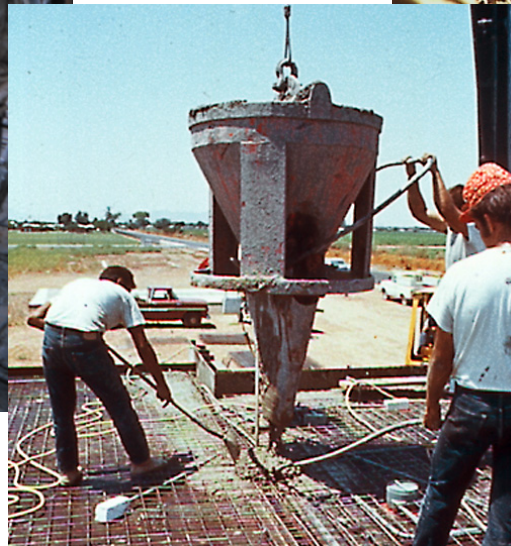
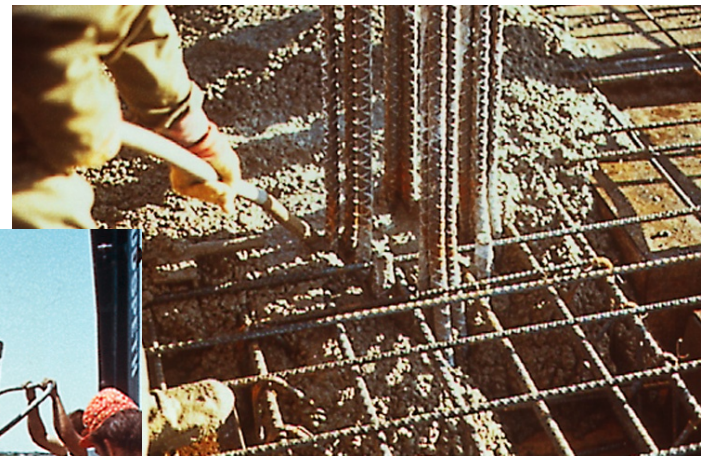


# Construction Procedures

## A Global Perspective





# Sources of Authority & Information

- American Concrete Institute
- Canadian Standards Association
- American Society of Testing Materials
- Portland Cement Association,  
Cement Association of Canada,
- International Concrete Repair Institute
- Corps of Engineers
- Bureau of Reclamation

# Why do concrete problems occur?



courtesy of M. Thomas





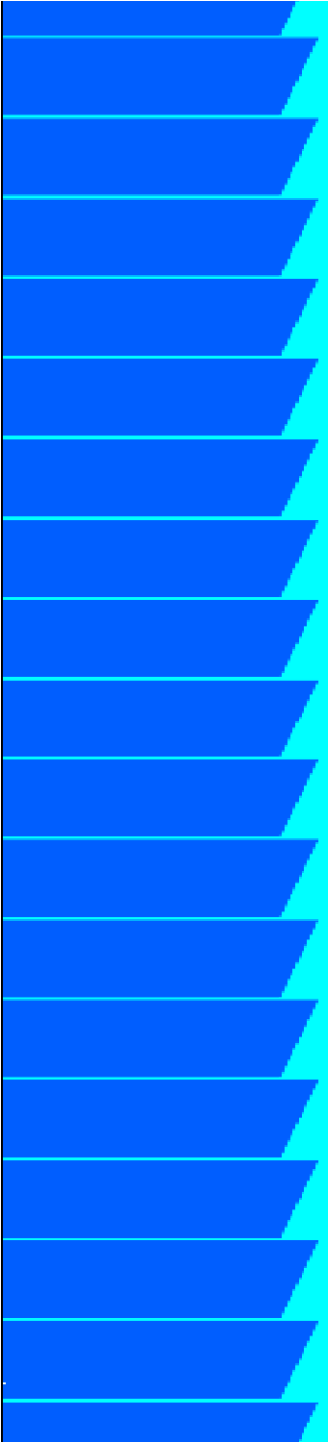




# The Big Picture

- Discussion:
  - ◆ Prevention of Failures
    - Inspection Program- QA/QC
  - ◆ Review of Project
    - **Pre-Construction Checklist**
    - Design- Constructability
    - Materials Selection
    - Mix Design
    - Placement Procedures
    - Environment



- 
- When troubleshooting concrete problems it is important to relate the symptom to causes of distress and deterioration.

# Preconstruction Meeting

- Owner
- Architect/Engineer
- General Contractor
- Sub-Contractors
- QA/QC Inspector





# Quality Assurance

- All planned and systematic actions necessary to provide adequate confidence that a structure, system or component will perform satisfactorily and conform with project requirements.



# Quality Control

- Specific implementation of QA program and includes checking and reviewing design and construction related activities.



# Identify Processes or Materials Causing Distress or Failure

- Design- Constructability
- Materials Selection
- Mix Design
- Placement Procedures
- Environment

# Design-Constructibility

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- Reinforcement location
- Tolerances
- Joints







# Review of the Project

- Contract Documents
  - ◆ Specifications
  - ◆ Construction Drawings
  - ◆ Shop Drawings



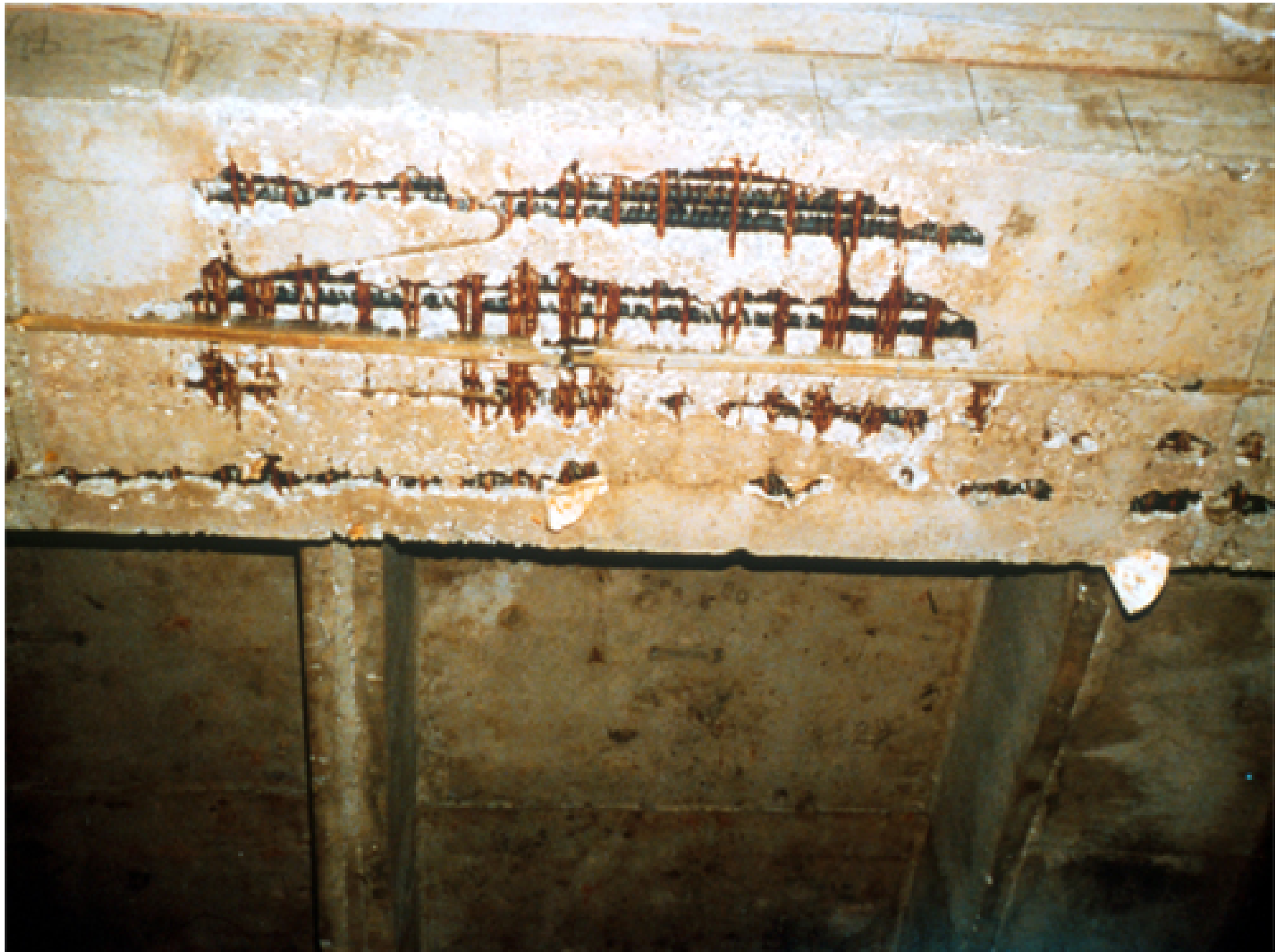
# Constructability

- Cover over rebar
- Detail of rebar
- Congestion
- Ease of placement and compaction
- Rock pockets
- Segregation
- Corrosion

“The design must be part of the solution not the obstacle.”







# Materials Selection

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- Cement
- Supplementary Cementing Materials
- Water
- Aggregates
- Admixtures

# Cement



- Cement Type
- Fineness (PSD/Blaine)
- Alkalies





- Compound Proportions
  - ◆  $C_3S$ ,  $C_2S$ ,  $C_3A$ ,  $C_4AF$



- Gypsum form



# Supplementary Cementing Materials SCMs



- Mineral Properties
- Particle Size
- Workability
- Strength Development
- Set Time

# Cement Content

$$\text{Cement Material Content} = \frac{\text{Water Content}}{\text{W/CM}}$$

A minimum cement content may be specified for the purpose of:

- Durability
- Finishability
- Improved wear resistance
- Appearance



# Cement Content

$$\text{Cement Material Content} = \frac{\text{Water Content}}{W/CM}$$



Excessively high cementitious material contents should be avoided for:

- economy
- avoid adverse effects
- workability
- shrinkage
- heat of hydration





## Water Quality

- Water  $> 2000$  ppm of dissolved solids should be tested for its effects on strength and time of set.

*Specified by  
ASTM C1602*

# Influence of Aggregates



*Specified by ASTM C 33*

- Gradation
- Shape
- Size
- Surface texture



# Influence of Aggregates



- **Durability**  
Weathering  
Impurities





# Admixtures



- Cement Compatibility
- Dosage Rates
- Sequencing

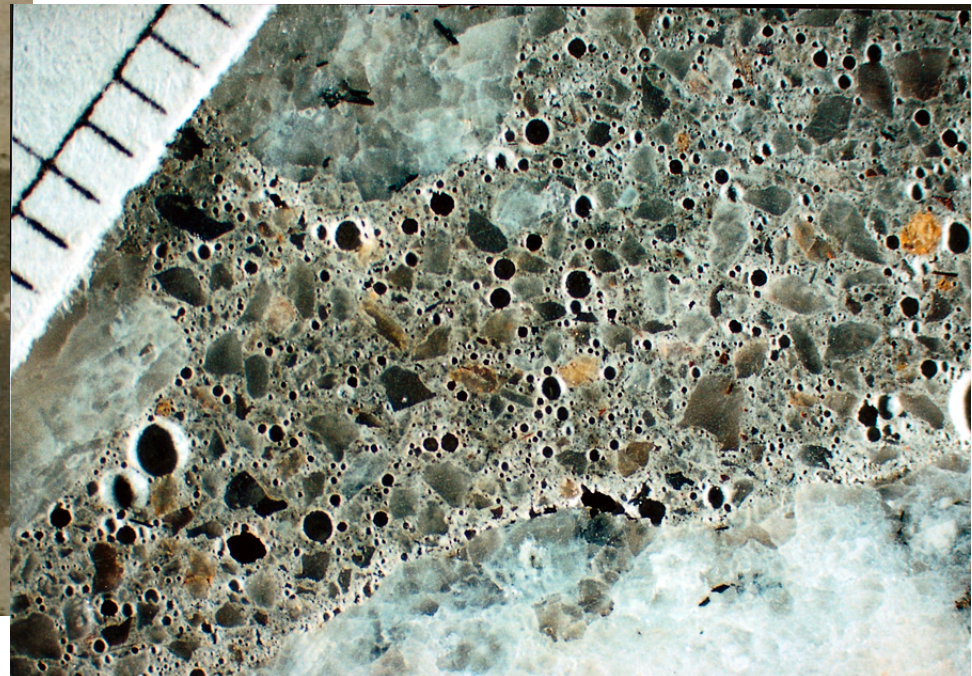




# Air-Entrainers



- Air Generation
  - ◆ Proper Volume
  - ◆ Spacing Factor & Specific Surface
- Vynsol vs. Synthetic



# Water Reducers

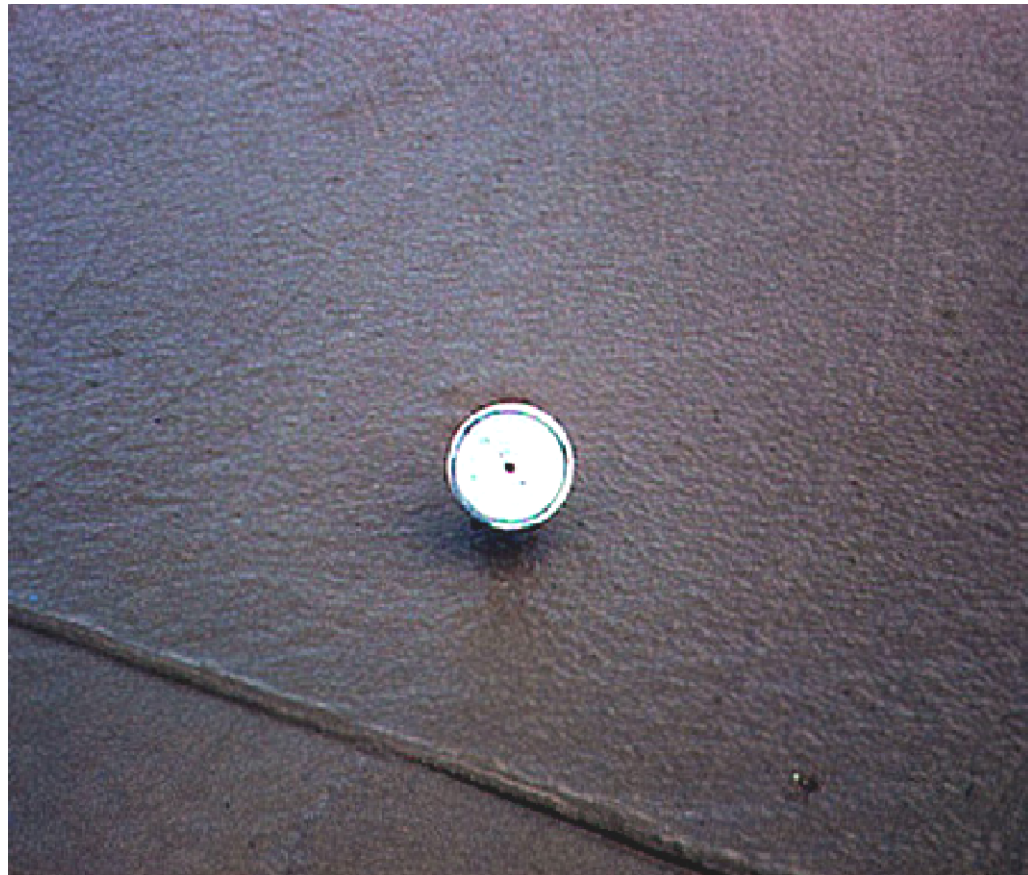


- Type
- Bleed Rate
- Effect on Air
- Set Time



# Retarders

- Workability & Slump Loss
- Strength Development
- Set Time



# Accelerators

- Chloride Bearing vs. Non-Chloride

- ◆ Corrosion
- ◆ Discoloration
- ◆ Strength Development





# Mix Design

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- Materials
- w/cm
- Slump
- Strength
- Durability
- Aesthetics

# Performance vs. Prescriptive

## Performance

- R/M producer assumes full responsibility
- A/E specifies required compressive strength
- R/M producer submits to A/E evidence of mix compliance with ACI 318

## Prescriptive

- Specifier assumes full responsibility for selection of proportions for concrete
- A/E or Owner specifies Cement content, maximum water content, and admixture dosage
- R/M producer submits to A/E evidence of material compliance with project specs and mix compliance with ACI 318

# Trial Mixes

Trial batches are performed to determine whether the slump, air content, strength and other design parameters are as required.

Modifications can be made and further trials are performed until the properties of the concrete are satisfactory.



# Placement

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- Transportation
- Placement
- Consolidation
- Finishing
- Curing





# Pre-Placement Checklist

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- How do pre-placing techniques affect the hardened concrete?
  - ◆ Subgrade prep?
  - ◆ Formwork?
  - ◆ Reinforcement?
  - ◆ Jointing prep?

# Method of Placement



- Chutes
- Conveyor
- Dropchute
- Bucket
- Cranes
- Pump
- Wheelbarrow & Buggies

# Adequate Consolidation



# Finishing Operations

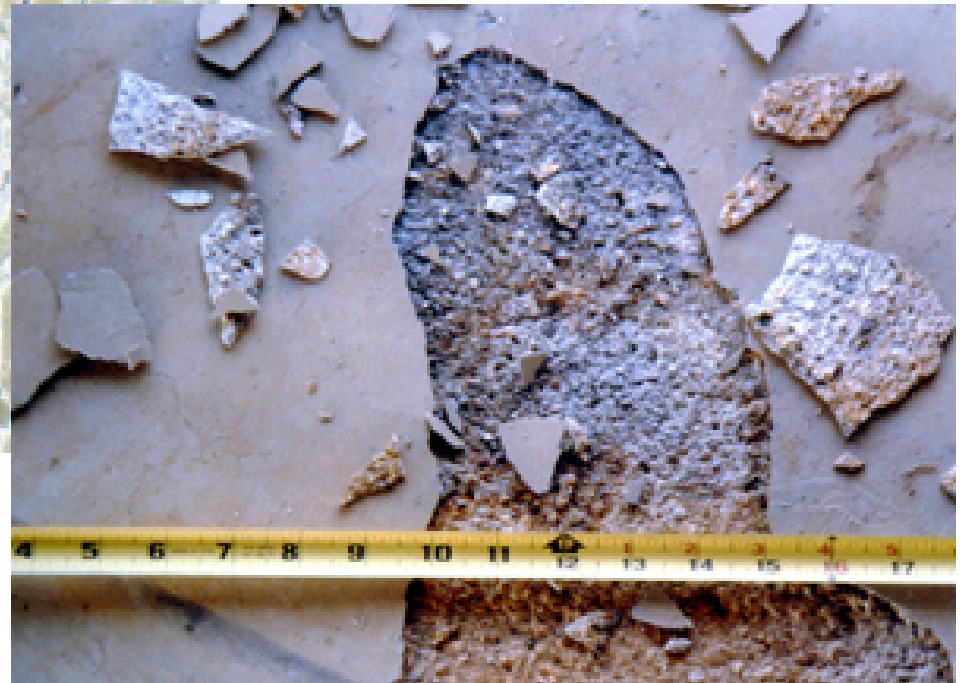




# Sealing The Surface



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



# Curing



# Curing During Placement









# Environment

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- Hot & Cold Placement
- Freeze-Thaw Cycles
- Chemical

# Controlling Temperature

ASTM C 1064

ACI 305- Hot  
Weather Concreting



ACI 306- Cold  
Weather Concreting



# Hot Weather Concreting Problems



- Increased Water Demand
- Accelerated Slump Loss
- Faster Set Times
- Rapid Water Evaporation
- Plastic Shrinkage

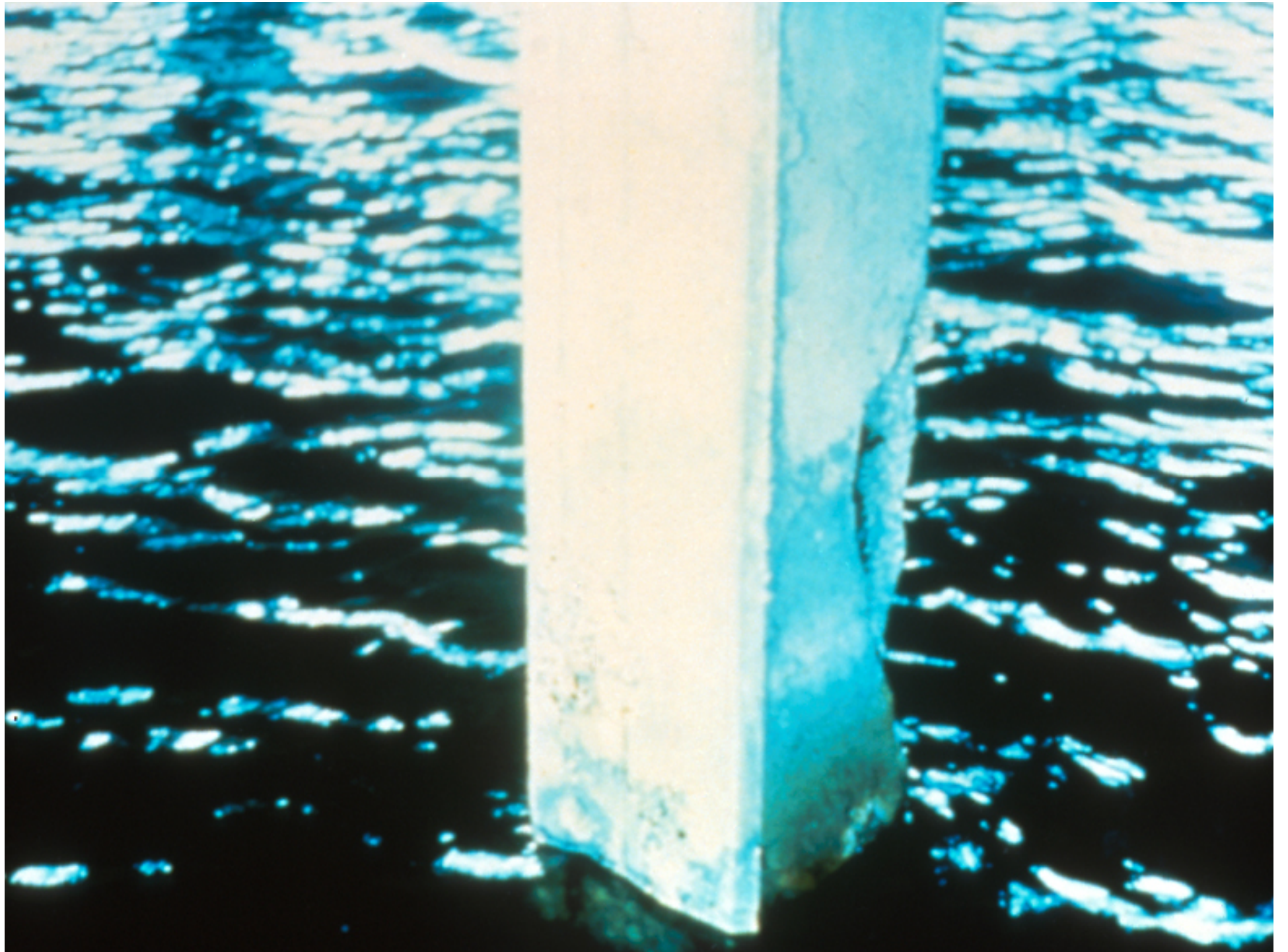


# Cold Weather Concreting Problems



- Freezing
- Dusting, Crazing, Plastic shrinkage
- Slower hydration
- Slower setting times







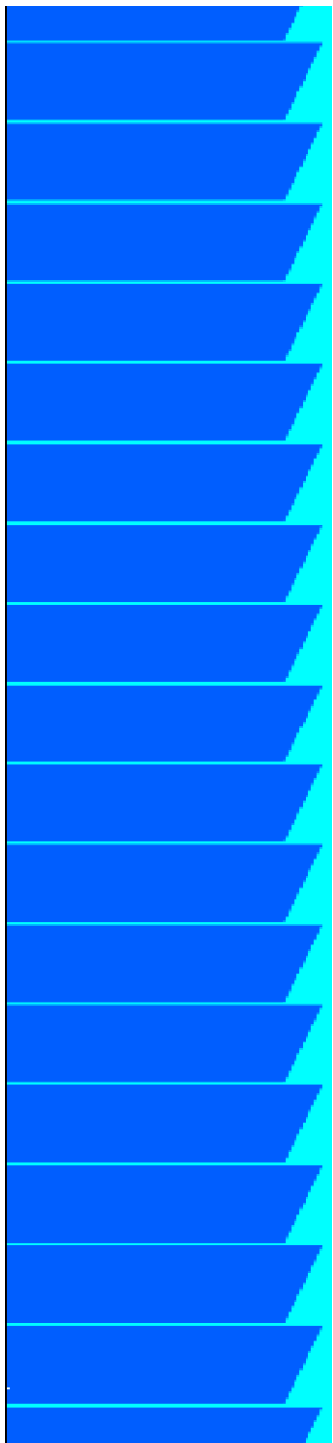


courtesy of M. Thomas



# Summary

- Prevention of Failures
  - Form an Inspection Program-QA/QC
- Review Project to Ensure Compliance
  - Design- Constructability
  - Materials Selection
  - Mix Design
  - Placement Procedures
  - Environment



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