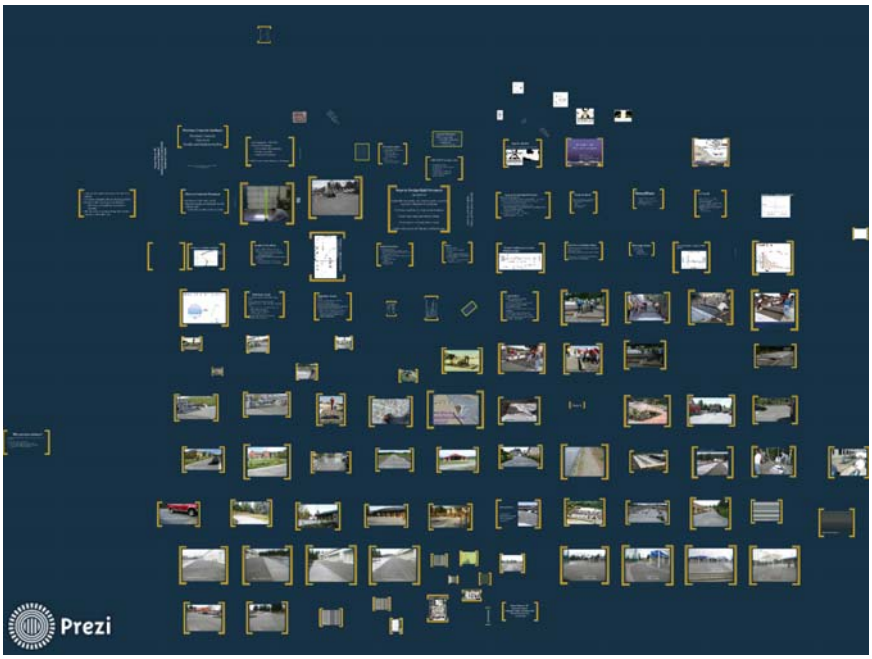


Pervious Concrete Surfaces

Pervious Concrete Pavement Design and Implementation

Prezi

Diane Warner, PE
Pavement Engineer
Portland Cement Association
Northwest Chapter

Prezi

Portland Cement Association

PCA
America's Cement Manufacturers™

Portland Cement Association
Northwest Region

Since 1916, PCA has been representing the cement and concrete industry as a resource for public and private owners, designers and consultants in making value-added pavement selection decisions for concrete and cement-based product applications.

Prezi

- Civil Engineer - OR & WA
- 18 Years Experience
  - Stormwater Management
  - Precast Concrete
  - Concrete Pavements

It will be your name/stamp on drawings...

Prezi

What is a pervious surface?

Prezi

- It carries load
- It allows water to pass
- It lasts a long time

Prezi

Why pervious surfaces?

- ...to let the rain and the soil do what they always have done before the soil was paved over.
- There are a lot of good reasons for doing that.
  - If there is no runoff, the runoff can't carry pollutants
  - If we slow the runoff, it still can't carry most of the pollutants
  - If we delay runoff, we still help the environment
    - A lot.

Prezi

Why Concrete surfaces?

- Concrete is environmentally benign
  - It does not degrade or change over time
- It is a rigid paving material
  - It can carry great loads
  - The pavement is the structure
    - More on those later...
  - It stays pervious over time
- It costs less.
- Many other reasons
  - You need to be able to identify them
  - ...That's the reason we're here

Prezi

Concrete Pavement

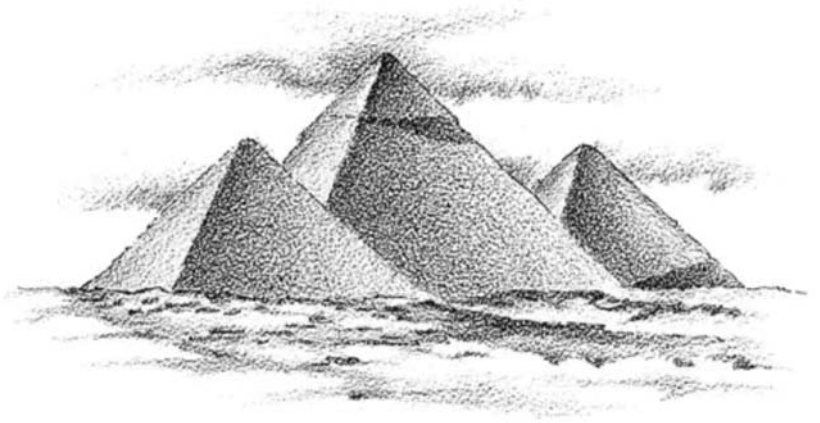
- What's important?
  - Strength? Flexural vs. Compressive
    - Neither, really

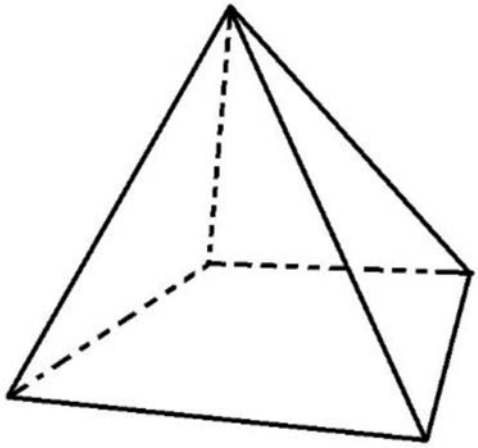
Prezi

THICKNESS is Important

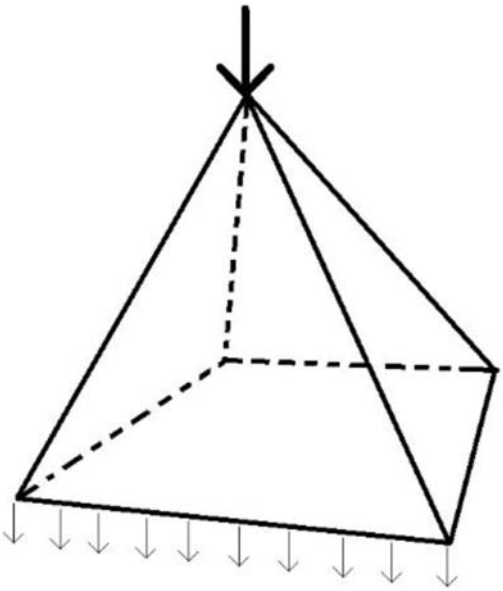
- Strength of section is proportionate to the square of the thickness
- Small changes in thickness results in large changes in section strength

Prezi





How much area does a load applied at the point of the pyramid get spread over?



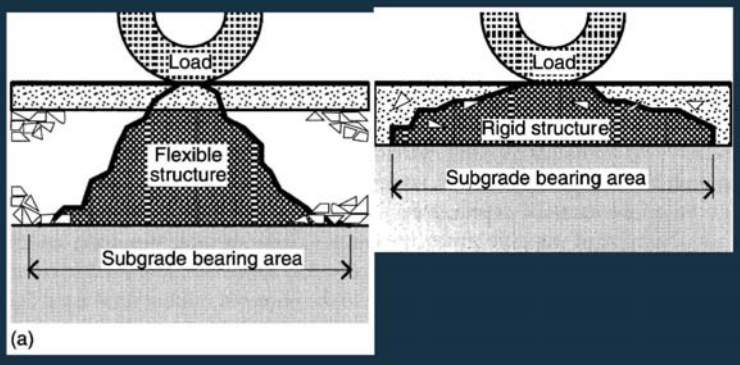
Prezi

It depends on the height of the pyramid, and slope of the sides.

Prezi

Rigid vs. Flexible

- Differences are significant and important



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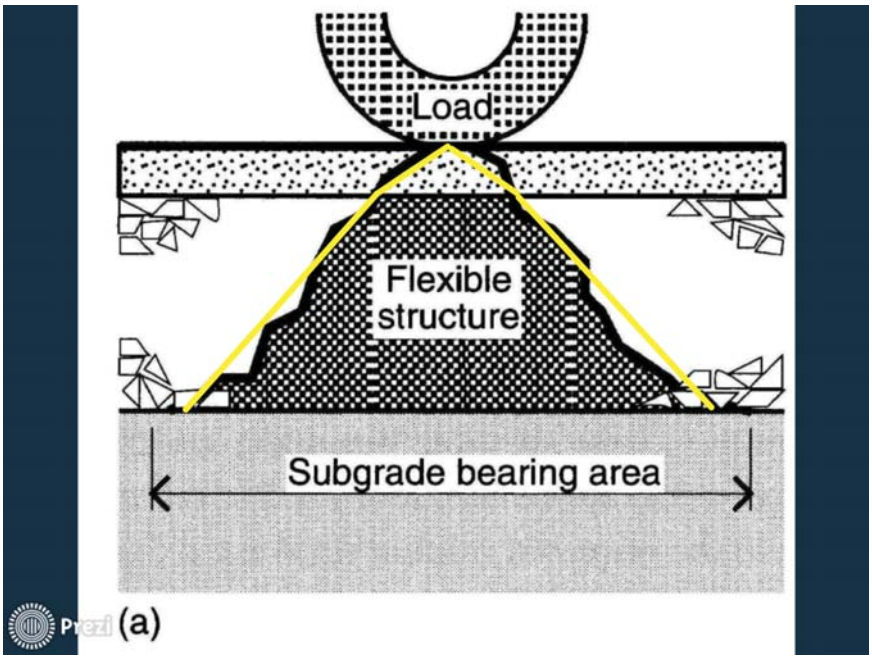
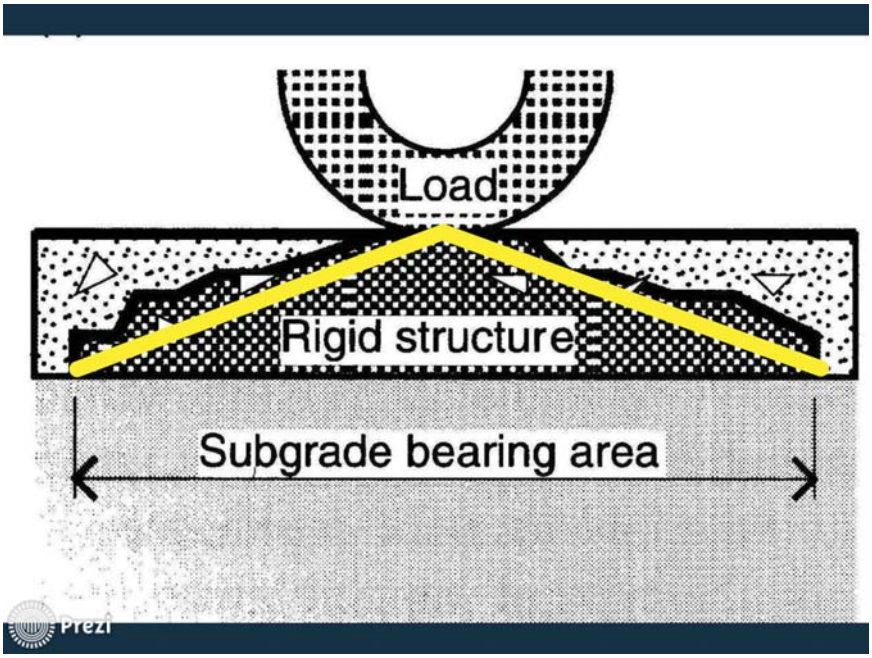
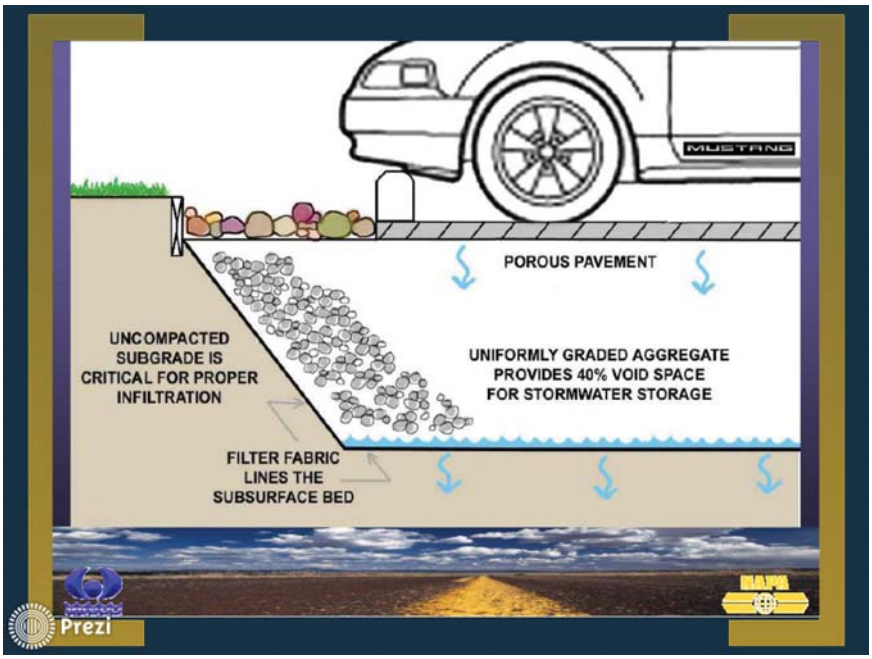




Asphalt-Based Porous Pavements

Howard Marks
Director, Regulatory Affairs
National Asphalt Pavement Association
in conjunction with Cahill Associates, Environmental Consultants



More on Concrete Pavement

- Soil support value isn't critical
- Rigid pavements are insensitive to soil support value
  - Soil will be weakened due to water

Prezi

- Concrete strength and porosity are inversely related
- Can't have strength without reducing porosity
- Porosity is the most important attribute
  - Otherwise we would use conventional concrete
- The net result is we must design for a weaker concrete, and weaker soil.

Prezi

We can do that because the pavement thickness doesn't increase that much.

Steps to Design Rigid Pavement

- Quantify load
- For flexible pavements, each load consumes structural capacity of (damages) the pavement
- ESAL's not applicable for rigid pavement design.
- Heavy single axles contribute to fatigue
- Heavy tandem axle loads drive erosion
- Light loads (cars) do not damage a rigid pavement

Quantify Soil Support Value

- Soil weakened by water

Steps to Design Rigid Pavement

- Characterize Paving Material
  - Normal concrete will have Flexural strength (MR) = 550-700 psi
  - Pervious concrete has been measured at 200 - 600 psi
    - No valid ASTM test for acceptance
  - Real value likely at the higher end of that range
    - Anecdotal evidence - low strength material is usually unsound
    - Visually acceptable material
    - Satisfactory plastic voids ratio
  - I typically use 375 psi, and E = 2.5 million
    - Asphalt is about E = 250,000

Design methods

- There are a number of programs available.
- I prefer, and recommend, StreetPave.
  - Conservative
  - Quick
  - Old, Stable technology
  - Documentation

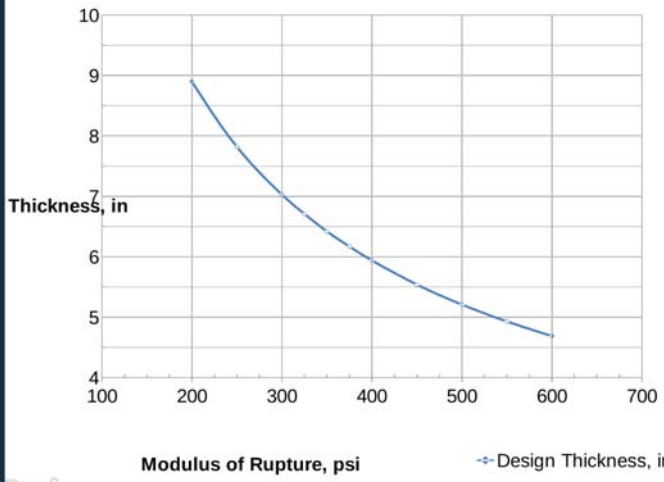
StreetPave (c)

- Uses PCAPAV engine, copyright 1985
  - DOS
- Compiled for Windows and elements of AASHTO added by ACPA
- Copies available on request

An Example

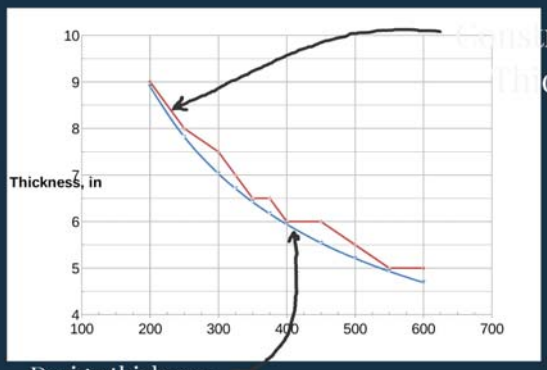
- Soil CBR = 1, k = 100 (Poor)
- ADT = 100 cars, 1% trucks, ADTT = 1
- Residential distribution
- MR = 375, E = 2.5 million - pervious concrete
- AC comparison with 12" base rock
- Thickness = 6" pervious concrete, no subbase
- If conventional concrete, MR = 550 psi,
  - thickness = 5"
  - 7.04" AC on 12" rock

Thickness vs. Modulus of Ruptu



Prezi

Thickness vs. Modulus of Rupture



ructed
ckness

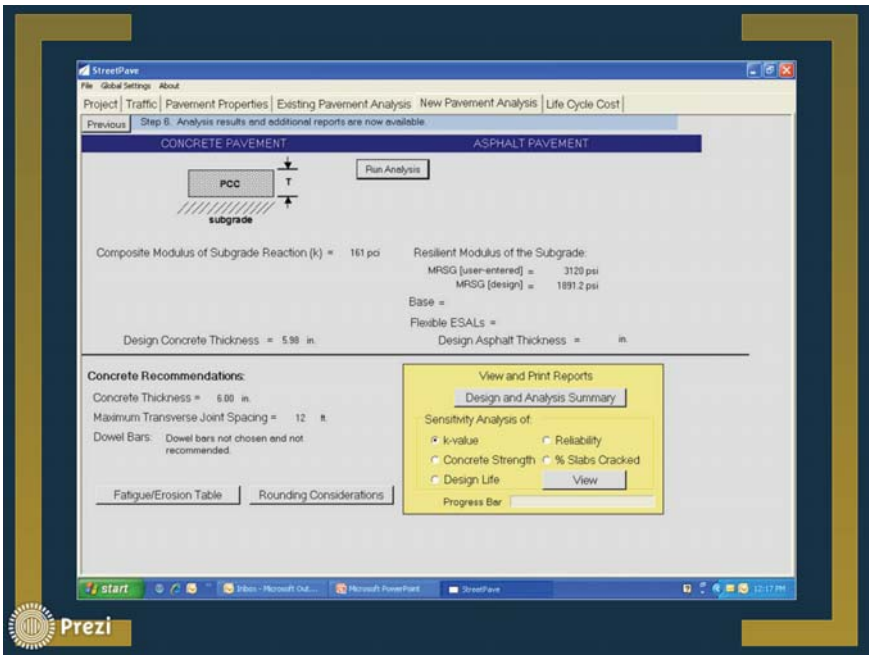
Design thickness

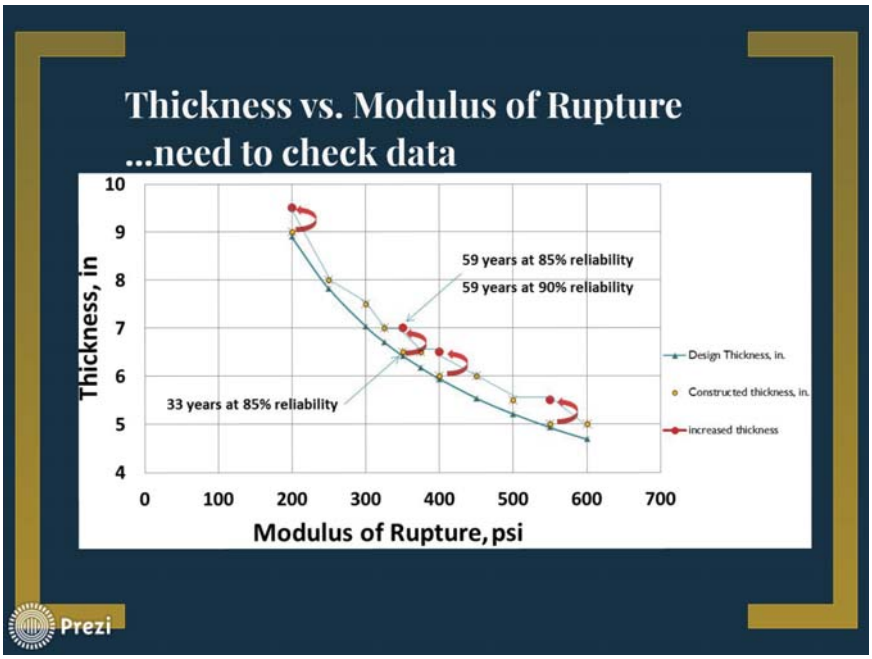
Prezi

Results of StreetPave

- Iterate to build confidence interval
- Subjective relative to input assumptions
  - Design results often obviate gathering additional information
- Recommended thickness is specific relative to calculations
  - Calculation of 5.99" = 6" thickness
  - Calculation of 6.01" = 6.5" thickness

Prezi


StreetPave
File Global Settings About
Project Traffic Pavement Properties Existing Pavement Analysis New Pavement Analysis Life Cycle Cost
Previous
Step 6. Analysis results and additional reports are now available.
CONCRETE PAVEMENT
ASPHALT PAVEMENT
Run Analysis
PCC
T
subgrade
Composite Modulus of Subgrade Reaction (k) = 161 pci
Resilient Modulus of the Subgrade:
MRSG [user-entered] = 3120 psi
MRSG [design] = 1891.2 psi
Base =
Flexible ESALs =
Design Concrete Thickness = 5.98 in.
Design Asphalt Thickness = in.
Concrete Recommendations:
Concrete Thickness = 6.00 in.
Maximum Transverse Joint Spacing = 12 ft.
Dowel Bars: Dowel bars not chosen and not recommended.
Fatigue/Erosion Table
Rounding Considerations
View and Print Reports
Design and Analysis Summary
Sensitivity Analysis of:
k-value
Reliability
Concrete Strength
% Slabs Cracked
Design Life
View
Progress Bar
start
Prezi


Thickness vs. Modulus of Rupture
...need to check data
Thickness, in
10
9
8
7
6
5
4
0
100
200
300
400
500
600
700
Modulus of Rupture, psi
59 years at 85% reliability
59 years at 90% reliability
33 years at 85% reliability
Design Thickness, in.
Constructed thickness, in.
increased thickness
Prezi


Design Procedure
• Select Structural Section
• Use StreetPave to iterate for data in question
• Assume weak subgrade, disregard drain rock layer
• Develop confidence interval
• Geotextile if necessary based on subbase material
• Run Hydrologic Model
• Continuous Flow Model
• WWHM3
• Single Event Model
• NRMCA, et al
Prezi

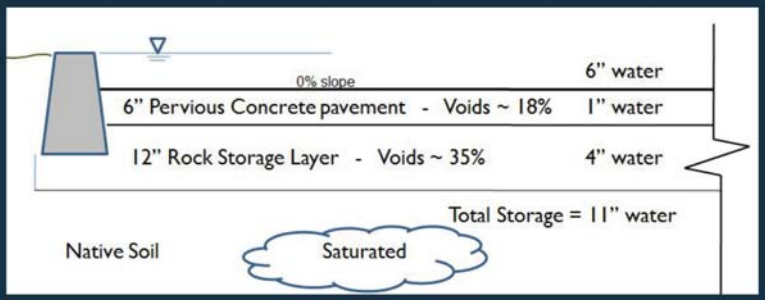
Prezi

Water...

- Model hydrology
- Calculate storage volume in pavement
  - Gross volume x 18% (disregard?)
- Calculate volume of rock needed to store remainder
  - Rock layer = approx. 36% voids
  - Ponded area, if any.

Prezi

"Typical" Parking area section (Florida design)



Prezi

Paved Area as retention volume

- Model the paved area as a wide, long, shallow infiltration trench.
- Reduction in depth needed to achieve volume.
- Large surface area makes the infiltration of even very poor soils significant.

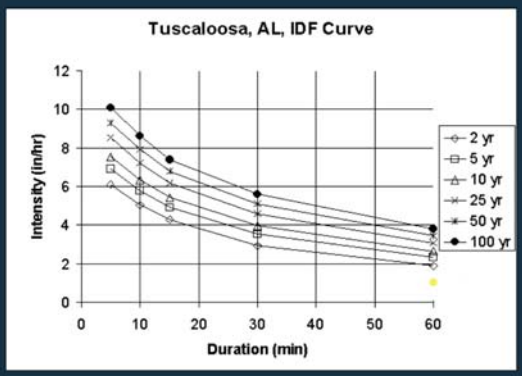
Prezi

Hydrologic Design

- Introduction
- Two Methods:
  - Single Event
  - Continuous Flow

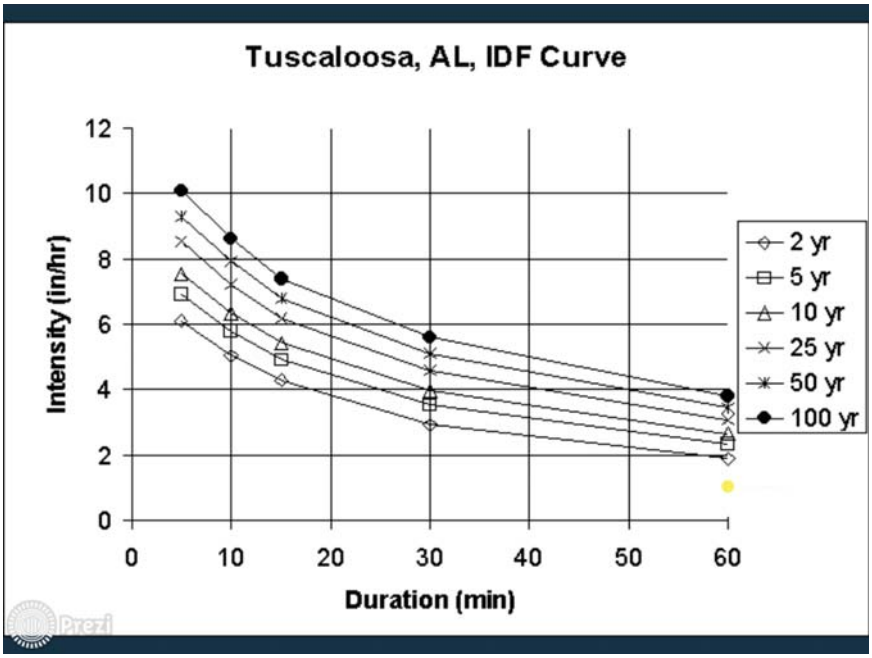
Prezi

Intensity-Duration- Frequency (IDF) Curves



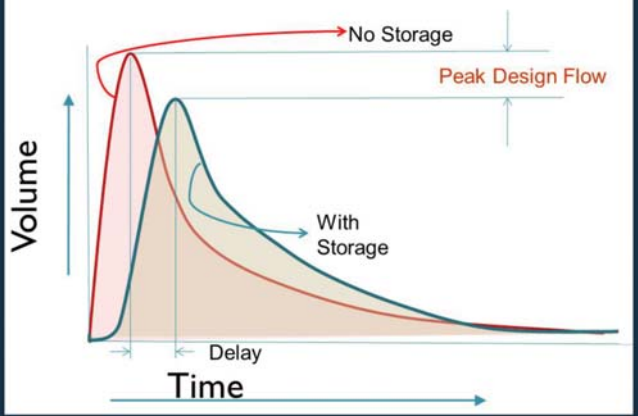
Prezi

Hurricane Katrina



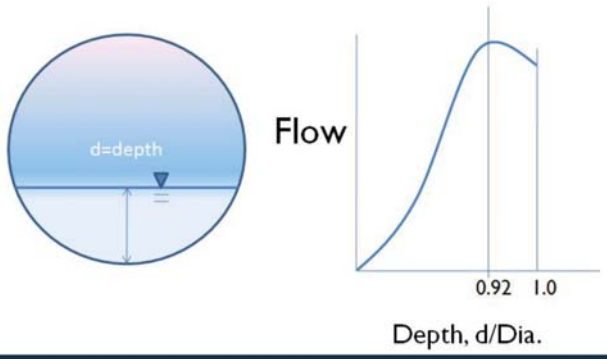
Why is time important?

Runoff Curve



Prezi

Maximum flow rate in gravity pipe



Prezi

Hydrologic design

- PCA/NRMCA method -Mass balance, single event
- Generic Hydrologic design procedure
- Available from PCA - Have some disks, no charge
- Soils
  - Sandy – use 0.5" – 1" per hour infiltration
  - Silty – use 0.1" per hour
  - Clayey – use 0.01" per hour.
  - WSU Puyallup - .003"/hr.
- Even poor soil infiltration rates can be significant over a large area

Prezi

Hydrologic Design

- WWHM3
- Dynamic, Continuous flow modeling,
- Also mass balance based
- Model as wide infiltration trench
- Even at low soil permeability rates, infiltration is significant due to large surface area.
- Available on line, tutorial and classes for fee.
  - http://www.ecy.wa.gov/programs/wq/stormwater/wwhm_training/wwhm/wwhm_v3/index.html

Specification for Pervious Concrete Pavement - ACI Committee 522

- ACI 522.1-08
- Available for purchase from ACI
  - $32 for non-members
  - $20 for members

Specification for Pervious Concrete Pavement - ACI Committee 522

- ACI 522.1-08 is recommended
- Control based on:
  - Mix design compliance
  - Unit Wt. and voids of plastic concrete
  - Thickness and unit wt. of hardened concrete
  - Visual inspection
  - Agreement with Accepted Test Panel
- Corrections on site at time of placement

Be wary of proprietary products and non-standard specifications

- Greater due Diligence
- Industry Standards?
- What about conflicting specification language?

...law of unintended consequences...

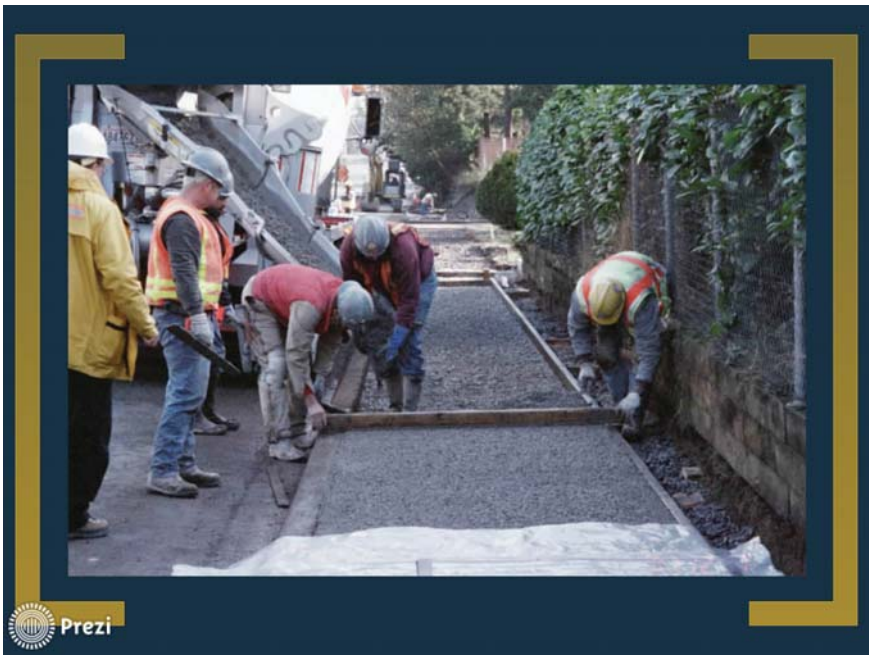
Prezi

Construction

- NRMCA certification program
  - Certified contractor
- Very low W/C, depends on mechanical energy to place and consolidate
- Susceptible to drying
- Curing by covering with plastic sheeting is mandatory
- Correct issues at time of placement
- Place, strikeoff, roll, joint, cover – done
- Discharge and placing rates will be slower
- Geotextile – soils dictate

Prezi

Prezi




Put Plastic on concrete first, then roll over it.


Prezi


Prezi


Prezi


Prezi


Prezi


Prezi


Prezi


Prezi


Prezi


Prezi


Olympia Federal Savings
The Willis Family Home
Prezi


Prezi


Rainier
Prezi


Prezi


8. 10. 2002
Prezi


Poor practice
Immediate attention
required!
8. 10. 2002
Prezi

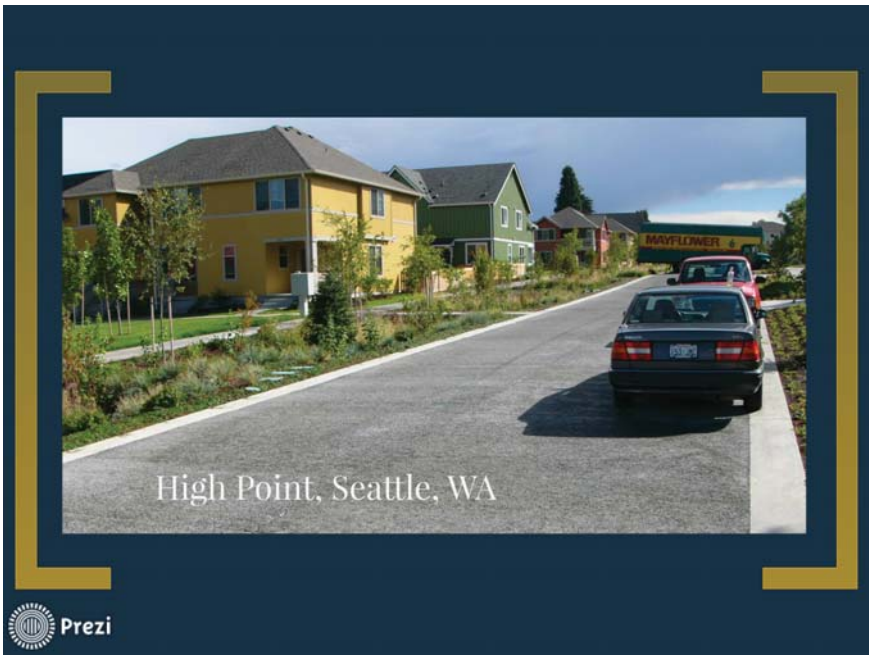

Prezi


Projects
Prezi

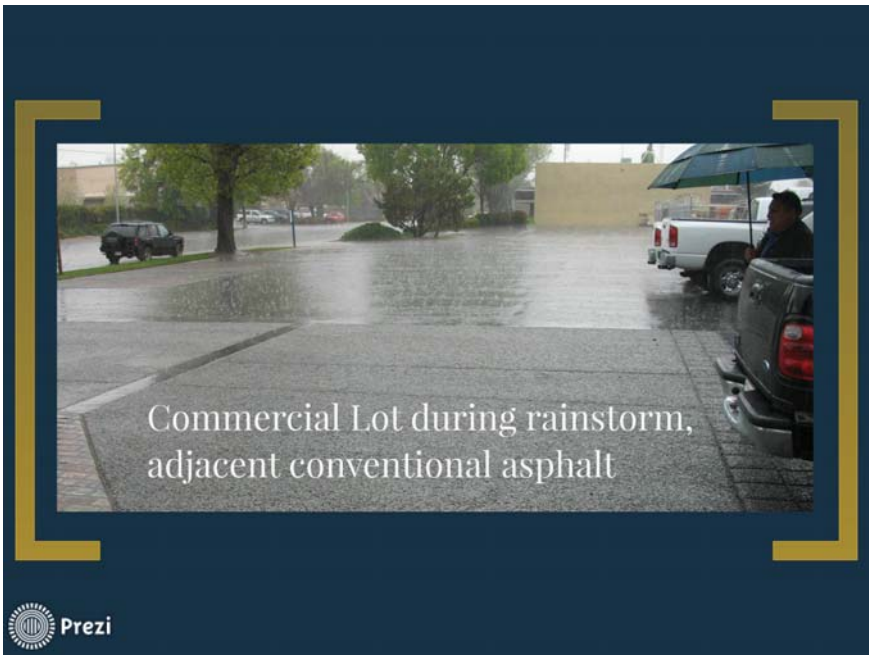

Whidbey Island, WA
Prezi

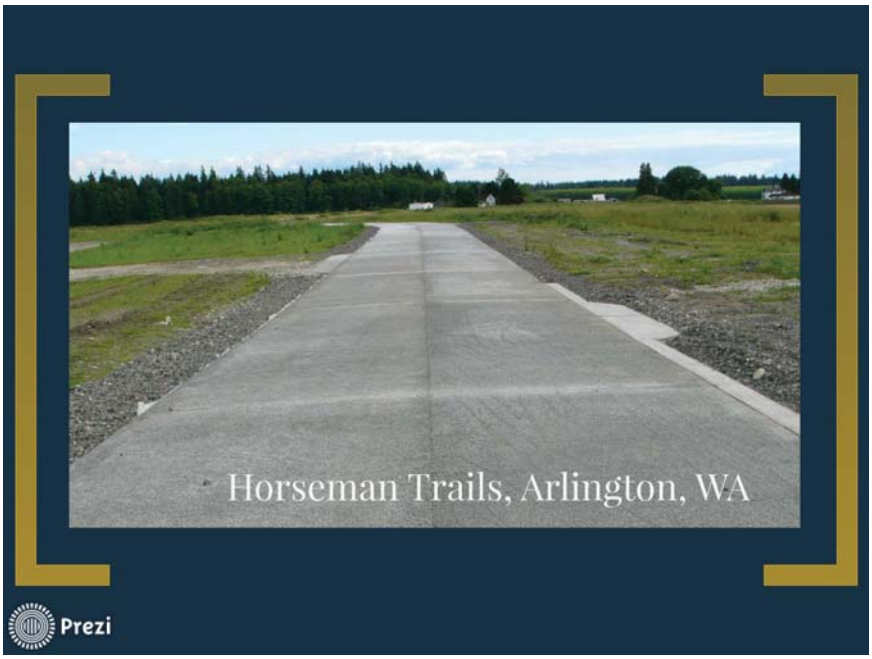

Commercial Parking Lot, Maltby, WA
Prezi


High Point, Seattle, WA
Prezi


MAYFLOWER
High Point, Seattle, WA
Prezi

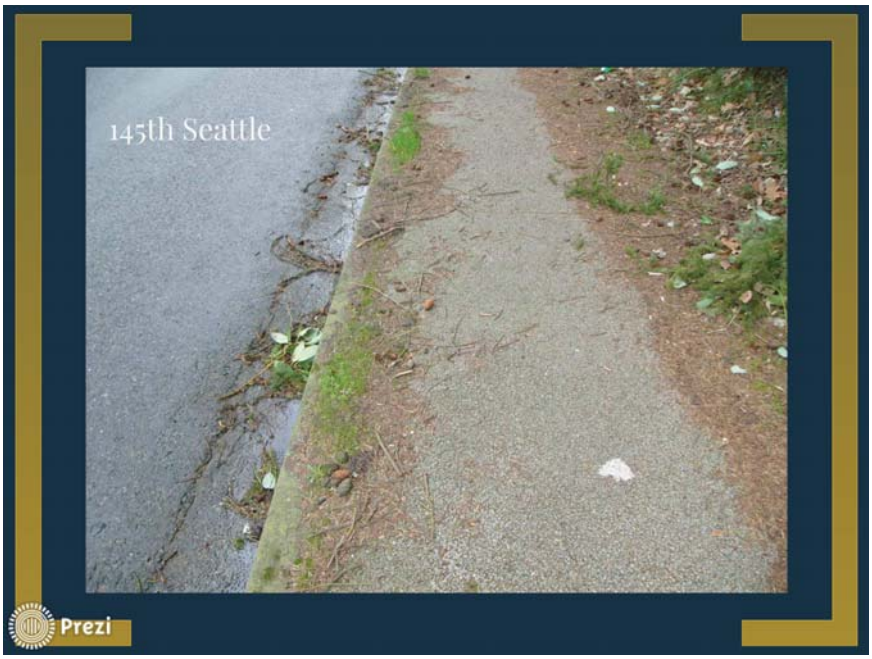

High Point, Seattle, WA
Prezi


Commercial Lot during rainstorm,
adjacent conventional asphalt
Prezi


Horseman Trails, Arlington, WA
Prezi


Prezi


Stratford Place, Sultan, WA
Prezi


145th Seattle
Prezi


Mt. Angel, OR
Prezi


2200 CY, Fort Lewis, WA
Prezi

Near Sandy R, OR

Prezi

Prezi

Prezi


SeaTac Headquarters Fire Station


SeaTac Headquarters Fire Station

Safeway Denver

- 24 hours after snowstorm, one week after construction completed

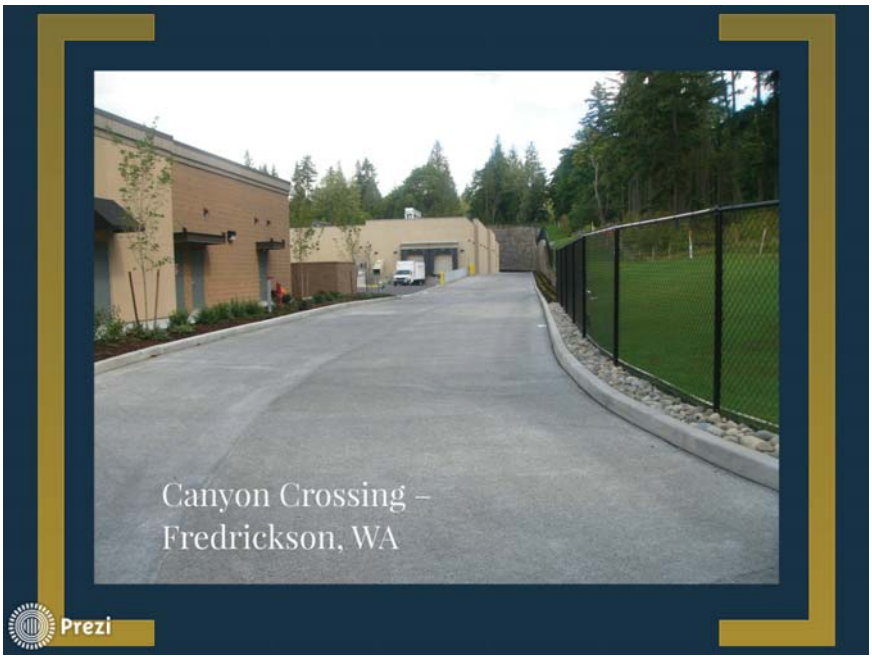
Prezi

Canyon Crossing – Fredrickson, WA

Prezi

Canyon Crossing – Fredrickson, WA

Prezi


Canyon Crossing –
Fredrickson, WA
Prezi


Ready Mix Plant, Kent, WA
Prezi


Ready Mix Plant, Kent, WA
Prezi


First Industrial Lacey
Prezi


First Industrial Lacey
Prezi

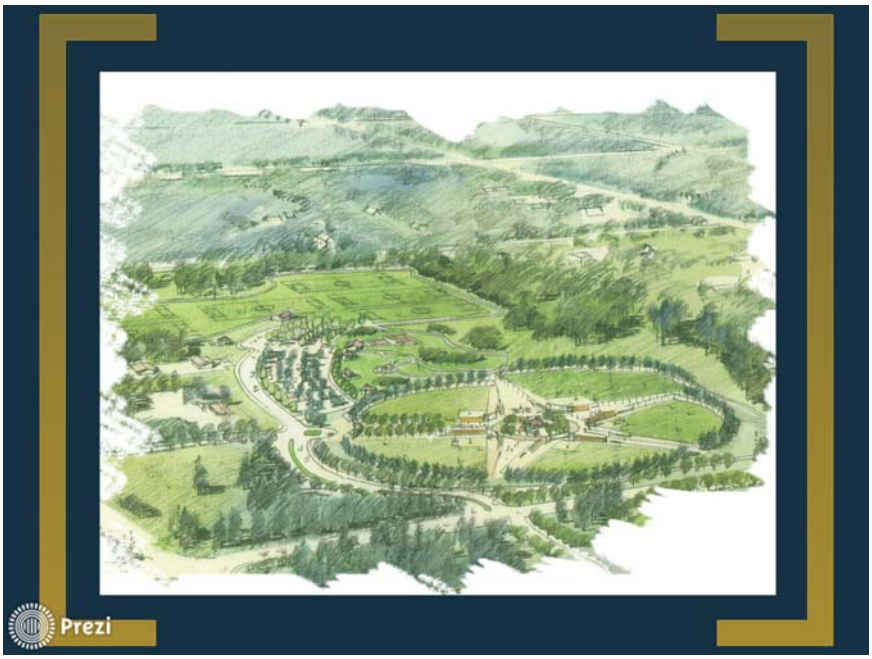

First Industrial Lacey
Prezi


First Industrial Lacey
Prezi


First Industrial Lacey
Prezi


Tulalip "Q" Casino
Prezi


Tulalip "Q" Casino
Prezi


Prezi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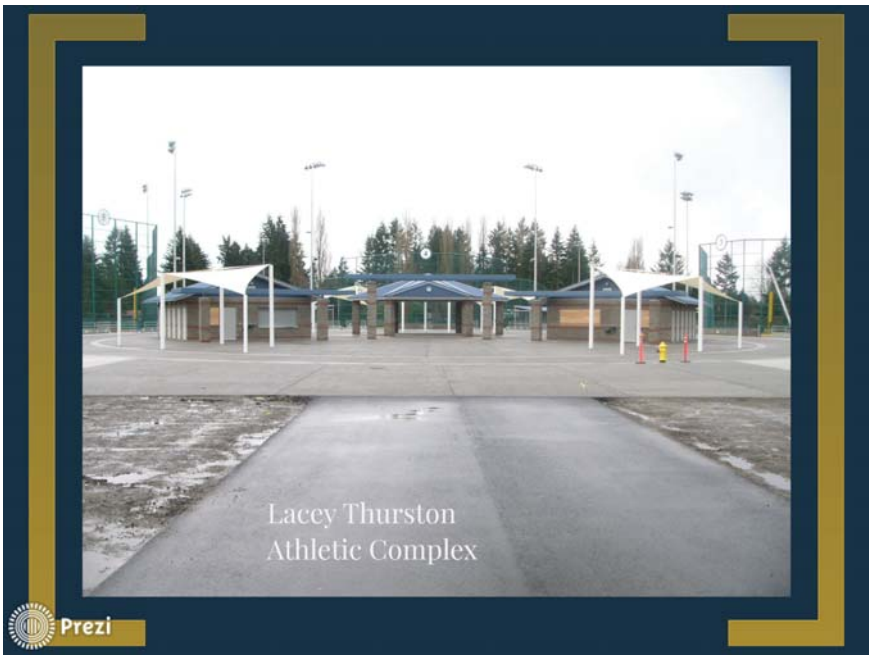
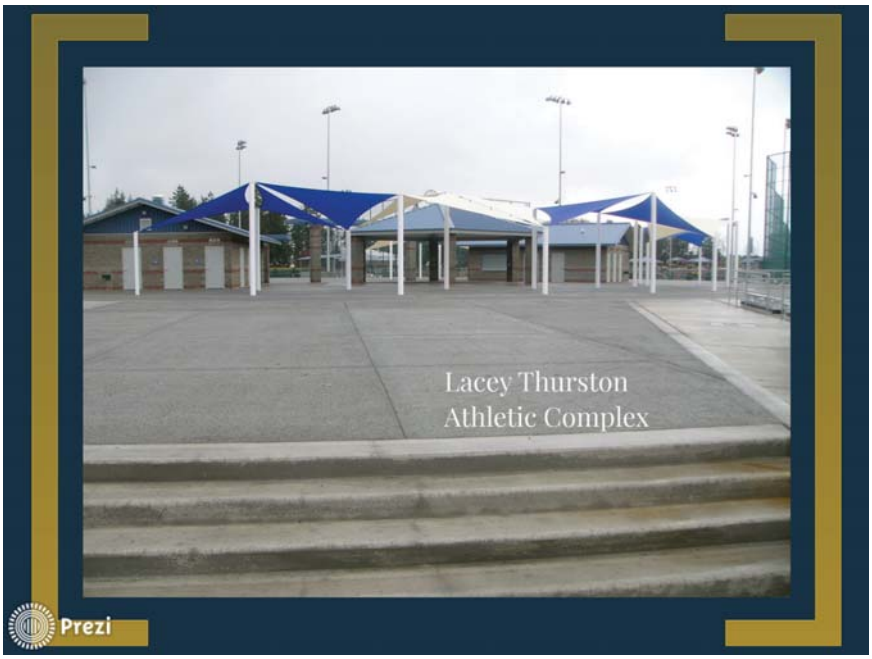

Lacey Thurston
Athletic Complex
Prezi


Lacey Thurston
Athletic Complex
Prezi

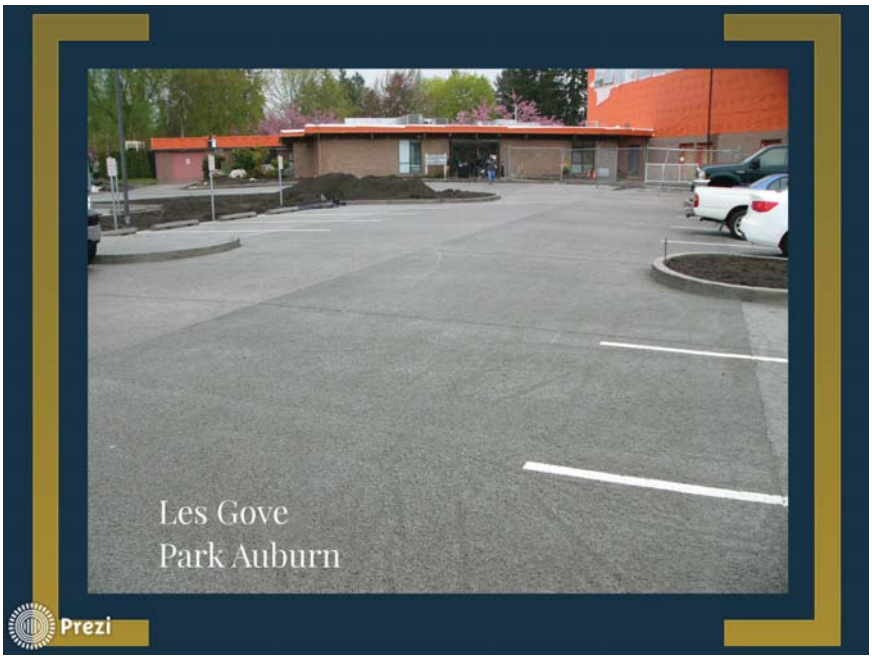

Lacey Thurston
Athletic Complex
Prezi


Lacey Thurston
Athletic Complex
Prezi


1
Lacey Thurston
Athletic Complex
Prezi

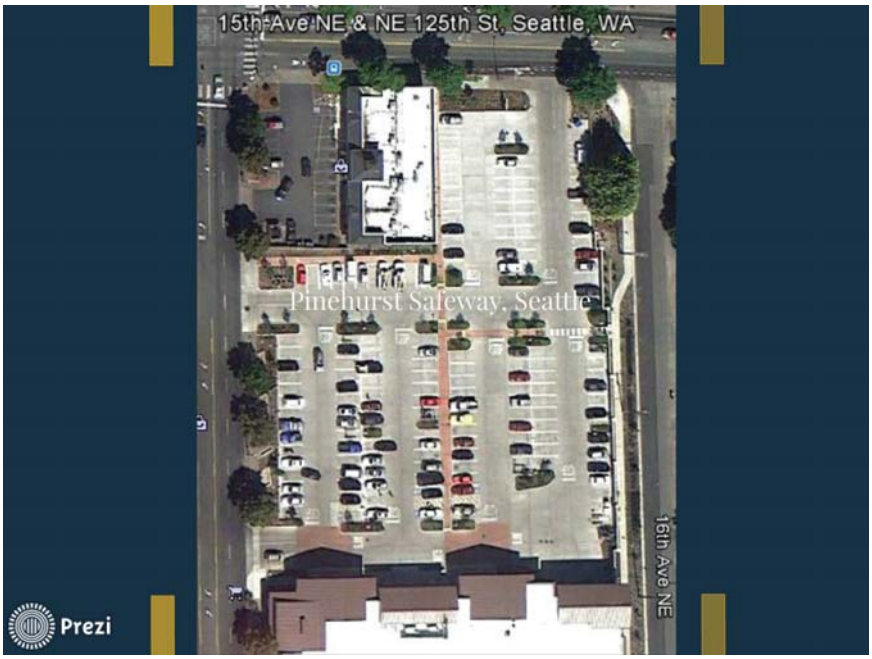

Les Gove
Park Auburn
Prezi

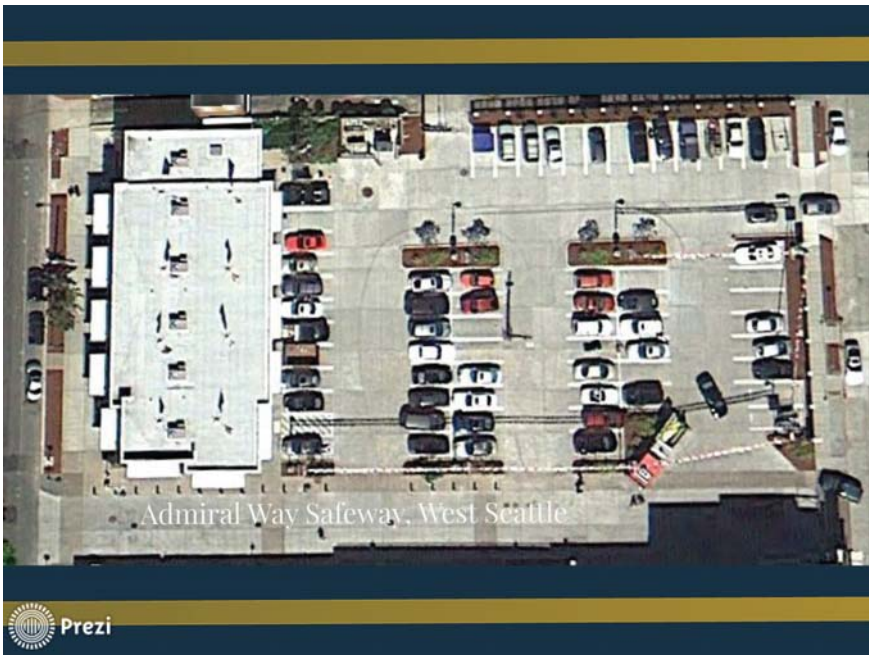

Les Gove
Park Auburn
Prezi


Les Gove
Park Auburn
Prezi


Les Gove
Park Auburn
Prezi


WSU Puyallup
Prezi


15th Ave NE & NE 125th St, Seattle, WA
Pinehurst Safeway, Seattle
16th Ave NE
Prezi


Admiral Way Safeway, West Seattle
Prezi

• Questions?

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Pavement Engineer
Portland Cement Association, NW
dwarner@cement.org
503 780 9505