

Concrete Physical & Mechanical Properties

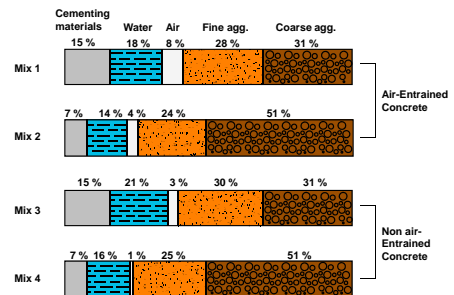
Introduction

- Composition.
- Physical Properties.
- Mechanical Properties.
- Defects & Deterioration.

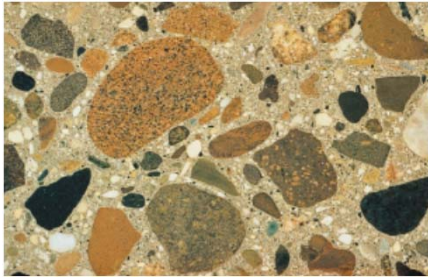
Composition

- Portland Cement.
- Aggregate.
- Mixing Water.
- Entrapped Air.
- Admixtures.
- Supplementary Cementing Materials.

Proportions of Materials in Concrete



Cross-section of Concrete

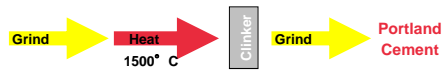


Portland Cement

- It was invented in 18th century and called Portland cement.
- Chemical compound which reacts with water to form a stone like mass (hydration).

Portland Cement

- 73% Limestone
- 23% Clay
- 2% Iron
- 3% Sand



Cement Manufacture



Cement Manufacture



Types of Cement

- Type “GU” – General use.
- Type “HE” – High early strength.
- Type “MS” – Moderate sulfate resistance.
- Type “HS” – High sulfate resistance.
- Type “MH” – Moderate heat of hydration.
- Type “LH” – Low heat of hydration.

Water



Water

- Impurities cause:
 - abnormal set
 - decreased strength
 - volume change
 - efflorescence
 - corrosion of reinforcement

Aggregate



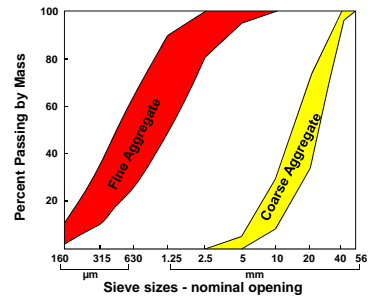
Aggregate



Characteristics of Aggregate

- Clean & sound.
- Abrasion resistance
- Freeze & thaw resistance
- Wetting & drying properties
- Chemical stability
- Alkali aggregate reactivity
- Shape and surface texture
- Aggregate grading

Grading Limits



Fineness Modulus

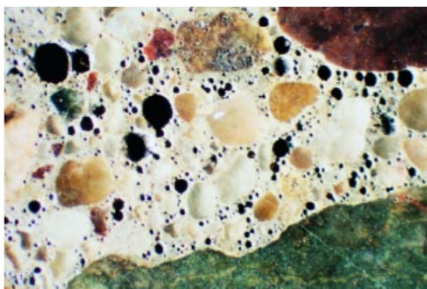
Sieve Size	Percentage Retained by Mass
10 mm	0
5 mm	2
2.5 mm	15
1.25 mm	35
630 µm	55
315 µm	79
160 µm	97
Total	283

Fineness Modulus = 283/100 = 2.83

Air-Entrained Concrete

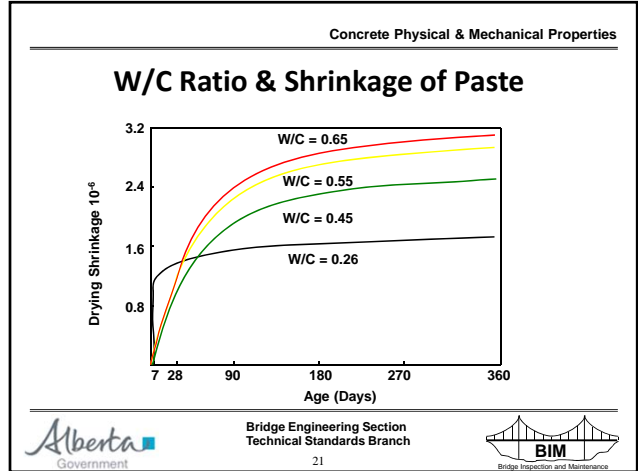
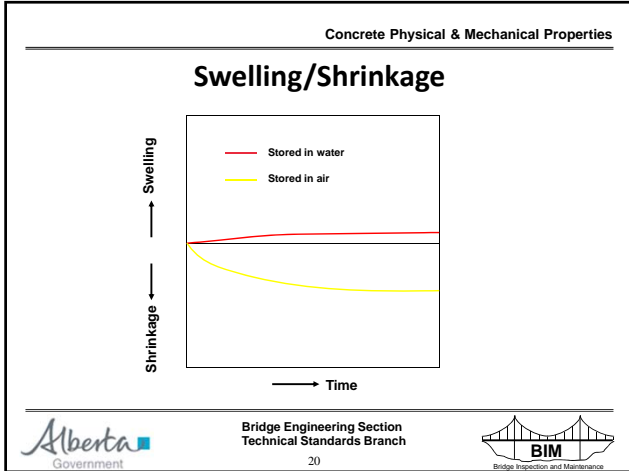
- Freeze-thaw resistance
- Improves workability
- Finishes sooner
- Reduces water
- Reduces segregation and bleeding
- Improves sulfate resistance
- Entrained air 5% to 8%

Air-Entrained Concrete

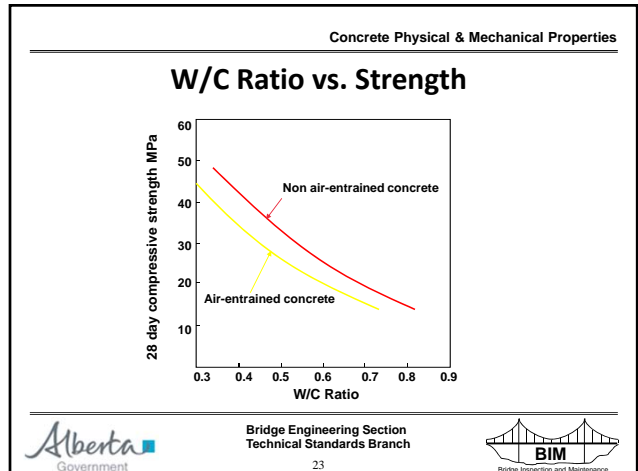


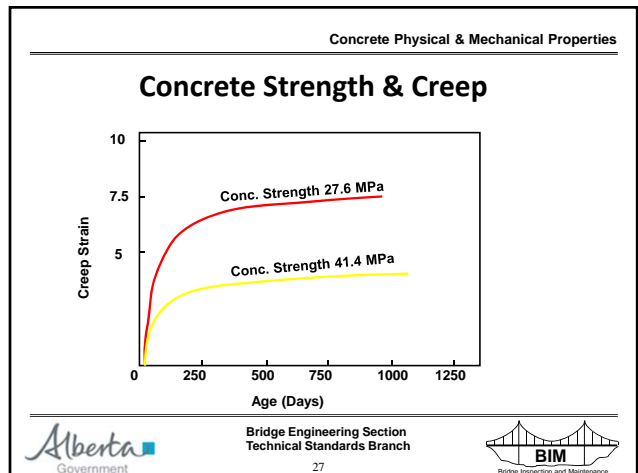
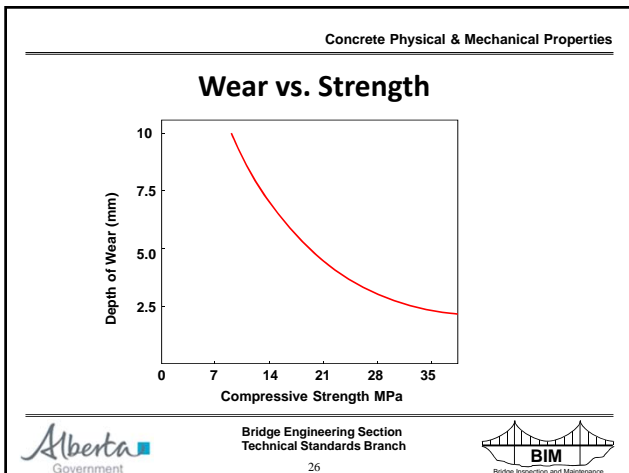
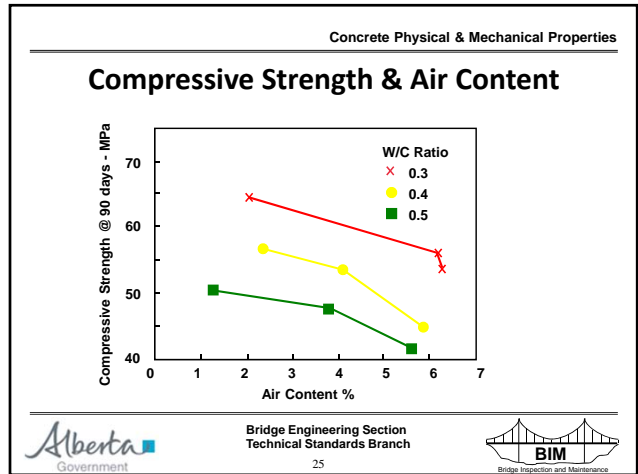
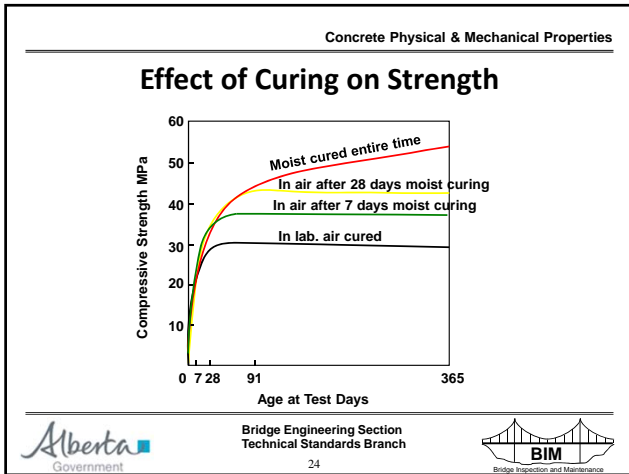
Physical Properties

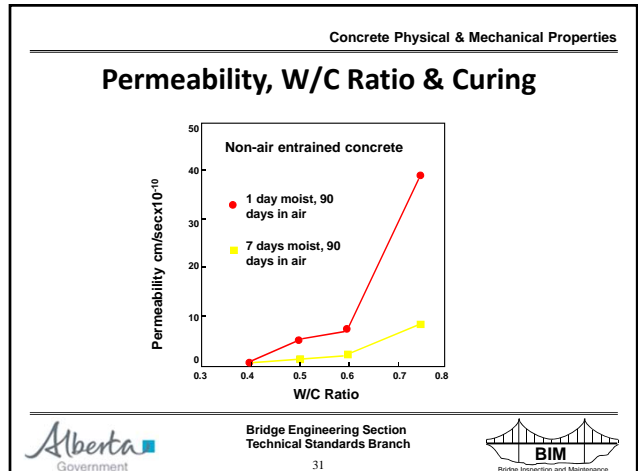
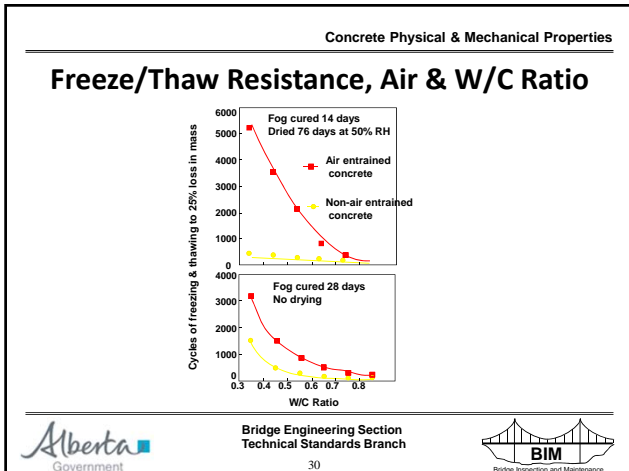
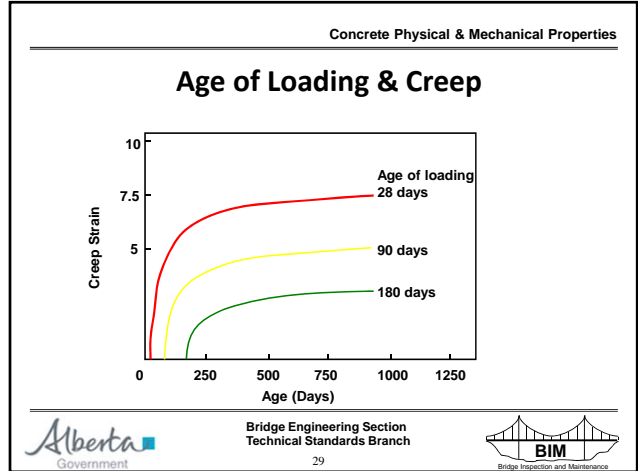
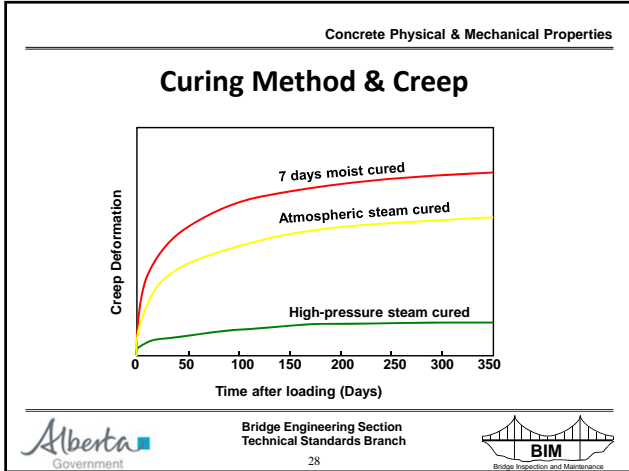
- Thermal expansion:
 - Concrete $9.9 \times 10^{-6}/^{\circ} \text{C}$
 - Steel $12.0 \times 10^{-6}/^{\circ} \text{C}$
- Volume change due to moisture:
 - Swelling
 - Shrinkage



- Concrete Physical & Mechanical Properties
- ### Mechanical Properties
- Strength
 - Compressive (28 day - $f'c$)
 - Tensile (10% of $f'c$)
 - Shear (12% to 13% of $f'c$)
 - Flexural (14% of $f'c$)
 - Abrasion resistance
 - Creep
 - Fire resistance
 - Durability
 - Permeability
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Deterioration Stains



Staining, Efflorescence & Corrosion



Deck Ponding



Surface Durability



Freeze-Thaw Damage



Light Scaling



Medium Scaling



Heavy Scaling



Sound Concrete Deck



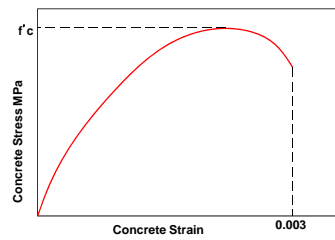
Sound Concrete Deck



Surface Abrasion



Concrete Stress-Strain Relationship



Strain = $\Delta L/L$
 $\Delta L = 0.003 \times 300 = 0.9 \text{ mm}$

High-Performance Concrete

- High strength.
- High modulus of elasticity.
- High abrasion resistance.
- Low permeability and diffusion.
- Resistance to chemical attack.
- High resistance to frost.
- Ease of placement



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Self-Compacting Concrete

- Able to flow and consolidate on its own.
- Must be cohesive to fill spaces without segregation.
- Useful wherever placing is difficult..
- SCC reduces the need for vibration.
- It is based on increasing the amount of fine material without changing the water content.



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Shrinkage Cracks



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Map Cracking



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Flexural Cracks



Construction Joint



Corrosion Spalls & Pop-outs



Corrosion Spall



Corrosion Spall



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Alkali Aggregate Reaction



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High Load Chip



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High Load Damage



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Questions??



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