


PCA
America's Cement Manufacturers™

Concrete Surface Defects:
Causes, Prevention, and Cure.

Presented to:

 Minnesota Concrete Council
Dedicated to Cast-in-Place Concrete

Wednesday, October 11, 2017

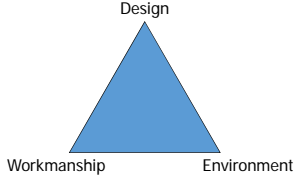
Presented by: **Michelle L. Wilson**
Director, Concrete Technology
Portland Cement Association
www.cement.org

1

PCA
America's Cement Manufacturers™

Identify Processes or Materials
Causing Distress or Failure

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



4

PCA
America's Cement Manufacturers™

Portland Cement Association



- Founded in 1916
- Mission:
To improve and extend the uses of portland cement and concrete.

 Since 1916
America's Cement Manufacturers™

2

PCA
America's Cement Manufacturers™

Identify Concrete Surface Defects
ACI 201.1 R

- Cracking
- Dusting
- Blisters
- Delaminations
- Crazeing
- Popouts
- Mortar Flaking & Scaling
- Spalling
- Bugholes
- Cold Joint
- Discoloration
- Efflorescence
- Honeycombing (Internal?)

5

PCA
America's Cement Manufacturers™

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

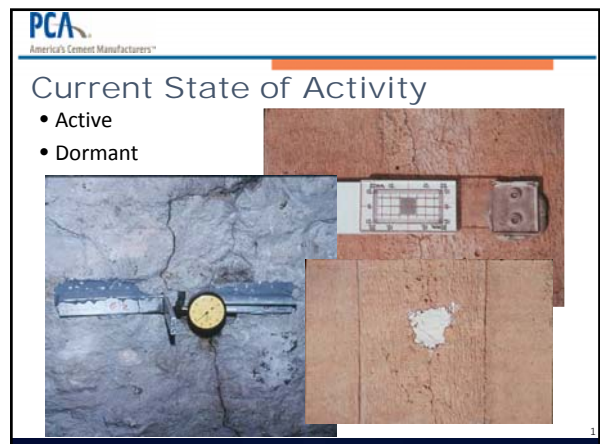
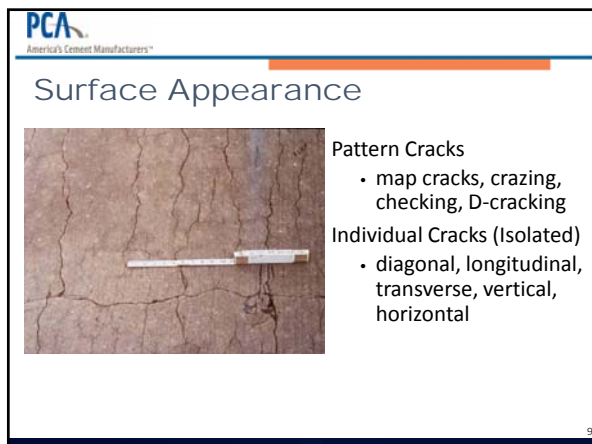
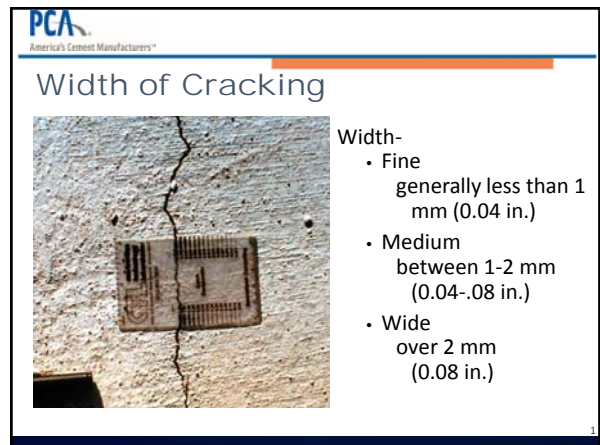
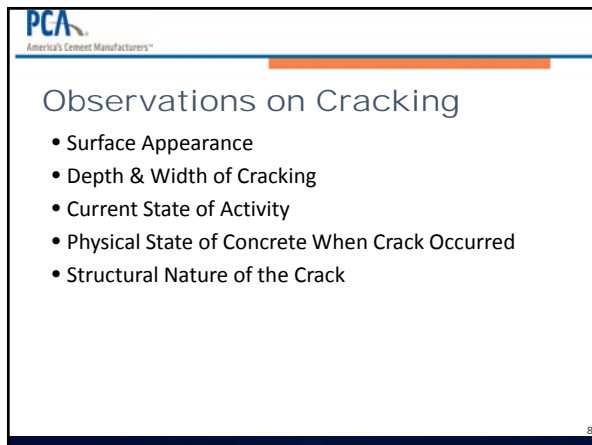
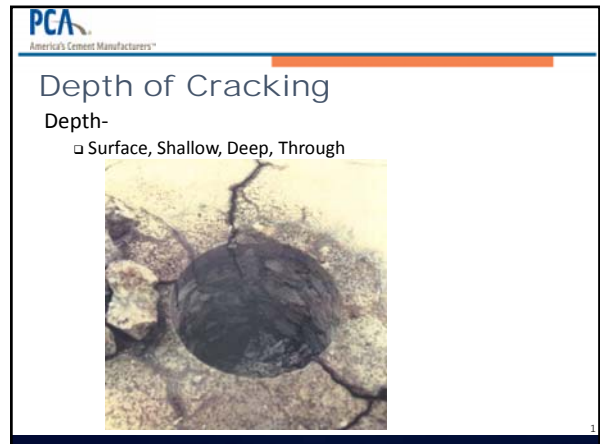
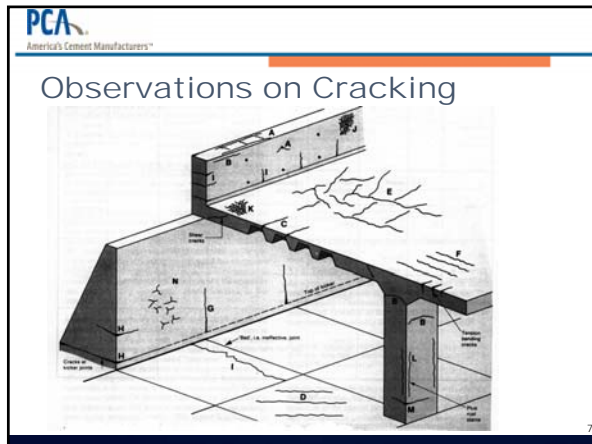
3

PCA
America's Cement Manufacturers™

References


- PCA- IS177- Concrete Surface Defects
- ACI 201- Condition Survey
- Corps of Engineers- Evaluation and Repair Guide

6



PCA
America's Cement Manufacturers™

Physical State of Concrete When Cracking Occurred



Before Hardening

- Plastic
 - Shrinkage
 - Settlement
- Construction Movement
 - Formwork Movement
 - Subgrade Movement

1

PCA
America's Cement Manufacturers™


Surface Appearance

- Pattern Cracks
 - map cracks, crazing, checking, D-cracking
- Individual Cracks (Isolated)
 - diagonal, longitudinal, transverse, vertical, horizontal

1

PCA
America's Cement Manufacturers™

Physical State of Concrete When Cracking Occurred



After Hardening


- Physical
 - Drying Shrinkage
 - Crazing
- Chemical
 - Corrosion of Reinforcement
 - Alkali-Aggregate Reactions
- Thermal
 - Thermal Contraction
 - Freeze-Thaw Cycles

1



PCA
America's Cement Manufacturers™

Physical State of Concrete When Cracking Occurred

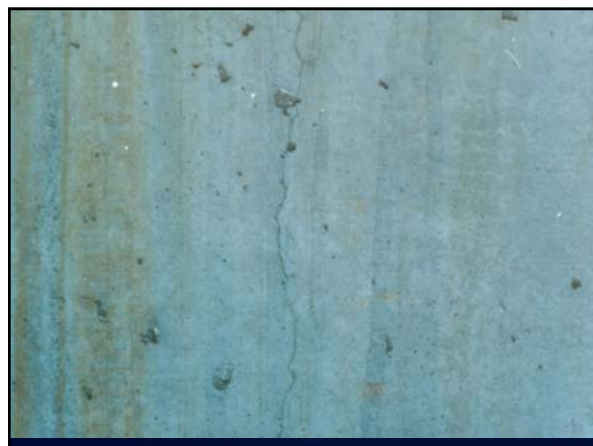


After Hardening

- Structural
 - Accidental Overload
 - Creep
 - Design Loads

1

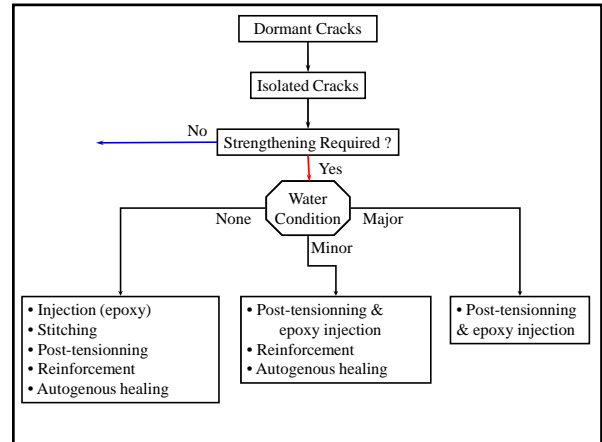




PCA
America's Cement Manufacturers™

Repair Approach - Cracking

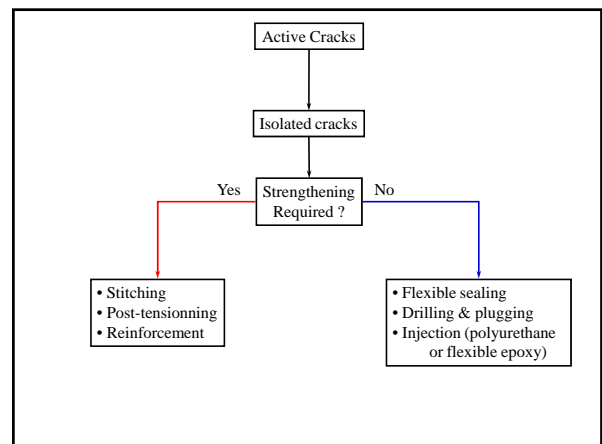
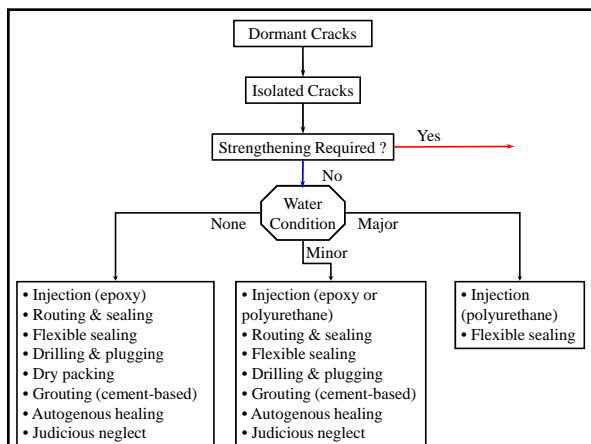
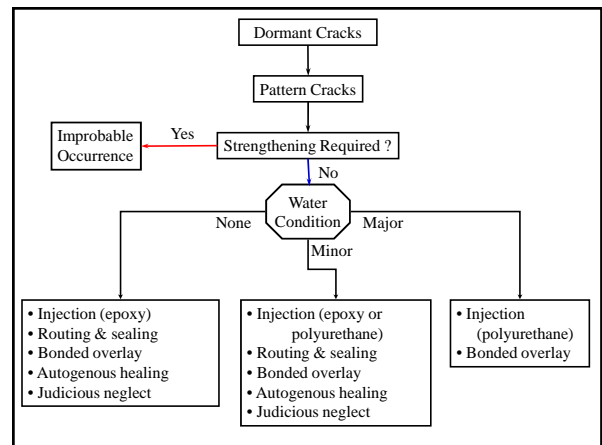
- Consider:
 - Future movement
 - Active vs. dormant
 - Strengthening required
 - Moisture
 - Degree of restraint for repair material

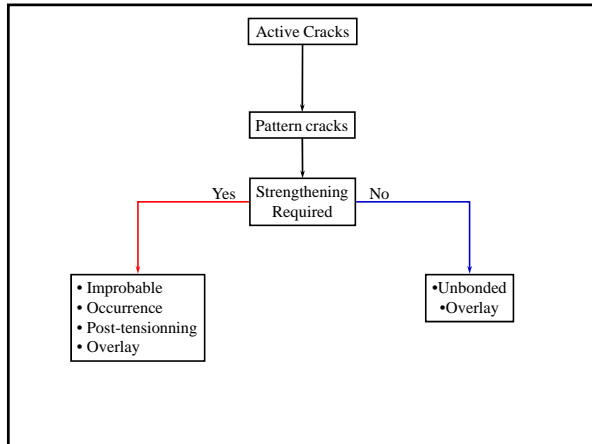


PCA
America's Cement Manufacturers™

Repair Approach - Cracking

- Consider:
 - Is mechanism likely to remain active?
 - Feasibility of repair
 - Should crack be treated as spall (corrosion)?





PCA
America's Cement Manufacturers™

Concrete Surface Defects

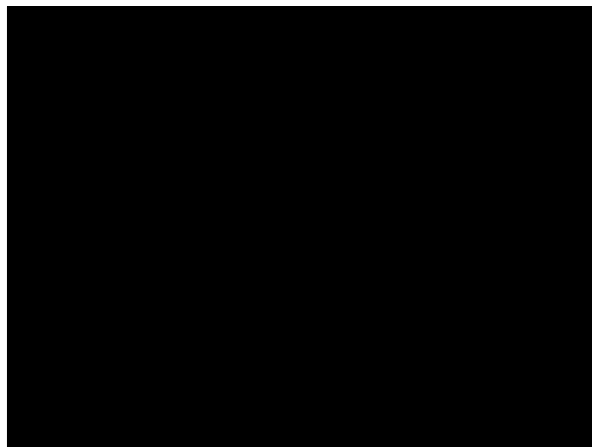
3

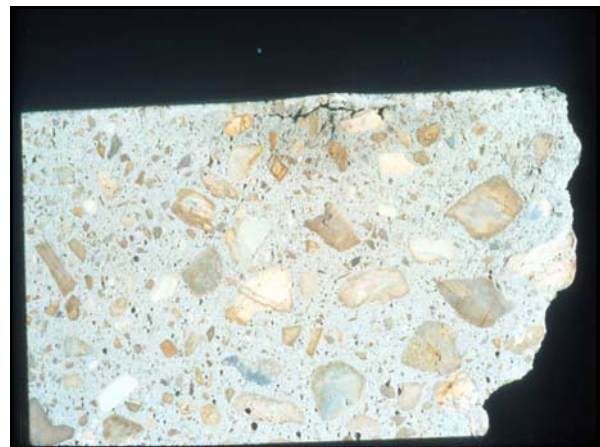
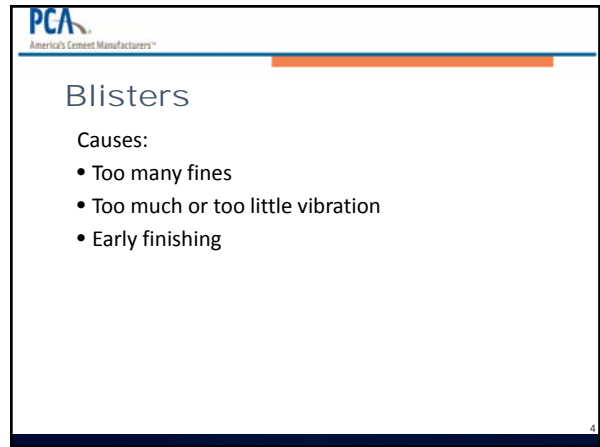
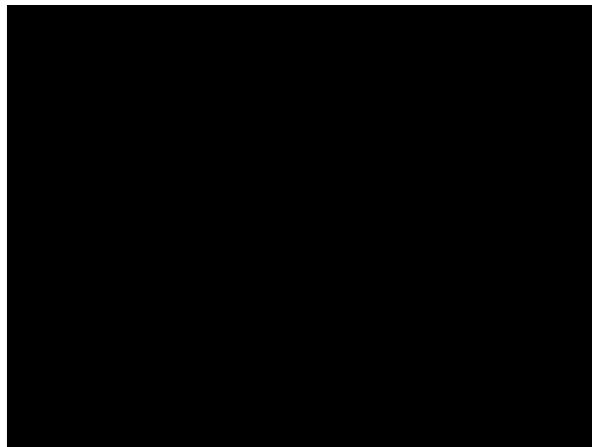
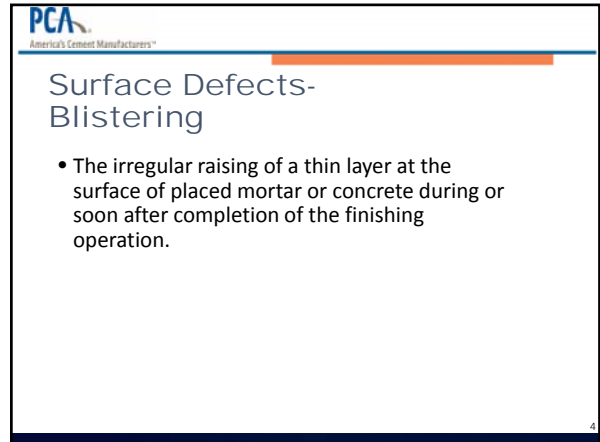
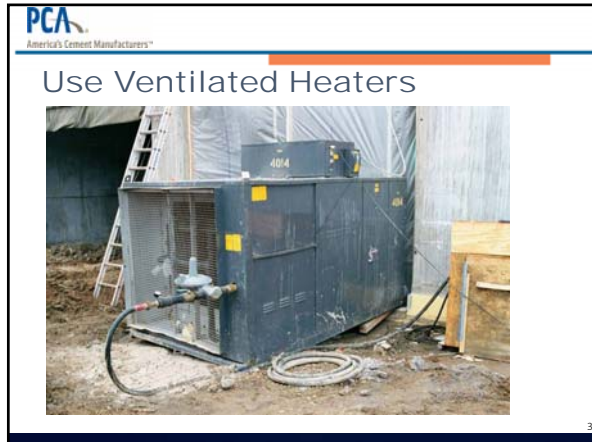
PCA
America's Cement Manufacturers™

Surface Defects- Dusting

- Development of a fine, powdery material at the surface of hardened concrete.

3





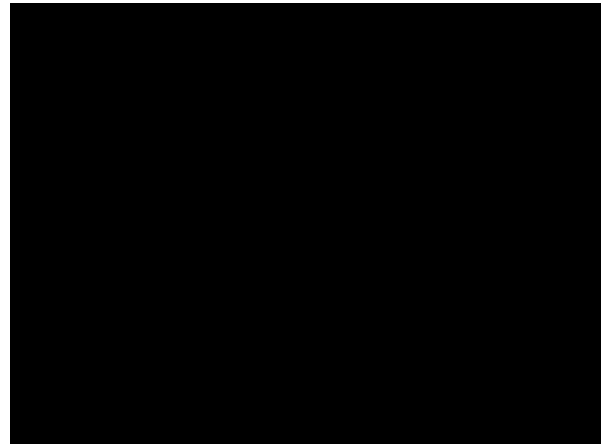
PCA
America's Cement Manufacturers™

Blisters

Prevention:

- Avoid high slumps and excess fines
- Use appropriate cement content
- Warm subgrade in cold weather
- Do not place slab directly on vapor retarder

4



PCA
America's Cement Manufacturers™

Blisters

Prevention:

- Do not overwork the concrete
- Do not seal (finish) the surface too soon
- Use proper finishing techniques and timing
- Reduce evaporation
- Avoid air contents of more than 3% for interior slabs

4



PCA
America's Cement Manufacturers™

Surface Defects- Delamination

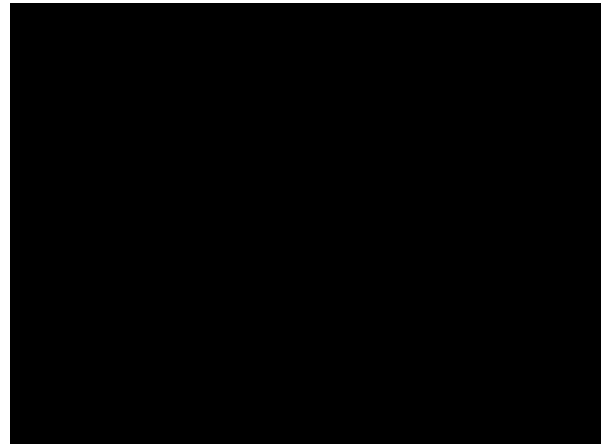
- A separation along a plane parallel to a surface. In the case of a concrete slab, a horizontal splitting, cracking, or separation of a slab in a plane roughly parallel to, and generally near, the upper surface.

4

PCA
America's Cement Manufacturers™

Sealing The Surface

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



PCA
America's Cement Manufacturers™

Surface Defects- Crazing

- Fine, random cracks or fissures in the surface of plaster, cement paste, mortar, or concrete.

5

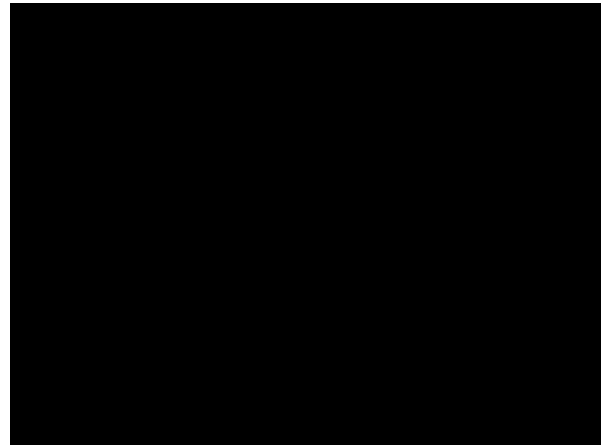
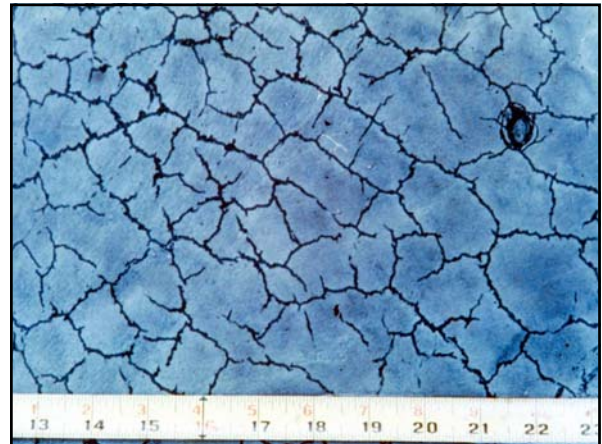
PCA
America's Cement Manufacturers™

Crazing

Causes:

- Rapid surface drying after setting
- Applying dry cement to surface during finishing

5



PCA
America's Cement Manufacturers™

Surface Defects- Popouts

- Conical fragment that breaks from the concrete surface. A fractured aggregate particle is often at the bottom of the hole.

6

PCA
America's Cement Manufacturers™

Popouts

Prevention:

- Use low slump, low water content mix
- Use durable crushed stone or beneficiated aggregate
- Slope the slab surface to drain water properly
- Use supplementary cementing materials to control ASR-induced popouts

6

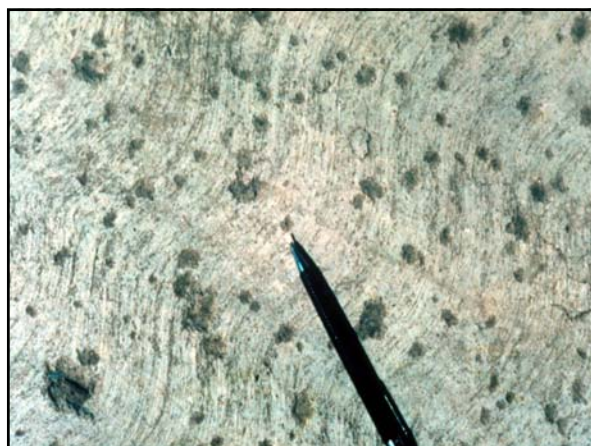
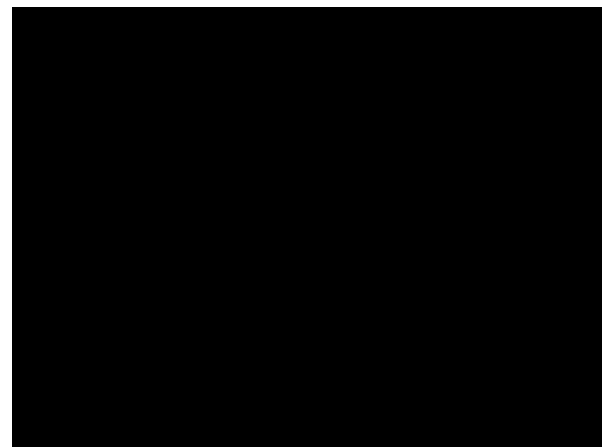
PCA
America's Cement Manufacturers™

Popouts

Causes:

- Porous rock with high absorption, low specific gravity:
 - Pyrite
 - Hard-burned dolomite
 - Coal
 - Shale
 - Soft, fine-grained limestone
 - Chert
- Alkali-aggregate reactivity

6

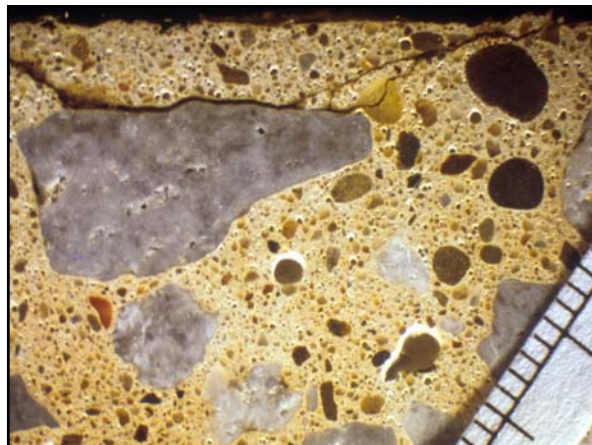


PCA
America's Cement Manufacturers™

Surface Defects- Mortar Flaking

- A form of scaling over coarse aggregate (“popoffs”)

6

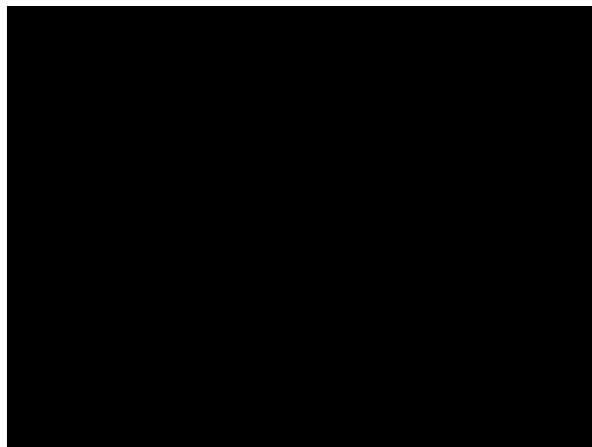


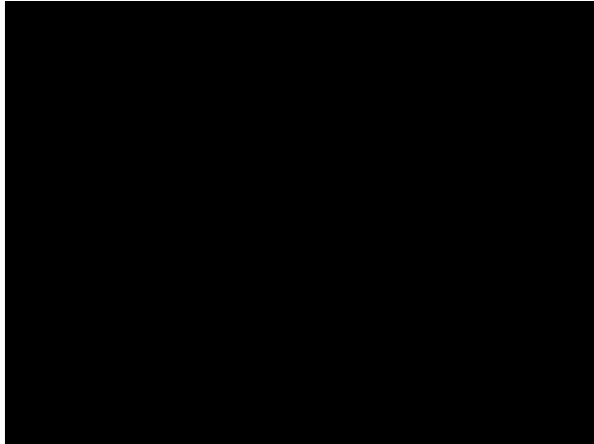
PCA
America's Cement Manufacturers™

Surface Defects- Scaling

- Local flaking or peeling away of the near-surface portion of concrete or mortar.

7



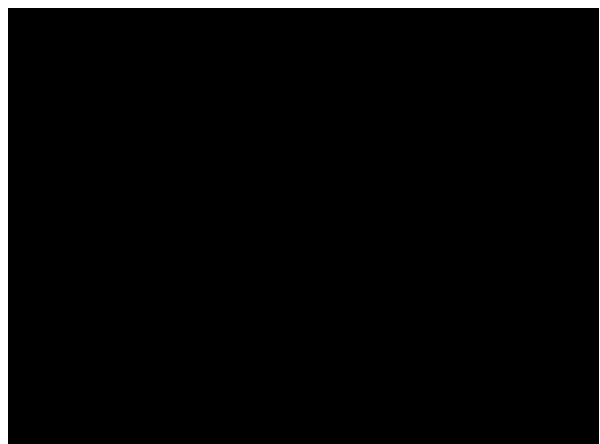


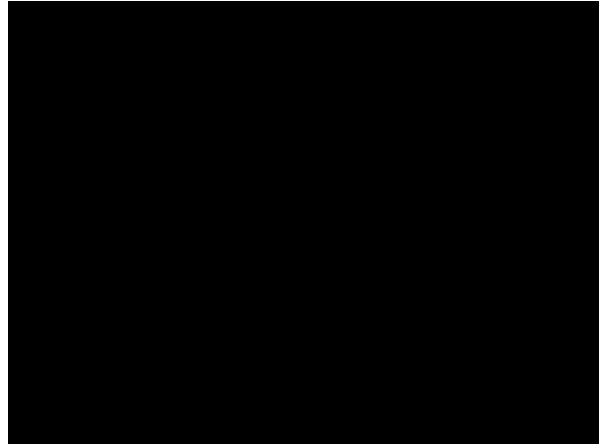
PCA
America's Cement Manufacturers™

Surface Defects- Spalling

- A fragment, usually in the shape of a flake, detached from a larger mass by a blow, by the action of weather, by pressure, or by expansion within the larger mass.

7





PCA
America's Cement Manufacturers™

Surface Defects- Bugholes

- Small regular or irregular cavities, usually not exceeding 15 mm in diameter, resulting from entrapment of air bubbles in the surface of formed concrete during placement and compaction.

8



PCA
America's Cement Manufacturers™

Surface Defects- Cold Joint

- Visible lines on the surfaces of formed concrete indicating the presence of joints where one layer of concrete had hardened before subsequent concrete was placed.

8

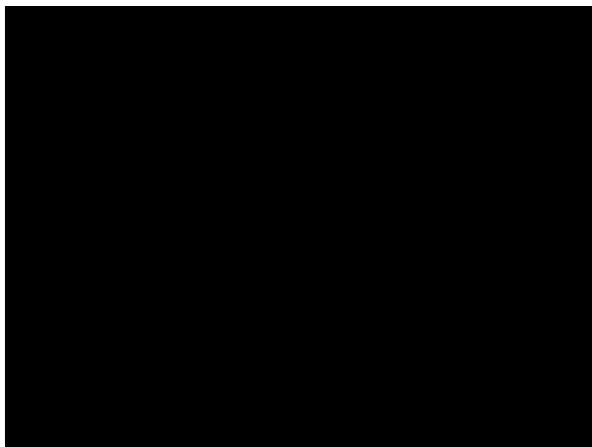


PCA
America's Cement Manufacturers™

Surface Defects- Discoloration

- A departure of color from that which is normal or desired.

8



PCA
America's Cement Manufacturers™

Surface Defects- Staining

- Spotted or mottled light or dark blotches.

9

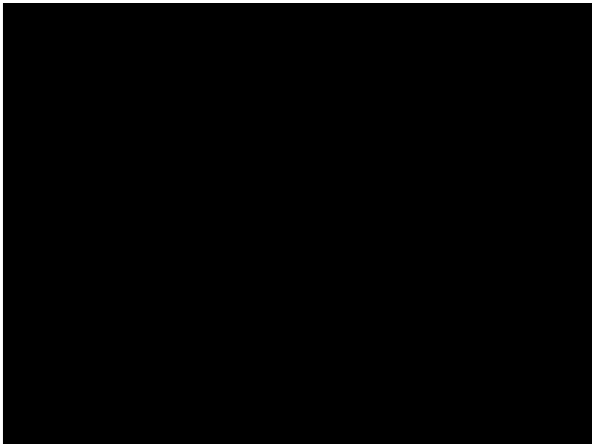


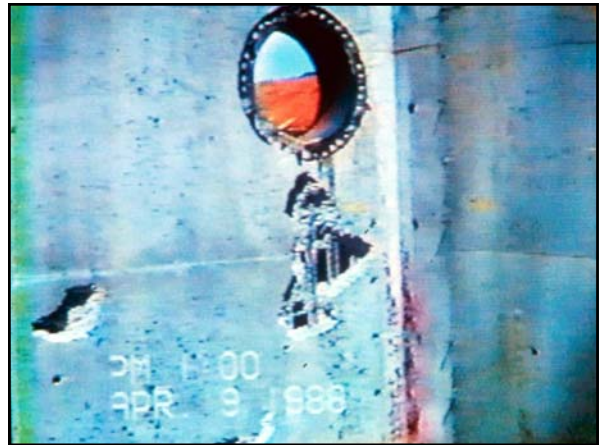
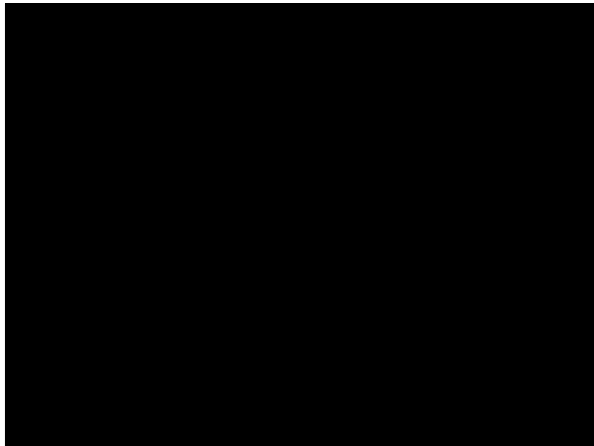
PCA
America's Cement Manufacturers™

Surface Defects- Efflorescence

- Deposit, usually white, formed on a surface, the substance having emerged in solution from within concrete or masonry and subsequently having been precipitated by evaporation.

9





PCA
America's Cement Manufacturers™

Surface (Internal?) Defects- Honeycombing

- Voids left in concrete due to failure of the mortar to effectively fill the spaces among course aggregate particles.

9





PCA
America's Cement Manufacturers™


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

1

PCA
America's Cement Manufacturers™

Questions?

Michelle L. Wilson
Director, Concrete Technology
Portland Cement Association
www.cement.org
847.972.9034 phone
mwilson@cement.org



1