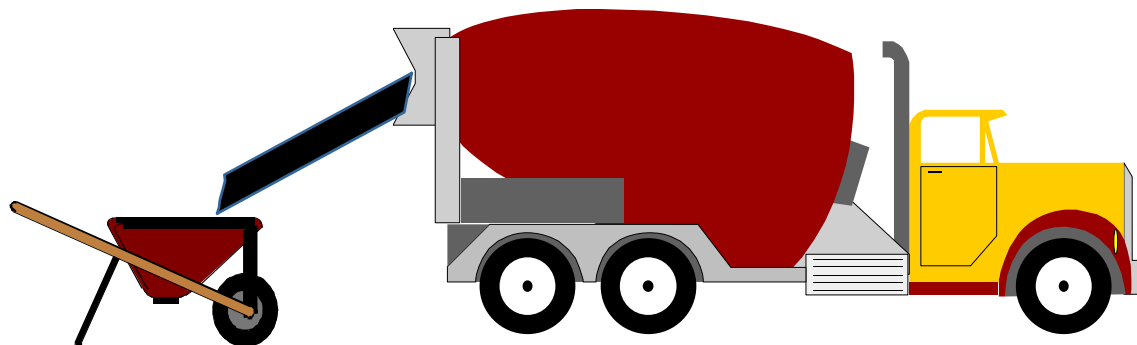


Quality Concrete



Fundamentals of Concrete

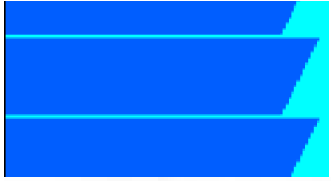
- Desired Properties of Concrete
 - ◆ Fresh (Contractor)
 - ◆ Hardened (Engineer)
 - ◆ Aesthetics (Architect/Owner)





ESSENTIALS of Quality Concrete

- 1. Suitable Materials
- 2. Proper Proportioning, Mixing, and Transporting
- 3. Proper Placing, Consolidation
- 4. Proper Finishing & Jointing
- 5. Proper Curing



Fresh Concrete

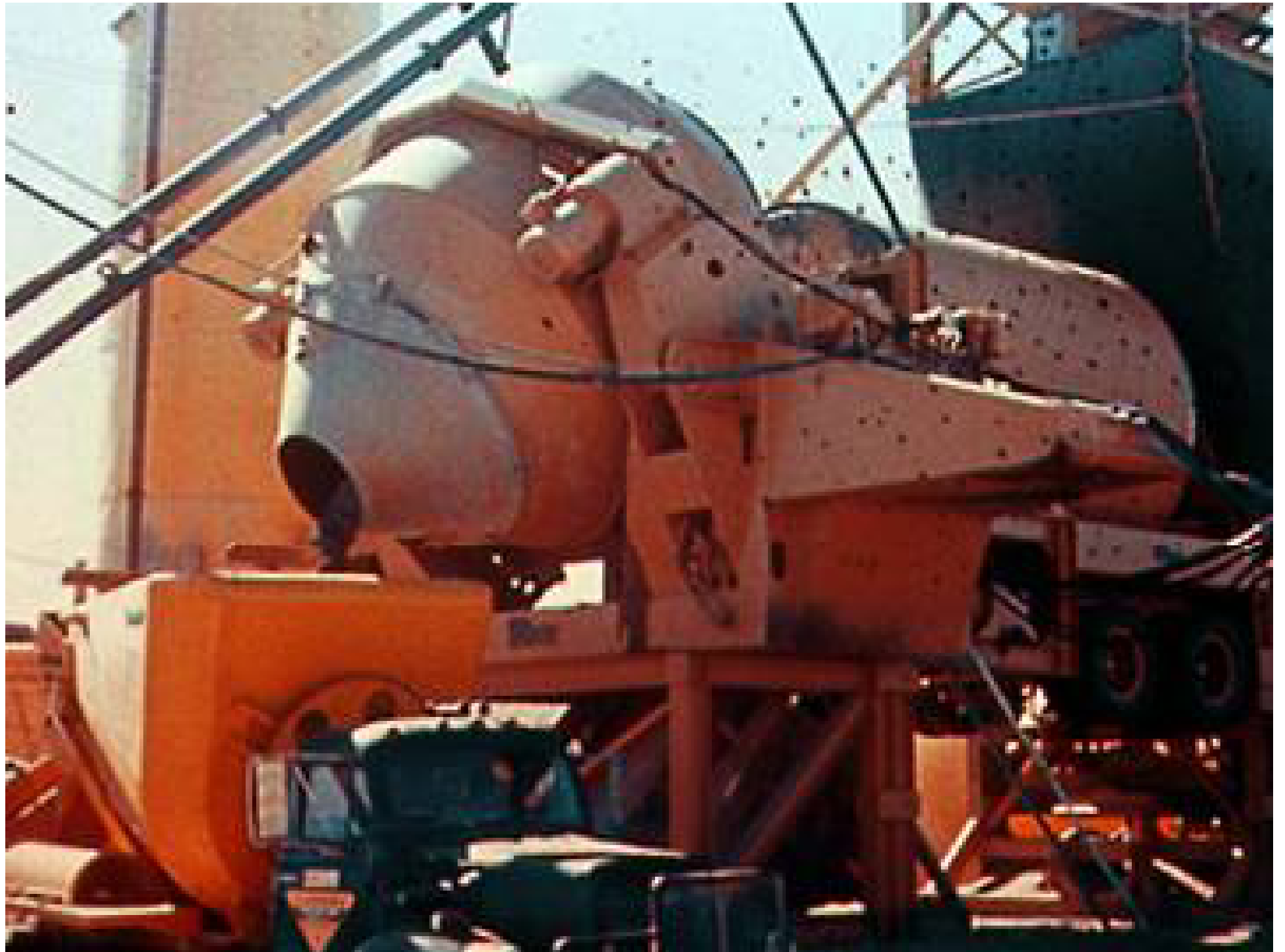


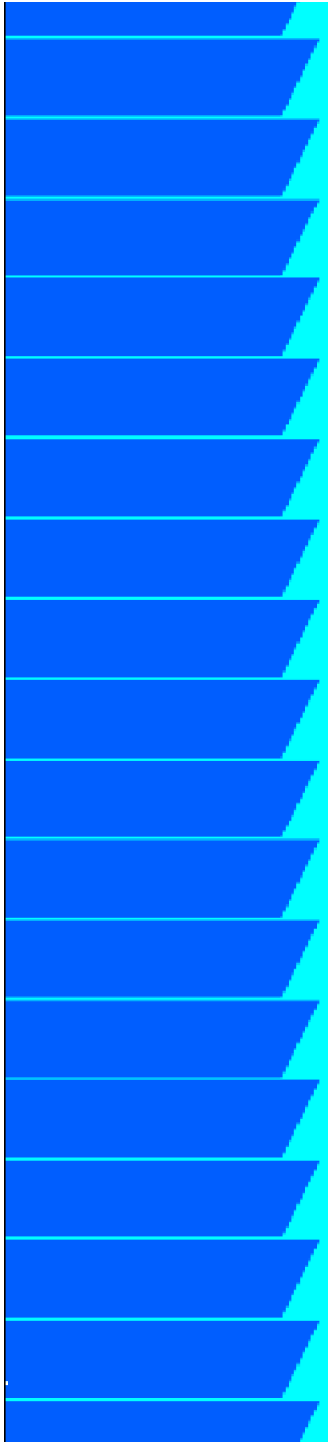
- Consistency
- Workability
- Uniformity
- Bleeding
- Setting & Hardening

Consistency

- Variability of Concrete Mix from Batch to Batch (Truck to Truck)
- Not a Measure of Workability!









Factors Impacting Consistency

- w/cm
- Wash Water
- Aggregate Moisture
- Temperature
- Haul Time
- Mixing Time
- Admixture Dosage

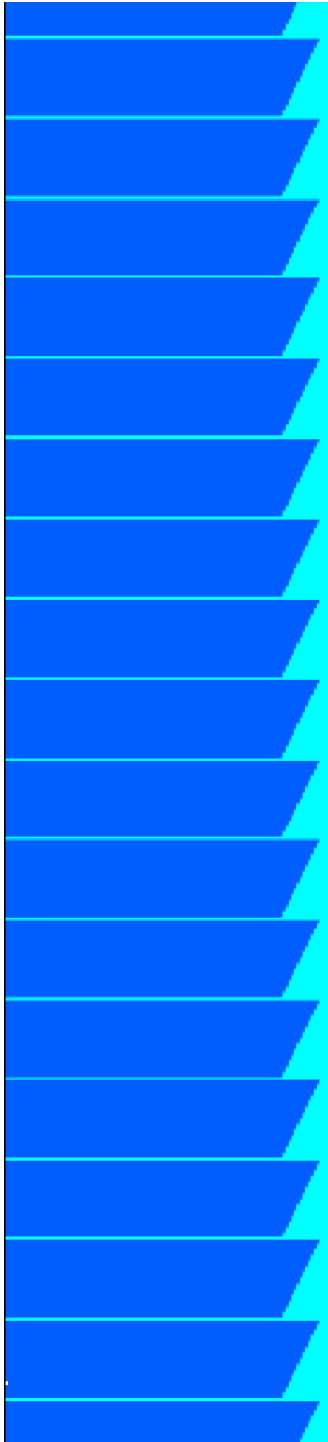


Workability

- Ease of Placing, Consolidating, and Finishing Freshly Mixed Concrete.
- Degree of Resistance to Segregation
- Control of Slump Loss







Factors Impacting Workability

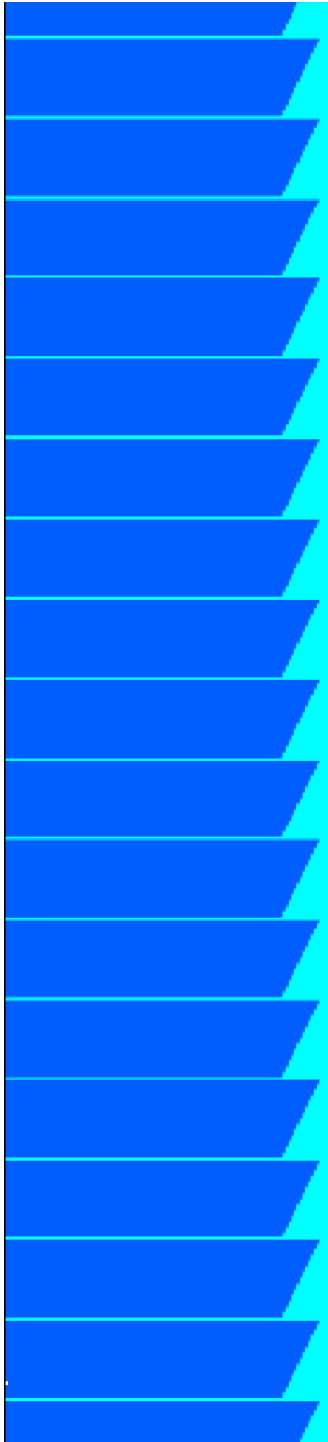
- w/cm
- Cement Fineness
- Use of SCM's,
- Admixtures
- Aggregates
 - ◆ Shape & Gradation
- Admixture Compatibility
 - ◆ Slump Loss
- Method of Placement



Uniformity

- Provide a Homogeneous Mixture
- Lack of Segregation
- Proper Consolidation







Improper consolidation



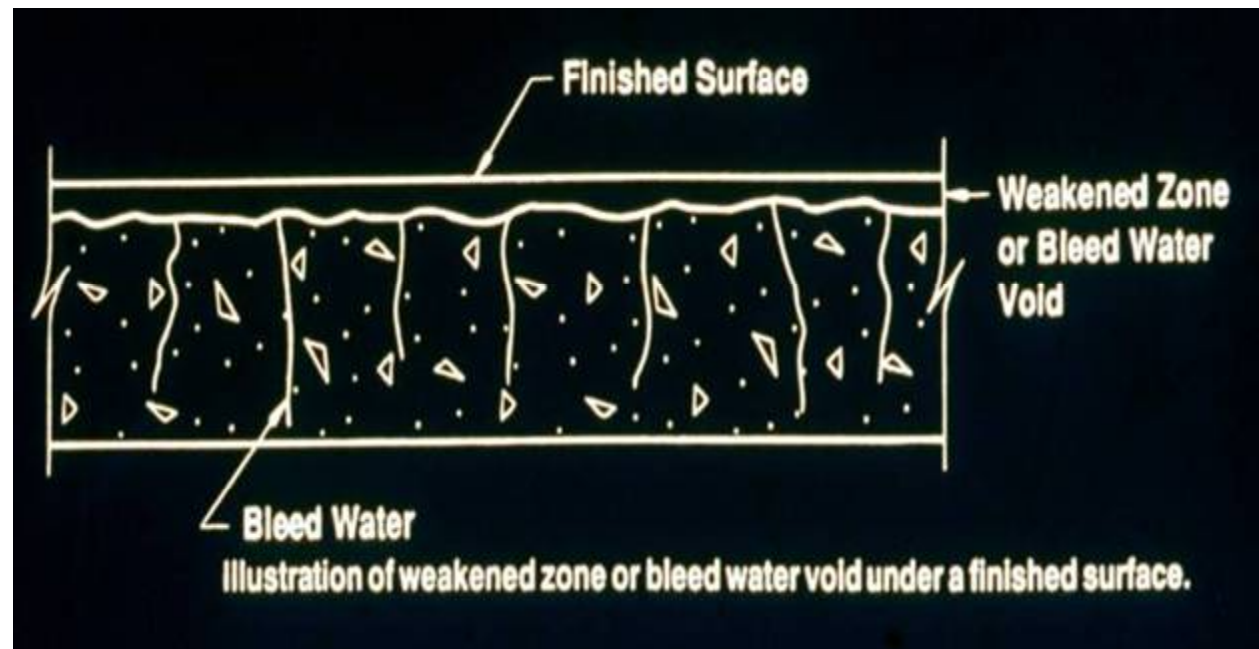
Factors Impacting Uniformity

- w/cm
- Aggregates
 - ◆ Gradation
- Mixing
 - ◆ Speed, Time
- Constructibility
- Method of Placement
- Consolidation

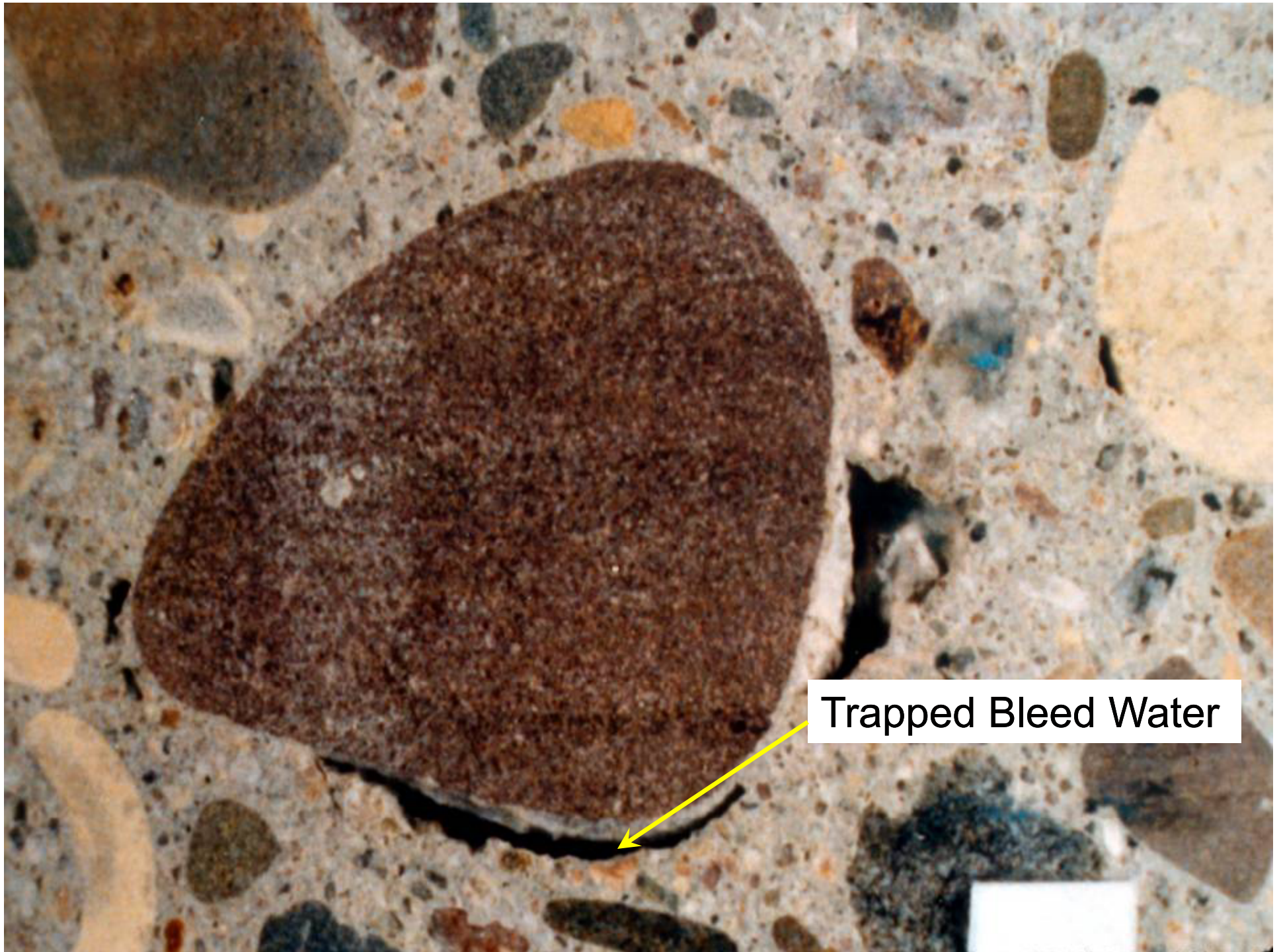


Bleeding

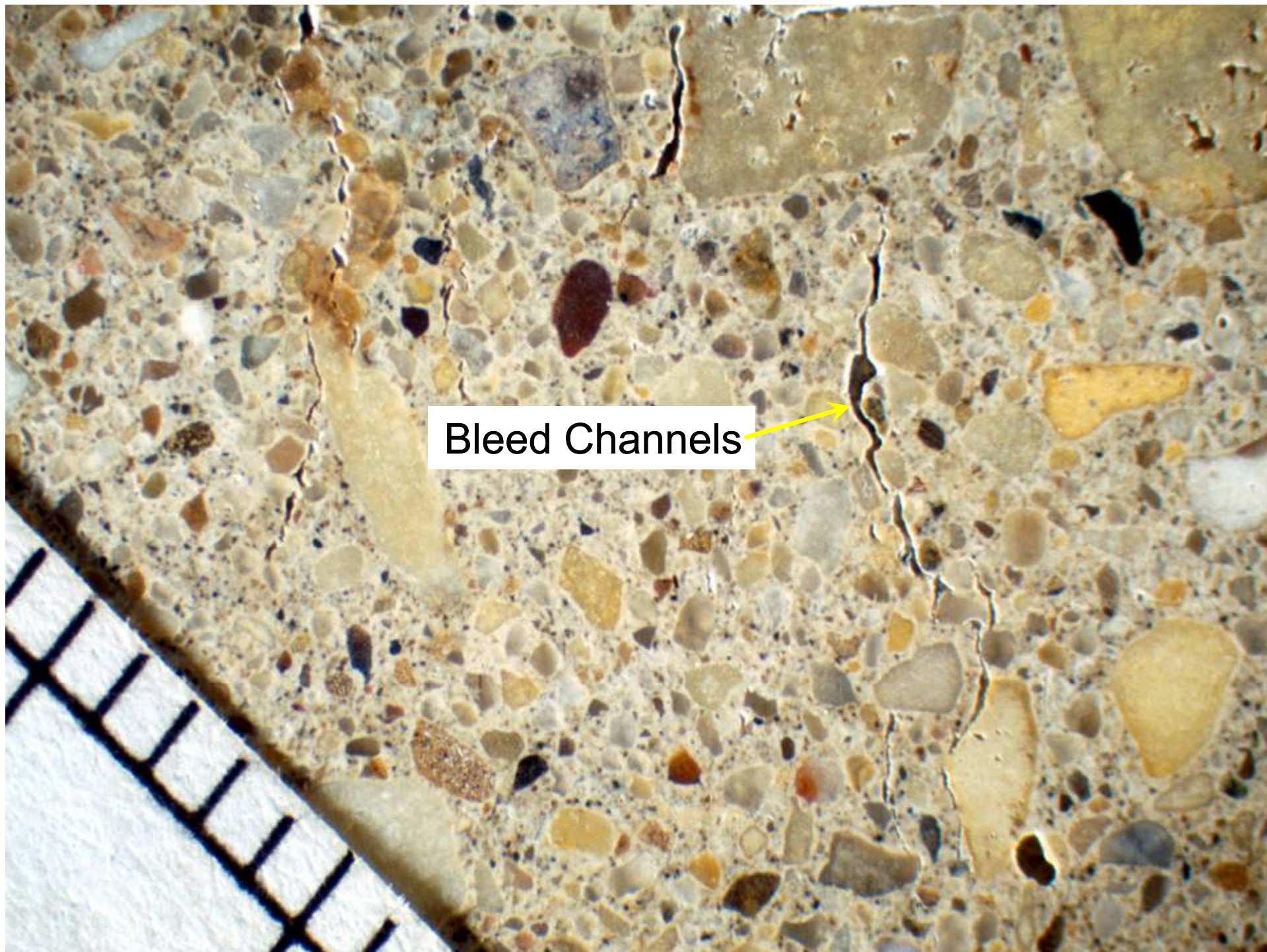
- Settlement of Solid Particles and Migration of Water to Surface of Concrete
- Timing with Finishing Operations







Trapped Bleed Water



Bleed Channels

Factors Impacting Bleeding

Rate and Capacity



- w/cm
- Cement Fineness
- Aggregate
 - ◆ Gradation
- Use of SCM's
- Admixtures
- Temp., RH, Wind

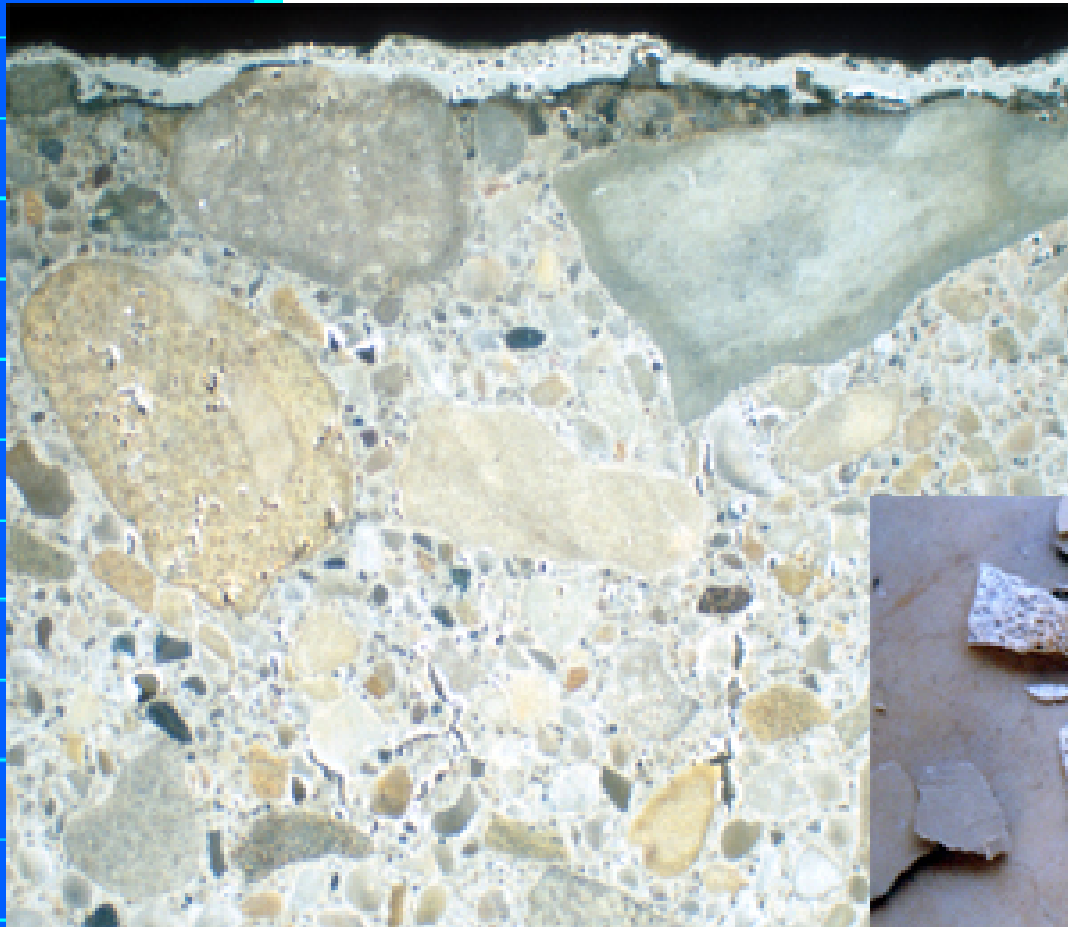
Setting and Hardening

- Setting- Loss of Plasticity of Paste and Conversion to Solid Material
- Hardening- Development of Hardness and Strength Following Set
- Impacts
Construction
Schedule





Sealing The Surface



- Improper Tooling
- Traps Bleed Water and Air Beneath Layer of Mortar





Factors Impacting Setting & Hardening



- w/cm
- Use of SCM's, Admixtures
- Temperature
- Rate & Heat of Hydration
- Cement
 - ◆ Gypsum (CaSO_4)
 - ✎ Content & Form

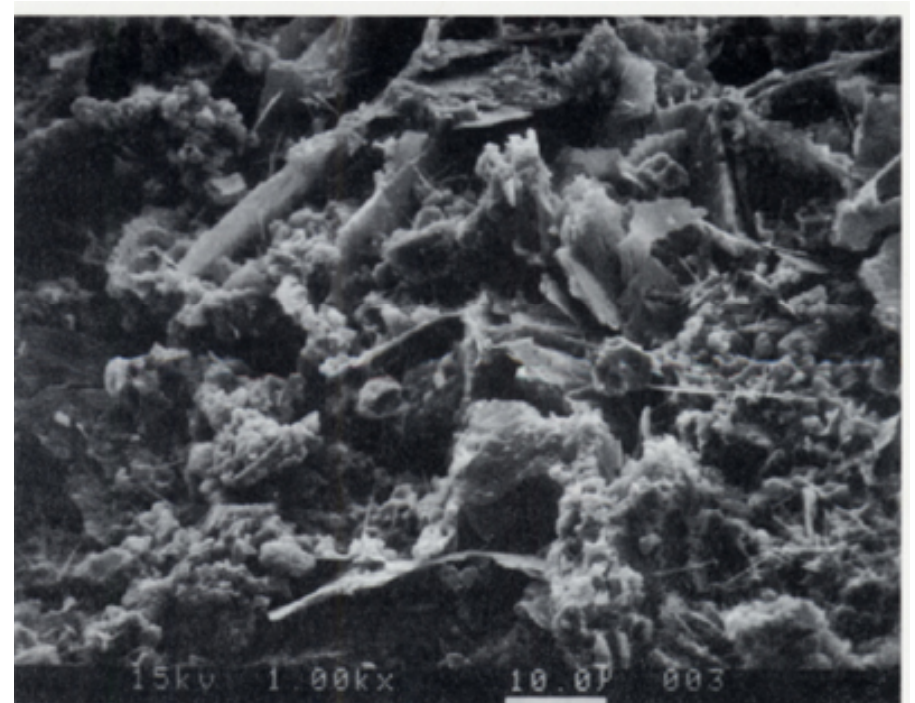
Hardened Concrete Properties



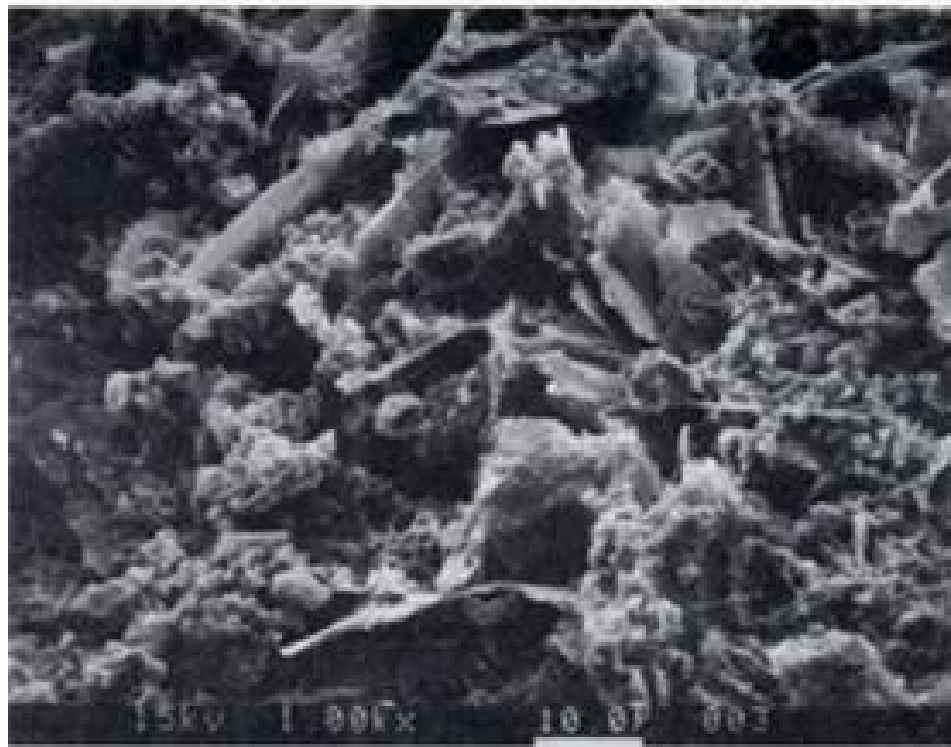
- Hydration
- Drying Rate
- Strength
- Durability
- Permeability & Watertightness
- Abrasion Resistance
- Volume Stability & Crack Control

Hydration

- Chemical Reaction between Cement and Water to Form New Compounds.
- Provides Setting, Hardening, and Strength Properties of Concrete



Hydration



Cement Hydrates in Layers...

Methods of Curing

SUPPLY ADDITIONAL WATER



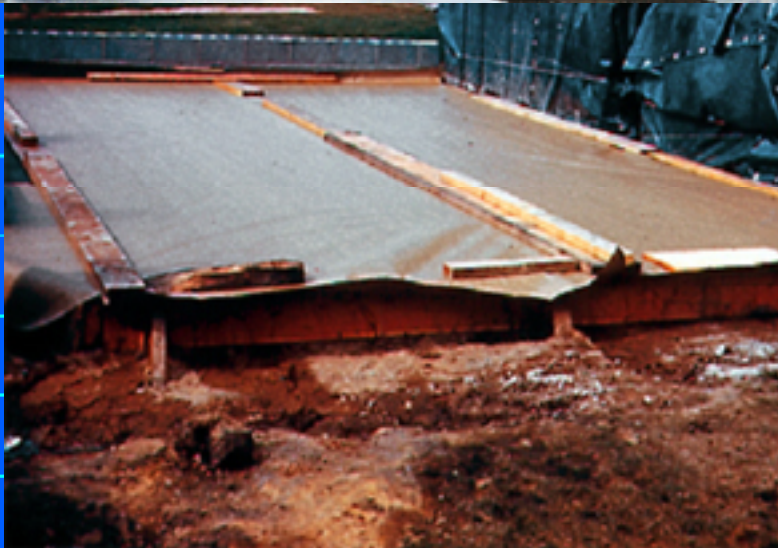
- Ponding
- Soaker hose
- Wet sand
- Wet burlap
- Immersion (precast)
- Steam curing

Methods of Curing



SEAL IN MIX WATER

- Curing compound
- Waterproof paper
- Polyethylene sheets





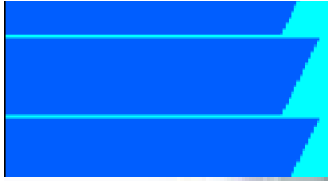
Controlling Temperature

ACI 305- Hot Weather Concreting



ACI 306- Cold Weather Concreting





Factors Impacting Hydration



- Amount of Water-
RH>80%
- Clinker Composition
- Cement Fineness
- Admixtures
 - ◆ Retarders
 - ◆ Accelerators
- Curing Temperature
- Curing Duration
- Space

Drying Rate



- Rate at Which Concrete Dries Out.
- Concrete Does Not Harden or Cure by Drying Out.
- Hydration Will Cease Once Loss of Moisture Drops Below 80% RH







Factors Impacting Drying Rate



- w/cm
- Materials
 - ◆ Density of Concrete
- Size of Element
- Drying Conditions
 - ◆ Temperature
 - ◆ External Moisture
- Vapor Retarders
- Curing
 - ◆ Method & Duration

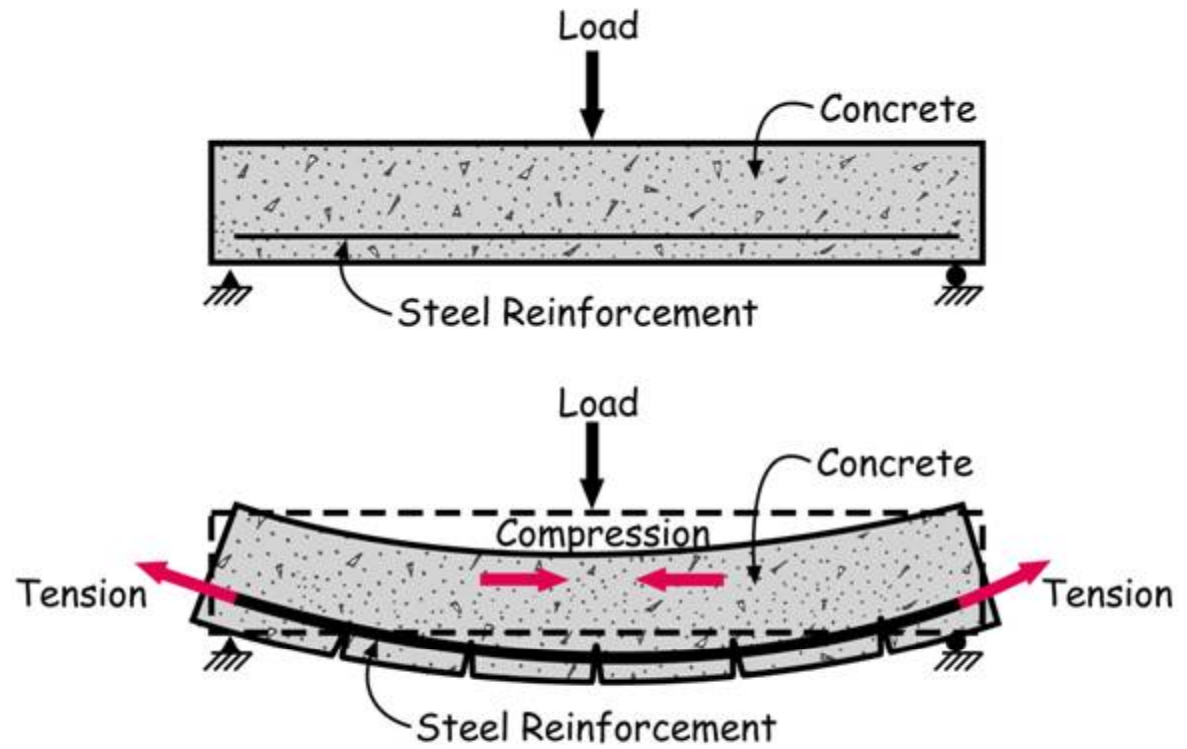
Strength

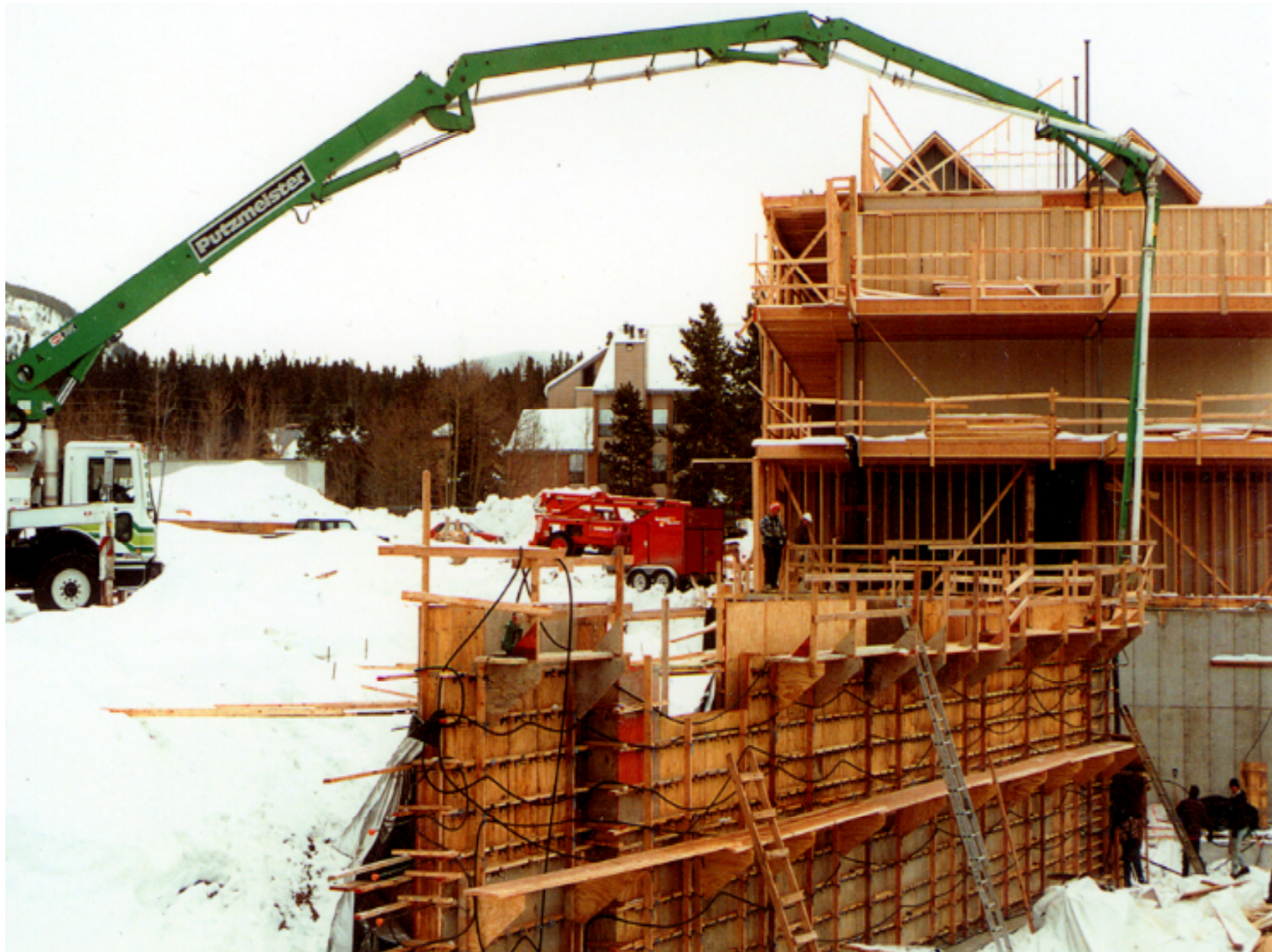


- Compressive Strength- Measured Resistance of Concrete to Axial Loading.

Strength

- Concrete is strong in compression, but weak in tension.









Factors Impacting Strength



- w/cm
- Age
- Air Content
- Aggregate Bond
- Handling
- Curing Temperature
- Testing Errors

Durability



Factors Impacting Durability




- ◆ Reactive Aggregate
 - ✧ ASR
 - ✧ ACR
- ◆ HIDE
- ◆ Carbonation
- ◆ Corrosion
- ◆ Chemical Attack
 - ✧ Sulfate Attack
- ◆ Seawater Exposure

Permeability & Watertightness

- Permeability-
Amount of Moisture Migration Through Concrete.
- Watertightness-
Ability of Concrete to Resist Moisture Penetration by Water or Other Substances (Liquid, Gas, or Ions).





GGBF slag
grade 120

The image displays four distinct piles of construction materials arranged on a blue background. Each pile is accompanied by a small white label with black text. The materials are: GGBF slag (white), Portland Cement (brown), Si Silica Fume (dark grey), and Fly Ash (light brown). The piles are roughly conical in shape.

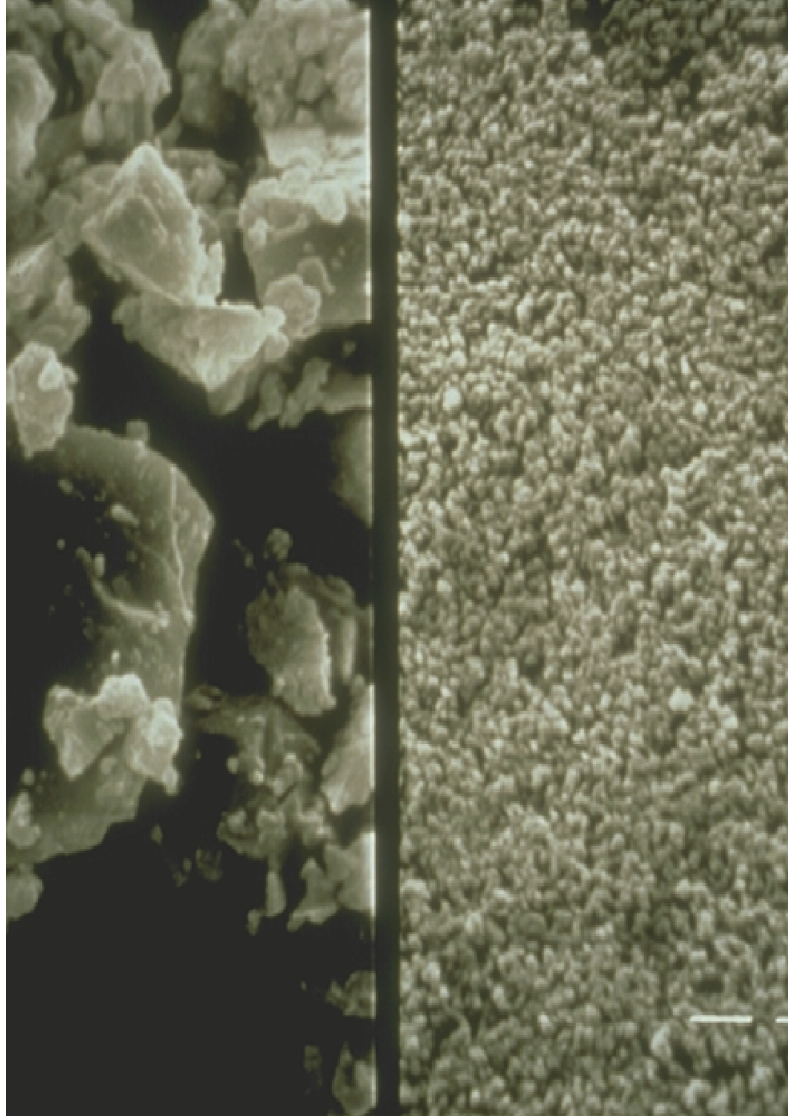
Portland Cement
Type I

Si Silica Fume
(microsilica)

Fly Ash
class C

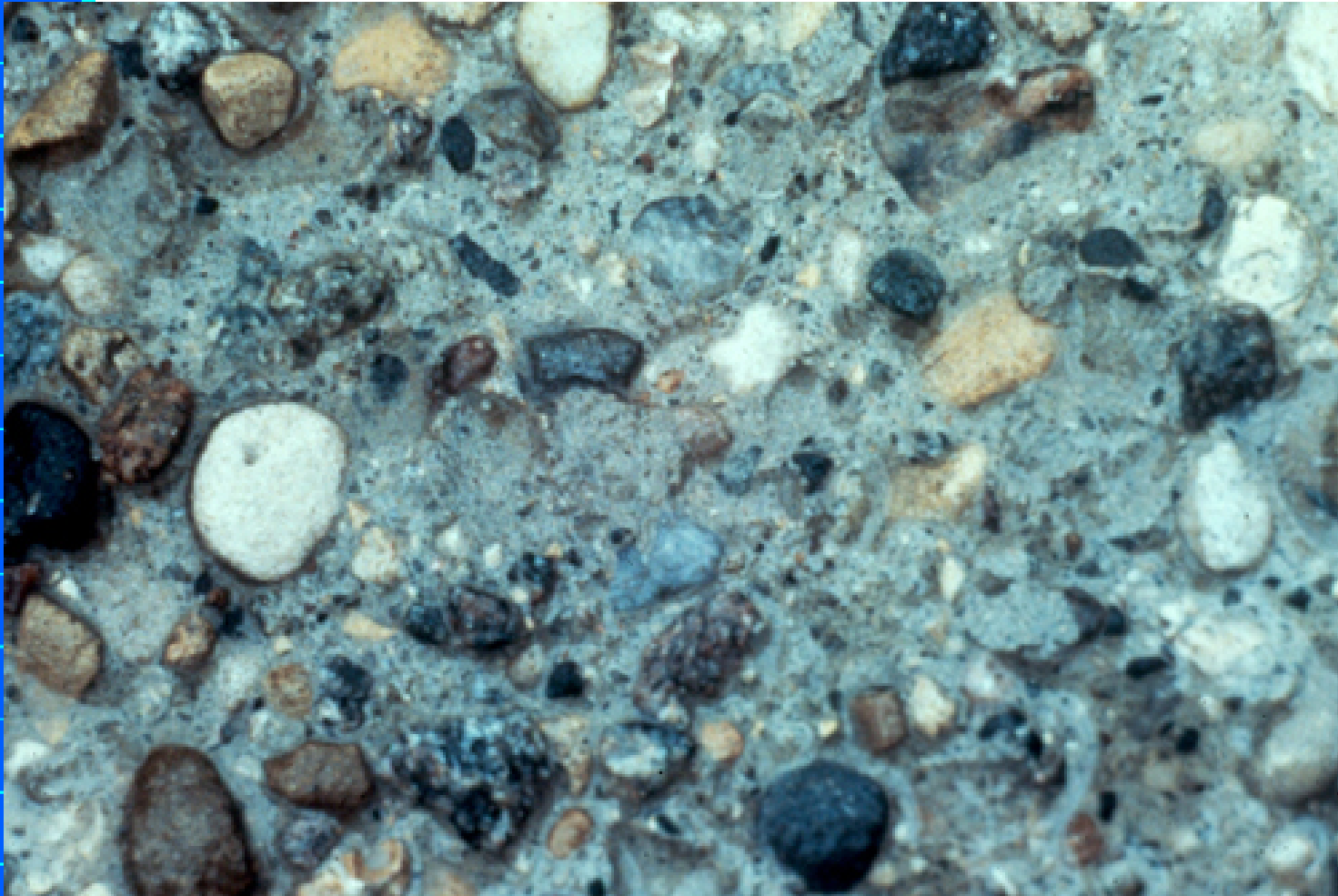


Factors Impacting Permeability & Watertightness



- Material Fineness
 - ◆ Cement
 - ◆ Use of SCM's
 - ◆ Aggregate Gradation
- Paste/Aggregate Ratio
- Aggregate Paste Bond
- Curing
- Sealers
- Vapor Retarders

Abrasion Resistance







Factors Impacting Abrasion Resistance



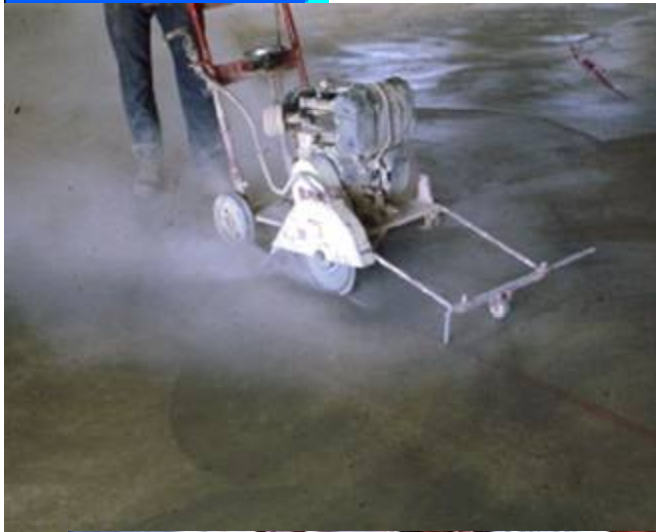
- w/cm
- Curing
- Type of Aggregate
- Surface Finish
- Surface Treatment
- Exposure

Volume Stability & Crack Control



- Concrete Changes Volume due to Changes in Temperature, Moisture, and Stress.
 - ◆ Creep
 - ◆ Shrinkage
- Control Volume Changes With Jointing.
 - ◆ Contraction
 - ◆ Isolation
 - ◆ Construction

Jointing-Crack Control



*Table 6-1. Maximum Spacing of Contraction Joints in Meters (Feet)**

Slab thickness mm (in.)	Maximum-size aggregate less than 19 mm ($\frac{3}{4}$ in.)	Maximum-size aggregate 19 mm ($\frac{3}{4}$ in.) and larger
125 (5)	3.0 (10)	3.75 (13)
150 (6)	3.75 (12)	4.5 (15)
175 (7)	4.25 (14)	5.25 (18)**
200 (8)	5.0 (16)**	6.0 (20)**
225 (9)	5.5 (18)**	6.75 (23)**
250 (10)	6.0 (20)**	7.5 (25)**





Factors Impacting Volume Stability



- Restraint, Jointing
- w/cm
- Amount of Aggregate
- Properties of Aggregate
- Size & Shape of Member
- RH and Temp
- Method of Curing & Drying
- Degree of Hydration
- Time



Summary

Desired Properties of Concrete:

- Consistency
- Workability
- Uniformity
- Bleeding
- Setting & Hardening
- Hydration
- Drying Rate
- Strength
- Durability
- Permeability & Watertightness
- Volume Stability & Crack Control

?

