Report on the National Aggregate Base Conference

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Presented at:

AASHTO Subcommittee on Materials

Asheville, NC

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- Pennsylvania Aggregates and Concrete Association
- 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

ICAR Anisotropic Mechanistic Design Model

Dallas Little- Texas A&M University

- 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.

Optimizing Value and Performance

Don Powell- Vulcan Materials Co.

- 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

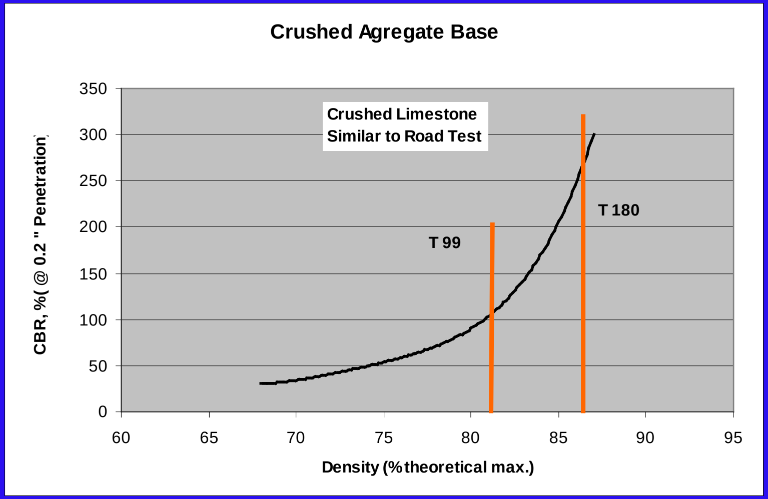
- Design Considerations
  - Insure subgrade strength and preparation is adequate
  - Require 100 % modified density in base
  - Single lift sections (max. 14 in.) if desired
  - Minimize thickness of HMA over base
  - Keep water out of the subgrade and base
  - Use larger top size grading
  - Require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

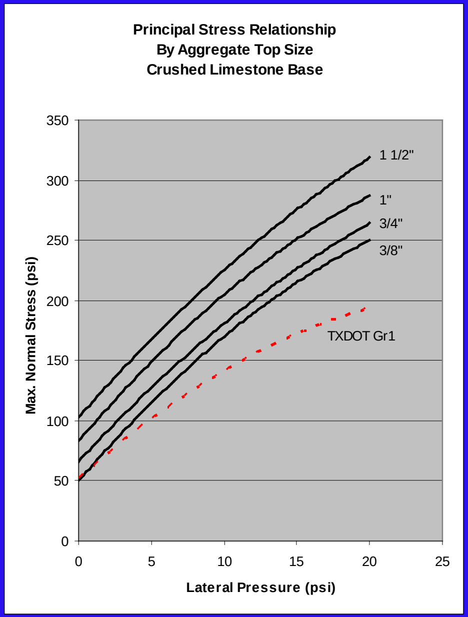
Optimizing Value and Performance

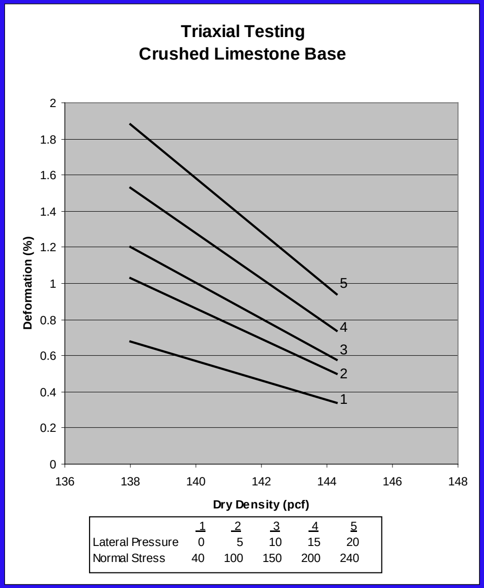
- Construction practices
  - Source approval for quality
  - Plant quality control for gradation and moisture
  - Establish the target density and optimum moisture (T-180)
  - Place with a spreader box to control thickness and minimize segregation
  - Avoid water additions on the roadway
  - Control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

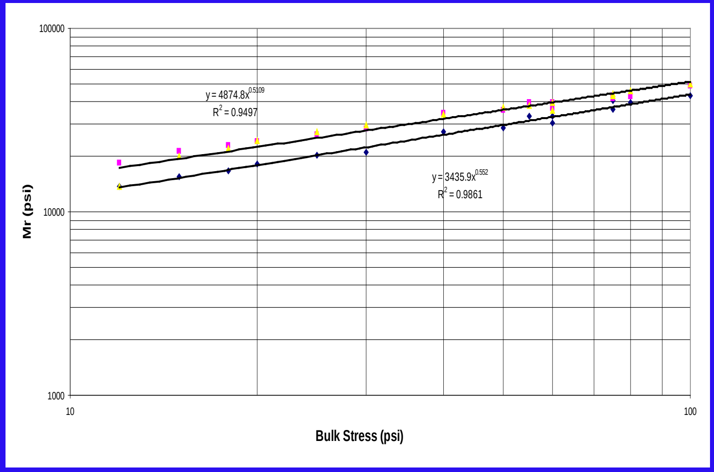
Optimizing Value and Performance

Impact of Density and Grading









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

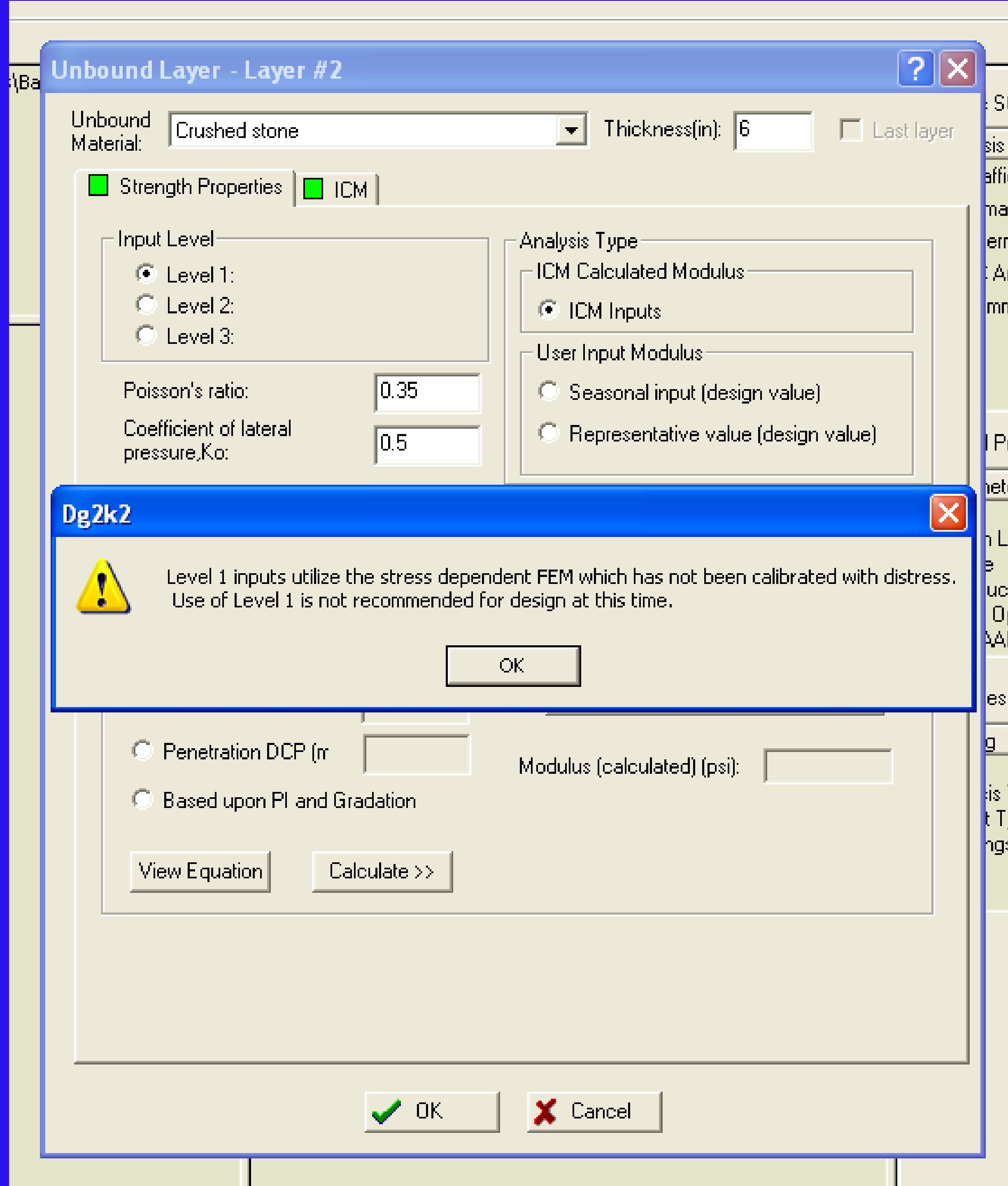
Texas Toll Road- High Performance Base Course Test Project

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

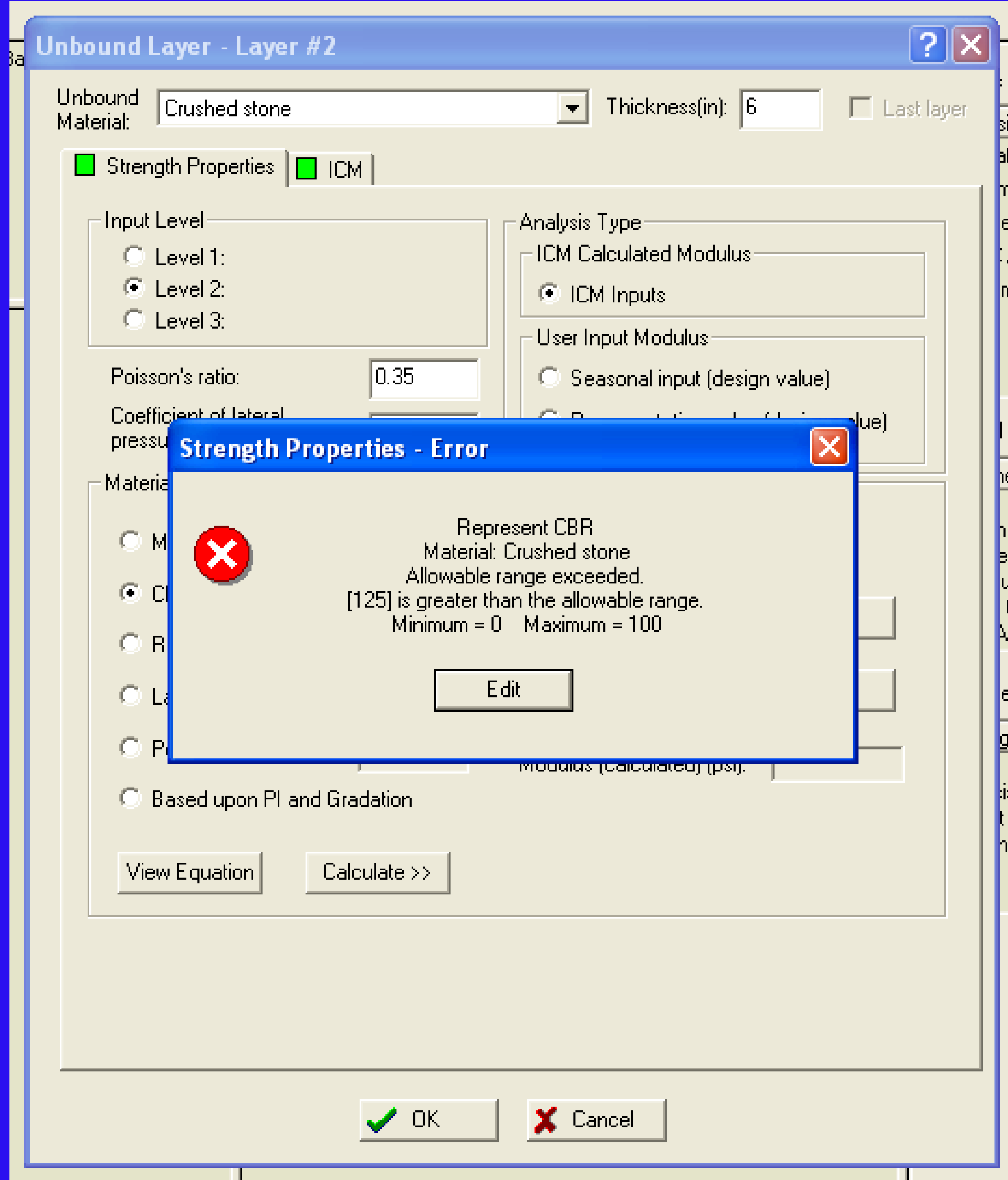
Level 1 Analysis Not Possible

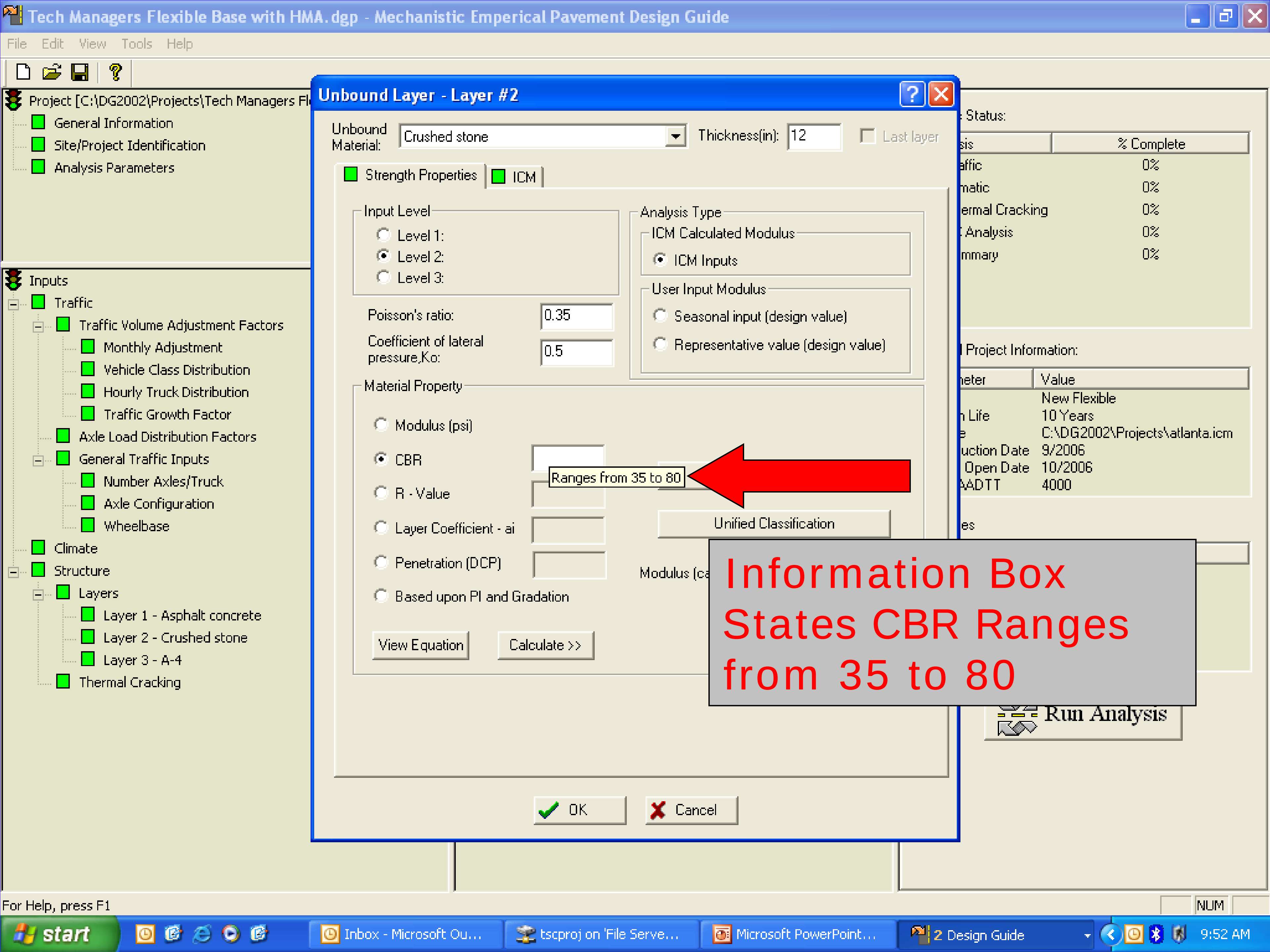
- Finite Element Method not calibrated.



Limited Maximum CBR

- CBR max is 100.
- CBR can greatly exceed 100 for good quality crushed aggregate bases.




Tech Managers Flexible Base with HMA.dgp - Mechanistic Emperical Pavement Design Guide
File Edit View Tools Help
Project [C:\DG2002\Projects\Tech Managers Fl
General Information
Site/Project Identification
Analysis Parameters
Inputs
Traffic
Traffic Volume Adjustment Factors
Monthly Adjustment
Vehicle Class Distribution
Hourly Truck Distribution
Traffic Growth Factor
Axle Load Distribution Factors
General Traffic Inputs
Number Axles/Truck
Axle Configuration
Wheelbase
Climate
Structure
Layers
Layer 1 - Asphalt concrete
Layer 2 - Crushed stone
Layer 3 - A-4
Thermal Cracking
Unbound Layer - Layer #2
Unbound Material: Crushed stone
Thickness(in): 12
Last layer
Strength Properties
ICM
Input Level
Level 1:
Level 2:
Level 3:
Poisson's ratio: 0.35
Coefficient of lateral pressure,Ko: 0.5
Analysis Type
ICM Calculated Modulus
ICM Inputs
User Input Modulus
Seasonal input (design value)
Representative value (design value)
Material Property
Modulus (psi)
CBR
Ranges from 35 to 80
R - Value
Layer Coefficient - ai
Penetration (DCP)
Based upon PI and Gradation
Unified Classification
Modulus (ca
View Equation
Calculate >>
OK
Cancel
Information Box States CBR Ranges from 35 to 80
Status:
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Analysis 0%
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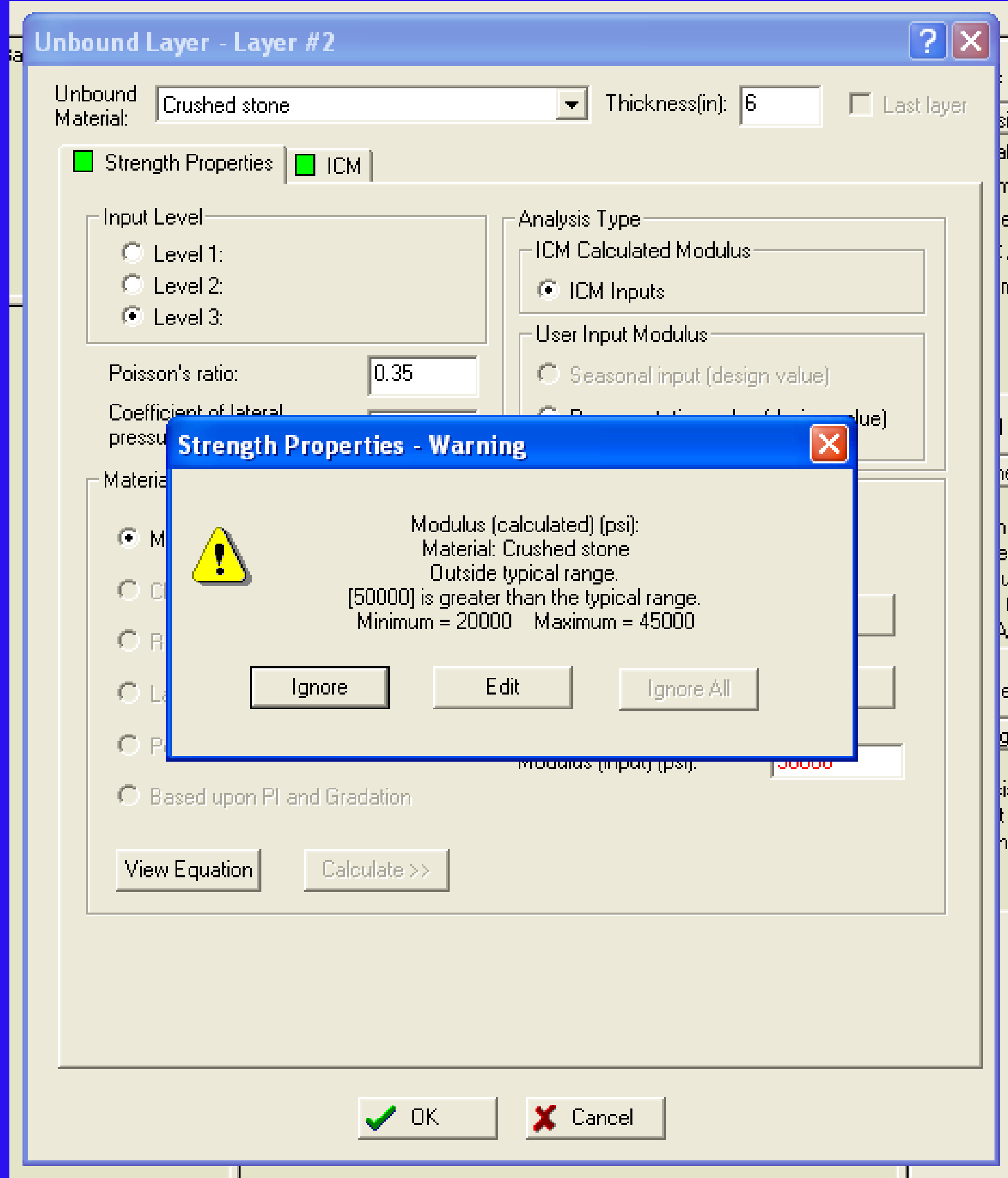
Limited Maximum Resilient Modulus

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



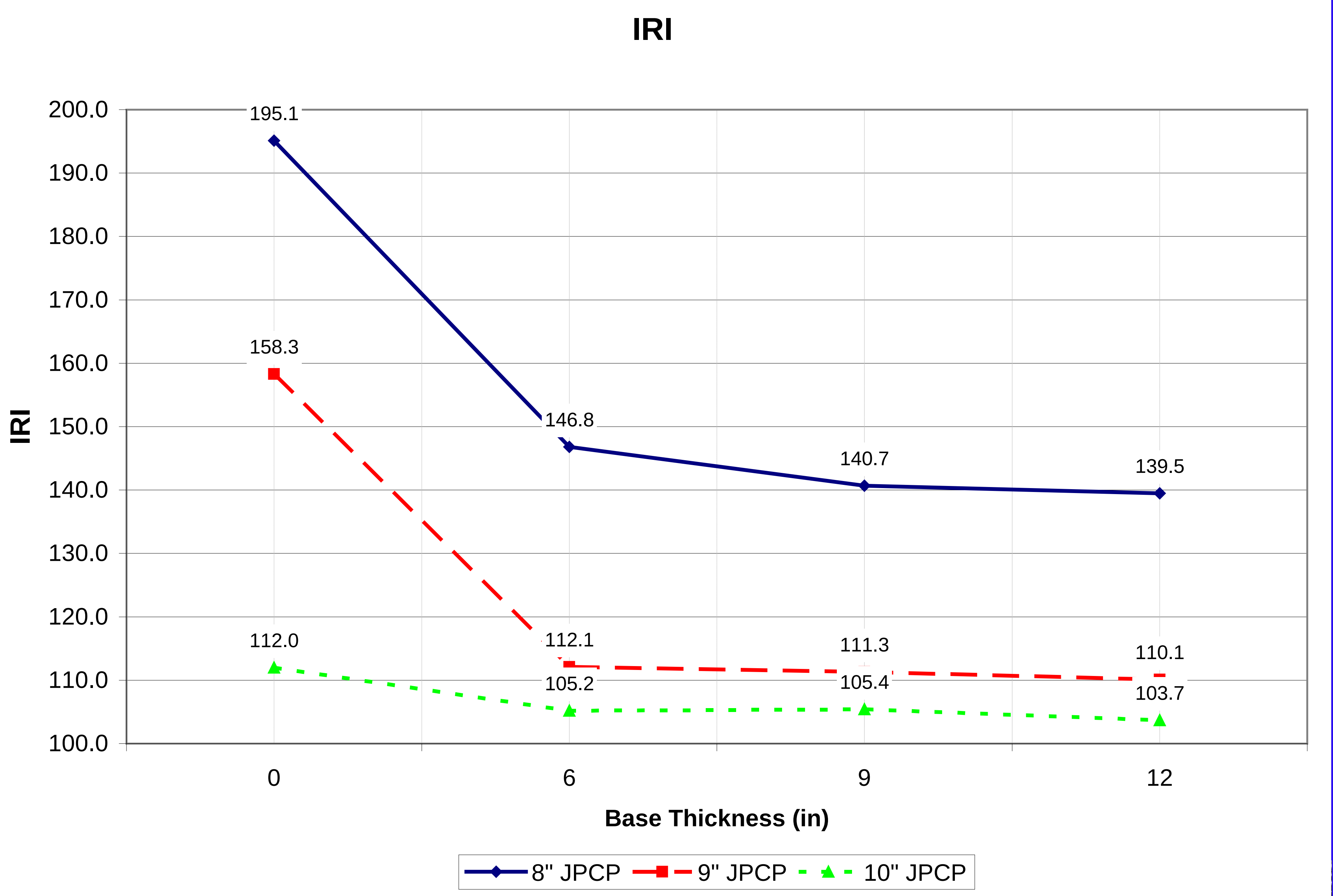
Rigid Pavement Analysis Example

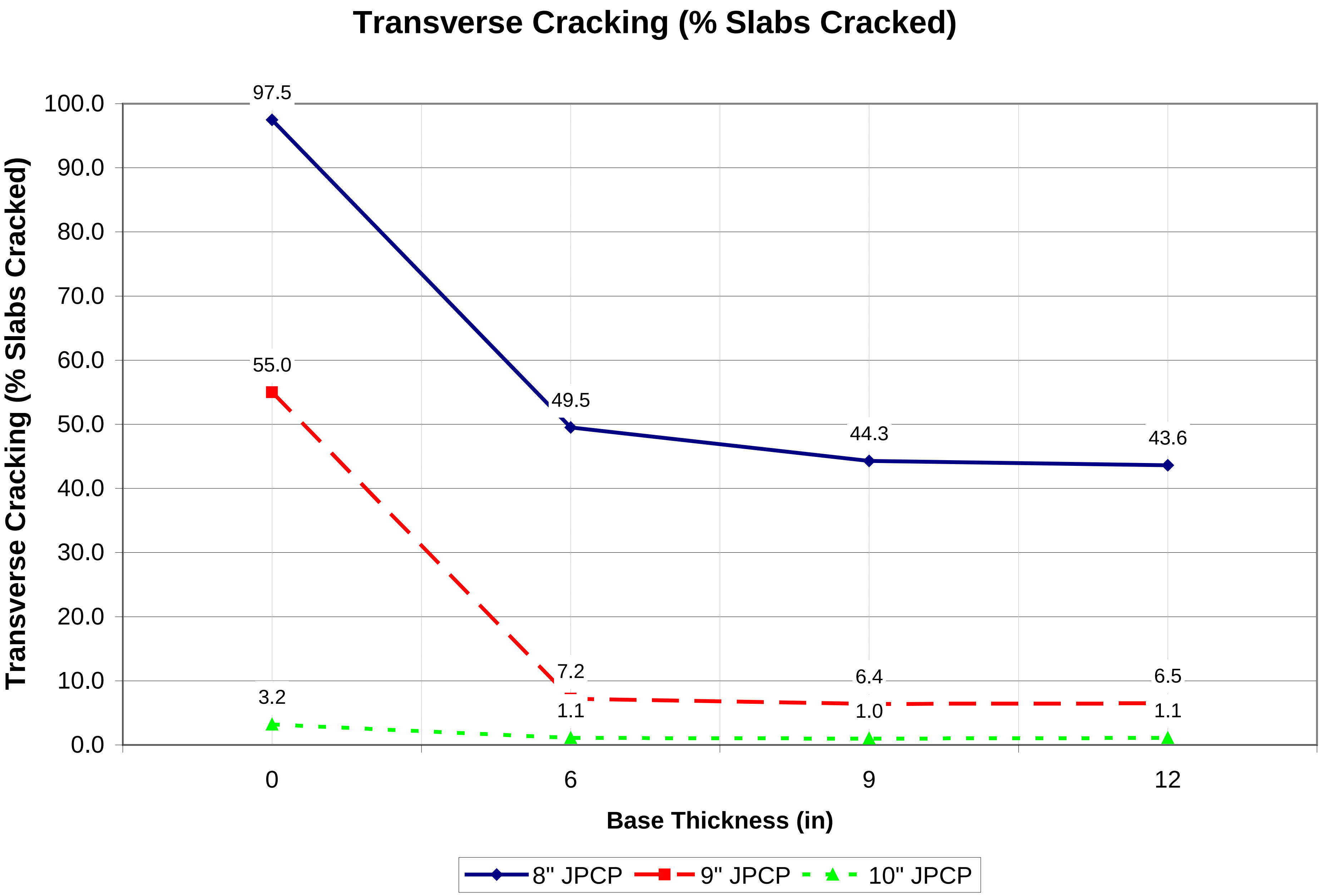
- JPCP thickness
  – 8, 9, and 10 inches
- Base thickness
  – 0, 6, 9, and 12 inches
  – 40,000 psi Mr input
- A4 Subgrade
- 4,000 trucks per day
- Atlanta climate data

From: MEPDG Design Guide Documentation 2007

Rigid Pavement Analysis Example

JCRP Thickness (in)	Base Thickness (in)	Terminal IRI (in/mi)	Transverse Cracking (% Slabs Cracked)	Mean Faulting (in)
8	0	195.1	97.5	0.077
8	6	146.8	49.5	0.060
8	9	140.7	44.3	0.057
8	12	139.5	43.6	0.056
9	0	158.3	55.0	0.074
9	6	112.1	7.2	0.061
9	9	111.3	6.4	0.061
9	12	110.1	6.5	0.058
10	0	112.0	3.2	0.068
10	6	105.2	1.1	0.058
10	9	105.4	1.0	0.058
10	12	103.7	1.1	0.055


IRI
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
IRI
195.1
158.3
146.8
140.7
139.5
112.0
112.1
111.3
110.1
105.2
105.4
103.7
0
6
9
12
Base Thickness (in)
8" JPCP
9" JPCP
10" JPCP



Transverse Cracking (% Slabs Cracked)
Transverse Cracking (% Slabs Cracked)
Base Thickness (in)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
6
9
12
97.5
49.5
44.3
43.6
55.0
7.2
6.4
6.5
3.2
1.1
1.0
1.1
8" JPCP
9" JPCP
10" JPCP