Report on the National Aggregate Base Conference

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Asheville, NC
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- Tennessee Road Builders Association
- Texas Aggregates & Concrete Association
- Virginia Transportation Construction Alliance
Base Conference Program

• Overview of Current Design Techniques
• ICAR Mechanistic Design Model
• Life Cycle Cost Comparisons
• Optimizing Value and Performance of Aggregate Base Courses
• Compaction Requirements and Techniques
• Measurement and Testing (Density vs. Stiffness)
• Inverted Base Design and Performance
• Subbase for Rigid Pavements
• Drainage Layers Under Porous Pavements
• Texas Toll Road: High Performance Base Course Test Project
Overview of Current Design Techniques
Erol Tutemluer- University of Illinois

- Design approaches: empirical, mechanistic and mechanistic-empirical
- Mechanistic involves determining pavement responses due to loading through mathematical models tied to pavement responses through transfer functions
- AASHTO design procedures very conservative due to high No. 200 and low compaction in test road
- Design does not recognize excellent compressive strength and stress dependency of crushed aggregate base
• Unbound granular materials display anisotropic behavior (modulus values differ in the vertical and horizontal direction)
• The lower Poisson's ratio, the more anisotropic (AASHO Road Test ~ 0.30)
• Anisotropy due to particle shape and methods of placement and densification
ICAR Anisotropic Mechanistic Design Model
Dallas Little - Texas A&M University

• Reductions in anisotropy
  – Decreases tensile strain at the bottom of the HMA layer
  – Reduces compressive strain at the top of subgrade
  – Reduces stresses at the top of the subgrade
  – Increases pavement performance
ICAR Anisotropic Mechanistic Design Model
Dallas Little- Texas A&M University

• Aggregate characteristics to reduce anisotropy
  – Larger top size, well-graded
  – Reduce flat/elongated particles
  – Increase angularity and texture
  – Control fines
Life Cycle Cost Comparisons
Bernie Kuta- FHWA

- Review of the elements and rationale for conducting life cycle cost analyses
- Demonstrated an analytical tool to provide a cost comparison of competing design alternatives producing equivalent benefits for the project being analyzed.
• Grading
  – Use the largest top size available that can be accommodated by thickness
  – Select a well graded material using the 0.45 power curve for a guide
  – Select a maximum No. 200 level consistent with environmental concerns
  – Use a grading that provides acceptable strength properties (CBR, triaxial or modulus)
  – Use care if designing grading for permeability because of influence on strength.
Optimizing Value and Performance

• Design Considerations
  – Insure subgrade strength and preparation is adequate
  – Require 100 % modified density in base
  – Single lift sections (max. 14 in.) if desired
  – Minimize thickness of HMA over base
  – Keep water out of the subgrade and base
  – Use larger top size grading
  – Require proper control and testing of placement
Optimizing Value and Performance

• Construction practices
  – Source approval for quality
  – Plant quality control for gradation and moisture
  – Establish the target density and optimum moisture (T-180)
  – Place with a spreader box to control thickness and minimize segregation
  – Avoid water additions on the roadway
  – Control compaction with nuclear gauge as placed & rolled
  – Seal quickly when sections are accepted
Optimizing Value and Performance
Impact of Density and Grading

Crushed Aggregate Base

Crushed Limestone
Similar to Road Test

T 99
T 180

Density (% theoretical max.)

0 50 100 150 200 250 300 350

0 60 65 70 75 80 85 90 95

CBR, % @ 0.2" Penetration

Crushed Limestone

Similar to Road Test

T 99
T 180

Principal Stress Relationship
By Aggregate Top Size
Crushed Limestone Base

1 1/2"
1"
3/4"
3/8"

TXDOT Gr1

Lateral Pressure (psi)

0 5 10 15 20 25

Max. Normal Stress (psi)

0 100 200 300 400

Triaxial Testing
Crushed Limestone Base

Deformation (%)

0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2

Dry Density (pcf)

0 136 138 140 142 144 146 148

Lateral Pressure
Normal Stress

40 100 150 200 250

y = 3435.9x^{0.552}
R^2 = 0.9861

y = 4874.8x^{0.5109}
R^2 = 0.9497

Mr (psi)

1000 10000 100000

Bulk Stress (psi)

10 100 1000 10000

y = 414.1x^{0.996}
R^2 = 0.984

y = 3435.9x^{0.998}
R^2 = 0.981
Optimizing Value and Performance

• Benefits
  – An economical alternative where available
  – Can be placed in thick, single lifts
  – Performs better when placed closer to the pavement surface
  – Used in many of the excellent perpetual pavements still performing
  – Performs best with a good subgrade
  – Higher densities provide superior performance
  – Low energy requirements (37 % less than HMA)
Compaction Requirements and Techniques
Chris Connelly- Bomag Corporation

• Reviewed the basic principles of compaction and the dynamic forces employed.

• Discussed the elements and potential of intelligent compaction and the opportunity to tie data acquisition with GPS for real time analyses.
Measurement and Testing (Density vs. Stiffness)  
Ed Hall- Humboldt Mfg.

• Review of various test methods for density
• Nuclear gauge applications
• Proposed use of GeoGauge for measuring stiffness/modulus of pavement layers as opposed to density
• Field tests for stiffness ties to pavement design parameters
Inverted Base Design and Performance
John Cardosa- Georgia Crushed Stone Assn.

• Unbound aggregate base over a cement stabilized layer with reduced HMA thickness

• Georgia Test Road @ Lafarge Quarry
  – 6 in. GAB over 10 in. CTB
  – 2 in. HMA
  – Inverted sections show about 50 % less deflections using FWD
  – Standard section of 12.5 in. HMA over 12 in. GAB
  – After 65 % of design ESAL’s, section shows no cracking
Inverted Base Design and Performance
John Cardosa- Georgia Crushed Stone Assn.

• LaGrange Bypass
  – Evaluate inverted base compared to a concrete paving section
  – Estimated 30 year LCCA savings of 20 %
Inverted Base Design and Performance
Randy Weingart- Luck Stone Corp.

- Virginia test sections on Hwy 659 Bypass to evaluate inverted base
- Joint effort with VDOT, FHWA and industry
- Project encompasses design, instrumentation, construction and monitoring
- Plan to incorporate deep-lift base construction techniques and intelligent compaction
- Compares current design practices with AASHTO MEPDG and the ICAR model
- Preliminary cost savings of 33 % over traditional design
Subbase for Rigid Pavements
Robert Rodden- ACPA

- Role of subbase/subgrade is not as critical for handling stresses as in flexible pavement
- Primary characteristics are uniformity, resist erosion, not susceptible to moisture
- Design of slab thickness not affected by subbase materials
- Don’t want high modulus materials
- Reduce friction between slab and subbase
- Don’t overdesign subbase for permeability (50 – 150 ft/day); daylight the subbase to ditches
Drainage Layers Under Pavements
John Yzenas- The Levy Co.

• Porous pavements
• Drainage layers under concrete pavement
Texas Toll Road- High Performance Base Course Test Project
Amit Basin- Texas A&M University

• SH 130 Austin Area
  – Variables are unbound and cement treated base, thick lift and large aggregate
  – Instrumented for permanent and resilient strain at various depths
  – Use a series of dynamic and long duration static loads
Level 1 Analysis Not Possible

- Finite Element Method not calibrated.
Limited Maximum CBR

- CBR max is 100.
- CBR can greatly exceed 100 for good quality crushed aggregate bases.
Information Box
States CBR Ranges from 35 to 80
Limited Maximum Resilient Modulus

- Modulus max = 45,000 psi.
- Greater modulus can exist when layer is placed closer to surface.
Rigid Pavement Analysis Example

- JPCP thickness
  - 8, 9, and 10 inches
- Base thickness
  - 0, 6, 9, and 12 inches
  - 40,000 psi Mr input
- A4 Subgrade
- 4,000 trucks per day
- Atlanta climate data

From: MEPDG Design Guide Documentation 2007
## Rigid Pavement Analysis Example

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<th>JCRP Thickness (in)</th>
<th>Base Thickness (in)</th>
<th>Terminal IRI (in/mi)</th>
<th>Transverse Cracking (% Slabs Cracked)</th>
<th>Mean Faulting (in)</th>
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