Constructing and Maintaining Durable Concrete

Rock Springs- 10/20/21

Casper- 10/21/21

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What is ACPA?

- World's largest **trade association** representing the interests of those involved with the design, construction, and preservation of concrete pavements
- Supports research and promotion to improve the quality of concrete pavements and expand their use
- Provides engineering expertise, design tools, pavement specifications, construction best practices, and education to members and agencies
  - Executive Director- Angela Folkestad, P.E.
  - Pavement Engineer- Sarah Sanders, P.E.

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Pavement Design Basics

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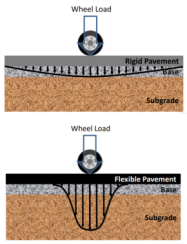
Concrete (Rigid) vs. Asphalt (Flexible) Pavement



- All pavement is rocks held together with a binder
- Concrete carries load in pavement structure
  - exerts less pressure on base materials
  - better for heavy loads
  - Strength is important
- Asphalt relies on strength of base materials and subgrade
  - Requires more thickness and layers
  - Characteristics change with ambient temperature

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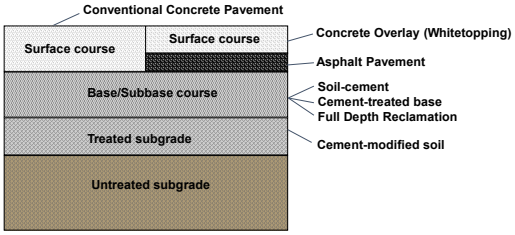
Materials in a Concrete Pavement Section



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Concrete Pavement Types

- Jointed Plain
  - Undoweled
  - Doweled
- Jointed Reinforced
- Continuously Reinforced

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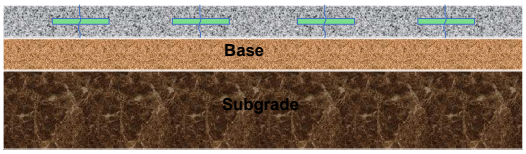
Conventional Concrete Pavement



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Thin Concrete Overlays on Asphalt Pavements

- Rely on existing asphalt pavement to provide additional load-carrying capacity, and bond to existing asphalt pavement to form a monolithic section
- Add structural capacity where traffic loads have increased or are anticipated to increase
- Eliminate surface defects such as rutting and shoving
- Improve surface characteristics (friction, noise, and smoothness)

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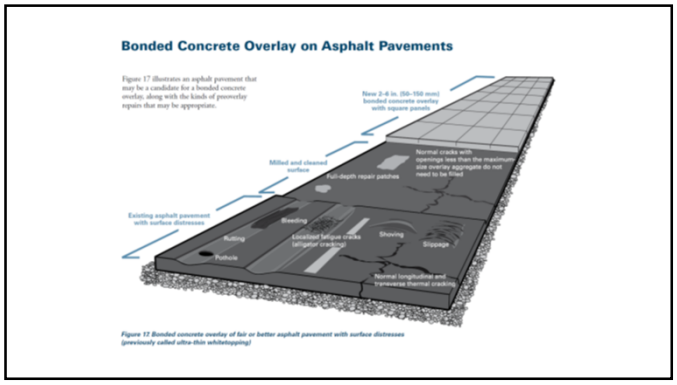

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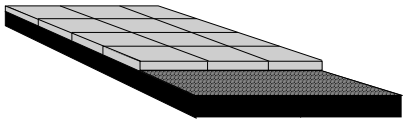
Ultra-Thin Concrete Overlay (Whitetopping)

- <5” concrete layer on top existing asphalt pavement
- Steps taken to bond the new concrete to existing asphalt
- Short joint spacing
- May or may not contain fibers



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Unbonded Concrete Overlays

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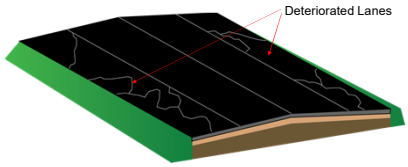
Concrete Inlays

- The same methodology can be applied to replace portions of ACC pavements.



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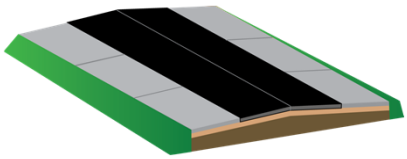
Concrete Inlays

- Replace deteriorated ACC lanes with PCC…the result can again be much cheaper than the overlay alternative.



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Concrete Inlays

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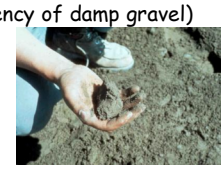
Definition

"Roller-Compacted Concrete (RCC) is a no-slump concrete that is compacted by vibratory rollers."

- Zero slump (consistency of damp gravel)
- No forms
- No reinforcing steel
- No finishing
- Consolidated with vibratory rollers



Concrete pavement placed in a different way!

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ROLLER COMPACTED CONCRETE

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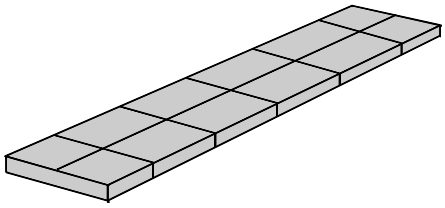
Jointing Concrete Pavements



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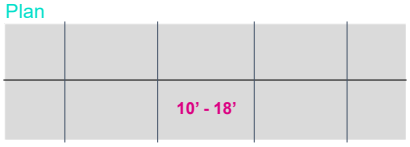
Jointed Plain Concrete Pavement (JPCP)

Plan



Profile

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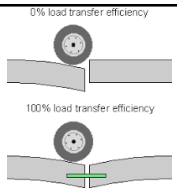

Dowel Bars

- Smooth steel bar
- Promotes load transfer between panels
- Prevents Faulting
- Size dependent on thickness
- Need to have one side oiled to prevent bonding
  - Pavement moves around bars
- Epoxy coated for corrosion resistance

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Tie Bars

- Deformed steel bars
- Placed across joints to hold faces tight
- Supplement aggregate interlock
- Designed to overcome subbase resistance to slab contraction

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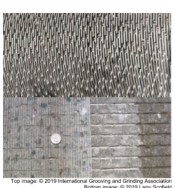
Pavement Texture

- Transverse Tining
- Longitudinal Tining
- Diamond Ground
- Macrotexture (Burlap Drag)




Top image: © 2019 International Grooving and Grinding Association
Bottom image: © 2019 Larry Scofield
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Source: FHWA

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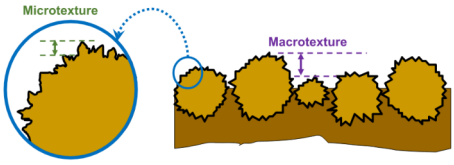
Pavement Surface Texture

Microtexture

- Provides direct tire-pavement contact
- Contributes to adhesion component of friction



Macrotexture

- Allows for rapid drainage of water from pavement
- Provides hysteresis component of friction

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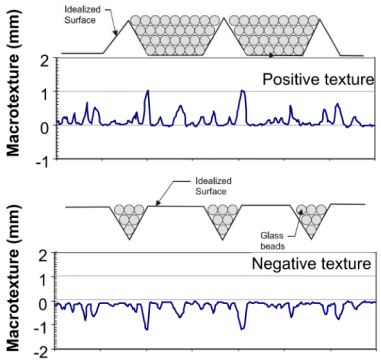

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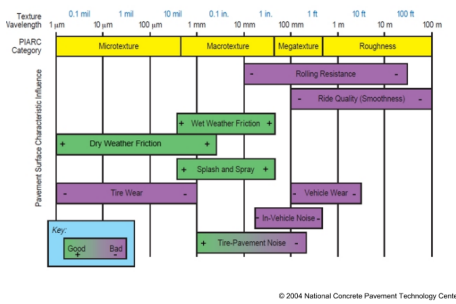

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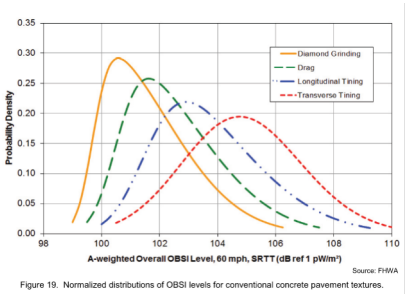

Figure 19. Normalized distributions of OBSI levels for conventional concrete pavement textures.

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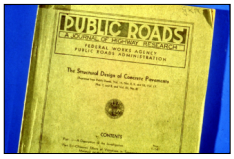
1st Pavement Design Equation

- 1926 - Prof. Westergaard, University of Illinois published equations for stresses and deflections of concrete pavement
- Bureau of Public Roads (forerunner of FHWA) conducted 4 years of testing and published a very complete report on the "Structural Design of Concrete Pavements" to test Westergaard's equation.



$$d = \sqrt{\frac{cp}{s}}$$

d = thickness
c = stress coefficient
p = wheel load
s = allowable tensile stress

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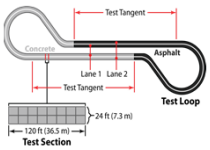
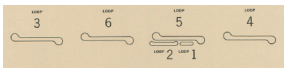
AASHO Road Test (1958-1960)

- Wholly empirical
- Included 368 concrete and 468 asphalt sections
- Focus was highway pavement





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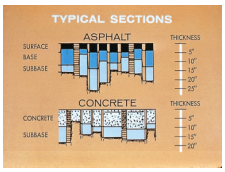
Thickness was Guessed!



Subgrade = Clay Soil

Sections Loaded for 2 Years & 1.1 Mil Reps

Max Single Axle

Max Tandem Axle

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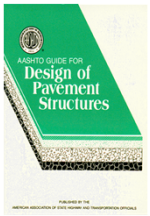
1986-93 JPCP AASHTO 93 Equation



Standard Normal Deviate
Overall Standard Deviation
Change in Serviceability
Thickness
Traffic
Terminal Serviceability
Modulus of Rupture
Drainage Coefficient
Load Transfer
Modulus of Elasticity
Modulus of Subgrade Reaction

$$Log(ESAL) = Z_R * s_o + 7.35 * Log(D+1) - 0.06 + \left[\frac{Log\left[\frac{\Delta PSI}{4.5-1.5}\right]}{1+\frac{1.624*10^7}{(D+1)^{8.46}}}\right] + (4.22-0.32*p_t) * Log\left[\frac{S_c' * C_d * (D^{0.75}-1.132)}{215.63 * J * \left[D^{0.75}-\frac{18.42}{(E_c/k)^{0.25}}\right]}\right]$$

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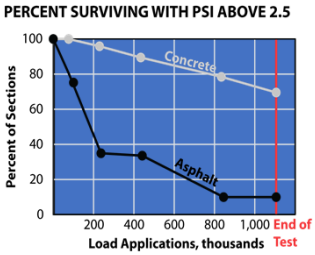
Performance Estimated Subjectively

- **Present Serviceability Index (PSI)**
  - 4.0 – 5.0 = Very Good
  - 3.0 – 4.0 = Good
  - 2.0 – 3.0 = Fair
  - 1.0 – 2.0 = Poor
  - 0.0 – 1.0 = Very Poor
- "Failure" at the Road Test considered @ 1.5
- Typical U.S. state agency terminal serviceability in practice = 2.5



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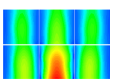
Pavement ME Design

- Not "perfect" & not intended to be a "final" product
- Complex
- For highways and NOT street, road, parking lot, etc.



Mechanistic Calculation of Responses

+

Empirical Tie to Ground

=

Pavement Performance Prediction

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AASHTO 93 vs. ME

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Need and Relevance – Addressing Demand

- High price point and learning curve for AASHTOWares's Pavement ME
- Non-DOT agency audience seeking affordable easy-to-understand design tools for pavement solutions, especially where traffic levels are low to moderate
- Consultants have similar needs and value quick-access design tools, providing quick answers

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Pavement Designer-Overview and Background

- ACPA, NRMCA, and PCA partnership, with a contribution from the RCC Council to develop a website application to design cement-based solutions for:
  - Streets and Local Roads
  - Parking Lots
  - Intermodal/Industrial Facilities
- Design guidance and tools for:
  - Jointed-Plain Concrete Pavements
  - Continuously Reinforce Concrete Pavement
  - Concrete Overlays
  - Composite Pavements
  - Roller Compacted Concrete
  - Cement Modified Soils
  - Cement-Treated Base
  - Full-Depth Reclamation

ACPA AMERICAN CONCRETE PAVEMENT ASSOCIATION
NRMCA
PCA America's Cement Manufacturers
RCC Pavement Council

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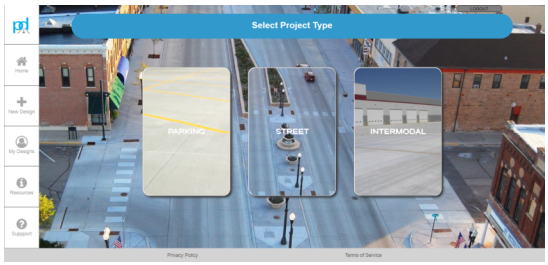
PavementDesigner



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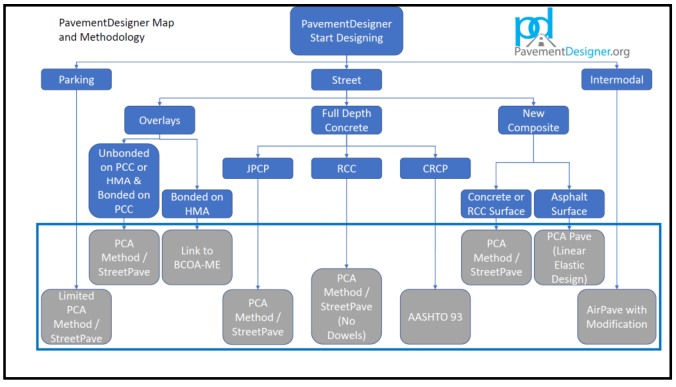

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Questions?

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