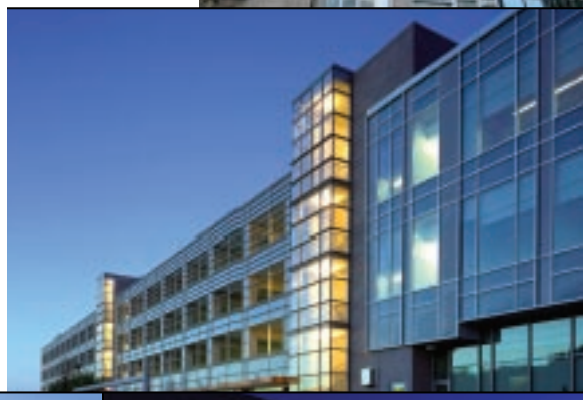
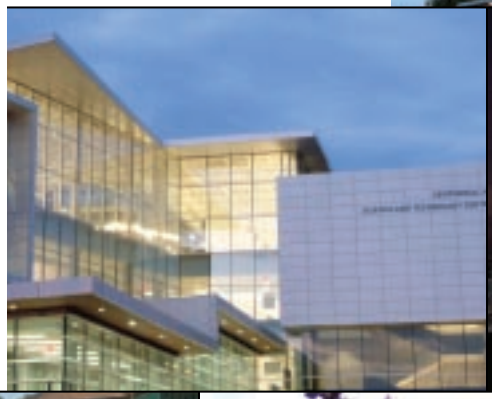
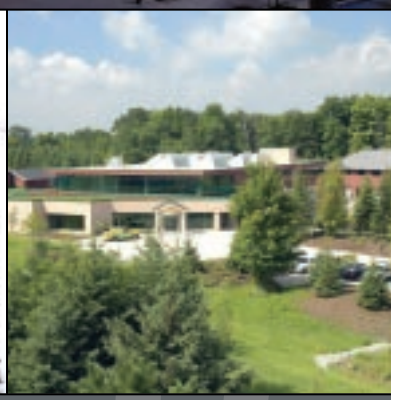
BEST PRACTICES GUIDELINES FOR CONCRETE CONSTRUCTION

OGCA

RMCAO







FOREWORD

The Best Practices Guidelines for Concrete Construction has been developed by the Ontario General Contractors Association (OGCA) and the Ready Mixed Concrete Association of Ontario (RMCAO) with the assistance of industry stakeholders.

The purpose of this document is to recommend standard procedures and guidelines to the industry, including suppliers, manufacturers, general contractors and sub-contractors involved in the use of ready mixed concrete. By using these methods it is the goal of the Guideline to increase communication between all parties and reduce or minimize potential problems. OGCA and RMCAO both strongly recommend that participants use these procedures in the construction process.

Every effort has been made to address the known issues facing our industry today, however the Guideline does not represent itself as the complete answer to these issues. Participants should continue to work with their professional partners in carrying out their responsibilities.

Acknowledgements of the contributions of the following organizations (alphabetical order):

- American Concrete Pumping Association (ACPA)
- Concrete Floor Contractors Association of Ontario (CFCAO)
- National Ready Mixed Concrete Association (NRMCA)
- Ontario General Contractors Association (OGCA)
- Ready Mixed Concrete Association of Ontario (RMCAO)
- RMC Research Foundation (RMC)

Enquiries should be directed to:

Ontario General Contractors Association
6299 Airport Road, Suite 703
Mississauga, Ontario
L4V 1N3
905-671-3969 Tel
905-671-8212 Fax
info@ogca.ca

Ready Mixed Concrete Association of Ontario
365 Brunel Road, Unit 3
Mississauga, Ontario
L4Z 1Z5
905-507-1122 Tel
905-890-8122 Fax
info@rmcao.org

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CSA A23.2-04 *Methods of Test and Standard Practices for Concrete*

Revised Sept. 14, 2007

BEST PRACTICES GUIDELINES FOR CONCRETE CONSTRUCTION

CHAPTER 1 CONCRETE SUPPLIER PRE-QUALIFICATION AND BIDDING PROCESS

This chapter provides a mechanism for identification of the specialized concrete performance requirements for the project and identifying the ability of the concrete supplier to deliver the product(s) as they are specified both by the contract documents and any supplemental contractor requirements.

The pre-qualification may be a process of anecdotal historical references presented in a statistically meaningful manner supporting similar experiences on past projects or may be a pre-determined scientific trial program that would demonstrate through testing the ability of the concrete supplier to deliver products that meet the requirements of the project.

Concrete Supplier Pre-Qualification Process

Items to be addressed during the pre-qualification process include the following:

- Verification of RMCAO Plant Certification
- Identification of production rate of the plant(s), delivery ability & maximum hourly capacity
- Ability to supply speciality concrete products
- Past performance history and similar completed projects

Specialized Materials

The concrete supplier shall indicate during the pre-qualification process the capability for handling, batching, controlling and producing concrete with any specialized materials. Any conditions relating to the supply of specialized materials shall be identified at the time of bidding. Such conditions may include (but not limited to):

1. Lead times for ordering and delivery of both the raw materials and the actual concrete
2. Assignment of responsibility and limitation of liability for specified materials that do not meet the standard requirements of CSA A23.1/.2
3. Special handling, placing, finishing and curing requirements

Specialized Needs

The concrete supplier shall indicate during the tender process the capability to supply special needs for the project. Any limitations related to the special needs shall be identified and communicated to the bidding contractor for consideration during the bidding process. Example: maximum production rates and volumes, limitations and special requirements relating to the cooling or heating of concrete, limits on the hours of work, etc.

Initiation of the Bidding Process

The initiation of the bidding process begins when the material supplier becomes aware of the project through their relationships with an owner, consultant, and the local construction association plans office, or when they receive a request for quotation directly from general contractors bidding the project.

The general contractor or construction manager will usually communicate with the concrete suppliers in the following ways.

1. Telephone solicitation
2. Fax solicitation
3. Publish an advertisement in the Daily Commercial News (DCN) or a local newspaper
4. Electronic communication via email (which may include attachments)

Once the concrete supplier is aware that a specific general contractor or construction manager has expressed interest in obtaining quotations for concrete supply, they should contact the estimator or manager in charge of that particular tender or trade package. Discuss with the estimator how you can view the specifications and drawings prior to supplying your quotation and how you will ascertain the approximate quantities and time frame when the concrete is scheduled to be required on site.

Most general contractors have a plans room at their office for trade contractors and suppliers to review the specifications and drawings. There are also documents available at the local construction associations. Recently drawings and specifications have become available over the internet through many printing houses. You may have to obtain a login and password from the general contractor or construction manager to access these documents or to pay for prints of the construction documents.

When developing quotations for the supply of concrete, the concrete supplier should ensure that they look at all the notes on the architectural and structural drawings to determine if they contain any additional or conflicting requirements.

Read all of the specifications pertinent to concrete production and supply including in particular the Division 1 & 3 Sections as per National Master Specification format. Finish schedules and Division 9 specifications may shed light on what characteristics the finished concrete must possess. Review the Supplementary General Conditions/Instructions to Bidders for any special conditions such as, payment restrictions or requirements for maintaining your bid for a specified time period.

Where the concrete supplier notices conflicting or unclear specification wording, bring it to the attention of the estimator or manager in writing. If they can't answer the query they will forward the question to the Tender Calling Authority or the Consultants to obtain clarification. The importance of this step cannot be overstated since clarification requests submitted before the tender closing prevent confusing or conflicting specification requirements from affecting the tender.

The following should be considered:

- Never assume that by only reviewing one part of the documents that you have covered all of your areas of responsibility (i.e. when reviewing mechanical drawings both the structural and architectural drawings should be cross referenced). Most documents today have clauses relating to this issue and require that a sub-trade or supplier as well as the general contractor conduct a review of all the documents. Failure to do so is cause for non-payment when it becomes apparent later.
- Read the documents carefully. Sub-trades and suppliers are subject to the same conditions imposed on the general contractor.
- Ensure you acknowledge having read all addendums (list them) and that any effect on your price has been accounted for.
- **READ ALL THE DOCUMENTS** to ensure that you are clear on the project requirements before the tender closes.

CHAPTER 2 QUOTATION SUBMITTAL AND REVIEW PROCESS

This section of the guide is to ensure that during the estimating and tendering phase of the project the general contractor, subcontractors and the concrete supplier all work together to properly quote the project as specified by the owner and their consultants.

Improved communication between all parties during the tendering phase allows for the clarification of confusing or conflicting specification requirements via the tender addendum process. The ultimate goal is to eliminate the need to make assumptions during the bidding process.

Roles of the Key Players in the Tendering Phase

The primary activities of the various team members are:

Contractor (or Purchaser of Concrete)

- Fully understanding the scope and requirements of all aspects of the project
- Identifying the work that will be completed by their own forces and the work that will be handed off to specialty sub-contractors and trades
- Identifying the sub-contractors and concrete suppliers that can be utilized based upon the previous pre-qualification process
- Determining the initial construction schedule and construction methods that will be employed for this project
- Requesting feedback from sub-contractors and material suppliers regarding specification requirements and the proposed scheduling of the work
- Clarifying with the consultant any questions raised during the tender period
- Determining where and when specialty concrete performance enhancement and protection allowances will be required (i.e. speciality admixtures and special concrete performance needs)
- Allow for flag person costs to direct trucks onto the site
- Verifying that all construction and specification issues have been addressed
- Obtaining quotations from sub-contractors and concrete suppliers
- Submitting the final quotation for the work

Sub-Contractor

- Identifying specification issues that will adversely affect their portions of the work
- Identifying maximum placement rates of concrete
- Confirm exclusions and qualifications to their scope of work
- Identifying the concrete performance requirements for the completion of the work as specified
- Submitting the final quotation to the general contractor for their portion of the work

Concrete Supplier

- Identifying conflicting or confusing concrete specification requirements
- Confirm exclusions and qualifications to their scope of work
- Identifying the concrete mixtures required for the project
- Providing options for concrete performance enhancement
- Submitting the final quotation for the identified concrete mixes and additional performance options

Development and Utilization of a Concrete Lead Letter

It is critical to the successful development of the project estimate that the general contractor utilizes the expertise of their sub-contractors and concrete suppliers to minimize the chance that items are overlooked. One of the more successful methods of doing this is requesting that your sub-contractors and concrete suppliers provide you with "Lead Letters" well before the closing of the tender process. These letters spell out any additional requirements or exclusions of the company and identify the key components of the work that they will be providing without including the pricing information (which is typically supplied at a later date). This information then allows the project estimator to confirm that his key sub-contractors and concrete suppliers:

- Understand the specification requirements of the project
- Understand their own scope of work
- Identified all the specialty requirements of the project
- Are aware of the general contractors specific construction and scheduling requirements

For example, if you received a lead letter from one of the three concrete suppliers providing you with pricing on a project for 15 L/m^3 of calcium nitrate corrosion inhibitor and you were not aware of this specialty material requirement, then your estimator needs to follow-up on this before you finalize your project estimate. Conversely, if one of the three concrete suppliers fails to indicate that they are pricing superplasticized concrete, which the tender documents have clearly specified, the supplier needs to be notified of this fact before they submit their quotation.

Standardized Concrete Quotation Form

Due to the wide variety of potential quotation forms, general contractors find it difficult to determine which additional performance options (i.e. air entrainment, superplasticizers, etc.) have or have not been included in the quotation. Appendix D contains a recommended concrete quotation form that provides the necessary concrete information in lead letter format (not including pricing information).

The Lead Letter's purpose is to standardize the concrete mix design quotation based upon the following two fundamental requirements:

1. The minimum performance requirements of the designer as specified in the contract specifications & drawings (strength, durability, etc.)
2. The minimum performance requirements of the general contactor and/or the sub-contractor (early strength, placement method, etc.)

In using the form the concrete supplier can clearly identify the concrete performance that will be supplied for each element of the project. This form then provides the general contractor with a list of the additional optional performance items that can be considered when developing their construction plan and project estimate. The document ensures improved communication between the concrete supplier and the contractor.

The concrete quotation form should include the following:

- Concrete application (footings, columns, etc.)
- CSA exposure class (C-XL, C-1, etc.)
- Specified strength (early or standard and age)
- Maximum w/cm ratio
- Actual slump range at placement
- Air entrainment range
- Maximum aggregate size
- Placement method
- Specialty products

CHAPTER 3 TENDER AWARD AND MIX DESIGN PRE-QUALIFICATION PROCESS

At the close of tender and upon award of the project by the owner, the general contractor should follow the process described below.

Standard Tender Award Process to Sub-Contractors and Concrete Suppliers

- Notify the successful tender applicant in a timely manner
- Qualify and re-iterate the list of deliverables and scope of work
- Confirm that pricing has been included for all work items and review the concrete quotation form
- Identify areas where extra over prices will be included (i.e. winter heat, early form removal, etc.)
- Identify the duration and schedule of the project deliverables
- Identify the reporting structure or organization charts that will be common for the project for the owner, contractor, sub-contractors and concrete supplier. The lead representative for each of the above parties needs to be nominated so the pre-qualification process can evolve

Mix Design Pre-Qualification Process

The primary basis of concrete supplier pre-qualification shall be certification of the concrete plant by the Ready Mixed Concrete Association of Ontario. Prior to the supply of concrete on the project, the concrete supplier shall supply a valid **RMCAO Certificate of Ready Mixed Concrete Production Facilities** as issued by the Ready Mixed Concrete Association of Ontario to the contractor prior to the placement of any concrete (see Appendix A). Verification of the plant status can also be confirmed on RMCAO's website.

Classification of Concrete Mixes

If required by the general contractor, the concrete supplier can classify their mix designs. In this case the supplier and the purchaser will classify all mixes that will be supplied to the project into one of the following two primary categories:

- **Standard Concrete** – Concrete with a compressive strength of less than 40 MPa produced using conventional raw materials and with standard performance requirements. These mixes shall have supporting historical test data that statistically demonstrates conformance to the specification requirements (defined below)
- **Non-Standard Concrete** – Concrete with strengths of 40 MPa or greater or concrete of any strength produced using non-standard raw materials (defined below)

In reference to these requirements, the following definitions are provided:

- **Historical Test Data** – Consist of a minimum of fifteen (15) 28 day compressive strength results analyzed over a maximum testing period of 12 months using RMCAO's *Mix Design Statistical Analysis Program* where the raw materials remain substantially unchanged to that of the proposed mix design
- **Non-Standard Raw Materials** – Materials that are typically not used by the concrete plant producing the concrete and where no historical test data using these materials is available. Non-standard raw materials may include the following:
  - Cementing Materials other than Portland Type GU (10), Fly Ash & Slag Cement

- Unique chemical admixtures other than air entrainment, water reducers (low, mid & high range), retarders, accelerators or colouring agents not typically used by the plant. This may include corrosion inhibitors or shrinkage reducing admixtures
- Non-standard aggregate sources. This includes both lightweight and heavyweight aggregates

Concrete Mix Design Strength Requirements

CSA A23.1 clause 4.4.6.7.1 defines that the strength level of each class of concrete is satisfactory for lab cured specimens if:

- The average of all sets of three consecutive strength tests for that class at one age equal or exceed the specified strength, and
- No individual strength test is more than 3.5 MPa below the specified strength

These criteria can be expected to be met 99% of the time if the concrete is proportioned to produce an average strength as follows:

- When the standard deviation of the concrete is not more than 3.5 MPa
  Target Strength = Specified Strength + (1.4 x Standard Deviation)
- When the standard deviation of the concrete is more than 3.5 MPa
  Target Strength = Specified Strength + (2.4 x Standard Deviation – 3.5)

Individual tests from concrete meeting these requirements can be expected to be below the specified strength about 10% of the time.

Utilization of Concrete Mix Design Statistical Analysis Data

CSA A23.1 clause 4.4.6.7.1 further allows the standard deviation used in the calculations above to be used to design concrete whose design strength is within ± 7 MPa of that of the required work provided that similar raw materials are used.

For example, in instances were the concrete supplier has historical test data for their 25 MPa concrete, they can use this test data to design concrete from 18 MPa to 32 MPa in strength, provided that they use similar raw materials. Additional information on this topic is available in RMCAO's "Mix Design Statistical Analysis Guidelines".

Trial Batches

In the event that historical test data within ± 7 MPa of the specified strength for standard mixes is not available, or where historical data is not available for non-standard mixes, concrete trial batches may be required as per CSA A23.1-04.

While the exact trial batch requirements will be dictated by the contract specifications, all project stakeholders must realize that these requirements will result in potential delays in the supply of concrete to the project. The exact extent of the delay will be a function of:

- The performance test method specified (the duration of the testing period can vary from 1 month to a year depending on the project requirements)
  - Standard testing times may be as follows:
    - Compressive Strength = 7 – 28 Days
    - Hardened Air Void System (AVS) = 3 – 14 days
    - Rapid Chloride Permeability (RCP) = 29 – 35 days
    - Linear Shrinkage = 42 – 56 days

- The total number of trial batches that must be performed on the project
- The total number of trial batch attempts required to obtain the performance properties specified in the contract (since multiple attempts may be necessary)

Submission of Concrete Mix Designs

Once the various performance requirements of both the contract documents and the contractors proposed placement methods and schedule have been identified, it is the responsibility of the concrete supplier to provide the performance based mix design submission for each of the concrete elements identified on the project.

The fundamental purpose of the concrete mix design submission is to ensure that the concrete supplier is fully aware of all of the specifications and contractor performance requirements prior to the supply of concrete to the project. In order to facilitate this process, the RMCAO has developed a standardized concrete mix design submission form (Appendix E) for use by all its members.

The mix design submission serves to provide a critical quality control aspect on a construction project. It allows the construction team members to review the document and offer comments prior to concrete placement. The concrete mix design submission is typically forwarded from the concrete supplier to the general contractor for review by the owner's consultants.

For specialty concrete applications the concrete mix design submission may also be accompanied by supporting concrete performance verification testing, as identified in the contract documents.

CHAPTER 4 PRE-CONSTRUCTION AND PRE-PLACEMENT MEETINGS

Proper coordination of the various trades and construction personnel is the major responsibility of the general contractor or construction manager. There are two key meetings that the concrete supplier needs to be involved in - the pre-construction and pre-placement. The following describes some of the items that should be identified and reviewed.

Pre-Construction Meeting

The purpose of the concrete Pre-Construction meeting is to review with all the construction personnel, prior to the start of the project, the major items of concrete construction. This includes:

- Proposed construction schedule
- Proposed concrete mix designs
- Determination regarding the need for the use of value-added concrete products
- Proposed concrete placement methods and rates
- Proposed concrete quality verification methods

This meeting allows for direct input from all parties and may result in modifications to the proposed schedule, placement methods or mix designs to address the actual site and contract requirements prior to the start of the work.

Identification of Key Team Members

The first objectives of the pre-construction and pre-placement meetings are to identify the key contacts from each company that will be involved in the construction of the project and each component of construction. These meetings ensure that all parties fully understand what is required of them and provides each team member with the opportunity to address any specific concerns or challenges that they may face with the other members of the construction team. Attendance of all the stakeholders should be mandatory at each meeting to ensure proper communication and coordination between all parties.

Recommended attendees include:

- Owner
- Architect
- Structural Engineer
- General Contractor
- Concrete Sub-Contractors
  - Forming Contractor
  - Rebar Installer
  - Placing Contractor
  - Floor Finishing Contractor
  - Curing Contractor
- Concrete Supplier
- Concrete Testing Company
- Speciality Material Suppliers

Assigning of Responsibilities on Project

A key component of the pre-construction and pre-placement meetings is to identify the key areas of responsibility and to assign overall responsibility for each component of the project to specific people. This is typically done via the use of a standardized pre-construction meeting form (Appendix F).

The following items should be addressed at the pre-construction meeting:

- **Review of the Concrete Mix Designs** – All members of the construction team should review the performance properties of each of the individual mix designs required for the project and confirm which mix designs will be used for each of the concrete components on the project. This is of significant importance given the fact that concrete must often be placed under changing environmental conditions
- **Review of the Anticipated Project Schedule** – Depending on the duration of the project, there may be a need for performance

modifications to the concrete mix designs to address either site or scheduling conditions

- **Proper Concrete Ordering** – The person responsible for ordering the concrete should be identified at the meeting and only this person should place the concrete orders. The contractor, if applicable, must indicate who has the authority to authorize the addition of value added materials to individual concrete orders (superplasticizers, retarders, etc.)
- **Concrete Delivery Acceptance** – The purpose of concrete delivery acceptance is to confirm that the delivery ticket for the concrete truck matches the concrete specifications for the concrete element being constructed. The item is especially important to address when the general contractor is supplying the concrete for placement by a speciality subcontractor
- **Concrete On-Site Performance Acceptance & Rejection** – The key is to identify who will be conducting the testing and what the acceptance parameters are before the project starts. These items should then be documented on the concrete mix design submissions (i.e. slump range, air range, temperature range, etc.). One person should then be responsible for either accepting or rejecting the concrete on the basis of the testing specified
- **Jobsite Water Addition** – The current edition of CSA A23.1 identifies the responsibility and requirements for the acceptable conditions for jobsite water addition. Only the authorized person may provide permission for jobsite water addition
- **Distribution of Concrete Test Results** – As per CSA A23.1, the concrete test results must be immediately distributed to the designers, general contractor, concrete supplier and concrete sub-contractors as they are produced. Electronic web based platform like CMATS™ (see Appendix C) should be used for efficient delivery of the test results
- **Flag Person for Concrete Delivery** – This person is responsible for ensuring that the construction site is safe for the concrete truck and no obstructions are in the path of the truck
- **Identification of Truck Washout Areas** – Facilities for concrete truck chute washout should be identified at the start of the project and the responsibility for cleaning and maintaining this area assigned to the appropriate organization to ensure that all environmental requirements are maintained

Pre-Placement Meetings

The purpose of the pre-placement meeting is to address the specific issues related to concrete placement of an individual concrete element or placement period. While the scheduling of a pre-construction meeting should be performed on all projects, the scheduling of a pre-placement meeting is determined on an individual basis depending on the complexity of the concrete element/application or the familiarity of the construction team with the type of project (i.e. the placement of a mud slab at the start of a project may not warrant a pre-placement meeting, but the placement of a super-flat industrial floor of significant size will almost always require a pre-placement meeting).

Jobsite Health and Safety Considerations

Jobsite Health and Safety considerations always take precedence over any other considerations on the project since a safe work environment must be provided for everyone at all times. Each construction project

should develop a site specific health and safety plan in accordance with the Occupational Health and Safety Act (OHSA).

The health and safety plan should be presented and reviewed with each and every worker prior to the start of construction and may contain items such as:

- **First Aid Stations** – Identification of the first aid station locations and the first aid supplies available to treat any medical needs directly on the site (eye wash stations, first aid kit, etc.)
- **Minimum Personal Protection Equipment (PPE) Requirements** – Identify the minimum level of PPE required for various construction activities that must be performed
- **Local Area Hospitals** – The location and directions to the various area hospitals should be identified to all the workers on their first day at the site and driving directions should be posted at both the site office and all first aid locations
- **Flag Person Requirements** – A flag person should be clearly identified prior to the start of concrete placement and they shall have all the necessary safety equipment required by the Occupational Health and Safety Act
- **Overhead Lifting** – Conditions where mobile or fixed cranes must lift loads directly over workers should be avoided whenever possible. When items must be repeatedly raised up to the working location, the hoisting/lifting area should be clearly identified for all workers on the jobsite to see and avoid

Environmental Requirements

The importance to ensuring the proper protection of the environment on construction projects has been receiving considerable emphasis in recent years. Environmental considerations such as the collection and recycling of construction waste, identifying the appropriate truck washout areas, and limiting dust and noise pollution are all issues that should be addressed prior to the start of the construction project.

Utilization of Specialty Concrete Performance

Given the significant advancements in both concrete and admixture technology over the past 15 years there is a very wide range of concrete performance and workability that can be utilized on Canadian construction projects. Ideally the issue of workability and performance will be addressed during the bidding phase of the project, but the pre-construction meeting also provides an opportunity for the concrete supplier and concrete contractor to modify the proposed mix designs to meet the contractor's actual production methods, construction schedule and job specific challenges.

While special concrete performance can be defined in an infinite number of ways, some of the more common examples of specialty performance include (see Appendix H for more detailed descriptions of each of these items):

- Self Consolidating Concrete (SCC)
- Winter Concrete
- Hot/Cold Weather Concrete
- High Early Concrete
- Fibre Reinforced Concrete
- C-XL Concrete
- Architectural Concrete
- Surface Hardened Concrete
- High Volume Supplementary Cementing Materials (HVSCM 1 & 2)

Specification of Standard CSA Concrete Exposure Classes

Persons involved in the concrete construction industry should be aware of the standard CSA A23.1 concrete exposure classes that are most often referenced in specifications and on construction drawings. The current edition of CSA A23.1/.2 defines the following concrete exposure classes:

- "C" Class — Concrete exposed to **c**hlorides or other severe environments with or without freezing and thawing conditions
- "F" Class — Concrete exposed to **f**reezing and thawing but not to chlorides
- "A" Class — Concrete exposed to **a**ggressive agricultural waste, municipal sewage or industrial effluent
- "S" Class — Concrete exposed to **s**ulphate exposure
- "N" Class — Concrete **n**ot exposed to chlorides or freezing and thawing

The CSA A23.1/.2 standard goes on to specify additional sub-classes of concrete exposure based upon additional concrete exposure conditions and sets minimum performance requirements based upon these various exposures in Tables 2, 3 & 4. Additional technical information relating to these exposure classes is available in Appendix I (CSA Concrete Exposure Classes).

Concrete Testing Requirements

It is important to ensure that the concrete testing company selected to perform both the plastic and hardened concrete testing is properly qualified to perform the work. Items to be addressed include:

- **CSA Laboratory Certification** – Confirmation that the selected laboratory has been certified by the Canadian Standards Association (CSA) for concrete testing.
- **Field Technician Certification** – As per CSA A23.1 all concrete field testing must be completed by a technician with the appropriate qualifications to properly test concrete. The recognized certifications CSA and ACI field testing technician certifications. The inspector must also have a wallet card confirming that they are qualified to test concrete.

- **Identifying the Minimum Project Testing Requirements** – CSA A23.1 and the contract specifications will indicate both the types of concrete tests and minimum concrete testing frequency that is required for the project. These requirements should be reviewed by all parties prior to the start of work and the responsibility for scheduling the required testing assigned to the appropriate person
- **Concrete On-Site Performance Acceptance & Rejection** – The minimum performance requirements and the associated acceptability ranges should be included in each performance mix design submission so that all parties are aware of the acceptance and rejection criteria. A clear procedure must be developed which indicates the steps that will be taken when the plastic concrete testing indicates that the concrete does not conform to specifications
- **Designating a Concrete Testing Area** – Prior to the placement of concrete on any project the concrete testing area and concrete sample storage area should be clearly identified. Proper concrete testing procedures require that the concrete cylinders used to evaluate the compressive strength of the concrete be cast as close as possible to the jobsite curing box. In some instances this location can be a significant

distance away from the concrete placement location so it is critical that all parties discuss the concrete testing procedures and timelines prior to the placement of concrete

- **Jobsite Storage of Concrete Test Cylinders** – CSA A23.1 requires that all concrete test cylinders be stored in a vibration free environment with the temperature maintained between 15 – 25°C. In addition, the curing environment must protect the samples from moisture loss. These requirements are best achieved through the use of a temperature controlled curing box. Storage of concrete test cylinders in (or under) a construction trailer is not acceptable and may produce a test result that does not actually represent the quality of the concrete supplied
- **Transportation of Test Cylinders to the Testing Lab** – CSA A23.1/.2 specifies that concrete with a compressive strength of less than 35 MPa must be transported to the laboratory for demoulding within a maximum of 76 hours. Concrete samples with strengths of 35 MPa or higher must be transported to the laboratory for demoulding with 28 hours ± 8 hours. If the concrete contains significant amounts of retarder there may be a need to extend the onsite curing period to ensure that the concrete has gained sufficient strength to be safely transported (this should be addressed at the pre-construction meeting prior to concrete placement). Cylinders should be transported in an upright position, secured to prevent damage during transportation and the temperature maintained between 15 – 25°C during the entire transportation process
- **Distribution of Concrete Test Reports** – Concrete test reports should be immediately distributed to all members of the construction team using electronic web based platform like CMATS™ to ensure that everyone has immediate access to the test information. In all cases both the contractor and the concrete supplier must have immediate access to the test information since they are in the position to immediately take corrective action to address any potential problems. While 7 day test results are not typically used for acceptance, it is critical that this information be immediately supplied to the construction team since these results may prompt immediate changes to the mix designs on the project even before the 28 day results are available
- **Distribution of Early Break Test Results** – Early break test results used to determine when formwork can be safely removed or when concrete elements can be exposed to construction loading conditions should be immediately distributed to all members of the construction team. Concrete samples used to evaluate the in place properties of the concrete are typically exposed to the same site conditions as the in-place concrete and the standard CSA A23.1/.2 initial curing requirements do not apply
- **Early Strength vs. Final Strength Requirements and Field vs. Lab Samples** – Due to issues relating to the concrete construction schedule, it is not uncommon for the contractor's early strength requirements to govern the development of the concrete mix design (i.e. the designer specifies 25 MPa concrete @ 28 days for the suspended floor slab, but the contractor specifies 20 MPa in 48 hours due to the proposed form cycling schedule). In these instances it is important to realize that there are two separate testing protocols that must be followed. The first concrete compressive strength testing program is based upon the contractors 48 hour specification requirement and is based upon field cured test cylinders to confirm that sufficient strength has been achieved before the forms can be safely moved. The second concrete compressive strength testing program is based upon concrete samples cast and cured according to CSA A23.1 requirements. The laboratory-cured samples are used to evaluate the concrete from an owner's/consultants acceptance standpoint and are treated in a completely different manner

CHAPTER 5 CONCRETE ORDERING PROCEDURES

While general contractors and concrete suppliers all have unique procedures for the processing and handling of concrete orders for their construction projects, it is important that the minimum ordering requirements are identified and addressed by both stakeholders.

It is strongly recommended that a formal quotation provided by the concrete supplier and/or a purchase order issued by the general contractor be used for the ordering of all concrete. These documents should specify the anticipated quantity and class of concrete being ordered and be identified by their unique mix number (see minimum document requirements in Chapter 2).

General contractors should place orders for concrete directly with the appropriate order entry/dispatch personnel. Concrete sales and management personnel may assist by facilitating communications between company dispatch personnel and the customer. The confirmation of the order and the time of delivery should be the responsibility of the order entry/dispatch personnel.

The concrete supplier should explain their company's methods for receiving orders. Most orders are received by telephone, over a dedicated line, or directly into the order entry/dispatch office. Some company's receive orders by fax and most recently by email.

Concrete Order Entry

As orders are received, they are recorded on the appropriate order entry form or entered directly into the concrete supplier's dispatch software. Each concrete company should use the Checklist for Ordering and Scheduling Ready Mixed Concrete (sample in Appendix J) as developed by the NRMCA and ASCC in the United States and modified for use by RMCAO on Canadian projects, or their own internal form. The recommended minimum information required for entering an order is:

- Name and address of the customer
- Individual placing the order and contact information (particularly a cell phone number)
- Date and time the order was received
- Customer number; all customers, except pre-paid and COD customers, should be assigned a customer number by the concrete supplier accounting department
- Product and quantity desired. This should include the mix number and any additional requirements (fibres, colour, etc.)
- Type of order (confirmed, will call, weather permitting, etc.)
- Purpose or use of the concrete and method of placement
- Address of the delivery and detailed directions to the site
- Requested date and time of delivery
- Special site conditions. These may include; no truck rinse water permitted on site; personal protective equipment; etc.
- Confirm the type of placement (pump, bucket, chutes, etc.)
- Delivery rate (m^3/hr)

- Special requests (minimum truck size, conveyor belt, concrete pumps, etc.)
- Individual receiving the order (general contractor, sub-contractor, etc.)

All orders should be verified to a Purchase Order or Concrete Quotation Form (Appendix D), where applicable. The general contractor should identify who has authority to add value added products to the order and the acceptable method of verification (verbal, updated purchase order number, etc.)

Directions to the Jobsite

Once the concrete order has been placed the concrete supplier should be provided with clear and understandable site information in order to properly dispatch the concrete trucks to the jobsite. The person placing the order should also provide additional information, such as:

- Street entrance location with assigned gate numbers when there are multiple entrance locations
- Layout of the proposed structures and buildings indicating the appropriate names of the structures (i.e. detached parking garage, Building 1, Shop 2, etc.)
- Layout of the proposed tower cranes or proposed concrete pumping locations (Tower 1, Pump Location 3, etc.)
- Location for concrete truck washout
- Location for proper site egress

Dispatch Process

When the concrete supplier is developing their delivery cycle they must consider many factors; total number of trucks available in their fleet, the number and locations of concrete plants that could supply the project, and the number and production demands of additional concrete customers. In some instances this process is now automated, but in most instances this process is still radio controlled. The concrete supplier must consider all these factors when attempting to balance their delivery cycle.

All concrete customers must submit their concrete orders with a minimum of 24 hours notice. For specialty concrete applications and products this pre-ordering period may be significantly increased and these limitations should have been identified during both the bidding and the pre-construction meeting processes.

The general contractor is responsible for supplying the dispatcher with requested concrete quantity and delivery rates. It is the responsibility of the concrete dispatcher to integrate these requests into their daily production schedules. The concrete dispatcher may therefore request that large volume or high delivery rate concrete projects be scheduled during off-peak load times. In extreme cases there may be a need to move to evening and weekends to accommodate extremely demanding projects. Early communication of these requirements is a critical component to the success of the project.

Specialty Concrete Products

CSA A23.1 clause 5.2.1.1 requires that all concrete products used in the production of ready mixed concrete be added by the concrete supplier. This requirement then necessitates early communication of value added products, such as colour, fibres, corrosion inhibitors, non-chloride based accelerators, specialty aggregates, etc., so that the concrete supplier can have the necessary quantity of material on hand for the project. Note: There is an exception for the addition of structural steel fibres (and therefore responsibility for concrete performance) by members of the CFCAO in Ontario. It should be noted that the concrete supplier may not take responsibility for the final concrete performance with the addition of certain materials by third parties or where materials are prescriptively specified.

Specialty concrete products may also raise the issue of plant added vs. site added materials. The preferred location for the addition of value added materials is the concrete supplier's plant. A permanent location allows for greater use of automated dispensing systems and a reduced likelihood of unintended errors. This does not mean that site material addition should be eliminated since there may be instances where the site addition of raw materials is either warranted or preferred from a concrete performance standpoint.

CHAPTER 6 TRANSPORTING AND RECEIVING CONCRETE

Each concrete supplier will have a unique procedure for supplying concrete to projects. The delivery process begins when the ready mixed concrete truck leaves the yard and ends when the truck returns to the plant or other designated facility.

Truck Tracking

The dispatcher at the concrete plant is responsible for utilizing a suitable method of tracking all their ready mixed concrete trucks. Concrete truck drivers may be in constant radio contact with dispatch or may drive a truck equipped with a global positioning system (GPS) locator system linked to a truck tracking software system. The concrete dispatcher will be aware of the current status (loading, mixing, transit to jobsite, and holding at jobsite, unloading, washing out, transit to plant) of the vehicles in their fleet.

Jobsite Monitoring and Control

Ready mixed concrete is unique as a construction material in that it is supplied to the jobsite in a plastic state and can be moulded into any shape required. Because of this fact the ready mixed concrete truck drivers are very important representatives of the concrete supplier. They are responsible for ensuring the proper mixing and transportation of the concrete to the jobsite. They represent the first level of technical service for the concrete supplier and are in direct contact with both the customer and the concrete plant. While each concrete supplier is responsible for providing the necessary training for their concrete drivers, the RMCAO has developed a *Truck Driver Certification Program* for use by its members starting in 2006.

Duties of a concrete truck driver include:

- Ensuring the general contractors representative receives and signs the concrete delivery tickets for the concrete supplied
- Confirming that appearance of the concrete is as expected given the properties specified on the delivery ticket
- Confirming that the concrete slump is within the range specified for the project

- Observing the sampling and testing procedures of the owner's testing agency
- Observing the proper care and handling of concrete cylinders
- Ensuring proper procedures are followed for the jobsite addition of water
- Loading or assisting with the loading of site added materials
- Documenting the actual quantities of any materials added to the load on the site
- Documenting any adverse weather or jobsite conditions at the time of concrete placement

Deviations from normal practices, as listed above, necessitate prompt notification of dispatch, batch plant, and/or technical services personnel. In such cases, each concrete supplier will follow their own standard response procedures.

On major and/or unique projects technical services personnel often visit the site to observe operations and monitor concrete sampling and testing. Specific areas observed include water demand, rate of slump loss, workability, bleeding rate, finishing characteristics, and time of set. Technical services personnel may also perform their own quality control testing as part of the concrete supplier's standard quality control procedures.

Prior to pump placements it is recommended that the Checklist for Concrete Pumping be reviewed. The Checklist was developed by the National Ready Mixed Concrete Association, the American Society of Concrete Contractors, and the American Concrete Pumping Association and modified by RMCAO for use on Canadian projects (Appendix G).

Identification and Traceability

The ready mixed concrete that is delivered to the jobsite must be identifiable and traceable. If it is later determined that a critical nonconforming mix component was used in batching concrete, it may be important to locate concrete used at other locations or projects with the same defective material. The concrete delivery ticket must identify the plant and time that the concrete was batched and the truck number of the truck delivering the concrete. From this information, the batch tickets at the plant can be reviewed by the concrete supplier and the component materials determined. RMCAO's plant certification program ensures that the concrete delivery tickets meet the necessary requirements and require that the concrete supplier retain all applicable records for a minimum period of 7 years.

Verification of Correct Concrete Ordering

Since there are multiple mix designs for most concrete projects and the need for accelerated construction schedules exist, it is not uncommon for multiple concrete placements to take place at the same time on the jobsite. The general contractor must implement a concrete verification system to ensure that the concrete supplied for the placement is the actual concrete that should be used in the construction of the element. The basic steps in this process are as follows:

- Identification of the personnel authorized to verify the correct ordering and receiving of concrete on the job should be established in the pre-construction meeting (site super, assistant site super, sub-contractor, etc.) and recorded on delivery ticket
- The ready mix drivers should notify the authorized personnel on the job what mix they have via the delivery ticket before the concrete is unloaded from the truck
- The designated representative on the job should confirm the details of the concrete delivery ticket with the master mix design summary prior to pouring (as specified in the contract documents and approved by the Owner's representative at the pre-construction meeting)
- If there are any disputes between what was ordered and what was delivered, the concrete should not be unloaded and the issue must be resolved immediately
- The person purchasing the concrete is responsible to ensure that the correct concrete is ordered and received on the jobsite
- The concrete shall be tested for acceptance prior to being sent to the area of concrete placement (see Chapter 7). No adjustments to the concrete mix shall be performed by any party other than the concrete supplier (i.e. water and plasticizer addition). Any variations or irregularities in the concrete shall be reported to the concrete supplier and general contractor immediately upon being observed
- All concrete mixes should be checked for air entrainment at the start of each pour (whether the concrete is air-entrained or not)
- Each concrete truck should be unloaded within 2 hours of batching as per CSA A23.1/.2. The only exception to this requirement is when chemical retarders have been approved to provide a delayed concrete set (as discussed at the pre-construction or pre-placement meeting)
- The actual volume of each pour should be compared with the theoretical volume to ensure that no large discrepancies have occurred
- Collecting and delivering all signed concrete tickets to the site management office

CHAPTER 7 MEASUREMENT AND ACCEPTANCE OF CONCRETE

This section defines the parameters that allow the custody of the concrete to change over from the concrete supplier to the concrete contractor. Delivery certificates, signing authorities and performance criteria are defined in this section along with the allowable field adjustments that can be made to the fresh concrete if the properties do not meet the originally specified requirements.

Concrete Compressive Strength

In accordance with CSA A23.1 for standard cured cylinders, "the strength level of each class of concrete shall be considered satisfactory if the averages of all sets of 3 consecutive strength tests for that class at one age, equal or exceed the specified strength and no individual strength test is more than 3.5 MPa below the specified strength".

Essentially, the failure of one strength test (an average of two cylinders) to meet the specified strength is not truly a failure unless the above conditions are not met. For example, for a 25 MPa (specified) mix, if the reported strength of a set of two cylinders is an average of 23.5 MPa, but all sets of three consecutive tests is 25.3 MPa, then the strength criteria has been met, and all concerned parties should be notified of such.

Remedial measures in the event of a failure include:

- changes in the mix proportions for the remainder of the work
- additional curing on those portions of the structure represented by the test specimens
- non-destructive testing
- cores to be drilled from the portions of the structure in question and destructive testing be performed
- load testing of the structure or structural elements

Remedial measures should never be initiated without discussion and agreement between the owner, general contractor, sub-contractor and concrete supplier. In addition to the test results supplied by the testing company, the concrete supplier may have internal test results that may confirm or dispute the site testing.

If corresponding Quality Control (QC) results are not available to indicate that specified strengths have been achieved, and coring is requested to verify in-situ strength, the owner, general contractor, sub-contractor, concrete supplier and concrete testing company should reach agreement on the following points before proceeding with an investigation:

1. The coring sub and/or lab selected to perform the work. The company performing the initial testing should not be used due to an inherent conflict of interest
2. Assigning responsibility for costs of coring and testing that will be dependent on the outcome of the additional testing
3. Confirm how the results of the selected testing method will be interpreted (in general, the strength of cores is satisfactory if the average of 3 samples meets or exceeds 85% of the specified strength, and no individual core is less than 75%, as per CSA A23.1. For high strength concrete, these values change to 90% and 80% respectively)

Plastic Concrete Testing Requirements

The following are recommended procedures for plastic concrete testing:

- The contractor shall designate during the pre-construction or pre-placement meeting the individual on site who is responsible for the acceptance and/or rejection of concrete
- The concrete test agency representative will be instructed to report the results of all plastic concrete testing to the designated contractor, owner and concrete supplier representative as soon as completed. Any tests that fail to satisfy the specified criteria (previously communicated during the pre-construction meeting) shall be repeated immediately. If the non-conformance is confirmed, the load shall be quarantined until the general contractor decides on the next course of action
- As a minimum, the following CSA tests should be performed:
  a. CSA A23.2-1C Sampling Plastic Concrete.
  b. CSA A23.1-3C Making and Curing Concrete Compression and Flexural Test Specimens
  c. CSA A23.2-4C Air Content of Plastic Concrete by the Pressure Method
  d. CSA A23.2-5C Slump and Slump Flow of Concrete
  e. CSA A23.2-6C Density, Yield and Cementing Materials Factor of Plastic Concrete
- Minimum Frequency of Tests:
  a. **Strength:** Not less than one test for every 100 m^3 of concrete placed, with no fewer than one test for each class of concrete placed on any one day
  b. **Slump:** A sufficient number of tests must be conducted to establish consistency. It is recommended to test the first 3 loads per mix per day, one for every strength test, and one for every air test
  c. **Air content:** For classes C-XL, C-1 and C-2, every load until consistency is attained, every 3rd load thereafter. An air test must be performed with every strength test (even if the concrete is not air entrained)
  d. **Unit weight:** Once per week per mix

Site Addition of Water

Responsibility for addition of water on site will vary depending on whether the concrete was specified using the Prescriptive or Performance specification alternatives of CSA A23.1.

- **Prescriptive:** The owner assumes full responsibility for the quality of concrete delivered, and as such is solely responsible for the management of performance. If the slump is less than specified, the owner's representative on site must indicate whether water may be added.
- **Performance:** The concrete supplier assumes full responsibility for the quality of concrete as delivered, and as such is solely responsible for

the management of performance. If the slump is less than specified, the supplier's representative alone may indicate whether water may be added.

In the Performance alternative identified above, the water addition must also satisfy the requirements of CSA A23.1-04 Clause 5.2.4.3.2, which requires:

- The concrete is less than 1 hour old
- The water addition will not exceed the specified maximum w/cm ratio
- The water added does not exceed 16 L/m^3 and 10% of the mixing water
- The specified slump is not exceeded
- The addition of water is only at the start of discharge
- The concrete is mixed for a minimum 30 revolutions at mixing speed

Time of Delivery

The responsibility for adherence to the maximum allowable time limit from initial mixing of concrete to complete discharge shall be clearly defined at the pre-construction meeting. Unless otherwise specified in the pre-construction or pre-placement meeting (via the use of retarders, hydration control admixtures, etc.) the maximum allowable time for discharge after initial mixing shall be 120 minutes per CSA A23.1. This time shall only be extended if the concrete is designed to use the appropriate amount of chemical retarders to provide a specified set retardation.

Failure of Concrete Tests in Meeting Specified Requirements

When the reported results for any concrete property fails to satisfy the specified criteria, all members of the construction team should be notified and corrective action immediately taken. This will include the general contractor, sub-contractor and concrete supplier. Experience shows that addressing issues in a timely manner can often minimize costs and potential construction delays.

CHAPTER 8 CONVEYING, PLACING, CONSOLIDATING AND FINISHING

The design and pre-qualification of concrete mixes for desired performance properties is critical for achieving the intended finished product. Equally important in achieving quality is the adherence to effective practices in conveying (from the concrete delivery truck), placing (into the forms being constructed) consolidating and finishing. The CSA Standard A23.1 shall be followed at all times with regard to concrete production, reinforcing, placing, finishing, curing and jointing. As previously discussed, no field activities shall commence until a pre-construction or pre-placement meeting has taken place.

Inspection

Inspection and testing play a vital role in ensuring a high quality finished product. The role of the inspection company as a quality assurance partner is a key to success in the field. The responsibility for quality assurance inspection must be assigned at the pre-construction meeting. All necessary inspection approvals must be received by the general contractor prior to concrete placement.

Granular Base Preparation

For slabs on grade, granular base elevations must be controlled within ±10mm of the specified elevation. These grades should be checked prior to ordering the concrete pour (**Note:** slab thickness reductions > 20 mm requires slab replacement as per CSA A23.1).

Formed Concrete Surfaces

For formed sections, due consideration of ambient conditions is necessary to ensure safety in stripping and bond strengths for anchors. Common practice is to design the forming system for a full liquid head scenario when supplementary cementing materials and/or retarding admixtures are used. The formwork designer can optimize their formwork design if they consider many of the potential factors that can affect the formwork pressures. These factors may include: constituent materials, aggregate gradations, chemical admixtures, ambient conditions, rate of pour, etc.

Field cured compressive strength testing is advised to confirm that the minimum strength requirements have been achieved before the forms are removed.

For architectural applications where the designer wishes to specify a minimum acceptable concrete finish, the construction team should be aware of the American Society of Concrete Construction "Guide for Surface Finish of Formed Concrete". This document defines the standard terms used in the concrete forming industry and provides presentation photos (P1 through P6) and acceptable dimensions for bugholes in formed concrete surfaces.

Conveying

Conveying refers to the method(s) used to transfer ready mixed concrete from the delivery truck to the point of final placement. Methods utilized include: truck chutes, concrete pumps, truck mounted or stationary conveyors, crane and bucket, motorized buggies, wheelbarrows, etc. In all cases, the equipment selected should be of the design, size and condition to ensure a continuous supply of concrete without unnecessary delay, and without harmfully affecting the concrete properties. The conveying method may cause segregation of the mix, changes in plastic properties such as measured slump and air content, and significantly impact the final product. Changes in conveying methods should be discussed prior to any placement, so any necessary mix changes can be made by the concrete supplier. For further information, refer to CSA A23.1-04 Clauses 7.1 and 7.2.

Placing

The placing of concrete is the act of depositing into the forms as close as practical to the final position without causing segregation. This may require inserting pump discharge hoses down into the formwork, the use of elephant trunks, or other methods to ensure the free-fall from the conveying equipment is minimized to avoid segregation. A good guide is to minimize free-fall to less than 1.5m. If greater heights must be used due to reinforcing or formwork details, discussions should be held with the concrete supplier to determine whether mix adjustments should be made.

Concrete should be placed in approximate horizontal layers (for walls, columns and beams) at a rate that allows each successive lift to be vibrated into the previous lift for proper bonding. The placement should be a continuous operation until the section being constructed is completed.

Initial Protection

Protection of the plastic concrete from the rapid surface evaporation has become more essential with the use of high volume supplementary cementing materials and specialty admixtures. Facilities shall be put into place such as fog spraying, evaporation reducers and wind breaks to protect the concrete from premature drying.

Minimum Qualifications of Concrete Finishers

The finishing contractor should have a valid **ACI Flatwork Finisher/Technician Certification.** This individual should be identified during the pre-construction meeting.

INTERIOR CONCRETE FLOOR SLAB – CONCRETE QUICK SPECS					
Concrete Application	**Concrete Floor (CF) Designation**	**Maximum W/CM**	**Minimum 28 Day Strength***	**Maximum Coarse Aggregate Size**	**Plasticized Slump Range At Point of Deposit**
COVERED APPLICATIONS (concrete with an applied finish such as carpet or vinyl)					
Slab on Grade	**CF 1**	0.65	20 MPa	20 mm (Hand Screed) 40 mm (Mech. Screed)	100 – 130 mm
Suspended Slabs*	**CF 2**	0.65	20 MPa	20 mm	100 – 130 mm
EXPOSED APPLICATIONS (with or without floor hardener)					
Slab on Grade	**CF 3**	0.55	25 MPa	20 mm (Hand Screed) 40 mm (Mech. Screed)	100 – 130 mm
Suspended Slab*	**CF 4**	0.55	25 MPa	20 mm	100 – 130 mm
Specialty Applications (Super Flat, Low Shrinkage, SCC, etc.)	Obtain recommendations from Concrete Floor Contractor and Concrete Supplier				

General Notes:

- Unit water content should be minimized to reduce shrinkage and a mid or high range plasticizing admixture used to produce the desired slump.
- Concrete set times can be dramatically effected by such things as: admixtures, ambient air temperature; haul time, sub-grade/formwork temperature; material temperature; SCM replacement levels and concrete thickness.
- Concrete floor contractor shall be a member in good standing of the Concrete Floor Contractors Association of Ontario (CFCAO www.concretefloors.ca) and have ***ACI Flat-work Finisher/Technician Certification***.
- Concrete suppliers shall have a valid ***"Certificate of Ready Mixed Concrete Production Facilities"*** as issued by the Ready Mixed Concrete Association of Ontario (RMCAO www.rmcao.org).

** Minimum strength to be determined by owner*

CHAPTER 9 CONCRETE PROTECTION AND CURING REQUIREMENTS

The precautionary procedures and methods used by the construction team must ensure that the environmental conditions for the fresh concrete are maintained within minimum thermal and moisture conditions identified in CSA A23.1. A level of awareness and accountability for these procedures needs to be transmitted during the pre-construction meeting to ensure that the precautionary methods are maintained throughout the construction program. CSA A23.1/.2 – 04 is the base standard that governs most minimum requirements for curing and protection.

Concrete mixes incorporating speciality admixtures and High Volume Supplementary Cementing Materials (HVSCM) requires special handling and protection.

Concrete Protection

Protection is summarized as additional precautionary methods used on fresh or immature concrete to prevent injurious degradation due to adverse weather conditions such as wind, precipitation and extreme temperatures. The climatic conditions (wind, humidity, radiation, temperature, etc.) can contribute directly to the degree of surface drying. The concrete mixture constituents can also significantly contribute to the drying potential of the concrete surface.

Protection must be planned and available for all exposed and freshly placed concrete surfaces. Particular attention need be made to the surface sheen of the concrete. As the surface sheen disappears, the potential for surface drying and plastic shrinkage is enhanced. Tradepersons must be ever on the alert for such drying conditions and be prepared to restore a higher level of surface humidity by utilizing a fog spray directly above the surface of the affected concrete. This operation needs to be continuous in maintaining the surface sheen, but not applied to the extent that surface ponding or erosion becomes prevalent. Thermal protection must be applied and maintained until the requirements of Table 21 of CSA A23.1-04 are achieved (see Table 1).

Protective measures that can be taken to prevent premature surface drying include: fog misting, application of monomolecular films (evaporation retardants), wind breaks, etc. Protective measures to reduce thermal gradients on exposed surfaces include the application of insulated tarps or heated enclosures.

Concrete Curing

Curing differs from protection in that curing provides the temperature and moisture conditions for the period of time necessary for concrete to develop its strength, durability and other properties through hydration and pozzolanic reactions.

Curing most affects the concrete in the **'curing-affected zone'**. This depth can vary from 5 mm to 15 mm in depth below the concrete surface. Concrete characteristics that are affected include: degree of hydration, liquid or air permeability, initial surface absorption, abrasion resistance and depth of carbonation. Curing can be achieved by a number of methods including: ponding or continuous sprinkling, absorptive mats or fabrics, curing compounds, waterproof paper or plastic films, forms left in place, vapour mist baths, etc. (see Table 2).

Method of curing and duration can depend upon the exposure class of the concrete and the end use of the concrete surface (surface wear and abrasion history). Effective curing requires regular supervisory inspections and may include regular remedial attention and re-application. For curing to be adequately addressed and monitored, it should be a line item on a schedule where manpower and resources are costed against its performance. Curing must be initiated immediately after the final finishing operations. Research has shown that delaying the curing by as little as 2 hours can have extremely detrimental effects to the quality and durability of the concrete.

Table 1: Concrete Curing Requirements

Allowable Curing Regimes (CSA A23.1 – Table 20)

Curing Type	Name	Description
1	Basic	3 days at ≥ 10°C **or** for a time necessary to attain 40% of the specified strength
2	Additional	7 days at ≥ 10°C **and** for a time necessary to attain 70% of the specified strength
3	Extended	A wet-curing period of 7 days. The curing types allowed are ponding, continuous sprinkling, absorptive mat or fabric kept continuously wet

Table 2: Potential Methods of Supplying Concrete Curing

Moisture Loss Prevention	**Curing Compounds**	Form a membrane over the top surface of the concrete preventing moisture loss
		Should be applied in two applications with the second being at right angles to the first to ensure uniform coverage
		Should be applied as soon as the concrete surface is finished and when there is no free water on the surface
		Must be applied at the manufacturers suggested application rate
		Confirm that this curing method is suitable for the final floor covering application
	Plastic Sheeting	Ensure that the plastic sheeting covers 100% of the concrete surface and that it is adequately sealed at the edges to prevent moisture loss (water may be added to the surface prior to the application of the plastic)
		Select the appropriate colour (white, black, or clear) of the plastic based upon the ambient air conditions
		If uniform colour is a requirement for the project this curing method may not be suitable
		Ensure that plastic sheeting is not damaged by subsequent construction activities during the curing period
	Leaving Formwork in Place	This system is most effective for vertical elements (walls, columns, beams, etc). Care must be taken to also protect the top surface of the concrete appropriately
		"Breaking" or "Releasing" the formwork dramatically reduces the effectiveness of this curing method since air flow is now possible between the concrete and the formwork
		If uniform colour is an issue then a uniform curing time and temperature must also be maintained and form removal scheduled accordingly
Supplying Supplemental Moisture	**Water Ponding**	Flooding of the concrete surface to provide both moisture and a uniform curing temperature
		Curing water should not be more than 12°C cooler than the concrete temperature to avoid the possibility of thermal cracking
		The water must cover the entire concrete surface
	Water Sprinkling	Spraying water over the concrete surface. The entire concrete surface must be wet for this method to be effective
		The concrete surface must have sufficient strength to avoid damaging the surface
		Excess water will run off the concrete and must be drained away
		This protection method can be adversely affected by high winds which prevent proper curing on the "upwind" side
	Wet Burlap, Geotextile and Coated Paper	Pre-soaked burlap is applied to the concrete surface and is covered with plastic to prevent moisture loss or water is reapplied as necessary to prevent the material from drying out
		Burlap should be rinsed prior to its first use to avoid possible staining (consider the use of other products)
		Materials utilizing both geotextile fabric and plastic top coatings can be reused throughout the project

CHAPTER 10 CONCRETE TESTING AND REPORTING

Concrete testing is the most common method used to confirm that the concrete supplied to the project is acceptable to the owner. The contract documents must therefore clearly identify the concrete test methods and the acceptance criteria that will be used to evaluate the concrete supplied to the project.

Reviewing the test methods specified and setting up the appropriate concrete verification system is one of the major tasks of the pre-construction meeting. Through the process of measuring key indicators, monitoring the concrete placement and analyzing the results of the testing program, we can:

- Evaluate the consistency of the concrete supply to the project
- Improve the concrete production and placing process
- Evaluate the effectiveness of the concrete testing system in ensuring quality concrete is supplied to the project

Normal Concrete Test Methods

The standard concrete test methods that can be used on all projects include:

- CSA A23.2-1C Sampling Plastic Concrete
- CSA A23.1-3C Making and Curing Concrete Compression and Flexural Test Specimens
- CSA A23.2-4C Air Content of Plastic Concrete by the Pressure Method
- CSA A23.2-5C Slump and Slump Flow of Concrete
- CSA A23.2-6C Density, Yield and Cementing Materials Factor of Plastic Concrete
- CSA A23.2- 16C Standard Test Method for the Determination of Steel Fibre Content in Plastic Concrete

Standard Frequency of Testing

- **Strength:** Not less than one test for every 100 m^3 of concrete placed, with no fewer than one test for each class of concrete placed on any one day
- **Slump:** A sufficient number of tests must be conducted to establish consistency. It is recommended to test the first 3 loads per mix per day, one for every strength test, and one for every air test
- **Air Content:** All concrete mixes should be tested for air entrainment (whether air entrained or not). For classes C-2, C-1 and C-XL, every load until consistency is attained, every 3rd load thereafter. An air test must be performed with every strength test

- **Unit Weight:** Once per week per mix
- **Speciality Testing Requirements:** Non-standard test methods (such as AVS, RCP or Linear Shrinkage testing) shall be identified in the contract documents and specifically addressed during the pre-construction meeting

Minimum Testing Qualifications

Ensuring that all concrete testing is performed in accordance with CSA A23.1/.2 is a major concern for all members of the construction team. The minimum qualifications for the performance of the concrete testing program should be as follows:

- **Laboratory Certification Requirements –** The concrete laboratory should be certified to CSA A283 – Qualification Code for Concrete Testing Laboratories. In addition, the laboratory should only conduct the concrete testing for the test methods that they are certified to perform. This information is included in CSA A283 and includes the following levels.
  - **Category O – Basic Tests** (CSA A23.2 1A, 1C, 3C, 4C, 5C, 9C & ASTM C1064)
  - **Category I – Intermediate Tests** (CSA A23.2 2A, 3A, 4A, 5A, 6A, 7A, 10A, 11A, 12A, 13A, 2C, 6C, 7C, 14C)
  - **Category II – Advanced Tests** (CSA A23.2 8A, 9A, 18A, 11C, 12C)
- **Field Personnel Certification Requirements –** The concrete field testing technician performing the onsite testing of the concrete must be either CSA or ACI certified.

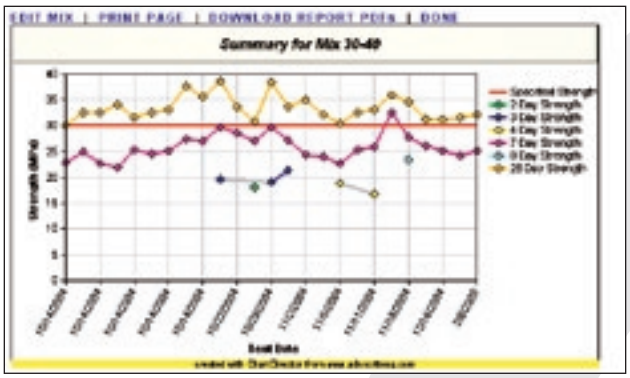
Distribution of Test Information

Concrete test reports should be immediately distributed to all members of the construction team using CMATS™ (Appendix C) to ensure that everyone has immediate access to the test information. In all instances both the person ordering the concrete and the concrete supplier must have immediate access to the test information since they are in the position to immediately take corrective action to address any potential problems. While 7 day test results are not typically used for acceptance, it is critical that this information be immediately supplied to the construction team since these results may prompt immediate changes to the mix designs on the project even before the 28 day results are available.

Recording and Reporting of Test Information

Access to the concrete test result information should be supplied instantaneously to all the people identified on the concrete test result distribution list via CMATS™ as the test results are reviewed and approved by the testing company. The testing company shall provide an electronic copy of the standard test report in PDF format for use by the construction team. In addition to the standard compressive test report, the testing company should provide the following summaries per mix design supplied to the project:

- Graphical representation of the specified and actual compressive strength results (see Figure 1)
- Average strength value for each age that the concrete is tested
- Average slump value for the mix design
- Average air content for the mix design
- Identification of non-conforming concrete test results
- Identification and exclusion of non-standard testing procedures from the statistical analysis



CHAPTER 11 EVALUATION OF CONCRETE HARDENED PROPERTIES

This section describes some of the typical hardened properties specified in concrete construction, provides guidance to test interpretation, and offers recommendations for additional testing in order to provide additional supporting evidence of performance achieved on site.

It is important to understand that these tests, as required by the CSA standard, are performed on cylinders cast either in a laboratory as part of a pre-qualification, or on site on concrete sampled from the concrete delivery equipment. The results represent an evaluation of potential concrete performance. In cases where in-situ performance measurements are required, the interpretation of results must also consider the impacts of placing, curing and ambient conditions. It is recommended that in these cases, correlations between cylinders and in-situ samples be established.

TYPICAL STRUCTURAL ACCEPTANCE CRITERIA

Compressive Strength

The strength level of each class of concrete shall be considered satisfactory if the average of all sets of 3 consecutive strength tests for that class at one age equal or exceed the specified strength, and no individual strength test is more than 3.5 MPa below the specified strength. These requirements shall not apply to field cured specimens. CSA A23.1-2004, Clause 4.4.6.7.1

For in-situ core testing, to be used only in cases where the cylinder strengths fail to satisfy the strength requirements above, the compressive strength of the concrete in the area represented by core tests shall be considered adequate if:

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

2. No single core is less than 75% of the specified strength." CSA A23.1-04, Clause 4.4.6.7.2
3. It should be noted that interpretation of core test results "shall take into consideration the placing and curing conditions of the concrete". CSA A23.1-04, Clause 4.4.6.8.1 Note (d)

Hardened Air Void System (AVS)

The hardened air void system properties shall be determined prior to the start of construction on concrete made with the same materials and mixing procedures intended for use on the project. Although no Standard requirement exists for frequency of testing, it is recommended that for exposure classes C-XL, C-1, and C-2, hardened air voids be determined on cylinders cast on site for every 500 m^3 supplied.

Testing for hardened air voids shall be in accordance with ASTM C457 using a magnification of between 100 and 125, with testing performed on concrete cylinders cast on as delivered concrete in accordance with CSA A23.2-3C, 2004. The air void system is considered to be satisfactory when the average spacing factor is ≤ 230 µm, with no single test greater than 260 µm and the air content is > 3.0%. For mixes with w/c ≤ 0.36, the average spacing factor shall not exceed 260 µm, with no single test > 300 µm. Test results shall be valid

for a period of 12 months and may be obtained from the supply of concrete to another project.

Rapid Chloride Permeability (RCP)

The resistance to chloride ion penetration shall be determined in accordance with ASTM C1202, on cylinders cast in accordance with CSA A23.2-3C, 2004. Any mix for which RCP is a requirement shall be pre-qualified prior to use on a project. Pre-qualification shall include testing of a minimum 2 cylinders, cast on concrete made with the same materials, mix proportions and mixing procedures intended for use on the project. Test results shall be valid for a period of 12 months and may be obtained from the supply of concrete to another project.

The suggested ASTM C1202 acceptance testing parameter for concrete exposure class C-1 is 1500 coulombs average with no single result greater than 1750 coulombs when tested at 56 days. Considering that the ASTM C1202 test is subject to variations, it is recommended that the target coulomb value be less than 1150 to have a reasonable assurance that the 1500 coulomb requirement will be met. The suggested ASTM C 1202 acceptance testing parameter for Concrete Exposure class C-XL is 1000 coulombs average with no single result greater than 1250 coulombs when tested at 56 days. Considering that the ASTM C1202 test is subject to variations, it is recommended that the target coulomb value be less than 700 to have a reasonable assurance that the 1000 coulomb requirement will be met.

Although no standard requirement exists for frequency of testing, it is recommended that for exposure classes C-XL and C-1 RCP testing be conducted for every 500 m^3 of concrete delivered to the site.

Linear Shrinkage

Recently, a number of specifications have been setting pre-qualification limits on the allowable amount of drying shrinkage acceptable for certain classes of concrete. Essentially this test measures the reduction in length of a prism during a specific curing regime over a given time frame. The drying shrinkage for pre-qualification purposes only shall be evaluated in accordance with ASTM C157, except that drying shall begin after 7 days of moist curing as per CSA A23.1-04, Clause 8.9.2. Given this requirement, the test takes approximately 35 days following mixing to obtain the 28 day result.

When this testing is specified the mix design must be tested once every 24 months, and the supplier must certify performance and indicate the maximum w/cm ratio for which the pre-qualification is applicable. Any significant change in raw material sources requires a new qualification. On projects for which this property is specified, it is recommended that field cast specimens be taken and shrinkage determined at least once during the project, or every 500 m^3 supplied.

RMCAO is currently participating in a research program with a number of highly qualified consulting engineers to develop a statistical based performance specification for field cast linear shrinkage samples and additional guidelines should be available in the spring of 2006.

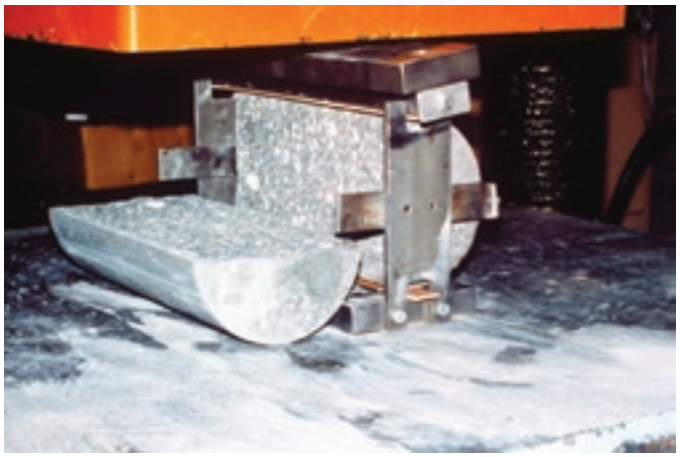
Creep

Creep is the time dependent deformation (compression) of concrete that occurs as a result of a sustained load. It is an important engineering property that can significantly impact the service life of a structure, and is of primary concern for tall reinforced concrete structures. The amount of creep depends on items such as the magnitude of the applied load, the age and

strength of the concrete when the load is applied, and the length of time the load is applied.

Factors influencing creep may include the type, amount and size of the aggregate, the type of cementing materials, the amount of cement paste, the size and shape of the concrete element, the volume to surface ratio of the concrete element, the amount of steel reinforcement, prior curing conditions and the relative temperature and humidity.

Creep testing is very time consuming and expensive, taking in excess of one year to complete, so it is not currently practical as either a pre-qualification or quality control test.



Modulus of Elasticity

The Modulus of Elasticity represents the relationship between the stress (MPa) and strain (percentage deformation or mm/mm) of concrete in the elastic range of the loading cycle. It can best be described as the stiffness of the material, and is measured in accordance with ASTM C469. Modulus of Elasticity is an important engineering property of concrete, and may be affected by aggregate type, size and content, the amount of cement paste, w/cm ratio, compressive strength, etc.

Although not a typical pre-qualification test, the Modulus of Elasticity should be determined for major structural mixes in high rise projects.

CHAPTER 12 DISPUTE RESOLUTION MECHANISMS

Corrective and Preventative Actions

This process differs from the standard dispute policies found in CCDC2 in that the CCDC process is designed to remedy disputes concerning the contract terms and clauses and their interpretation. This process is designed to address the issue of product failure.

It is essential to develop an acceptable method for parties to share information in the event of a major failure on a project. This process recognizes the right of the concrete industry to protect their proprietary interests and yet allow for the exchange of information between the general contractor and their concrete suppliers to resolve disputes quickly and effectively.

The process is not intended to be used in a manner that would be deemed to be frivolous, rather it is to assist the parties in resolving serious issues and should only be used in that capacity.

DISPUTE RESOLUTION PROCESS

Stage 1

Problem arises on site and expands beyond the control of the site personnel to resolve. Meeting is arranged immediately with consultant, general contractor, concrete supplier, and any applicable sub-contractor. The general contractor and concrete supplier will have knowledgeable technical personnel attend this meeting. As a result of this meeting a solution is arrived at without having to go beyond the standard documentation and test results provided for under the contract – no further action required.

Stage 2

No resolution in Stage 1. Parties will identify what information or actions may be required to resolve the issue. This may include additional testing and the involvement of senior representatives who have knowledge of the mix design and the site conditions surrounding the problem. The general contractor may request additional information be confirmed by the supplier without revealing their proprietary interests. The concrete supplier will make all necessary inquiries and tests as is reasonably asked for by the consultant or general contractor. Resolution – no further action required.

Stage 3

The parties may elect to move directly to this stage based upon the seriousness of the issue. The most senior and knowledgeable representatives would be involved representing the major stakeholders in the project, this may include a separate representative of the owner, along with external consultants asked to report on the event. It is at this stage where specific knowledge may be required including a review of the quality procedures at the plant, mix information, placing, curing, etc. All parties must be willing to cooperate at this stage to resolve the event.

To facilitate the process, an independent party agreed to by the general contractor and the concrete supplier will be asked to investigate any and all relevant aspects of the event. The individual shall be chosen from the recognized third party engineers currently used by the concrete industry for the plant certification process. The parties will follow the procedures for appointing and holding arbitration as outlined in the Arbitration and Mediation Institute of Ontario's guidelines and the arbitration process will be binding on all parties.

Stage 4

If the parties fail to come to an agreement to follow Stage 3 then they are free to move to litigation. The parties may decide to move immediately to this stage, but it is recommended that they first attempt to resolve the issue using the previous methods.

It is recommended that the general contractors and the concrete suppliers agree to include this process in their contractual agreements.

CHAPTER 13 PROJECT CLOSE-OUT MEETING

At the completion of the concrete phase of the project the team members should meet to review the history of the project with everyone involved. This will provide an opportunity for all stakeholders to learn how to avoid problems in the future and to implement better practices learned during the project.

This meeting should include the general contractor/ construction manager, consultants, concrete supplier, trade contractors and even the owner. The meeting should be "minuted" by the general contractor/ construction manager and copies distributed to all parties.

The following topics should be reviewed:

- **Specifications/Drawings** – Were they clear and are there any recommendations for future changes?
- **Project Set-Up** – Was there a well defined communication system that was implemented with clear directions understood by all?
- **Team Identification/Performance** – Did all members of the team fulfill their responsibilities or are there recommendations for future improvements?
- **Concrete Testing** – Was the inspection and quality control testing performed properly and were the results shared completely and expeditiously with all of the appropriate team members? Are there changes proposed for future projects? Was the CMATS™ Program used? Testing results should be reviewed to identify any areas that can be improved upon in the future such as techniques (for example) related to sampling, storing cylinders, access and egress and communication.
- **Concrete Ordering** – Were there any communication problems?

- **Concrete Delivery** – Were any problems with delivery identified? If so, was the issue dealt with expeditiously?
- **Customer Relations** – Were problems addressed by all parties and was there the proper level of mutual respect?
- **Placement and Finishing** – Were any problems or specific requirements dealt with? Are there any recommended changes to ordering or specifications?
- **Payments** – Was there an acceptable cash flow and have all monetary issues been resolved?

The cooperation of all parties will help to achieve success on all future projects.

APPENDIX A RMCAO PLANT CERTIFICATION PROGRAM

One of the most valuable initiatives of the Ready Mixed Concrete Association of Ontario (RMCAO) is the assurance of quality concrete supply and production through the execution of a strict plant certification process. The RMCAO certification process was first implemented in the early 1960's. It is completed by independent third party engineers and has become the most stringent concrete certification program in North America.

RMCAO certification designation means that all materials, material handling, batching methods and tolerances, statistical product quality analysis, truck mixers, weighing equipment, certificates and records meet or exceed CSA A23.1 requirements.

Current concrete specifications such as those of the Ontario Provincial Standards (OPS), Ministry of Transportation (MTO), Ontario Municipalities, Ontario Ministry of Agriculture (OMAF), consulting engineers, design/build firms and general contractors typically require RMCAO plant certification.

Highlights of the RMCAO Plant Certification process include:

- Third party consulting engineer inspections
- Raw material conformance to CSA, OPSS or MTO requirements

- Scale inspection and calibration on a 6 month basis
- Batching inspection and accuracy requirements
- Inspection and certification of mixing and transportation equipment
- Standardizing of minimum information requirements for delivery tickets and mix designs
- Implementation of a mix design statistical analysis program for two categories of concrete
- Record keeping
- Random plant inspections and audits

For additional information please contact RMCAO at **www.rmcao.org** or **info@rmcao.org**

APPENDIX B OGCA GOLD SEAL PROGRAM

The Ontario General Contractors Association (OGCA) remains a strong supporter of continuing education for the construction industry. Gold Seal is an excellent opportunity for contractors to expand the qualifications of their staff which in return improves the professionalism at every level from the site to the office, and results in better productivity, fewer problems, safer sites and a better bottom line for the contractor.

The Gold Seal Certification Program was developed by the Canadian Construction Association to recognize the skills and competence of the key managerial positions of Superintendent, Estimator and Project Manager on a national basis.

Certification Requirements

Certification of Superintendents, Estimators and Project Managers requires satisfaction of 3 criteria – Experience – Education – Examination. Applicants must have a minimum level of experience and have undertaken at least five construction management courses totalling 150 hours of instruction to qualify to write the Gold Seal examination. The only exemption from the three criteria permitted by the National Gold Seal Committee is for "senior" managers who have a lengthy demonstrated track record in the industry. A separate guideline is available upon request by senior practitioners. A development category, known as the Gold Seal Intern (GSI), is available to candidates who do not meet the examination eligibility criteria.

Experience as a Superintendent, Estimator or Project Manager in a non-residential construction firm is the first critical criterion to be met. In order to be eligible to challenge the Gold Seal examination, an applicant must document a minimum of three years experience in the occupation.

Education in construction management courses is a key requirement. The Gold Seal Certification program will recognize construction management training in subject areas defined in the Gold Seal Curriculum Standard. The Curriculum details the content of the following management courses:

- Law and Contracts in Construction
- Construction Planning and Scheduling
- Project Costing Control and Accounting
- Construction Job Site Controls
- Communication
- Construction Safety
- Management of Human Resources
- Construction Estimating

For more information, please contact **www.ogca.ca** or **www.cca-acc.com**

APPENDIX C CONCRETE TEST FORMS & REPORTING – CMATS™

What Is CMATS™?

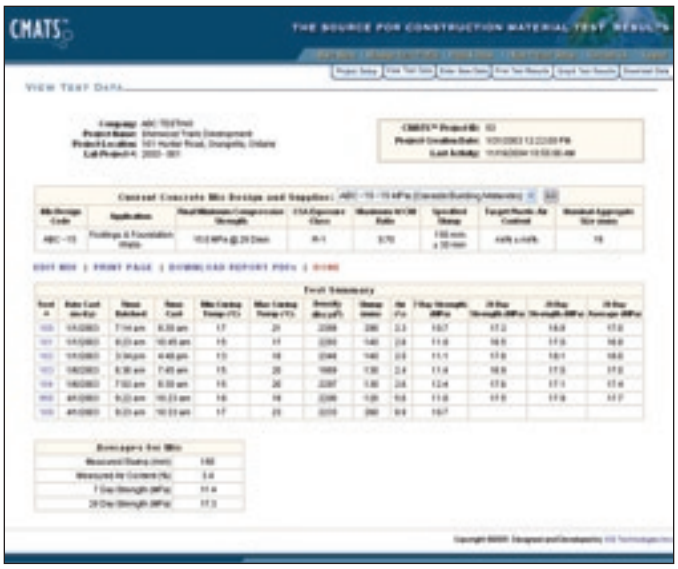
CMATS™ is a secure website where construction industry concrete test data can be recorded, viewed and distributed to owners, architects, engineers, testing companies, contractors and material suppliers, on a project by project basis.

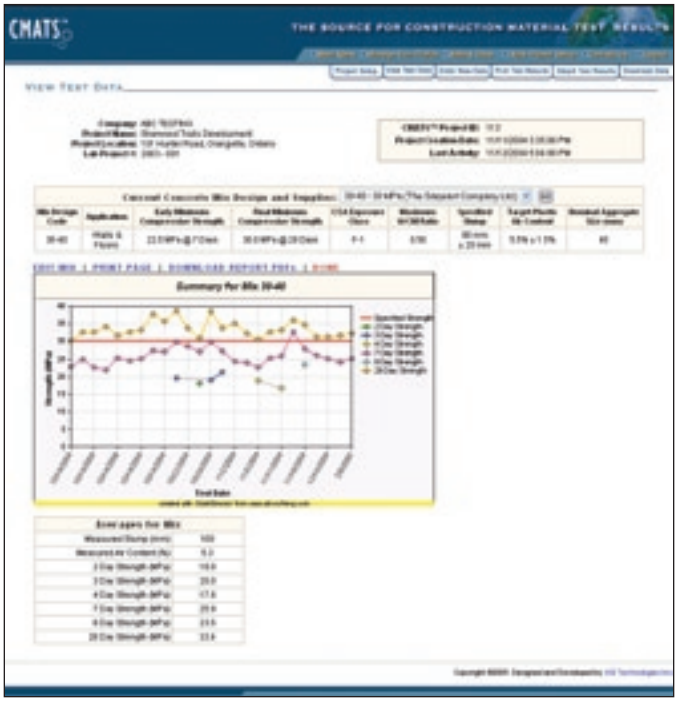
How CMATS™ Works

Quite simply, users access the CMATS™ website via their web browser and enter their email address and password to **instantly obtain access to the test results for all the projects they are involved with**. CMATS™ mirrors the existing paper method of providing test information to construction team members and is implemented by the testing company. At the start of a new project, the testing company identifies those who will be given access to the test information (owner, architect, engineer, etc.) when they create a new project.

The software immediately notifies all the users via email of the new project and updates their security records to provide them access. The testing company then performs the necessary testing and inputs the results into CMATS™. Once the information has been entered, reviewed and certified by the supervising engineer of the testing company, the information is then immediately viewable to all users.

LOG on to... WWW.CMATS.COM





Key Advantages of CMATS™ include:

- Instant secure access to the project data from any location via the internet
- Rapid distribution of material test results to all members of the construction team
- Quality assurance features to identify trends and provide statistical analysis
- Graphing features allow users to view control charts on material quality
- Electronic notification when new test data is available
- Eliminates repetitive data entry
- Eliminates paper handling and distribution costs
- Creates greater accountability while improving project communication
- Improved reaction times result in a higher quality final project
- Download features allow users to create historic records electronically and to perform additional statistical analysis

While CMATS™ currently handles concrete test results, work is underway to add additional modules for both aggregate and hot mixed asphalt test data. In fact, CMATS™ can be easily adapted to any reporting system that uses standardized reporting forms.

For more information regarding CMATS™, please visit www.cmats.com and register as a new user you will then be able to try the system yourself and see just how easy it is to use.

Contact Information: Bart Kanters, P.Eng. at (905) 507-1122 or bkanters@rmcao.org

APPENDIX D CONCRETE QUOTATION FORM

ABC Concrete
365 Brunel Road, Mississauga, Ontario, L4Z 1Z5
Phone: 905-507-1122 Fax: 905-890-8122

Sample Concrete Quotation Form

To: ABC Contracting
Re: RMCAO Office Expansion Project
Date: September 29, 2005

Attn: John Smith
Contract #: 2005-001

Mix Design Requirements

Application	CSA Exposure Class	Specified Strength (MPa)	Maximum W/CM Ratio	Slump & Range (mm)	Air Entrainment (%)	Aggregate Size (mm)	Placement Method	Other	Unit Cost ($/m^3)
Suspended Slab	C – 1	35 @ 28 d	0.40	80 ± 30	4 – 7	20	Chute	Corrosion Inhibitor	
Sidewalk	C – 2	32 @ 28 d	0.45	130 ± 30	5 – 8	20	Pump		
Interior Slab	N/A	25 @ 28 d	N/A	80 ± 20	N/A	40	Buggy		

Additional Options:

After hours delivery
Air Entrainment
Calcium 1%
Calcium 2%
Concrete cooling (25 – 30°C)
Concrete cooling (under 25°C)
Conveyor Charge
Demurrage (unloading time past 60 min)
Fibres
Non Chloride Based Accelerator
Partial loads (under 5 m^3)
Pump Mix
Retarder
Superplasticizer (from 80mm to 150mm)
Superplasticizer (from 80mm to 200mm)
Winter Handling

APPENDIX E MIX DESIGN SUBMISSION FORM

Concrete Supplier _____
Address _____
City/Province _____
Phone _____ Fax _____ Email _____

RMCAO MEMBER

CONCRETE MIX DESIGN SUBMISSION

Project: _____ Date: _____
Location: _____ Submitted By: _____
Contractor: _____ Contact: _____

	CONCRETE MIX CODE				
SPECIFICATION	Application				
	Structural Requirements				
	• CSA Exposure Class				
	• Maximum W/CM Ratio				
	• Minimum Specified Strength - age				
	• Plastic Air Range (%)				
	• Nominal Maximum Aggregate Size				
	• Maximum % SCM Replacement				
	• HVSCM Type 1 or 2				
	Durability Requirements				
	• Exposure to Sulphate Attack				
	• Alkali Aggregate Reactivity				
	• Aggressive Chemical/Waste				
	Architectural Requirements				
	• Colour/Texture				
	• Other				
CONTRACTOR REQUIREMENTS	Quantity m^3				
	Rate (m^3/h)				
	Slump Range (mm)				
	Method of Placement				
	Strength/Age (MPa/Days)				
	Other				
	Specialty Information				
	• Concrete Set (Delay, Normal, Accelerated)				
	Floor or Slab Type – (Exposed / Covered)				
	Other (e.g. Fibres)				
MATERIALS SECTION	Source & Type				
	• Portland Cement				
	• SCM – Slag, Fly Ash, Silica Fume				
	• Fine Aggregate				
	• Coarse Aggregate				
	• Air Entraining Admixture				
	• Water Reducing Admixture				
	• Other (e.g. Fibres)				

NOTES:
1) *The **"Concrete Supplier"** provides to the contractor, a valid **"Certificate of Concrete Production Facilities"** as issued by the Ready Mixed Concrete Association of Ontario, as described in CSA A23.1 Table 5.*
2) *All Concrete and materials shall be supplied in conformance to CSA A23.1-04.*
3) *Concrete testing shall electronically incorporate **CMATS™** (www.cmats.com) and shall be used by the testing company.*
4) *Concrete tests not done according to CSA Standards shall not be accepted for any basis of measurement.*
5) *The Owner shall be responsible for all concrete performance when specifying any material proportion(s).*

APPENDIX F CHECKLIST FOR CONCRETE PRE-CONSTRUCTION CONFERENCE

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) and the Ontario General Contractors Association (OGCA) 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 safety issues. Please operate safely and within all the legislations in your area

NRMCA™
NATIONAL READY MIXED CONCRETE ASSOCIATION

ASCC AMERICAN SOCIETY OF CONCRETE CONTRACTORS
Enhancing the Capabilities of Those Who Build with Concrete

RMCAO

OGCA

INDEX

References

Canadian Standards Association
CSA A23.1
CSA A23.2
CMATS™ www.cmats.com

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 _____

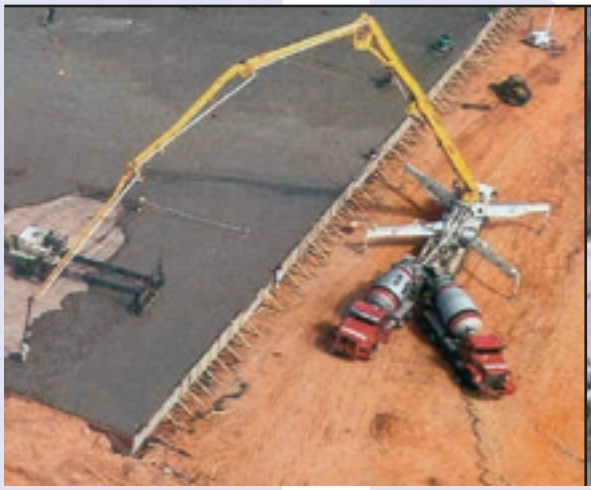
Safety inspections _____

Signalers _____

Safety meetings _____

3. Emergency contacts _____

APPENDIX G CHECKLIST FOR CONCRETE PUMPING



Introduction

This short Checklist for Concrete Pumping was developed by National Ready Mixed Concrete Association (NRMCA), American Society of Concrete Contractors (ASCC) and the American Concrete Pumping Association (ACPA). With permission of the original author, the Ready Mixed Concrete Association of Ontario (RMCAO) and the Ontario General Contractors Association (OGCA) have reviewed and revised this document for use on Canadian construction projects following the requirements of the most recent CSA A23.1/.2.

The intent of this document is to identify details of the process of pumping concrete prior to the start of the placement so that all impacted parties are aware of the issues related to the construction specification, equipment and schedules, responsible persons and jobsite safety.

The presumption is that on larger projects the concrete construction team has been through a pre-construction conference and has addressed the pertinent items in the **Checklist for Concrete Pre-Construction Conference** and those items are excluded from this document. This document can be included in a broader pre-construction meeting agenda.

This checklist is not intended to be all inclusive of the items that need to be considered and depending on a specific project many items regarding specification requirements, testing details, construction logistics and jobsite safety may need to be addressed in greater detail than outlined in this document. Many of these items will be critical to the success of the project and should be discussed and agreed upon prior to the placement of concrete with appropriate notification to the owner and his representative.

CHECKLIST FOR CONCRETE PUMPING

Project: _____

Location: _____

Directions: _____

1. Contacts

Who	Name	Phone	Mobile	Fax	E-Mail
C. Contractor					
RMC Supplier					
Pump Contractor					

2. General Conditions

Start Time	Pump:	am/pm	Concrete:	am/pm
Placement Location	☐ Slabs	☐ Walls	☐ Footings	Other
Placement Rate (m^3/hr.)		Volume (m^3)		
Type of Pump	☐ Regular	☐ Z-Boom	☐ Telescoping	☐ Trailer
Size of Pump (m)		Pipeline dia, mm		
Pumping Distance (m)	Vertical		Horizontal	
Slump/Air Spec	☐ Point of Discharge		☐ Point of Placement	
Testing	☐ Point of Discharge		☐ Point of Placement	
Priming Agent	☐ Grout		☐ Slick Pack	

3. Concrete Mixture

Strength (MPa)	28 days:		Other:	
Max Size of Aggregate (mm)		(no larger than 1/3 pipeline diameter)		
Density (kg/m^3)		Lightweight	☐ Yes	☐ No
Slump (mm)		Air (%)		
Water Reducer	☐ Regular	☐ MRWR	☐ HRWR	
Fibres	☐ Yes	☐ No		
Special Requirements				
Set Time Requirements (hr.)	Initial:		Final:	
Water Addition Permitted	☐ Yes	☐ No		

4. Jobsite/Safety

Wash Out Area	☐ Yes	☐ No	Location:
Power Lines	☐ Yes	☐ No	
Safe Set Up Area	☐ Yes	☐ No	Restrictions:
Clean Water Available for Washout	☐ Yes	☐ No	

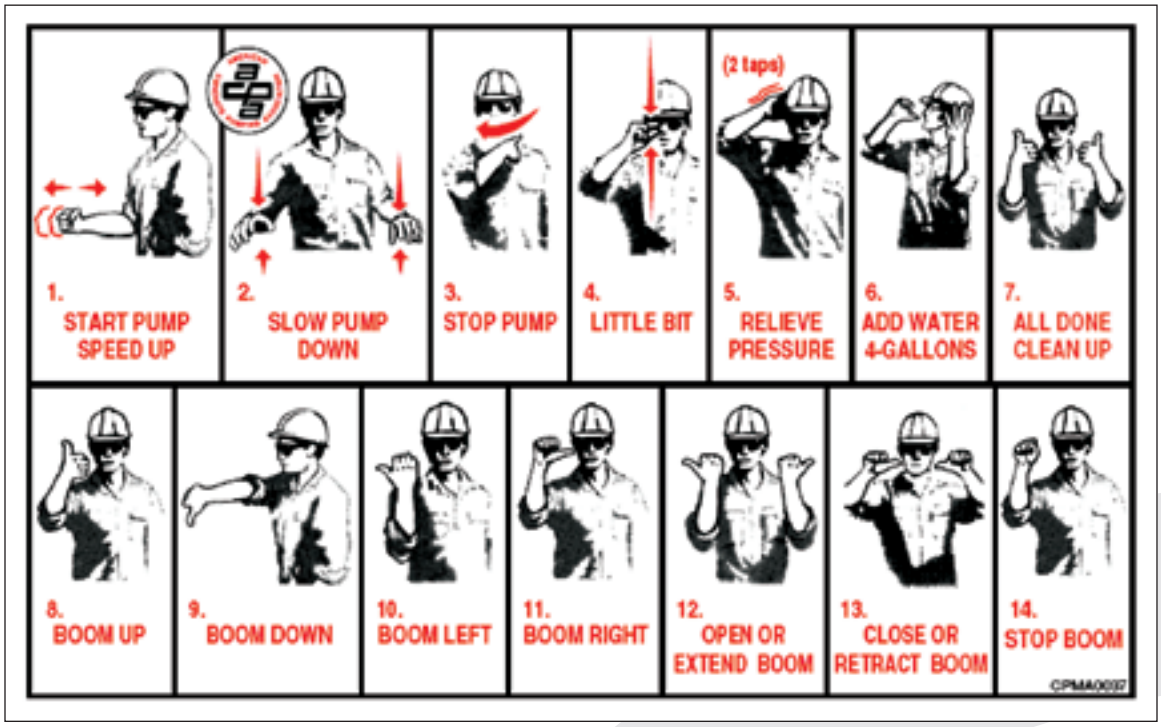
5. Notes

_____

_____

_____

CONCRETE PUMP OPERATORS HAND SIGNALS



APPENDIX H SPECIALTY CONCRETE APPLICATIONS

While special concrete performance can be defined in an infinite number of ways, some of the more common examples of specialty performance include the following descriptions. Always consult with your concrete supplier and concrete sub-contractors.

- **Self Consolidating Concrete (SCC)** – Concrete with extremely high slump and flow characteristics that can be placed with little or no concrete consolidation. This concrete offers advantages to the owner and contractor where there is congested concrete reinforcing steel or restricting formwork that prevents traditional consolidation; improved architectural appearance of the concrete surface, significantly reduced labour and placement costs due to the extreme flow characteristics; and resistance to concrete segregation under adverse site conditions. Caution must also be exercised when first using this product due to its high flowability and fluidity. The formwork must have a high quality of surface finish since the concrete will mirror any imperfections that exist. The contractor must also ensure that formwork is tight to prevent leakage at form panel edges and they must account for the additional formwork pressures initially generated by the product.

- **Hot/Cold Weather Concrete** – Concrete that has been proportioned to provide normal or improved concrete set characteristics during either hot or cold weather construction periods. The objective is to modify the mix design to offset the accelerated or extended concrete setting period that results from a differential ambient, concrete or formwork temperatures encountered on the jobsite. Hot weather conditions may necessitate the use of higher levels of Supplementary Cementing Materials (SCMs), chemical retarders or ice or nitrogen in the concrete (these conditions necessitates significant project planning). Cold weather conditions may necessitate the use of chemical accelerators (either chloride or non-chloride based), reduced SCMs or accelerated mixes.

- **High Early Concrete** – Concrete that provides a strength gain at earlier times than normal set concrete. High early strengths achieved at prescribed times of one, three or seven days can offer the opportunity to "fly" forms faster resulting in a faster scheduling for building construction and labour and equipment. This concrete may also apply to a faster set time concrete that may be applicable in areas where there are noise by-laws or concerns, and also other labour issues such as cost and equipment availability.

- **Fibre Reinforced Concrete** – Synthetic or steel fibres can offer a range of benefits to the owner. Sometimes referred to micro, macro and structural fibres they can offer greater resistance to plastic shrinkage cracking of the concrete as well as other advantages.

- **C-XL Concrete** – New to CSA A23.1-04, the C-XL designation is for structurally reinforced concrete exposed to chlorides or other severe environments with or without freezing and thawing conditions, to provide concrete that would meet higher durability performance expectations than C-1, A-1 or S-1 classes of exposure as per CSA A23.1. There is a chloride ion penetrability limit of <1000 coulombs within 56 d that is generally used as a pre-qualification to concrete supply.

- **LEED™ Concrete** – Leadership in Energy and Environmental Design (LEED™) is a voluntary, market-based rating system for defining what elements make a building "green" and to quantify how "green" a building is in comparison to another building. LEED™ is based on accepted energy and environmental principles and strikes a balance be-

tween known effective practices and emerging concepts. It encourages a whole building approach over a building's life cycle that guides a collaborative and integrated design and construction process.

- **Architectural Concrete** – Concrete that has been designed to meet visual or other aesthetic performance characteristics such as colour, texture, finish or pattern. These performance concretes are concerned with concrete relating to overall mix consistency, flow and consolidation, and finish and uniformity.

- **Surface Hardened Concrete** – Typically concrete floors that require a "hardener" to be applied need a concrete mix that has been designed so the concrete can easily accept the "hardener" for its application to be monolithic. Several things must be carefully considered by the concrete supplier, such as water content, SCMs (i.e. fly ash or slag) for available surface moisture, set and finish time, and entrained air content. Concrete to receive a surface hardener should not be air entrained.

- **High Volume Supplementary Cementing Materials Concrete (HVSCM 1 & 2)** – CSA A23.1-04 has included these designations for concrete that contains a level of supplementary cementing materials above that typically used for normal construction.

APPENDIX I SUMMARY OF CSA EXPOSURE CLASSES

Determination of the minimum concrete performance properties is based upon identifying the following key requirements:

- Applicable Exposure Conditions – The designer must assess the environmental conditions that the concrete will be exposed to during its service life. Direct input is also required from the Owner regarding possible future uses since they can significantly affect the exposure class selection
- Structural Requirements – The designer must determine the minimum concrete properties required to meet the applicable loading conditions
- Architectural Requirements – The designer must consider the effects of selecting various architectural finishes on concrete material properties.
- Minimum Durability Requirements – Based upon the designer's assessment of the exposure conditions, the CSA A23.1 standard sets minimum concrete properties.

In cases where these various factors result in differing material properties, the designer must select the most stringent requirement as the minimum concrete performance requirement.

CSA A23.1-04 – Concrete Materials and Methods of Concrete Construction, Tables 1 – 4 outline the minimum durability requirements.

CSA A23.1 – Table 1

Definitions of C, F, N, A, and S exposure classes

(See Clauses 4.1.1.1.1, 4.1.1.5, 4.4.4.1.1.1, 4.4.4.1.1.2, 6.6.7.5.1, 8.4.1.2 and Tables 2 and 12.)

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, A-1 or S-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 marine structures located within the tidal and splash zones, concrete exposed to seawater spray, and salt water pools.
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 marine structures.
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 not exposed to chlorides nor to freezing and thawing. Examples: footings and interior slabs, walls and columns.
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 may be generated. Examples: reinforced beams, slabs and columns over manure pits and silos, canals, pig slats, 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, 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., force mains), 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.
S-1	Concrete subjected to very severe sulphate exposure (Tables 2 and 3).
S-2	Concrete subjected to severe sulphate exposure (Tables 2 and 3).
S-3	Concrete subjected to moderate sulphate exposure (Tables 2 and 3).

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) "A" class pertains to agricultural, municipal or industrial projects exposed to human or animal wastes.
(5) All classes of concrete, exposed to sulphates, shall comply with the minimum requirements of of "S" class noted in Tables 2 and 3.

CSA A23.1 – Table 2

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

(See Clauses 4.1.1.1.1, 4.1.1.3, 4.1.1.4, 4.1.1.5, 4.1.1.6.2, 4.1.2.1, 4.3.1, 7.4.1.1, 8.8.3, and 8.8.6.1, and Table 1.)

REQUIREMENTS FOR SPECIFYING CONCRETE							
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 20)			Chloride ion penetrability test requirements and age at test‡
				Normal concrete	HVSCM 1	HVSCM 2	
C-XL	0.37	50 within 56 d	1 or 2§	3	3	3	< 1,000 coulombs within 56 d
C-1 or A-1	0.40	35 at 28 d	1 or 2§	2	3	2	< 1,500 coulombs within 56 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	0.55	25 at 28 d	2††	1	2	2	
N‡‡	For structural design	For structural design	None	1	2	2	
S-1	0.40	35 at 56 d	2	2	3	2	
S-2	0.45	32 at 56 d	2	2	3	2	
S-3	0.50	30 at 56 d	2	1	2	2	

** See Table 1 for 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. The water-to-cementing materials ratio shall not be exceeded for a given class of exposure.

‡ In accordance with ASTM C 1202. An age different from that indicated may be specified by the owner. Where calcium nitrite corrosion inhibitor is to be used, the same concrete mixture, but without calcium nitrite, shall be prequalified to meet the requirements for the permeability index in his Table.

§ Use Category 1 for concrete exposed to freezing and thawing. Use air content Category 2 for concrete not exposed to freezing and thawing.

*** For class of exposure C-4, 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 that is required.*

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

‡‡ To allow proper finishing and wear resistance, Type N concrete intended for use in an industrial concrete floor with a trowelled surface exposed to wear shall have a minimum cementing materials content of 265 kg/m^3.

CSA A23.1 – Table 3

Additional requirements for concrete subjected to sulphate attack*

(See Clauses 4.1.1.1.1, 4.1.1.6.2, 4.1.1.6.3, 8.4.1.2 and Tables 1.)

Class of exposure*	Degree of exposure	Water soluble sulphate (SO_4)† in soil sample, %	Sulphate (SO_4) in ground-water sample, mg/L‡	Water soluble sulphate (SO_4) in recycled aggregate sample, % §	Cementing materials to be used**
S-1	Very severe	> 2.0	> 10,000	> 2.0	HS or HSb
S-2	Severe	0.20 – 2.0	1,500 – 10,000	0.60 – 2.0	HS or HSb
S-3	Moderate	0.10 – 0.20	150 – 1,500	0.20 – 0.60	MS, MSb, LH, HS, or HSb

** For sea water exposure, see Clause 4.1.1.5.*

† As per CSA A23.2-3B.

‡ As per CSA A23.2-2B.

§ Cementing material combinations with equivalent performance maybe used (see Clauses 4.2.1.2, 4.2.1.3, and 4.2.1.4). Type HS cement shall not be used in reinforced concrete exposed to both chlorides and sulphates. Refer to Clause 4.1.1.3.

CSA A23.1 – Table 4

Requirements for the air content categories

(See Clauses 4.1.1.1.1, 4.1.1.3, 4.1.1.4, 4.1.1.5, 4.2.3.2.2., 4.3.1.1, 4.3.3.1, 4.3.3.2, 4.4.4.1.1.1, and Tables 2)

	Range in air content* for concrete 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.

References:

1 CSA A23.1-04 – Concrete Materials and Methods of Concrete Construction, Canadian Standards Association International

APPENDIX J CHECKLIST FOR CONCRETE ORDERING AND SCHEDULING

Introduction

A Task Group of the National Ready Mixed Concrete Association (NRMCA) and the American Society of Concrete Contractors (ASCC) has developed this checklist for Ordering and Scheduling Ready Mixed Concrete. With permission of the original author, the Ready Mixed Concrete Association of Ontario (RMCAO) and the Ontario General Contractors Association (OGCA) 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 intent is to simplify the ordering process through a logical approach while establishing the necessary information from the supplier's and the purchaser's perspective, especially on smaller projects. The presumption is that on larger projects the concrete construction team has been through a pre-construction conference and has addressed the pertinent items in the **Checklist for Concrete Pre-Construction Conference** and those items are excluded from this document. The ordering requirements of CSA A23.1/.2 *Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete* generally govern unless over-ridden by the purchaser.

A Task Group of the Ready Mixed Concrete Association of Ontario (RMCAO) and the Ontario General Contractors Association (OGCA) has revised this document for use on Canadian projects with the co-operation and permission of the RMC Foundation and NRMCA.

Besides items covered in this checklist other items that need to be defined and clarified between the supplier and purchaser include:

- **Advance notice for concrete orders**
- **Add-on orders**
- **Change orders**
- **Will call orders and advance confirmation**
- **After hours placements and charges,**
- **Weekend/holiday orders and charges**
- **Cancellation of orders**
- **Clean-up load estimates and advance notice**
- **Additional charges for items such as returned concrete, short loads, etc.**
- **Requirements for personnel and plant certification**

This checklist will facilitate the person taking the order to assist the person placing the order by walking him/her through these items and documenting the order.

The section on type of construction is to facilitate tracking changes in concrete market segments for promotion activities.

CHECKLIST FOR CONCRETE ORDERING AND SCHEDULING

Project: _____

Location: _____

	Name	Phone	Mobile	Fax
Order taken by				
Ordered by				
Purchased by				

Time/Date Called		**Quantity (m^3)**	
Date Required		**Truck Spacing/Duration**	
Start Time		**Placement Rate (m^3/hr.)**	

Location	Mix Code	Strength (MPa)	Early Strength Requirements (MPa/Hours)			Slump (mm)		Air Content (%)		
			No	Yes			±	No	Yes	

Concrete Temperature Limits ☐ No ☐ Yes Minimum: _____°C Maximum:_____°C

Admixtures or Other Ingredients	No	Plant-added	Site-added	Admixtures or Other Ingredients		No	Plant-added	Site-added
Synthetic Fibres				High Range Water Reducer				
Steel Fibres				Accelerator	Chloride			
High Early Cement (HE)					Non-Chloride			
Mid-Range Water Reducer				Maximum Aggregate Size (mm):				

Directions to the Jobsite _____

Site Access _____

Transportation Units Access _____

Safety Info to Drivers _____

Wash-Out Areas Other _____

Placement Method ☐ Pumping ☐ Conveyor ☐ Bucket ☐ Other _____

Emergency Contacts for schedule changes, equipment breakdown, plant/truck breakdown, mixture adjustments

	Contact	Phone	Mobile	Home Phone
Supplier				
Contractor				
General Contractor				

Type of Project

- ☐ Highway
- ☐ Airports
- ☐ Bridges
- ☐ Water resource structures
- ☐ Parking areas
- ☐ Residential walls (ICFs)
- ☐ Streets and local roads
- ☐ Parking garages
- ☐ Transit
- ☐ Waste management structures
- ☐ Driveways/residential flatwork
- ☐ Other: _____
- ☐ Recreational paving
- ☐ Tilt-Up construction
- ☐ Buildings
- ☐ Flowable fill
- ☐ Basement walls

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WEBSITE LINKS

American Concrete Pumping Association (ACPA) **(www.concretepumpers.com)**
American Society of Concrete Contractors (ASCC) **(www.ascconline.org)**
American Concrete Institute (ACI) **(www.aci-int.org)**
Canadian Standards Association (CSA) **(www.csa.ca)**
Concrete Floor Contractors Association of Ontario (CFCAO) **(www.concretefloors.ca)**
Concrete Construction Magazine **(www.concreteconstruction.net)**
National Ready Mixed Concrete Association (NRMCA) **(www.nrmca.org)**
Ontario General Contractors Association (OGCA) **(www.ogca.ca)**
Ready Mixed Concrete Association of Ontario (RMCAO) **(www.rmcao.org)**
Ready Mixed Concrete Foundation (RMC) **(www.rmc-foundation.org)**
World of Concrete **(www.worldofconcrete.com)**