Concrete Pavement
New M-E Design Guide

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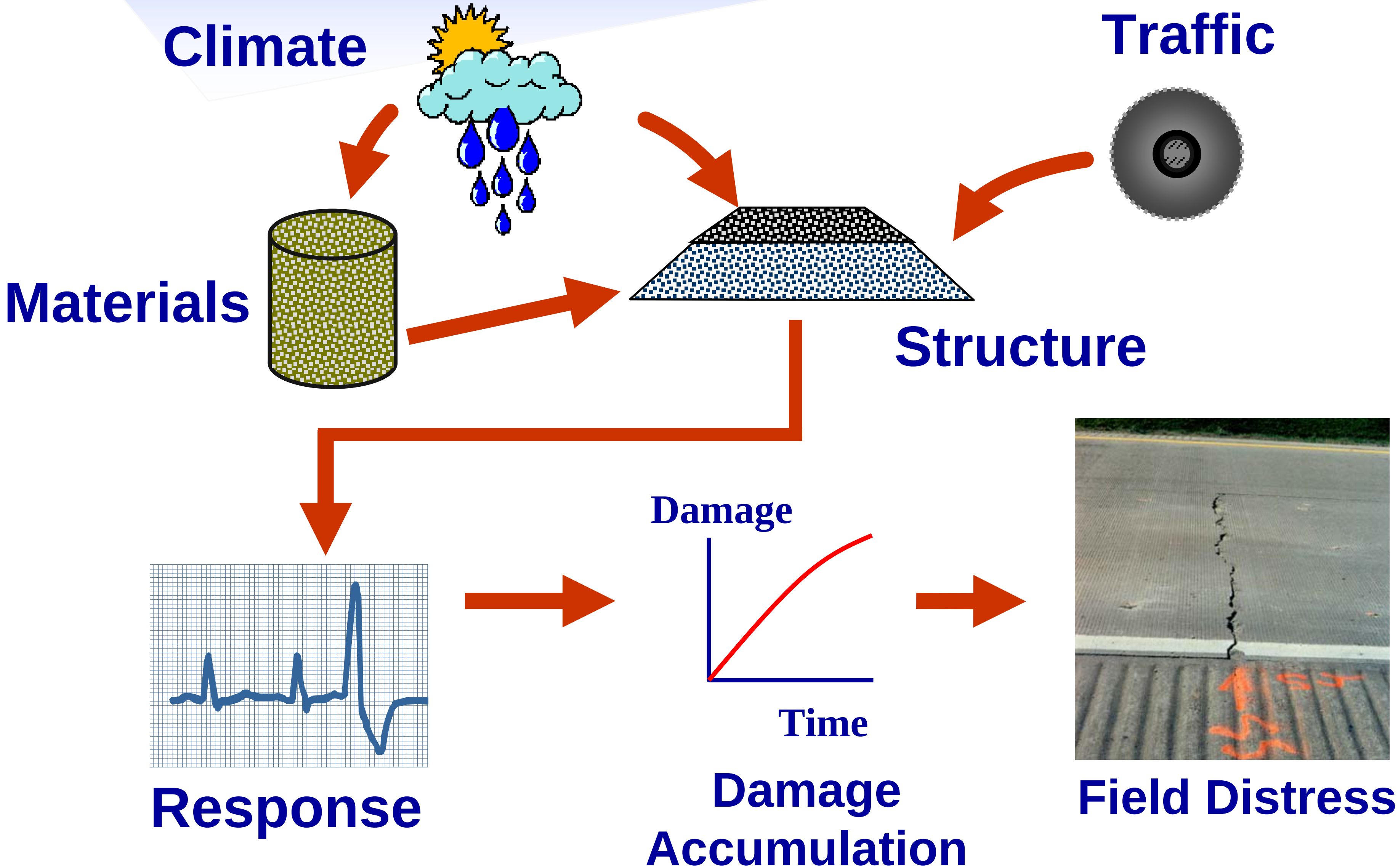
2002
Design Guide

PCC Pavement Presentation

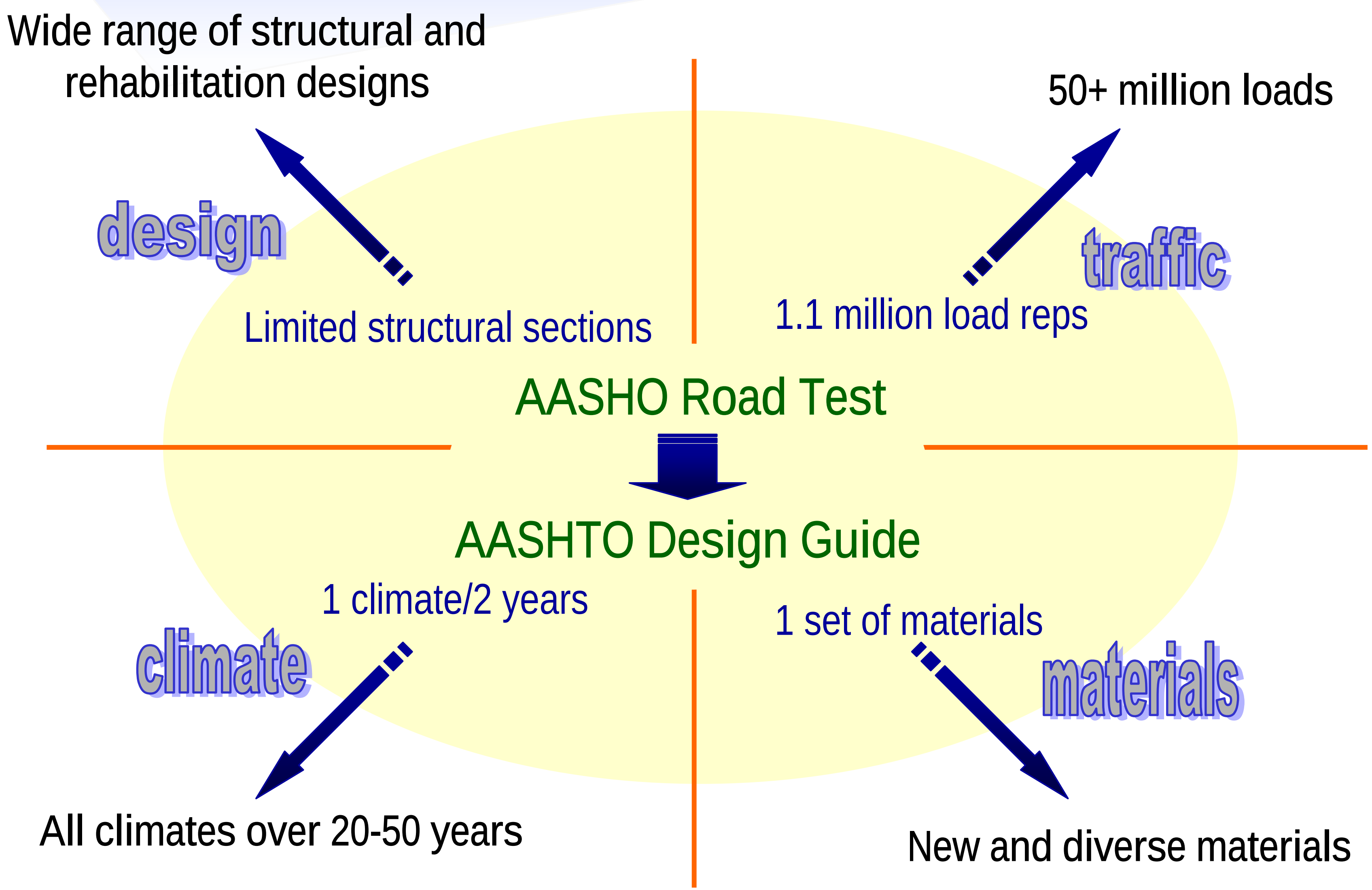
- Value of M-E “comprehensive design”
- Control of key distress
- Pavement types and rehab
- Inputs
- Design features
- Reliability
- Calibration

Benefits

Mechanistic-Empirical Design

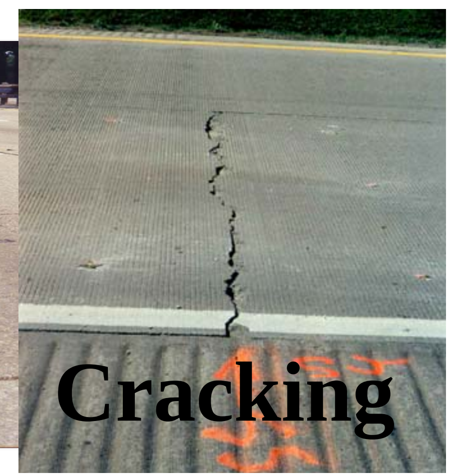


Current AASHTO vs. Current Needs



Biggest Advantage of M-E Design

- "Comprehensive" design procedure: Directly considers key types of structural distress and ride quality.

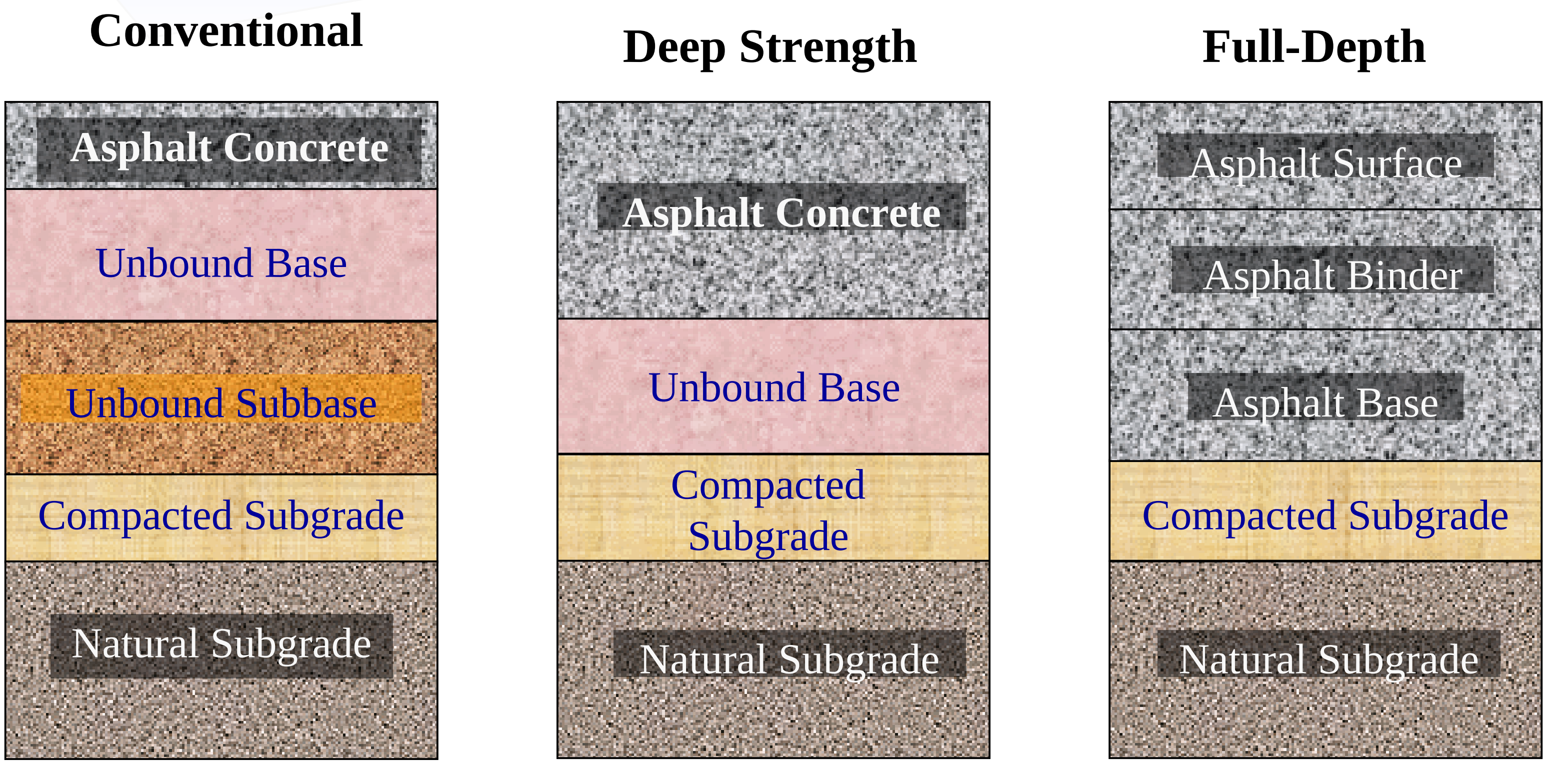


Benefits

The Biggest Advantage of M-E Design

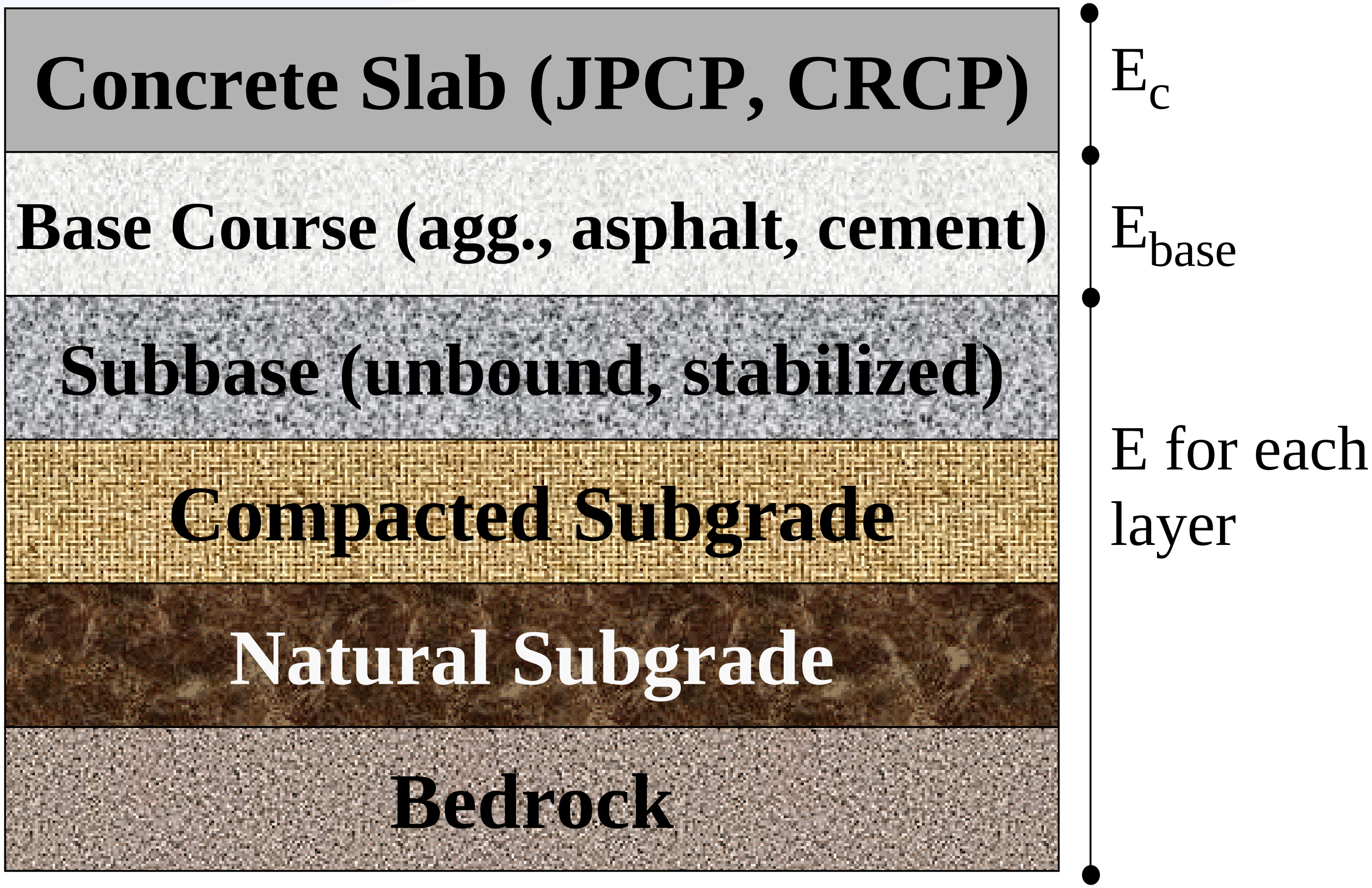
- Illustration:
  - Increase PCC strength and expect improved performance?
  - True for simplistic AASHTO Guide!
  - Not necessarily true in the field because Ec, shrinkage, and CTE all increase causing higher stresses!
  - Could be increased cracking and faulting!
- Comprehensive design procedure would tell you this, before you build

Flexible Pavement Layers

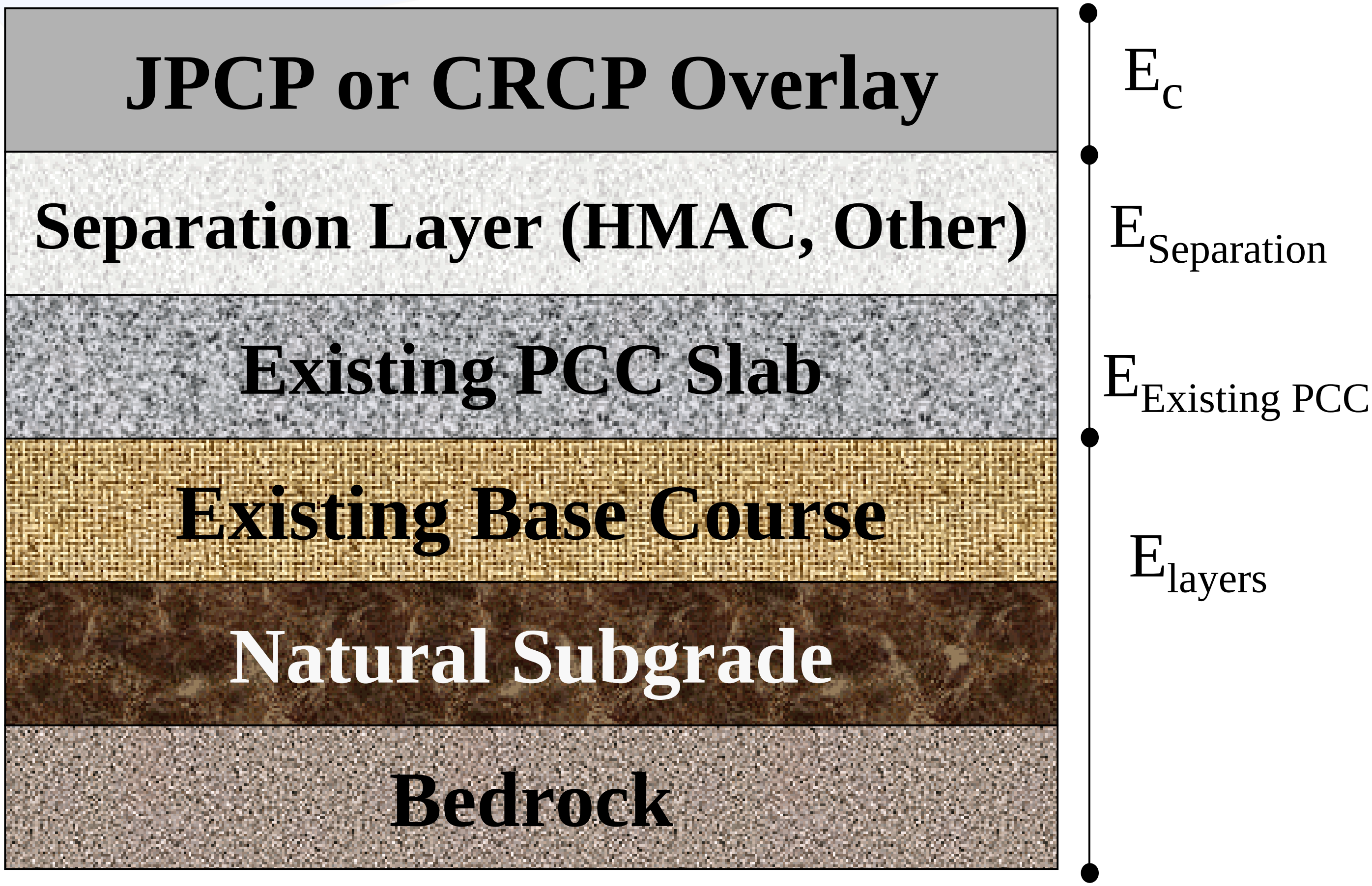


Rigid Pavement Layers

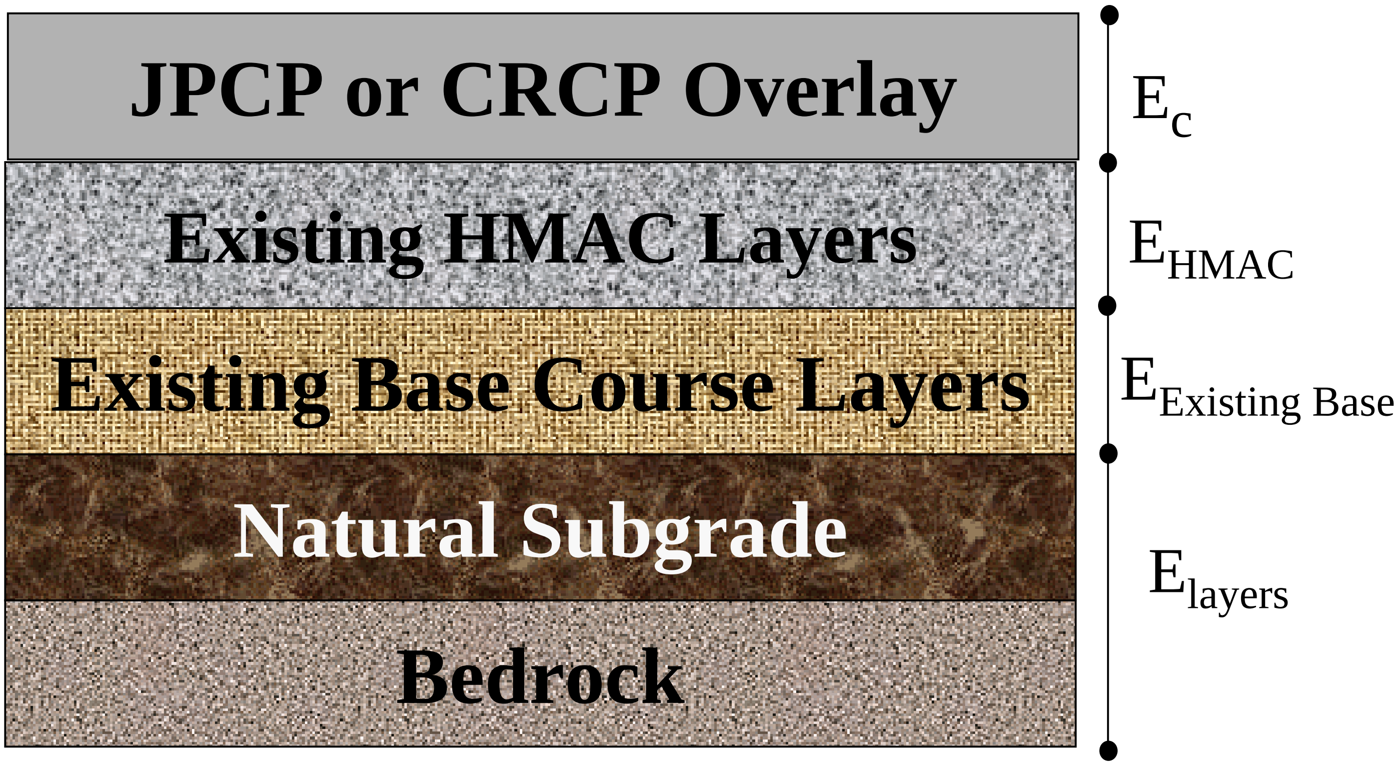
(also Diamond Grinding)



Unbonded PCC Overlay Layers



PCC Overlay of Flexible Pavement

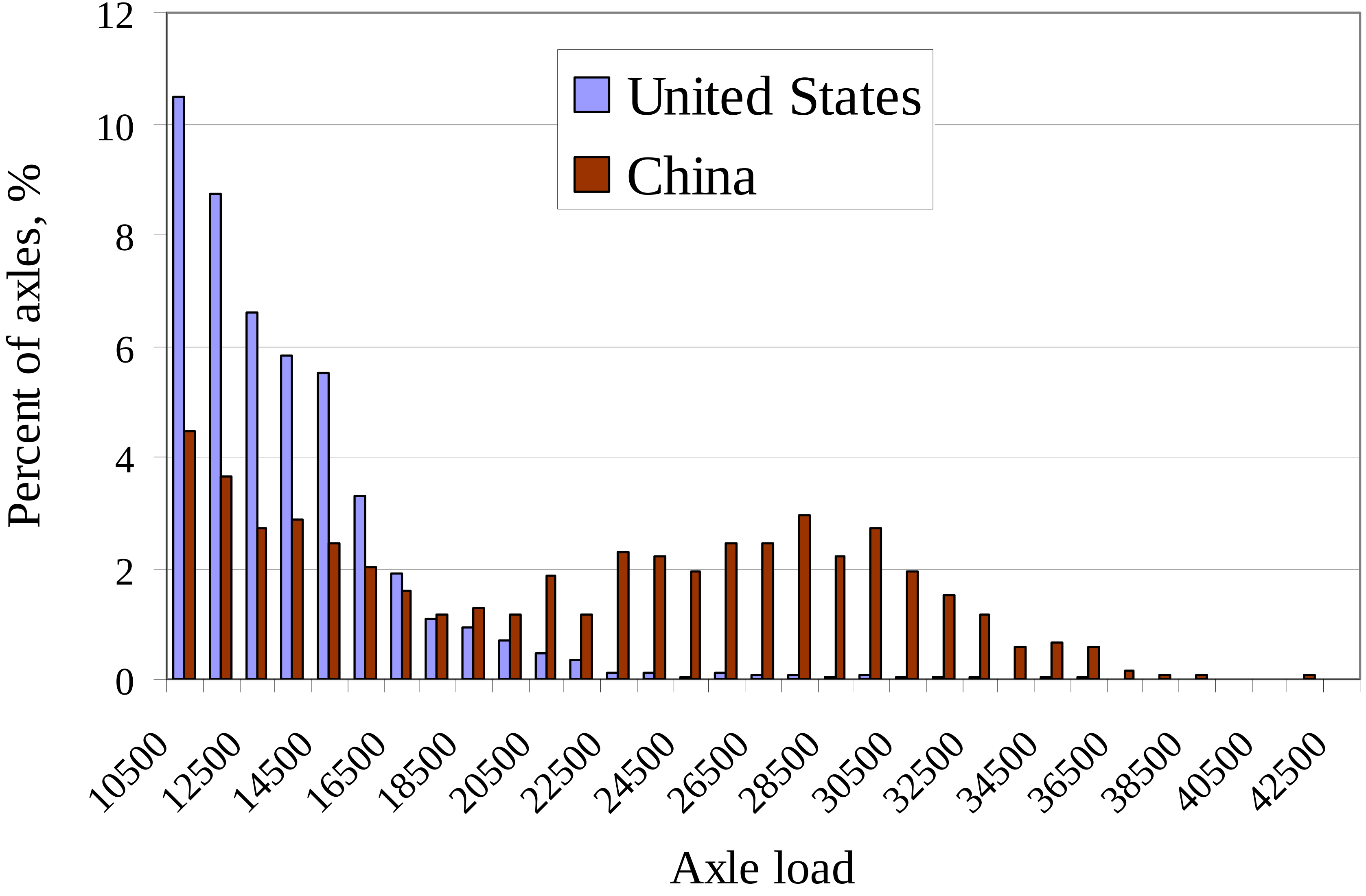


Traffic Loadings

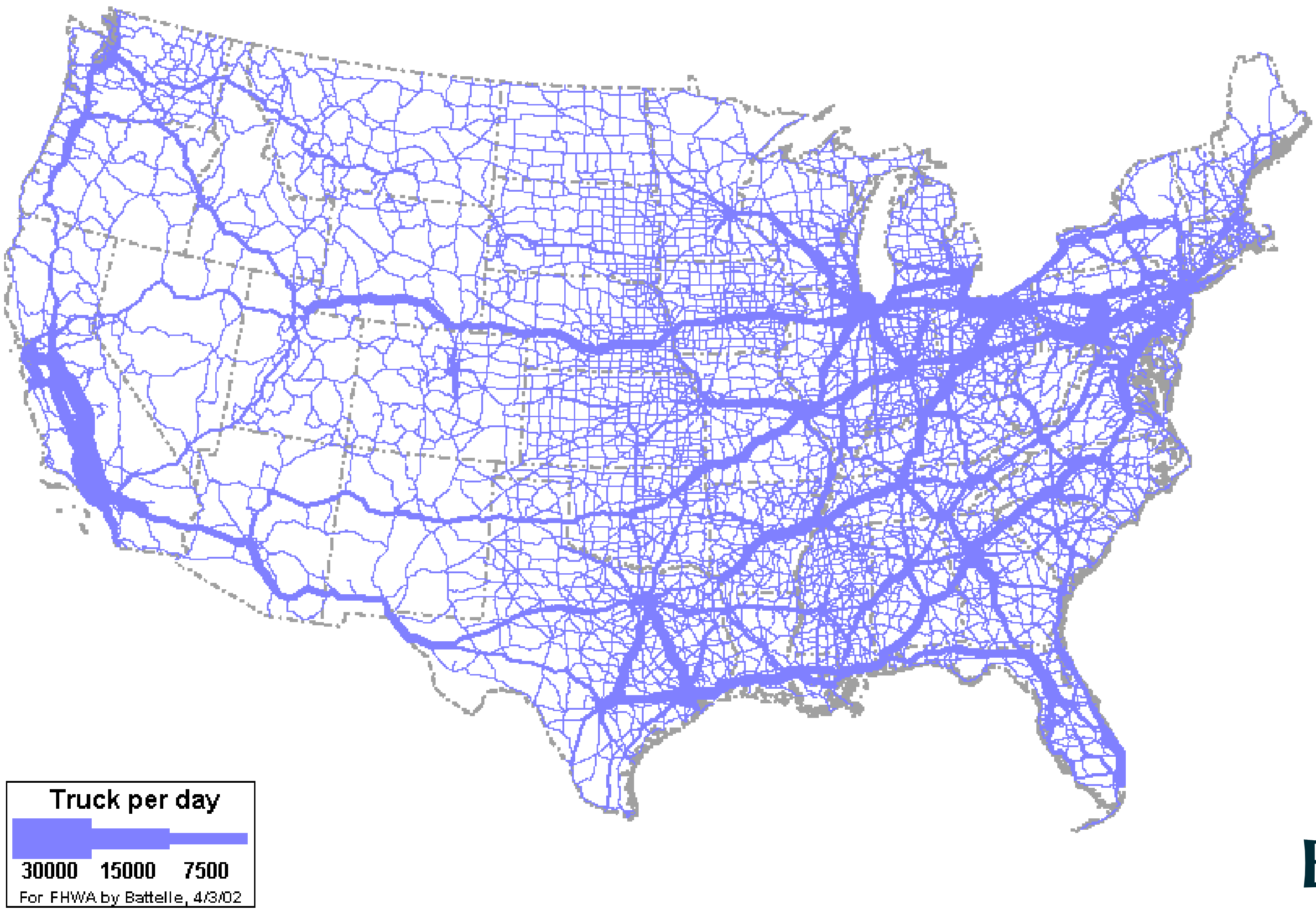
- Vehicle volume, growth & classification
- Single, tandem, tridem, quad axle load distributions
- Monthly vehicle distribution
- Hourly load distribution
- Lateral lane distribution
- Tire pressure
- Tractor wheelbase

Benefits

Axle Load Spectrum (Single Axles)

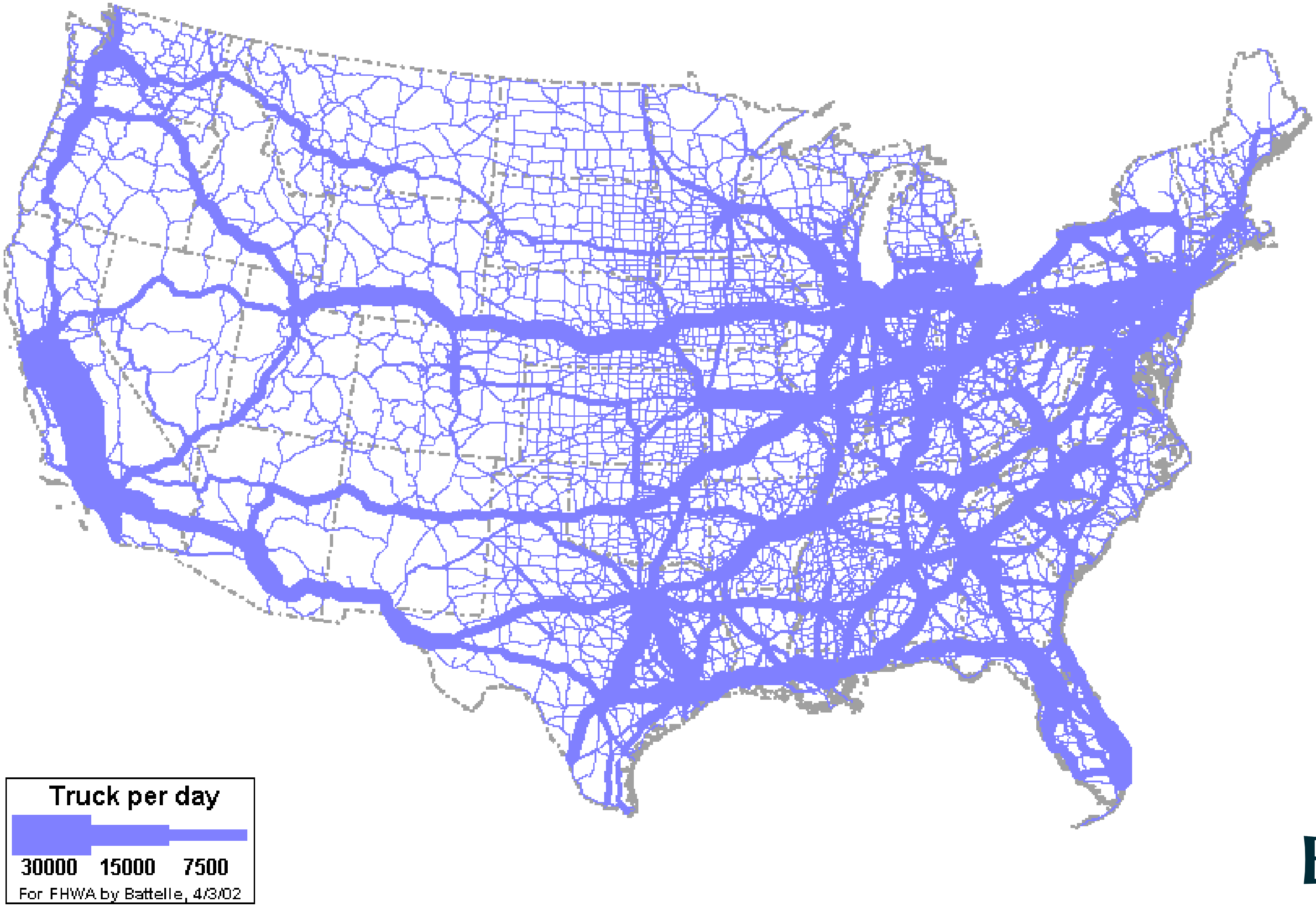


1998 Truck Flow



Battelle

2020 Forecast Truck Flow



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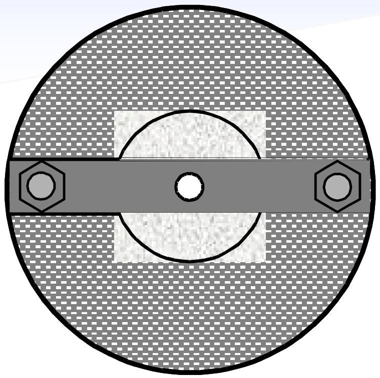
PCC Material Tests

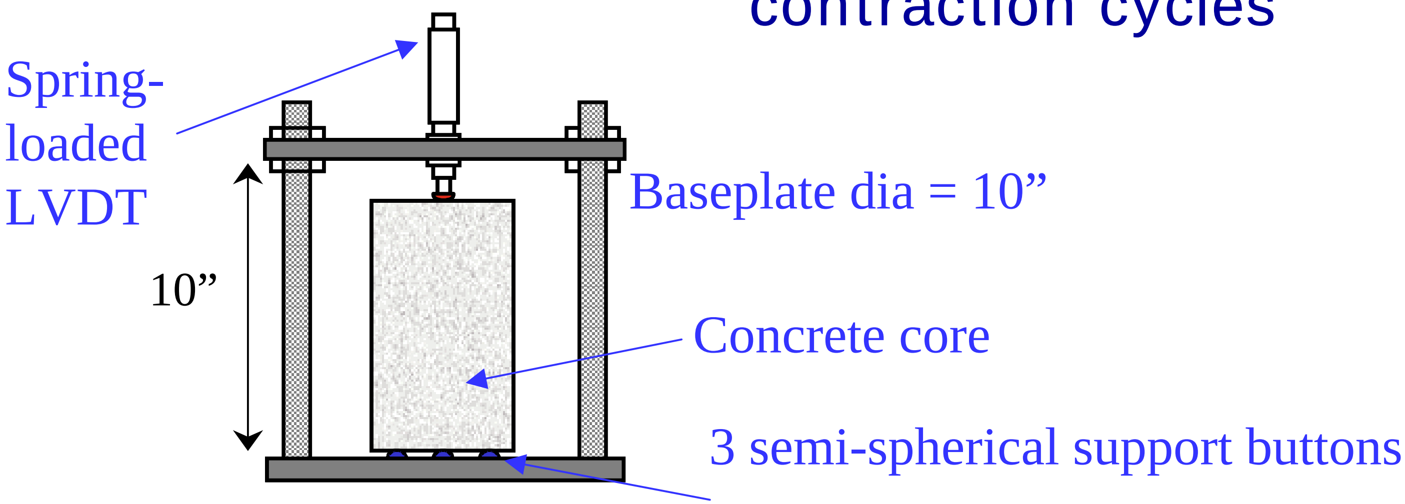
- Elastic Modulus, “E”
  - ASTM C 469
- Flexural Strength, MR, modulus of rupture
  - Third point loading test
  - ASTM C 78
- Concrete coefficient of thermal expansion
  - AASHTO TP60-00
  - Test performed at 10 to 50 deg C
- Concrete shrinkage
  - ASTM C 157

Concrete Thermal Expansion—AASHTO TP60



Top View

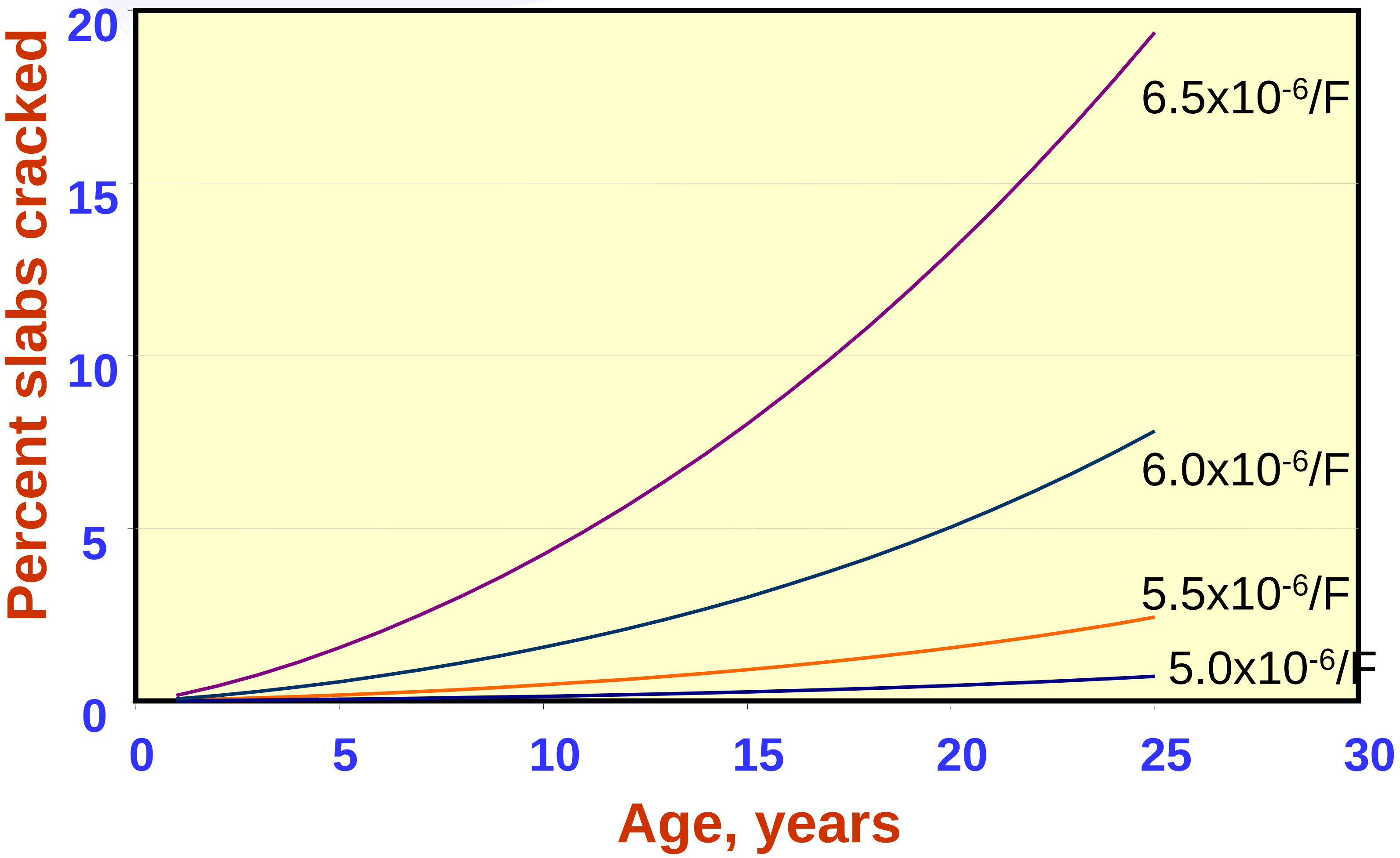
- Test procedure involves measuring change in length of specimen at different temperatures
- Length change is measured after expansion and contraction cycles



Test Frame

Benefits

Concrete Coefficient of Thermal Expansion



Benefits

Materials/Subgrade Characterization

- HMA Overlays & base course
  - Dynamic modulus (temp., loading speed)
- Cement treated & lean concrete base
  - Elastic modulus
- Unbound aggregate base & soils
  - Resilient modulus (moisture, freezing)

Better Characterization & Selection

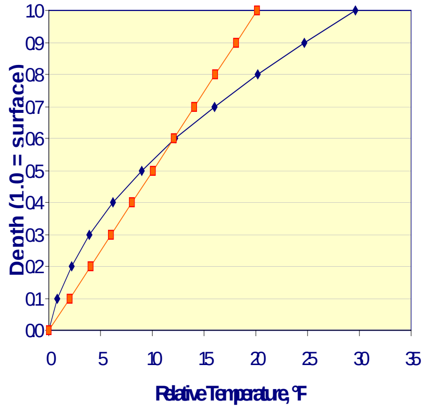
- Bring daily, seasonal, and yearly changes in materials into design process
  - Better use of available materials
  - HMA & PCC material mix optimization to minimize distress.

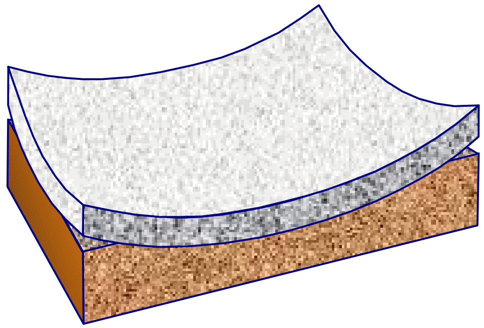
Benefits

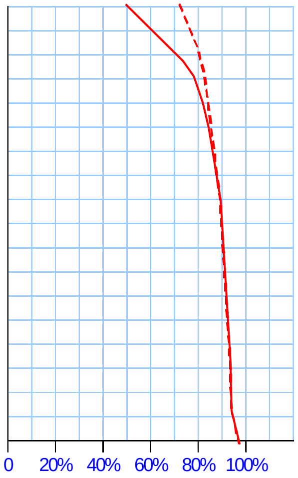
Climate

- Hourly climatic data
  - Temperature
  - Precipitation
  - Wind speed
  - Cloud cover
  - Relative ambient humidity
- Water table level

Components of Curling Stress







Actual Temperature Gradient

Built-in Curling

Moisture Gradient

$$\Delta T = \Delta T_{Hourly} + \Delta T_{Built-in} + \Delta T_{Shrinkage}$$

JPCP Design Features

- Slab thickness
- Slab length (joint spacing)
- Slab width (widened slab)
- Tied PCC shoulder
- Joint load transfer (dowels & interlock)
- Base and subbase layers (bonding)

CRCP Design Features

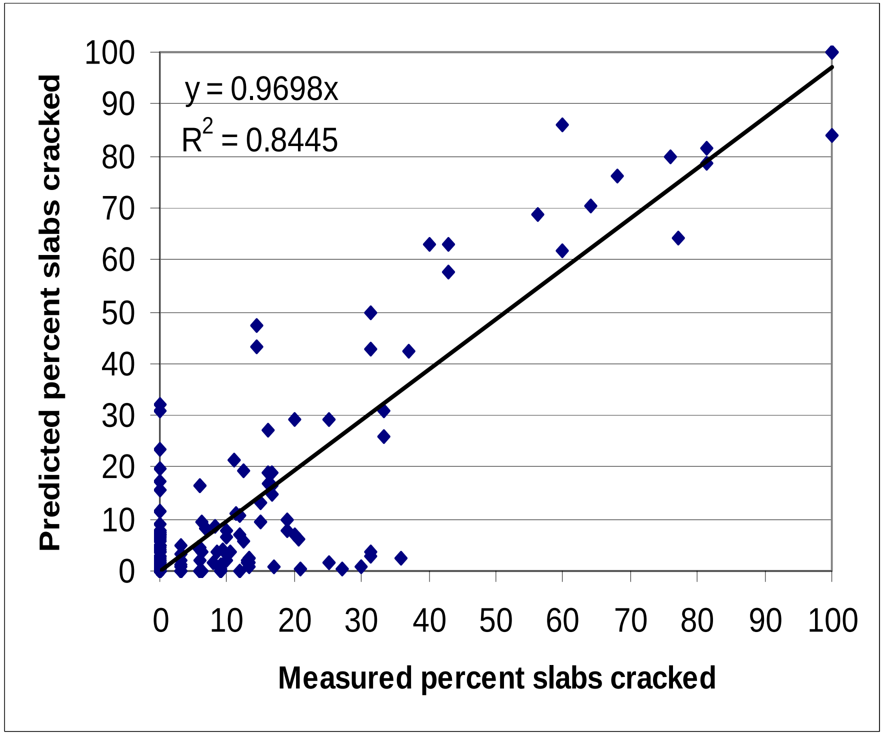
- Slab thickness
- Reinforcement content
- Slab width (widened slab)
- Tied PCC shoulder
- Base and subbase layers (bonding)

Design Reliability

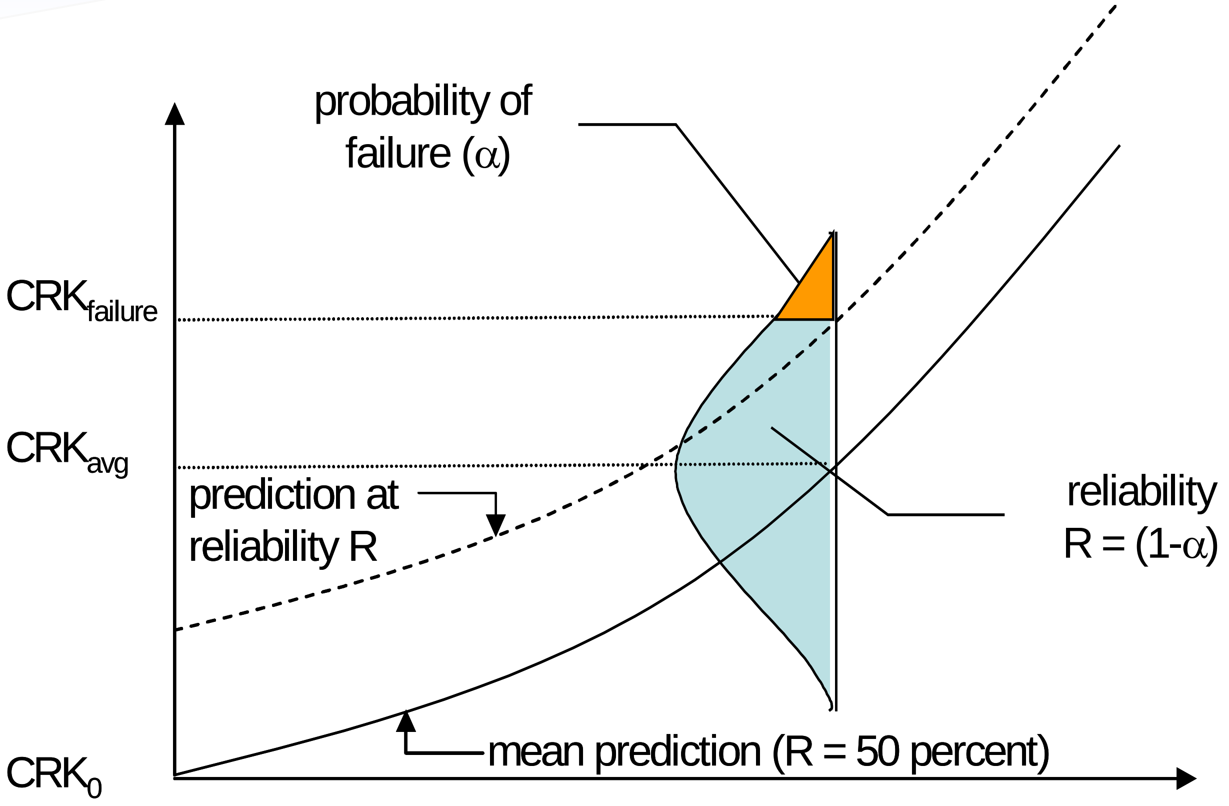
- Totally different than AASHTO 93
- Not multiplier of traffic loadings as in AASHTO 93
- Based on accuracy of predicting performance

Residuals from Performance Prediction during Calibration

- "Residuals" represent the knowledge that exists of the accuracy of the distress prediction model
- Standard error of estimate

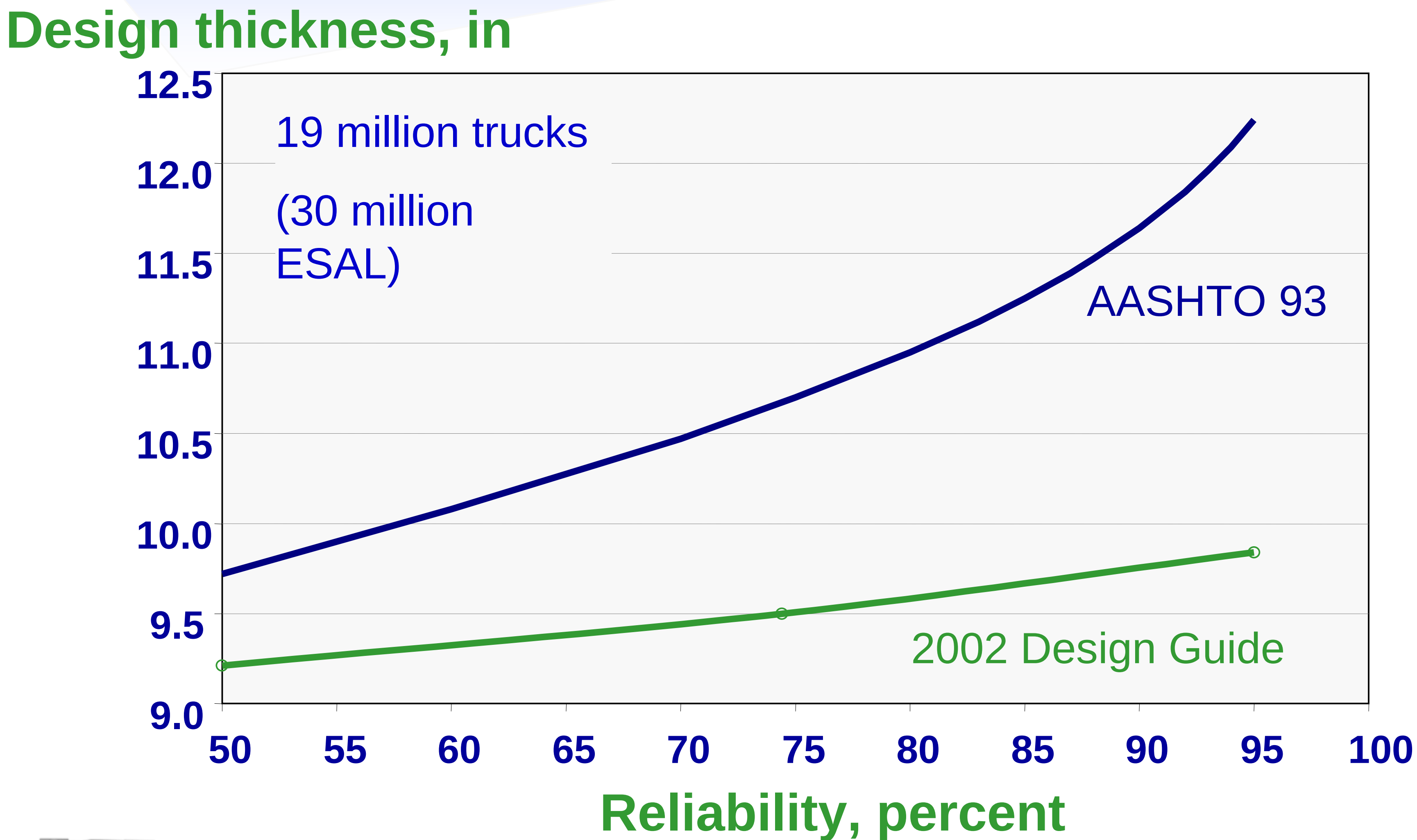


Cracking Reliability Example



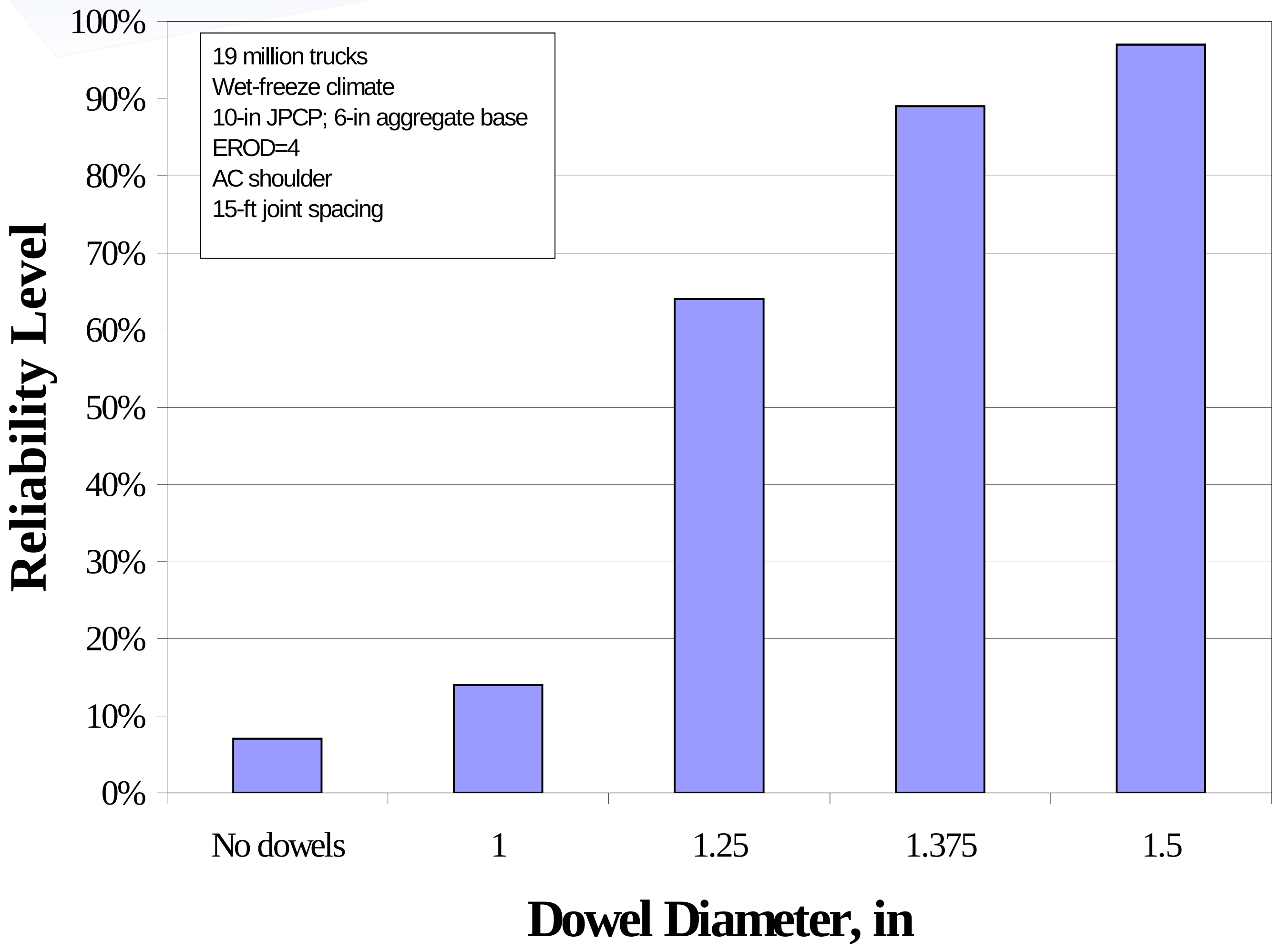
AASHTO 93 & Design Guide

I-80 Chicago — Heavy Traffic



Benefits

Dowel Diameter Effect on Reliability Level

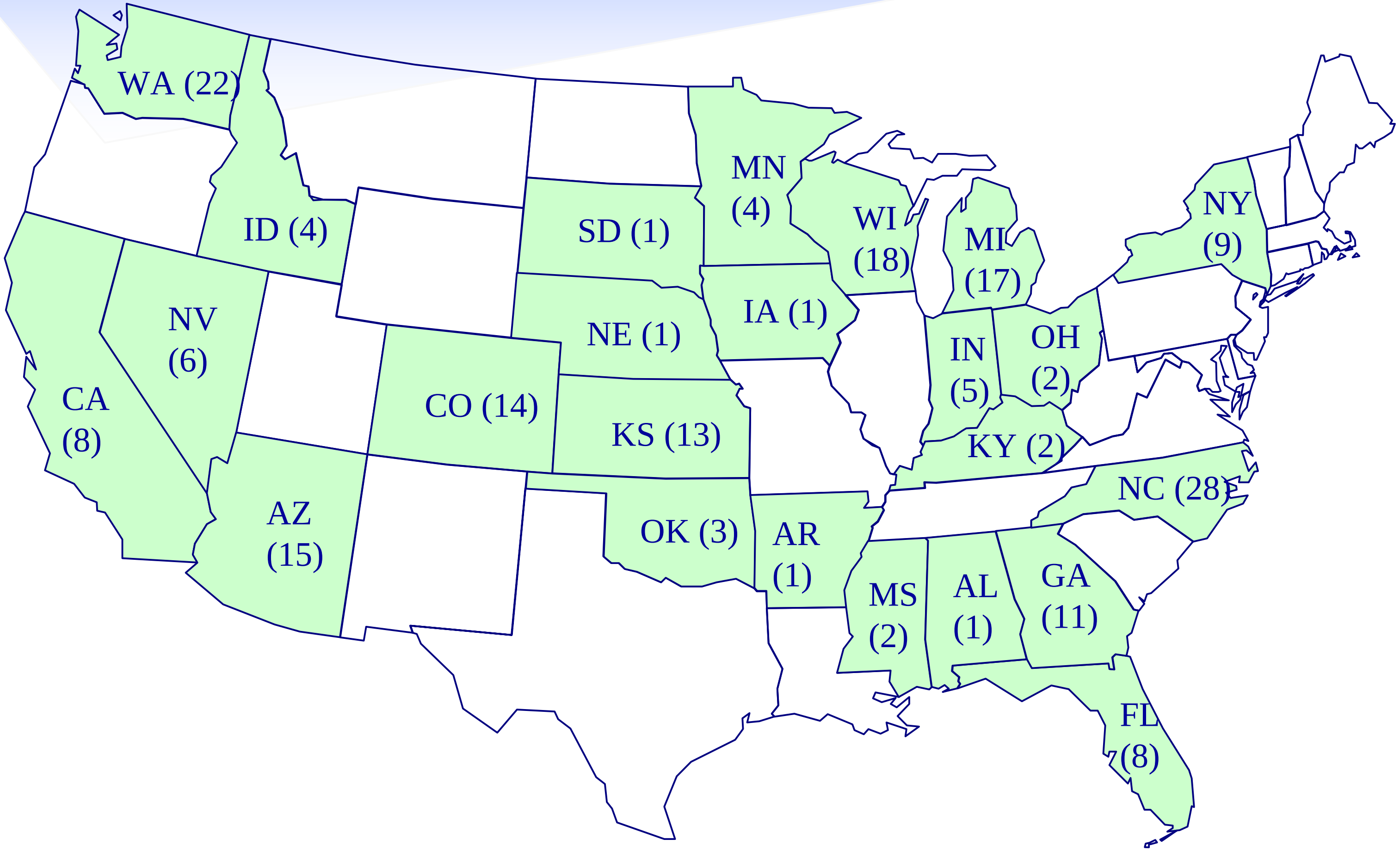


National Calibration Models & Local Calibration

- All concrete pavement models successfully calibrated using national LTPP & other data
  - Joint faulting
  - Slab cracking
  - IRI
  - Transverse cracks/Punchouts-CRCP

Benefits

Calibration database JPCP Cracking



196 LTPP sections
36 RPPR sections
522 total observations

Utah JPCP Case Study

- 10-in JPCP, non-doweled
- PCC w/high thermal coef. expansion
- Lean concrete base
- Tied PCC shoulders
- Random joint spacing of 12, 13, 17, and 18-ft.

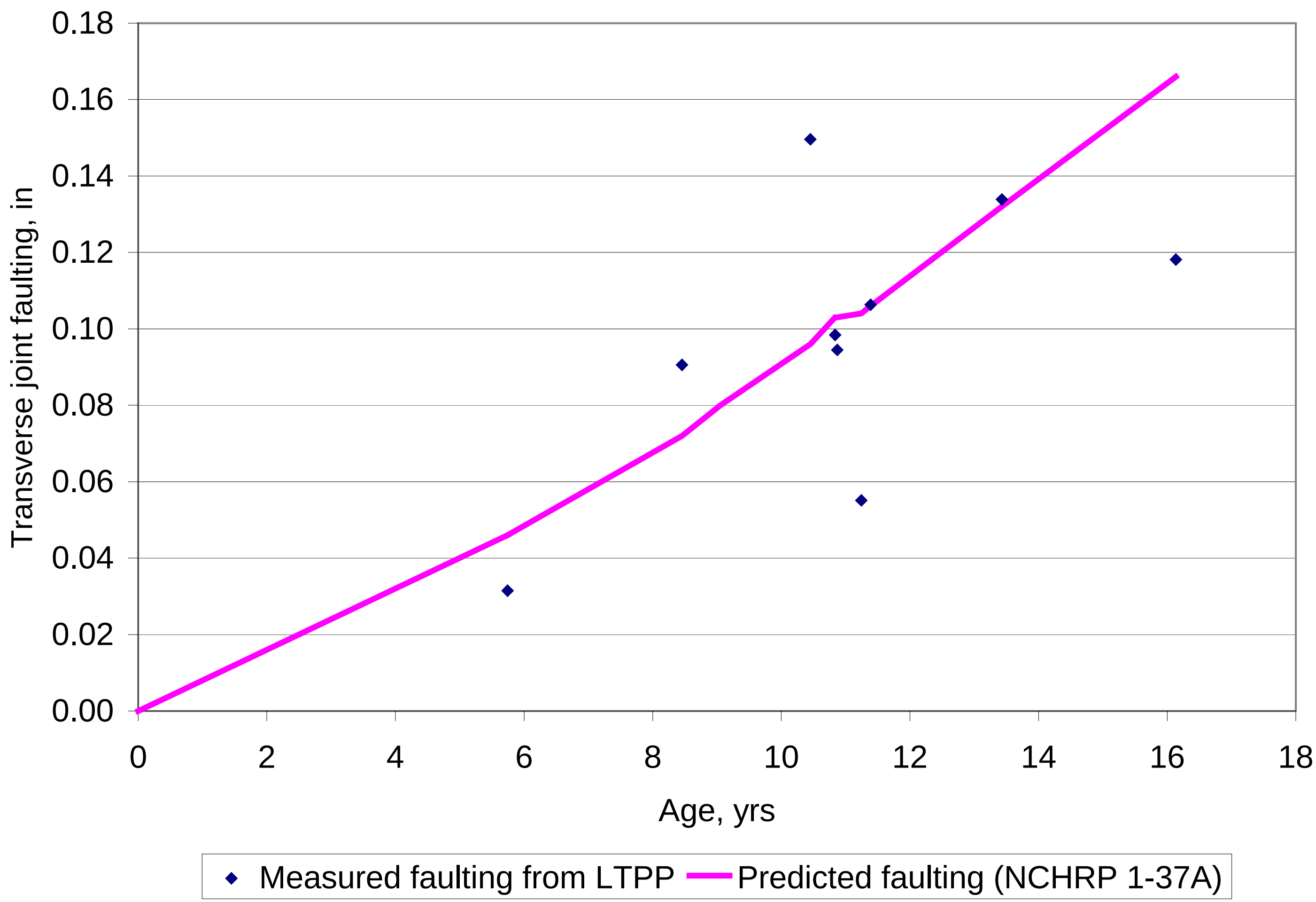
Utah JPCP Case Study

Inputs obtained and following predicted:

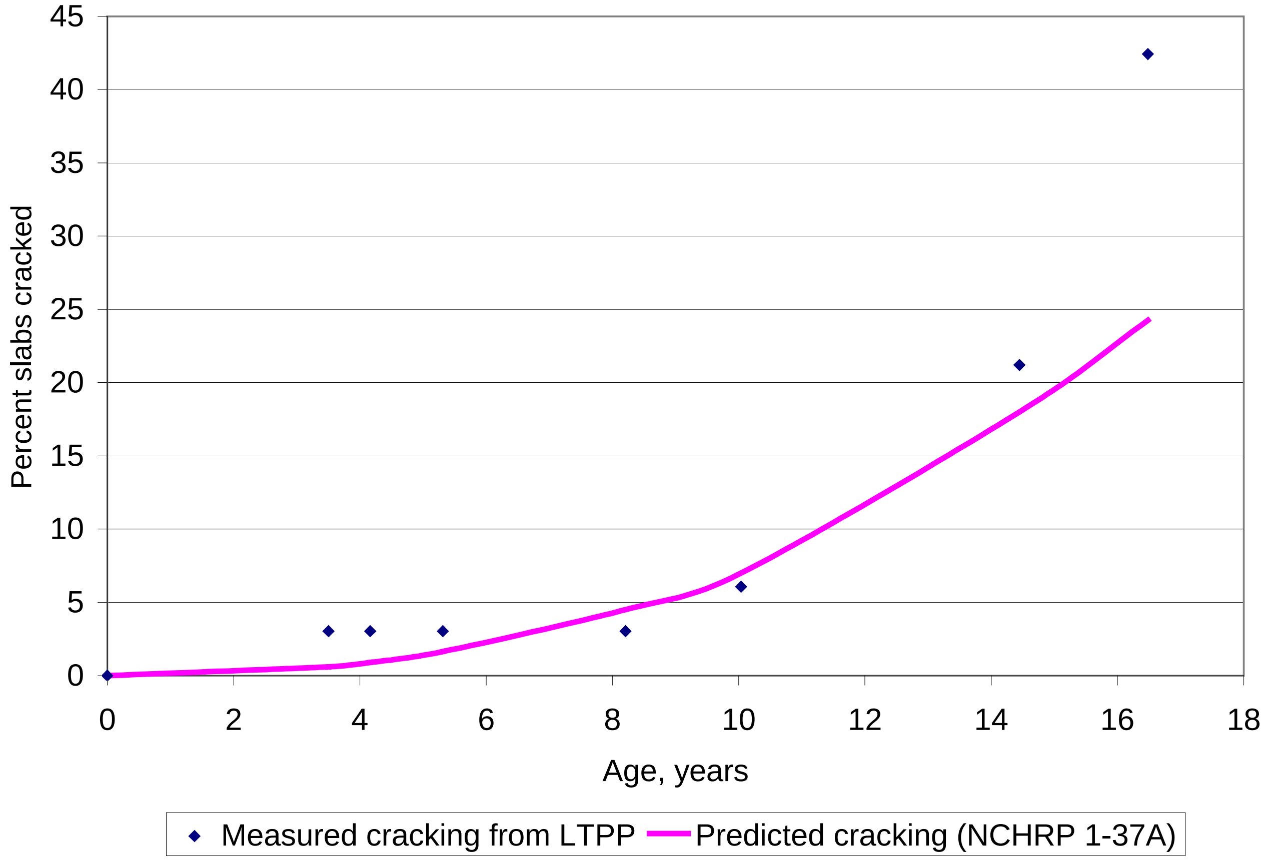
- Joint faulting, in
- Slab cracking, percent slabs
- IRI, in/mile

Benefits

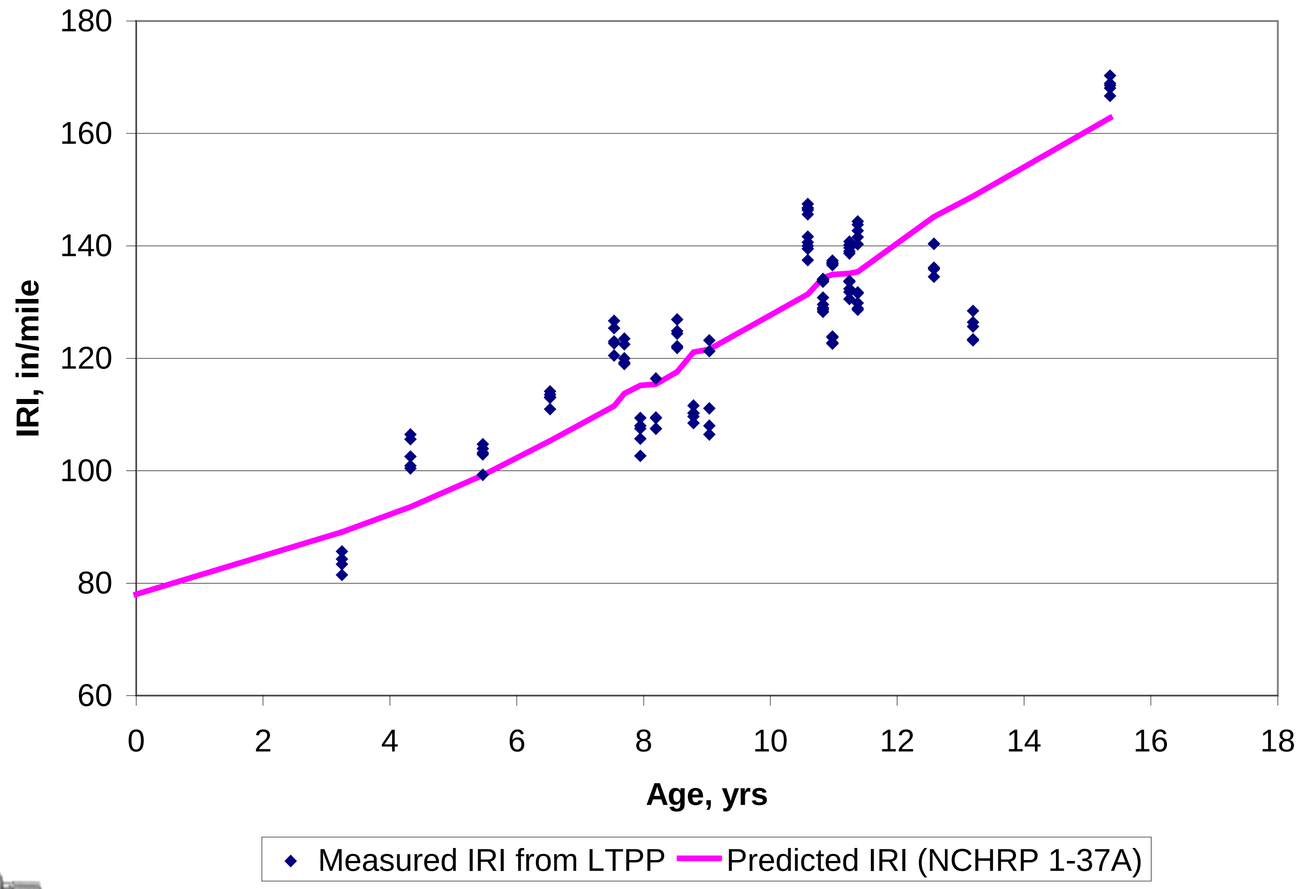
Utah JPCP Case Study —Joint Faulting—



Utah JPCP Case Study —Fatigue Cracking—



Utah JPCP Case Study —IRI (Ride Quality)—



What If . . . Modified JPCP Design?

- Add 1.25-in diameter dowel bars at transverse joints.
- Use of an aggregate in the PCC with a lower coefficient of thermal expansion.
- Use of 15-ft uniform joint spacing.

Utah JPCP Comparison

Distress	Existing Design (4.2 million trks, 17 years)	New Design (65 million trks, 35 years)
Slab cracking	26 %	0.7 %
Joint faulting	0.18-in	0.10-in
IRI	171-in/mile	139-in/mile

M-E Design Guide Benefits

- Superior engineering tools

- Economic savings

- Improved traveling conditions for public
- Innovative contracting tools

- Improved management of highway network