DIAGNOSIS AND PREVENTION OF SURFACE IMPERFECTIONS

Claude Goguen, PE, LEED AP
National Precast Concrete Association

IMPERFECTION
a fault, blemish, or undesirable feature.
the state of being faulty or incomplete.

CONCRETE SURFACE
Concrete is a natural product, so an as-cast finish will have some imperfections.
The question is:
What is acceptable?

DEPENDS ON APPLICATION?

SURFACE ISSUES
• Cracking
• Honeycombing
• Bugholes
• Efflorescence
• Discoloration
• Delamination
• Scaling
• Pop Outs
SURFACE ISSUES

- Cracking
- Honeycombing Most common in precast.
- Bubholes
- Efflorescence
- Delamination
- Crazing
- Scaling
- Pop Outs

CRACKING

PLASTIC SHRINKAGE CRACKING

- Occurs on the surface of fresh concrete while it is still plastic
- Short cracks spaced a few inches to 10 feet apart
- Rarely extend to edges
PLASTIC SHRINKAGE CRACKING

CAUSES:
• Windy, low humidity conditions, high temperature that causes rapid surface moisture evaporation.
• Surface shrinks faster than concrete interior
• Stresses develop that exceed the concrete’s tensile strength.
• Silica Fume concrete susceptible
PLASTIC SHRINKAGE CRACKING

- Optimize aggregate gradation to minimize paste content
- Use low water to cementitious ratio
- Prevent rapid loss of surface moisture
- Use fiber reinforcing

DRYING SHRINKAGE CRACKING

- Occurs on the surface of hardened concrete
- Concrete shrinks due to drying (1/16” in 10 feet)
- Due to restraint

DRYING SHRINKAGE CRACKING

- Loss of excess water
- Increases in sand content
- Use of high shrinkage aggregates
- Improper curing

DRYING SHRINKAGE CRACKING

- Low water content
- Increase coarse aggregate content
- Optimize aggregate gradation to minimize paste
- Thorough curing
- Shrinkage reducing admixtures
OTHER TYPES OF CRACKING

- Thermal cracking
- Settlement cracking
- Freeze Thaw
- Alkali Aggregate Reactivity
- Sulfate Attack
- Corrosion of reinforcing

THERMAL CRACKING

CAUSES
- Excess temperature differential within concrete
- Using cold formwork
- Casting in cold temperatures

REMEDIES
- Use cold weather practices when needed
- Warm formwork
- Watch concrete temps when steam curing

SETTLEMENT CRACKING

DEFORMATION CAUSE BY TENSILE STRESSES OVER A RESTRAINT

Figure 2: Schematic representation of plate settlement crack formation
### SETTLEMENT CRACKING

**CAUSES**
- Excess water content
- Excessive bleeding
- Inadequate cover

**REMEDIES**
- Control excessive bleeding
- Low water content
- Adequate cover over reinforcing
- Vibration

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### FREEZE THAW CRACKING

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### ALKALI AGGREGATE CRACKING

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### SULFATE ATTACK CRACKING

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### CORROSION REINFORCING CRACKING
AND CRACKS CAN ALSO BE CAUSED BY...

AND CRACKS CAN ALSO BE CAUSED BY...

HONEYCOMBING

Lack of mortar between coarse aggregates

CAUSES
• Concrete too stiff and unworkable
• Improper consolidation
• Leaky forms
• Congested reinforcing
• Improper placement of concrete

REMEDIES
• Increase fineness of aggregates
• Proper consolidation
• Fix forms
• Proper placement - training
• Use water reducer

HONEYCOMBING

Lack of mortar between coarse aggregates
Can be due to:
- Entrapped Air
- Free Water
BUGHOLES

Air can be entrapped in concrete in two ways:

- Paste can’t fill all voids between aggregates
- Entrapped during mixing and placing of concrete

Free water

- Excess not needed for hydration or absorbed by aggregates
- Not evacuated by bleeding

CAUSES

- Excessive water in concrete
- Improper/lack of vibration
- Over application or type of form release
- Improper placement of concrete
- Sand with low fines

Form Release

- 2 types:
  - Barrier
  - Reactive
  - Combination of both

PREVENTION

- Redesign mix (increase fines)
- Use SCC
- Apply form release properly
- Use a VMA
- Ensure proper vibration
- Proper concrete placement

Form Release

Less is better!!
**Bugholes**

SCC
- Use a VMA
- Minimize splashing

**Efflorescence**

Not...

Or....
EFFLORESCENCE

- A deposit of salts, usually white, formed on a surface, the substance having emerged in solution from within either concrete or masonry and subsequently been precipitated by reaction, such as carbonation, or evaporation. ACI 116R

- Conditions for Efflorescence
  - There must be soluble salts available.
  - There must be a source of water that is in contact with the salts, forming a salt solution.
  - There must be a pathway for the salt solution to migrate to the surface and evaporate.
  All three of these conditions must exist for efflorescence to occur.

EFFLORESCENCE

REMEDIES

- Mix Design
  - Low alkali cement, use SCM, low(er) w/c, well graded aggregate, use efflorescence controlling admixture

- Curing
  - Insure strength and density before subject to weathering

- Storage
  - Protect from extraneous water for as long as possible
  - Good air circulation around pieces

DISCOLORATION

Factors that affect color
- Cementitious materials
- Aggregates
- Admixtures
- Water content
- Batching
- Curing
- Finish/Surface texture
- Efflorescence

Every mix component as well as other outside influences!!

DISCOLORATION

- Variation in materials, dosing, finishing and curing are the main causes for discoloration
- Key to uniform color is consistency in the entire process….materials → delivery
DELAMINATION

CAUSES
- Premature Sealing of the Concrete Surface
- Rapid Evaporation of Bleed Water
- Placement of Concrete against cool form
- High Percentage of Entrained Air

REMEDIES
- Ensure proper air content
- Accelerator or heated concrete
- Delay finishing

SCALING

CAUSES
Improper Use of Finishing Tools
- Premature Sealing of the Concrete Surface
- Over-finishing
- Excessively Wet Concrete
- Lack of Proper Air Void System

REMEDIES
- Ensure proper air content
- Proper finishing
- Careful with deicing salts

POP OUTS

CAUSES
- Poor quality aggregates
- Improper finishing
- Rapid moisture loss at surface

REMEDIES
- Stronger concrete
- Air entraining
- Low slump concrete
- Proper finishing
SURFACE ISSUES

• Cracking
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GENERAL BEST PRACTICES

• Consistency, consistency, consistency!
• Low water content
• Training
• Thorough QC program
• Effective root cause analysis

QUESTIONS

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