

### Type II Cement (PLC) Concrete

w/wo Supplementary Cementitious Materials (SCMs)

- **Type II Cement or Portland-Limestone Cement (PLC)**
  - ASTM C595/C595M blended cement with 5% to 15% limestone (8% & 14%)
  - Perform similarly to Type I or I/II Cements (OPCs) but offer more sustainability advantages
    - *Similarly* – resembling without being identical
- **SCMs: fly ash, slag cement, silica fume, natural pozzolans**
  - Supplementary cementing materials (SCMs) that in conjunction with portland or blended cements contribute to the properties of concrete through hydraulic or pozzolanic activity or both
    - **Hydraulic** – react chemically with water to cementitious compounds
    - **Pozzolan** – chemically reacts with calcium hydroxides to form calcium silicate hydrate (CSH)

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### Potential Finishing Issues Associated with PLC Concrete w/wo SCMs

- **Unacceptable final finish or surface distress including:**
  - Early surface crusting
  - Soft, weak, and absorptive surfaces
  - Surface delaminations
  - Excessive crazing
  - Early age cracking

} Delayed bleeding & reduced bleed capacity compared to OPC

- **Potentially slower early-age strength gain than OPC...**
  - Delayed finishing but not delayed moisture loss and shrinkage
  - Delayed saw cutting contraction joints increases risk of random slab (out-of-joint) cracking
  - Delayed final curing increases risk of plastic and early-age shrinkage cracking

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### Bleed Rate & Capacity

#### Function of ...

- Water content and w/cm ratio
- Cementitious materials content
- Fineness of the cementitious materials
- Inclusion of SCM and quantity of SCMs
- **Setting characterizes of cementitious materials**
- **Chemical admixtures – air entrainers creating microscopic air bubbles & retarders & water reducers (super plasticizers)**
- Gradation and shape of the fine aggregates
- Vibration for consolidation (enhances settlement of heavy particles)
- Placement heights
- Temperature of concrete (setting characteristics)

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### These will reduce bleed rate & capacity

1. Reducing water content and w/cm ratio
2. Increasing cementitious materials content
3. Using finer cementitious materials
4. Using blended hydraulic cement including Type II Cement (PLC)
5. Using SCMs (fly ash, slag cement, silica fume, etc.)
6. Increasing amount of SCMs
7. Increasing quantity of fines in the sand
8. Using chemical admixtures that reduce water content & w/cm ratio (Need to offset higher water demand of PLC concretes. PLC may increase water demand 1 to 3 gal/cuyd to maintain slump as compared to OPC Concrete.)
9. Using air-entrained concrete (micro-bubbles block rising water)

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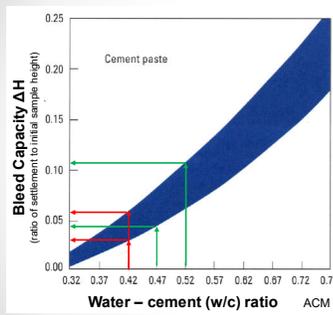


### Does bleeding have a purpose?

## YES

- o Keeps surface from prematurely drying to avoid sticky surfaces, plastic shrinkage cracks, crusting, and early-age shrinkage cracks.
- o Keeps the surface paste mobile and lubricates the finishing tools to avoid tearing of surface.

### W/C Ratio vs Bleed Capacity



ACI 302.1-15, Section 8.4.4 recommends w/cm from 0.47 to 0.52 for interior troweled slabs

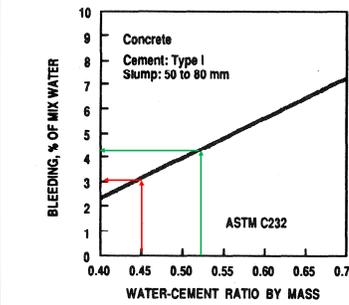
What about interior steel-troweled slabs where specifications set a maximum w/cm less than 0.47.... say 0.42 or less?

Concrete with w/cm less than about 0.47 with PLC and SCMs at risk for rapid surface drying including crusting, crazing, etc.

Ref. Design & Control of Concrete Mixtures 17<sup>th</sup> Ed, ACM (PCA), p166, Fig. 9-7

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### Bleeding % of Mix Water VS W/C Ratio



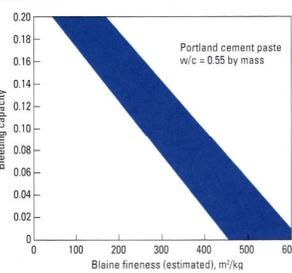
Increasing water content increases both bleeding rate and capacity.

Increasing the mix water by 1/5 increases can increase the bleed rate by as much as 2.5 times.

Ref. Kosmatka, S. H., Bleed Water, PCA R&D Serial No 2973, 2006

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### Blaine Fineness vs Bleed Capacity



Portland cement paste w/c = 0.55 by mass

Blaine Fineness – indirect method to measure surface area of cementitious particles per unit mass

Higher Blaine Fineness means finer cements with smaller individual cement particles (PLC can increase water demand 1 to 3 gal/cuyd)

**Type I Cement**  
Mean Blaine Fineness – 397 m<sup>2</sup>/kg  
Range 375 - 440

**Type II Cement (PLC)**  
Mean Blaine Fineness - 479 m<sup>2</sup>/kg  
Range 409 – 660

**Slag Cements**  
Range 350 to 650 m<sup>2</sup>/kg or higher

**Fly Ashes**  
Range 170 to 1000 m<sup>2</sup>/kg

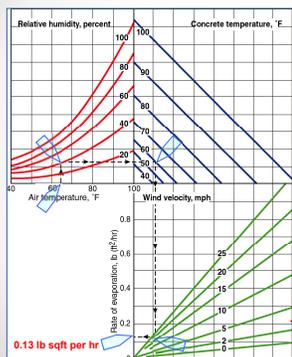
**Silica Fume**  
Range 450 to 20,000 m<sup>2</sup>/kg

So, what does this mean?  
As the Blaine Fineness increases, less bleed water (rate & capacity).

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### Evaporation Chart

Estimates surface evaporation potential for jobsite conditions.



**Instructions**

1. Air temperature (65F)
2. Relative humidity (40%)
3. Concrete temperature (60F)
4. Wind velocity (20 mph)
5. Read evaporation rate

0.13 lb sqft per hr

When evaporation exceeds 0.2 lbs(sqft/hr), take precautions.  
[ 0.05, 0.10, 0.15 also used - check specifications ]

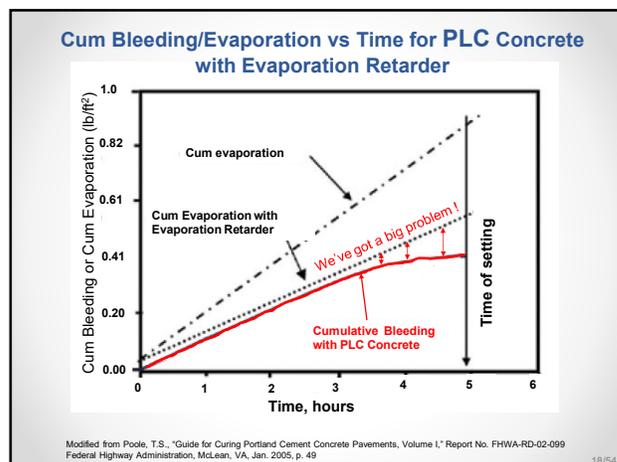
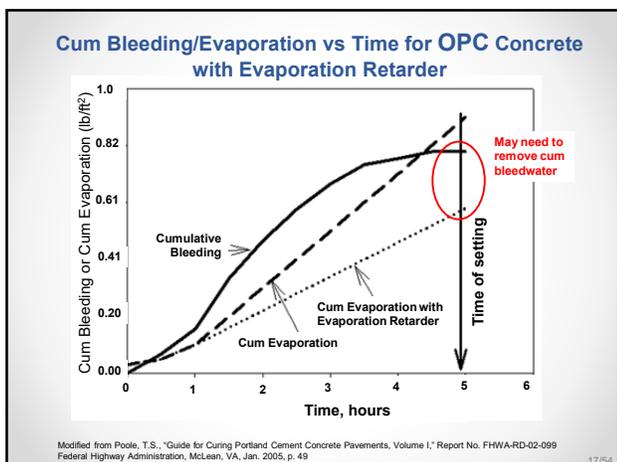
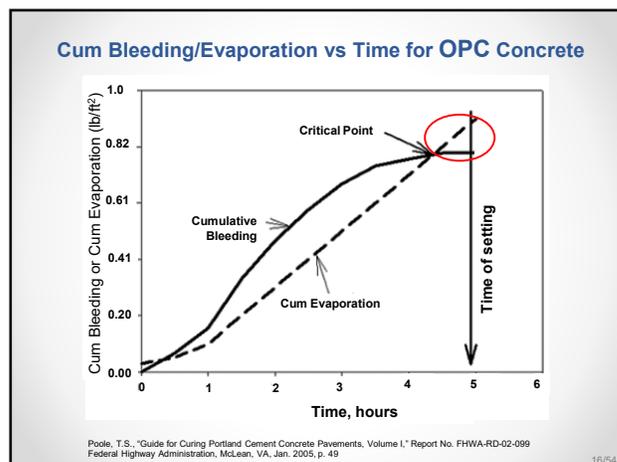
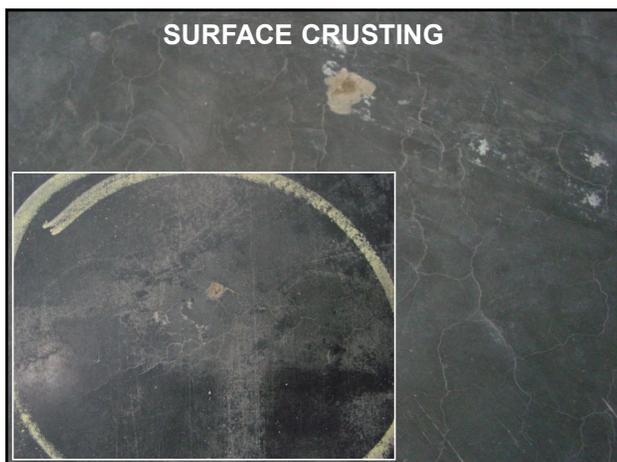
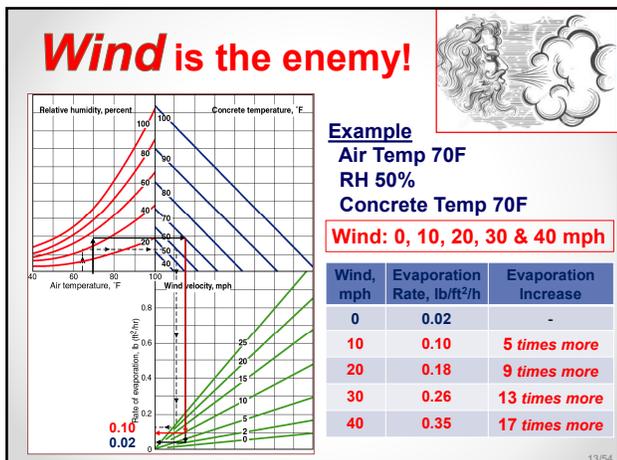
For PLC use 0.05 lbs/sqft/hr

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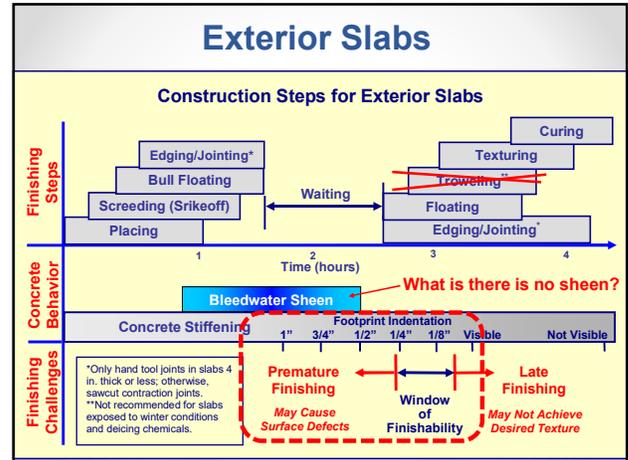
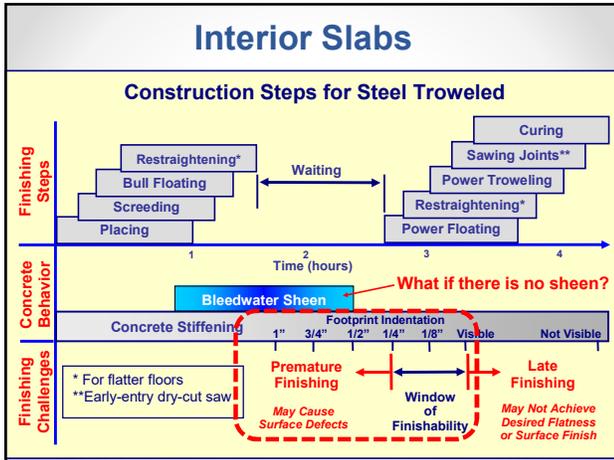
# Life with Type II: Cement in Practice

Sponsored by Central PreMix & Inland Asphalt Co

# Best Finishing Practices for PLC Concrete w/wo SCMs



Kim Basham, PhD, PE, SE(UT), FACI  
 KB Engineering, LLC  
 kbasham@KBEngLLC.com



## Adding & Trapping Water

**Finishing Water into Surface**

**Trapping Bleed Water & Air Beneath Surface**

### Scaling & Delaminations

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## Do NOT Finish Bleedwater, Rainwater or Added Water Into Concrete Surface

### Remove water from surface before floating and texturing

Use broom, squeegee, air compressor or water hose to remove surface water

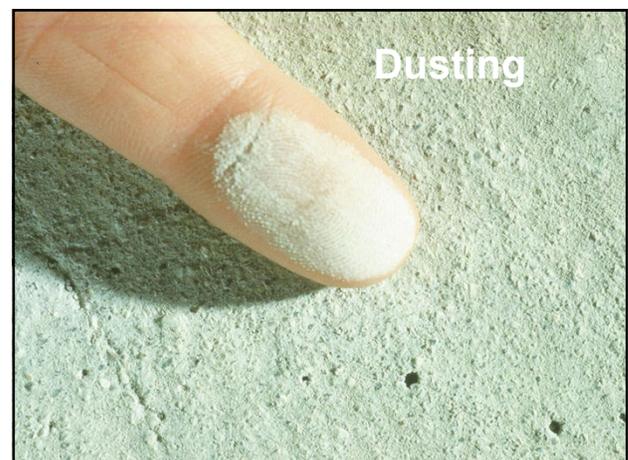
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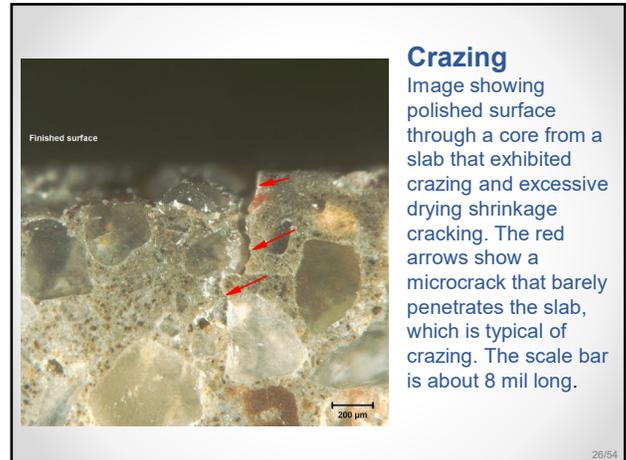
## Premature Wear

### Finishing water into Top Surface

A polished surface of a drilled core where the red bar measures depth of paste affected by finishing. The yellow arrow highlights white paste which resulted from finishing bleed water into the slab. The darker paste is typical densification that results from hard troweling. **The lighter or white paste areas will not be wear resistant.**

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### Do NOT Trap Rising Bleed Water and Entrapped Air Below Surface

- Trapping rising bleed water below the surface is classified as improper or premature finishing
- Recall the **waiting period**? What are we waiting for? Waiting for the bleed water sheen (accumulated surface water) to dissipate and concrete to *stiffen by hydration* – *not surface drying*.
- What is there is not visible bleedwater sheen?

***This is the great finishing challenge.***

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### Trapping Water & Air Beneath Surface

#### Delamination

Trapping bleed water and air by prematurely sealing the top surface of the concrete typically results in surface delamination.

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**For concretes with reduced bleeding & delayed strength gain (PLC & SCMs), Do NOT Manipulate Surface Paste During Bleeding Period**

- Mixing rising bleed water into top surface zones create zones with high w/cm ratios & water voids
- Creates a soft, weak, & absorptive (non-durable surface)
- Steel Troweled Slabs** – creates weak surfaces, dusting, surface delaminations, & severe crazing
- Broomed Slabs** – creates soft, weak and absorptive surface prone to dusting, premature wear, mortar flaking & winter surface scaling
- Improper finishing can be identified by petrographer under a stereoscopic microscope, surface hardness testing and pH indicator due to carbonation*

### Field Observations

Soft Surface

Surface Scaling

Mohs Hardness

### Mohs Hardness

Mineral Name	Scale Number	Common Object
Diamond	10	Masonry Drill Bit (8.5)
Corundum	9	Steel Nail (6.5)
Topaz	8	
Quartz	7	Knife-Glass Plate (3.5)
Orthoclase	6	
Apatite	5	Copper Penny (3.5)
Fluorite	4	
Calcite	3	Fingernail (2.5)
Gypsum	2	
Talc	1	

**Mohs Hardness** – qualitative means to measure a mineral's (concrete's) resistance to scratching.

Typ. Concrete Mohs Scale No

- Soft & weak surface < 3
- Surfaces (broomed, etc.) 3 to 4
- Typ. Concrete (body) 5 to 7
- Steel Troweled Surface 7 to 9

### Petrographic Examination

Estimated w/cm ratio

- At surface, top zone vs. body

Finishing defects

**Premature finishing**

- Finishing accumulated bleed water or added water into top surface
- Trapping bleed water beneath a densified/sealed surface or crusted surface
- Soft, weak and absorptive surface caused by **manipulating top surface paste during the bleeding period** (mixes rising bleed water into top zone of concrete)

### Broomed Exterior PLC Concrete

Figure 5: Lighter colored paste above the yellow line is soft and absorptive, consistent with higher w/cm than the bulk of the concrete. The large irregularly shaped voids are entrapped air / water voids. Fine small spherical entrapped air voids are observed.

Figure 6: Thin section micrographs of the top region of C1 (control) and C2 are shown. Red arrows show examples of microscopic bleed channels. Bleed channels are rare in C1 and seldom reach the top surface. C2 contains abundant bleed channels and water lenses (yellow arrows). These polished light. Yellow epoxy fills open spaces.

### Soft Surface of PCL Concrete Confirmed by pH Indicator

Using a phenolphthalein (organic chemical indicator) that changes color based on pH of concrete.

- pH < 9.5 colorless** (carbonated concrete)
- pH > 9.5 pink to deep magenta** (no carbonation)

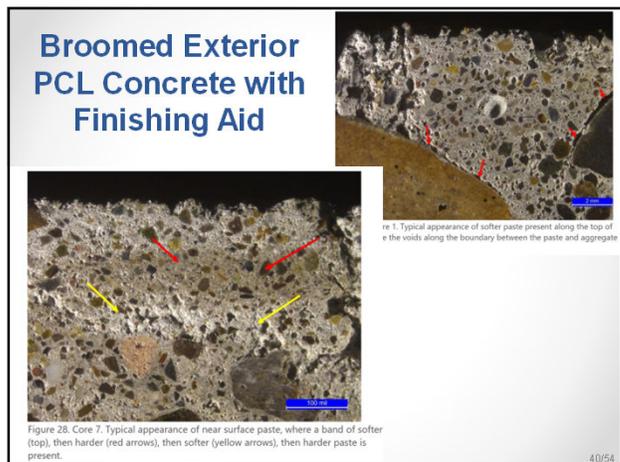
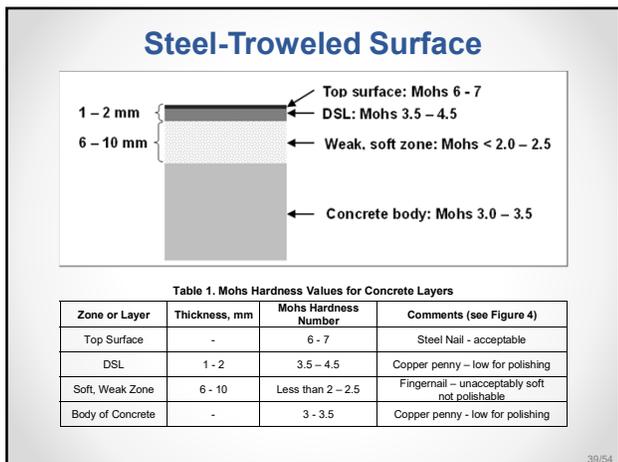
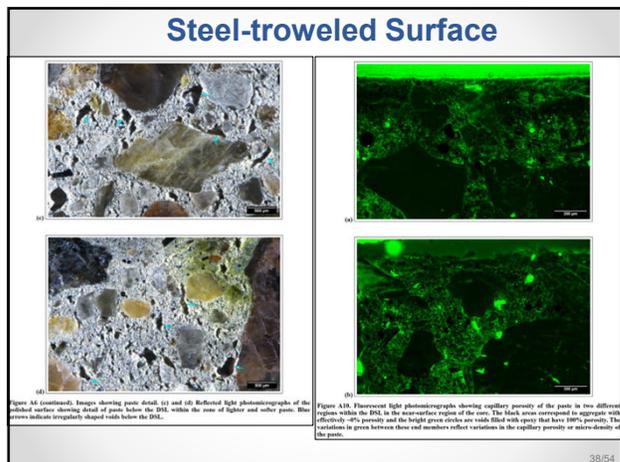
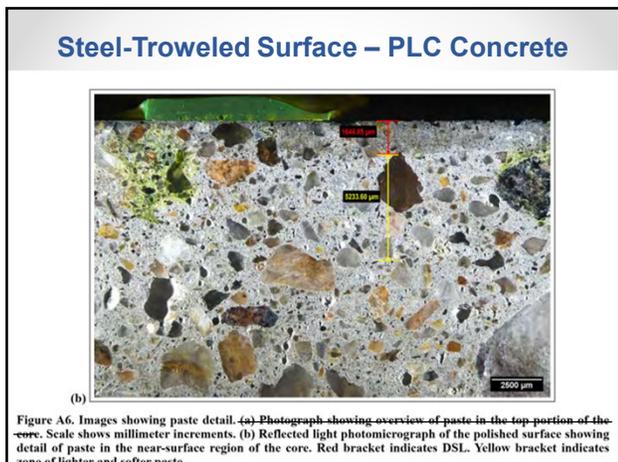
pH reduced by CO<sub>2</sub> from the atmosphere penetrating concrete & reacting with cement hydration products (calcium hydroxide)

Rate of Carbonation

- 1 to 2 mm/year for high-quality concrete
- >2 mm up to 5 mm/year for porous/low-quality concrete that allows CO<sub>2</sub> to penetrate concrete faster & deeper, f(w/cm & curing)

Core 1 sawcut surface

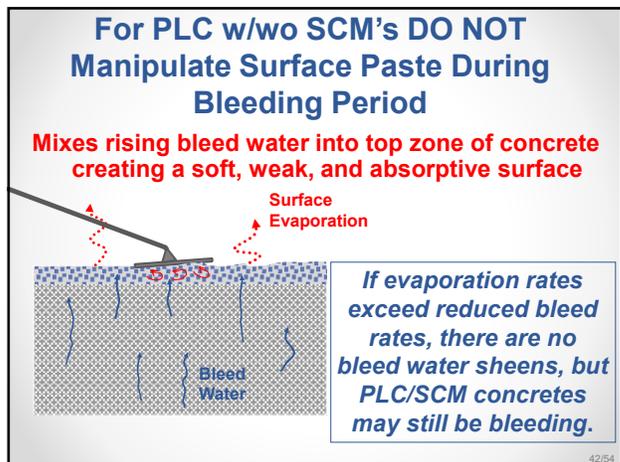
Core 3 fracture surface



**April 1941, Professor C. H. Scholer\* stated ...**

*There is every reason to believe that many of the bad results believed to have been due to overfinishing, late finishing, excess water, poor cement or other materials, etc. were really caused by the continued manipulation during the bleed period, and the resultant high water content of the upper layers of the concrete.*

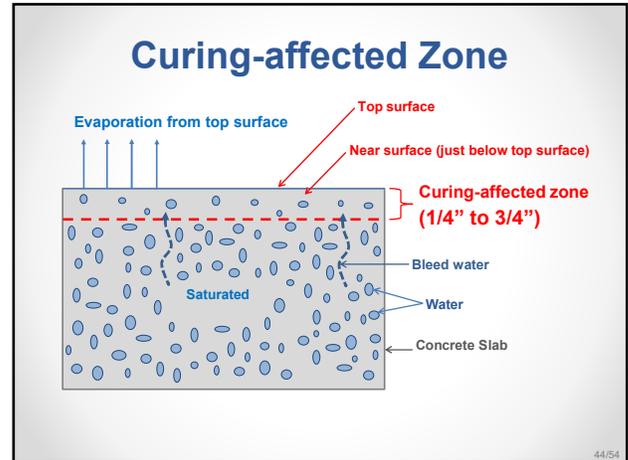
Ref: Scholer, C. H., *Consistent Inconsistencies in the Consistency of Concrete*, Journal of the American Concrete Institute, Vol. 37, April 1941 (\*Dept Head of Applied Mechanics, Kansas State College, Manhattan, KS)



### Improper Finishing & Curing

1. **Premature finishing**
  - a. Finishing bleed water, added water or rainwater into the surface  
*Creates soft, weak surface prone to premature wear and scaling*
  - b. Manipulating the surface paste during the bleeding period  
*Mixing in rising bleed water creates soft, weak & absorbent zone along top surface*
  - c. Trapping bleedwater and air beneath surface  
*Creates weak zone beneath surface - top surface prone to delamination & scaling*
2. **Overworking the surface** (especially wet concrete)
  - a. Ext. Flatwork - Damages the air void system along the top surface  
*Reduces freeze/thaw resistance – increases risk of scaling*
  - b. Int. Flatwork – Brings more fines to surface that can block rising bleedwater  
*Increases the potential for surface delaminations*
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 surface scaling*

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### Curing: Stages & Methods

Method	Stages of Curing		
	Initial	Intermediate	Final
Sunshades and windbreaks	●	●	
<b>Fogging</b>	●	●	
<b>Liquid-applied evaporation reducers</b>	●	●	
<b>Sprinkling with water</b>			●
<b>Ponding</b>			●
<b>Wet burlap, cotton mats and synthetic covers</b>			●
<b>Wet sand, straw or hay</b>			●
<b>Plastic sheeting or reinforced paper*</b>	●	●	●
<b>Liquid membrane-forming compounds</b>			●

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### Fogging

Prevents Premature Surface Drying

Keeps surface moist by reducing evaporation rate and replacing bleed water when evaporation rate exceeds bleed rate of concrete.

PCA

### Fogging

#### Fogging Cautions

1. Keep water droplets small to avoid surface damage from droplet impact
2. Minimize amount of accumulated water on surface
3. Careful on sloped surfaces to avoid runoff and erosion of plastic concrete
4. Stand upwind to fog surface
5. Allow accumulated water to evaporate before finishing

**Do NOT finish accumulated water into surface!**

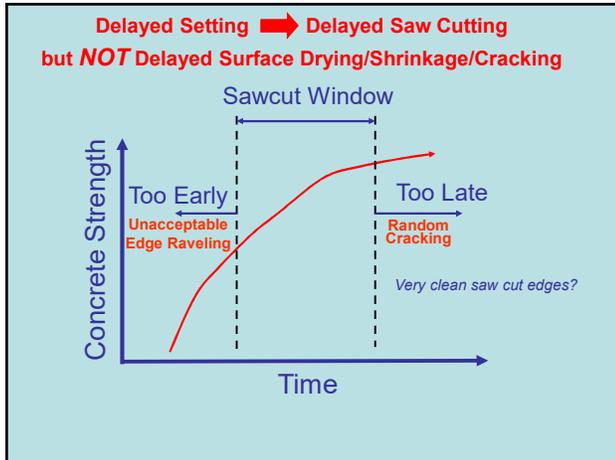
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### Evaporation Retarders

Prevents rapid moisture loss from surface

- Spray on between finishing operations (not cure compound)
- Forms a monomolecular film on surface that retards surface evaporation
- Doesn't interfere with finishing operations
- Apply as fine spray at recommended dosage rate
- **Don't mix into top surface**
- **Don't use as finishing aid**
- Typically mixed 1 part ER to 9 parts water

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- ### Best Practices for PLC w/wo SCMs
- ❑ Discuss **Setting and Bleeding Characteristics** of PLC Concrete w/wo SCMs with concrete supplier
  - ❑ Establish potential **Bleed Capacity** - review mix design for w/cm ratio, aggregate gradations and quantities, quantities & mill certs for PLC and SCMs (Compare Blaine Fineness Values)
  - ❑ Establish potential **Evaporation Rates** – reviewed weather forecast, time of concrete placement, expected jobsite conditions (consult evaporation chart)
  - ❑ Partner with concrete supplier to **Adjust Mix Design** to mitigate potential problems associated with reduce bleed rate & capacities, and potential delayed setting
  - ❑ **Develop a Plan** to mitigate the effects of delayed and reduced bleeding and premature surface drying
  - ❑ **Develop a Plan For Initial Curing** (fogging, evaporation retarder, other)
  - ❑ **Develop a Plan** to mitigate possible delayed setting, finishing, and saw cutting
  - ❑ **Adjust Timing of Finishing Steps** - **understand & recognize that PLC Concretes w/wo SCMs may still be bleeding** even if there is no accumulated bleed water on surface and firmness may be due to drying – not hydration.
  - ❑ **Do not miniplate the surface paste during the bleed period.**
  - ❑ **Place a Mockup Slab** using the mix, haul times, etc. same as jobsite conditions and evaluate performance. Adjust mix, **finishing steps and timing** as needed to produce a quality slab.

- ### Best Practices for Interior Concrete
- ❑ Order & place non-air-entrained concrete (3% max air)
  - ❑ Complete bull floating before bleed water sheen appears
  - ❑ For a flatter floor, restraighnten floor using a channel float, etc.
  - ❑ **Wait for the concrete to start setting ... not drying**
  - ❑ Don't finish accumulated bleed or rainwater into surface
  - ❑ **Don't miniplate surface paste during bleeding period**
  - ❑ Don't finish too soon or trap bleed water and escaping air below surface
  - ❑ Start floating (hand or power) with small blade angle
  - ❑ Always float before troweling – always!
  - ❑ Start troweling with small blade angle and slowly increase angle
  - ❑ Don't spray water on surface during finishing
  - ❑ Protect surface from rapid and early moisture loss
  - ❑ Cure (protect from moisture loss & freezing temperatures)

- ### Best Practices for Exterior Concrete
- ❑ Max. w/cm ratio of 0.45; Min. strength 4,500 psi
  - ❑ Total air content of 6% ± 1.5% air for ¾" rock
  - ❑ Drainage slopes (1% min., 2% preferred)
  - ❑ Don't finish accumulated bleed or rainwater into surface
  - ❑ Don't finish too soon and trap rising bleed water & air below surface
  - ❑ Use fogging, evaporation retarders, etc. to avoid rapid surface drying
  - ❑ **Don't miniplate surface paste during bleeding period**
  - ❑ **Don't let surface prematurely dry and mistake concrete stiffening due to drying as stiffening due to hydration of cementitious materials**
  - ❑ Don't overwork surface & destroy entrained air bubbles
  - ❑ Don't use steel finishing tools on exterior slabs (improperly densifies and seals surface)
  - ❑ Cure, Cure, Cure (reduce surface permeability)
  - ❑ Consider using silane, siloxane or cure/sealer
  - ❑ Advise owner not to use deicing chemicals 1<sup>st</sup> winter – used sand

- ### Learn More about PLC Concrete
- *What's Next After Type II Cement and How Can We Use Blended Cements Successfully?* by Giannini, E., Harris, B., Koebler, E., Ley, T., Uddin, M., Ghanei, A., Martinsoki, J., & Casilio, J. February 2026 [www.concreteinternational.com](http://www.concreteinternational.com)
  - *Field Guide to Placing and Finishing Type II Cement Concrete* by C. White, B. Birdwell, J. Holland and M. Hernandez, August 2025, [www.concreteinternational.com](http://www.concreteinternational.com)
  - *Type II Cement and Concrete Scaling* by D. Lankard, July 2025, [www.concreteinternational.com](http://www.concreteinternational.com)
  - *Minimizing the Risk for Portland-Limestone Cement Concrete Slabs* by J. Klinger, J. Neuber, J. Ondo & B. Suprenant, January 2024, [www.concreteinternational.com](http://www.concreteinternational.com)
  - *State-of-the-Art Report on Use of Limestone in Cements at Levels of up to 15%* by P. Tennis, M. Thomas, J. Weiss, J. Farny, and E. Giannini, PCA R7D SN3148, 2024, [2024-SN3148-03.pdf](https://www.pca.org/2024-SN3148-03.pdf)
  - *Guide for Portioning Concrete Mixtures with Ground Limestone and Other Mineral Fillers*, ACI 211.7R-15, [www.concrete.org](http://www.concrete.org)
  - *Early-Age Shrinkage Behavior of Portland Limestone Cement* by T. Barrett, H. Sun, C. Villani, L. Barcelo, J. Weiss, February 2014, [www.concreteinternational.com](http://www.concreteinternational.com)

