MUNICIPAL EXTERIOR FLATWORK CONSTRUCTION BEST PRACTICES GUIDE

Sidewalks and Curbs

Cement Association of Canada
Association Canadienne du Ciment

CONCRETE ONTARIO
Ready Mixed Concrete Association of Ontario

ONTARIO GOOD ROADS ASSN. · 1894 ·

PREFACE

The **"Municipal Exterior Flatwork Construction Best Practices Guide"** has been developed by the Ontario Good Roads Association (OGRA), Municipal Concrete Liaison Committee. The Committee consists of members from various municipalities across Ontario; consulting firms; contractors; ready-mix concrete suppliers and associations.

It is the intention of this guide to provide a resource for municipal staff, consultants, contractors and ready-mix concrete producers for municipal projects and to have a single resource for information on municipal exterior flatwork across the province of Ontario. The Committee recognized the need to have a guide that summarizes the specifications and best practices across the province in order to provide consistency. Having everyone on the same page, no matter where they work, should reduce problems and improve communication on municipal exterior flatwork projects.

Municipalities previously and currently represented by the OGRA Municipal Concrete Liaison Committee

DISCLAIMER

The material presented in this text was carefully researched by the Ontario Good Roads Association (OGRA), Municipal Concrete Liaison Committee. Unfortunately, no warranty expressed or implied is made on the accuracy of the contents or their extraction from reference to publications; nor shall the fact of distribution constitute responsibility by OGRA, Concrete Ontario (Ready Mixed Concrete Association of Ontario) and the Cement Association of Canada (CAC), or any researchers or contributing authors for omissions, errors or possible misrepresentations that may result from use of interpretation of the material contained herein. This manual is intended to represent a synopsis of concrete infrastructure best practices. The manual may require updates as new applications mature, and you are encouraged to share your best practice by contacting Concrete Ontario or the Cement Association of Canada or the Ontario Good Roads Association.

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INTRODUCTION

The construction of concrete sidewalks and curbs is a daily occurrence in the province of Ontario, and Municipalities expect a durable, long-term product. In addition, other attributes of good sidewalks and curbs include safety to the public and appearance, not only at the end of the construction period but for also for the intended service life.

Owners, contractors and concrete suppliers must work collectively to provide exterior concrete flatwork that is both aesthetically pleasing and durable when the optimal concrete performance mix is ordered, handled, placed, finished, cured and protected meeting the Municipalities' specifications. Every aspect of the project must be carefully designed, planned and constructed to ensure that the hardened concrete, will be resilient and visually appealing. A noteworthy example can be seen in Figure 1 of a properly constructed sidewalk.

Since the concrete's durability and service life will be tested by weathering action, chemical attack, abrasion and a variety of different types of loading, it becomes imperative that proper specifications are followed, and appropriate construction practices are observed. If proper care is not taken, surface and structural defects such as scaling, mortar flaking, pop-outs, cracking and heaving may occur which all will impact the service life of the sidewalks and curbs. Although common surface defects such as scaling and mortar flaking as observed in Figure 2, may initially only be visually unappealing, the continued detrimental impacts of the attacking mechanisms will lead to a safety issue as sidewalks will become tripping hazards.

In addition, if structural aspects such as cracking and heaving are also factored into the picture and have become an issue, the tripping hazard will only be amplified leading to the eventual removal of the sidewalk. Figure 3 demonstrates a complete structural failure of a sidewalk panel. The causes and avoidance of common municipal defects are outlined on the following page

Figure 1 – Properly constructed sidewalk (Hamilton, ON)

Figure 2 – Scaling and mortar flaking (Etobicoke, ON)

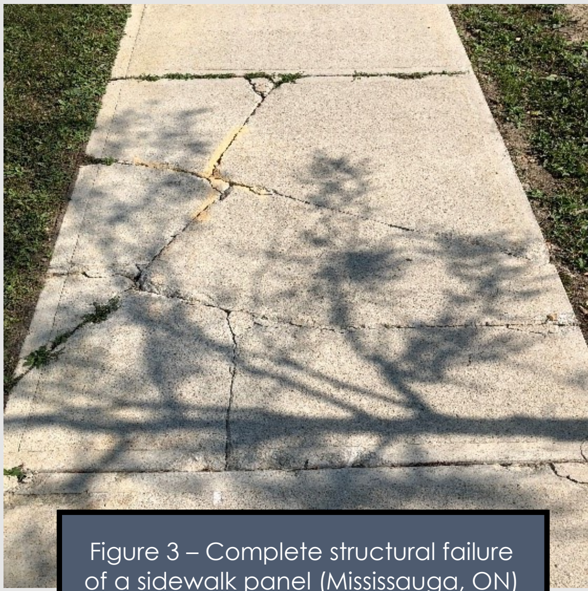
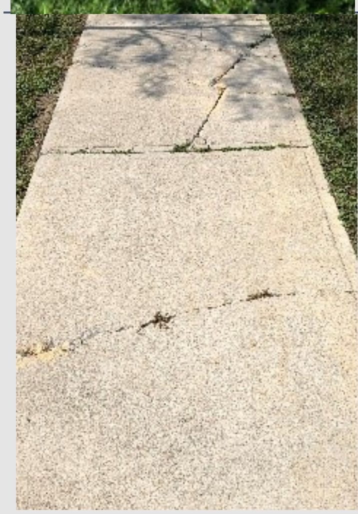


Figure 3 – Complete structural failure of a sidewalk panel (Mississauga, ON)

COMMON MUNICIPAL CONCRETE DEFECTS

	MUNICIPAL CONCRETE DEFECTS	**CAUSES**	**AVOIDANCE**
	**SCALING** Local flaking or peeling away of the top surface portion of hardened concrete	• The concrete contains insufficient air entrainment or is non-air entrained • The concrete has not been properly cured • The concrete is exposed to deicing chemicals prior to gaining proper strength and air-dry time • When finishing operations are completed with bleed water still on the surface • When concrete is placed during extreme temperatures	• Order and place the correct concrete • Ensure that the air content of the concrete meets specification requirements • Properly cure the concrete • Avoid overworking the surface • Minimize use of deicing chemicals • Utilize wet curing methods during hot weather conditions • Allow at least 30 days of air drying after the curing period
	**MORTAR FLAKING** The dislodging of small sections of concrete mortar directly over top of the coarse aggregate particles	• The concrete is placed during periods of rapid surface drying without protection • The concrete is not properly cured • When curing compounds are applied too late after concrete placement or not until after the following day • Any of the above combined with freeze-thaw cycles and deicing chemicals	• Ensure proper curing procedures are followed at all times • During period of rapid surface drying consider the use of evaporation retardants • Consider the use of wet curing procedures during severe drying and hot weather conditions • Consider the use of fog spraying systems to protect the concrete surface
	**DRYING SHRINKAGE CRACKING** Cracking of concrete due to failure in tension caused by external or internal restraints as a reduction in moisture content develops	• The designer or contractor has not developed a proper jointing system and layout • The sub-grade has not been properly inspected and compacted • There is excessive amounts of jobsite water addition • Control joints are not installed in a timely fashion • The concrete is inadequately cured	• Ensure that the sub-grade is adequately compacted prior to concrete placement • Ensure positive drainage of both the subgrade and concrete surface • Ensure the proper and timely use of concrete jointing (Control, isolation, construction and expansion joints)

	MUNICIPAL CONCRETE DEFECTS	CAUSES	AVOIDANCE
	**POPOUTS** Conical fractures of the concrete surface caused by the expansion of ice inside porous coarse aggregates located just below the concrete surface	• The local aggregate sources contain soft, porous material • The concrete is in a fully saturated condition • The concrete hasn't achieved its ultimate durability potential due to inadequate curing and lack of air-dry time	• Consider the use of alternative aggregate sources • Consider changing the aggregate processing process to remove more of these porous materials • Ensure the concrete is properly graded and drained to minimize the saturation level in the concrete • Properly cure and air-dry time for the concrete to maximize the durability
	**HEAVING** Uplift and/or settlement of the concrete	• Expansive native soils • Frost action • Thermal expansion of the concrete slabs • Improper uniform support of the base and/or subgrade • Incompressible in expansion joints	• Proper placement and compaction of the sub-base and/or of the sub-grade • Proper use of expansion and isolation joints
	**STRUCTURAL CRACKING** Complete failure of the slab	• Improper uniform support of the base and/or subgrade • Freeze and thaw cycles • Heavy loading	• Proper placement and compaction of the sub-base and/or of the sub-grade • Ensuring the loading consists of only foot traffic

To avoid these common defects, contractors and concrete suppliers must work together to provide a final product that Municipalities can be proud of. This can only be achieved by dissecting every aspect of the construction process and by carefully following all applicable municipal standards and best practices. This guide will serve as a tool to outline all specific areas that the construction process entails for municipal exterior flatwork and will highlight the important aspects where care must be taken to ensure success.

The Committee would like to acknowledge and thank DiCrete Construction Ltd., for their continued support and for allowing us to document the many phases of construction that are contained within this guide.

SUBGRADE AND GRANULAR BASE

The construction of any structure begins with a stable foundation and uniform support, which is free from contamination and debris. This will minimize settling issues and prevent premature cracking due to uneven loads. The construction of sidewalks is no different and all applicable municipal standards must be consulted when preparing the subgrade. Based on soil conditions, some municipalities require the placement of a granular base to mitigate heaving due to frost susceptible soils as well to provide a stable, uniform support platform for the concrete. This requirement varies by region and can range from no granular base to up to 150 mm of granular material.

Figure 4 – Granular A typically used for the subbase of sidewalks

Typical Municipal requirements for the preparation of the subgrade and granular base include:

1. Subgrade compaction to be a minimum of 95% of maximum dry density
2. Granular base and backfill, if required, shall be Granular A (Figure 4)
3. The moisture content and compaction of the granular base shall be uniform
4. The granular base shall be moistened prior to the placement of concrete, but without any standing (ponding) water

City of Vaughan Municipal Specification - 25 mm Granular A placement and compaction. (Figures 5-7)

Figure 5 – 25 mm Granular A placement

Figure 6 – Subgrade compaction using a vibratory plate compactor

Figure 7 – Subgrade compaction continued and almost ready for concrete

CONCRETE FORMING

Forming is used to define the structure being built and for concrete sidewalks and curbs can consist of steel, wood or metal plate. Forms shall be cleaned and coated with form oil before each use. Common materials for the forming of sidewalks using wood are shown in Figure 8.

The forms shall be pinned or staked and secured to resist the pressure of the plastic concrete as well as to prevent springing or settlement as demonstrated in Figure 9.

Forms shall be set true to the lines and grades as specified in the municipal specification and must be in direct contact with the base. A cross fall typically of 2% toward the gutter is used to direct rainwater away from the surface of the sidewalk. This prevents water from ponding on the surface of the sidewalk and minimizes a slip hazard especially during the winter months.

Figure 8 – Wood materials for forming

Figure 9 – Staking wood forming

Slip-formed curbs typically use string lines to guide the paver and only use temporary forming to brace the initial concrete that is being placed. It is crucial that these string lines are properly set as the grade of the curbs will be defined by them.

Figure 10 shows a typically flip-form paver used to place concrete curbs.
If utilities are present such as shown in Figure 11, the slip-form paver is unable to be used and hand-curb forming operations are conducted. The material types and preparation of the forms are still governed by the same requirements outlined previously.

Figure 10 – Concrete curb slip-form paving

Figure 11 – Hand-curb form set-up around utilities

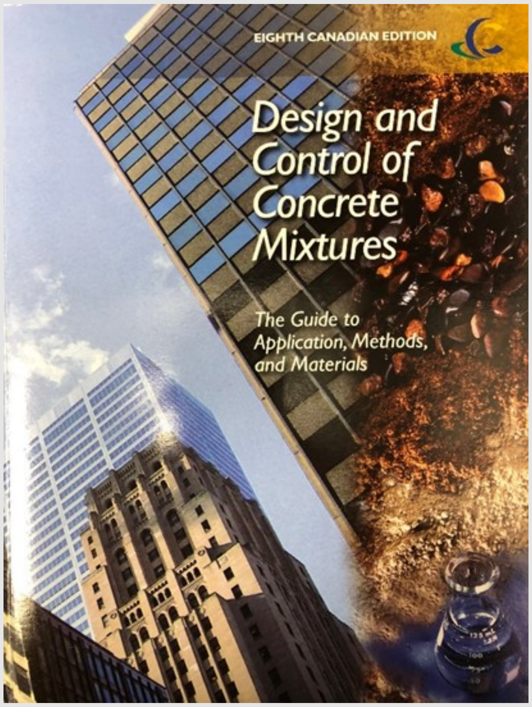
ABOUT CONCRETE

Concrete is a highly engineered building material, which is a mixture of cement and supplementary cementitious materials, water, stone, sand and admixtures which enhance its properties. Initially plastic, concrete will set and harden after a short dormancy period due to a chemical reaction between the cementitious materials and water, called hydration. This reaction consumes both the cement and water to produce new compounds which gradually grow, spread, and interlock with each other and adhere to the aggregates, providing the concrete structure with the necessary strength and durability.

The benefits of properly designed concrete cannot be over-stated – it's easily placed, strong, durable, robust, sustainable, and visually appealing. The concrete producer can adapt mix design proportions to achieve the specific goals for the intended application.

There are many concrete reference documents available, however, the **"Design and Control of Concrete Mixtures, The Guide to Applications, Methods, and Materials"** has been the industry's primary reference on concrete technology for over 85 years. The text is backed by over 95 years of research by the Portland Cement Association and the Cement Association of Canada. It reflects information on standards, specifications, test methods and guides of the Canadian Standards Association (CSA), ASTM International (ASTM), the American Association of State Highway and Transportation Officials (AASHTO), the American Concrete Institute (ACI), and the National Ready Mixed Concrete Association (NRMCA).

This book presents the properties of concrete as required in construction, including strength and durability. All concrete ingredients (cementing materials, water, aggregates, chemical admixtures, and fibres) are reviewed for their optimal use in designing and proportioning concrete mixtures. The use of concrete from design to batching, mixing, transporting, placing, consolidating, finishing, curing, sustainability and durability is addressed.



Additionally, new information has been included in Chapter 3 on Portland-limestone cements that are now included in CSA cement and concrete standards. Manufacturing Portland-limestone cement reduces CO_2 emissions by up to 10% over that of regular Portland cement.

This comprehensive manual benefits personnel from municipalities, ready-mixed concrete producers, concrete contractors, and material suppliers and is a reference publication for many national and provincial certification programs. Design and Control of Concrete Mixtures also meets the growing needs of architects, engineers, builders, and students. This book is a "must have" for anyone involved with concrete.

For more information please visit:

http://www.cement.ca/technical-publications/

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CONCRETE PERFORMANCE SPECIFICATION

To supply concrete to a Municipal project, the concrete supplier must possess a current valid Certificate of Ready Mixed Concrete Production Facilities or a current valid Certificate of Mobile Mix Concrete Production Facilities for the plant being used to produce ready mixed concrete. The batching plant and equipment shall be audit by an approved third-party Engineer according to the certification requirements of Concrete Ontario.

An up to date list of all current ECO Green and ECO Gold Concrete Ontario certified members and their plants can be accessed at: https://www.rmcao.org/certification/rmcao-production-facilities/

All Concrete Ontario ECO certified ready mixed concrete producers **strictly** follow the **Alternative #1 Performance, of CSA A23.1-14 Table 5** titled **"Alternative methods for specifying concrete."** This alternative allows the suppliers to provide an optimized product through their available resources and encourages competition amongst themselves. In turn, an overall superior product is provided to the industry.

When owners or concrete specifiers impose limits on mix proportions, plastic concrete specifications or ask for other requirements in contrast to the aforementioned design, the full responsibility of concrete performance is assumed by the owner as per the **Alternative #2 Prescription, of CSA A23.1-14 Table 5.**

Concrete Ontario has reviewed all the **latest municipal and national specifications** for concrete sidewalks and curbs. Based on the concrete exposure conditions for these applications, the following mix design specification should be the **only** standard used in Ontario **by all municipalities**. The raw materials comprising the specified mix design below must be in conformance with the latest OPSS and CSA A23.1 standards.

32MPa @ 28D, Max. 0.45 w/cm, Class C-2, 5-8% air

~~25MPa~~ ~~30MPa~~

Not 25MPa, not 30MPa, but a minimum 28-day strength of 32MPa.
(CSA A23.1-14 Table 2)

Max. 0. 45 w/cm refers to the maximum water to cementing materials ratio. The lower the value, the less permeable and more durable the concrete will be.

(CSA A23.1-14 Table 2)

~~**Min. 325 kg/m³**~~ ~~**Min. 355 kg/m³**~~

Air entrainment provides freeze-thaw durability and the plastic air content range is dependent on aggregate size used. For typical 20 mm aggregate, the required air range is 5-8% air.
(CSA A23.1-14 Table 4)

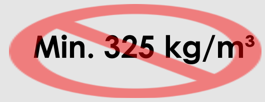
~~**4.5-7.5%air**~~

The class of exposure identifies the type of concrete and the environment the concrete will be subjected to.

Class C-2 refers to non-structurally reinforced (i.e., plain) concrete exposed to chlorides and freezing and thawing. Class C-2, by default, requires a minimum 28-day strength of 32MPa.
(CSA A23.1-14 Tables 1 & 2)

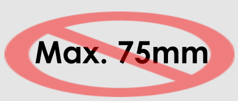
FREQUENTLY ASKED SPECIFICATION QUESTIONS

1. **Does a minimum cement content need to be specified?** The answer is **NO**. Specifying minimum cement contents is an obsolete approach and should be discontinued for any sidewalk, curb and gutter projects. The concrete supplier uses their available resources to meet the minimum requirements for these applications. If a minimum cement content is specified, alternative 2, the prescription approach is in effect and the owner assumes full responsibility for the concrete. (CSA A23.1-14 Table 5)



2. **Should the slag or fly ash percentage be limited in the specification?** The answer is **NO**. The concrete supplier is responsible for the performance of the mix and through customer feedback and experience will be able to set percentage limits internally to provide a quality product. In addition, effective use of supplementary cementing materials must be encouraged from a sustainability aspect. The percentage of supplementary cementing materials is not disclosed until the values approach HVSCM 1 and HVSCM 2 limits. (CSA A23.1-14 8.7.1)

3. **What slump should be specified for concrete sidewalks, curbs and gutters?** The answer is, **It depends!** The applications will dictate what slump the contractor wishes to use. Limiting a slump range other than using the tolerances specified in **CSA A23.1 4.3.2.3.2** hinders the concrete supplier from providing a consistent mixture and it limits the contractor's ability to perform their work. Implications may include additional costs due to rejected loads and delays in the project schedule. Slump and workability requirements are best addressed by the designer, contractor, and producer discussing the project requirements.



For example, City of Brampton BSS 1350 states:

"Concrete slump shall be selected by the contractor based on the method of placement. Slump acceptance and/or rejection shall be based upon the slump tolerances identified in CSA A23.1 using the Contractor's target slump value."

4. **Should the plastic air content range be adjusted?** The answer is **NO.** The plastic air range is defined in CSA A23.1-14 Table 4 and must be followed to meet the durability requirements of the required class of exposure. Without any technical justification, the air range should not be altered as it compromises the supplier's ability to provide a consistent and predictable air content.

For all current Municipal specifications in Ontario please consult Appendix A.

Other important municipal specification requirements that must be followed include:

1. The concrete temperature at the time of discharge from the truck shall be between 10 and 28 °C.
2. When concrete is transported to the site by means of a ready-mix truck, discharge of the concrete shall be completed within 1.5 hours after introduction of the mixing water

CONCRETE TESTING

FIELD-TESTING & CERTIFICATION

To verify the aforementioned concrete performance criteria, field testing must be conducted. Field sampling and testing of concrete shall be performed by a person holding either of the following certifications (OPSS.MUNI 1350 1350.08.02.01.01):

1. CCIL Certified Field Testing Technician
2. ACI Concrete Field Testing Technician – Grade 1

ACI Ontario Chapter and Concrete Ontario offer the ACI Field Testing Certification Course and for more information and registration details please visit the Concrete Ontario website events page at:

https://www.rmcao.org/category/events/

The following performance field testing is required for all concrete sidewalk and curb construction:

1. The concrete mix shall be sampled according to CSA A23.2–1C
2. The slump of the concrete shall be tested in accordance with CSA A23.2–5C
3. The air content of the concrete shall be tested according to CSA A23.2–4C
4. The temperature of the concrete shall be tested in accordance with CSA A23.2–17C
5. The casting of compression test specimens shall be conducted as per CSA A23.2–3C

LABORATORY TESTING

Laboratory tests shall be completed by a laboratory certified according to CSA A283 for the category appropriate to the test required by CSA.

Concrete compressive test reports **shall be distributed immediately** to the Owner, Contractor and concrete supplier by electronic files and no later than 5 business days as per the requirements of CSA A23.1 clause 4.4.1.7.1.

ON-SITE ADDITION OF WATER

Concrete strength and durability is directly related to the water-to-cementitious materials ratio. When water is added on-site, there is a risk of exceeding the design limits and weakening the concrete performance. However, under CSA A23.1, when the slump of the concrete is less than what is designated, water may be added on the following basis:

a) The specified water-to-cementitious materials ratio is not exceeded
b) No more than the lesser of 16 L/m³ or 10% of the mixing water is added
c) No more than 60 minutes has elapsed since the time of batching
d) The mixer drum is turned at mixing speed for at least 30 revolution
e) The amount of water added and by whose authority is recorded on the delivery ticket

CONCRETE PLACING AND FINISHING

Once the concrete delivered is within the required municipal specification limits, the placing operation can begin. The delivery ticket must be checked and signed, prior to placing a load, to confirm that the correct mix has been received. No matter the placement method, the concrete shall be placed to the specified thickness, line and grade and must be thoroughly consolidated by the use of vibrators or other suitable tools to eliminate voids, honeycombing and entrapped air.

FINISHER TRAINING & CERTIFICATION

To ensure proper placing and finishing techniques are used, the foreman/lead hand or the supervisor of the placing crew must have **ACI Flatwork Certification**. (City of Toronto TS 3.50 & 3.70)

ACI Ontario Chapter and Concrete Ontario offer the ACI Flatwork Certification Course and for more information and registration details please visit the Concrete Ontario website events page at:

https://www.rmcao.org/category/events/

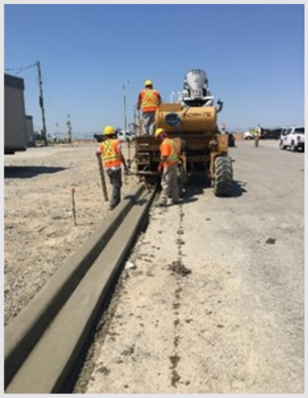
General sequence of operations

OPERATION	
Placement	

Placement

- Concrete can be placed on the subgrade or a subbase depending on the municipal requirements (See Subgrade and Granular Base Section)
- Ready-mix truck for sidewalks and hand curbs
- Slipform for curbs





Placement on Poly

- While the majority of the concrete for sidewalks is placed on the subgrade or granular base, some municipalities (i.e. City of Toronto) require the concrete to be placed on polyethylene vapour barrier
- Municipal specifications should always be consulted before placing any concrete

Advantages:
- Reduces moisture uptake from the subgrade
- Acts as a slip-sheet to reduce the friction of horizontal movement

Disadvantages
- Prevents bleeding into the subgrade
- Increases concrete set times
- Increases potential finishing issues

OPERATION

Spreading, consolidating & screeding

- Concrete is spread continuously as near as possible to its final position to avoid segregation
- Spreading tools include square-ended shovels and come-alongs
- Consolidate by the use of vibrators or other suitable tools to eliminate voids
- Straightedge is used to screed and strikeoff

Finishing

- Tools shall be aluminum or magnesium floats
- **Steel trowels shall not be used at any point on exterior flatwork concrete**
- Sidewalks– Bull Floating
- Curbs– Hand floats
- **Concrete is ready for finishing when the bleed water sheen is gone**
- The application of water, neat cement or sand to the surface shall not be permitted in any instance
- Overworking the surface of the concrete shall be minimized as it can have a detrimental impact on the air void structure at the surface of the concrete

Edging

- Rounded edges are less vulnerable to chipping and spalling
- The concrete adjacent to all formwork and joints shall be finished with a tool that produces a 5 mm rounded edge and a smooth, horizontal surface with a maximum width of 50 mm
- Edging shall be conducted before jointing to ensure that water is not trapped in the channel

OPERATION

Final Finish

- Light broom texturing for slip resistance

Jointing

- Joints can be formed or sawcut
- Typically constructed to a depth of at least one quarter the concrete thickness for both sidewalks and curbs

HOT AND COLD WEATHER CONSIDERATIONS

Ambient conditions have a significant influence on the concrete during its early stages. Appropriate preparations for hot or cold weather concreting, as well as other weather events, should be made well in advance.

HOT WEATHER (ACI 305R) is defined as any combination of high ambient temperature (above 25°C), low relative humidity, high wind velocity, or high solar radiation that tends to impair the quality of freshly mixed or hardened concrete by accelerating moisture loss, rate of cement hydration, or otherwise causing detrimental results. During HOT-WEATHER conditions, it is important to reduce the rate of evaporation from concrete to minimize early stiffening tendencies, plastic shrinkage cracking, and the potential for mortar flaking. Considerations include dampening subgrades, erecting windbreaks or sunshades, fog misting the air over the concrete surface, application of evaporation retardants, rescheduling the placement for a cooler time, and so forth.

COLD WEATHER (ACI 306R) requires precautions be taken if the ambient temperature is expected to drop below 5°C, if it will not be above 10°C for at least half of a day, or if there is a probability that the temperature will fall below 5°C within 24 hours of placing the concrete. During COLD-WEATHER conditions, the primary concern is to keep the concrete element's temperature above freezing so that hydration continues and the concrete gains enough strength before being exposed to freezing temperatures. Additionally, concrete placed late in the construction season may not be mature enough, or have had a sufficient drying period after reaching maturity, to properly withstand freeze-thaw and salt scaling damage. Cold Weather Protective Measures identified in OPSS.MUNI 904 must be followed.

CURING

Protection and curing of concrete provides the greatest benefit for the smallest investment. Curing pertains to maintaining sufficient moisture and temperature within the concrete for a specified period of time following placement and finishing to ensure the desired properties are achieved. Proper curing will result in increased durability, strength, abrasion resistance and resistance to freeze/thaw and de-icers.

The process of curing shall commence as soon as possible and not more than 30 minutes after surface finishing.

CSA A23.1-14 Table 19—Allowable curing regimes states that 32MPa Class C-2 concrete is curing type 2, meaning "Additional Curing" and shall be cured 7 days total at ≥ 10°C and for the time necessary to attain 70% of the specified strength. (22.4MPa)

Each curing method may be used at ambient temperatures up to 28°C. At temperatures above 28°C, only the geotextile fabric and water procedure is recommended. At temperature below 5°C, curing compound is not recommended.

CURING METHOD	SPECIFICATION REQUIREMENTS
Burlap and Water 	• Burlap cloth shall be made from jute or kenaf • Pre-soaked for at least 6 hours • Shall cover entire width and edges of the exposed concrete • Shall overlap 300 mm and shall be held down to prevent displacement • Shall be maintained in place and kept saturated for a minimum period of 7 days • The Contractor may constantly water the mats or cover them with opaque polyethylene film, or a combination of both, in order to keep the mats saturated • Alternatively, this method shall be used for a minimum period of 3 days following which the surface shall be cured with curing compound
Geotextile Fabric and Water 	• Geotextile fabric shall be a synthetic, permeable textile with a minimum thickness of 0.9 mm • Pre-soaked by immersion in water for at least 6 hours • Two layers of fabric shall be applied • Shall overlap 100mm and shall be held down to prevent displacement • The Contractor may constantly water the mats or cover them with opaque polyethylene film, or a combination of both, in order to keep the mats saturated • Alternatively, this method shall be used for a minimum period of 3 days following which the surface shall be cured with curing compound

CURING METHOD	SPECIFICATION REQUIREMENTS

Polyethylene Film

- White, opaque polyethylene film (100 µm thick) – 6 mils
- Shall be placed such that air flow between it and the concrete surface is prevented
- Shall be overlapped a minimum of 150 mm, to prevent displacement.
- The film shall be kept in place for a minimum period of 7 days.
- Alternatively, this method shall be used for a minimum period of 3 days following which the surface shall be cured with curing compound

Membrane Compound

- Prior to application, the curing compound shall be agitated by mechanical means to provide a homogeneous mixture
- It shall be applied immediately after finishing of the concrete surface, within 2 to 4 m of the finishing operation, completely covering the surface of the concrete
- Applied in two coats, with the second being applied at the right angle to the first coat
- Application should be uniform in thickness and colour over the entirety of the concrete (Generally as white as possible!)
- Shall be maintained in this condition for a minimum period of 7 days
- The rate of application shall not be less than that specified by the manufacturer of the compound.
- Curbs – Both the front and back must be sprayed

JOINTING

As the hydration process develops and the concrete begins to harden, stresses begin to form due to shrinkage. These stresses must be alleviated through jointing to ensure that the concrete will crack as is predetermined by the jointing pattern and not randomly or more specifically naturally. All concrete will crack naturally unless pre-emptive action is taken. The timing of the joints and their depth must carefully be determined so that the jointing pattern is effective and visually appealing. If joints are cut too early, raveling will occur (Figure 12) while cutting the joints too late will result in random shrinkage cracking. (Figure 13)

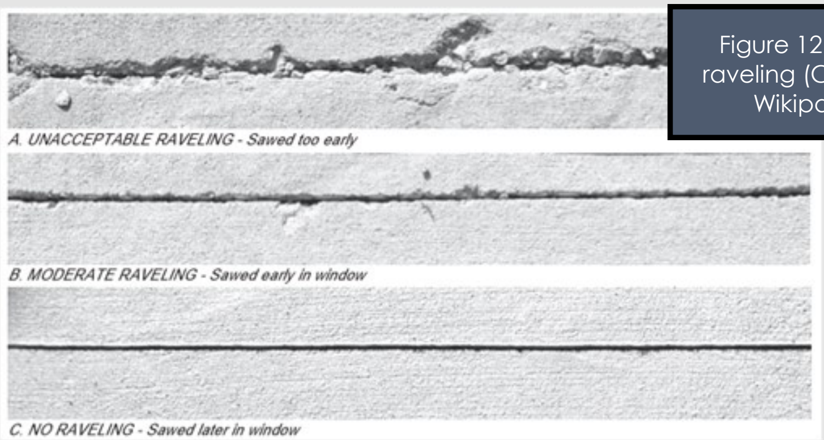


Figure 12 – Levels of raveling (Credit: ACPA Wikipave.org)

Figure 13 – Random shrinkage cracking

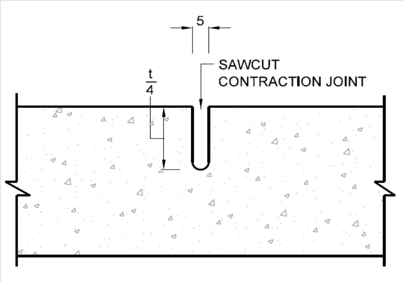
The timing of saw-cutting is dependent on the properties of the concrete, as well the environmental that the concrete is placed in.

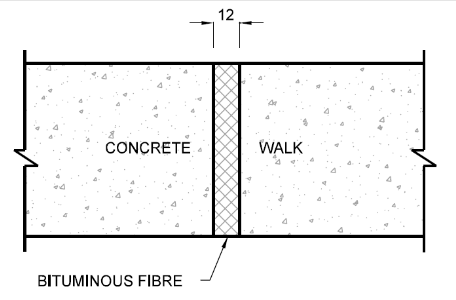
In addition to shrinkage cracking, thermal expansion must be addressed as well. Thermal expansion is a result of hot temperatures that cause the concrete to expand. If this expansion is not accounted for through expansion joints, the restraint of the concrete will cause sidewalk panels to fault as there is no space to accommodate the increase in volume. Proper planning of expansion joints will allow the concrete to expand and contract accordingly and will minimize any damage that will occur to the panels.

JOINTING TYPE	SPECIFICATION REQUIREMENTS

Contraction

- Contraction joints can be formed or sawcut
- Curb/Gutter - The joints shall coincide with joints in the concrete road base and sidewalks
- Depth of the contraction joint shall be **at least one quarter the concrete thickness**
- Sidewalks - Maximum distance between contraction joints is 2 meters (TS 3.70)
- Curbs - The maximum distance between contraction joints shall be 6 meters (TS 3.50)



JOINTING TYPE	SPECIFICATION REQUIREMENTS
Expansion 	• Expansion joints shall be constructed to the full thickness of the sidewalk or raised median and shall be a maximum of 6 m apart. (12mm bituminous fibre expansion joint material) • In the event of an unavoidable stoppage of concrete placement extending more than 30 minutes, an expansion joint shall be constructed 

The section of newly constructed concrete shall be closed to all vehicular traffic, including construction equipment, until such time as the concrete has attained at 20 MPa. Pedestrian traffic shall be kept off the newly constructed concrete for at least eight hours. The Contractor shall provide adequate measures to protect the newly constructed concrete section from damage by vehicular or pedestrian traffic. (TS 1350)

SUMMARY

Concrete is a robust, sustainable, high performance building material. In order to ensure the success and longevity of concrete structures, it is important that the product is respected and treated accordingly. Pre-planning and communication between all parties involved is critical to ensuring that success. The quality and performance on the product depends on the quality of the whole concreting system – from proper design and specifications, to mix design, to batching and delivery, through to proper construction practices, protection, and curing. For further information, please refer to CSA A23.1 or contact your local concrete supplier.

For additional information and the latest up to date copy of this guide please visit:

www.ConcreteOntario.org

APPENDIX A

Municipal Concrete Specifications 2019/20

Concrete Ontario has reviewed all the **latest municipal and national specifications** for concrete sidewalks and curbs. Based on the concrete exposure conditions for these applications, the following mix design specification should be the **only** standard used in Ontario **by all municipalities**. The raw materials comprising the specified mix design below must be in conformance with the latest OPSS and CSA A23.1 standards.

32MPa @ 28D, Max. 0.45 w/cm, Class C-2, 5-8% air*

***Air range is based on 19/20mm aggregate size according to CSA A23.1-14 Table 4.**

Municipalities are strongly encouraged to contact Concrete Ontario at **info@concreteontario.org** to update their specifications or if already available to provide newer versions of the specifications. This list will be periodically updated to reflect the most up to date versions in Ontario.

The following specifications are currently in use for the outlined Municipalities below.

Red text represents non-conformance to OPSS.MUNI 1350 (Nov. '17) and/or CSA A23.1-14.

Recommendations are provided to align all Municipalities with the most up to date standards.

Municipality	Current Municipal Specifications/ Drawings with Update Recommendations
Town of Ajax	AS-231 (Jan. '11) Concrete sidewalk — Concrete to conform to OPSS 1350, 30MPa, 7.0 ± 1.5% **Recommendation: Change to 32MPa @ 28D, Max. 0.45 w/cm, Class C-2, 5-8% air** AS-261 (May '18) Replacement concrete sidewalk — 32MPa @ 28D, Max. 0.45 w/cm, Class C-2, 5-8% air, Slump Max. 80 mm **Recommendation: See "Specifying Slump" section for slump change.**
City of Barrie	Transportation Design Manual (2017) 2.4.1 Concrete curb and gutter — Concrete to conform to OPSS 353 (Nov. '16) Concrete shall be according to OPSS 1350 and Minimum specified 28-Day compressive strength: 30 MPa **Recommendation: Change to 32MPa @ 28D, Max. 0.45 w/cm, Class C-2, 5-8% air** Transportation Design Manual (2017) 2.4.2 Concrete Sidewalk — Concrete to conform to OPSS 351 (Nov. '15) Concrete shall be according to OPSS 1350, with a minimum specified 28-Day compressive strength of 30 MPa. **Recommendation: Change to 32MPa @ 28D, Max. 0.45 w/cm, Class C-2, 5-8% air**
City of Brampton	BSS 1350 (July '13) Concrete curbs and sidewalks — 32MPa @ 28D, Max. 0.45 w/cm, 5-8% air **Recommendation: Add Class C-2** STD 227 (Dec. '10) Concrete Walkway — All concrete to be 30MPa **Recommendation: Change to 32MPa @ 28D, Max. 0.45 w/cm, Class C-2, 5-8% air**
City of Burlington	COB OPSS Amendments (March '17) Sidewalks, curbs and gutters — Min. 30MPa @ 28D, 6.5 ± 1%, 325kg/m³, Slump Max. 80 mm **Recommendation: Change to 32MPa @ 28D, remove 325kg/m³ and replace with Max. 0.45 w/cm, Class C-2, 5-8% air, see "Specifying Slump" section for slump change.**
Town of Georgina	Development Design Criteria and Standards (2013) Concrete curb and gutter — 32MPa @ 28D, 7 ± 1.5%, 355kg/m³, Slump 60 mm **Recommendation: Remove 355kg/m³ and replace with Max. 0.45 w/cm, Class C-2, 5-8% air, see "Specifying Slump" section for slump change.**

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Municipality	Current Municipal Specifications/ Drawings with Update Recommendations
City of Hamilton	Form 700 (June '17) Sidewalks and curbs — 32MPa **Recommendation: Expand to 32MPa @ 28D, Max. 0.45 w/cm, Class C-2, 5-8% air**
City of Kingston	Subdivision Development Guidelines and Technical Standards (Jan. '14) Sidewalks — 30MPa, 6-8% air, Slump Max. 75mm Curb and Gutter — 30MPa, 6-8% air, Slump Max. 75mm **Recommendation: Change to 32MPa @ 28D, Max. 0.45 w/cm, Class C-2, 5-8% air, see "Specifying Slump" section for slump change.**
City of Kitchener	CKSS 351 (Nov. '17) Concrete sidewalks — Concrete shall be according to OPSS 1350 as amended by CKSS 1350 CKSS 353 (Nov. '17) Concrete curb and gutter — Concrete shall be according to OPSS 1350 as amended by CKSS 1350 CKSS 1350 (Nov. '17) All concrete — 32MPa @ 28D, Max. 0.45 w/cm, Class C-2, 5-8% air Hand placement — Slump 70 ± 20 mm Machine placement — Slump 45 ± 10 mm **Recommendation: See "Specifying Slump" section for slump change.**
City of Mississauga	Standard No. 2230.010 (Sep. '16) Barrier curb with gutter — CSA, C-2, 32MPa Standard No. 2240.010 (March '15) Concrete sidewalk — C-2, 32MPa
Town of Newmarket	Engineering Design Standards and Criteria (Sep. '18) Concrete curbs and sidewalks — 30MPa @ 28D, 7.0 ± 1.5% **Recommendation: Change to 32MPa @ 28D, Max. 0.45 w/cm, Class C-2, 5-8% air**
Town of Oakville	STD 6-1 (Feb. '99) Concrete curb and gutter — Concrete as per OPSS 1350 **Recommendation: Clarify to 32MPa @ 28D, Max. 0.45 w/cm, Class C-2, 5-8% air** STD 6-3 (May '03) Concrete sidewalk — Concrete as per OPSS 1350, Min. 355kg/m^3 **Recommendation: Clarify to 32MPa @ 28D, Max. 0.45 w/cm, Class C-2, 5-8% air, remove Min. 355kg/m^3**
City of Ottawa	F-3510 (March '19) Sidewalks and curbs — 32MPa @ 28D, Max. 0.45 w/cm, Class C-2, 5-8% air Extruded concrete curbs — Slump 40 ± 20 mm Concrete curbs and sidewalks — Slump 70 ± 20 mm **Recommendation: See "Specifying Slump" section for slump change.**
City of Peterborough	Standard Drawings CP351.01 (Jan. '18) Sidewalks, curbs and gutters — 32MPa @ 28D, Class C-2
City of Pickering	P-601 (July '03) Standard curb and gutter — 32MPa @ 28D, 5-8%, Slump Max. 80 mm **Recommendation: Add Max. 0.45 w/cm, Class C-2, change Slump to 80 ± 30 mm** **Also applies to P-600, P-602, P-603, P-604** P-610.1 (May '12) Standard sidewalk — Concrete to conform to OPSS 1350 32MPa @ 28D, 5-8%, Slump Max. 80 mm **Recommendation: Add Max. 0.45 w/cm, Class C-2, see "Specifying Slump" section for slump change.** **Also applies to P-610.2, P-620**
City of Sarnia	Division 4.3 (2018) Sidewalks, curbs and gutters — 32MPa @ 28D, Max. 0.45 w/cm, Class C-2, 5-8% air, Slump 75 ± 20 mm **Recommendation: See "Specifying Slump" section for slump change.**
City of Thunder Bay	Contract section 02510 (2018) Sidewalks — 32MPa, 5-8%, Slump 75 mm, no chemical admixtures **Recommendation: Add Max. 0.45 w/cm, Class C-2 and see "Specifying Slump" section for slump change.**

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Municipal Concrete Specifications 2019/20

Municipality	Current Municipal Specifications/ Drawings with Update Recommendations
City of Toronto	TS 3.50 (Sep. '17) Concrete curb and gutter — 32MPa, Max. 0.45 w/cm, Class C-2, 5-8%, Slump 80 ± 30 mm TS 3.70 (Sep. '17) Concrete sidewalk and raised median — 32MPa, Max. 0.45 w/cm, Class C-2, 5-8%, Slump 80 ± 30 mm **Recommendation: See "Specifying Slump" section for slump change.**
City of Vaughan	STD. DWG. R-128 (2016) Sidewalk and ramp — Class C-2 (32MPa), Max. 0.45 w/cm, 6.0 ± 1% **Recommendation: 5-8%** STD. DWG. R-129 (2016) Walkways — Class C-2 (32MPa), Max. 0.45 w/cm, 6.0 ± 1% **Recommendation: 5-8%**
Town of Whitby	DWG. No. 206 (Oct. '18) Base stage concrete — 32MPa @ 28D, 7.0 ± 1.5%, 355kg/m³ **Recommendation: 5-8%, remove 355kg/m³ and replace with Max. 0.45 w/cm, Class C-2** DWG. No. 206 (Oct. '18) Top stage curb and gutter concrete — 32MPa @ 28D, 7.0 ± 1.5%, 325kg/m³ **Recommendation: 5-8%, remove 325kg/m³ and replace with Max. 0.45 w/cm, Class C-2** DWG. No. 208 (Oct. '18) Concrete sidewalk — 32MPa @ 28D, 7.0 ± 1.5%, 355kg/m³, Slump 70 ± 20 mm **Recommendation: 5-8%, remove 355kg/m³ and replace with Max. 0.45 w/cm, Class C-2** DWG. No. 209 (Oct. '18) Overland flow walkway — 32MPa @ 28D, 7.0 ± 1.5%, 355kg/m³ **Recommendation: 5-8%, remove 355kg/m³ and replace with Max. 0.45 w/cm, Class C-2**
City of Windsor	S-5 (Feb. '15) Concrete curb and gutter — Concrete shall be as per City of Windsor Standard Specification S-9 S-6 (Oct. '15) Concrete sidewalk — Concrete shall be as per City of Windsor Standard Specification S-9 S-9 (Feb. '15) Concrete Curb and gutter—32MPa @ 28D, Max. 0.45 w/cm, Class C-2, 5-8%, Slump 20-60 mm Sidewalk — 32MPa @ 28D, Max. 0.45 w/cm, Class C-2, 5-8%, Slump 80-120 mm **Recommendation: Sidewalk — See "Specifying Slump" section for slump change.**

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SPECIFYING SLUMP

The long-term durability of concrete for specific applications is ensured by specifying the design strength, the applicable water to cementing materials ratio and the required air content. Once these parameters are satisfied, the slump of concrete is introduced to help with ease of placement and it varies depending on the placement method, as well as the tools being used to place, consolidate, and finish the concrete.

The slump and workability requirements are best addressed by the **DESIGNER, CONTRACTOR, and PRODUCER DISCUSSING THE PROJECT REQUIREMENTS TOGETHER** with the contractor leading the discussion and advocating for their needs. OPSS.MUNI 1350 1350.05.02.05 clearly states that ***"Slump requirements shall be identified and reviewed by the Contractor and concrete supplier prior to construction".***

Limiting a slump range to other than the tolerances specified in **CSA A23.1 4.3.2.3.2** hinders the concrete supplier from providing a consistent mixture and limits the contractor's ability to perform the work, with potential cost impacts due to unnecessarily rejected loads and project delays.

Overall, specifying a slump exposes Municipalities to potential liability as it directly contradicts the Performance Alternative option in CSA A23.1-14 Table 5.

The following is a clause currently used by the **City of Brampton BSS 1350 Material Specification for Concrete Materials and Production** and conforms to the latest OPSS.MUNI 1350 slump requirements.

> ***"Concrete slump shall be selected by the contractor based on the method of placement. Slump acceptance and/or rejection shall be based upon the slump tolerances identified in CSA A23.1 using the Contractor's target slump value."***

<u>This clause accurately represents the concrete industry's viewpoint on slump for performance based mix designs.</u>

CSA A23.1 - 4.3.2.3.2 Tolerances in slump or slump flow

Tolerances for slump shall be within the following applicable ranges:

(a) when the specified slump is less than 80 mm, the allowable variation shall be ± 20 mm; **(I.e. 70 ± 20 mm)**

(b) when the specified slump is 80 mm to 180 mm, the allowable variation shall be ±30 mm; and **(I.e. 80 ± 30 mm)**

(c) when the specified slump is greater than 180 mm, the allowable variation shall be ±40 mm. **(I.e. 190 ± 40 mm)**

REFERENCES

1. ACI 305R-10—Specification for Hot Weather Concreting
2. ACI 306R-16—Guide to Cold Weather Concreting
3. ACPA – Wikipave.org
4. City of Brampton BSS 1350 Material Specification for Concrete Materials and Production
5. CSA A23.1-14/A23.2-14 - Concrete materials and methods of concrete construction/Test methods and standard practices for concrete
6. OPSS.MUNI 351 (Nov. '15) – Construction Specification for Concrete Sidewalk
7. OPSS.MUNI 353 (Nov. '16) – Construction Specification for Concrete Curb and Gutter Systems
8. OPSS.MUNI 904 (Nov. '12) – Construction specification for concrete structures
9. OPSS.MUNI 1350 (Nov. '17) – Material Specification for Concrete – Materials and Productions
10. TS 3.70 Construction Specification for Concrete Sidewalk and Concrete Raised Median (September 2017)
11. TS 3.50 Construction Specification for Concrete Curb and Concrete Curb and Gutter (September 2017)
12. TS 1350 Amendment to OPSS.MUNI 1350 (Nov 2014) – Material Specification for Concrete – Materials and Production

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