



# CALIFORNIA COUNCIL OF TESTING AND INSPECTION AGENCIES

**September 30, 2010  
Sheraton Park Hotel  
Anaheim, California**

## **General Meeting Minutes**

1. Call to Order – Jeffry Cannon at 11:45am

Attendees:

*Jim Backman (CEL)*

*George Battey (CHJ)*

*John Byerly (John Byerly, Inc.)*

*Greg Degener (Kleinfelder)*

*Dennis Heider (Heider Engineering)*

*Aaron Kidd (Kleinfelder)*

*David Ryan (URS-Signet)*

*Jeremy Larsen (Kleinfelder)*

*Elizabeth Levi (BSK Associates)*

*Tim Slegers (Kleinfelder)*

*Lloyd Suehiro (Leighton Group)*

*Linas Vitkus (Twining)*

*Rob Ryan (Twining)*

2. Speaker:           Basic Pervious Concrete for Engineers  
                          David J. Akers, P.E., California Nevada Cement Association

3. Adjournment – 1:50pm

*Respectfully submitted,  
Elizabeth Levi, Treasurer*

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# Pervious Concrete Pavement ...more than just pavement.

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What makes it different?

What makes it work?

What makes it fail?

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## Agenda

- Defining Pervious Concrete
  - Materials
  - Evaporation
  - Construction
  - Testing – Approved and in the Works
  - Pervious Section Design
  - Architectural Pervious Concrete
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## Pervious Pavement Defined:

- Pavement
- Storm Water Management System
  - Permeable Surface
  - Filtration
  - Permeable Dry Detention Reservoir
  - Permeable Subgrade
- Aerobic Microbial Environment

## An Unnatural Act

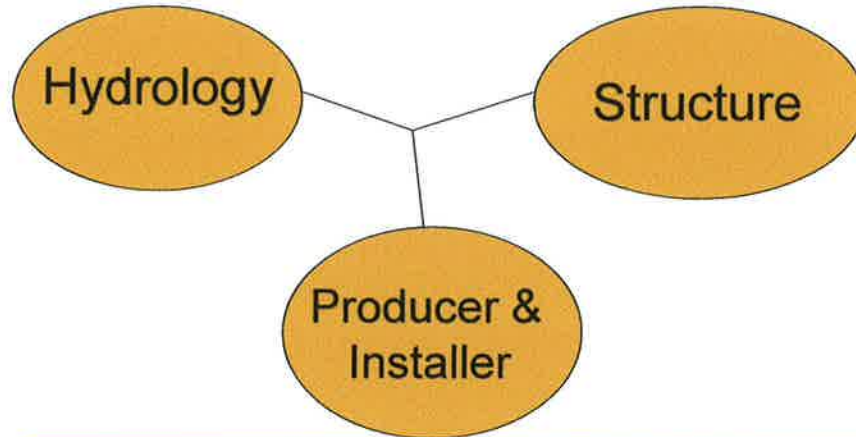
- Making concrete that includes voids.
- Intentionally reducing concrete density.
- Knowingly reducing concrete strength.



We have very good reasons to do such an unnatural act... hydrological reasons.

## Objectives

- Three positions influence the decisions.



## Hydrology wants...

- Low Unit Weight
- High Porosity
- High Permeability
- Low Strength

Considering hydrology alone  
would design gravel or sod, lacking structural performance.

## Structure wants...

- High Unit Weight
- Low Porosity
- Low Permeability
- High Strength

Considering structure alone  
would design conventional concrete pavement, lacking hydrologic performance.

## Combined hydrology and structure

- Moderate Unit Weight
- Moderate Porosity
- Moderate Permeability
- Moderate Strength

Moderate combination of these properties can provide  
adequate performance in both hydrology and structure.

## Producer needs...

- Source of marketable aggregate.
- Appropriate cementitious content.
- Delayed hydration.
- Quick and thorough discharge.
- A careful and informed installer.
- Predictable QC.

Pervious production needs to fit into the production of conventional concrete.

## Installer needs...

- A producer with good service.
- A producer with a good price.
- Appropriate cementitious content.
- Delayed hydration.
- Placement and compression features.
- Quick and thorough discharge.
- Quick and thorough curing.

Pervious requires the team effort of both producer and installer.

## Six points of successful pervious.

- Balance
  - Gradation, fines, cement and voids.
  - Cement paste coating thickness.
- Hydration
  - Cement hydration.
  - Wet out.
- Discharge
- Strike-off
- Compression
- Curing

## Aggregate Gradation

ASTM specifications pertain to conventional concrete.  
Gradation for size 89 allows 10% to 50% passing the #4 sieve.  
Pervious concrete must be designed  
with careful attention to amounts passing the #4 sieve.



Excessive fines increase the unit weight, obstruct the void structure  
and cause some unmanageable traits for discharge and placement.

## Aggregate Selection

Aggregate voids must contain enough space for the paste components of the mix.

Low amounts of aggregate passing the #4 sieve allows a higher cementitious content.

High amounts of aggregate passing the #4 sieve requires a reduction in cementitious content.

Calculate aggregate voids:

$(\text{unit weight} / \text{specific gravity}) / 62.4 = \% \text{ volume filled with aggregate.}$



An appropriate dose of cementitious material is based on the available voids.

## Pervious Surface Texture

- ✦ Determine the expectations of the client
- ✦ Determine the type of traffic

High amounts of aggregate retained in the ½ inch sieve is usually too coarse to for foot traffic.



Select the largest aggregate with surface texture in mind.

Narrow heels, wheelchairs, canes, and handicap walkers have difficulty if the surface is too gnarly.

## The Gnarly Modulus

Certain applications of wheel traffic and limited foot traffic will allow coarse aggregate.



Economy mixes are used in Multi Layered Pervious to build a structural course on the bottom of the slab.



## Normal Surface Texture



Align the coarse aggregate gradation with the client's expectations.

## Cementitious Quantity

- Maintain the void structure
- Maintain point to point aggregate contact
- Maintain the paste thickness

Adjust the cementitious content to coat the aggregate with .015 inch thickness.



## Cement Hydration

- Recognize low water traits
- Recognize early hydration process
- Recognize evaporation

Water / Cement ratio is about  $\frac{1}{2}$  the water of conventional concrete.  
The low water cement ratio causes hydration to flash.  
Normal pervious materials require more mixing.  
Batch water and add water must be more closely controlled.  
Mixer discharge is slower and may batter the inside of the drum.

## Cement Hydration Launch

- The first fifteen minutes
  - Tricalcium Aluminate
- The first two hours
  - Tricalcium Silicate



The rich cement content and low water content is prone to flash.  
the hydration, starting during the first fifteen minutes.  
The clock begins ticking when the ingredients are combined.  
Load 80% of the water and all the admixtures  
before introducing the cement and aggregate.

## Hydration Stabilizer

- Differs from Normal Retarders
  - Stops hydration in Tricalcium Aluminate
  - Stops hydration in Tricalcium Silicate
- Dose according to ambient temperature
  - 80 degrees F, 8 oz/cwt
  - 90 degrees F, 11 oz/cwt
  - 100 degrees F, 14 oz/cwt

HSA, the most essential admixture for a manageable mix.  
HSA, dosed to maintain cement paste consistency for 90 minutes.

## Water Reducer

- **Aids Wet-Out**
  - Causes negative ions on cement particles
  - Separates the cement particles
  - Water enters the space
  
- **Acts as a Surfactant**
  - Aids the wet metallic sheen on cement paste

Water Reducer is used in moderate dose.  
Water Reducer is not used to reduce the water content.

## Water and Plasticity

- Recognize an unstable paste
- Recognize a wet, metallic sheen
- Recognize a flat, dull appearance

The cement paste is delicate. If water content or plasticity is too high, the paste falls off the aggregate and sinks to the lower parts of the slab.



## Viscosity Modifier

- **Firmer Cement Paste**
  - Cement paste clings to aggregate
  - Allows higher water content
  - Aids discharge
- **Faster Placement**
  - Aids the strike-off
  - Aids the compression

VMA counteracts the plasticity effects of water reducer.

## Whipping Cream

- The water / cement ratio of conventional concrete has cement paste resembling the consistency of whipping cream.

The water content is too high.  
The cement paste coating the aggregate is too thin.  
The connection between the aggregate is too small.  
The paste is falling to the lower parts of the slab.



## Yogurt

- The perfect water / cement ratio for pervious concrete resembles the consistency of fresh yogurt.

The cement paste shows an apparent wet, metallic sheen. The cement paste coating is stable and clinging to the aggregate. The connection between the aggregate is thick and full. The aggregate readily connects when compressed.



## Broken Cheese

- Shortage of water in the mix
- Hydration has proceeded
- Evaporation has dried the paste

The cement paste shows a flat, dull appearance. The cement paste coating is not flexible. The connection between the aggregate is broken and crumbling.



## “Bleed-out” of Paste

- Too much cement or too much water will cause “bleed-out”.
  - Depending on aggregate gradation, some mixes are using 400 pcy total cementitious.
  - Keep w/c near 0.30.



## Hand Test for Paste Content

- At the right w/c ratio, there is no dripping of paste.
- Some rock adheres to the glove; very little paste.



## Evolving Knowledge –

less cement makes better pervious

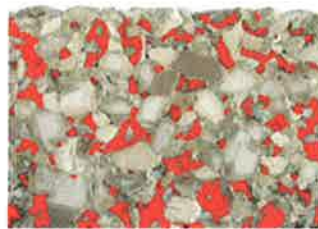
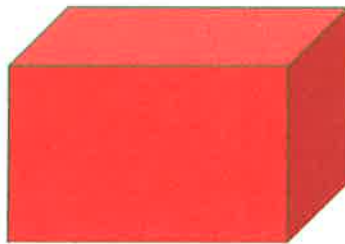
### Same aggregate and admixtures

- Lower cement content more consistent consolidation and even void spacing
- Lighter color



## Evaporation

- Recognize surface area exposure
- Recognize air humidity
- Recognize windy conditions



## Plane Crash

- Failed pervious is similar to a plane crash.
  - An expensive, tragic, heartbreaking event.
  - Usually happens from more than one cause.
  - The culmination of multiple events, each compounding and complicating the events that follow.



## Planning Pervious Precautions

- Ready Mix Producer
  - Manageable mix design
  - Trained delivery drivers
- Installer
  - Trained crew members
  - Test placement
  - Visqueen sheeting prepared, 6 mil
  - Machinery and tools prepared



## Prepare the Visqueen

- Unpacked, Unfolded, Rolled
  - Quick installation
  - Follow closely behind the placement
  - Full supply, roll on PVC pipe
  - Full length = slab + 3 feet
  - Full width = slab + 3 feet



## Transit Mix Delivery

- Fins
  - Clean
  - Aggressive
- Chute
  - Full down
  - Short



Don't get your hopes up  
about using all the chutes.

## Belt Placement

- Reach into limited access
- Discharge up to three mixers



More exposure the open air requires more water in the mix.  
Paste buildup on the belt drops paste clumps.

## Forward Speed

- Minimum exposure
  - Quick delivery
  - Quick placement
  - Quick strike-off
  - Quick compression
  - Quick poly sheeting



## More Safety

### ☛ Curing compound

Soybean based curing compound will inhibit evaporation and enhance the paste connection.



### ☛ Fogger

The harsh conditions of dry humidity and wind is safer with a fogging device.



## Strike-off and Compression

### ☛ Efficiency

- ☐ Cut elevation
- ☐ Compress
- ☐ Recover flaws
- ☐ Eliminate riser strip
- ☐ Eliminate static roller



## Jointing and Edging



The jointing cross roller divides the aggregate to a depth of 1-1/2 inch and forms a radius on each side.

Edging compacts and reinforces the formed edge and dresses up the appearance.



## Cross Rolling



The standard cross roller is used on top of the poly sheeting. It is used to apply light compression and remove surface flaws.



## Crash and Burn



## Insufficient Curing



## Raveling



## Loose Edges



## Short Poly Sheeting



## Gaps



## Quality Control and Testing

- **Observation by all parties**
  - Appearance of concrete
  - Installation of visqueen in timely manner
- **Standard Tests**
  - Density and Void Content
  - Infiltration Rate
- **Non-standard Tests**
  - Hand squeeze
  - “Bleed-out”
  - Toughness

## Observation

- **Does the concrete have “bright metallic” sheen?**
  - Multiple water additions are allowed to the concrete during placement if the concrete is mixed thoroughly
- **Smooth placement of concrete**
  - Surface quickly covered with visqueen
    - 20 minutes may be too long – quicker is better
- **Time placements for optimal weather conditions**

## Density and Void Content

- ASTM C1688 – Standard Test Method for Density and Void Content of Freshly Mixed Pervious Concrete
  - Proctor hammer per ASTM D698
  - 0.25 cf container
  - Compact two lifts at 20 blows per lift
- NRMCA training recommends the test be performed at the batch plant.
- Usual acceptance - +/- 5 pcf of design

## Infiltration Rate

- ASTM C1701 – Standard Test Method for Infiltration Rate of In Place Pervious Concrete
- 12" dia. Ring x 2" high
- 3 tests per 25,000 sf plus 1 test per 1,000 sf > 25,000 sf
- Infiltration rate used for monitoring



## Toughness Test – Mix Design Development

- 3 briquettes per test
- Known volume
  - 4" dia. X 4" high
- Consistent density
- Tumbled in LA Rattler for 50 revolutions
  - Measure % loss



## Monitor Weather

- Portable weather station can download via Bluetooth to computer .
- Attach to tripod at an elevation near the top of concrete.



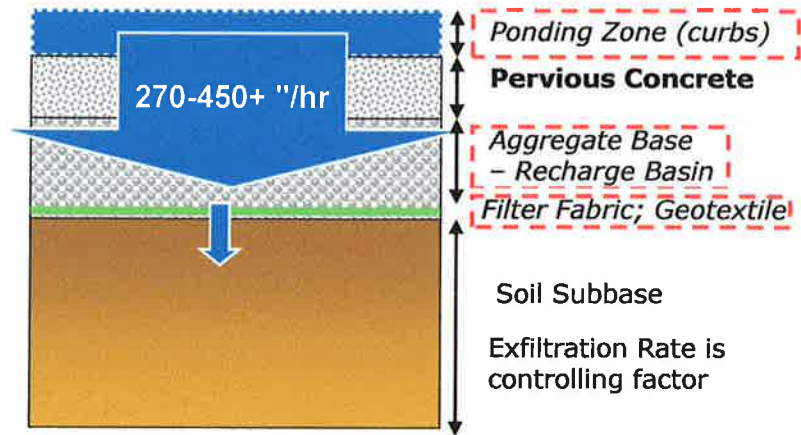
## Pervious Pavement Section Design

- Hydrologic Design – capture and control storm, landscape, and nuisance water
- Structural Design – traffic loads
- Use thicker of two sections
- Pervious pavement typically includes aggregate recharge basin for water storage
- Quick & dirty - % voids X thickness = storage
  - Pervious - 15% – 20% voids
  - Aggregate - 30% to 40% voids

## Hydrologic Design

- Pervious Concrete: Hydrological Design and Resources (CD063.02)
  - Storm size
  - Areas of pervious, impervious, and off-site drainage
  - Void content of pervious concrete and aggregate
  - Thickness of pervious concrete and aggregate
  - Infiltration rate of soil
- Iterative process to determine thicknesses for complete control

## Basic Hydrological Section



*optional*

## Recharge Beds

Filter fabric is used to isolate the subgrade soil from migrating into the voids of the recharge bed.

The perk rate of the subgrade soil and storm water event determines the thickness of the recharge bed.

Clean aggregate will provide about 40% of it's volume in water storage.



## Active Recharge Beds

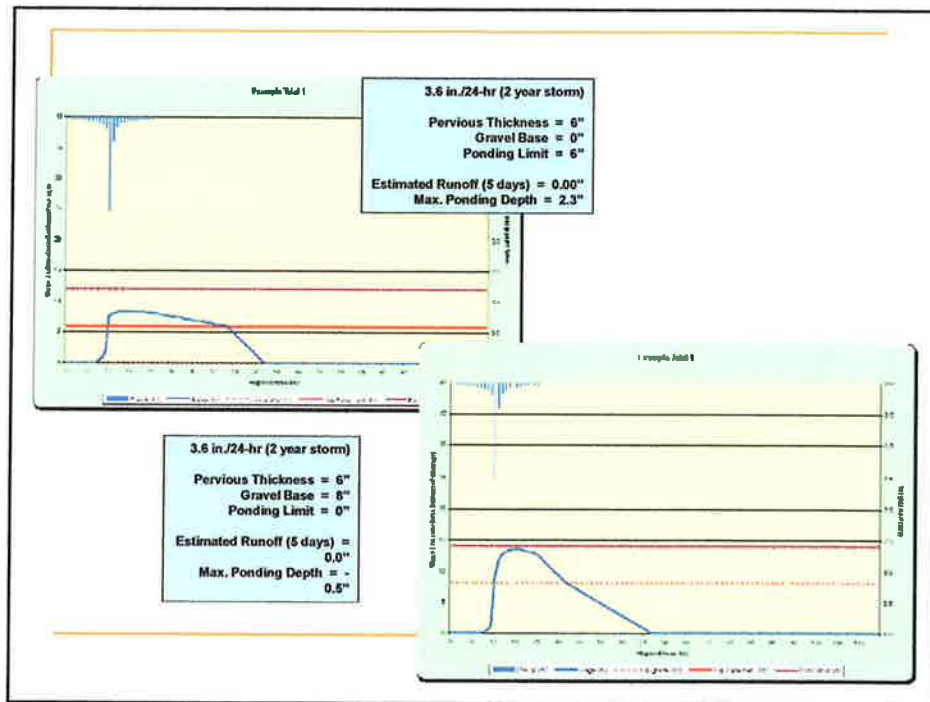
Pervious pavement that receives active flow from adjacent impervious pavement is designed for extra storage capacity. This area is prepared with a recharge bed depth of 84 inches.



## Subgrade Storage Vessels

Extra storage capacity is provided with inverted half-pipe included inside the recharge bed.





## Pavement Structural Design

- Use any pavement design program
- Assume strength of 3,000 psi to 2,500 psi
  - Higher strengths have been reported in research reports
  - There is no accepted test for strength of pervious concrete
- Standard traffic sections are 6" minimum; 4" for sidewalks
- Aggregate base (1" rock) adds strength

## Architectural Pervious Concrete



Stamped Pervious Concrete



## Stained Pervious Concrete



## Multi Layered Pervious

Pervious pavement may be placed in multiple layers to utilize the economy of a gnarly mix for a structural component. This allows the wear course to use rich colors and selected aggregate, while remaining cost effective.



## Colored Wear Course

The normal thickness of pervious pavement becomes quite expensive when a heavy dose of color is used. This wear course is 1.5 inches thick, yielding 220 square feet per cubic yard.



## Gnarly Structural Course

The structural course is placed 20 minutes ahead of the placement of the wear course. The economy of large aggregate and low cement as well as no admixtures makes the structural course very cost effective. The structural course is jointed and the wear course is jointed at the same location.



## Patterned Pervious

Multi layered pervious opens many options while remaining cost effective. Rich colors and selected exposed aggregate gives a dazzling product.



## Pervious Concrete

- A proven 30 year material
  - Proper design
  - Good Specifications – [www.concreteresources.net](http://www.concreteresources.net)
  - Contractor with certified personnel
- Low Impact Development Material
- Can be used in place of grassy swales and detention basins
- Numerous projects throughout California
  - [www.sccpconcrete.com](http://www.sccpconcrete.com)

## Questions?



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