

SEAUPG 2003 CONFERENCE

Determination of Layer Coefficients for New HMA Materials

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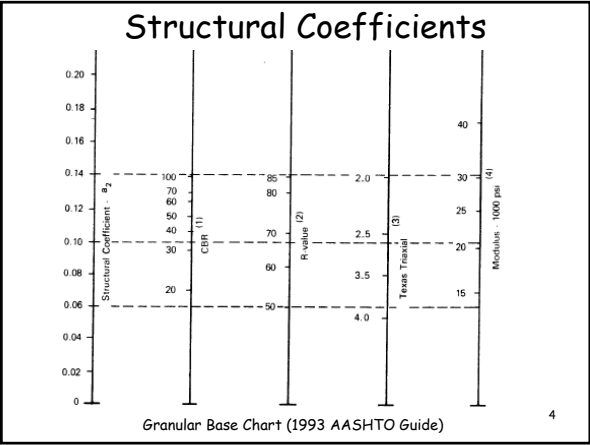
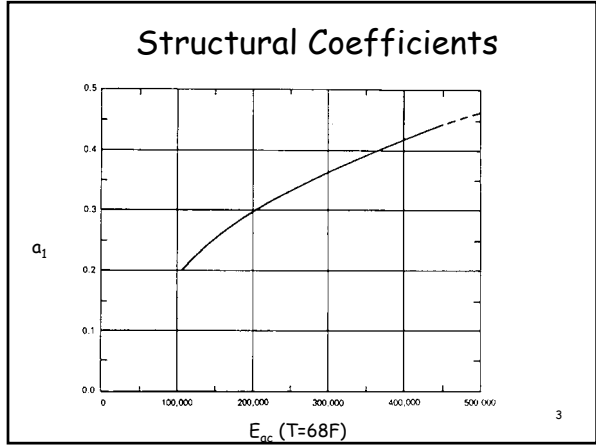
Background

- Structural coefficients central to current flexible pavement design

$$SN = a_1 D_1 + a_2 m_2 D_2 + \dots + a_n m_n D_n$$

Diagram illustrating the structural equation and pavement layers: Granular Base ($a_2 m_2$), Granular Subbase ($a_3 m_3$), and Roadbed Soil. Structural numbers SN_3, SN_2, SN_1 are shown above the layers, and thicknesses D_1, D_2, D_3 are indicated on the right.

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Drainage Coefficients

- Depends on quality of drainage and availability of moisture

m_i Values for Modifying Structural Layer Coefficients (Untreated Base and Subbase Materials)

		% Time Saturated			
Quality	Water Removed	< 1%	1 - 5 %	5 - 25%	> 25%
Excellent	2 hours	1.40 - 1.35	1.35 - 1.30	1.30 - 1.20	1.20
Good	1 day	1.35 - 1.25	1.25 - 1.15	1.15 - 1.00	1.00
Fair	1 week	1.25 - 1.15	1.15 - 1.05	1.05 - 0.80	0.80
Poor	1 month	1.15 - 1.05	1.05 - 0.80	0.80 - 0.60	0.60
Very Poor	Never Drain	1.05 - 0.95	0.95 - 0.75	0.75 - 0.40	0.40

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Problem Statement

- Structural Coefficients based on AASHTO Road Test
- Typically not revised/improved
 - ALDOT
 - $a = 0.44$ HMA Surface
 - $a = 0.30$ asphalt treated base layer
- Many new mixes
 - Superpave
 - OGFCs
 - SMAs
 - Polymer modification
- Need to update/revise/improve coefficients

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Key Question

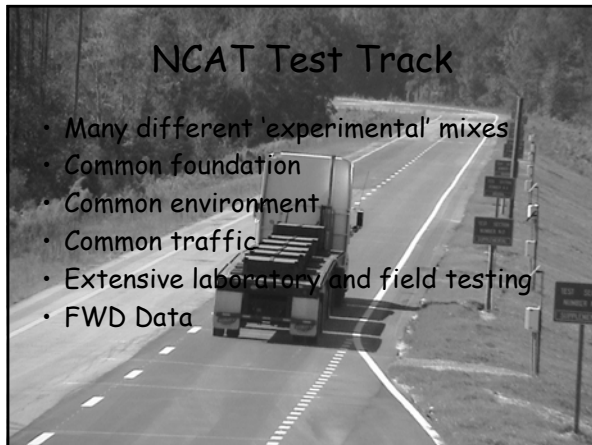
- Can we distinguish mixtures by structural coefficients?

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Scope

- NCAT Test Track
 - 46 mixes
 - 26 on tangent section
- Deflection Data
 - Estimate structural number
 - Derive structural coefficients

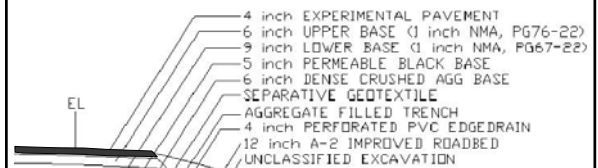
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NCAT Test Track

- Many different 'experimental' mixes
- Common foundation
- Common environment
- Common traffic
- Extensive laboratory and field testing
- FWD Data

Structural Buildup at Track



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Methodology

- Utilize AASHTO 2-layer backcalculation
 - Estimate SN_{eff}
- Determine a_i relative to a reference section
 - S_7
 - Superpave
 - PG 67-22 (6.66% Asphalt Content)
 - Unmodified
 - Gradation below the restricted zone
- Look for trends and explanatory variables

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FWD Testing

- Conducted by ALDOT
- Outside wheelpath
- 2 stations / section
- 2 to 3 drops / station
- Approx. 9 kip load

Testing Dates
Jan. 22, 2001
Jan. 29, 2001
Feb. 26, 2001
Mar. 26, 2001
May 7, 2001
June 11, 2001
Aug. 27, 2001

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AASHTO Backcalculation

- Section L5.3 of 1993 AASHTO Guide
- 'Two-layer' approach

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Mr Calculation

- Boussinesq Theory

$$M_r = \frac{0.24P}{d_r \cdot r}$$

- typically radius at sensor 7
- Not temperature dependent

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Ep Calculation

- Use center deflection
- Need to temperature correct d0
- Solve for Ep numerically

$$d_0 = 1.5qa \left[\frac{1}{M_r \sqrt{1 + \left(\frac{D}{a} \sqrt{\frac{E_p}{M_r}} \right)^2}} + \frac{1 - \frac{1}{\sqrt{1 + \left(\frac{D}{a} \right)^2}}}{E_p} \right]$$

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Determine SN_{eff}

$$SN_{eff} = 0.0045 D \sqrt[3]{E_p}$$

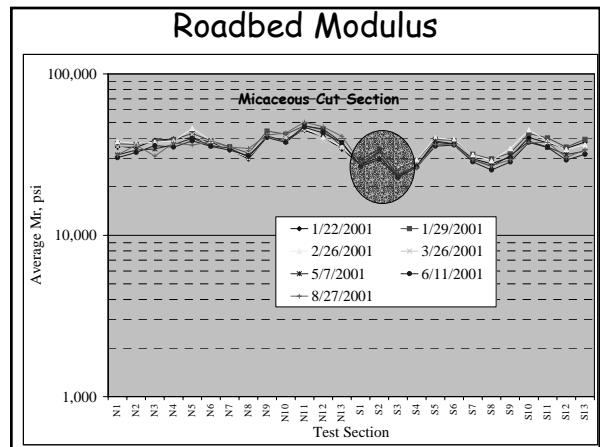
- D = depth of pavement above subgrade
- Ep = composite pavement modulus

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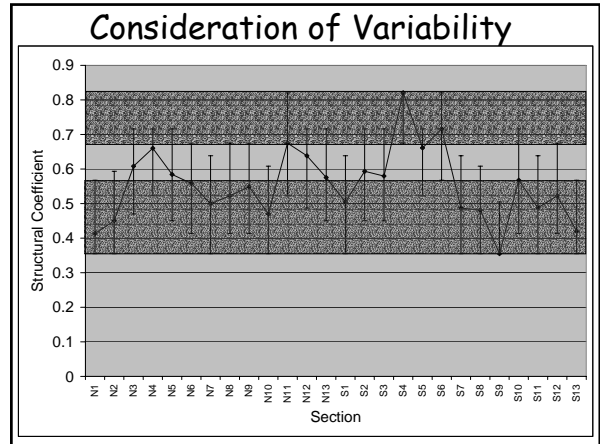
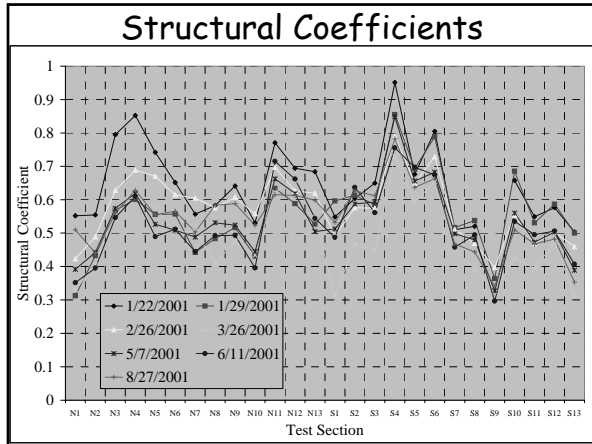
a₁* Determination

Control Section	Unknown Section
a ₁ , D ₁	a ₁ *, D ₁ *
a ₂ , D ₂	a ₂ , D ₂
Subgrade	Subgrade
$SN = a_1 D_1 + a_2 D_2$	$SN^* = a_1^* D_1^* + a_2 D_2$
$a_1^* = \frac{SN^* - SN + a_1 D_1}{D_1}$	

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Summary Statistics (S7 as Reference)

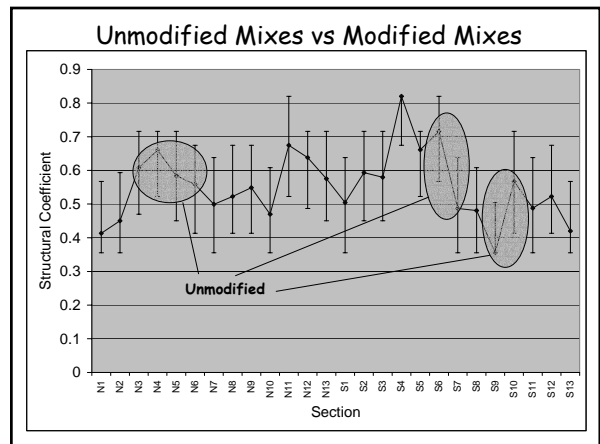
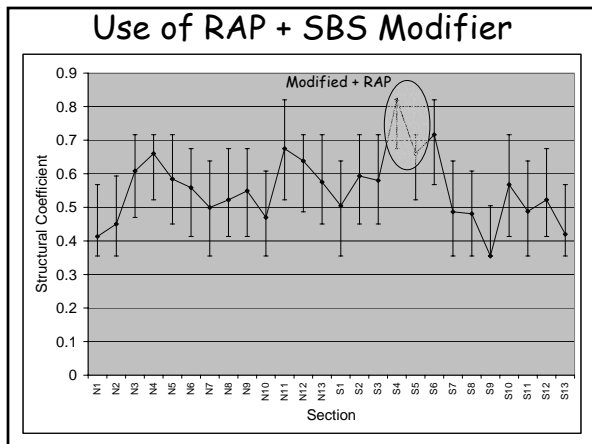
- Average Value = 0.55
- Range of Values = 0.34 - 0.82

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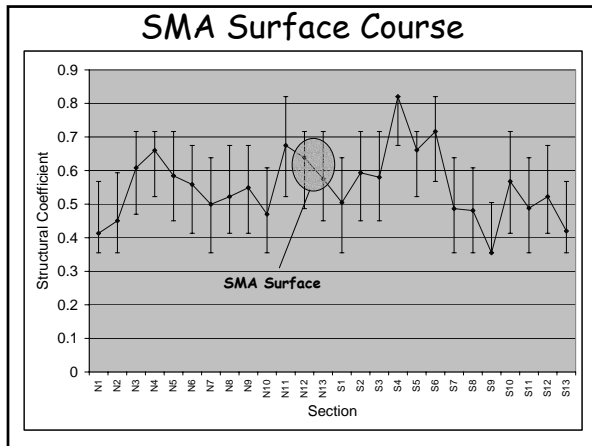
Factors to Investigate

- Asphalt Content
- Binder Grade
- Binder Modification
- Mix Design
- Field Density
- Aggregate Type
- Aggregate Gradation

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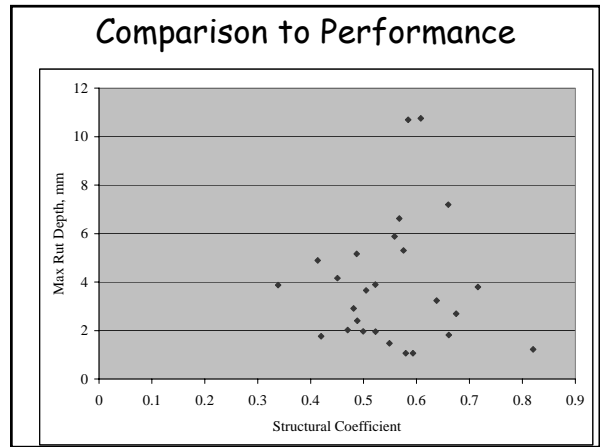
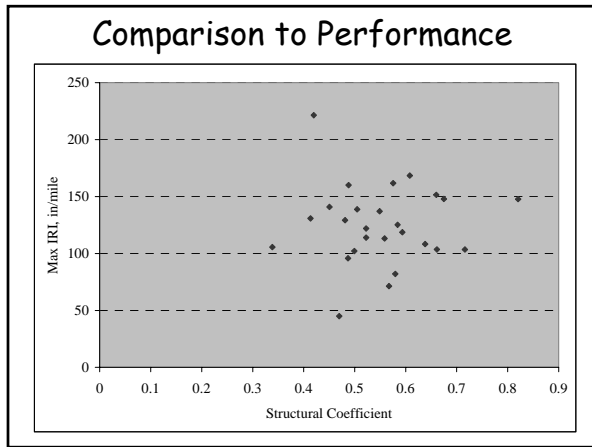
Example Statistical Evaluation

$$a = - 2.08 - 0.00143 \text{ Failure Grade} + 0.013 \text{ ACRICH} \\ - 0.00010 \text{ P4} + 0.0108 \text{ P16} + 0.0405 \text{ P200} \\ + 2.17 \text{ Section Compaction} + 0.0253 \text{ AGG TYPE}$$

$R^2 = .311$

Where:
 Failure Grade = PG Performance Grade
 ACRICH = optimum + 0.5%
 P4, P16, P200 = %Passing Respective Sieves
 Section Compaction = As-built % max density
 AGG Type = 1 (limestone), 2 (slag/limestone), 3 (gravel)
 4 (granite), 5 (Marble/Schist),
 6 (Limestone/RAP)

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Conclusions

- Unable to clearly distinguish mix types by structural coefficient
- Using 0.44 is a reasonable value for most mixes
- Need for mechanistic characterization

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