St Marys Cement: Concrete Basics!

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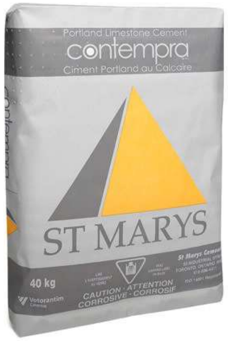
st marys cement

Outline

- Product Types and Uses
- Supplementary Cementing Materials (SCM)
- Fundamentals of Concrete
- Masonry Construction
- Customer Applications



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Cement vs Concrete

What's the difference between

CEMENT and CONCRETE?

Types of Cement

CSA & ASTM Designations

Name and intended use of the cement	Portland Cement	Blended Hydraulic Cement	Portland Limestone Cement	Blended PLC
General use cement	GU I	GUb IS, IP	GUL IL	GULb IT
Moderate sulphate resistant cement	MS II	MSb IS(MS), IP(MS)	MSL IL(MS)	MSLb IT(MS)
Moderate heat of hydration cement*	II(MH)	IS(MH), IP(MH)	IL(MH)	IT(MH)
High early strength cement	HE III	HEb IS(HE), IP(HE)	HEL IL(HE)	HELb IT(HE)
Low heat of hydration cement*	IV	IS(LH), IP(LH)	IL(LH)	IT(LH)
High sulphate resistant cement	HS V	HSb IS(HS), IP(HS)	HSL IL(HS)	HSLb IT(LH)

* Requirements for MH and LH cement were removed from CSA
May still report HOH values for modelling and design of heat plan for construction

Type GU/GUL – General Use

- **General Purpose Cement**
- Accounts for 90% of all cement used:
    - Sidewalks, floors, pavements, buildings, bridges, tanks, etc.

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Type HE/HEL- High Early Strength

- **Precast Operation**
  - Form turn-over
  - Concrete girder tensioning
- **Cold Weather**
  - Instead of accelerating admixtures

Type MH/MHL – Moderate Heat
Type LH/LHL – Low Heat

- **Type MH/MHL Moderate Heat**
  - Large piers, heavy abutments

- **Type LH/LHL Low Heat**
  - Massive structures, dams

- **Typically achieved using mix of <u>slag</u> or <u>certain fly ashes +</u> GU/GUL**

Type MS/MSL – Moderate Sulphate Resistant
Type HS/HSL – High Sulphate Resistant

- **Type MS/MSL Moderate Sulphate Resistant**
  - Drainage structures where soil and/or groundwater sulphate levels are high but not severe
- **Type HS/HSL Sulphate Resistant**
  - Sulphate levels in soil and groundwater severe
- **Typically achieved using mix of <u>slag</u> or <u>certain fly ashes</u> + Type GU/GUL**

Types of Supplementary Cementitious Materials

- CSA A3001 **Cementitious Materials for Use in Concrete**
  - Type N: Natural Pozzolan (trass, metakaolin)
  - Type F: Fly Ash (low calcium, ≤15% CaO)
  - Type CI: Fly Ash (intermediate calcium, >15- ≤20% CaO)
  - Type CH: Fly Ash (high calcium, >20% CaO)
  - Type S: Ground Granulated or Pelletized Slag
  - Type SF: Silica Fume (high silicon dioxide)
  - Type SFI: Silica Fume (intermediate silicon dioxide)
- Used in concrete as a partial and specific proportion replacement of Portland/ Portland-Limestone cement to add desired properties to the concrete
  - Improved workability
  - Improved durability
  - Higher ultimate strength
  - Lower permeability

Supplementary Cementitious Materials
Effect on Concrete Properties

Water requirement
- Generally less for a given slump
  - Affected by Blaine

Workability
- Improved for concrete of equal slump and strength
  - Affected by the Blaine, Initial Vicat, SO3

Bleeding
- Less with fly ash
- Increase with slag
- Much less with silica fume

Setting Time
- Retarded
  - Affected by Initial Vicat, SO3

Heat Generated
- Reduced

Pumping
- Improved

Colour
- Will be changed

Strength
- May develop more slowly
- Higher 28-day strengths
- Faster gain with silica fume

Permeability
- Reduced

Sulphate Attack
- MS and HS resistance can be achieved with SCMs

Silica Fume

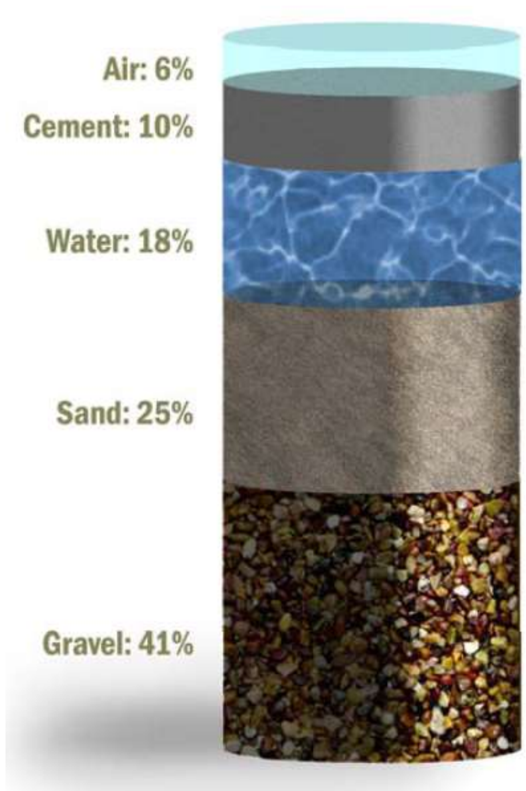
Confederation Bridge
PEI to New Brunswick - 1997
High Durability Required

Silica Fume

80 MPa Columns
Toronto - 2013
High Strength Required

Fundamentals of Concrete

Basic Components of Concrete



- Cement
- Water

PASTE

- Coarse Aggregate
- Fine Aggregate (Sand)

Properties of Quality Concrete

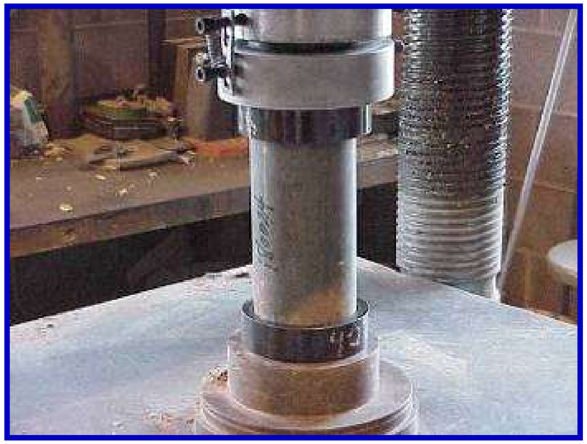
Weather Resistant
- Freeze-thaw cycles
- Deicing agents
- Wetting and Drying

Wear Resistant

Adequately Strong
- Compressive Strength
- Flexural Strength

Uniform Texture
- Colour
- Desired finish

Economical



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Mixing Water

- Water must be potable
- Recycled water can be used
  - Clean and free from impurities that can harm the concrete or interfere with cement hydration

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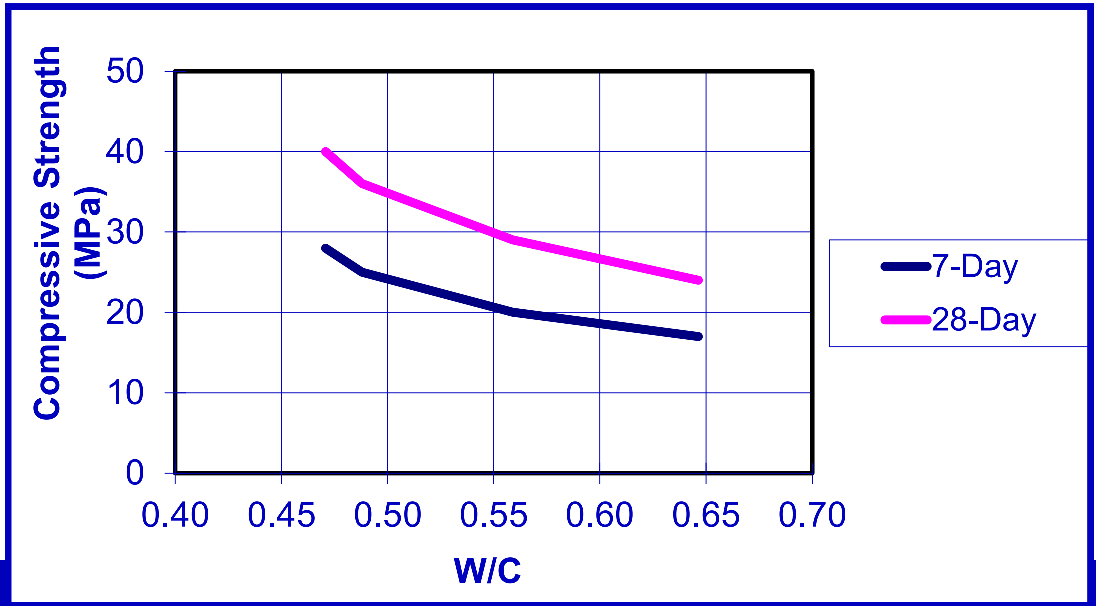
Water-Cement Ratio "Law"

- The water-cement ratio is the ratio of mass of water to mass of cement (including SCMs) in concrete. The ratio is calculated by dividing the weight of the water in one cubic metre of the mix, by the weight of cement in one cubic metre of the mix

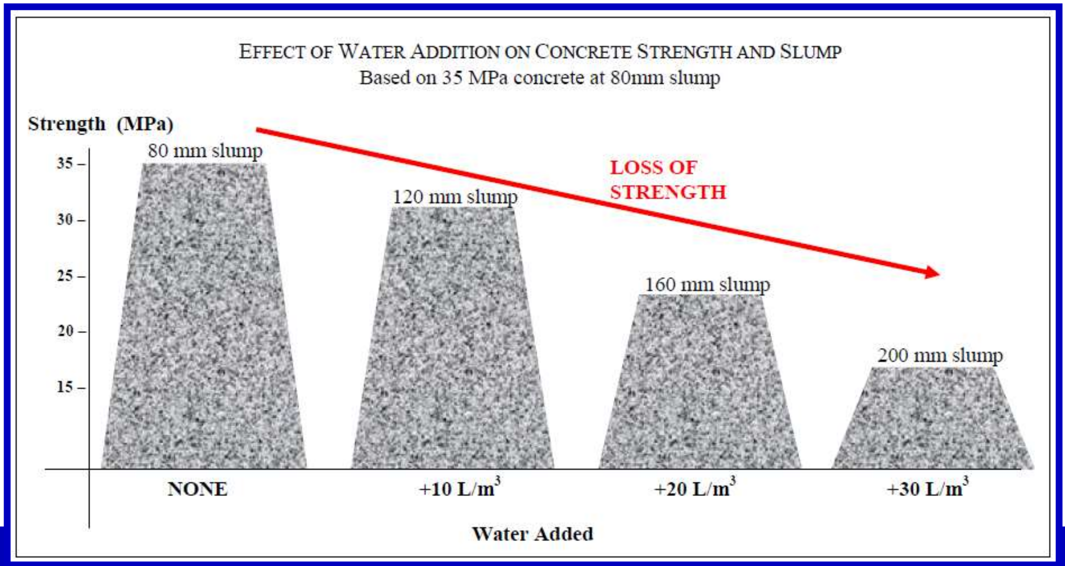
$$\frac{W}{C} = \frac{\text{Weight of Water}}{\text{Weight of Cement}} = \frac{160\ \text{kg}}{320\ \text{kg}} = 0.50 \text{ is the ratio}$$



Water-Cement Ratio "Law"

Excessive water addition (Importance of Water Demand)

- Reduced Strength
- Increased Permeability
- Reduced Durability



Aggregates for Concrete

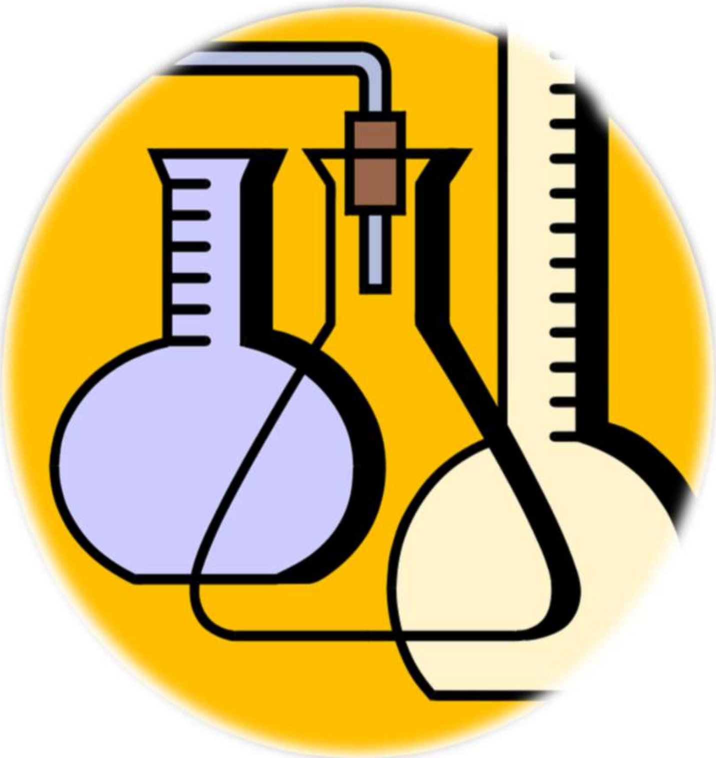
Aggregates for Concrete
Properties of Aggregates

- Gradation
  - Workability
  - Permeability/ paste requirement
- Particle Shape
  - Finishability
- Surface Texture
  - Rough vs smooth

- Strength
  - Aggregate/Paste bond
- Abrasion Resistance
  - In transit/ during mixing
  - Concrete surface wear
  - Traction in concrete roads
- Freeze/Thaw Durability
  - Absorptive aggregate

Admixtures for Concrete

Admixtures for Concrete



Air Entraining Admixtures (AEA)

Water Reducing (WR) Admixtures

- Base (WR)
- Mid-range (MRWR)
- High-range (HRWR/ plasticizer)

Retarding Admixtures

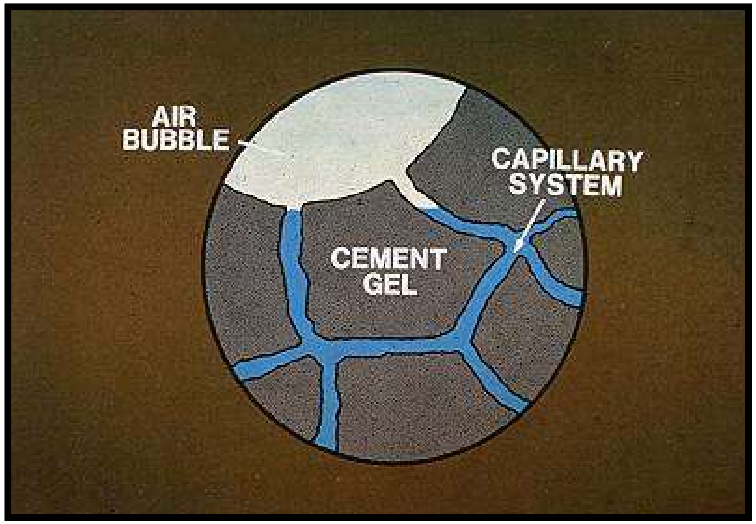
Accelerating Admixtures

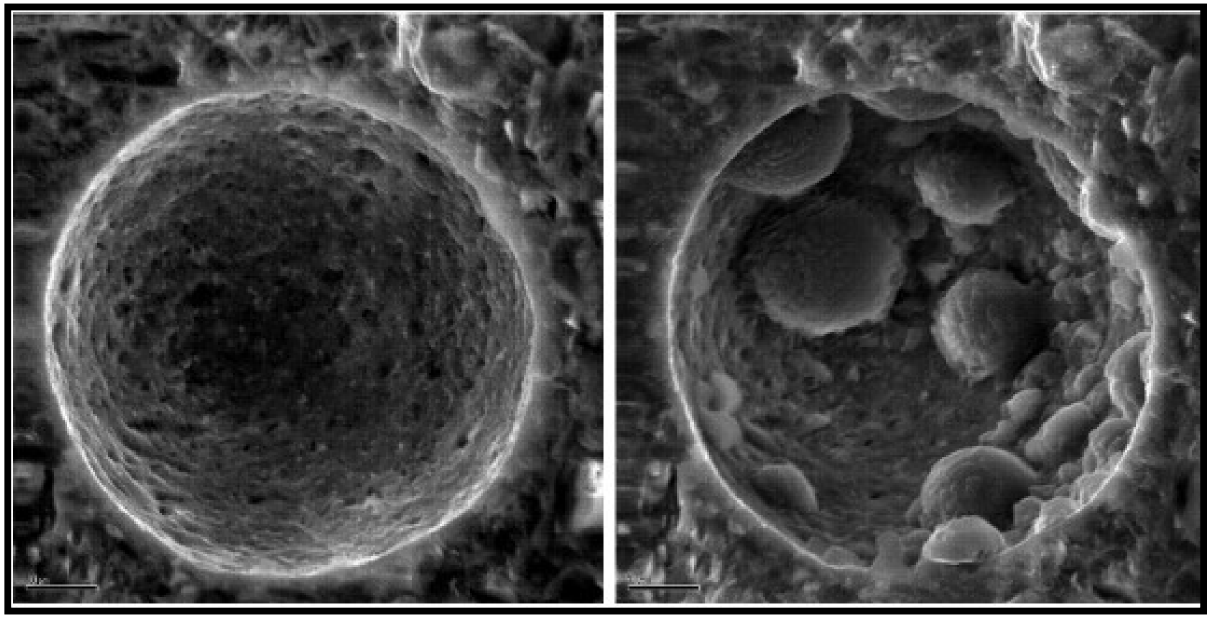
- Chloride
- Non-chloride

Air Entrained Concrete

Air Entrained Concrete

Air Voids & Freeze/Thaw





Air Entrained Concrete

Plastic and Hardened Properties

Fresh Concrete

- Improves Workability
- Reduces segregation
- Reduces bleeding
- Finishes sooner
- Reduces required sand content
- Reduces water 5-15 liters/ m^3

Hardened Concrete

- Increases freeze-thaw resistance **10-20** times over non-air concrete
- Improves resistance to salt scaling
- Improves resistance to sulphate action

Exposure and Durability

"When concrete is exposed to aggressive environments its **successful performance** is dependent to a greater extent on its ***durability*** against the environment, than on strength properties"

ACI Publication SP-47, Durability of Concrete

Specifying Concrete Durability

CSA A23.1 – Concrete Materials and Methods of Concrete Construction

Table 1
Definitions of C, F, N, A, S, and R classes of exposure
(See Clauses 3, 4.1.1.1.1, 4.1.1.1.3, 4.1.1.5, 4.1.1.8.2, 4.1.2.3, 6.1.4, 6.6.7.6.1, 6.8.2.5, 7.1.2.1, 8.13.2.2, 9.2, A.1, I.4.1.2.1.3, and L.3 and Tables 2, 3, and 17.)

C-XL	Concrete exposed to chlorides or other severe environments with or without freezing and thawing conditions, with higher durability performance expectations than the C-1 classes.
C-1	Concrete exposed to chlorides with or without freezing and thawing conditions where the reinforcing steel must be protected from corrosion. For seawater exposures, the requirements for S-3 exposure shall also be met. Examples: bridge decks, parking decks and ramps, portions of structures exposed to seawater located within the tidal and splash zones, concrete exposed to seawater spray, airborne chlorides, and saltwater pools.
C-2	Concrete exposed to chlorides and freezing and thawing without reinforcement or where corrosion of reinforcement will not be critical to the performance of the element. Examples: residential garage floors, porches, steps, pavements, sidewalks, curbs, and gutters.
C-3	Continuously submerged concrete exposed to chlorides, but not to freezing and thawing. For seawater exposures, the requirements for S-3 exposure shall also be met. Examples: underwater portions of structures exposed to seawater.
C-4	Concrete exposed to chlorides, but not to freezing and thawing. Examples: underground parking slabs on ground.
F-1	Concrete exposed to freezing and thawing in a saturated condition, but not to chlorides. Examples: pool decks, patios, tennis courts, freshwater pools, and freshwater control structures.
F-2	Concrete in an unsaturated condition exposed to freezing and thawing, but not to chlorides. Examples: exterior walls and columns.
N	Concrete that when in service is neither exposed to chlorides nor to freezing and thawing nor to sulphates, either in a wet or dry environment. Examples: footings, walls, and columns.
N-CF	Interior concrete floors with a trowel finish that are not exposed to chlorides, nor to sulphates either in a wet or dry environment, and are either not exposed to cycles of freezing and thawing or only exposed to very limited cycles of freezing and thawing while in an air dry condition. Examples: interior floors, surface covered applications (carpet, vinyl tile) and surface exposed applications (with or without floor hardener), ice rinks, freezer floors.
A-XL	Structural concrete exposed to manure and/or silage gases, with or without freeze-thaw exposure or exposed to the vapour above municipal sewage or industrial effluent, where hydrogen sulphide gas might be generated, with higher durability performance expectations than A-1 or A-2 class.
A-1	Structural concrete exposed to the vapour above municipal sewage or industrial effluent, where hydrogen sulphide gas might be generated. Examples: reinforced beams, suspended slabs, and columns over manure pits and silos, canals, and pig slats; and access holes, enclosed chambers, and pipes that are partially filled with effluents.
A-2	Structural concrete exposed to manure and/or silage gases and liquids, with or without

(Continued)

Table 1 (Continued)

	freeze-thaw exposure. Examples: reinforced walls in exterior manure tanks, silos and feed bunkers, and exterior slabs.
A-3	Structural concrete exposed to manure and/or silage gases and liquids, with or without freeze-thaw exposure in a continuously submerged condition. Concrete continuously submerged in municipal or industrial effluents. Examples: interior gutter walls, beams, slabs, and columns; sewage pipes that are continuously full (e.g., forcemains); and submerged portions of sewage treatment structures.
A-4	Non-structural concrete exposed to manure and/or silage gases and liquids, without freeze-thaw exposure. Examples: interior slabs on ground.
S-1	Concrete subjected to very severe sulphate exposures (Tables 2 and 3).
S-2	Concrete subjected to severe sulphate exposure (Tables 2 and 3).
S-3	Concrete subjected to moderate sulphate exposure and to seawater or seawater spray (Tables 2 and 3).
R-1	Residential concrete for footings for walls, columns, fireplaces, and chimneys.
R-2	Residential concrete for foundation walls, grade beams, piers, etc.
R-3	Residential concrete for interior slabs on ground not exposed to freezing and thawing or deicing salts.

Notes:
1) *"C" classes pertain to chloride exposure.*
2) *"F" classes pertain to freezing and thawing exposure without chlorides.*
3) *"N" class is exposed to neither chlorides nor freezing and thawing.*
4) *All classes of concrete exposed to sulphates shall comply with the minimum requirements of S class noted in Tables 2 and 3. In particular, Classes A-1 to A-4 and A-XL in municipal sewage elements could be subjected to sulphate exposure.*
5) *No hydraulic cement concrete will be entirely resistant in severe acid exposures. The resistance of hydraulic cement concrete in such exposures is largely dependent on its resistance to penetration of fluids.*
6) *Decision of exposure class should be based upon the service conditions of the structure or structural element, and not upon the conditions during construction.*

- **Exposure Classes**
  - > Minimum 28-day strength
  - > Maximum w/cm ratio
  - > Range of air content
  - > Permeability

Table 2
Requirements for C, F, N, A, and S classes of exposure
(See Clauses 4.1.1.1.1, 4.1.1.1.3, 4.1.1.3, 4.1.1.4, 4.1.1.5, 4.1.1.6.2, 4.1.1.8.2, 4.1.1.11, 4.1.2.1, 4.3.1, 4.3.5.1, 4.3.5.2, 4.3.7.1, 4.3.7.2, 4.3.7.3, 7.1.2.1, 7.5.1.1, 7.8.1, 7.8.2.1, 8.7.1, 8.7.4.1, 9.3, 9.4, 9.5, A.1, I.4.1.8.6.2, K.4, K.5, L.1, L.3, and O.1.2 and Tables 1, 3, and 17.)

			Air content category as per Table 4[d]		Curing type (see Table 19)			Resistance to chloride ion penetration	
Class of exposure[a]	Maximum water-to-cementitious materials ratio[b]	Minimum specified compressive strength (MPa) and age (d) at test[b, i]	Exposed to cycles of freeze/thaw	Not exposed to cycles of freeze/thaw	Normal concrete	HVSCM-1	HVSCM-2	Chloride ion penetrability requirements and age at test	Bulk resistivity requirement and age at test
C-XL or A-XL	0.40	50 within 56 d	1	[e]	3	3	3	< 1000 coulombs within 91 d[c]	[c]
C-1 or A-1	0.40	35 within 56 d	1	[e]	2	3	2	< 1500 coulombs within 91 d[c]	[c]
C-2	0.45[h]	32 at 28 d	1	n/a	2	2	2	—	—
C-3	0.50	30 at 28 d	n/a	[e]	1	2	2	—	—
C-4[e]	0.55	25 at 28 d	n/a	[e]	1	2	2	—	—
A-2	0.45	32 at 28 d	1	[e]	2	2	2	—	—
A-3	0.50	30 at 28 d	1	[e]	1	2	2	—	—
A-4	0.55	25 at 28 d	n/a	[e]	1	2	2	—	—
F-1	0.50[j]	30 at 28 d	1	n/a	2	3	2	—	—
F-2 or R-1 or R-2	0.55[j]	25 at 28 d	2[f]	n/a	1	2	2	—	—
N	As per the mix design for the strength required	For structural design	n/a	[e]	1	2	2	—	—
N-CF[g] or R-3	0.55	25 at 28 d	n/a	[k]	1	2	2	—	—
S-1	0.40	35 within 56 d	1	[e]	2	3	2	—	—
S-2	0.45[j]	32 within 56 d	1	[e]	2	3	2	—	—
S-3	0.50[j]	30 within 56 d	1	[e]	1	2	2	—	—

[a] *See Table 1 for a description of classes of exposure.*
[b] *The minimum specified compressive strength may be adjusted to reflect proven relationships between strength and the water-to-cementitious materials ratio provided that freezing and thawing and de-icer scaling resistance have been demonstrated to be satisfactory. The water-to-cementitious materials ratio shall*

Concrete Deterioration

Chemical
- AAR
- Sulphate
- CO_2
- Acid

Physical
- Freeze/Thaw
- Corrosion
- Thermal
- Abrasion
- Cracking/ Shrinkage

Achieving Durability

Use proper concrete
- Quality materials
- Proper mix design

Use proper construction practices
- Proper placing, finishing, and curing
- Air drying before freezing

Chemical Admixtures
- Air void system
- Reduced water-cementitious materials ratio
- Reduced cracking

Supplementary Cementitious Materials
- Silica fume
- Slag
- Fly ash

The “Easy” Factors to Ensure a Good Quality Concrete Project

- Proper detailing and design
- Good concrete mix for the project/ day
- Adequate mix design
- Good quality materials for the mix
- Adequate mixing

Placing Concrete

At the Job Site

Concrete is one of the only construction materials that is delivered to the job in its "unfinished" state. Factors at the job site after delivery still affect concrete quality!

Placing Concrete

Subgrade Uniformity

- The key to good subgrade is UNIFORMITY
- Materials, Level, Compaction

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Placing Concrete

- Subgrade Compaction

Placing Concrete

- Moistening Subgrade

Placing Concrete

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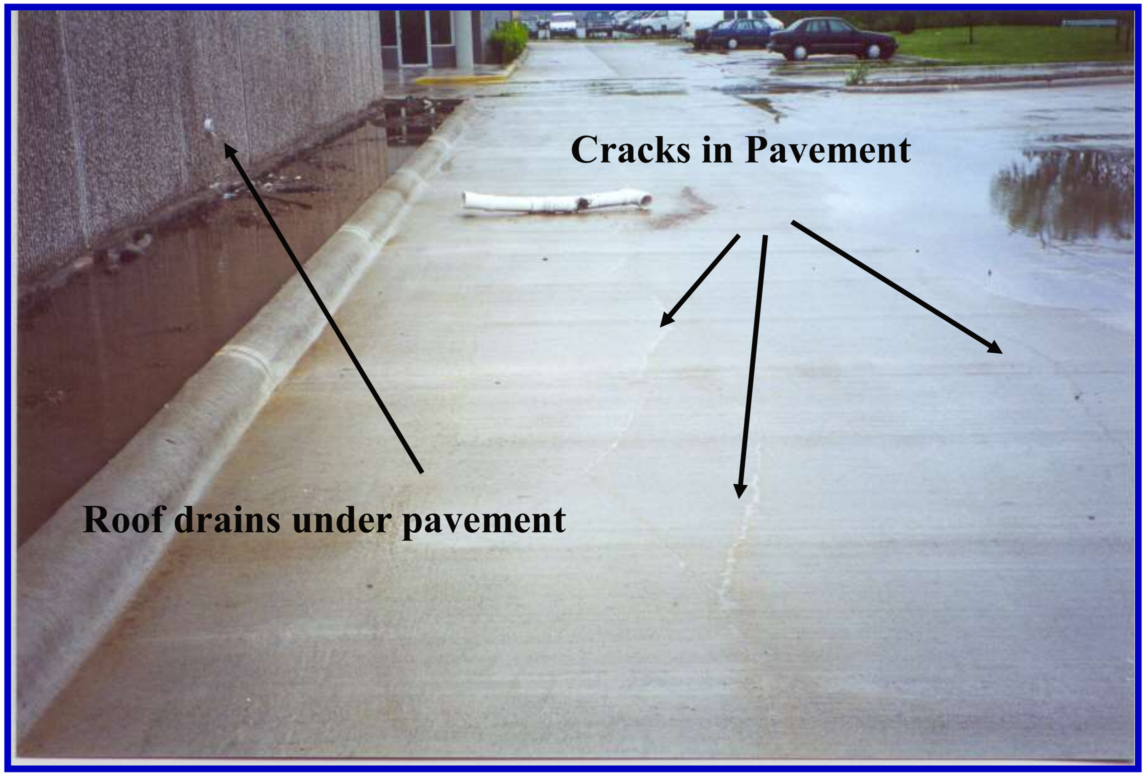
- Details...



Placing Concrete

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Placing and Finishing

- Place as soon as possible (Within 2 hours)
- Place concrete INTO concrete. Distribute using wheelbarrow or directly from mixer truck if possible; use shovels to bring to rough grade avoiding segragation
- Strike off the concrete to finish grade using a straight board on edge between the forms using a “sawing” motion – tap forms to consolidate the concrete
- Smooth the surface using a long handled bullfloat

Placing Concrete

- Placing and Finishing

Placing Concrete

- Placing and Finishing

Finishing Concrete

- Wait...............

(final finishing should occur once “bleeding” has finished)

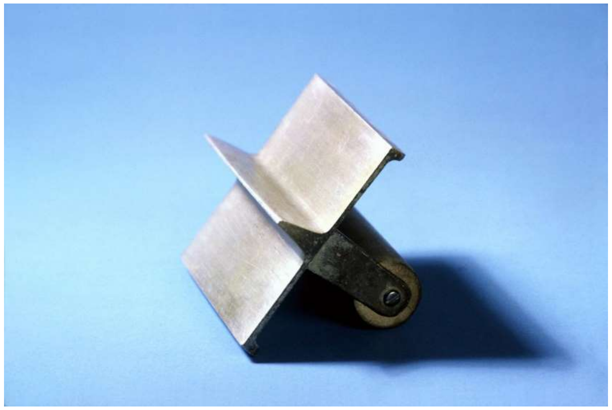
- Edge
- Groove
- Exterior – Broom finish

Interior -

- Float and/or Trowel?
- Trowel again? And again?

Finishing Concrete

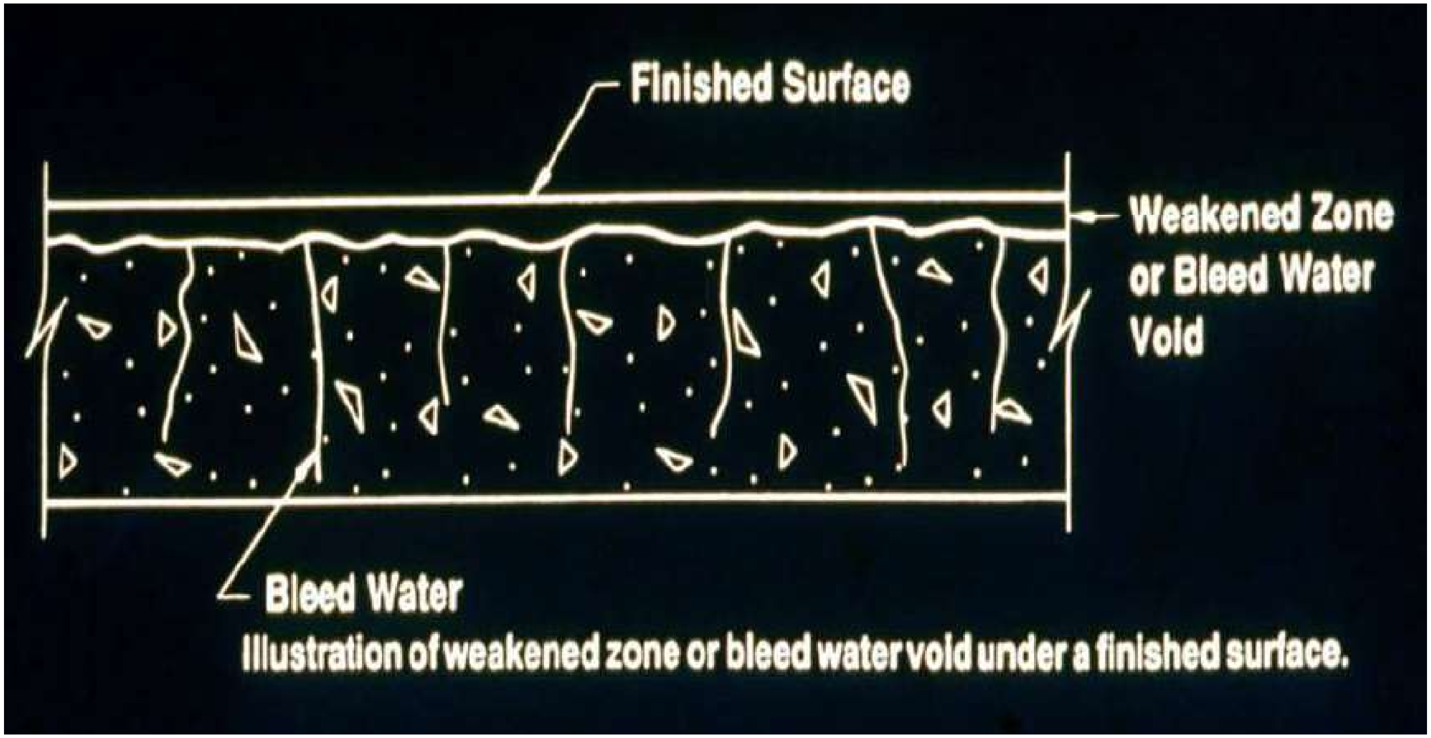
- Finishing Concrete



Finishing Concrete

Hard Trowel Finishes

- Could potentially cause problems if finished prior to the evaporation of bleed water on the surface or finishing air-entrained concrete



Finishing Concrete

First Rule in Concrete Finishing

- Never finish concrete surface when bleed water is present
- This increases the localized water/cement ratio at the surface
- “Blessing” is another common issue with the same effect

Curing Concrete

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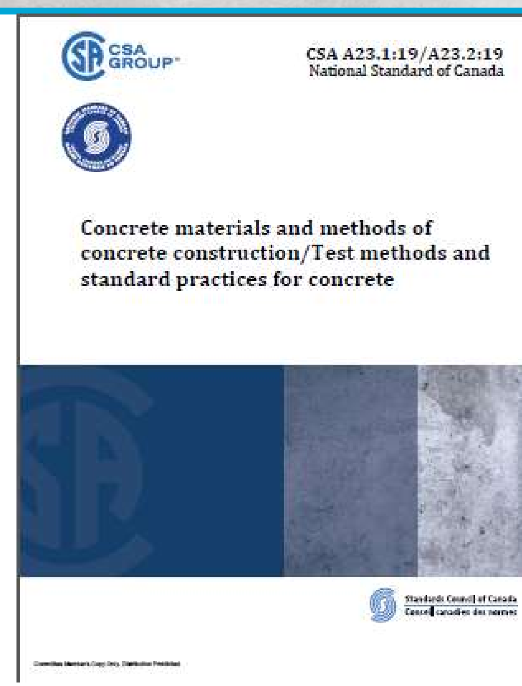
Curing Concrete

Why Cure Concrete?

- Prevent the loss of moisture from concrete
- Maintain a favourable concrete temperature

- Provide the above conditions for a defined period of time


CSA GROUP
CSA A23.1:19/A23.2:19
National Standard of Canada

Concrete materials and methods of concrete construction/Test methods and standard practices for concrete

Standards Council of Canada
Conseil canadien des normes

Curing Concrete

Basic Curing: CSA A23.1

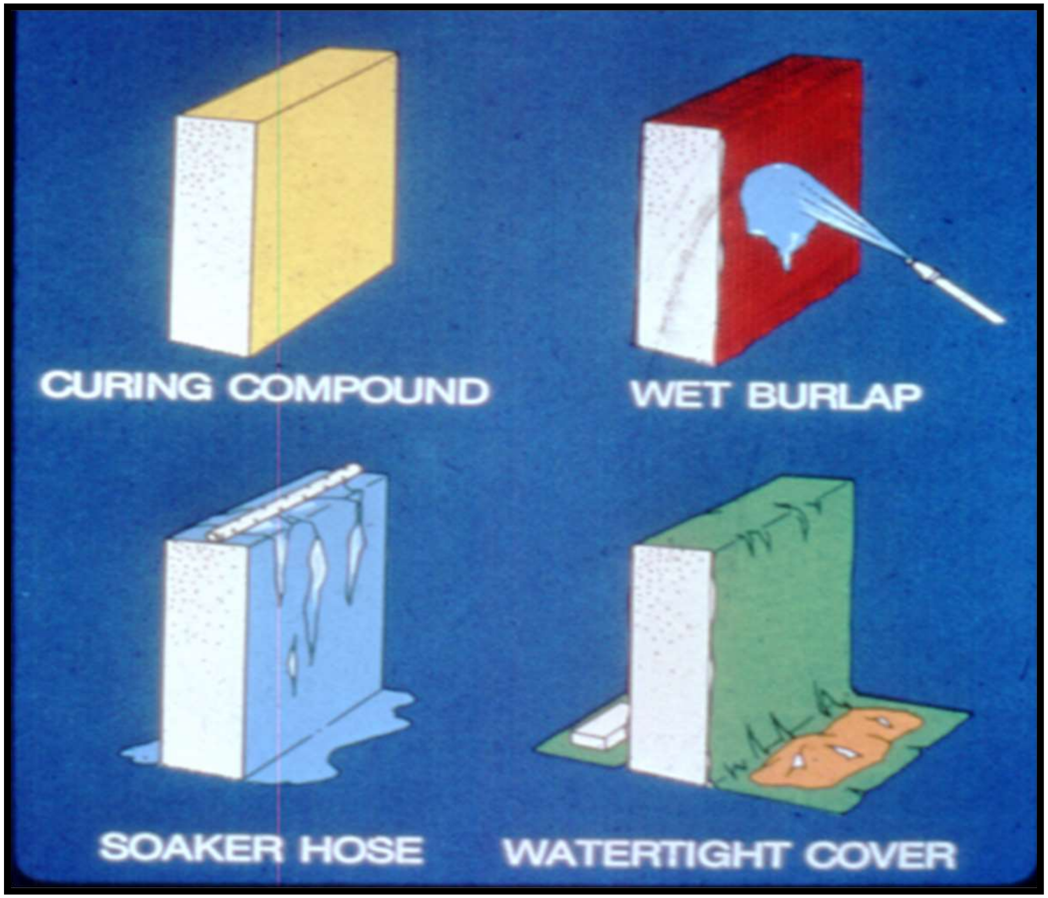
- Protect from:
  - Freezing
  - High temps or temp differentials
  - Premature drying
  - Moisture loss

- Minimum requirements:
  - 3 days
  - ≥ 10°C
  - Or until 40% of specified 28-day strength is reached

- Additional Durability:
  - 7 days
  - ≥ 10°C
  - Or until 70% of specified 28-day strength is reached

Curing Concrete

Methods of Curing



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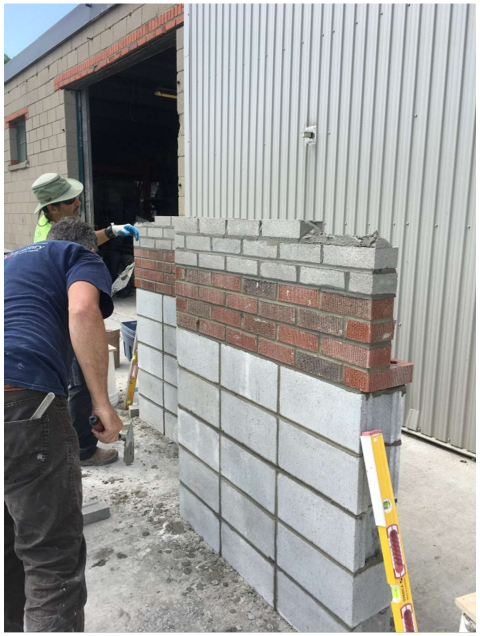
Masonry Construction

- Masonry is the building of structures from individual units (Masonry Units) laid in and bound together by mortar
  - Masonry Units: brick, block, stone etc.
  - Mortar: mixture of masonry cement, masonry sand, and water
- Masonry cements (Type N, S, PLN, PLS) are for use in **masonry construction only**



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Customer Applications

- Ready Mix Concrete
  - Produce and deliver concrete in a plastic state
  - Types GUL, HEL, GUb-SF, Slag, GULb-S

- Mobile Mix Concrete
  - Plastic concrete produced on-site
  - Typically 1-silo or Totes
  - Types GUL

Precast Concrete

- Precast Concrete
  - Produce and deliver hardened concrete pieces
  - Types GUL, HEL, GUb-SF, Slag

Customer Applications

- Concrete Block and Pavers
  - Colour
  - Types GUL, HEL, Slag

Gordie Howe Bridge

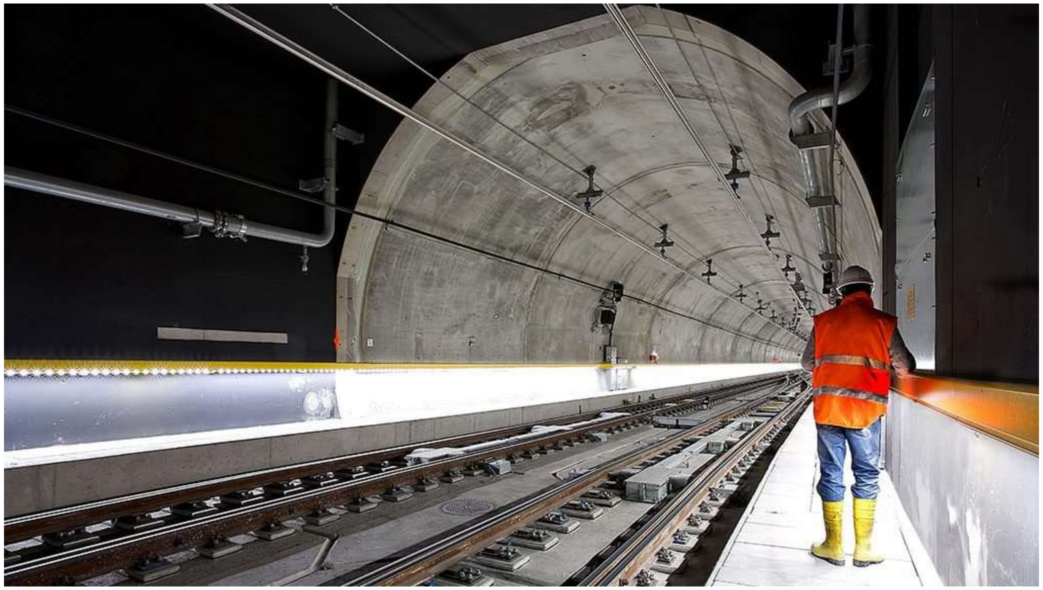
41.4 Mpa S-1 @ 56 days

60 Mpa S-1 @ 56 days

70 Mpa S-1, 24MPa @ 12 Hours

-All mix designs designed for 125 year service life, with shirinkage requirement of 0.03%

Crosstown LRT



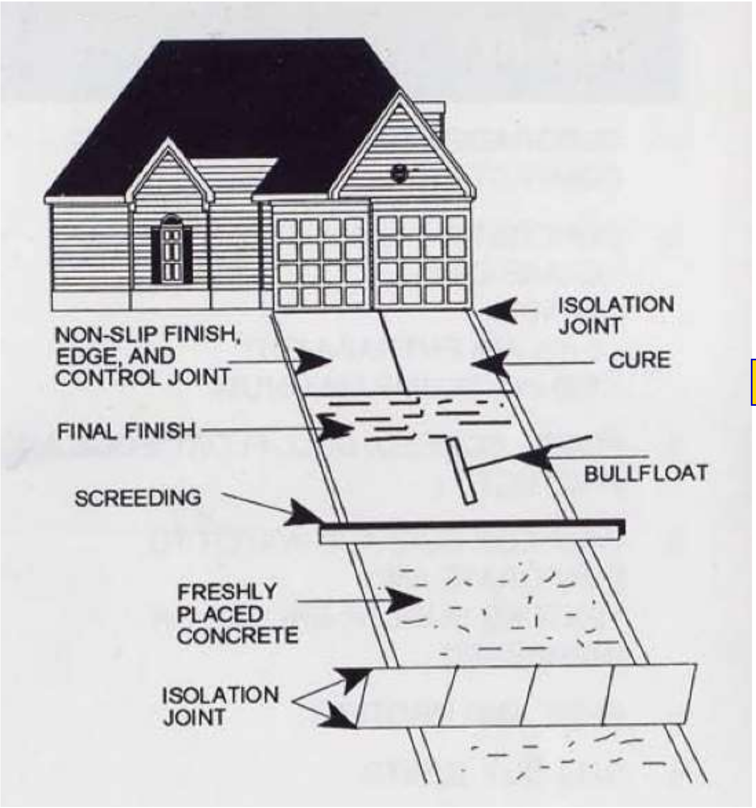
Tracks, Archs, Cross Passages

- High Supplementary Cementing Materials (up to 70%)
- Integral Waterproofing
- Fire Resistant
- Extended Workability
- Shrinkage Requirements

Resources

- www.stmaryscement.com
- www.Canadabuildingmaterials.com
  - **Cement and Concrete info –** Tech Data Sheets & MSDS's
  - **Locations --** Cement and Concrete plants
- www.rmcao.org
  - **Standards & Best Practices -** Concrete Construction, SCC, Pumping
  - **Publications –** E-blast, Newsletters, Technical
  - **Power of Concrete Brochures** – Concrete Construction Troubleshooting tips, Curing Concrete, What every homeowner should know about Concrete

Questions?


ISOLATION
JOINT
NON-SLIP FINISH,
EDGE, AND
CONTROL JOINT
CURE
FINAL FINISH
BULLFLOAT
SCREEDING
FRESHLY
PLACED
CONCRETE
ISOLATION
JOINT

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Thank you, Questions?

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