Avoiding Surface Defects on Exterior Slabs

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Causes of Surface Defects

1. Premature finishing
   a. Finishing bleed water, added water or rain water into the surface
      Creates soft, weak surface prone to premature wear and scaling
   a. Trapping bleed water and air beneath surface
      Creates weak zone beneath surface - top surface prone to scaling

2. Overworking the surface (especially wet concrete)
   a. Damages the air void system along the top surface
      Reduces freeze/thaw resistance – increases risk of scaling

3. Late Finishing
   May not achieve desired surface texture

4. Inadequate Curing
   Plastic shrinkage cracking
   Surface crusting
   Mortar flaking
   Premature surface wear and increases risk of scaling

Surface Scaling

Popouts

Mortar Flaking

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“Skin Failure” Due to Improper Finishing

“Meat Failure”
Deterioration goes deeper than surface or skin

Inadequate Air Entrainment

Scaling Causes
1. High w/cm ratios - too much water
2. Inadequate air void system
3. Improper finishing
   - finishing water into top surface
   - trapping bleed water
   - overworking of wet concrete
4. Inadequate curing & air drying
5. Exposure
   - deicing chemicals
   - poor drainage
   - early age freezing & thawing

Damage caused by water, freezing and thawing.

Drainage ?

Effects of Deicing Chemicals
1. Increases degree of surface saturation
2. Exacerbates effects of osmotic & hydraulic pressures within pore structure
3. Increases the number of freeze-thaw cycles
4. Thermal shock
5. Layer by layer freezing due to salt gradients
6. Possible salt crystal growth in pore structure

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Reducing Water Content ...

- Increases strength
- Lowers permeability
- Increases resistance to weathering & wear
- Reduces drying shrinkage & cracking

As w/cm increases, void spaces increase reducing strength & porosity

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International Building Code (IBC) Mix Requirements

<table>
<thead>
<tr>
<th>Exposure Condition</th>
<th>Max. w/cm ratio</th>
<th>Min. f’c (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete intended to have low permeability when exposed to water</td>
<td>0.50</td>
<td>4,000</td>
</tr>
<tr>
<td>Concrete exposed to freezing &amp; thawing in a moist condition or to deicing chemicals</td>
<td>0.45</td>
<td>4,500</td>
</tr>
<tr>
<td>For corrosion protection of reinforcement in concrete exposed to chlorides from deicing chemicals, salt, salt water, seawater, or spray from these sources</td>
<td>0.40</td>
<td>5,000</td>
</tr>
</tbody>
</table>

Entrained Air Bubbles

Freezing Water Causes Hydraulic Pressures

Water & Ice

Entrained air bubbles

Interconnecting channels

Porosity of Paste

Air dry concrete Drainage

Number of Bubbles

Size of Bubbles

Distance Between Bubbles

Hydraulic Pressures Create Micro Cracks

Total Air Content for Frost Resistant Concrete (IBC, ACI)

<table>
<thead>
<tr>
<th>Max. Aggregate Size (inch)</th>
<th>Air Content, percent*</th>
<th>Severe exposure</th>
<th>Moderate exposure</th>
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</thead>
<tbody>
<tr>
<td>3/8</td>
<td>7.5</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>1/2</td>
<td>7.0</td>
<td>5.5</td>
<td></td>
</tr>
<tr>
<td>3/4</td>
<td>6.0</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>6.0</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>1½</td>
<td>5.5</td>
<td>4.5</td>
<td></td>
</tr>
</tbody>
</table>

* Tolerance = ± 1½% (or consider -1.0% & 2.0%)

Adequate Air-entrainment

Air Void System
1. Amount of air voids
2. Spacing factor
3. Size of the bubble

Provides freeze/thaw resistance by providing means to relieve hydraulic pressure

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Petrographic Analysis

Air void analysis
- total air content
- spacing factor
- bubble size

w/cm ratio
- at surface vs. body

Finishing defects
- premature finishing
- soft surface from adding water or finishing bleedwater into surface
- overworking surface

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Don’t add water to surface!

Premature Wear Due to Soft Surface

Poor curing and failure to protect surface from evaporation can also cause weak and soft surface.

How to Handle Rained-on Concrete Pavements

- **Wait** – Don’t place concrete if chance of rain or thunderstorm
- **Cover** - Try to protect
- **Sit in truck** - Hope for the best!

Do **NOT** Finish Rainwater Into Concrete Surface

1. **Remove Rainwater**
   - Broom, squeegee, use air compressor or water hose to remove surface water
2. **Repair Surface**
   - Bull float or float surface to remove damage
   - Don’t finish rainwater into surface

Common Hand-finishing Tools
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Common Finishing Tools
- Bull Float (Magnesium, Resin, or Wood)
- Darby
- Highway Straightedge
- Fresno (Spring Steel Trowel)
- Bump Cutter
- Edger
- Jointer
- Steel Trowels
- Rubber Float

Do not use steel tools on air entrained concrete.

Use magnesium floats, do not use fresno or steel trowels.

Wait until bleeding has stopped and bleedwater has evaporated. Do not overwork wet surface.

Float and broom after bleeding stops

Power Floating?
What about the air entrainment along top surface?
What about the angle of the float blades?
Ok, if concrete is not exposed to winter conditions

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Use caution with vibratory screeds. Excessive vibration can bring too much paste to surface and may damage the microscopic air bubbles reducing the scale resistance of the concrete.

What about the angle of this bull float?

Minimize hand finishing of slipform curb and gutter.

Evaporation Retarders

- Spray on between finishing operations
- Retards surface evaporation
- Doesn't interfere with finishing operations
- Don't use as finishing aid
- Typically mixed 1 part ER to 9 parts water
- Don't mix into top surface

Proper Curing

Increases …

- Strength
- Watertightness
- Abrasion resistance
- Freeze-thaw resistance
- Resistance to effects of deicing chemicals
- Volume stability

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Curing

- Moist Curing, Fogging
- Plastic Sheeting
- Insulation Blankets
- Curing Compounds

Spray-on Curing Compounds

Need 30 days of air drying before exposed to freezing & thawing.

Spray-on curing compounds typically last 60 to 90 days.
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Late Fall Curing Options

1. Use sheet (plastic) or insulation blankets for 7 days; air dry for 21 days; optional - apply silane or siloxane penetrating water repellent
2. Use exterior grade spray-on cure/sealer

Apply Silane or Siloxane Water Repellent

Checklist for Finishing Ext. Concrete

- Use 4,500 psi concrete (max. w/cm = 0.45)
- Use properly air entrained concrete (6% ± 1.5% air for ¾” rock)
- Don’t exceed max. w/cm when adjusting slump
- Don’t retemper (add water after discharging part of load)
- Don’t spray water on surface during finishing
- Don’t finish bleed or rain water into surface
- Don’t overwork surface & damage microscopic air bubbles
- Don’t finish too soon or trap bleed water below surface
- Use proper finishing procedure & don’t prematurely seal surface (keep tools flat as possible, avoid using steel tools)
- Protect surface from rapid and early moisture loss
- Cure & protect from early freezing
- Provide drainage – minimize exposure
- Consider using a silane, siloxane or a cure/seal material

For new concrete...

1. Specify a max. w/cm ratio of 0.45
2. Specify a min. concrete strength of 4,500 psi
3. Specify total air of 6% ± 1.5% air for ¾” rock
4. Specify drainage slopes (1% min., 2% preferred)
5. Specify no steel finishing tools for exterior slabs
6. Specify and enforce curing requirements
7. Consider special curing for late fall placements
8. Consider using silane, siloxane or cure/sealer
9. Don’t use deicing chemicals 1st winter – used sand
10. Contractor’s warranty?

For existing concrete...

1. Have a snow removal plan
   a) Remove snow totally from concrete
   b) Do not allow snow melt to drain across concrete
   c) Gutters and roof drains?
2. Minimize use of deicing chemicals
   a) Use sand for traction – not deicing chemicals
   b) Premix sand and deicing chemicals together for workers to use
3. Correct poor drainage areas
   a) Good drainage is key factor for reducing risk of scaling
4. Use silane or siloxane sealers
   a) Remember water is the enemy!
   b) Should be applied every 4 to 6 years

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