

Pervious Concrete and Construction

International Concrete
Sustainability Conference
Dubai, December 2010



Pervious Concrete

- Concrete with 15-30% voids
- Allows water to pass through it
- Typically used for exterior flatwork
- Reduces stormwater runoff
- Recharges groundwater
- Eliminates retention ponds



Permeable



Permits a large volume
of water to infiltrate through the pavement

Concrete Surface



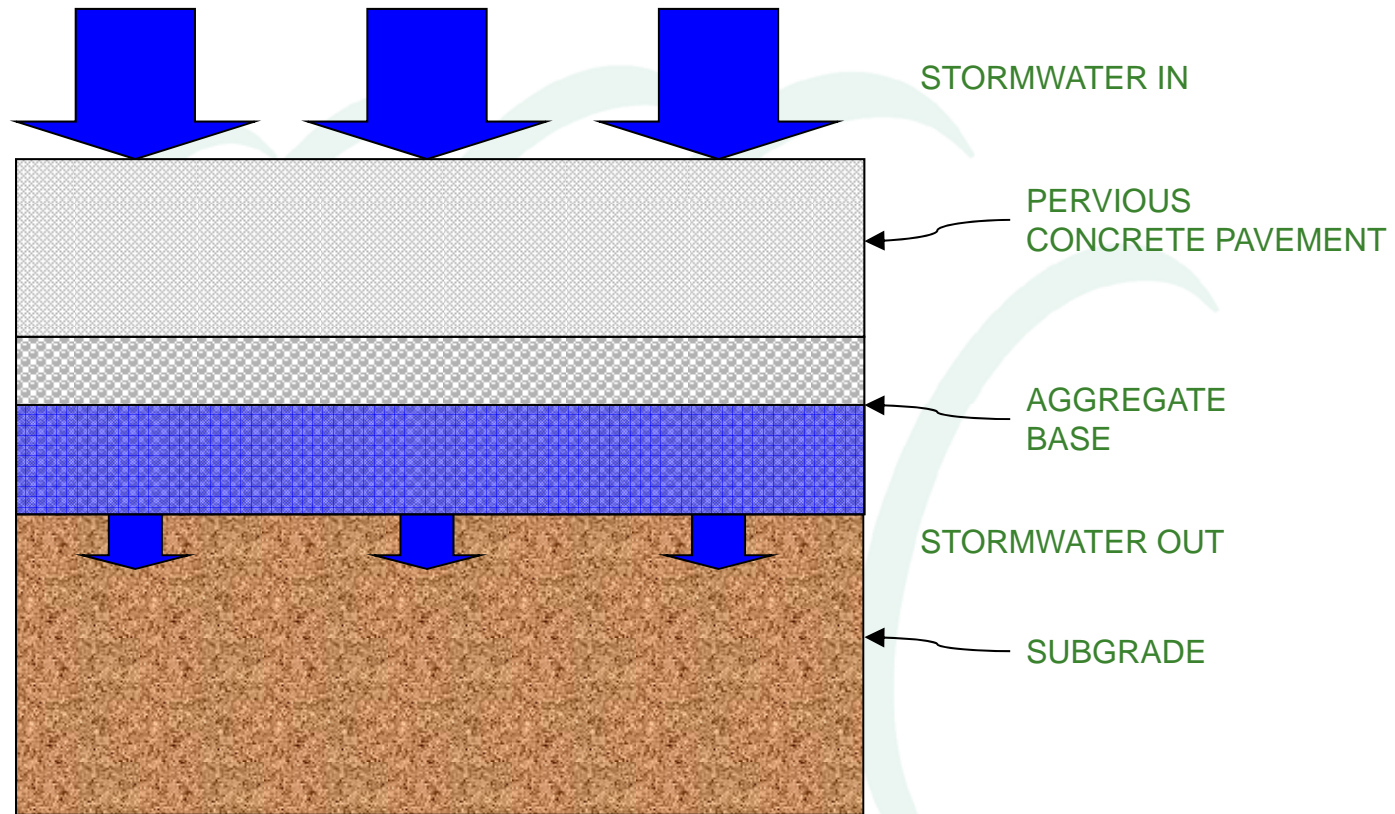
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Structure of pervious concrete

- Paste bonds aggregates
- Voids are interconnected
 - 15-25% void content
- Drainage rate:
 - 5000-45,000 mm/hr
 - 80-750 L/m²/min.



Pervious Pavement System



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Impact to Sustainable Development

- Economic Stormwater Management
- Pollution Treatment
- Low-Impact Development
- Recharging Groundwater
- Tree Protection
- Reducing Urban Heat Islands
- LEED Recognition



Types of Storm Water Management

- Infiltration Basin
- Infiltration Trench
- Bioretention
- Grassed Filter Strip
- Sand and Organic Filter
- Grassed Channel
- Wetlands
- Dry Extended Detention Pond
- Wet Pond
- Porous/Pervious Pavement



Pervious Concrete Systems

- Eliminate expensive stormwater management systems
- Use land set aside for retention ponds
- Stormwater runoff is eliminated
- Pollutants are filtered naturally



Stormwater Pollutants

- Oils and Grease
- Metals
- Sediment
- Inorganic
- Organic
- pH



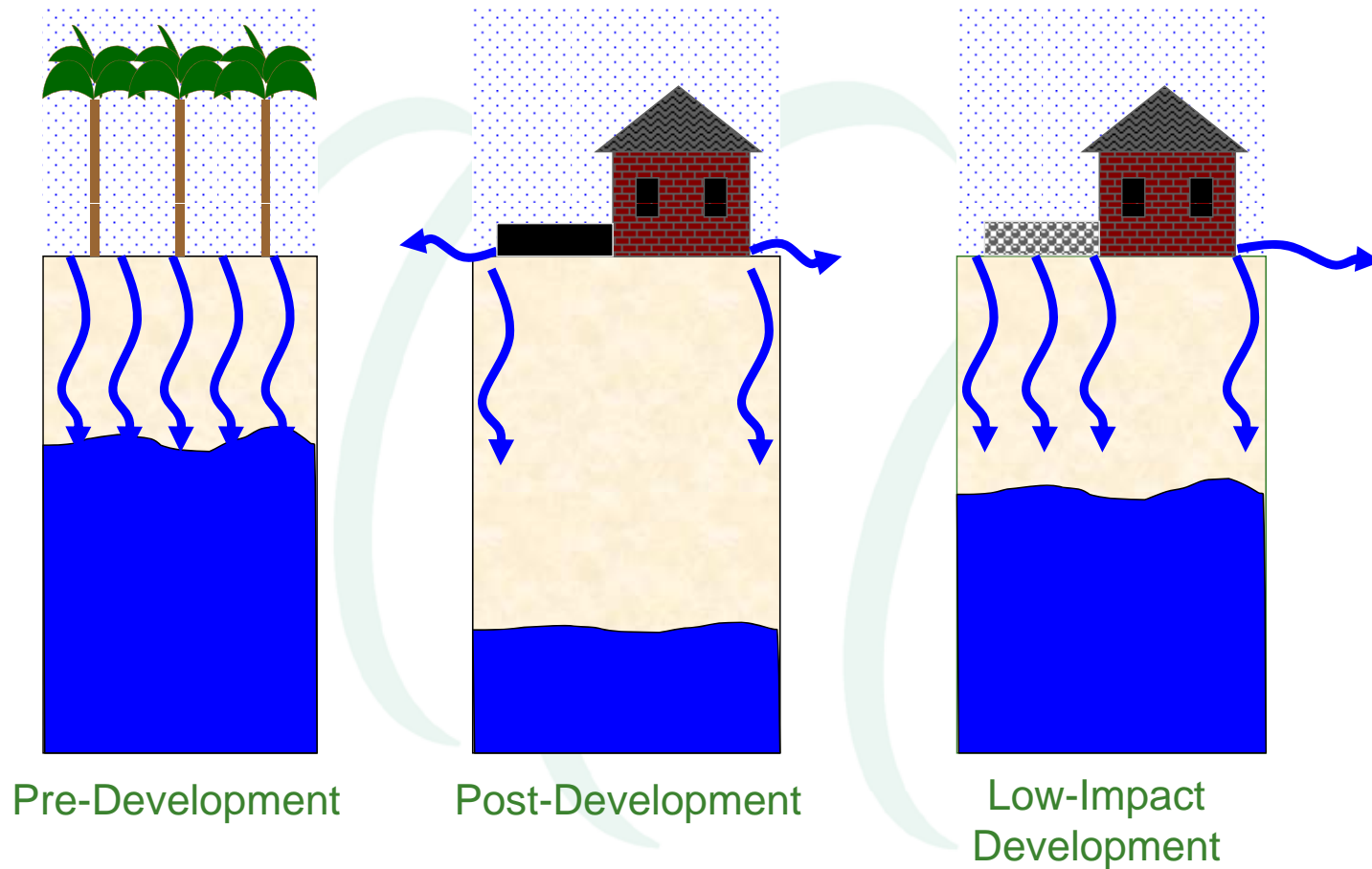
Pollution Treatment

- About 90% of surface pollutants carried off by first 10 to 25 mm of rainfall
 - First flush
- First flush passes through pavement into soil
- Soil filters and treats rainfall
- Rainfall is spread over entire parking area
- Instead of detention pond



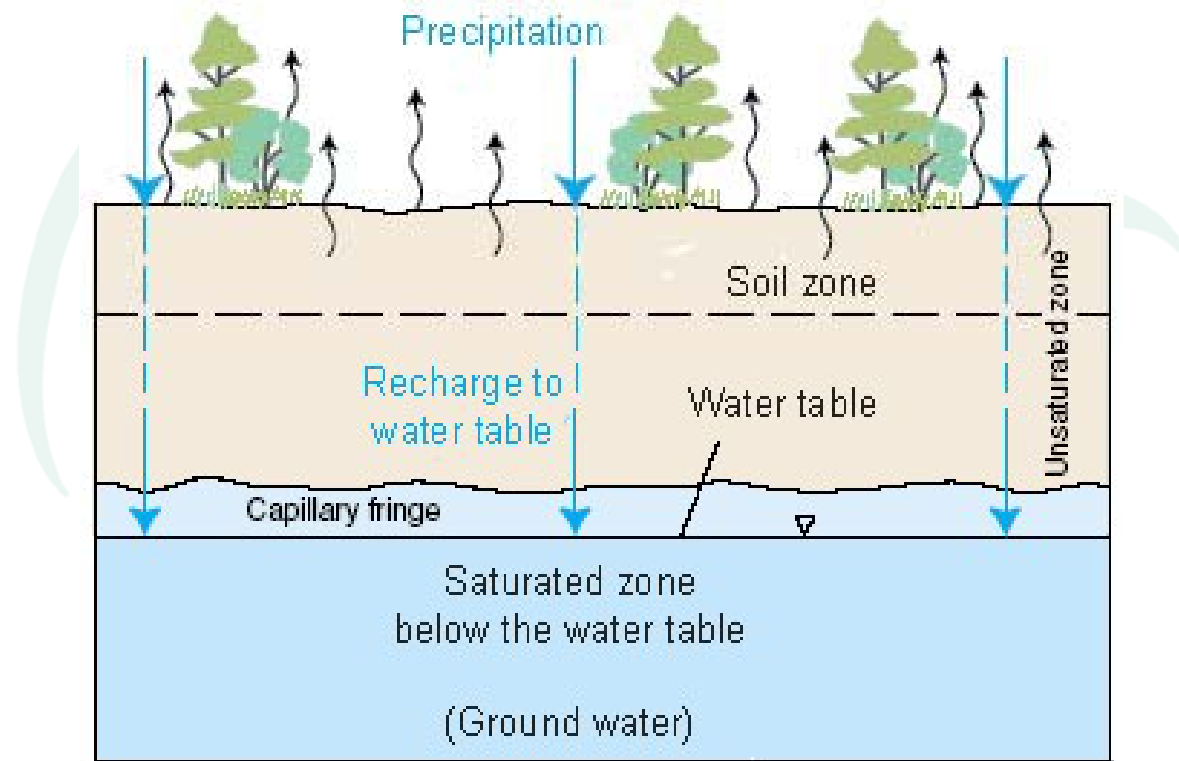
Hydrocarbons treated by filtration and microbial conversion

Low Impact Development

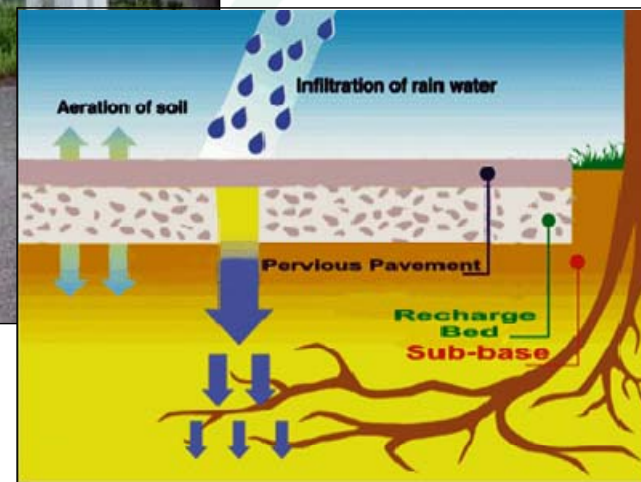


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Recharging Groundwater



Protecting Trees



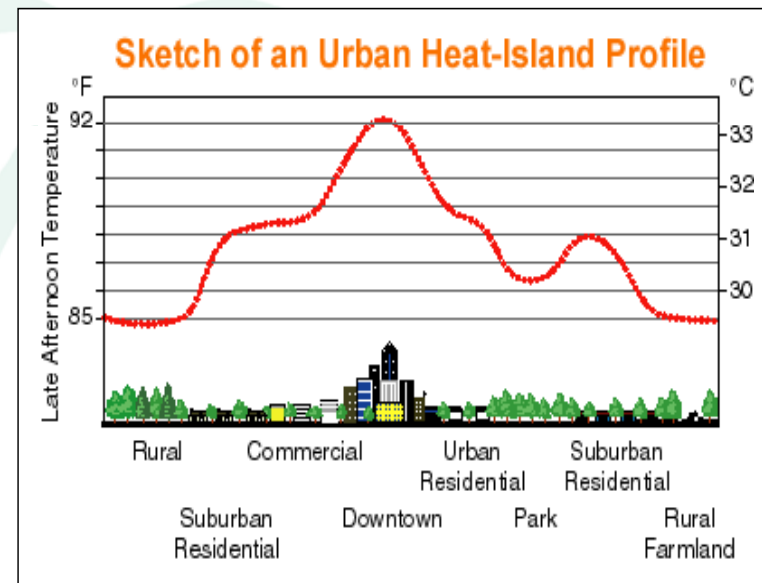
**Can pave within the drip line
Water and air filters to roots**



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The Urban Heat Island Effect

- Residential zones are 3°F warmer
- Downtown areas are 7°F warmer
- Due to dark-colored roofing and pavement



Source: Lawrence Berkeley National Laboratory

Reducing Urban Heat Islands

- Use light colored roofing and cladding
- Use light colored pavements
- Landscape shading
- Reduce air temperatures by 5°F
- Reduce air conditioning by 18%



Pervious Concrete Stores Less Heat



Lighter colored pervious concrete surfaces reduce heat absorption

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Contributes to LEED Credits

- Reduce stormwater runoff
- Improve stormwater quality
- Reduce urban heat islands
- Recycled Materials
- Regional Materials



Applications

- Primarily used as a pavement
 - ❑ Parking areas
 - ❑ Roadways
 - ❑ Walks
 - ❑ Driveways
 - ❑ Recreational areas
 - ❑ Erosion Control



Mount Angel, OR

Parking Lots



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Two type pavement



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Rain water harvesting



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Tree Wells



Driveways



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Sidewalks



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Nature Paths



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Streets and Roadways



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Heavy Duty Applications



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Materials, Properties and Mixture Proportioning



Aggregate

- Little or no fine aggregate
 - Small quantity to improve durability and increases strength
- Coarse aggregate
 - ASTM C33
 - 10 mm to 25mm
 - Reduced fine sizes
 - Crushed stone or rounded gravel

Aggregate Angularity



Engineering Properties

- Fresh Properties
 - Stiff mixture – slump not applicable
- Hardened Properties
 - Density: 80% of normal concrete
 - Compressive Strength: 4 MPa – 30 MPa
 - Flexural Strength: 1 MPa – 4 MPa
 - Shrinkage: 200×10^{-6}

Mixture Proportioning

Materials	Proportions
Cementitious Materials	250 to 400 kg/m ³
Aggregate	1200 to 1500 kg/m ³
Water/Cement	0.27 – 0.34
Admixtures	Several used

Consistency

- Optimize for delivery, discharge and installation
- Close contact of aggregate
- Paste uniformly coat aggregates
- Flexible during placement
- Adequate strength when hardened
- Insufficient paste prevents
 - proper coating of aggregates
 - bonding of aggregates
- Excessive paste will
 - Reduce void content
 - Clog void structure



Mix evaluation



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Jobsite mix evaluation



Too dry – raveling



Too wet or excess paste - sealed



Correct consistency



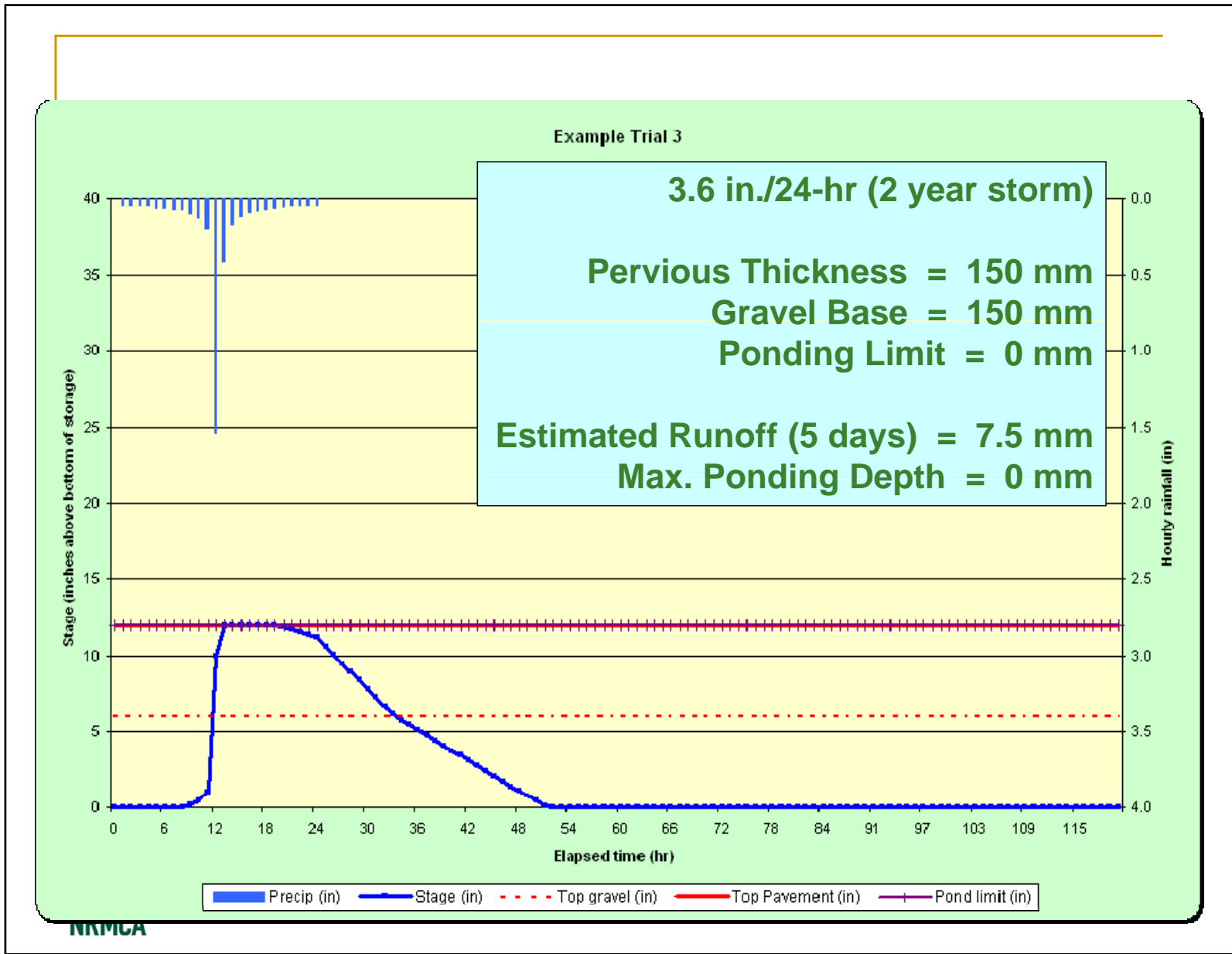
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Design

- Two factors for thickness:
 - Hydraulic properties
 - Structural properties
- Material properties and thickness for:
 - Hydrological requirements
 - Anticipated loading
 - Larger of two values governs design

Hydrological Design Considerations

- Intensity of surface runoff acceptable
- Design rainfall event
 - Two-year storm often used
 - Quantity (per 24 hr) and intensity (per hr)
- Storage capacity
 - (20%) 150 mm + (40%) 150 mm. (base) = 90 mm
- Soil permeability
- Surrounding runoff capture



Structural Design Considerations

- Empirical based on experience
- ACI 330 is the simplest approach for parking areas
- Soil support (k value)
- Traffic loading
 - Axle loading
 - Average daily truck loading
 - Design life of pavement
- Material properties
 - $M_R = 2.3f'_c{}^{2/3}$

Design Example

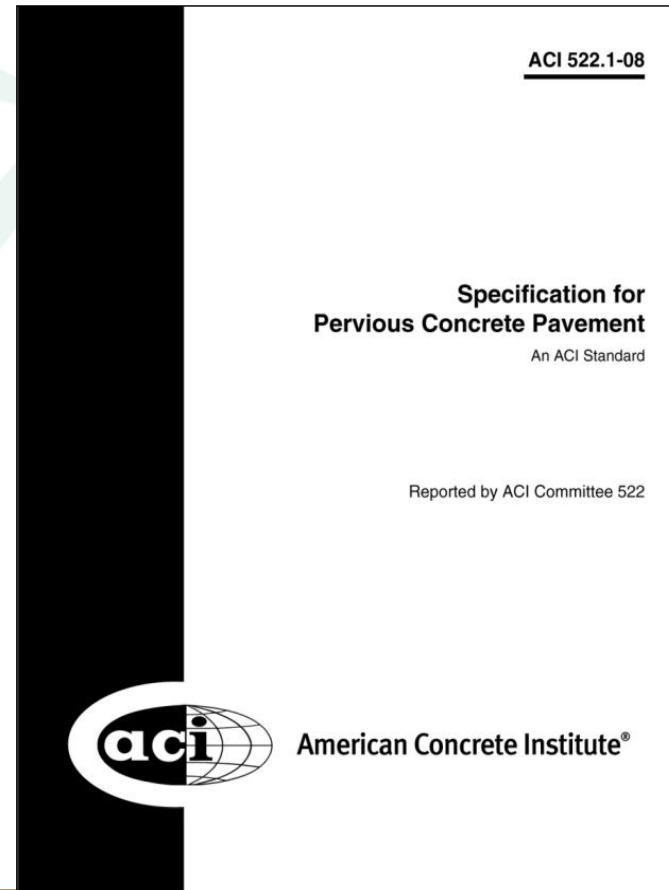
- Design a pervious concrete parking lot
 - 20 year design life
 - 4 trucks per day
 - Front single axle load = 12 kips
 - Rear tandem axle load = 28 kips
 - $k = 150 \text{ lbs/in}^3$
- 4 trucks per day for 20 years = 29,200 repetitions
- Estimate 6 in. slab with $M_R = 300 \text{ psi}$
($f'_c = 1500 \text{ psi}$)



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Specifications for Pervious Concrete

- ACI 522.1-08
- www.concrete.org



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Construction

- Sub-grade and Base Preparation
- Spreading
- Strike-off
- Compacting
- Jointing/Edging
- Curing

Adequate Crew



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Qualified crew

- NRMCA Certification
 - Technician
 - Installer
 - Craftsman



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Site Preparation - Compaction



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Filter Fabric if Specified



Non-woven geotextile fabric



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Base Preparation



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Check mix consistency



Look for 'wet metallic sheen'

Mixer Discharge



Use only one chute section



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Spreading Concrete



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Riser Strips (2-Step Placement)



10mm Riser Strips



Static Roller (2-Step Placement)

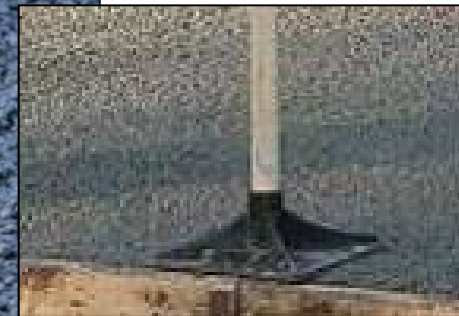


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No Riser Strip (1-Step Placement)



Compact the Edges



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Edging



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Jointing



Joint Roller



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Jointing



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Cross Rolling



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Moist Cure



Cure with 6 mil plastic

**Cover within 20
minutes**

Secure edges of plastic

For at least 7 days



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Quality Assurance

- Establish density of Mix
- Construct test panel
- Fresh Concrete Density
 - One per day
 - Density ($\pm 80 \text{ kg/m}^3$)

- After 7 days:
 - 3 core samples for every 500 m^2 (ASTM C 42)
 - Thickness (- 6mm, +40 mm)
 - Density ($\pm 5\%$ of test panel)



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Maintenance and Cleaning



Importance of Cleaning

- Maintenance different than other pavements
- Keep permeability close to design
- Owner's responsibility.
- Ensures longevity of system
- Prevent clogging during construction
- Limit debris from construction



Cleaning or Vacuuming



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Water Flushing



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Testing Permeability



ASTM C1701



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Other Precautions

- Construction Runoff
- Construction Traffic



Design Landscape



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Architectural Pervious Concrete



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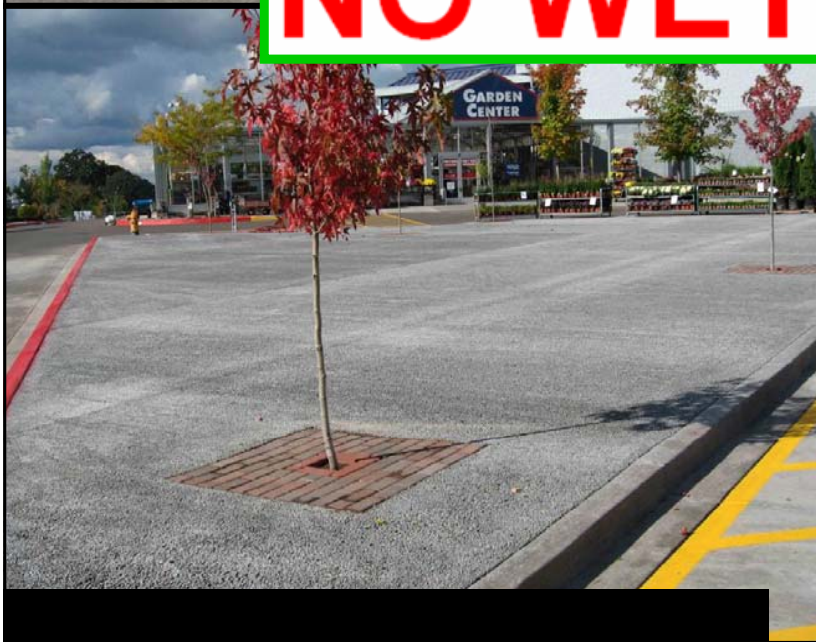
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NO WET FEET !



Pervious Concrete



THANKS !



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