



- ◉ Changes in cement composition
- ◉ Changes in concrete composition
- ◉ Changes in Flatness Measurement
- ◉ Changes in expectations



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## Aesthetics and Slabs

- ◉ When Structural Concrete is Architectural Concrete



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## Definitions

- ◉ Architectural concrete : Concrete that will be permanently exposed to view And therefore requires special care in selection of the concrete materials, forming, placing, and finishing to obtain the desired architectural appearance.
- ◉ Structural concrete: Plain or Reinforced concrete in a member that is part of a structural system required to transfer gravity loads, lateral loads or both along a path to the ground.



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**CONCRETE POLISHING COUNCIL**  
**POLISHED CONCRETE**  
**APPEARANCE CHART**  
REPLACES SP-4 PUBLISHED BY THE SOCIETY

| LEVEL | NAME            | DISTINCTNESS OF IMAGE (DOI) CLAS   | IMAGE CLARITY VALUE, % | HAZE INDEX |
|-------|-----------------|--|------------------------|------------|
| 1     | Flat (Grind)    | Images of objects being reflected have a flat appearance.  | 0 - 5                  |            |
| 2     | Subtly Polished | Images of objects being reflected have a matte appearance.   | 10 - 30                |            |
| 3     | Polished        | Images of objects being reflected do not have a sharp and crisp appearance but can be easily identified.                                       | 40 - 60                | <10        |
| 4     | Highly Polished | Images of objects being reflected have a sharp and crisp appearance as would be seen in a mirror (with like reflection, may require grinding). | 70 - 100               |            |

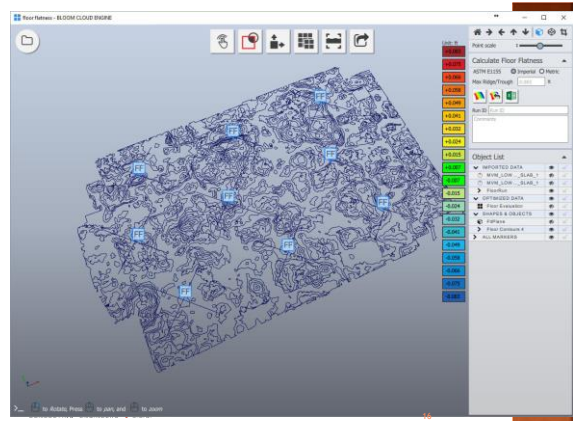
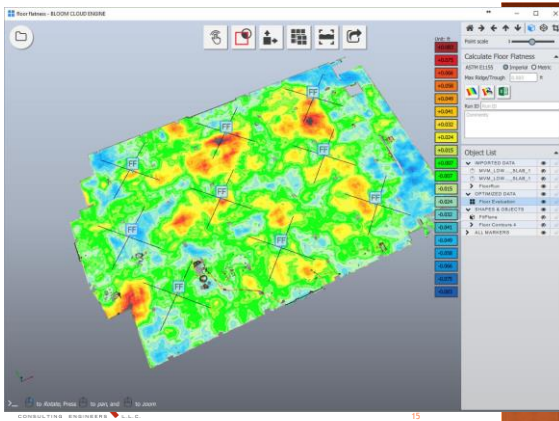
**Distortions of Image (DOI) Class**  
 • DOI is the character of images produced by reflection at a polished surface, sometimes called image clarity.  
 • Measurement by Image Clarity Meter (ASTM D20707). The DOI, Image Clarity Value, obtained from this test method, range from 0 to 100 with a value of 100 representing perfect DOI (image clarity).  
**Haze**  
 • Haze is the cloudiness or milky appearance of images of objects produced by reflection in a polished surface.  
 • Measurement by Glossometer (ASTM D4059). The Haze Index, obtained from this test method, is computed using the numeric difference between the value of specular gloss at 60° and the value of specular gloss at 20°.

**Measurements for Compliance**  
 • The Image Clarity Meter and Glossometer must be calibrated and used in accordance with ASTM D20707 and ASTM D4059.  
 • The minimum number of tests distributed across the polished surface should be three for areas up to 1000 ft<sup>2</sup> and one additional test for each 1000 ft<sup>2</sup> or portion thereof. This applies to both the Image Clarity Value and Haze Index.  
 • The mean (average) values of the test results should be used to evaluate compliance with this chart.



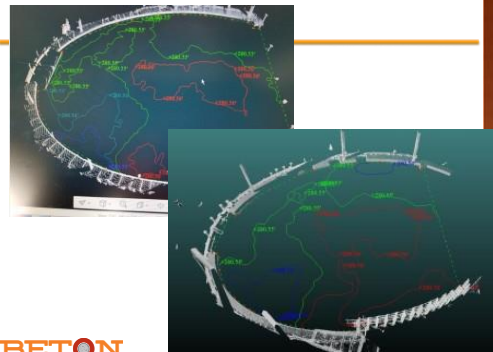


$F_F$  and  $F_L$



## F-Numbers with Scans

- Scanning a concrete floor with a 3D laser scanner is an application that has great potential to improve construction quality.
- ASTM E1155, "Standard Test Method for Determining FF Floor Flatness and FL Floor Levelness Numbers." updated in 2014 to allow the use of a "laser imaging device;"
- but didn't change how results are to be reported or the test's limitations, such as measuring within 72 hours, having sample measurements greater than 11 feet, and taking no measurements within 2 feet of slab edges, columns, or penetrations.







## Green Initiative



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## ASTM C1157

- Performance-Based Cement
- Type IL cement
- Contains a larger replacement of clinker with Limestone



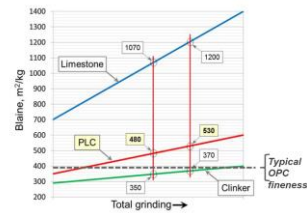
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## Type I L Cement

*What, why & how of PLC*

**How is it made, and what's different about it?**

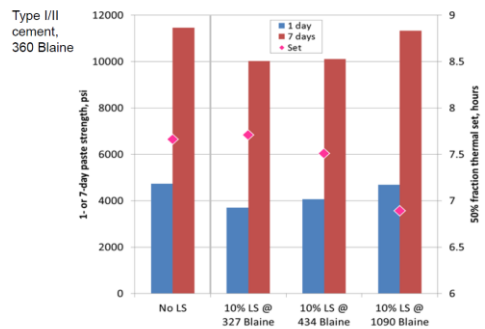
*Example fineness trends, PLC vs. clinker and limestone component fractions*



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## No SCM's, 10% LS @ 327 to 1090 Blaine



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## Pozzolans, Nucleation and Size

## Thermodynamics and Kinetics

- ⦿ Nucleation
  - the first step in the formation of either a new thermodynamic phase or a new structure via self-assembly or self-organization.
- ⦿ Catalysis
  - The process by which a substance speeds up a chemical reaction without being consumed or altered in the process.

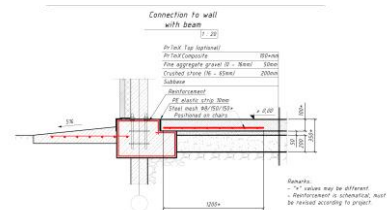
## Admixtures

- ⦿ Admixtures can cause uncontrolled / unexpected air entrainment
- ⦿ ASCC

## Core 1



## Design Methods



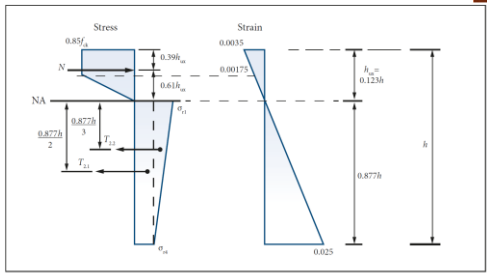


Figure 6.2: Stress block: fibre-reinforced concrete.

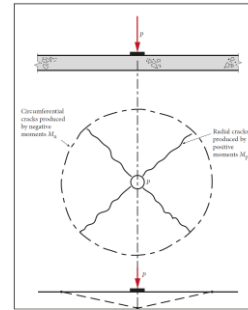
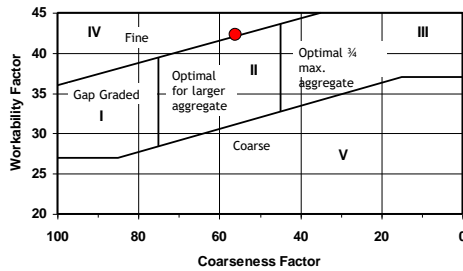


Figure 7.2: Development of radial and circumferential cracks in a concrete ground-supported slab.

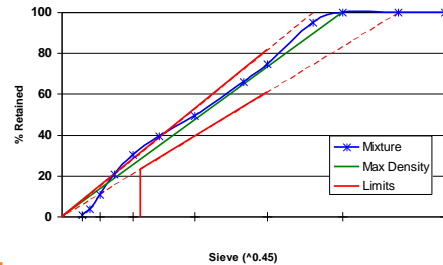


### Shilstone Coarseness Chart



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### 0.45 Power Chart



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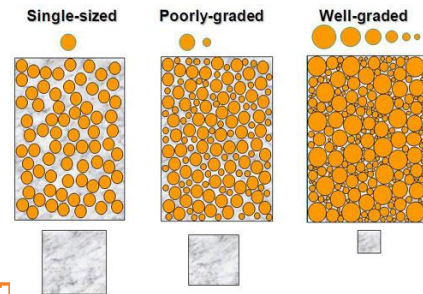
### Gap Grading

- Grading in which one or more intermediate size fractions are omitted
  - Can be economical, require less sand and lower w/c for given slump
- Can create segregation prone concrete
  - Recommended for stiff mixes of very low workability, compacted by vibration
- Applications
  - Architectural concrete
  - Pervious concrete



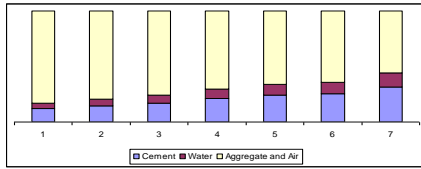
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### Gradation vs Paste Content



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## Volumetric Problems



## Extended Floor Joint Spacing

## Why do we care?

- Joints 24 to 36 times the slab thickness
- Cut at the appropriate time
- Load transfer devices where applicable

## Largest Cost to Owner is Joint Maintenance

- Joints are discontinuities
  - Stress at the edge or
  - Maintenance of Joint sealant

### Financial / Safety Impacts

#### Equipment Damage



- Reduces repair costs associated with fork lift, AGV equipment and robotics damage from joints



### Worksite Productivity

- Smoother material-handling aisles
- Perfect for high racking applications – flat and level floors that stay flat and level
- Eliminates costly maintenance and downtime associated with saw cuts – caulking and crack repairs

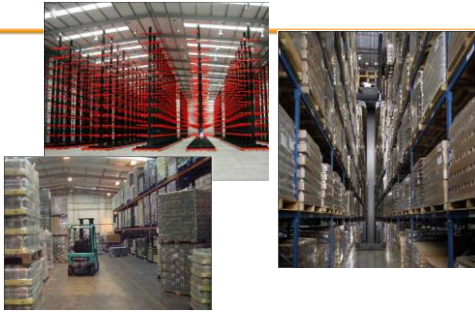


### Workplace Safety

- Reduces back injuries
- Allows for safe and faster driving speeds
- Safer for workforce – trips and falls, less vibration to drivers and operators

## Loads





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## Materials

- ◉ Concrete
- ◉ Fiber
- ◉ Subgrade

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## Concrete

- ◉ Elastic (not Linearly)
- ◉ Fails at defects as cracks move in plastic process zone
- ◉ Cracks propagate rapidly

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## Subgrade

- ◉ Westergaard Theory
- ◉ Slabs on a Winkler Subgrade
- ◉ “k” factor
- ◉ Used in most methods of Design

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## Slab on Grade Design - Who does that?

- ◉ ACI 318
- ◉ ACI 360
- ◉ TR34

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## Reinforcement

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## Subgrade Drag Theory (Ytterberg)

$$A_s = \frac{FLw}{2f_s} \text{ or } L = \frac{A_s 2f_s}{Fw}$$

$A_s$  = cross sectional area of steel reinforcement in square inches per lineal foot  
 $f_s$  = allowable stress in the reinforcement in psi; use  $0.70 \times f_y$  (yield strength of the steel: 60 grade = 42,000 psi)  
 $F$  = friction factor; use 1.5  
 $L$  = distance between control joints in feet  
 $w$  = dead weight of the slab in pounds per square foot; use 12.5 pounds per square foot per inch of slab thickness

## Shrinkage must be low(!)

- ⊙ Concrete mix design is critical
  - Low Shrinkage
  - Excess paste

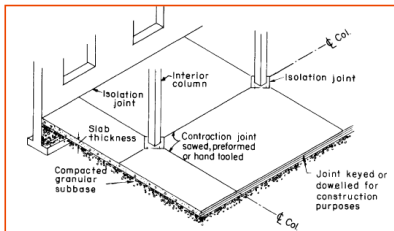


Fig. 8.1—Joints in a slab-on-ground. Isolation joints permit the slab to move up or down (very slightly) relative to walls, columns or footings. Contraction (control) joints permit slabs to shrink without excessive cracking between joints. Contraction joints are stopping places for a day's work.

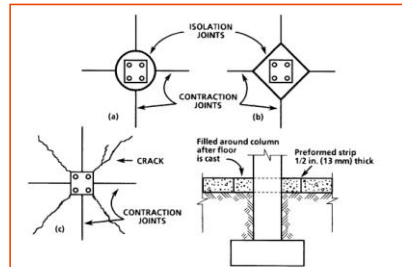


Fig. 8.2—Isolation joints around columns should be either circular as shown in (a), or diamond shaped as shown in (b). If no isolation joints are used around columns, or if the corners of the isolation joint do not meet the contraction joints, radial cracking as shown in (c) may occur.

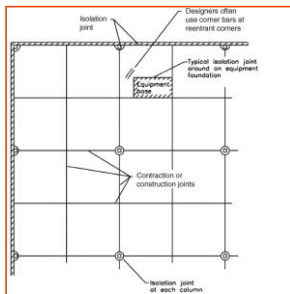


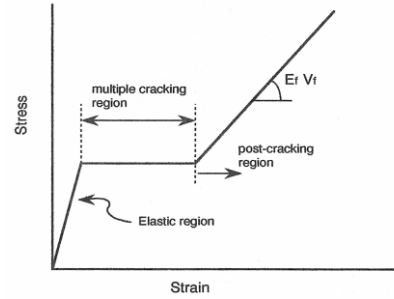
Fig. 8.4—Contraction joints should be placed on column lines, with intermediate joints between column lines. When reentrant corners cannot be eliminated by changing joint spacing, reinforcing bars keep cracks tightly closed (after ACI 302.1R-04).

## Dominant Joint

## Outline

- Fibers are often used to distribute cracking due to thermal, shrinkage and load induced strains in plain concrete

## ACK Model



## Strain Softening Behavior $E_f > E_c$

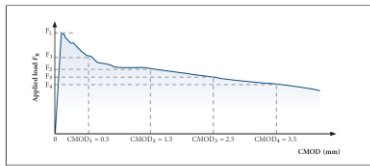
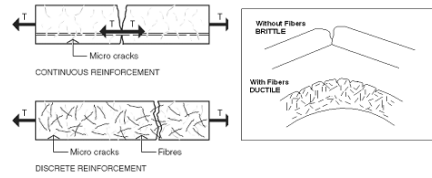
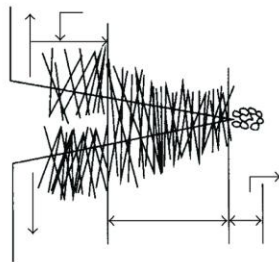


Figure 6.1: Typical graph of test load  $P_n$  vs CMOD.



## Pass Stress Across the Crack



## Barzin Mobasher ASU



### Fiber addition to truck, chute & ring



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### Finishing ring



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### Cylinders



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### Fiber and no fiber



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### Slabs



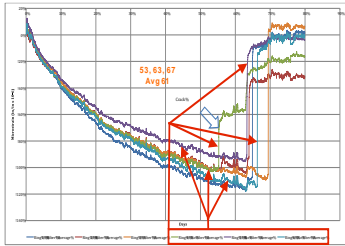
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### Measuring slabs



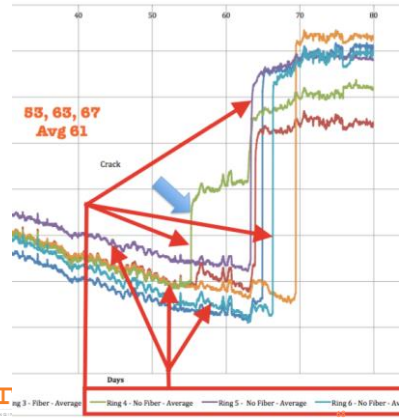
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### No fiber



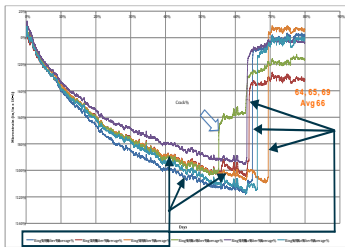
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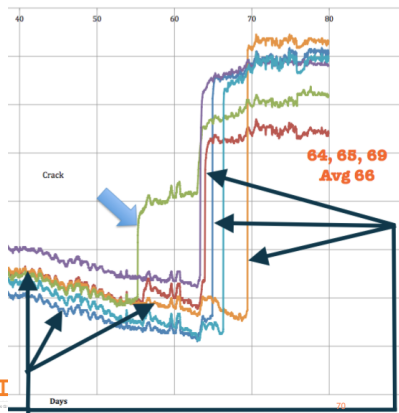
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### Fiber

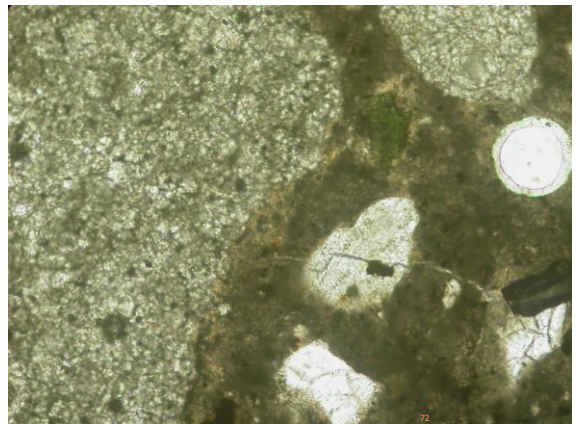
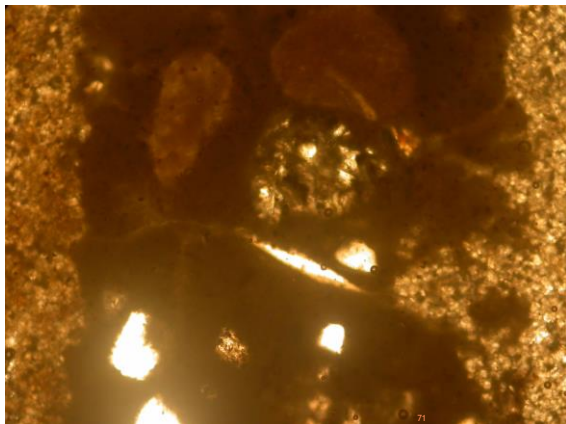


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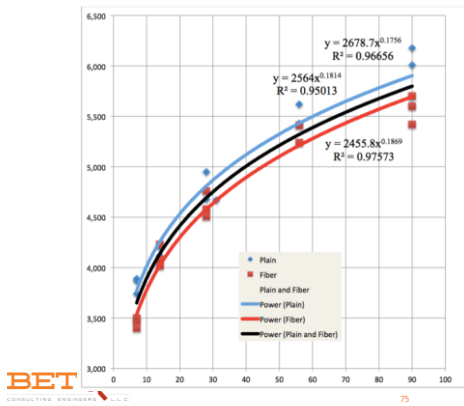
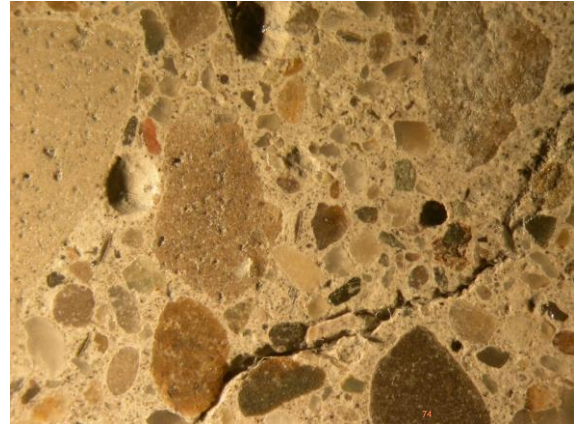
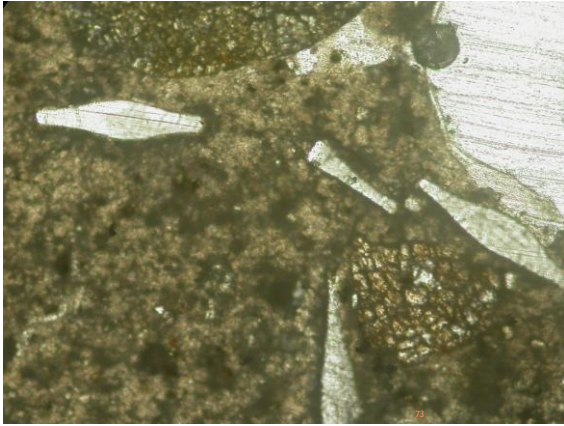
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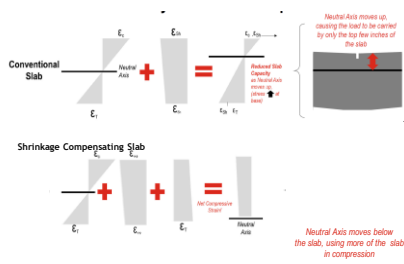






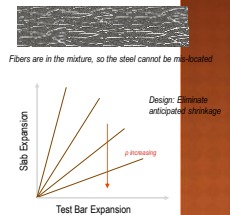
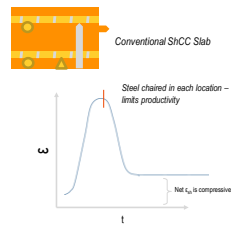
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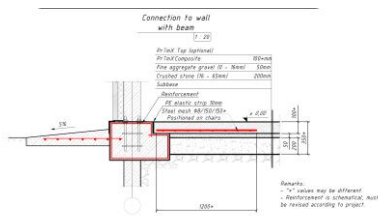
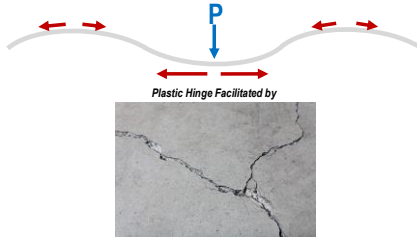
### The Science Behind the System



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The Science Behind the System



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Rapid Drying Concrete

- ⊙ Water needs to go somewhere
  - In the pores
  - In the Atmosphere
  - In the Hydration products

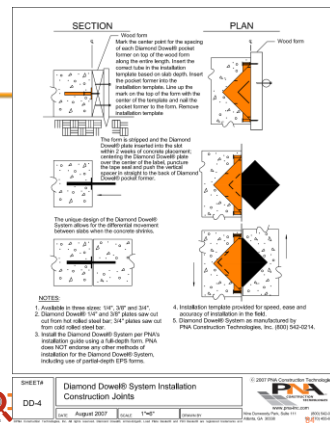


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Joints



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## Conclusions

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- ⦿ Almost 1/3 of concrete is placed as soil supported floors
- ⦿ Changes are occurring and there are good and bad, intended and unintended consequences

## Thank You

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