Concrete Surface Defects: Causes, Prevention, and Cure.

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Portland Cement Association
• Founded in 1916
• Mission:
  To improve and extend the uses of portland cement and concrete.

Identify Processes or Materials Causing Distress or Failure
• Design- Constructability
• Materials Selection
• Mix Design
• Placement Procedures
• Environment

Identify Concrete Surface Defects
ACI 201.1 R
• Cracking
• Dusting
• Blisters
• Delaminations
• Crazing
• Popouts
• Mortar Flaking & Scaling
• Spalling
• Bugholes
• Cold Joint
• Discoloration
• Efflorescence
• Honeycombing (Internal?)

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

• When troubleshooting concrete problems it is important to relate the symptom to causes of distress and deterioration.
Observations on Cracking

- Surface Appearance
- Depth & Width of Cracking
- Current State of Activity
- Physical State of Concrete When Crack Occurred
- Structural Nature of the Crack

Depth of Cracking

Depth:
- Surface, Shallow, Deep, Through

Width of Cracking

Width:
- Fine generally less than 1 mm (0.04 in.)
- Medium between 1-2 mm (0.04-.08 in.)
- Wide over 2 mm (0.08 in.)

Surface Appearance

Pattern Cracks
- map cracks, crazing, checking, D-cracking

Individual Cracks (Isolated)
- diagonal, longitudinal, transverse, vertical, horizontal

Current State of Activity

- Active
- Dormant
Physical State of Concrete When Cracking Occurred

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

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

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

Physical State of Concrete When Cracking Occurred

After Hardening
- Structural
  - Accidental Overload
  - Creep
  - Design Loads
Subsidence

Drying Shrinkage

Thermal Shrinkage
Repair Approach - Cracking

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

Water Condition

Strengthening Required?

None

Major

Minor

• Injection (epoxy)
• Stitching
• Post-tensionning
• Reinforcement
• Autogenous healing

Active Cracks

Isolated Cracks

Strengthening Required?

Yes

No

• Injection (epoxy)
• Routing & sealing
• Bonded overlay
• Autogenous healing
• Judicious neglect

Pattern Cracks

Strengthening Required?

Improbable Occurrence

Yes

No

• Injection (epoxy or polyurethane)
• Routing & sealing
• Bonded overlay
• Autogenous healing
• Judicious neglect

Dormant Cracks

Isolated Cracks

Strengthening Required?

Yes

No

• Injection (epoxy or polyurethane)
• Routing & sealing
• Dry packing
• Grouting (cement-based)
• Autogenous healing
• Judicious neglect

• Injection (epoxy)
• Routing & sealing
• Flexible sealing
• Drilling & plugging
• Grouting (cement-based)
• Autogenous healing
• Judicious neglect

• Injection (polyurethane)
• Flexible sealing

• Post-tensionning
• Drilling & plugging
• Injection (polyurethane or flexible epoxy)
**Concrete Surface Defects**

1. **Active Cracks**
   - Pattern cracks
   - Yes: Strengthening Required
   - No: Unbonded Overlay

2. **Surface Defects - Dusting**
   - Development of a fine, powdery material at the surface of hardened concrete.

**Textual Content**
- Improbable
- Occurrence
- Post-tensioning
- Overlay

**Image Description**
- Finger with dusting material
- Person applying material to concrete surface
**Use Ventilated Heaters**

**Surface Defects - Blistering**
- The irregular raising of a thin layer at the surface of placed mortar or concrete during or soon after completion of the finishing operation.

**Blisters**
Causes:
- Too many fines
- Too much or too little vibration
- Early finishing
**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

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**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

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**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.
Sealing The Surface

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

Surface Defects - Crazing

- Fine, random cracks or fissures in the surface of plaster, cement paste, mortar, or concrete.
Crazing
Causes:
• Rapid surface drying after setting
• Applying dry cement to surface during finishing
Surface Defects - Popouts

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

Popouts

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

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
Surface Defects - Mortar Flaking

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

Surface Defects - Scaling

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

**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.
Surface Defects - Discoloration

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

Surface Defects - Staining

- Spotted or mottled light or dark blotches.
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.
Surface (Internal?) Defects - Honeycombing

- Voids left in concrete due to failure of the mortar to effectively fill the spaces among course aggregate particles.
When troubleshooting concrete problems it is important to relate the symptom to causes of distress and deterioration.

Questions?

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