testing on selected concrete repair projects and for information purposes in specialty concrete applications. Where a limit has been specified, it has been 0.06%.

Key issues on MTO projects:

- Linear shrinkage testing is one of the only concrete test methods where the MTO doesn't implement a laboratory prequalification system. The potential for highly variable test results therefore exists
- MTO shrinkage requirements are typically on repair projects. While the shrinkage limit is higher than the CSA A23.1 limit (0.06% versus 0.04%), the owner is also specifying a small aggregate size (13.2 mm) which may result in greater shrinkage
- The prequalification testing is performed in a laboratory environment, but the jobsite testing is performed under highly variable site conditions
- Potential uncertainty as to what happens when the field test results do not meet the specification requirements

Greenhouse Gas Reduction (GHG) Initiative

To combat climate change, the MTO implemented a Greenhouse Gas Reduction (GHG) Initiative in January 2018 by introducing two special provisions that would serve as amendments to OPSS 1350.PROV (Nov. '16). The purpose of these amendments is to use available resources such as Portland-limestone cement, ground granulated blast furnace slag or fly ash and limestone filler at specified replacement levels to either achieve a GHG reduction of 10% or 20%.

No matter the GHG reduction that is being pursued, it is still expected that the material selection and concrete mix design will be optimized to ensure that concrete performance requirements continue to be met.

Some basic limitations to keep in mind include:

- Slag shall be limited to a maximum of 25% by mass of the total cementing material (OPSS.PROV 1350)
- Fly Ash shall be limited to a maximum of 10%, except for silica fume overlays and HPC where up to 25% is permitted (OPSS.PROV 1350)
- A mixture of slag and fly ash up to 25%, except the amount of fly ash shall not exceed 10% (Restriction of 10% fly ash not applicable to silica fume overlays and HPC) (OPSS.PROV 1350)
- Limestone filler shall be restricted to a maximum of 15% of the cement by mass.
- Portland limestone cement or limestone filler shall not be used in concrete exposed to a sulphate environment.

10% GHG Reduction Initiative
The 10% GHG reduction is applicable to all MTO contracts and will be the basis of the initiative.

To achieve a 10% GHG reduction, the use of one or a combination of the following options is required:

- Use of Portland-limestone cement.
- Use of ground granulated blast furnace slag or fly ash to replace at least 10% of the cement content of the mix
- Use of limestone filler to reduce the cement content of the mix by at least 10% through enhanced particle packing, optimized aggregate gradation or other means.

20% GHG Reduction Initiative
The 20% GHG reduction is classified as an "enhanced reduction" and will only be used for demonstration contracts.

To achieve a 20% GHG reduction, the use of one or a combination of the following options is required:

- Use of supplementary cementing materials to replace at least 20% of the cement content of the mix
- Use of Portland limestone cement **and** minimum 10% supplementary cementing materials
- A combination of the use of limestone filler **and** supplementary cementing materials to ensure that 20% of the cement content of the mix is replaced

Supplementary cementing materials in this case shall be ground granulated blast furnace slag, fly ash or silica fume. Use of each individual supplementary cementing material shall be limited to the maximum replacement level for the material permitted by the contract.

References

The following documents have been utilized in the creation of this publication:

- **CSA A23.1-14 –** Concrete Materials and Methods of Concrete Construction
- **CSA A23.2-14** - Methods of Test and Standard Practices for Concrete
- **OPSS PROV 1350** – Material Specification for Concrete - Materials and Production – November, 2016
- **Concrete Digest** – Second Edition – Ready Mixed Concrete Association of Ontario
- **RMCAO 2003 Inter-Laboratory Comparison of Air Void Structure Testing in Hardened Concrete (ASTM C – 457)** – Ready Mixed Concrete Association of Ontario
- **Greenhouse Gas Reduction Initiative NSSP CONC0004 (January 5, 2018)**
- **Greenhouse Gas Reduction Initiative – Enhanced (20%) Reduction for Demonstration Contracts (January 18, 2018)**

Appendix A - Sample Terms & Conditions for Concrete Sale & Supply

SPECIFICATIONS

The concrete producer agrees to provide materials and product that meets the requirements of the specification as provided by the purchaser at the point of discharge from the ready mix truck.

MIX DESIGN

If concrete is specified as per the Performance Specification alternative in CSA A23.1-09 Table 5, mix proportions will not be disclosed by the concrete producer. If the specifier or purchaser orders concrete as per the Prescription Specification alternative the purchaser/specifier is responsible for the proportions and source of any or all materials and the performance of the concrete.

SLUMP

Prices quoted are for slumps up to and including 80mm unless otherwise specified.

ORDERING

All concrete shall be ordered with the proper information as determined by the concrete producer.

NOTICE OF POUR

24 hours or more notice prior to each pour is required. Speciality materials may require significantly more notification (weeks or months) and shall be identified at the start of the project.

CANCELLATION POLICY

Unrecoverable costs that are incurred if a project or pour is cancelled within _____ hours shall be charged to the purchaser.

DELIVERY CONDITIONS

1. The purchaser agrees to provide suitable entrances and exits, roadways and access points of delivery.
2. If, in the opinion of the concrete producer, entrances, roadways or access points are not suitable, the concrete trucks will not proceed past the curb line.
3. If a purchaser orders delivery past the curb line, the purchaser assumes all liability for damage to curbs, sidewalks, driveways or any and all other property.
4. If a purchaser orders delivery past the curb line, the purchaser is held liable for injury or damages caused to employees or trucks as a result of any contravention of OSHA Regulations.
5. If a concrete mixer truck is required to be towed out of a job site, the purchaser shall pay for the cost associated with the towing and any resulting damage to the vehicle.
6. Concrete is deemed to be accepted when the purchaser or purchaser's representative signs the concrete delivery ticket.
7. The purchaser is responsible for the removal of soil tracked onto the roadway.
8. The purchaser shall provide a signaller for backing up the truck.
9. The purchaser shall not add any materials or ingredients to the product in the truck.
10. The purchaser shall identify and supply an environmentally acceptable area for truck wash out.
11. Any concrete that exceeds specification time limits (e.g. CSA or OPSS) shall be immediately returned to the concrete plant and all applicable return and disposal costs shall be the responsibility of the purchaser.
12. Prices quoted are for deliveries from Monday to Friday 7:00 am to 5:00 pm excluding weekends and holidays.

UNDERLOADS

Prices are based on loads of not less than 6 cubic metres, except for one load required to finish a day's pour. All Underload charges will be assessed $ _____ per cubic metre for deliveries of less than 6 cubic metres.

DEMURRAGE

Prices quoted herein are based on prompt unloading of trucks. A truck held at the job beyond the maximum of 60 minutes per load will be charged at a rate of $_____ per minute.

LATE POURS

Concrete deliveries made outside of the standard 7:00 am to 5:00 pm working window shall be subject to an additional charge of ____ $/m^3.

QUANTITIES DELIVERED

The quantity shown on the delivery ticket shall be considered conclusive evidence of the quantity delivered unless otherwise reported at the time of delivery.

PRODUCT TESTING

1. All concrete field and laboratory tests shall conform to CSA A23.1/.2 requirements.
2. All test reports shall contain complete Field and Lab information in accordance to CSA A23.1./.2.
3. All test reports shall be immediately sent to the concrete producer. Failure to supply all concrete acceptance testing reports within the 5 working days, as defined in CSA A23.1 Clause 4.4.1.4, shall be considered complete and unconditional acceptance of the concrete as is. Where referee testing mechanisms exist, the concrete test results shall be forwarded to the concrete producer within 2 working days to allow for their proper review and analysis.
4. Where referee testing systems exist, the concrete producer retains the rights to invoke referee testing at their sole discretion. Failure by the purchaser to invoke referee testing when it is requested by the concrete producer shall result in discarding of that concrete test result for the determination of acceptance and payment to the concrete producer.
5. CMATS™ shall be used by the test laboratory for recording, reporting and distribution of all test results.
6. Concrete Field and Laboratory testing not done according to the CSA A23.1/.2 shall not be considered valid by the concrete producer and not accepted as part of any measurement of acceptance.

PRODUCT ACCEPTANCE

Product that meets concrete order requirements shall be accepted "as discharged" off the chute. From the concrete producer's position, concrete testing and evaluation shall be performed at the following locations:

Concrete Producer Responsibility for Concrete Performance

- Sampling Location for All Test Methods – at point of discharge from the concrete truck
- Concrete Slump – at point of discharge from the concrete truck
- Concrete Temperature – at point of discharge from the concrete truck
- Plastic Air Content – at point of discharge from the concrete truck
- Compressive Strength – from concrete cylinders cast at the point of discharge from the concrete truck and tested in conformance with the requirements of CSA A23.1/.2
- Hardened Air Void System (AVS) – from concrete cylinders cast at the point of discharge from the concrete truck
- Chloride Ion Penetrability (RCP) – from concrete cylinders cast at the point of discharge from the concrete truck
- Linear Shrinkage – from laboratory concrete samples used for mix design prequalification only. Field cast samples shall not be used for concrete producer acceptance
- Any other concrete tests – all testing shall be performed from concrete samples obtained at the point of discharge from the concrete truck.

Responsibility for the concrete performance for any test method that is performed after the concrete is discharge from the ready mix truck is the responsibility of the purchaser and shall not be used for material acceptance and payment to the concrete producer.

The purchaser of the concrete acknowledges that following discharge from the ready mix truck, the acts of transportation, placement, and consolidation, finishing and curing all can have significant effects on the final performance properties of the concrete. The purchaser of the concrete, not the concrete producer, is responsible for the in-place quality of the concrete on the project.

GENERAL

1. This quotation is valid for a period of _____ working days from date of tender award, and the prices will apply for the duration of the project or until _____.
2. The prices quoted are subject to change in provincial sales tax or other taxes payable in respect of the above material or ingredients.
3. This quotation is subject to credit approval of the purchaser.
4. The concrete producer will not be liable for delays in deliveries caused by a failure of plant or transportation facilities, strikes, accidents or any other cause beyond our control.
5. All concrete will be manufactured and supplied according to Ontario Building Code and CSA A23.1/.2.
6. The concrete producer shall not be responsible for the concrete air void structure after initial discharge off the chute. The purchaser is responsible for maintaining the proper air void structure during placement, consolidation, finishing and curing of the concrete element.
7. The concrete producer shall not be responsible for the chloride ion penetrability after the initial discharge off the chute. The purchaser is responsible for maintaining the proper chloride ion penetrability during placement, consolidation, finishing and curing of the concrete element.
8. When low shrinkage concrete is specified, the concrete producer shall only be responsible for mix design pre-qualification as per the requirements of CSA A23.1. The purchaser is responsible for maintaining the linear shrinkage performance requirements during placement, consolidation, finishing and curing of the concrete element. Field cast shrinkage samples shall not be used for concrete producer material acceptance or payment purposes.

This is the approved standard Terms and Conditions form as recommended by the Ready Mixed Concrete Association of Ontario (RMCAO) for use by its members.

Ontario
Ministry of Transportation

CONCRETE MIX DESIGN SUBMISSION FORM A

CONTRACTOR: _____ YR ____ MO ____ DAY ____

CONTRACT NO.: _____ SPECIFIED 28 DAY STRENGTH (MPa): _____

CONCRETE SUPPLIER: _____

PRIMARY PLANT NAME AND ADDRESS: _____

BACK-UP PLANT NAME AND ADDRESS: _____

MATERIALS AND SOURCES

CEMENT	1) Cement Type: _____ Source: _____ 2) Cement Type: _____ Source: _____
SUP. CEMENTING MATERIALS	Slag ☐ Y / ☐ N Max % _____ Source: _____ Fly Ash ☐ Y / ☐ N Max % _____ Source: _____
COARSE AGGREGATE	1) Nominal Max. Size: _____mm Source: _____ Inventory No.: _____ 2) Nominal Max. Size: _____mm Source: _____ Inventory No.: _____
FINE AGGREGATE	1) Fineness Modulus: _____ Source: _____ Inventory No.: _____ 2) Fineness Modulus: _____ Source: _____ Inventory No.: _____
WATER	Source: _____
CHEMICAL ADMIXTURES	Type: _____ Name: _____ Source: _____ / Type: _____ Name: _____ Source: _____ Type: _____ Name: _____ Source: _____ / Type: _____ Name: _____ Source: _____
AIR ENTRAINING	Name: _____ Source: _____

CONCRETE SUPPLIER DECLARATION

I declare that:
1) The proportions of all supplementary cementing materials above meet the contract requirements.
2) The dosages of all chemical admixtures above are at least the minimum dosage shown on the DSM for that product.
3) Form B for this mix design, including all material quantities required by the contract, will be submitted to MTO prior to concrete placement.

Print Name: _____ Company: _____

Signature: _____ Date: _____

INTENDED MIX USE (COMPONENT AND LOCATION)	TARGET AIR CONTENT (%)	SLUMP RANGE (mm)
_____	_____	_____ TO _____
_____	_____	_____ TO _____
_____	_____	_____ TO _____

MTO MIX DESIGN NUMBER

Mix Design No.: ___ ___ ___ ___ – ___ ___ ___ ___ – ___ ___ – ___ ___ (– ___)

Mix Design Number is made up of the contract number, specified strength of concrete, submission number of the mix design and (if applicable) revision number (e.g. 2005-0428-30-01-2).

SUPPLIER'S MIX DESIGN NUMBER (OPTIONAL)

CONTRACTOR'S REPRESENTATIVE SUBMITTING MIX DESIGN FORM A

Print Name: _____

Signature: _____

FOR MTO USE ONLY

Contract Administrator:

Print Name: _____

Form A received.

Signature: _____ Date (Yr Mo Day): _____

Form A and supporting documentation meet contract requirements.

Signature: _____ Date (Yr Mo Day) _____

PH-CC-433 A 05-11

Ontario
Ministry of Transportation

CONCRETE MIX DESIGN SUBMISSION FORM B

CONTRACTOR: _____ YR | MO | DAY

CONTRACT NO.: _____ SPECIFIED 28 DAY STRENGTH (MPa): _____

CONCRETE SUPPLIER: _____ TEL. NO.: _____

PRIMARY PLANT NAME AND ADDRESS: _____

BACK-UP PLANT NAME AND ADDRESS: _____

MATERIALS AND PROPORTIONS

CEMENT	1) Cement Type: _____ Source: _____	_____ kg/m³
	2) Cement Type: _____ Source: _____	_____ kg/m³
SUP. CEMENTING MATERIALS	Slag % _____ Source: _____	_____ kg/m³
	Fly Ash % _____ Source: _____	_____ kg/m³
	Total Cementitious Materials Content	_____ kg/m³
COARSE AGGREGATE	1) Nominal Max. Size: _____mm Source: _____ Inventory No.: _____	
	2) Nominal Max. Size: _____mm Source: _____ Inventory No.: _____	
FINE AGGREGATE	1) Fineness Modulus: _____ Source: _____ Inventory No.: _____	
	2) Fineness Modulus: _____ Source: _____ Inventory No.: _____	
WATER	Source: _____	Total Water Content Range: _____ TO _____kg/m³
CHEMICAL ADMIXTURES	Type: _____ Name: _____ Source: _____ Dosage Range: _____ TO _____ (mL/100 kg Cement)	Type: _____ Name: _____ Source: _____ Dosage Range: _____ TO _____ (mL/100 kg Cement)
	Type: _____ Name: _____ Source: _____ Dosage Range: _____ TO _____ (mL/100 kg Cement)	Type: _____ Name: _____ Source: _____ Dosage Range: _____ TO _____ (mL/100 kg Cement)
AIR ENTRAINING	Name: _____ Source: _____	

MATERIAL QUANTITY INFORMATION IS CONFIDENTIAL AND IS FOR INTERNAL MTO USE ONLY

INTENDED MIX USE (COMPONENT AND LOCATION)	TARGET AIR CONTENT (%)	SLUMP RANGE (mm)
_____	_____	_____ TO _____
_____	_____	_____ TO _____
_____	_____	_____ TO _____

MTO MIX DESIGN NUMBER

Mix Design No.: ___ ___ ___ ___ – ___ ___ ___ ___ – ___ ___ – ___ ___ (– ___)

Mix Design Number is made up of the contract number, specified strength of concrete, submission number of the mix design and (if applicable) revision number (e.g. 2005-0428-30-01-2).

SUPPLIER'S MIX DESIGN NUMBER (OPTIONAL)

FORM B SUBMITTED BY

Print Name: _____

Company: _____

Signature: _____

Date of Submission: _____

FOR MTO USE ONLY

Ministry Representative Receiving Form B:

Print Name: _____

Signature: _____

Date of Receipt (Yr Mo Day): _____

Date Contract Administrator Advised of Receipt (Yr Mo Day):

_____

Advised via: _____

PH-CC-433 B 05-11

Appendix C - List of Reference Websites

- Concrete Ontario (Ready Mixed Concrete Association of Ontario) – www.concreteontario.org
- Ontario Road Builders Association – www.orba.org
- Ministry of Transportation of Ontario – http://www.mto.gov.on.ca/english/
- Ontario Provincial Standards & Specifications (OPSS) – (http://www.raqsb.mto.gov.on.ca/techpubs/OPS.nsf/OPSHomepage).
- MTO Special Provisions – http://www.raqsb.mto.gov.on.ca/techpubs/cdedsp.nsf/cdedwv?openview&count=1000
- Provincial Government Employee Phone Directory – http://www.infogo.gov.on.ca/infogo/searchDirectory.do?actionType=changeLocale&locale=en
- MTO Designated Source Materials List – http://roadauthority.com/mpl/mpl.asp?MPlShortName=MTO%20DSM
- MTO List of Approved Aggregates for Concrete Pavements – https://www.raqsa.mto.gov.on.ca/login/raqs.nsf/English/Graphic/ViewconcretePavementAggregateLists?OpenForm
- MTO Laboratory Testing Manual (LS Test Methods) & Lists of Qualified Testing Labs – https://www.raqsa.mto.gov.on.ca/login/raqs.nsf/English/Graphic/ViewQualifiedLaboratories?OpenForm
- MTO Contract Bulletin Website (listing of projects out for tender and tender results) – https://www.raqsb.mto.gov.on.ca/login/raqs.nsf/English/Graphic/viewContractBulletin?OpenForm

Appendix D - Sample Pre-Construction Meeting Checklist

Introduction

Pre-construction meetings are of prime importance in planning concrete construction work because many potential problems can be avoided at the right time – before the start of the project when the cost impact is relatively low.

In 1999, the National Ready Mixed Concrete Association (NRMCA) and the American Society of Concrete Contractors (ASCC) joined in a partnership to enhance the quality of concrete construction. This checklist is one of the ongoing initiatives of the partnership.

With permission of the original author, the Ready Mixed Concrete Association of Ontario (RMCAO) have reviewed and revised this document for use on Canadian construction projects following the requirements of the most recent CSA A23.1/.2 Standard.

The checklist allocates responsibilities and establishes procedures related to concrete construction – subgrade preparation, forming, concrete mix design, necessary equipment, ordering and scheduling materials and operations, placing, consolidating, finishing, jointing, curing and protection, testing and acceptance, as well as safety and environmental issues.

The checklist covers some of the issues that need to be discussed at a pre-construction meeting and is not intended to be all-inclusive. **This checklist is meant to be a guide and is not intended to address all issues. Please operate safely and within all the regulations.**

Index

References

Canadian Standards Association

CSA A23.1

CSA A23.2

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 _____
   - Contract Administrator _____
   - Construction Manager/General Contractor _____
   - Concrete Contractor _____
   - Concrete Supplier _____
   - Concrete Pumping Contractor _____
   - Concrete Finishing Contractor _____
   - Field Testing Company _____
   - Area Laboratory _____
   - 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 key construction and milestone dates

_____

_____

_____

_____

_____

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. Signaler responsible for directing/backing up/exiting truck _____

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. Placing concrete: equipment and procedures

Deposit from truck _____

_____

Buggy _____

_____

Belt conveyor _____

_____

Bucket placement _____

_____

Pumping _____

_____

Other _____

_____

12. Consolidation of concrete: equipment and procedures

Vibrators _____

_____

Vibratory screeds (surface vibrators) _____

_____

Back up equipment _____

_____

Power source _____

_____

Other _____

_____

13. Responsibility for inspection of placing and consolidation of concrete _____

14. Ventilation in enclosed spaces

Type of test required _____

Responsibility for ventilation:

During placement _____

During finishing _____

15. Strike off technique

Hand strike off _____

Vibratory screed _____

Laser screed _____

Other _____

16. 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 _____

17. 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

_____

_____

18. 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 _____

19. 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 _____

20. 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_____

21. Protection of concrete

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 _____

22. Responsibility for storage areas and site security

_____

_____

23. 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

_____

24. Procedures for hot weather concreting

_____

_____

25. Procedures for cold weather concreting

_____

C. Concrete Requirements

1. Concrete mix designations

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

2. Concrete mix designs submittal

Have mix submissions been received	☐ Yes	☐ No
Form A Mix Designs	☐ Yes	☐ No
Form B Mix Designs	☐ Yes	☐ No

Comments: _____

_____

Copies of the mix submittal provided to

Owner	☐ Yes	☐ No
Contract Administrator	☐ Yes	☐ No
General Contractor	☐ Yes	☐ No
Concrete Sub-contractor	☐ Yes	☐ No
Concrete Pumping Contractor	☐ Yes	☐ No
Concrete Finisher	☐ Yes	☐ No
Field Testing Company	☐ Yes	☐ No

3. Additional mix designs required ☐ Yes ☐ No

Specify _____

4. Pumped concrete ☐ Yes ☐ No

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

6. Lightweight concrete ☐ Yes ☐ No

7. Other ☐ Yes ☐ No

Comments _____

8. Concrete supply

RMCAO Production Facility Certification received ☐ Yes ☐ No

Primary Plant _____ Backup Plant _____

Plant Contacts _____ Phone Number _____

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

_____

_____

10. 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*

11. Project specification requirements for air content

Normal weight air-entrained concrete

Comments _____

_____

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

Comments _____

_____

Other requirements

Comments_____

_____

12 Project specification requirements for slump limits

Conventional concrete Max. _____ Min. _____

Pumped concrete Max. _____ Min. _____

Comments_____

_____

Plasticized concrete Max. _____ Min._____

Comments_____

_____

Other: Max _____ Min. _____

Comments_____

_____

13. 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) _____

14. 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

_____

_____

15. Project specification requirements for concrete delivery time – 90 minutes as per OPSS PROV 1350

Other _____

16. 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 placement 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. ACI and CSA/CCIL Accreditation requirements_____

2. Certification requirements for

Field testing technicians name(s)

ACI Grade I Certified _____

CSA Certified Concrete Tester _____

CCIL Certified Concrete Tester_____

3. Advance notice for scheduling testing personnel

4. Procedures for verification of specified requirements

Strength tests_____

Other _____

5. Concrete Sampling and Testing Requirements

Sampling frequency _____

Sampling location

Point of discharge _____

Point of placement _____

Comments (agreement on sampling location) _____

6. Tests performed on each sample

Slump _____

Temperature _____

Density (unit weight) _____

Air content _____

Compressive strength _____

Flexural strength _____

Other _____

7. Cylinder size for compressive strength test

☐ 100X200 mm ☐ 150x300 mm

8. Beam size for flexural strength test

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

☐ Other size _____

9. Number of cylinders per sample

10. Number of beams per sample

11. Number of cylinders/beams to be cured _____ Field? _____ Lab? _____

12. At what age are cylinders/beams to be tested?

13. Number of cylinders/beams per test (minimum 2)

14. Are reserve cylinders/beams required? ☐ Yes ☐ No How many?_____

15. Frequency of yield tests and compliance checks (three-load average of unit weight)

_____

16. Test Cylinder Storage and Transportation

As per contract requirements

17. Acceptance/Rejection of Fresh Concrete

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*

What criteria will be used to reject concrete?

Slump _____

Air content _____

Unit weight _____

Temperature _____

Time limit _____

Other _____

Are re-tests allowed before rejection? ☐ Yes ☐ No

Procedure _____

18. Acceptance Criteria for Hardened Concrete

Review acceptance criteria

Other _____

19. Distribution of Test Reports (to all participants)

Contractor will forward test reports to concrete producer within 1 business day

Early age test result strength requirements

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

20. Testing of Hardened In-Place Concrete

Compressive strength testing

Responsibility for field testing:

_____

Responsibility for extracting cores:

_____

Concrete producer can invoke referee testing: _____ ☐ Yes

_____ ☐ No

Hardened Air Void System

Responsibility for extracting cores:

_____

Concrete producer can invoke referee testing: _____ ☐ Yes

_____ ☐ No

Concrete producer frequency for casting AVS samples at the end of the chute:

_____

Rapid Chloride Permeability Testing

Responsibility for extracting cores:

_____

Responsibility for extracting referee samples:

_____

Concrete producer can invoke referee testing: _____ ☐ Yes

_____ ☐ No

Concrete producer frequency for casting RCP samples at the end of the chute:

_____

Linear Shrinkage Testing

Responsibility for prequalification testing:

_____

Responsibility for jobsite testing:

_____

Concrete producer can invoke referee testing: _____ ☐ Yes

_____ ☐ No

G. Safety

1. Personal protective equipment required:

    Hard hats

    Safety boots

    Eye protection

    Safety vests

    Specific protective clothing

    Respirators

    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 _____

    Fall protection _____

    Safety inspections _____

    Signalers _____

    Safety meetings _____

3. Emergency contacts _____

    _____