Asphalt Pavement Research Trends

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MARC MODIFIED ASPHALT RESEARCH CENTER

WAPA WISCONSIN ASPHALT PAVEMENT ASSOCIATION

THE UNIVERSITY OF WISCONSIN MADISON

Current / Future Focus Areas

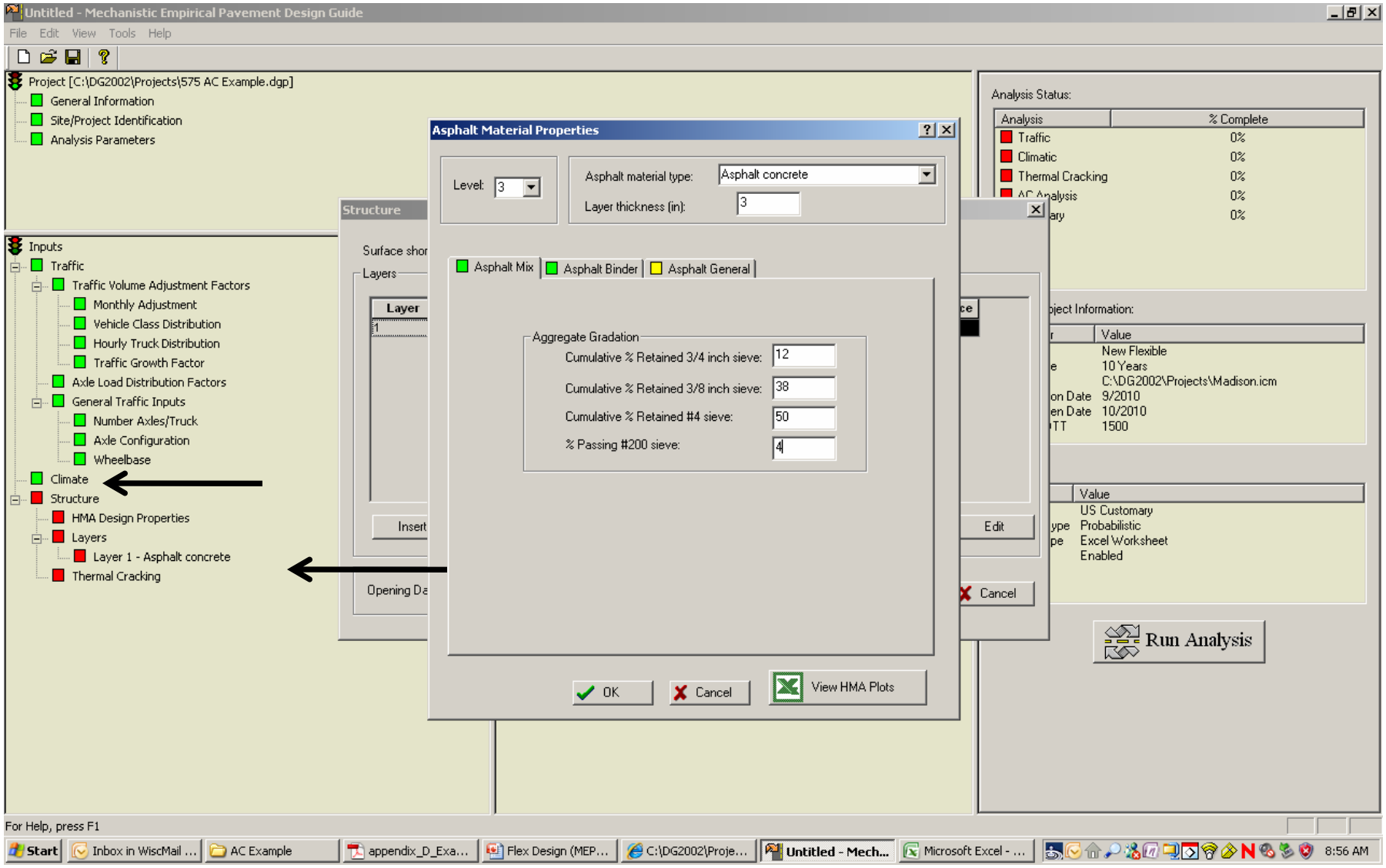
- Mechanistic Design
  - AASHTO MEPDG
- The Environment
  - Energy, Emissions & Noise
- Safety
  - Friction and tire-surface interaction
- Superior Materials
  - Modified Binders
  - Micro-mechanics, Imaging & Visualization to learn

AASHTO MEPDG

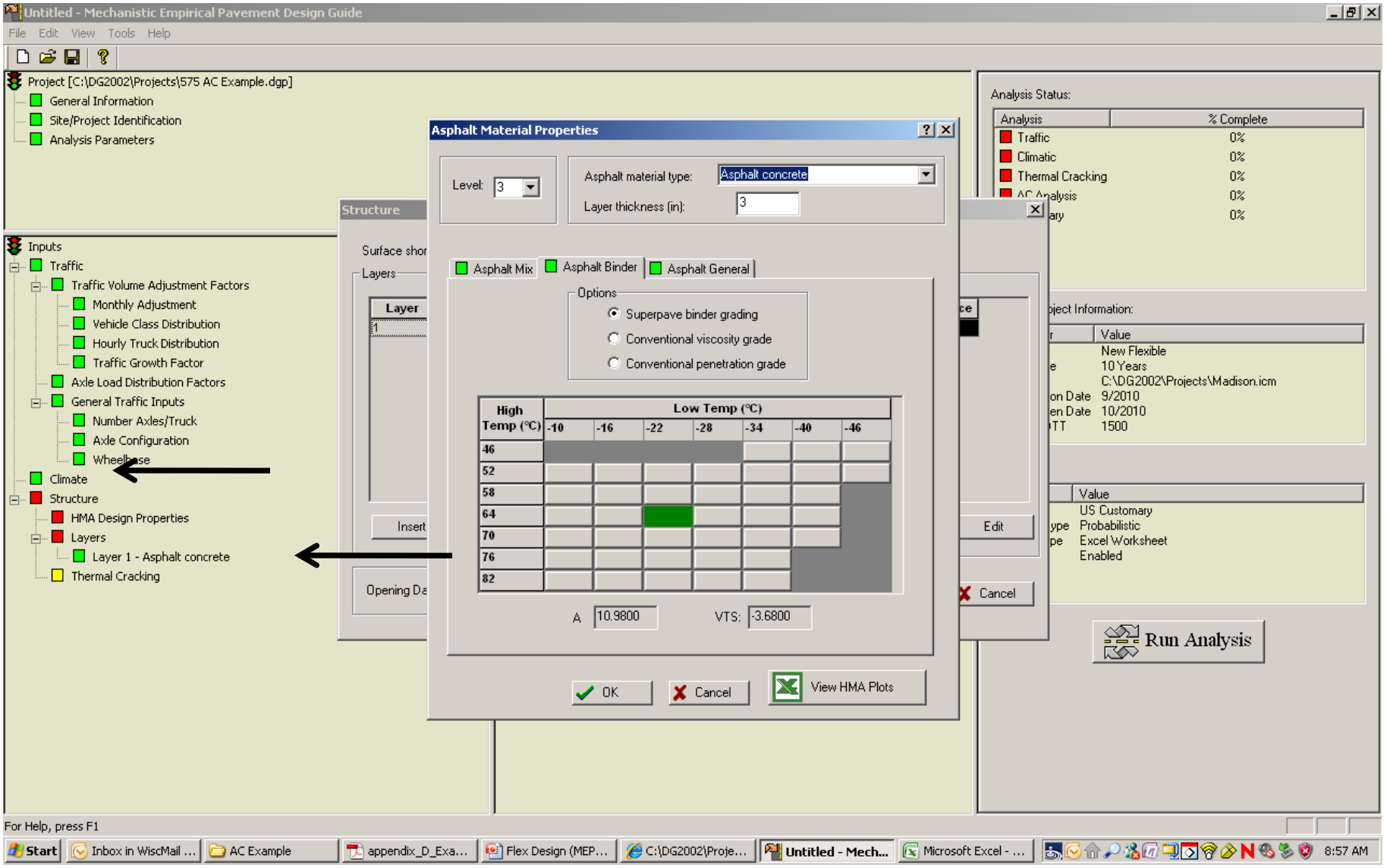
Fully Integrated Design Software

- **Traffic**
- **Environment**
- **Structure**
- **Mix Design**
- **PG Grading**
- **Pavement Distresses**

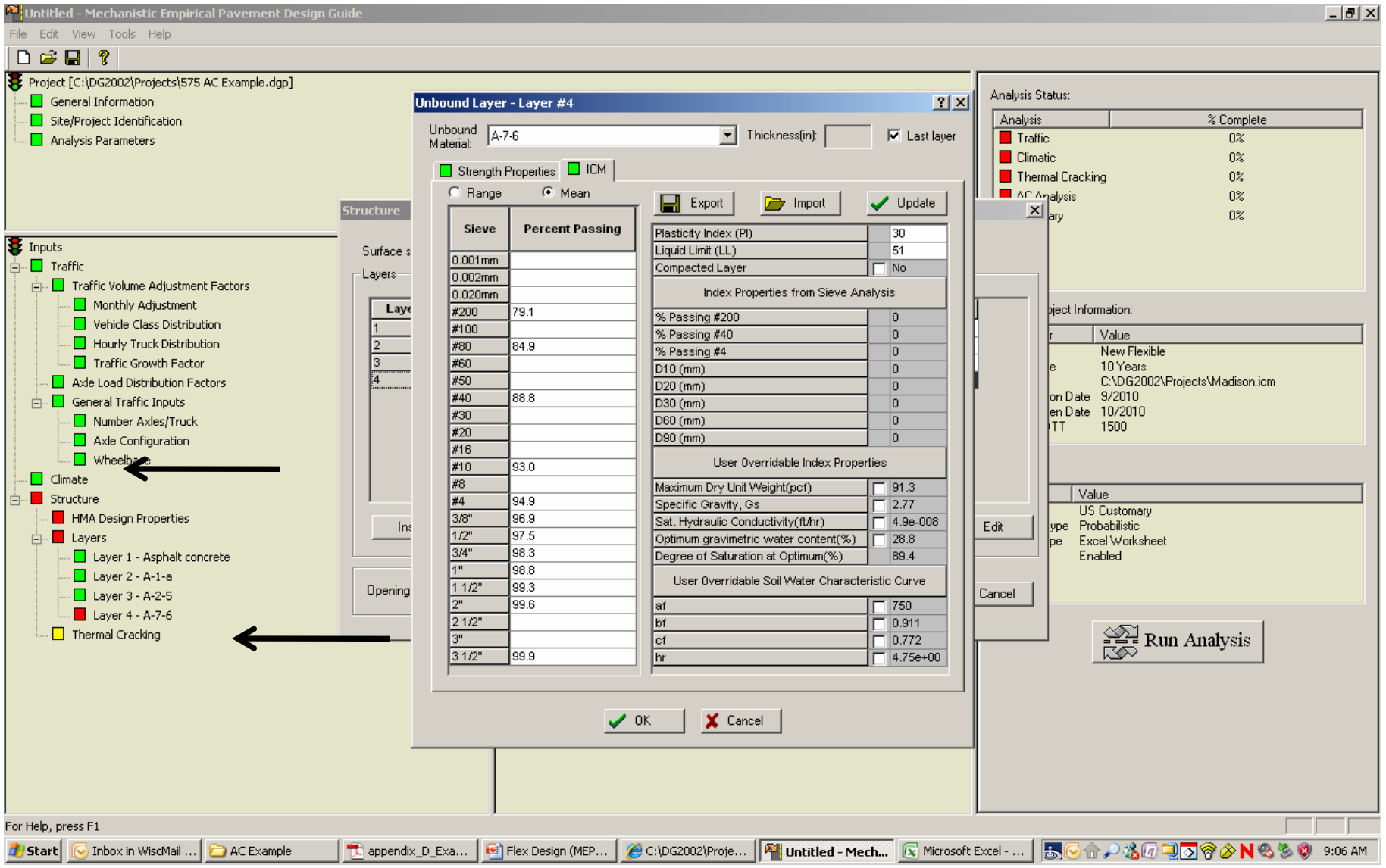
You can enter changes in gradation, and estimate changes in performance



You can enter changes in PG grading, and estimate changes in performance



You can enter changes in subgrade and base, and estimate changes in performance



Output Example - PG 64-22

Performance Criteria	Distress Target	Distress Predicted	Reliability Predicted	Acceptable
Terminal IRI (in/mi)	172	104.1	98.9	Pass
AC Bottom Up Cracking (Alligator Cracking) (%):	25	4.9	92.2	Pass
AC Thermal Fracture (Transverse Cracking) (ft/mi):	1000	74.8	99.9	Pass
Permanent Deformation- AC Only (AC Only) (in):	0.25	0.21	71.1	Fail
Permanent Deformation – All Layers (Total Pavement) (in):	0.75	0.65	81.6	Fail

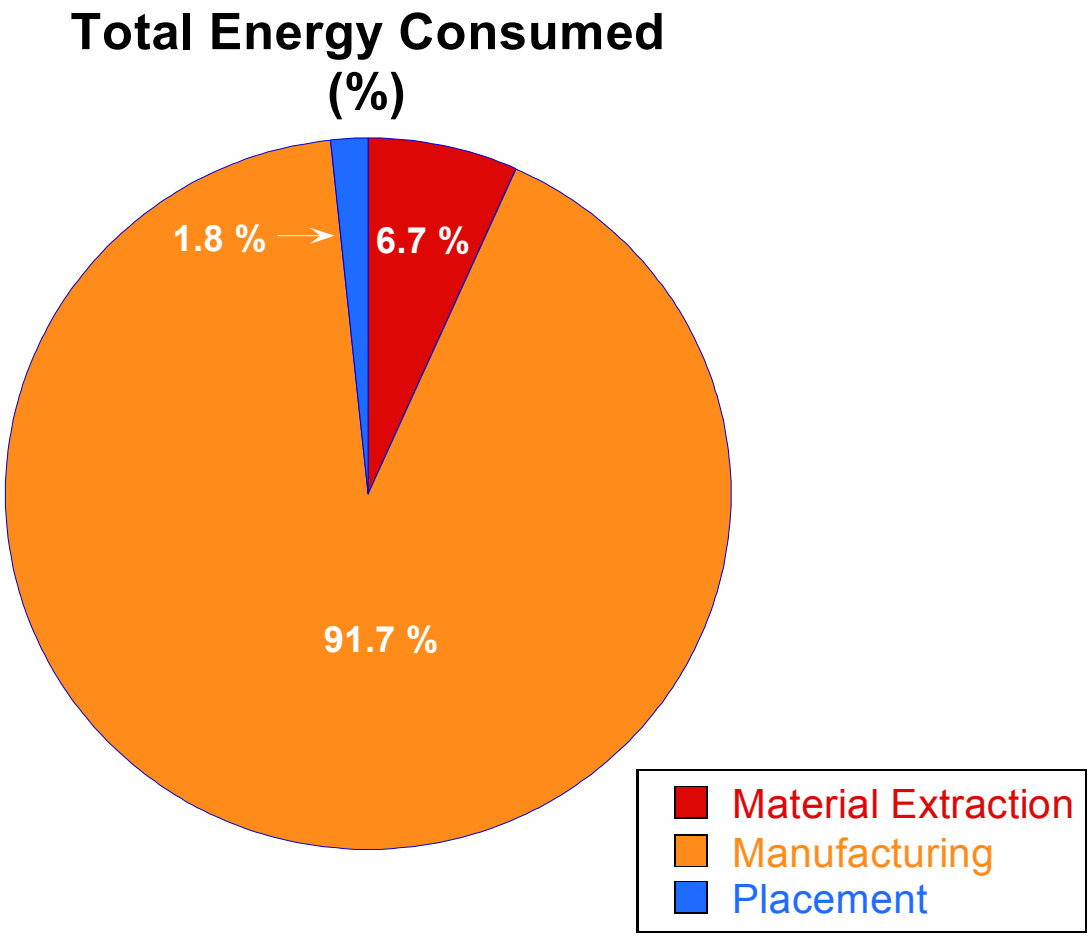
Output Example - PG 76-22

Performance Criteria	Distress Target	Distress Predicted	Reliability Predicted	Acceptable
Terminal IRI (in/mi)	172	90	99.3	Pass
AC Bottom Up Cracking (Alligator Cracking) (%):	25	4.9	92.8	Pass
AC Thermal Fracture (Transverse Cracking) (ft/mi):	1000	74.8	99.9	Pass
Permanent Deformation- AC Only (AC Only) (in):	0.25	0.17	90.6	Pass
Permanent Deformation – All Layers (Total Pavement) (in):	0.75	0.61	92.2	Pass

The Environment (Sustainable Roads)

- Asphalt is one of the most sustainable construction materials
- The next few years will quantify this for designers and specifiers of roads
  - Increased recycling by design
  - Reduce energy and emissions
    - Warm mix practice
  - Quiet roads by design of surface texture

Distribution of Energy Consumption Asphalt Roads



Current Practice: Focus on materials' initial cost

Future Practice: Focus on profit from reduced energy and lower emissions

Source: Image used courtesy of Payne & Dolan

Evolving Estimation & Analysis Tools

- Pavement Life-cycle Assessment Test for Environment and Economic Effects (PaLATE)

- Plant Diagnostic and Optimization Tool
  - Pennsylvania Asphalt Pavement Association (PAPA)

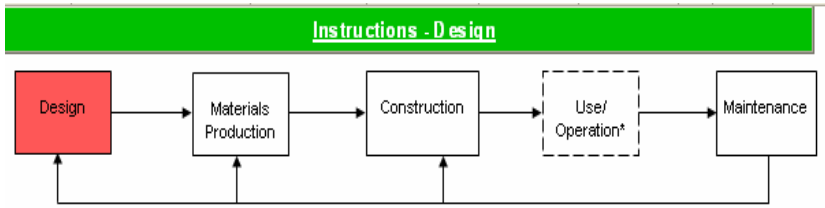
- Spreadsheet models for Energy and Emissions
  - World Bank
  - Land Transport New Zealand

Existing Tools: PaLATE

Pavement Life Cycle Analysis for Environment and Economic effects

Consortium on Green Design and Manufacturing
University of California, Berkeley

PaLATE
Pavement Life-cycle Assessment Tool for Environmental and Economic Effects

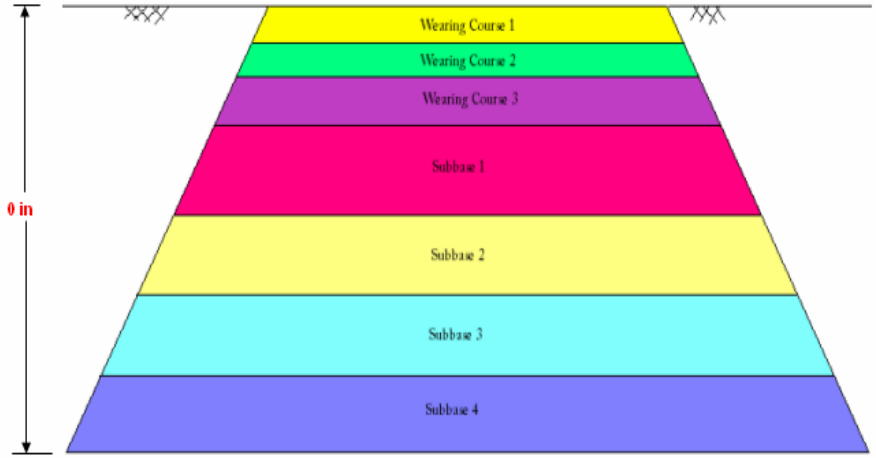


Only fill in the appropriate cells

Layer Specifications				
Layer	Width [ft]	Length [miles]	Depth [inches]	Volume [yd^3]
Wearing Course 1				0
Wearing Course 2				0
Wearing Course 3				0
Subbase 1				0
Subbase 2				0
Subbase 3				0
Subbase 4				0
Total			0	0

Embankment and Shoulder Volume [yd^3]:	

Period of Analysis [yrs] (40 yrs or less)	**40**



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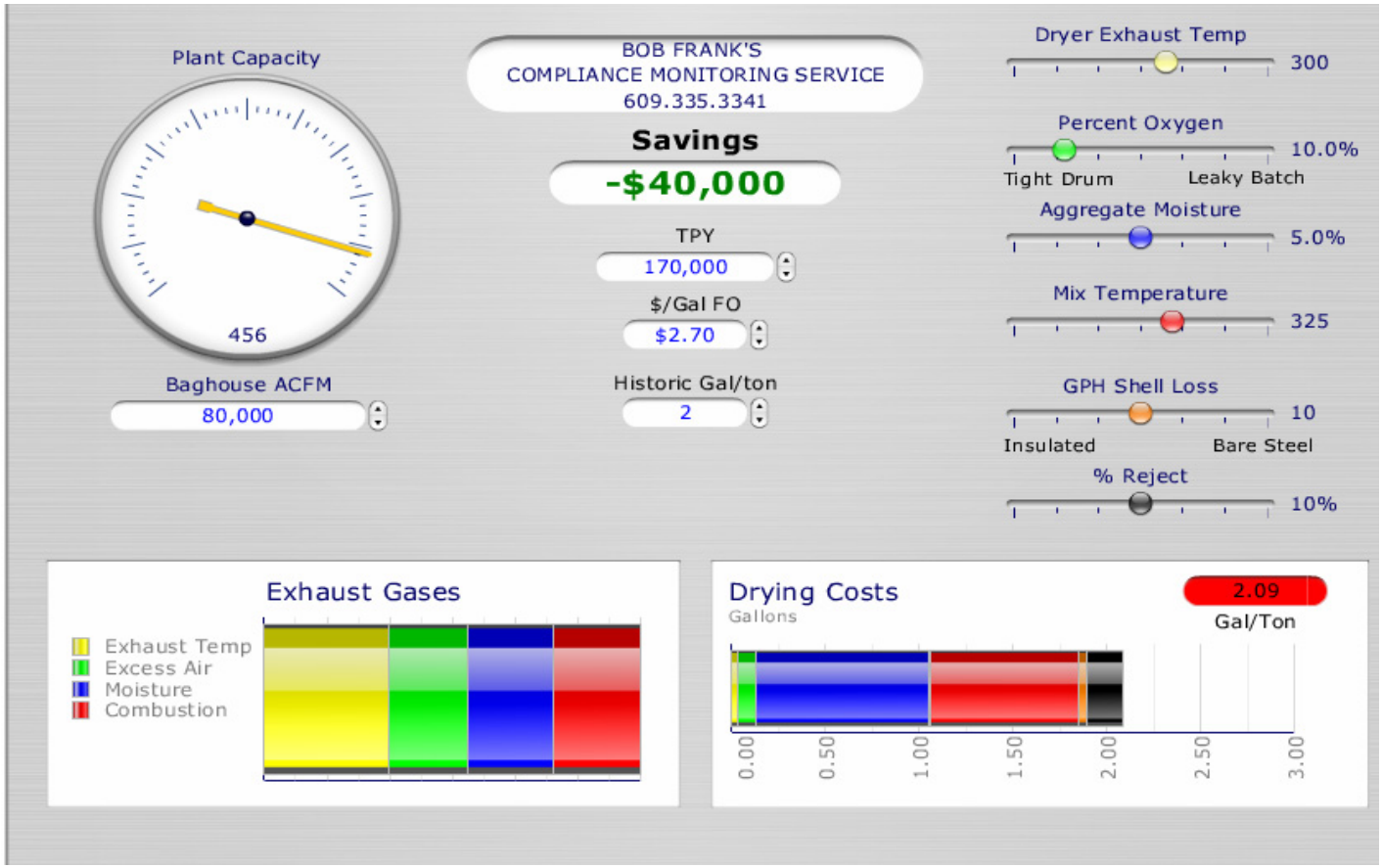
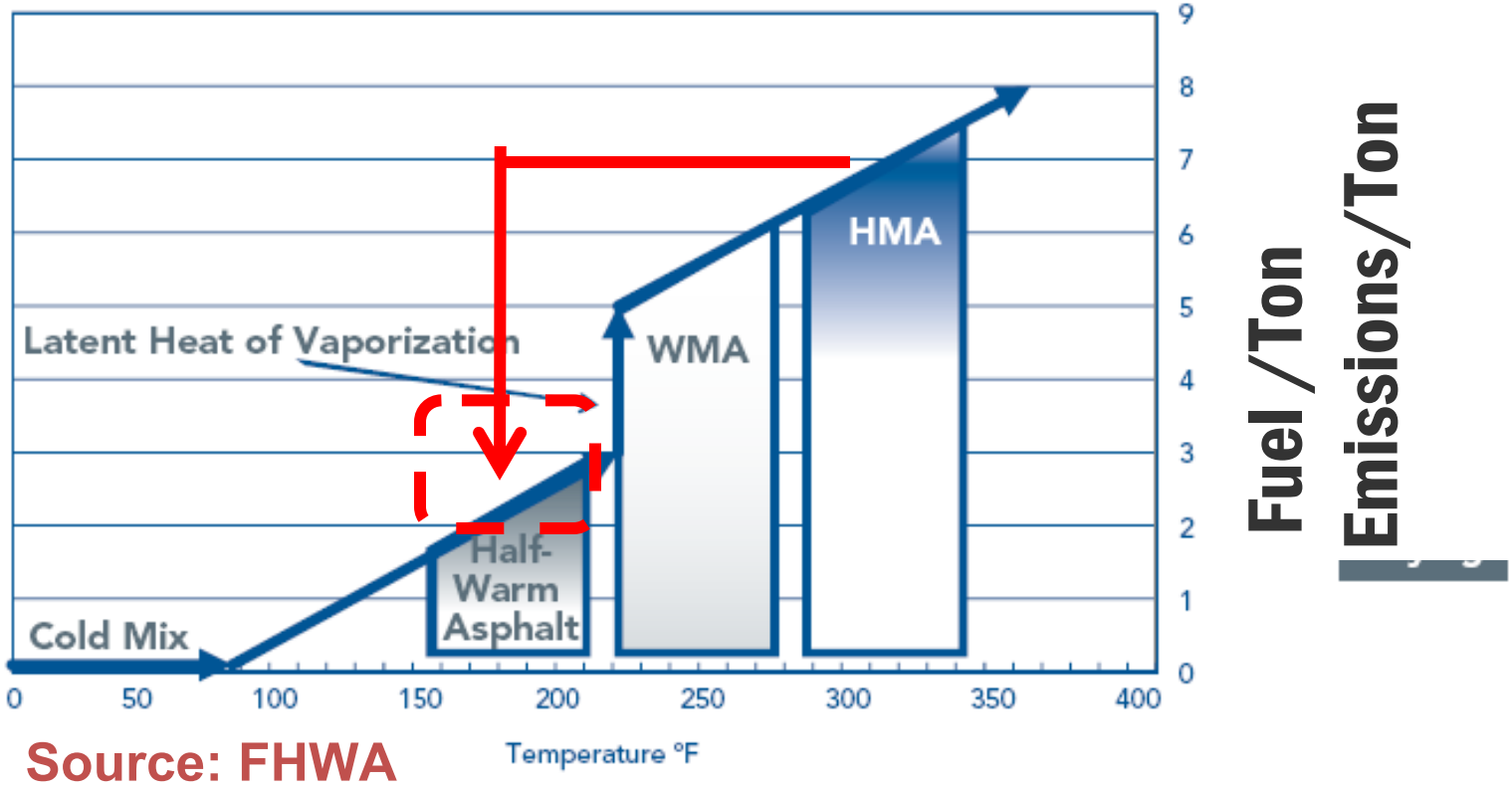
Existing Tools: Plant Diagnostic Tool



Source: Pennsylvania Asphalt Pavement Association

The Promise: Production Impact

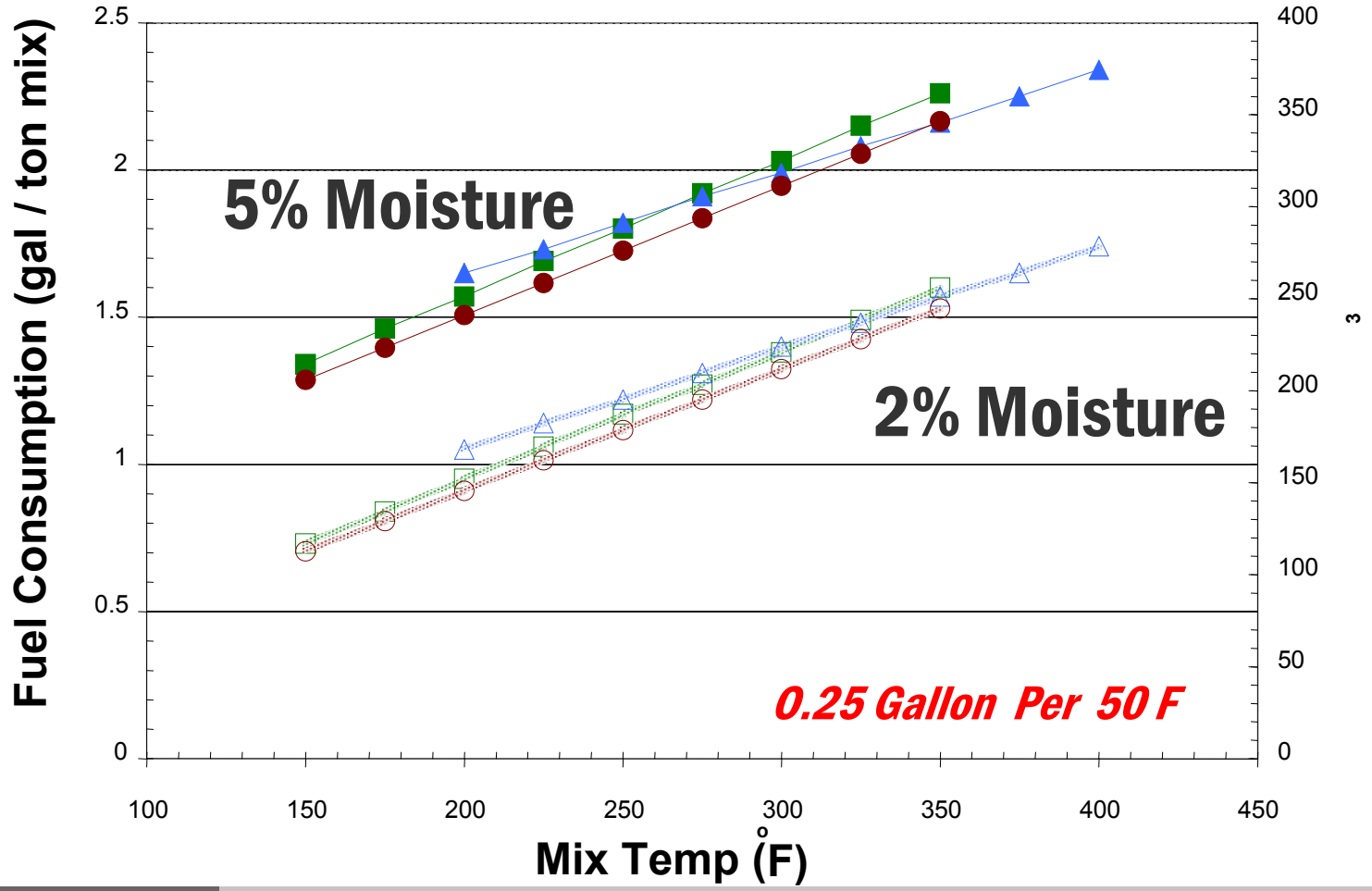
Less Energy + Less Impact on Environment



Source: FHWA

Models: Fuel Consumption

Estimate how much energy you can save



Opportunities for Asphalts

- **Design for superior safety**
  - Selecting gradation to control texture spectrum
  - Better water drainage results in lower skid risk and better visibility
  - Specific surface texture can increase friction
- **Design for less noise**
  - Dense graded but selected texture spectrum
  - Reduce noise generation
  - Increase noise absorption

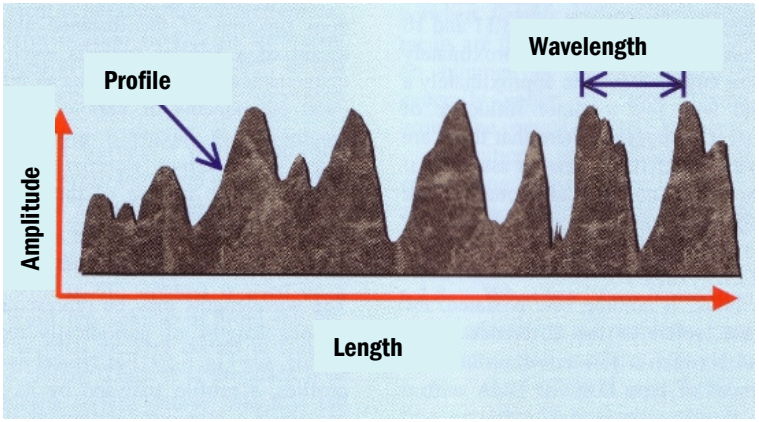
Asphalt – Drainable Surface

Safety through better visibility and friction

San Antonio Interstate Highway IH 35 before and after paving with Asphalt Rubber (RPA News, Vol 7, No.4, Spring 2004)

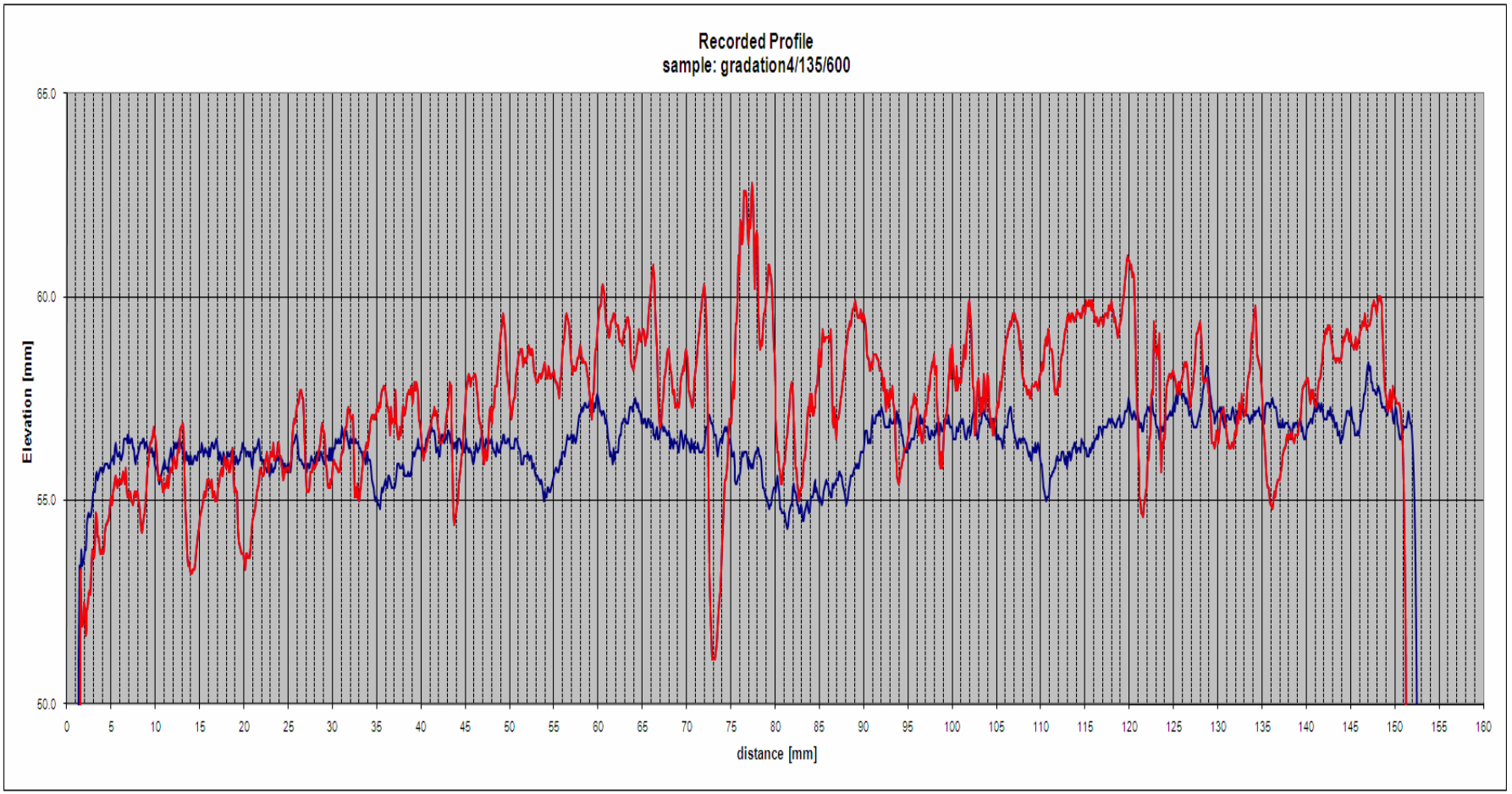
Macro-texture/Laser Profilometer

Work in collaboration (University of Pisa)



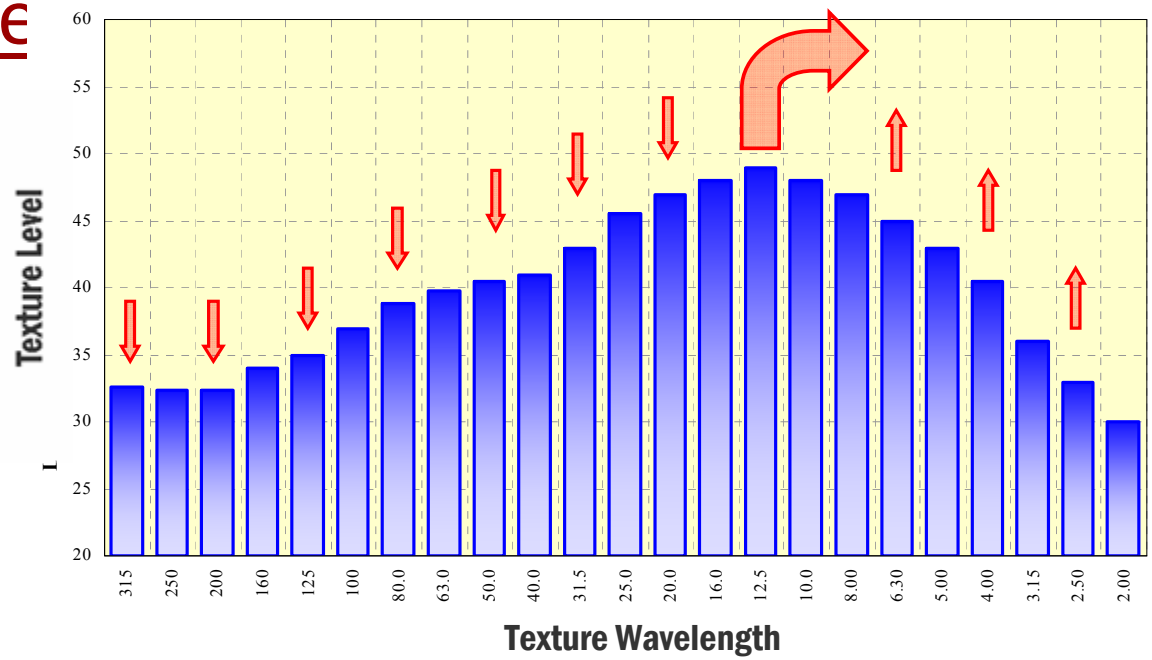
•Device	•Sampling Rate	•Sampling Interval	•Vertical Resolution	•Measuring Speed	•Length of Profile
•*Stationary Profilometer*	•16 kHz	•0.1 mm	•0.05 mm	•Manual	•750 mm
•*Mobile Profilometer*	•16 kHz	•1 mm	•0.05 mm	•20 km/h	•unlimited

Example of Measurements Wisconsin – WHRP Project Mixes



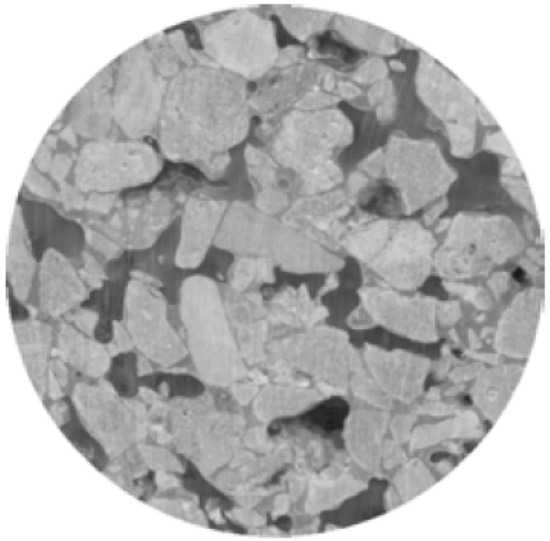
Macrotexture Spectrum To Reduce Tire/Road Noise

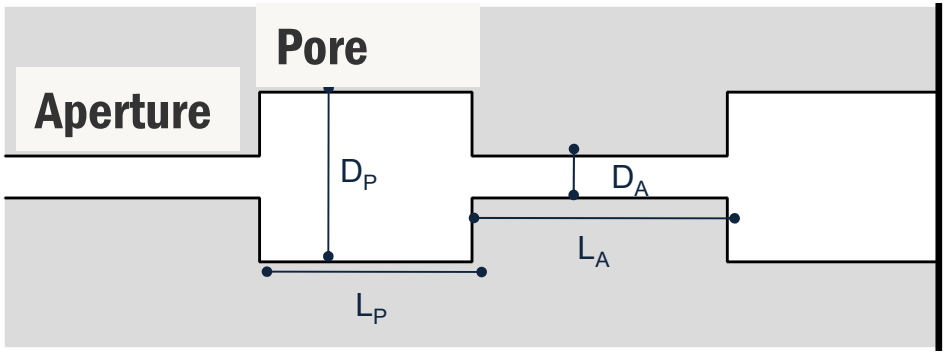
- Optimize "Texture level" to generate less noise



(After Losa et al. 2009)

Noise Absorption Modeling
Voids Structure (Losa et al. 2008/09)





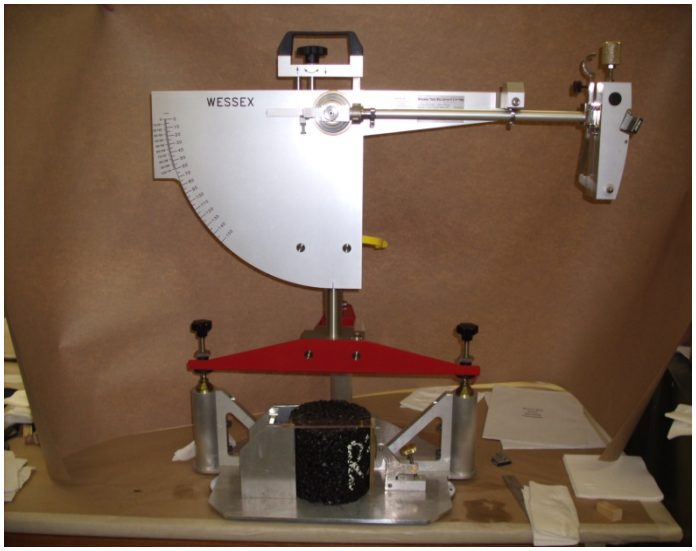
F = Microstructural Model $\alpha = F(D_P, L_P, D_A, L_A)$

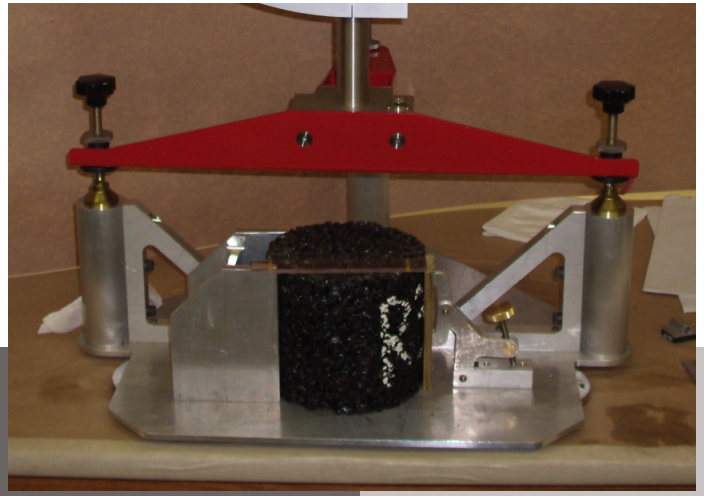
G = Theoretical Model $(D_P, L_P, D_A, L_A) = G(\text{Composition Characteristics})$

Noise Absorption Measurements

Absorption Coefficient (Alpha)

Micro-texture (Friction) Measurements





- British Pendulum Skid Resistance Tester
- Friction measured by swinging the pendulum.

- The loss of the kinetic energy as result of the interaction between the rubber and the sample surface is reported as the British Pendulum Number (BPN)

- Higher BPN values indicate higher surface microtexture and better skid resistance.

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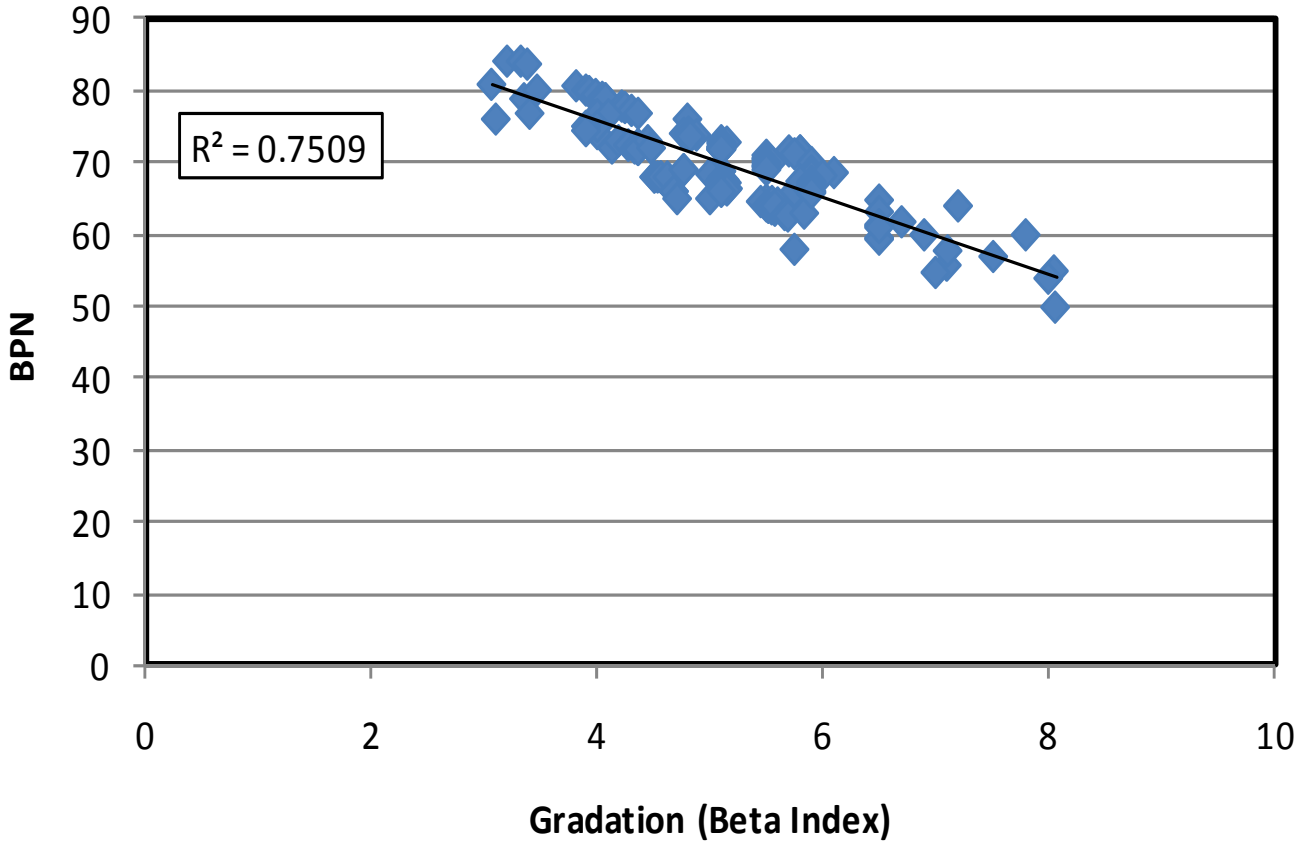
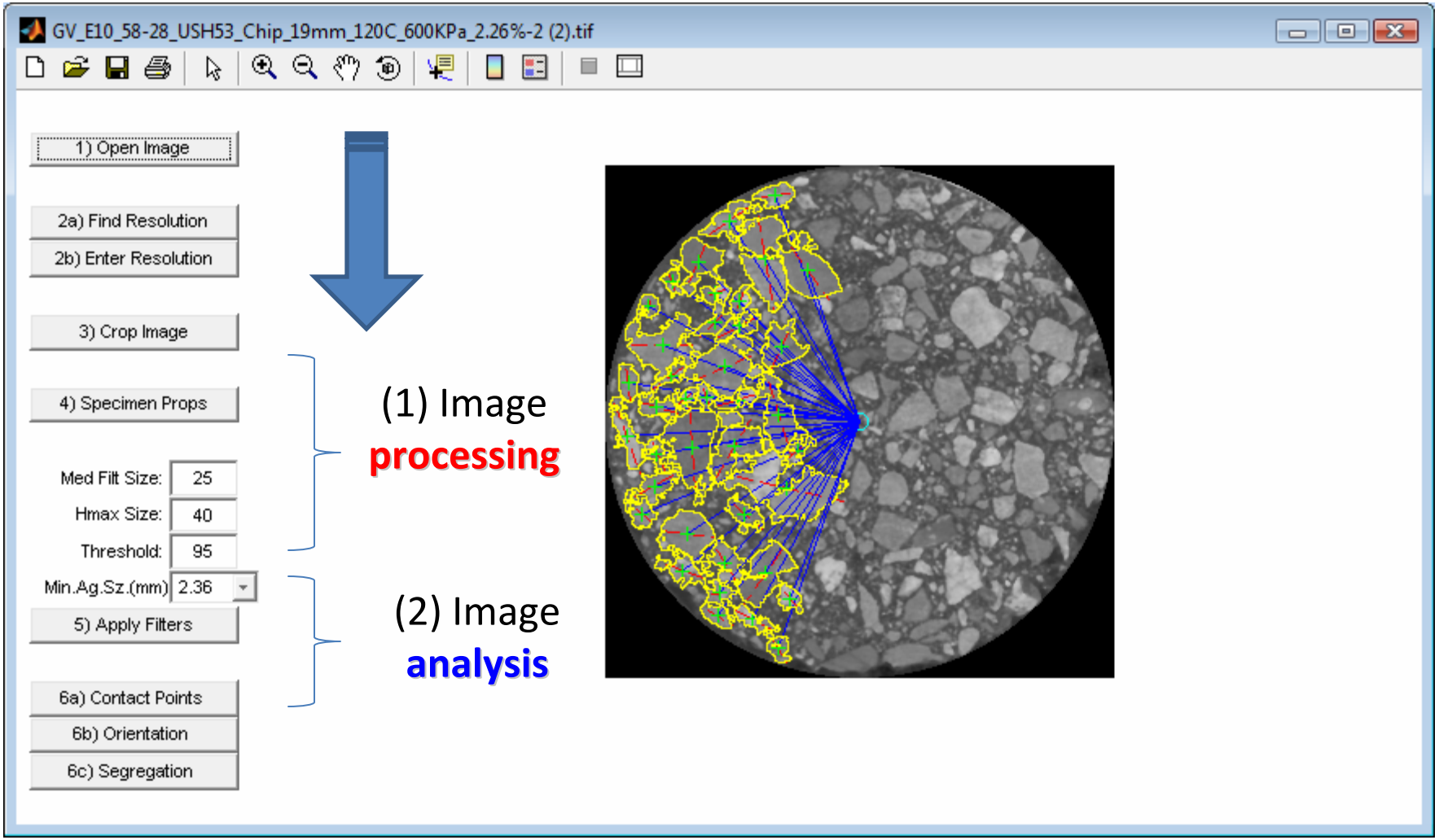
BPN – Friction Number
As a function of Aggregate Gradation



Visualization and Imaging
UW- MSU Software 09

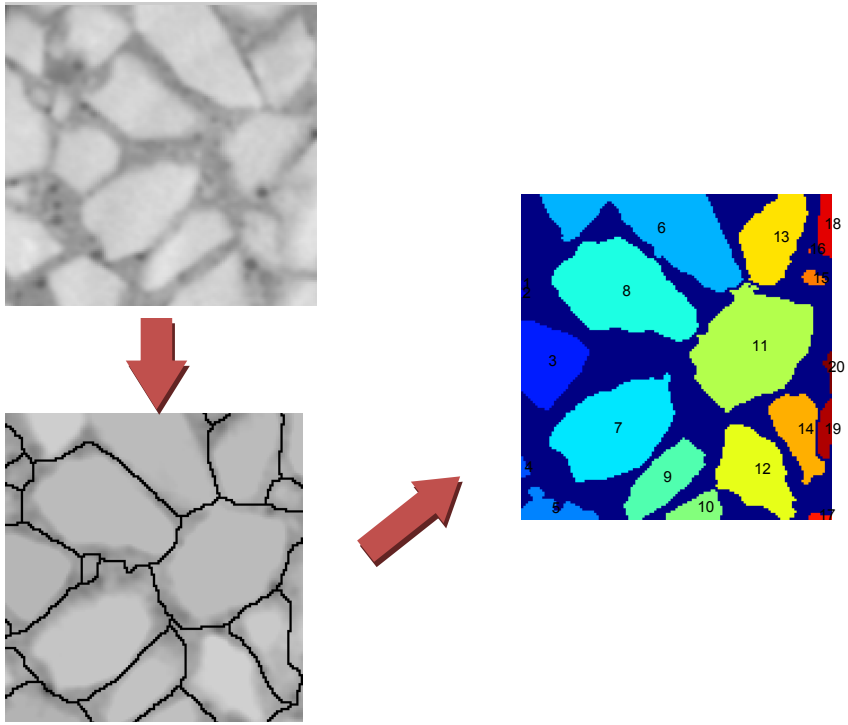
Will be proposed as an AASHTO Standard



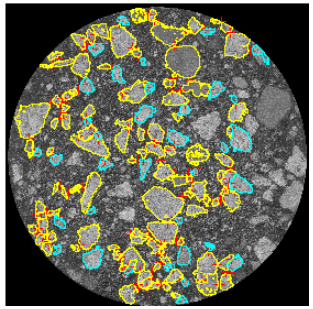
Software Updates of ’09

Detail of two part process

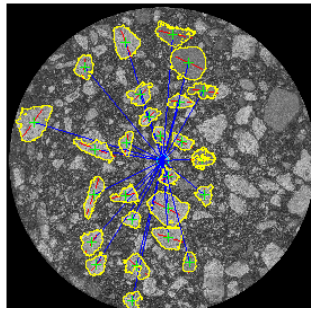
(1) Image **processing**



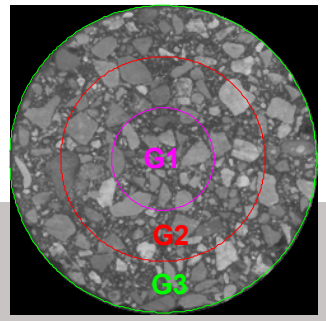
(2) Image **analysis**



Contact points

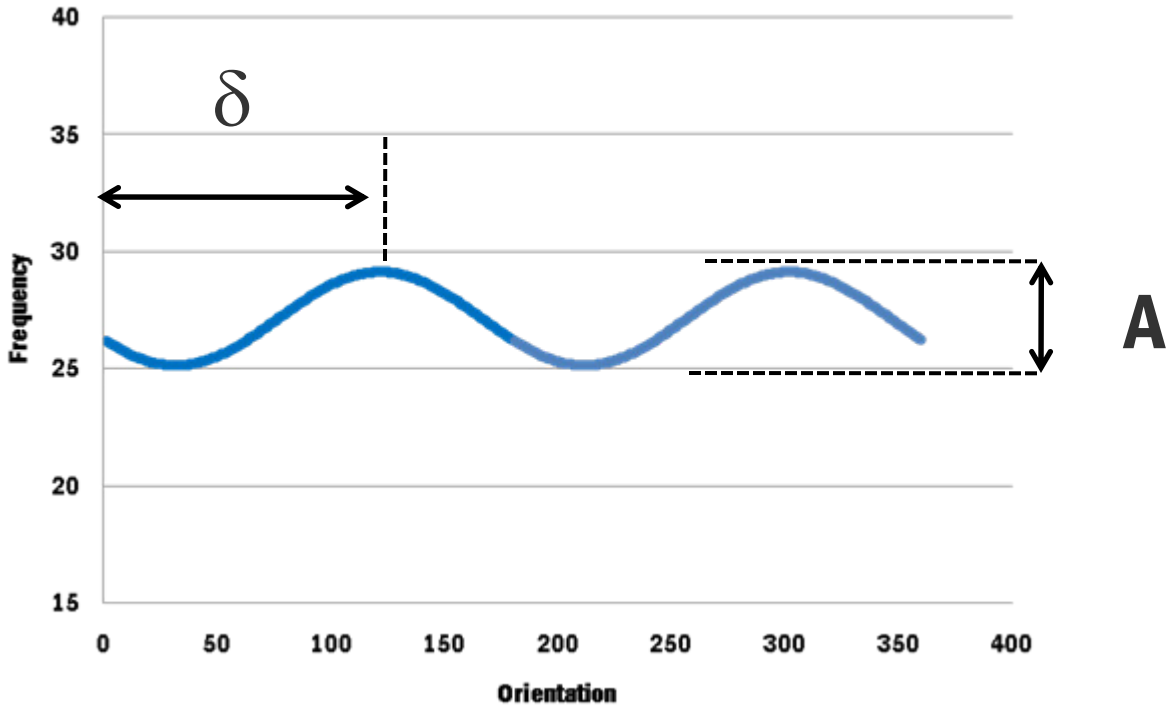


Orientation



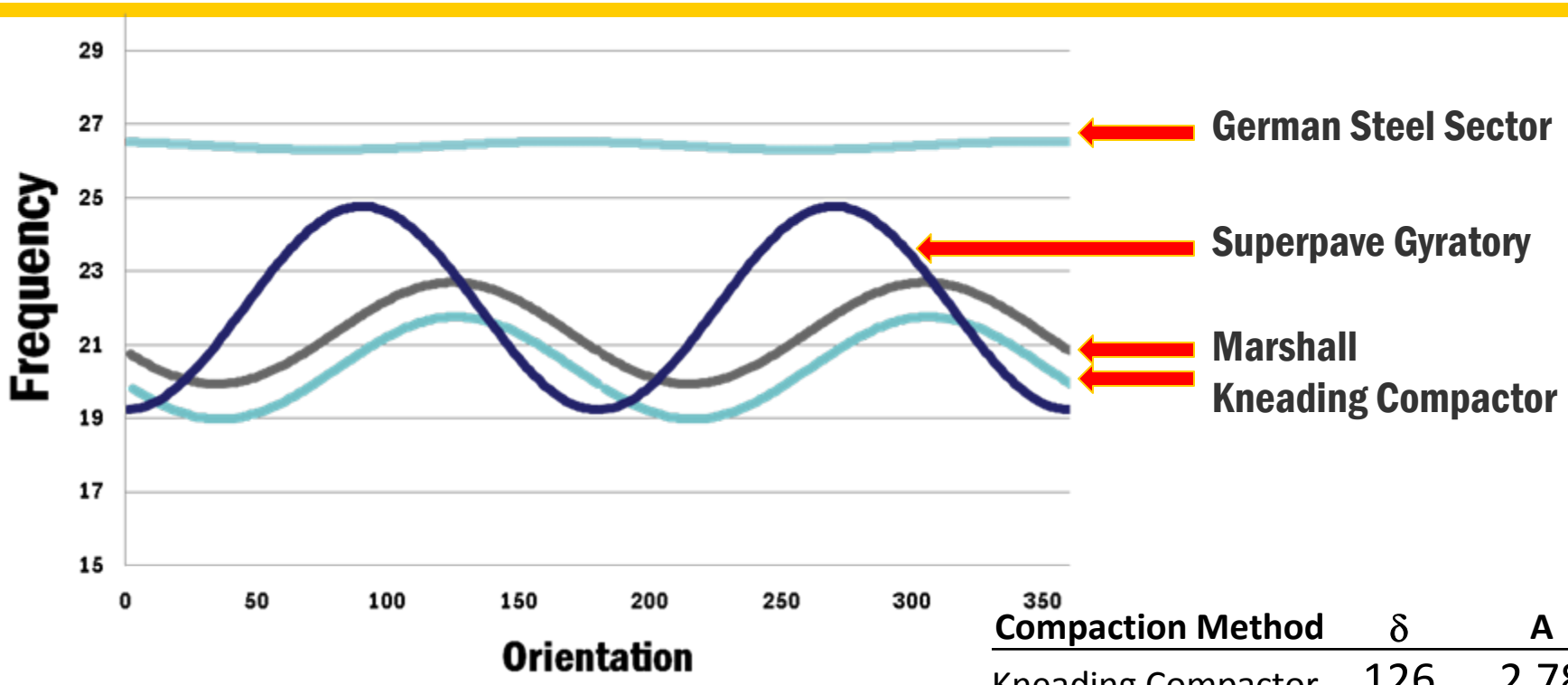
Segregation

Harmonic Fit Parameters



δ = Predominant angle, A= Severity of angle dispersion

Effect of Compaction Method – Initial Analysis

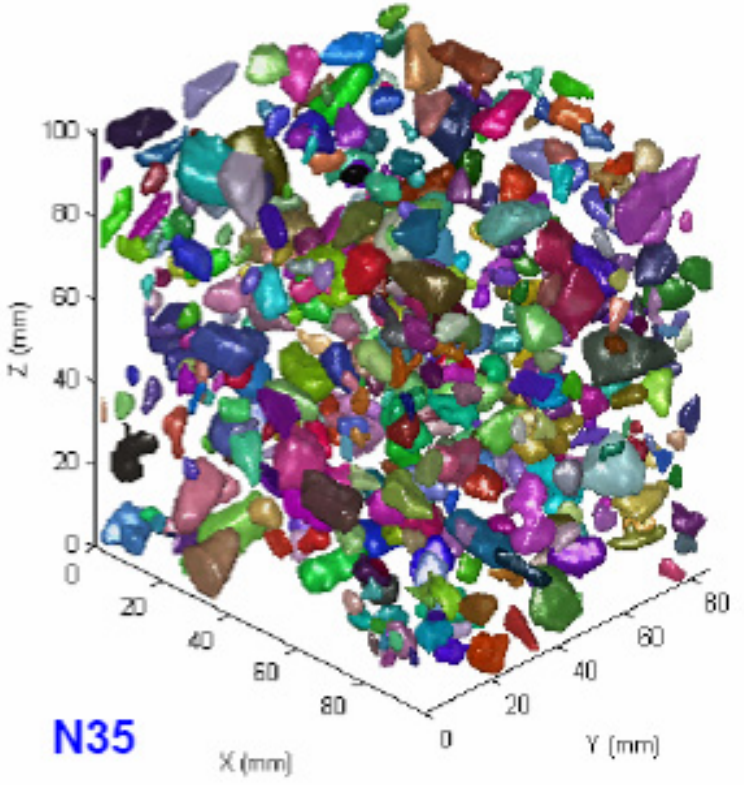


δ: Indicates the predominant orientation angle
A: represents the amplitude or severity of deviation from uniform (zero=uniform)

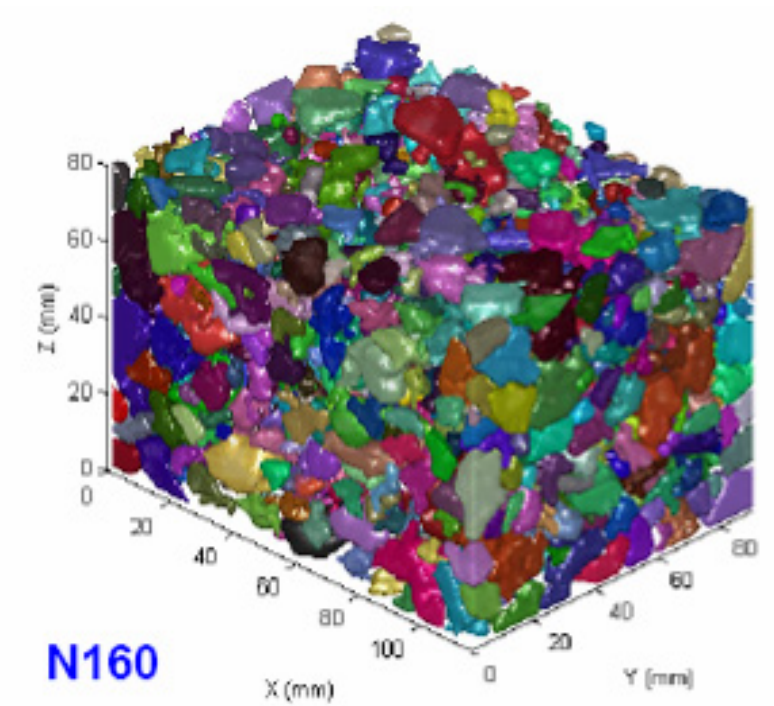
Compaction Method	δ	A
Kneading Compactor	126	2.78
Marshall	125	2.76
German Steel Sector	167	0.22
Superpave Gyratory	90	5.54

FHWA-UW -- X-Ray CT Imaging Hot Mix Asphalt

LCPC Mix compacted to 35 gyrations (~4% air voids)



LCPC Mix compacted to 160 gyrations (~1.5% air voids)



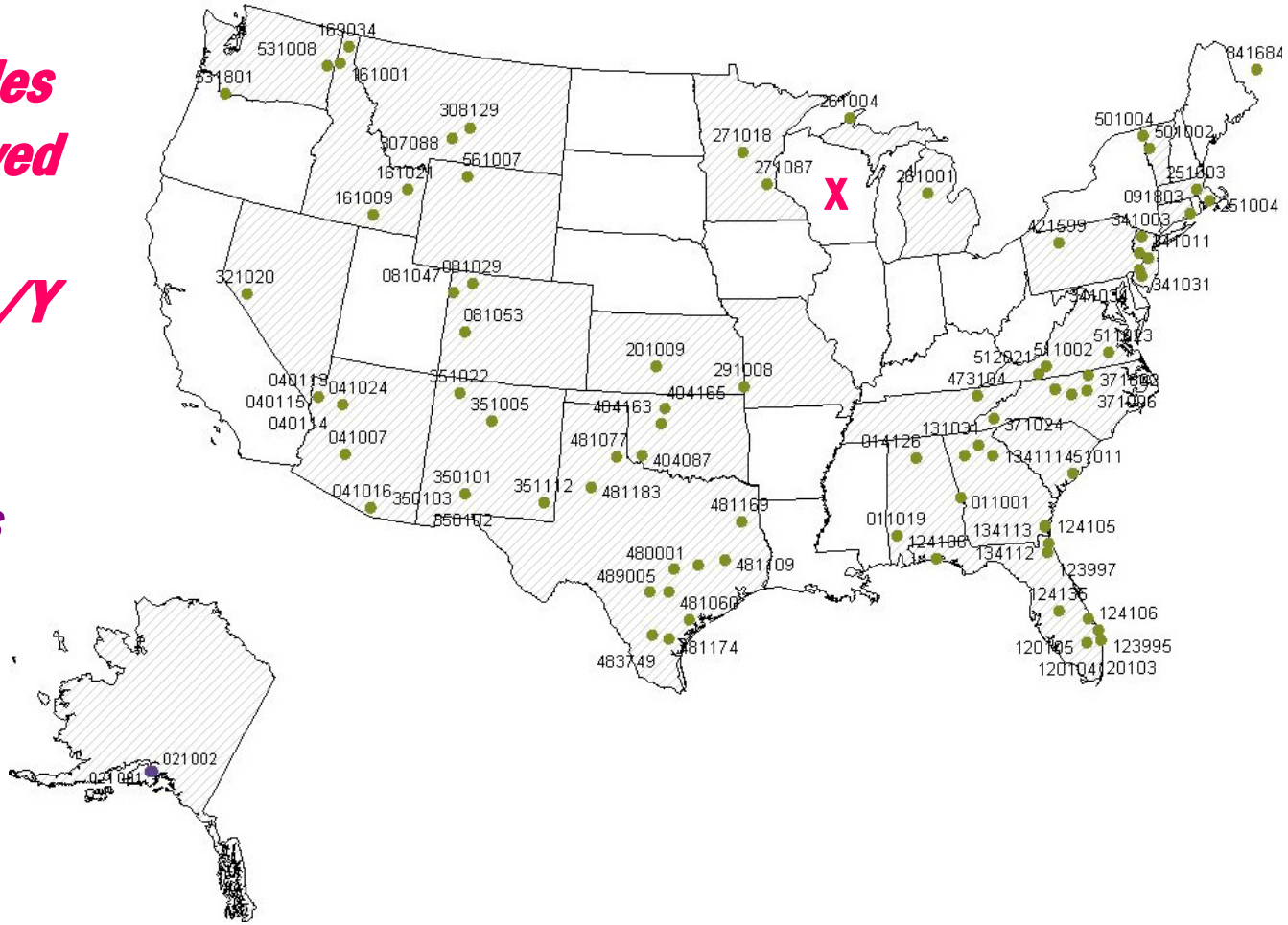
Images from Kutay et al. 2008

Future Highways in The USA –
Will be built <u>with Less Impact on Environment</u>
Low Energy, Low Emissions, and Low Noise Asphalt, can deliver these in the NEAR future

- *~ 4.0 Million Miles*
- *~ 2.2 million Paved*
- *~ 93 % Asphalt*
- *~30 million tons/Y*

- *~ 4-5 million*

Modified Asphalts



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Concluding Remarks

- *The next 10 years, many opportunities*
- *Asphalt will not be the same , it will much improved and more function specific*
  - *Opportunities for better role in pavement structure through MEPDG*
  - *Opportunities for lower cost and less impact on environment*
  - *Less energy, less emissions, and less noise*
  - *We will see more modified binders and mixtures*

Thank You
for this
Opportunity

Questions !