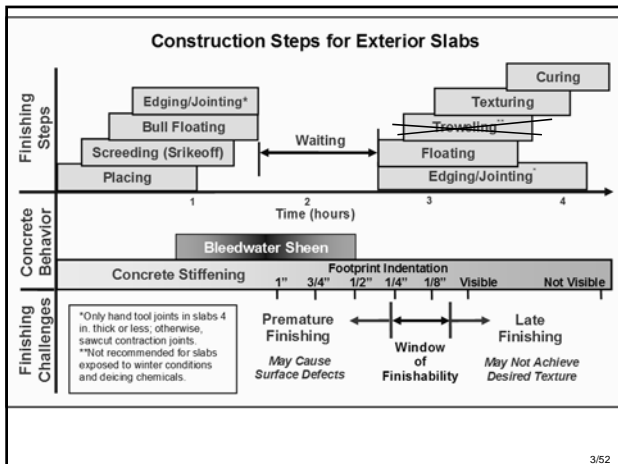


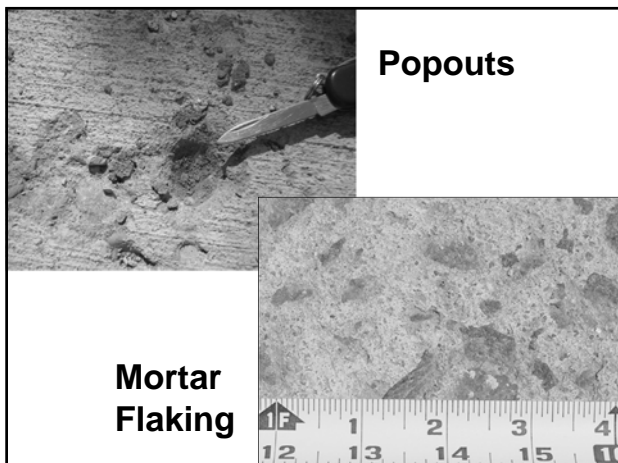
**Causes of Surface Defects**

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 bleedwater 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*

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**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

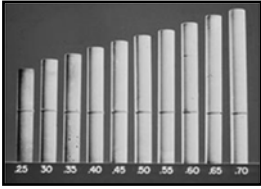
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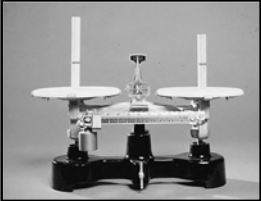
**Effects of Deicing Chemicals**

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

### 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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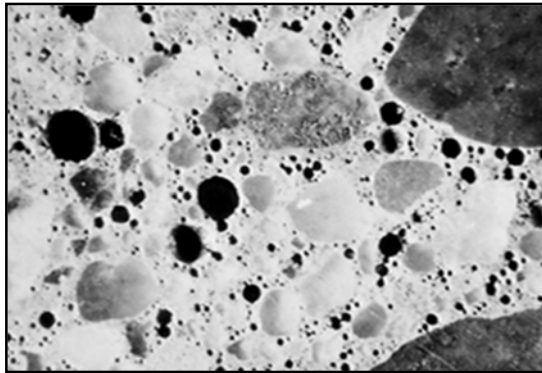
### International Building Code (IBC)

#### Mix Requirements

Exposure Condition (from ACI 318 Building Code)	Max. w/cm ratio	Min. f'c (psi)
Concrete intended to have low permeability when exposed to water	0.50	4,000
Concrete exposed to freezing & thawing in a moist condition or to deicing chemicals	0.45	4,500
For corrosion protection of reinforcement in concrete exposed to chlorides from deicing chemicals, salt, salt water, seawater, or spray from these sources	0.40	5,000

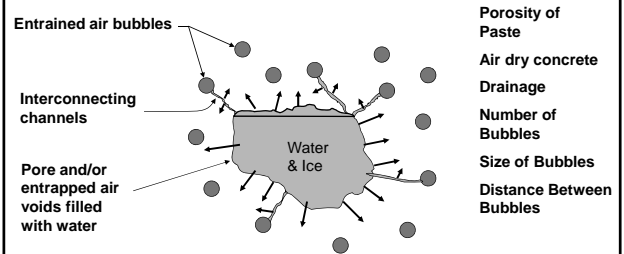
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### Entrained Air Bubbles



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### Freezing Water Causes Hydraulic Pressures



Hydraulic Pressures Create Micro Cracks

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

Max. Aggregate Size (inch)	Air Content, percent*	
	Severe exposure	Moderate exposure
3/8	7.5	6.0
1/2	7.0	5.5
3/4	6.0	5.0
1	6.0	4.5
1 1/2	5.5	4.5

\* Tolerance = ± 1 1/2 % (or consider -1.0% & 2.0%)

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### 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

Water → Ice → 9% Expansion → Entrained Air → Relieve

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### Petrographic Analysis

**Air void analysis**


- total air content
- spacing factor
- bubble size

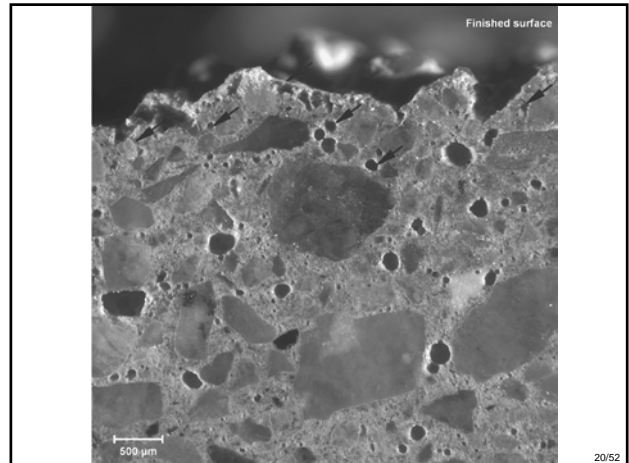
**w/cm ratio**

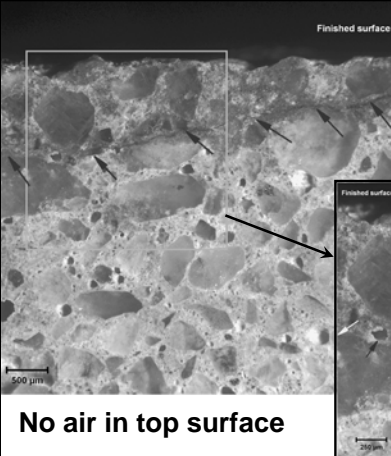
- at surface vs. body

**Finishing defects**

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

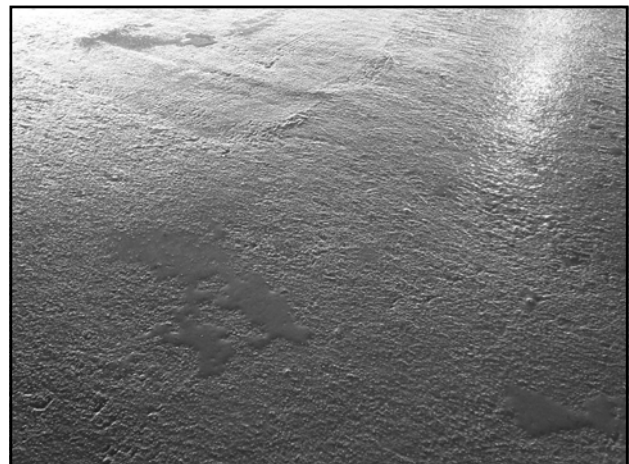






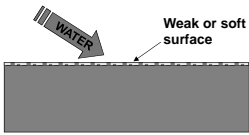
**Overworking wet concrete**

**No air in top surface**



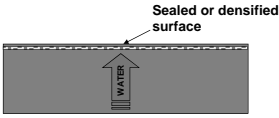
### Adding & Trapping Water

**Finishing Water into Surface**



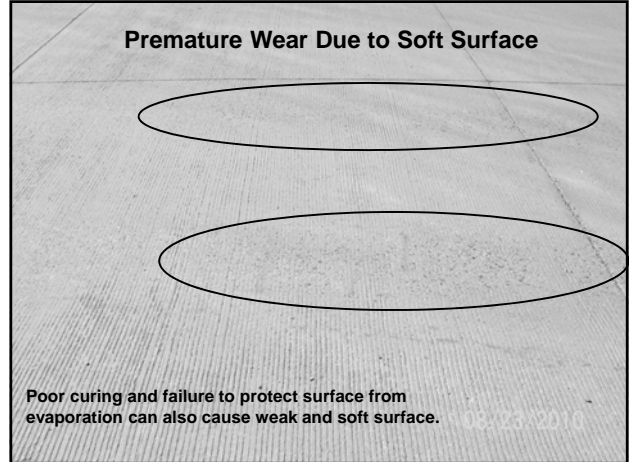
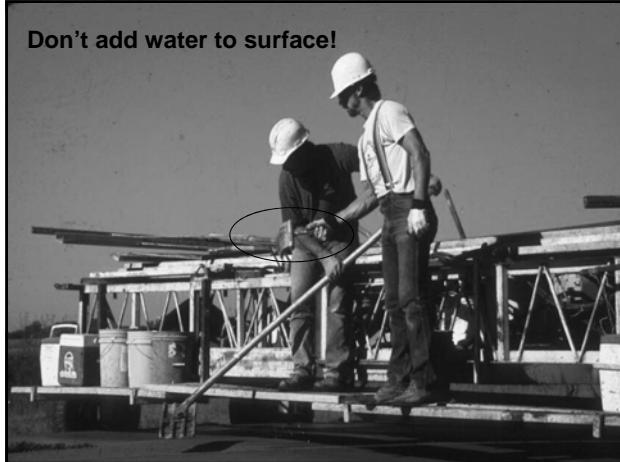
Weak or soft surface

**Trapping Bleed Water & Air Beneath Surface**



Sealed or densified surface

### Scaling & Delaminations



### How to Handle Rained-on Concrete Pavements

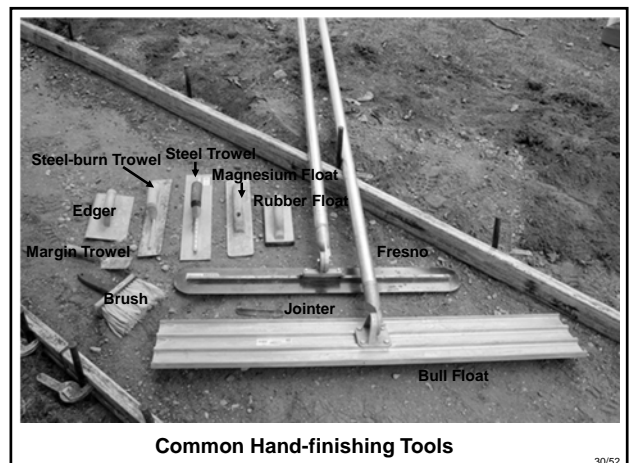
- **Wait** – Don't place concrete if chance of rain or thunderstorm
- **Cover**- Try to protect
- **Sit in truck** - Hope for the best!

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### 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

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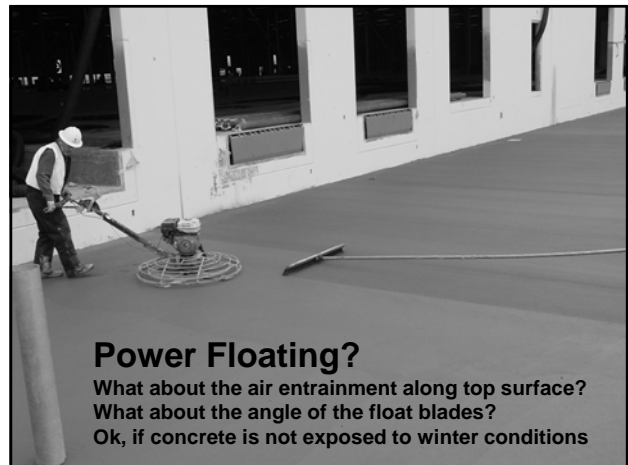
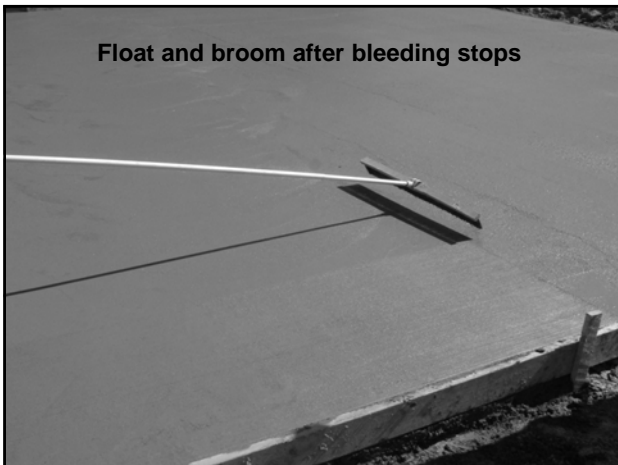
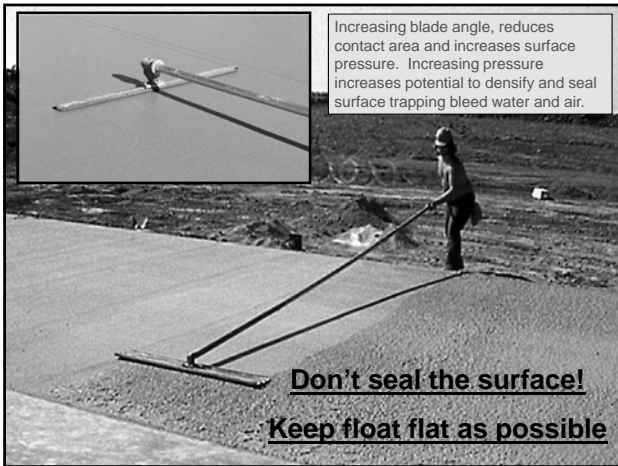


Common Finishing Tools

- 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.

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**Plastic Shrinkage Cracking**

Wind  
Humidity  
Air Temp.

Surface Evaporation  
Shrinkage  
Bleed Water

Concrete Temperature (Set times)

Occurs while concrete is plastic: 1 to 6 hours

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**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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## Late Fall Curing Options

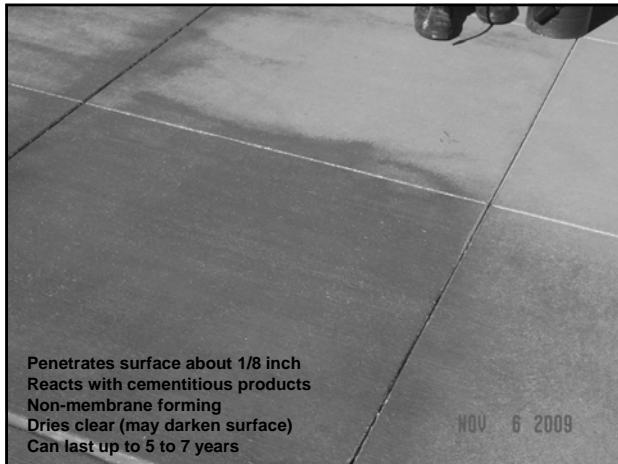
1. Use sheet (plastic) or insulation blankets for 7 days; air dry for 21 days; optional - apply silane or siloxane penetrating water repellent
2. Use exterior grade spray-on cure/sealer

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## Avoiding Surface Defects on Exterior Slabs



Apply Silane or Siloxane Water Repellent



Penetrates surface about 1/8 inch  
 Reacts with cementitious products  
 Non-membrane forming  
 Dries clear (may darken surface)  
 Can last up to 5 to 7 years

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## 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

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The Owner's Circle

## 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 1<sup>st</sup> winter – used sand
10. Contractor's warranty?

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The Owner's Circle

## 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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