La Nueva AASHTO Guia de Diseno de Pavimentos Hormigon

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Current AASHTO vs. Current Needs

Wide range of structural and rehabilitation designs

50+ million loads

10 design

10 traffic

Limited structural sections

1.1 million load reps

AASHO Road Test

AASHTO Design Guide

1 climate/2 years

1 set of materials

10 climate

10 materials

All climates over 20-50 years

New and diverse materials

1996: AASHTO Decided New Design Needed

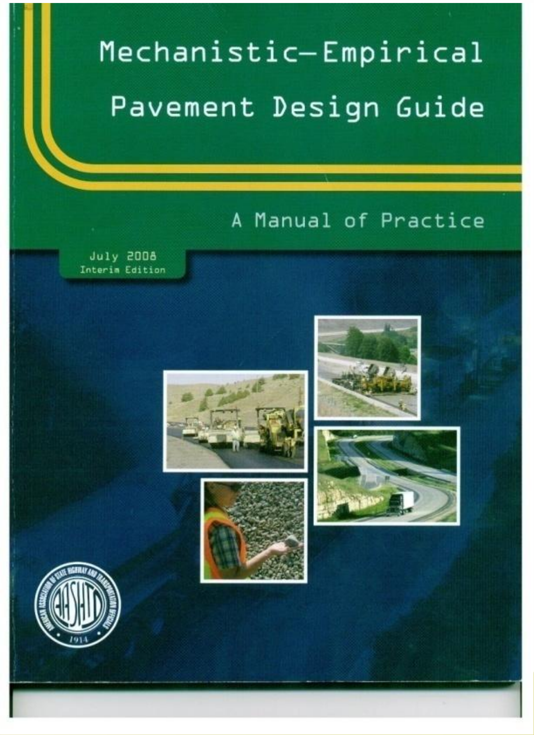
- 1998-2007: Development of new AASHTO design procedure.
- 2007: AASHTO Interim Mechanistic-Empirical Pavement Design Guide approved.
- 2011: New software DARWin-ME.
- Implementation by many States, Canadian Provinces, & Others since 2004.

Definitions

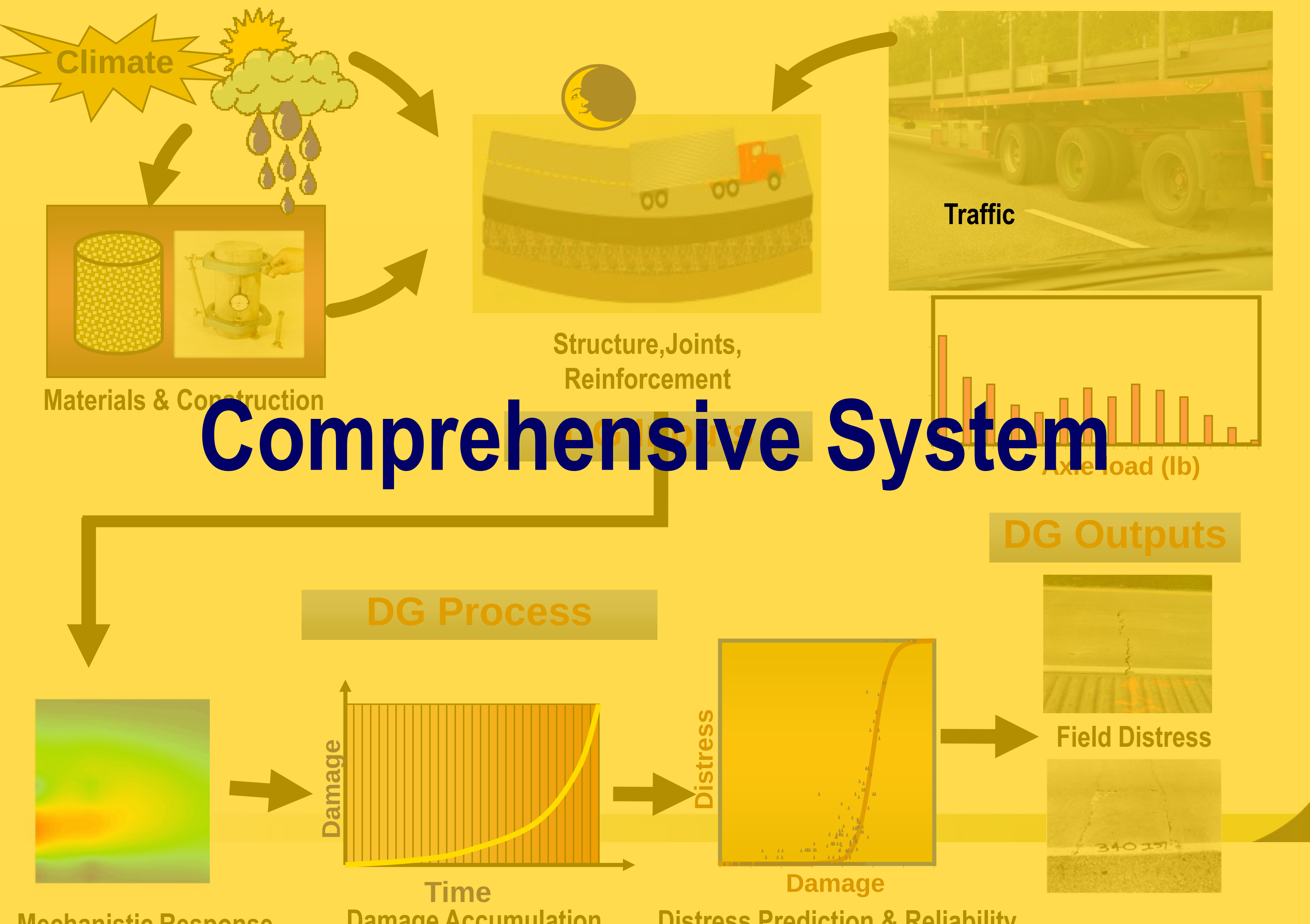
- *Mechanistic-Empirical* Pavement Design Guide, or MEPDG (now named **DARWin-ME**).
- Fundamental engineering *mechanics* as basis for modeling (stress, strain, deformation, fatigue, cumulative damage, etc.).
- *Empirical* data from field performance.
- M-E "Marriage" of theory and data.

AASHTO Interim DARWin-ME

- **AASHTO Interim DARWin-ME Manual of Practice**



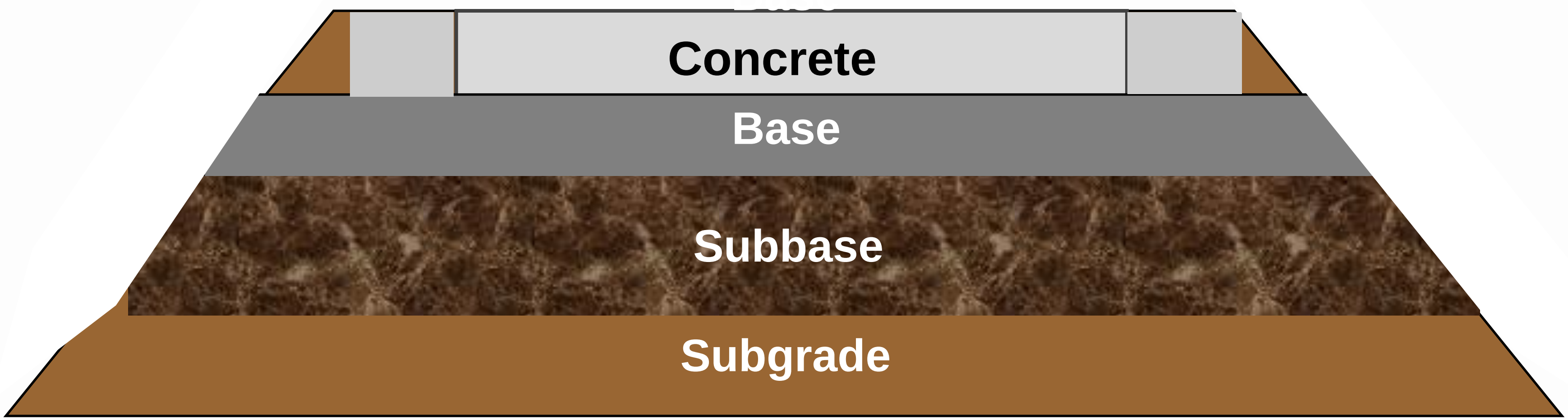
Comprehensive System



Pavement Characterization

For Each Layer:

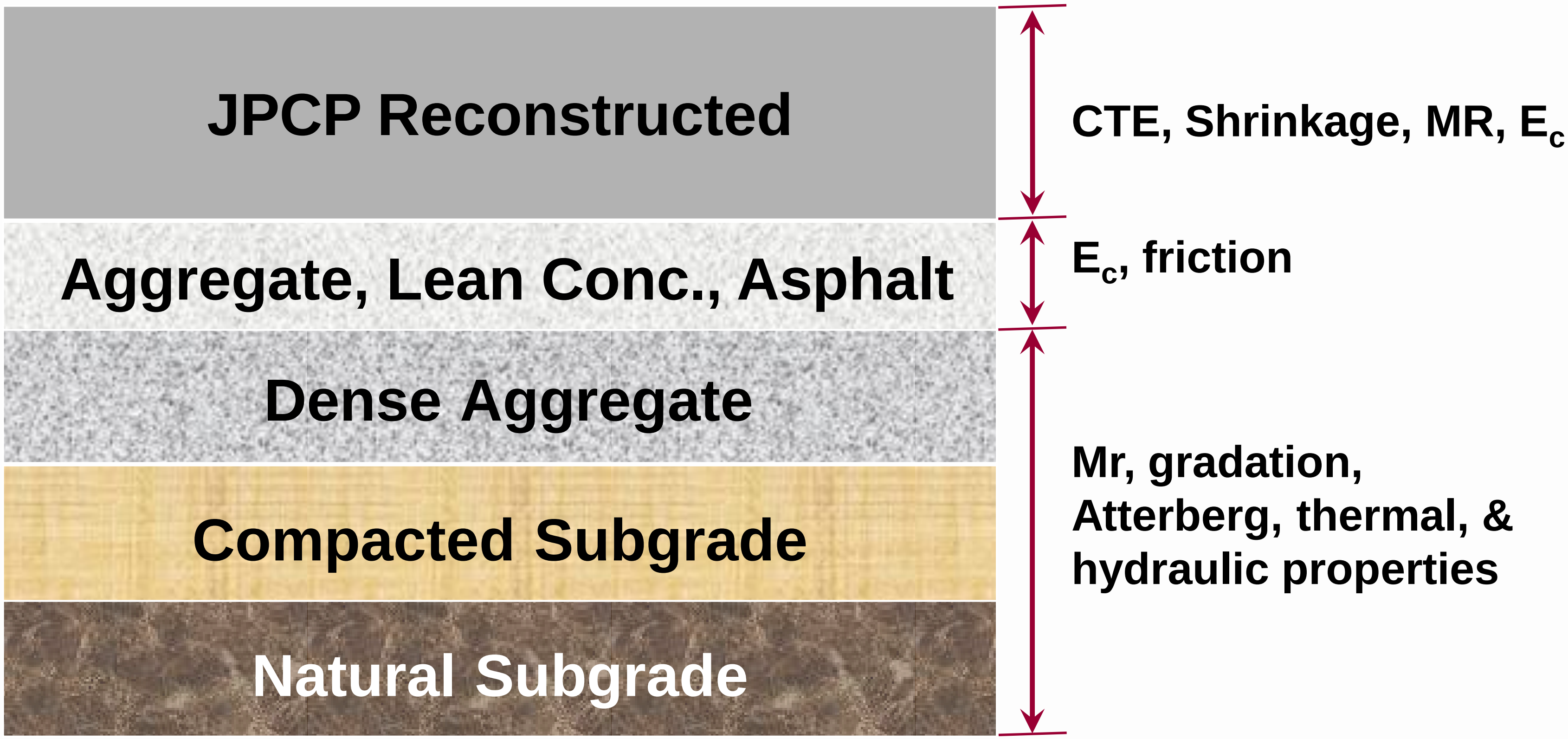
- Physical properties
- Thermal properties
- Hydraulic properties



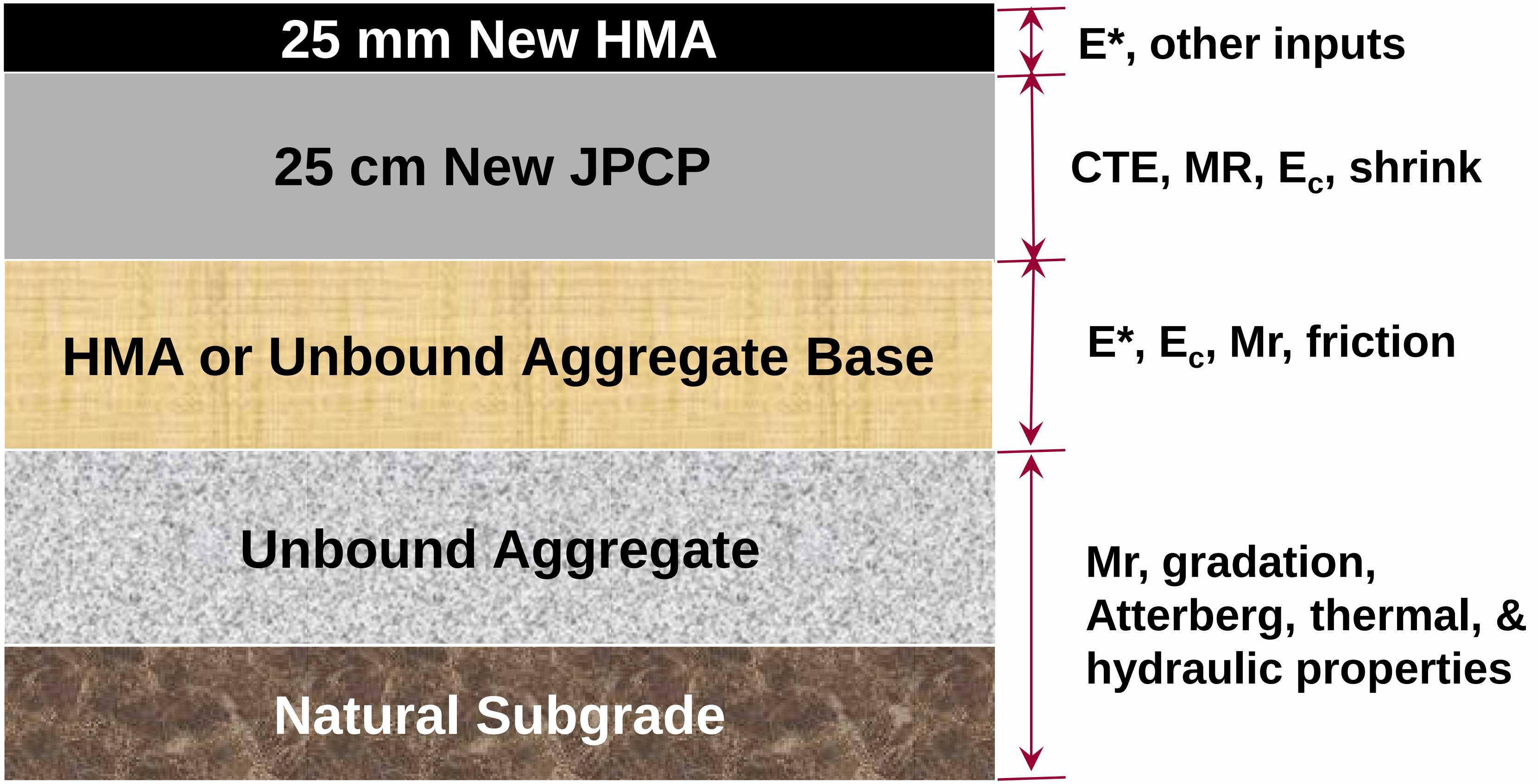
New Or Reconstructed JPCP

Joint spacing = 4 m

Dowel Dia. = 27 mm



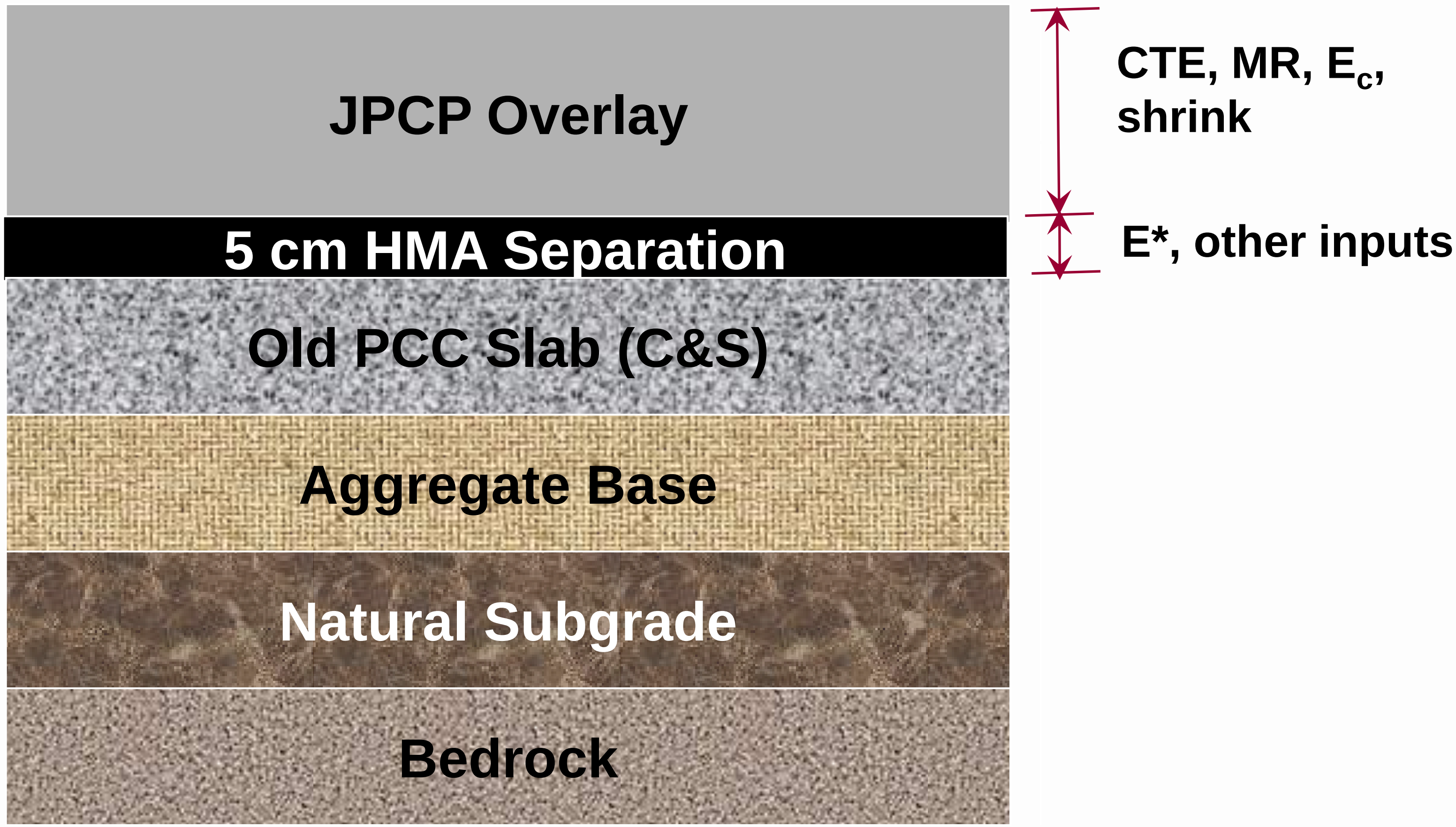
Composite Pavement, Phoenix, AZ



Concrete Pavement Restoration California

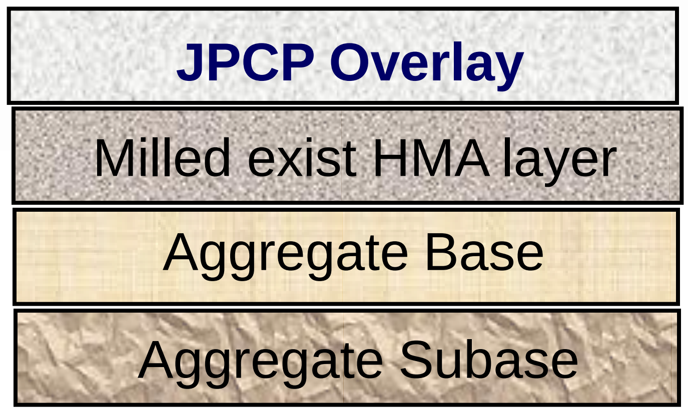
Restoration of joint load transfer, slab replacement (past damage), tied PCC shoulder, diamond grinding

JPCP Overlay Georgia



JPCP Overlay of Existing Asphalt

Kansas Turnpike

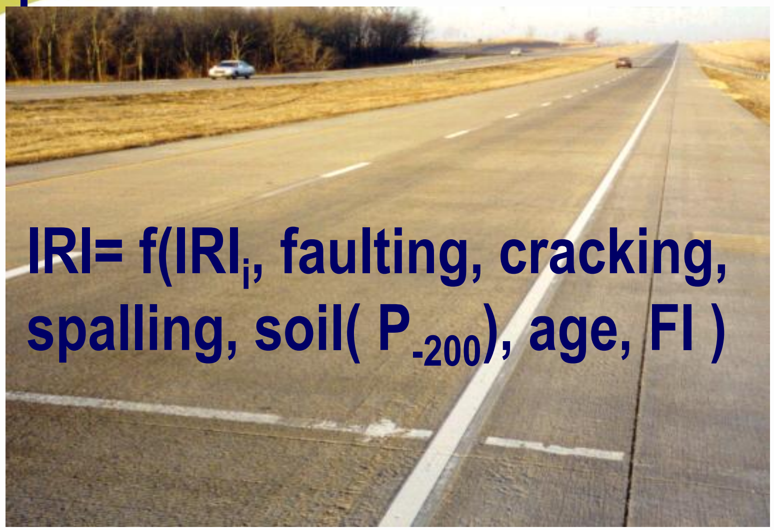


4 m joint spacing

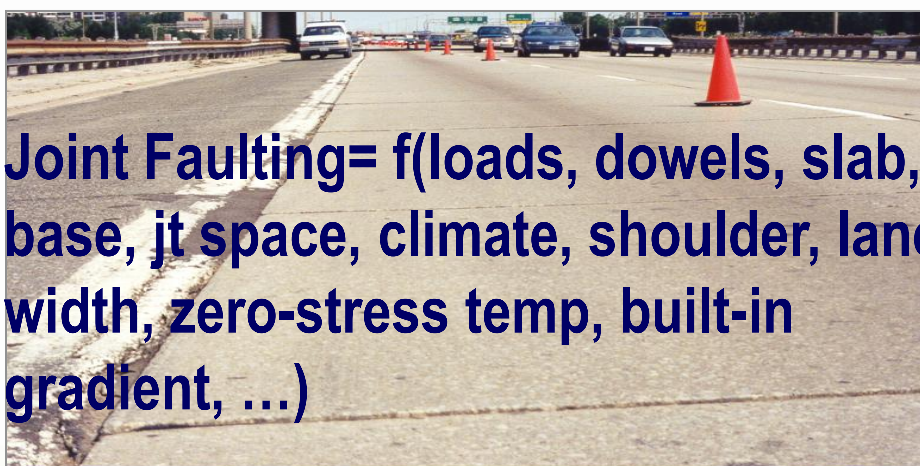
33 mm dowels

3.9 m outer lane width

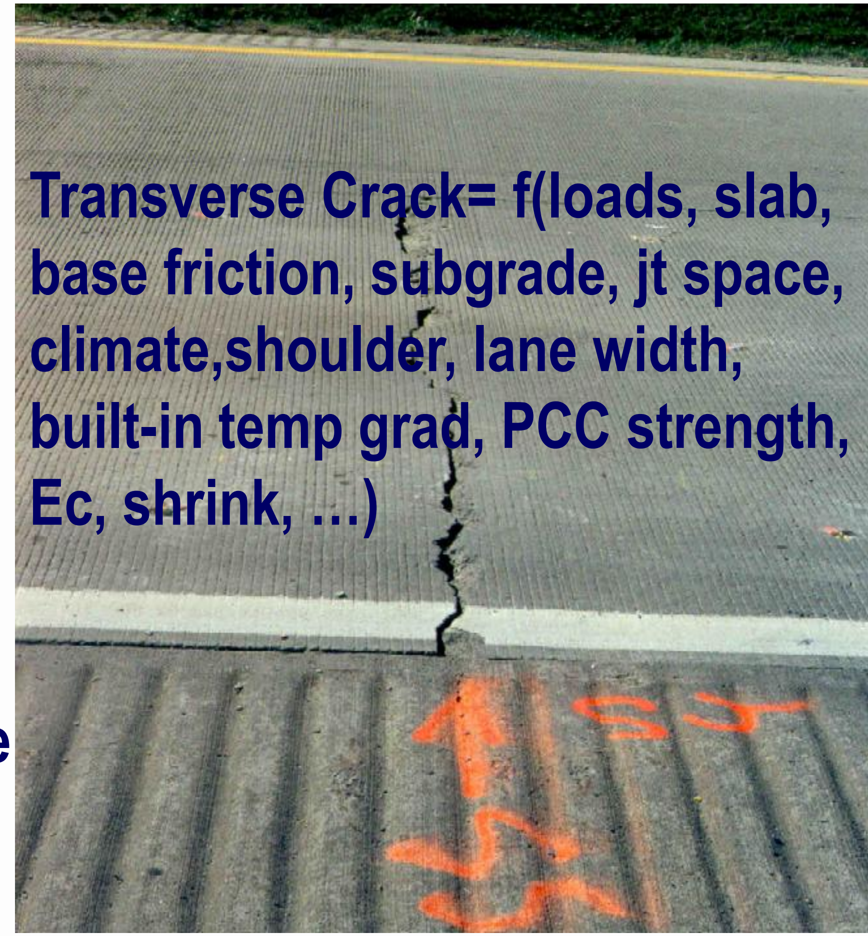
Design for Performance JPCP: Models



IRI= f(IRI$_i$, faulting, cracking, spalling, soil(P$_{-200}$), age, FI)



Joint Faulting= f(loads, dowels, slab, base, jt space, climate, shoulder, lane width, zero-stress temp, built-in gradient, …)

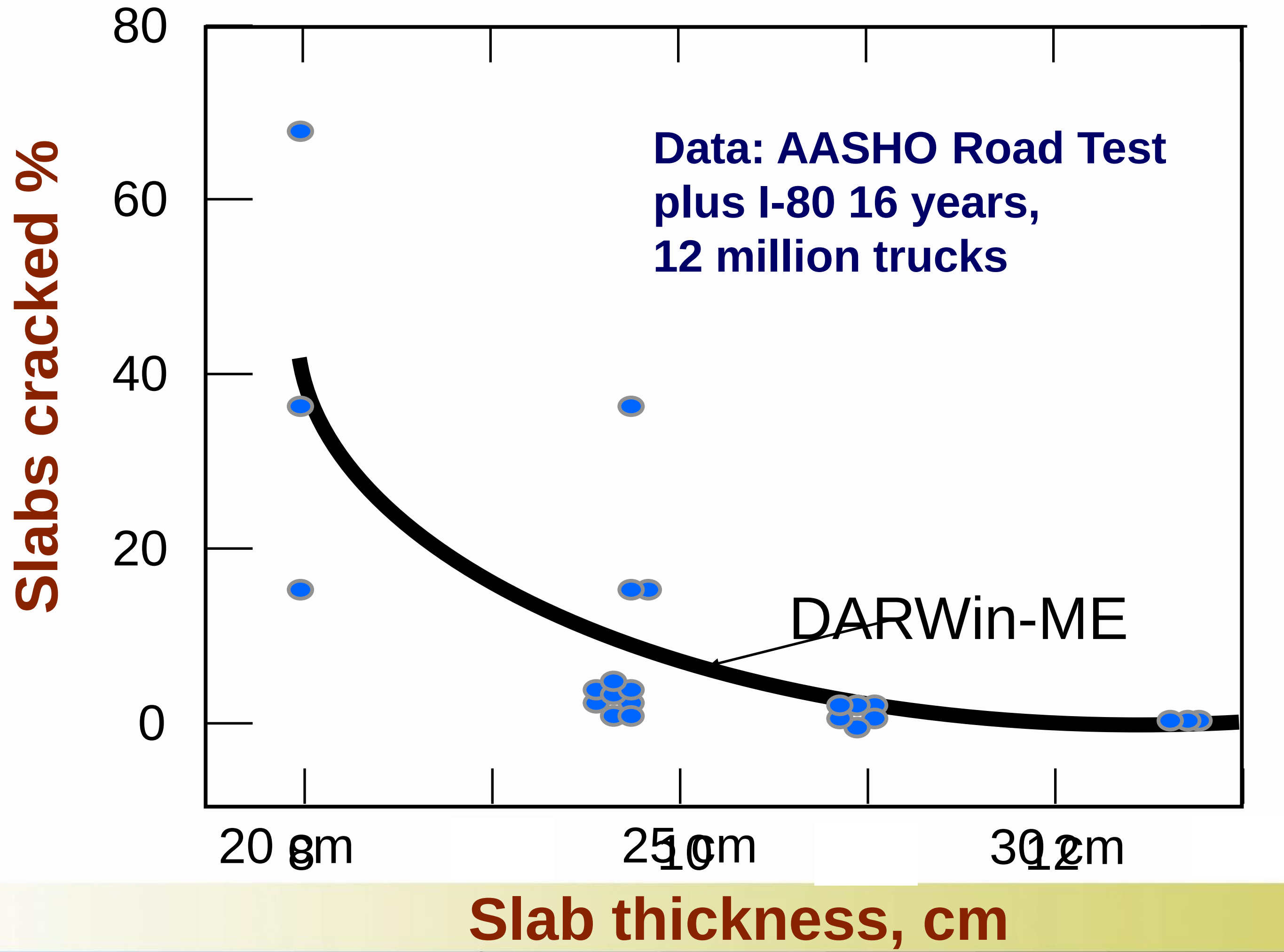


Transverse Crack= f(loads, slab, base friction, subgrade, jt space, climate,shoulder, lane width, built-in temp grad, PCC strength, Ec, shrink, …)

Slab Dimensions & Base Friction

- Slab thickness: 15 to >40-cm
- Slab width: conventional, widened
- Tied shoulders: load transfer
- Slab/Base friction: Full (typical)

Slab Thickness Vs. Cracking

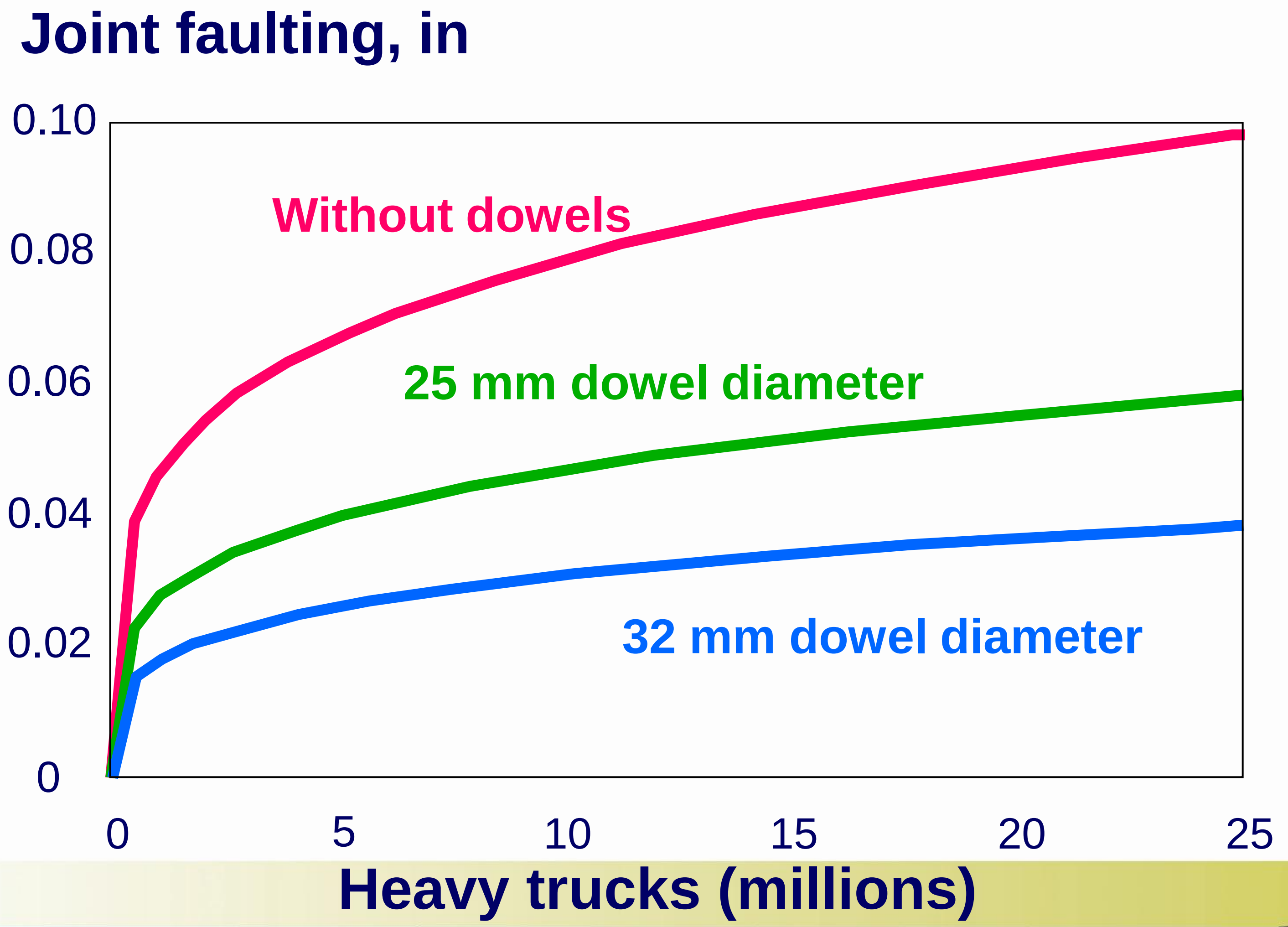


Impact of Slab Width/Edge Support

Transverse Joints

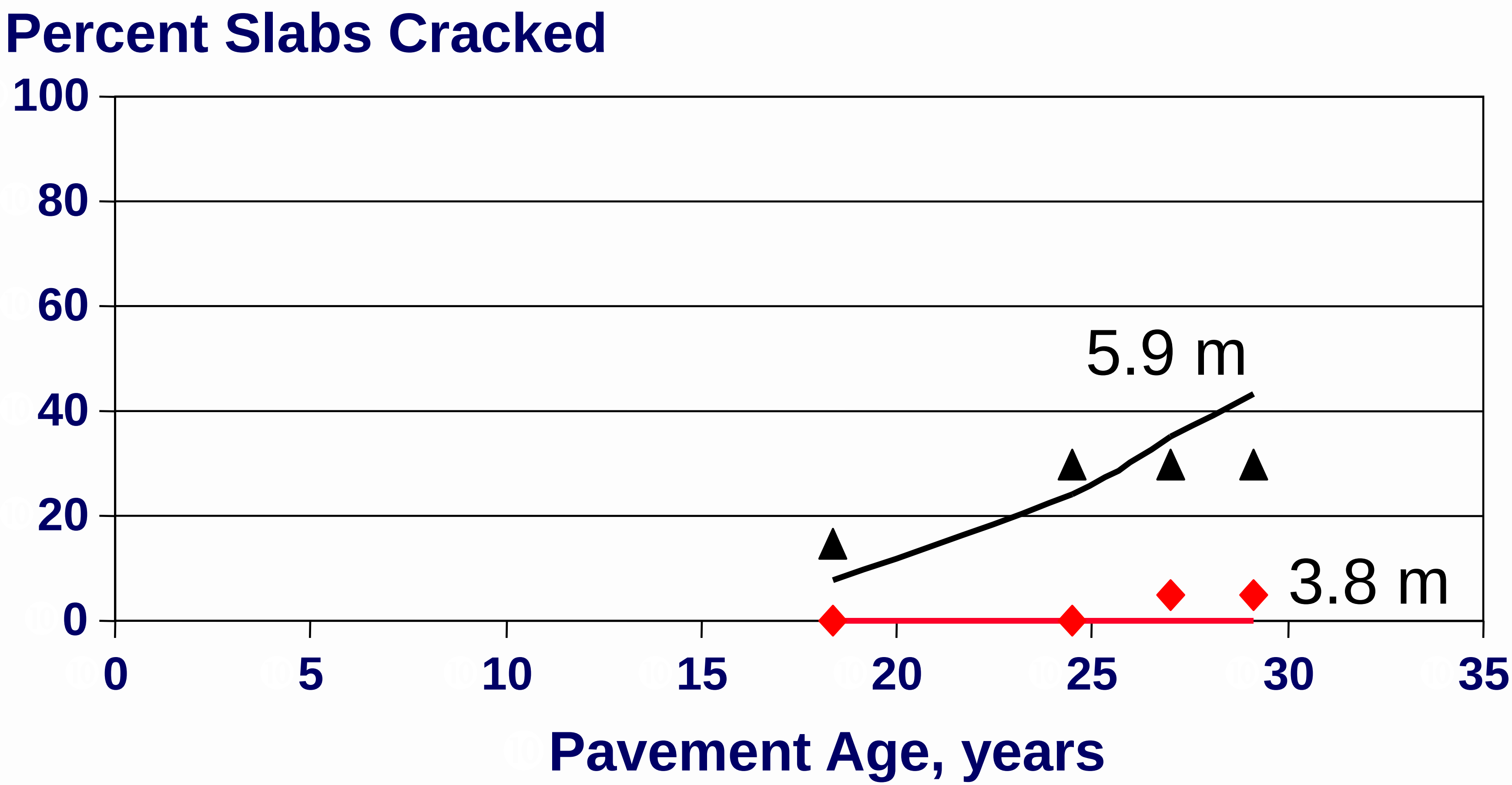
- Need for dowels.
- Benefit of larger dowels.
- Transverse joint spacing.

Need for Dowels & Diameter



MEPDG

Joint Spacing Effect: CA Project



Base & Subbase Materials, Thickness

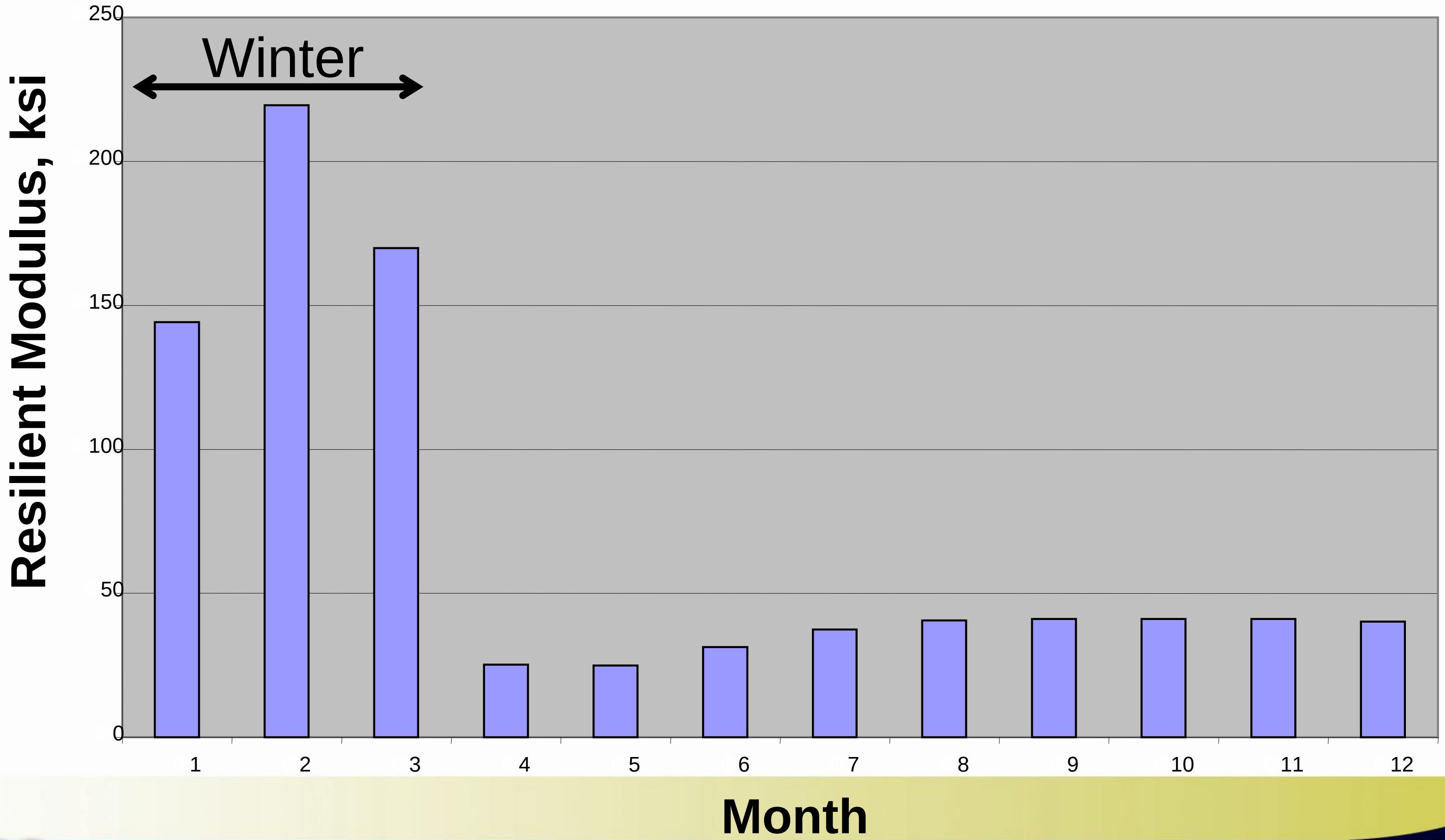
- Base types:
  - unbound aggregate,
  - asphalt,
  - cement/lean concrete.
- Base modulus, thickness, friction with slab.
- Subbase(s): unbound aggregate, lime treated soils, cement treated soils, etc.

Subgrade / Embankment / Bedrock

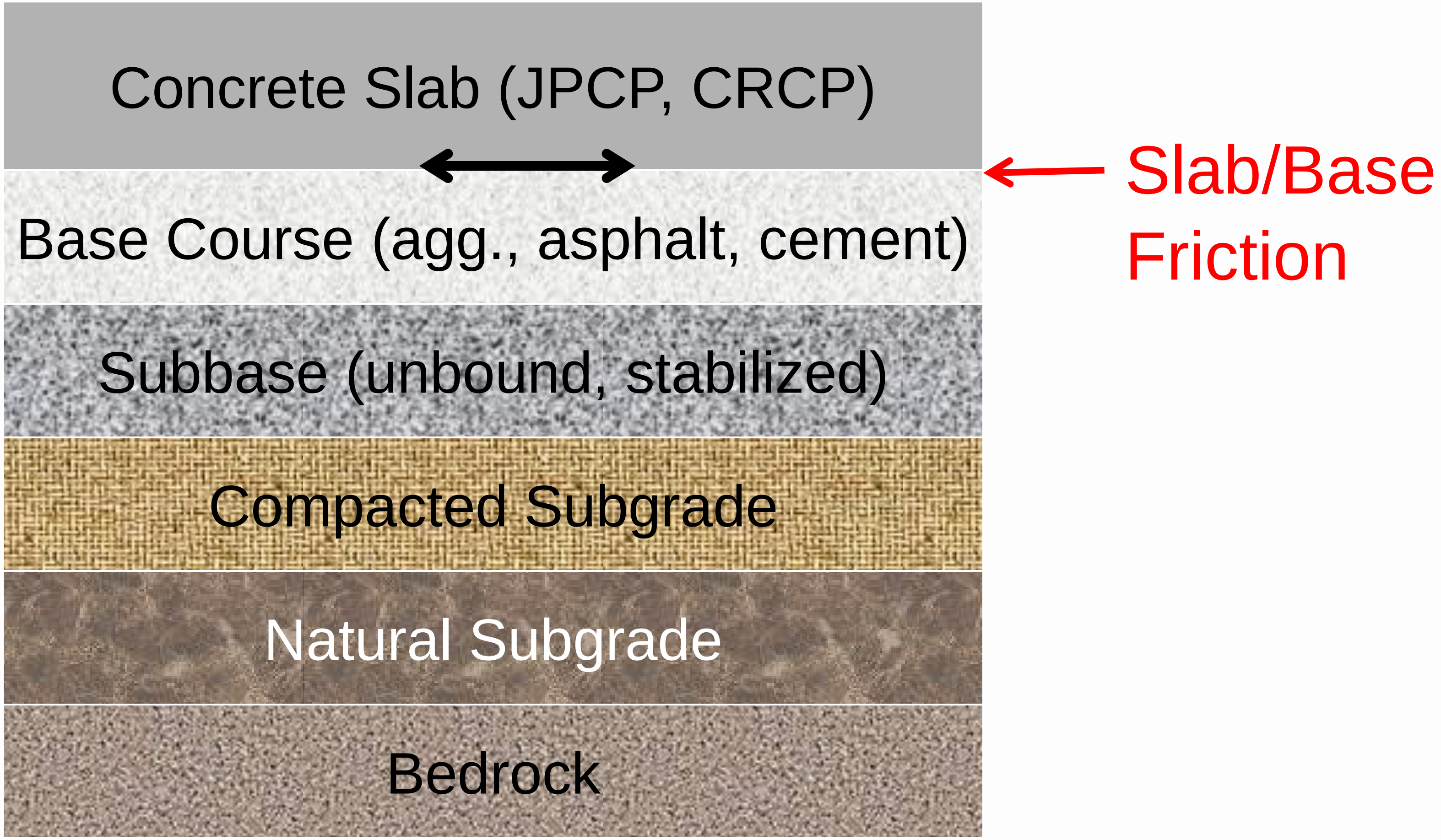
- **Soil types**: all AASHTO classes with defaults for gradation, PI, LL, resilient modulus.
- **Subgrade resilient modulus**: changes due to temperature & moisture over year.
- Lime and cement treated soils.
- Thick granular layers.
- Bedrock layer.

Temperature & Moisture Effects

Unbound Aggregate Base Mr Vs Month



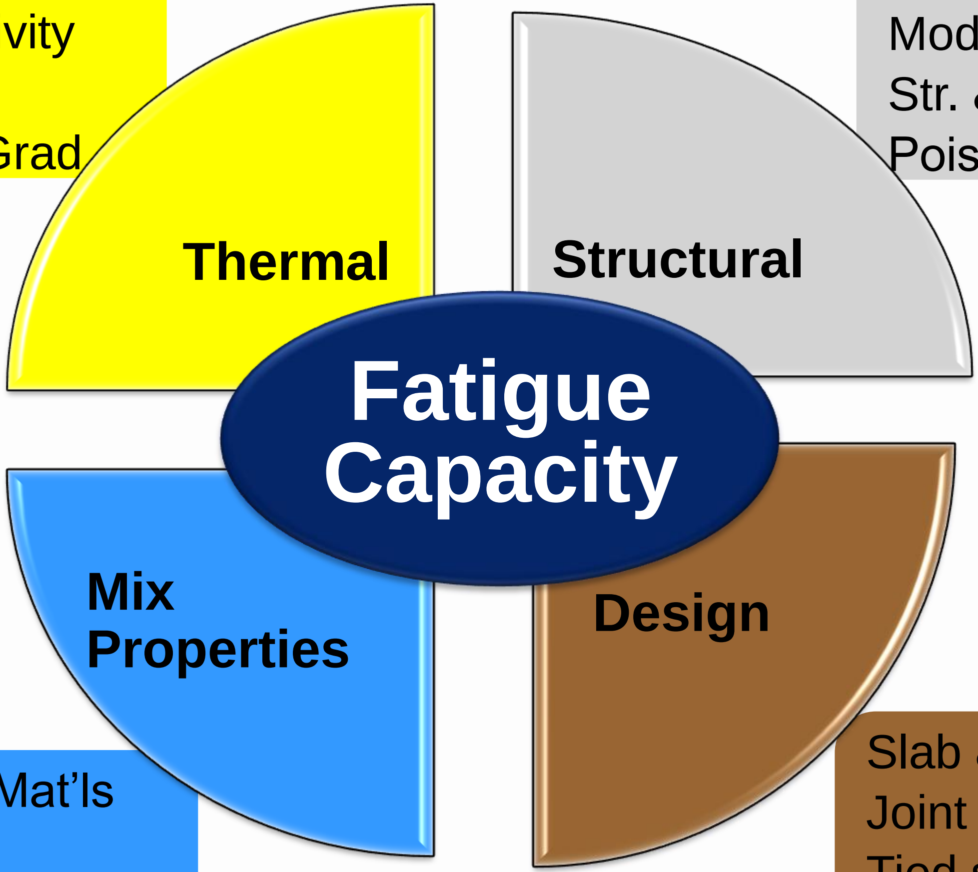
Concrete Slab/Base Contact Friction



Concrete Slab & Structure Inputs

Coef. Thermal Expan.
Thermal Conductivity
Specific Heat
Built-In Thermal Grad

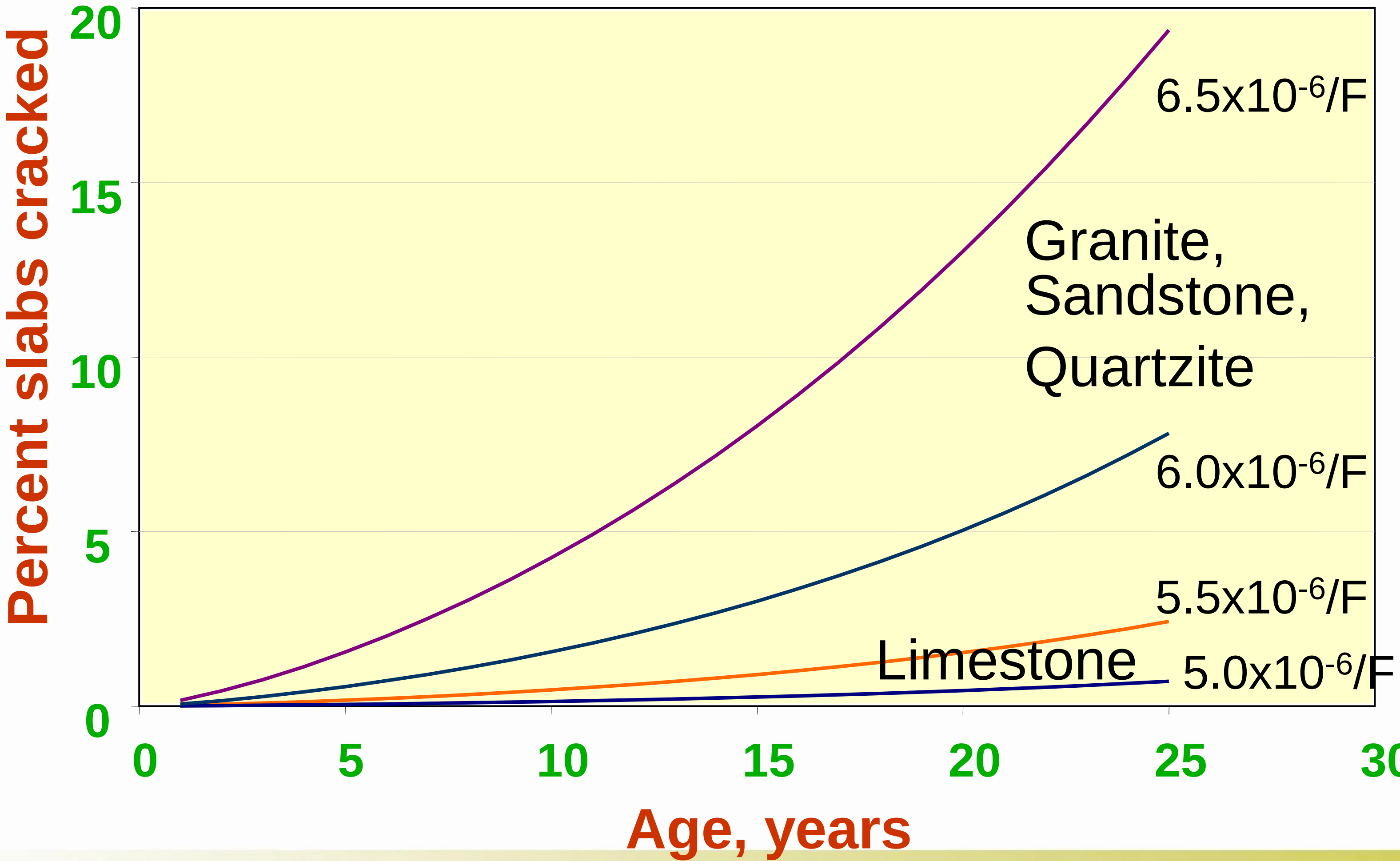
Flex & Comp Strength
Modulus Elasticity
Str. & Mod. gain w/time
Poisson’s Ratio



Cementitious Mat’ls
W/C
Shrinkage (drying)
Unit weight

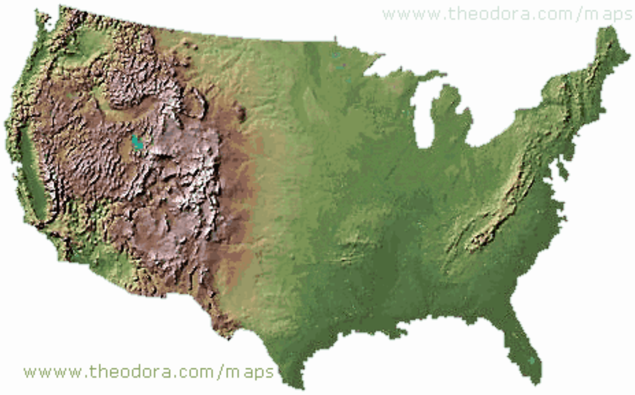
Slab & Base Thick
Joint spacing
Tied shoulder, widened
Friction slab/base

Concrete Coefficient of Thermal Expansion

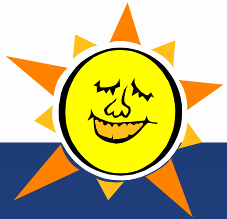


Climate (temperature, moisture, solar rad., humidity, wind)

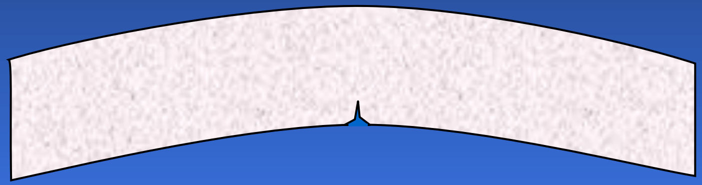
- Integrated Climatic Model (ICM)
  - User identifies local weather stations:
    - Hourly temperature, Precipitation
    - Cloud cover, Relative ambient humidity
    - Wind speed.
  - User inputs water table elevation.
  - ICM Computes temperatures in all pavement layers and subgrade.
  - ICM Computes moisture contents in unbound aggregates and soils.
  - ICM Computes frost line.



Climatic Factors Slab Curling/Warping

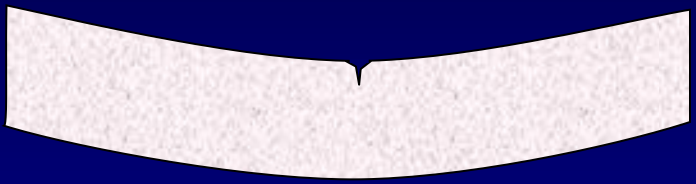


Positive temp. gradient



Bottom Up Cracking

Negative temp. gradient
& shrinkage of surface



Top Down Cracking

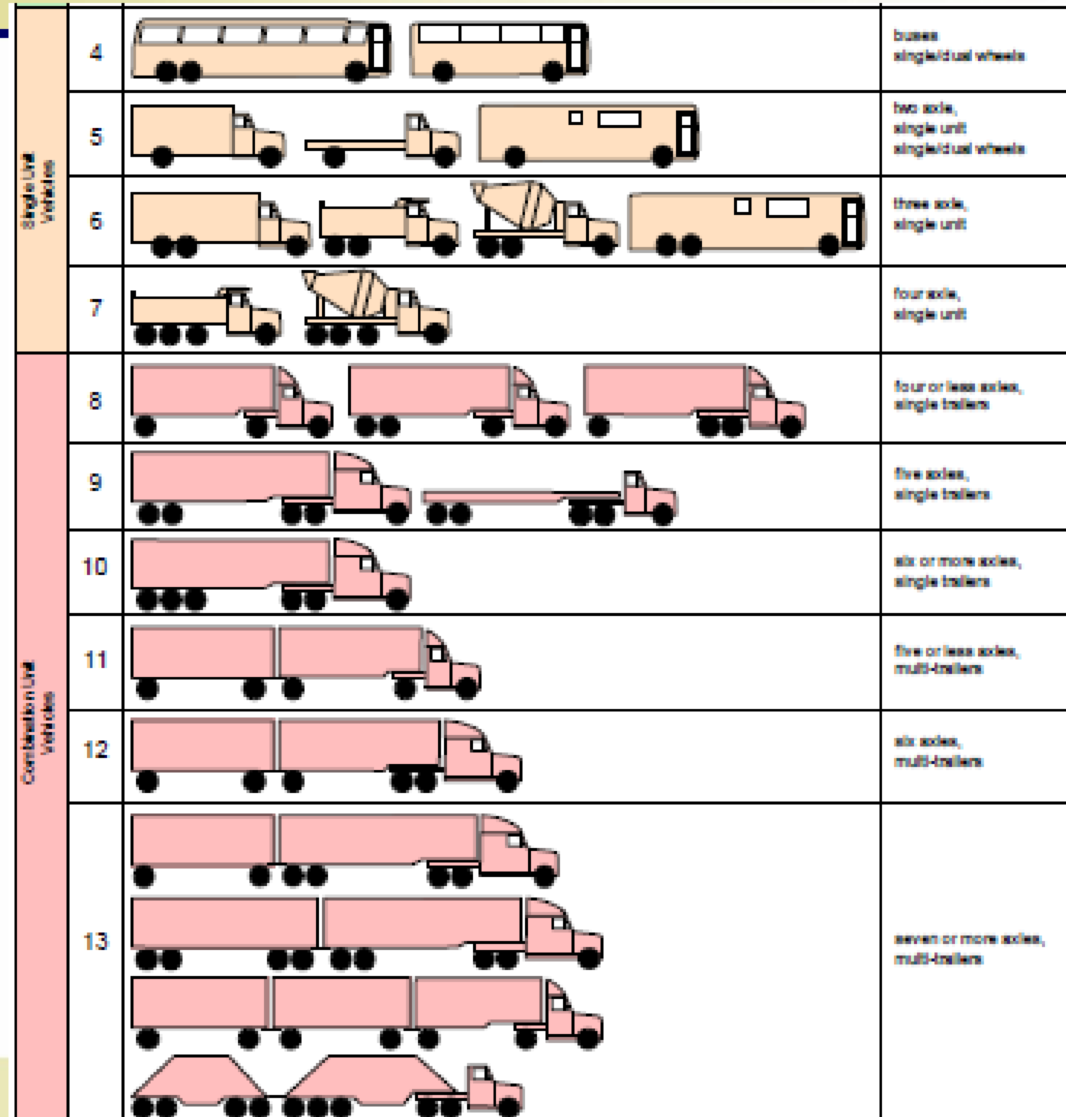
Slab Built-In temperature gradient during construction at time of set (solar radiation)

Traffic Loading

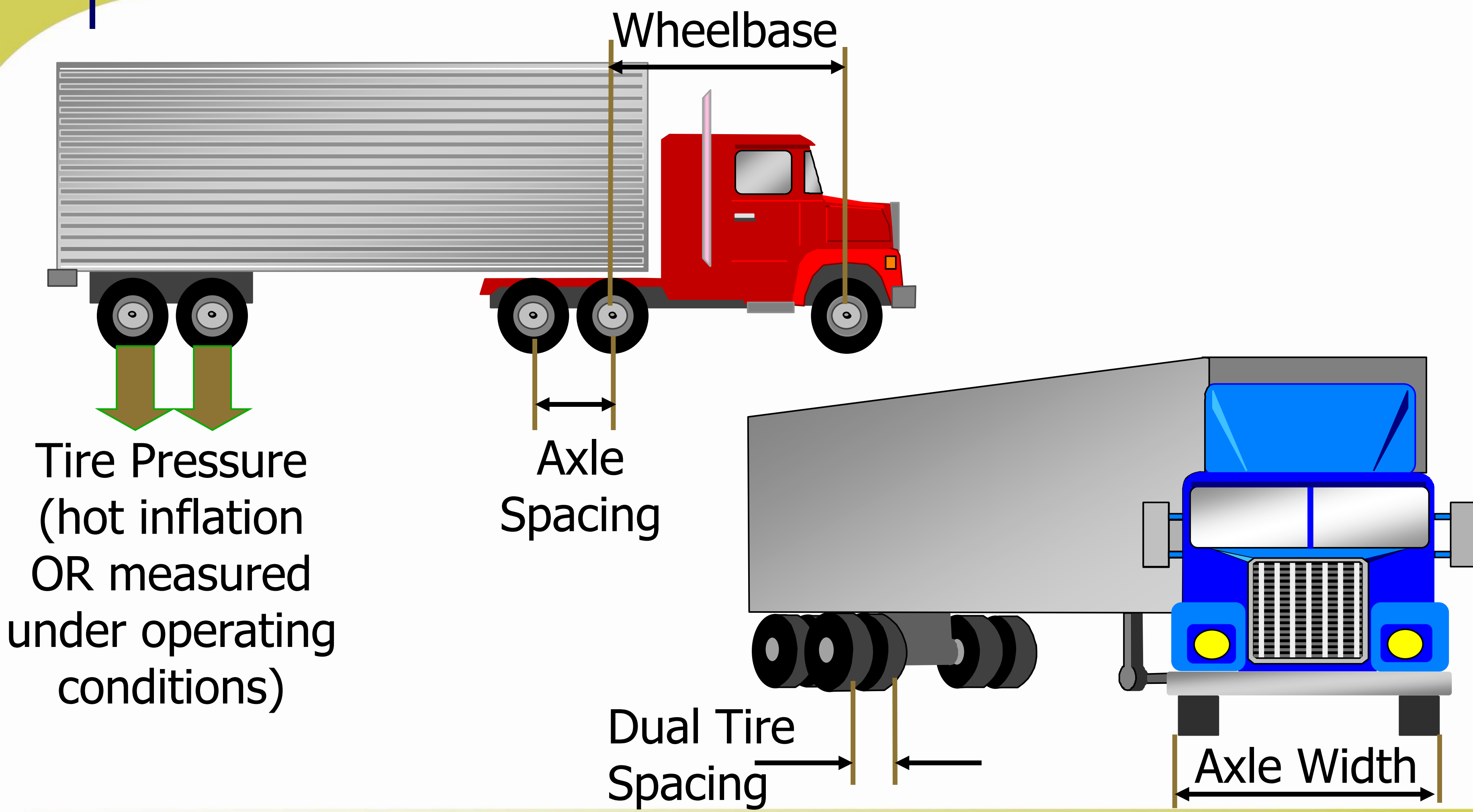
- Vehicle volume, growth & classification
- Single, tandem, tridem, quad axle load distributions
- Monthly vehicle distribution
- Hourly load distribution
- Lateral lane distribution
- Tire pressure
- Tractor wheelbase

Vehicle Class Distribution

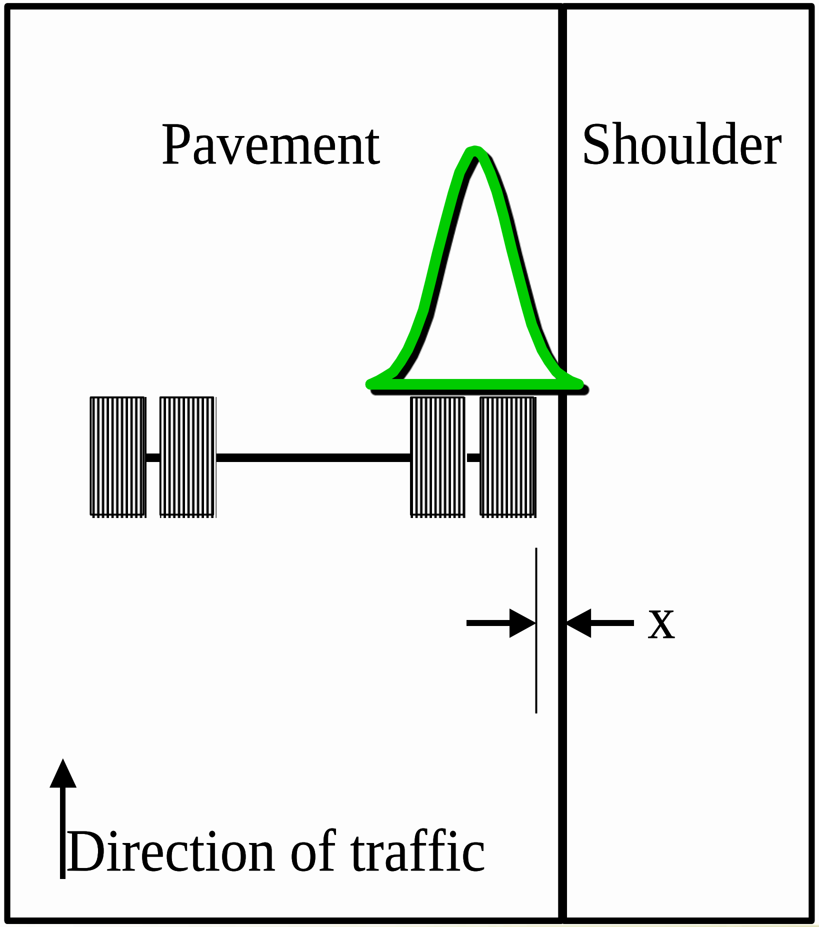
- Level 1 – Site-specific distribution
- Level 2 – Distribution for given highway class
- Level 3 – DARWin-ME Truck Traffic Class (TTC)



Axle Configuration Factors



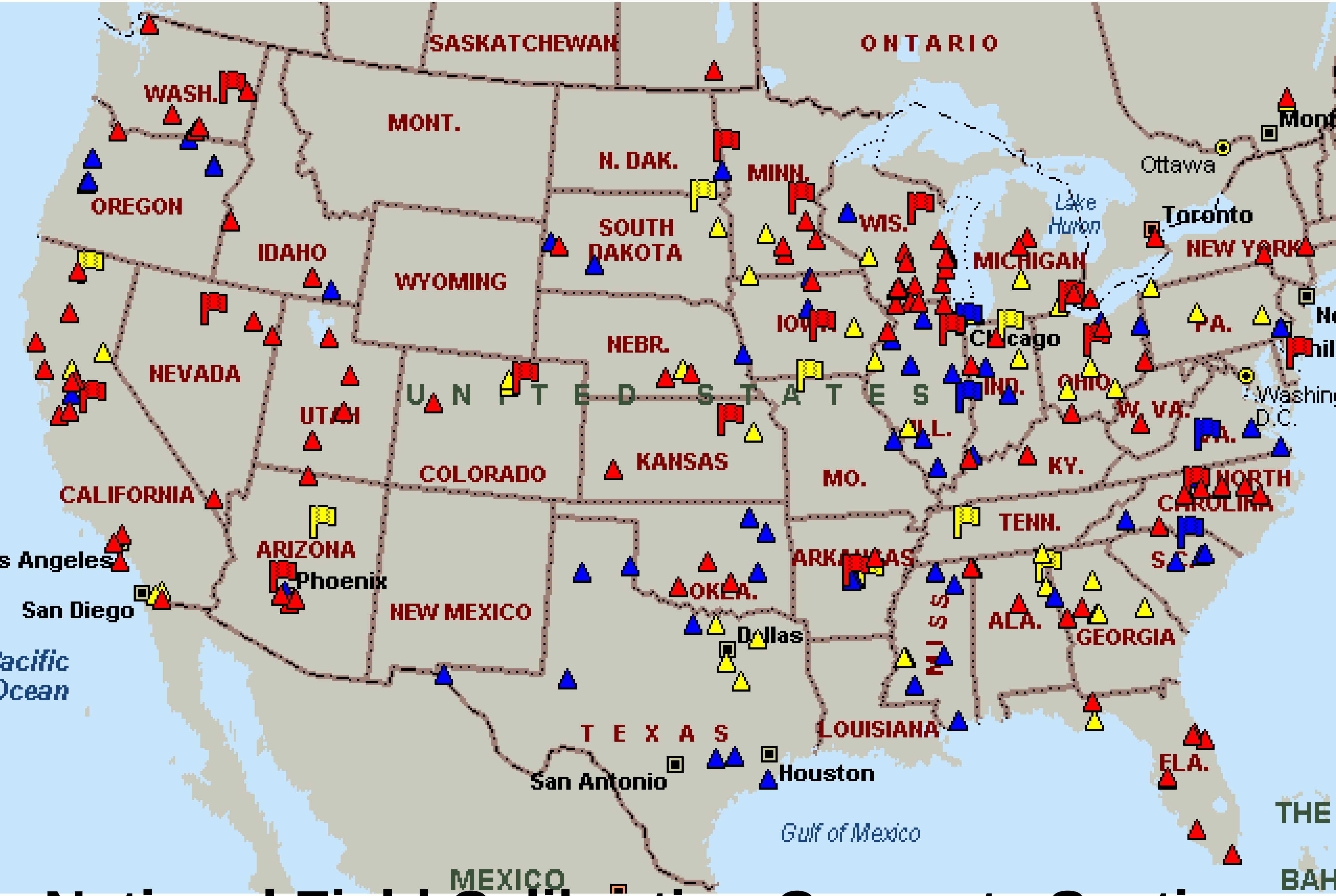
Traffic Wander



Typical Values
X (mean) = 45.7 cm
X (SD) = 25.4 cm

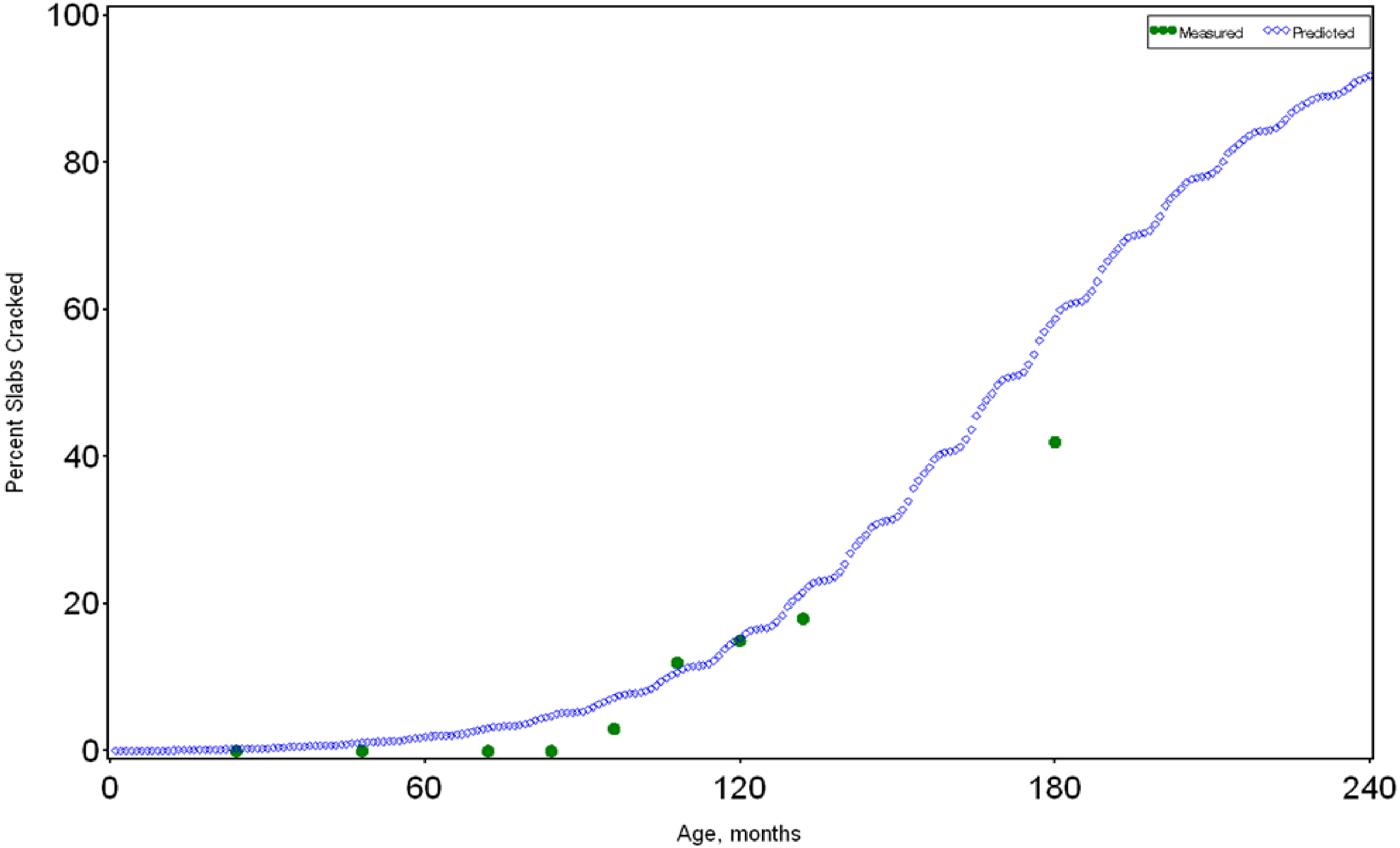
Design Reliability

- Design life: 1 to 100 years.
- Select design reliability: 50 to 99 percent
  - Transverse cracking
  - Joint faulting
  - Smoothness, IRI
- Standard error based on prediction error of distress & IRI from hundreds of field pavement sections.

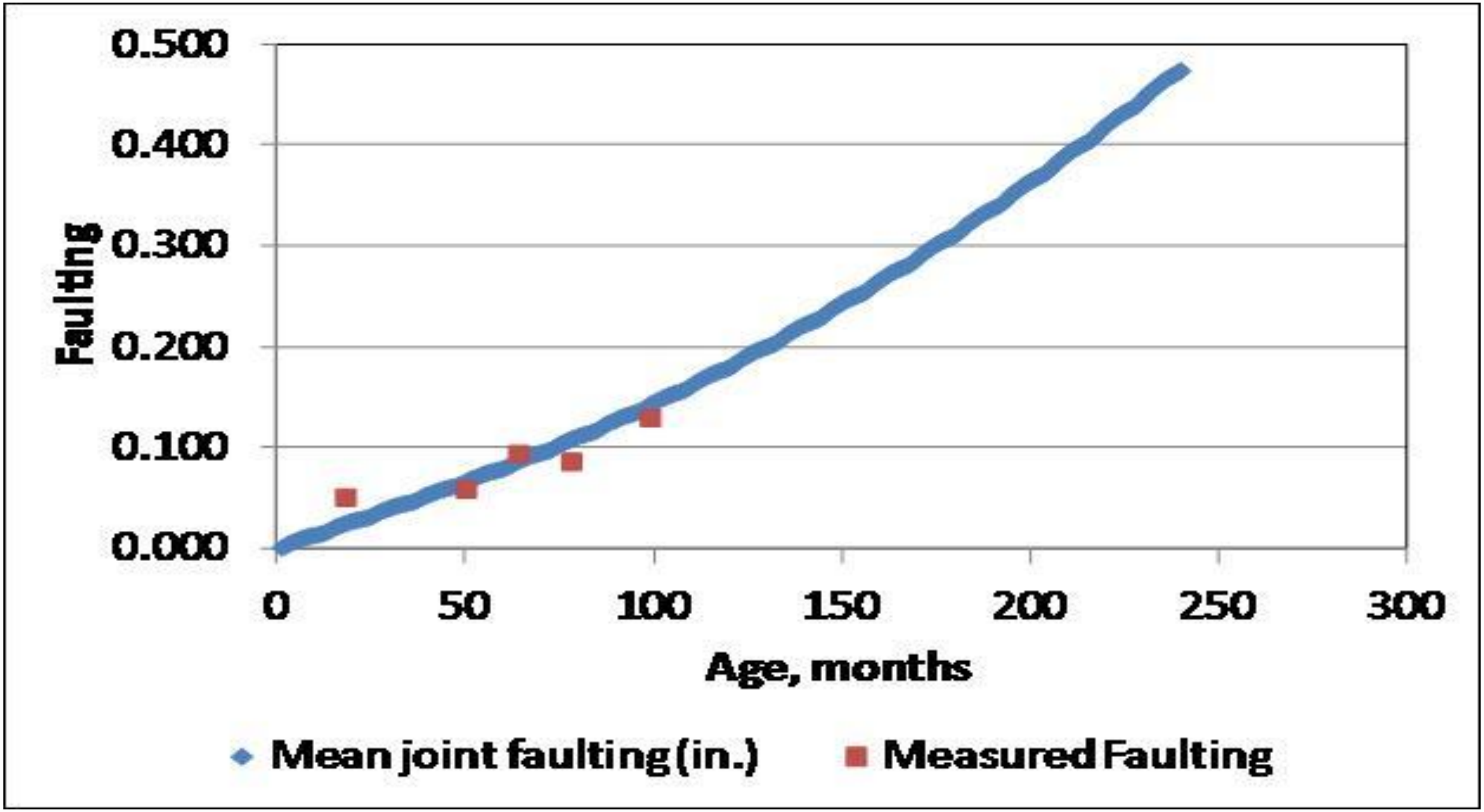


National Field Calibration Concrete Sections

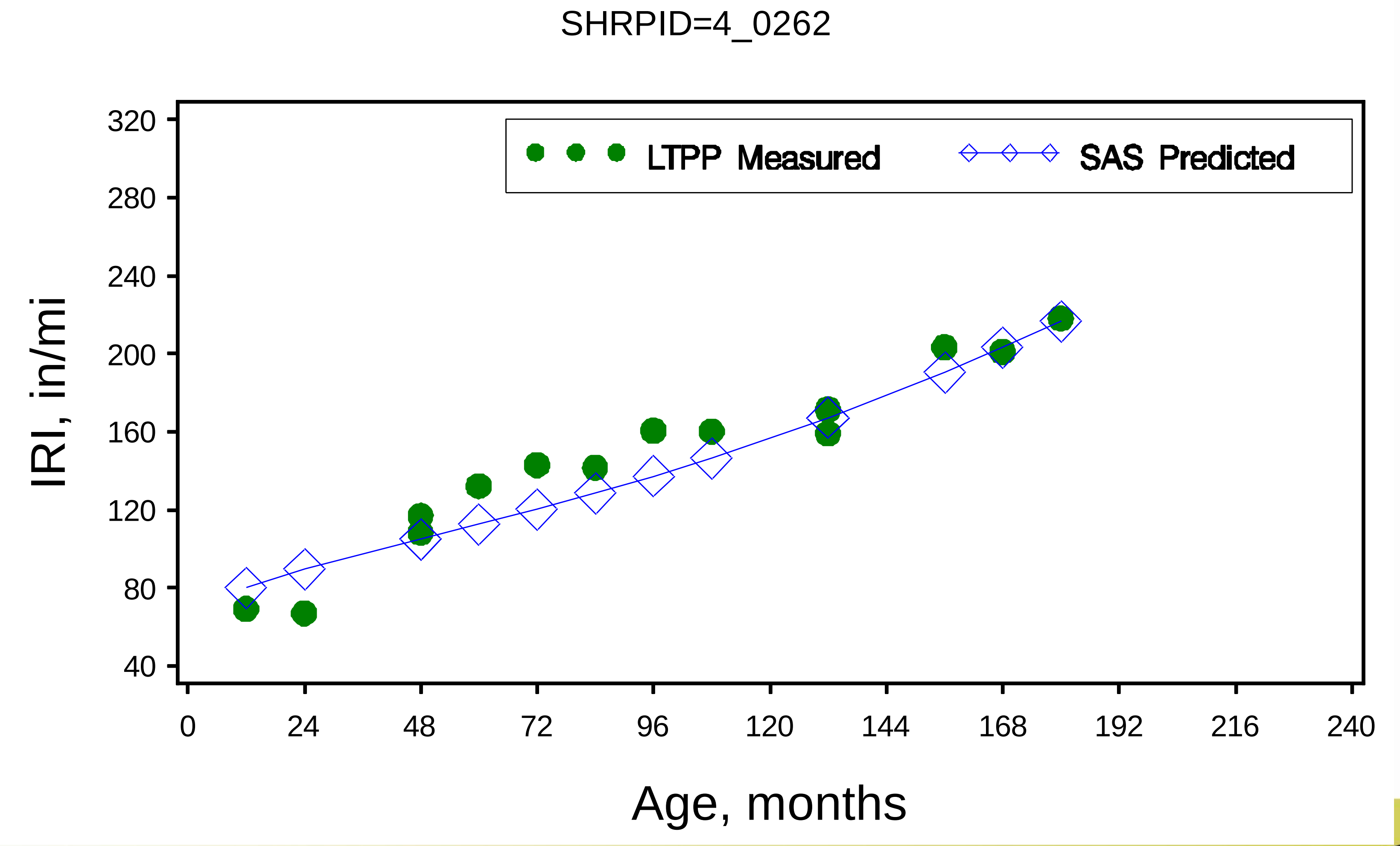
Example Prediction of Transverse Fatigue Cracking



Example Prediction Joint Faulting



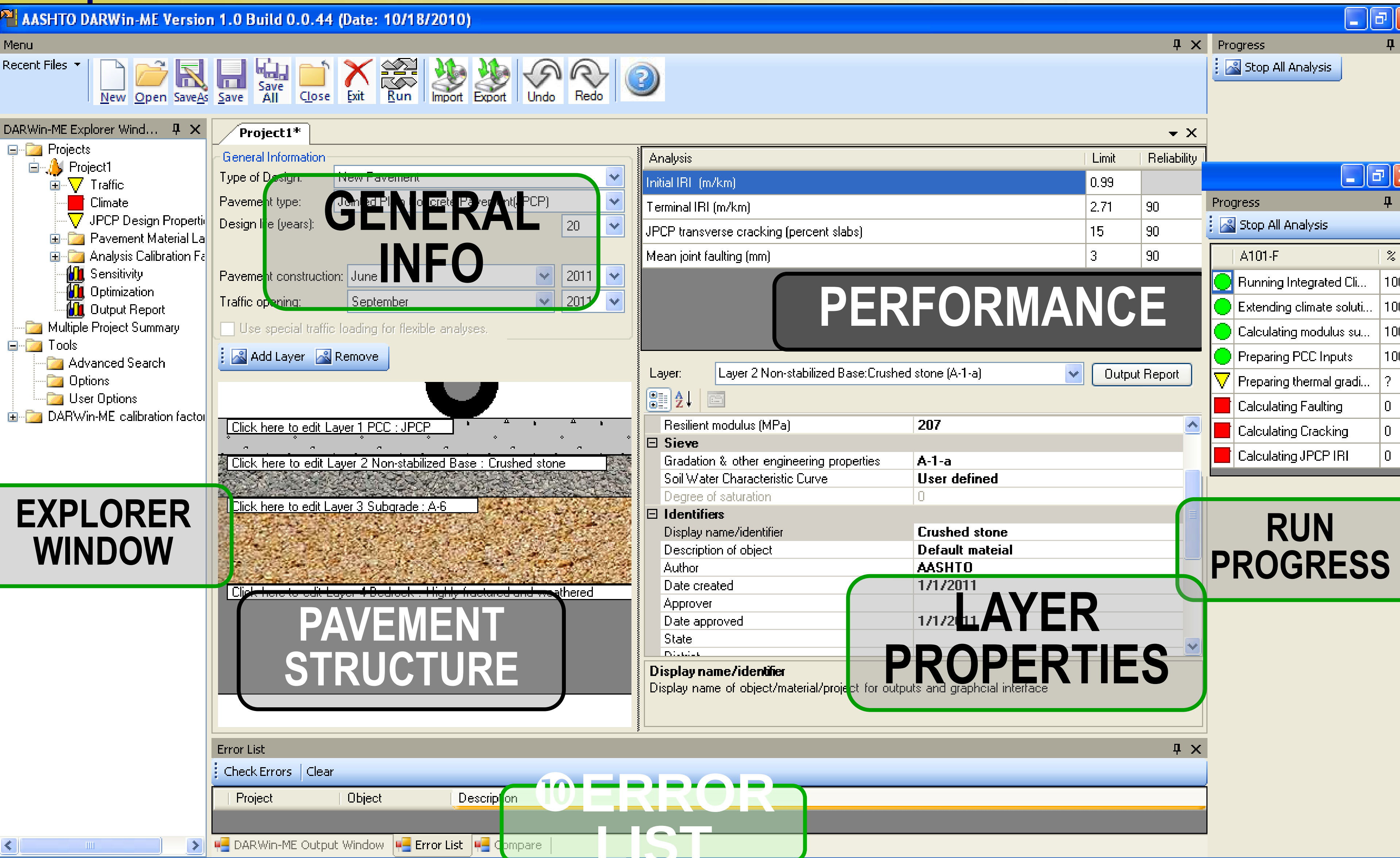
Example Prediction IRI



DARWin-ME

Software sold by AASHTO

www.aashto.org

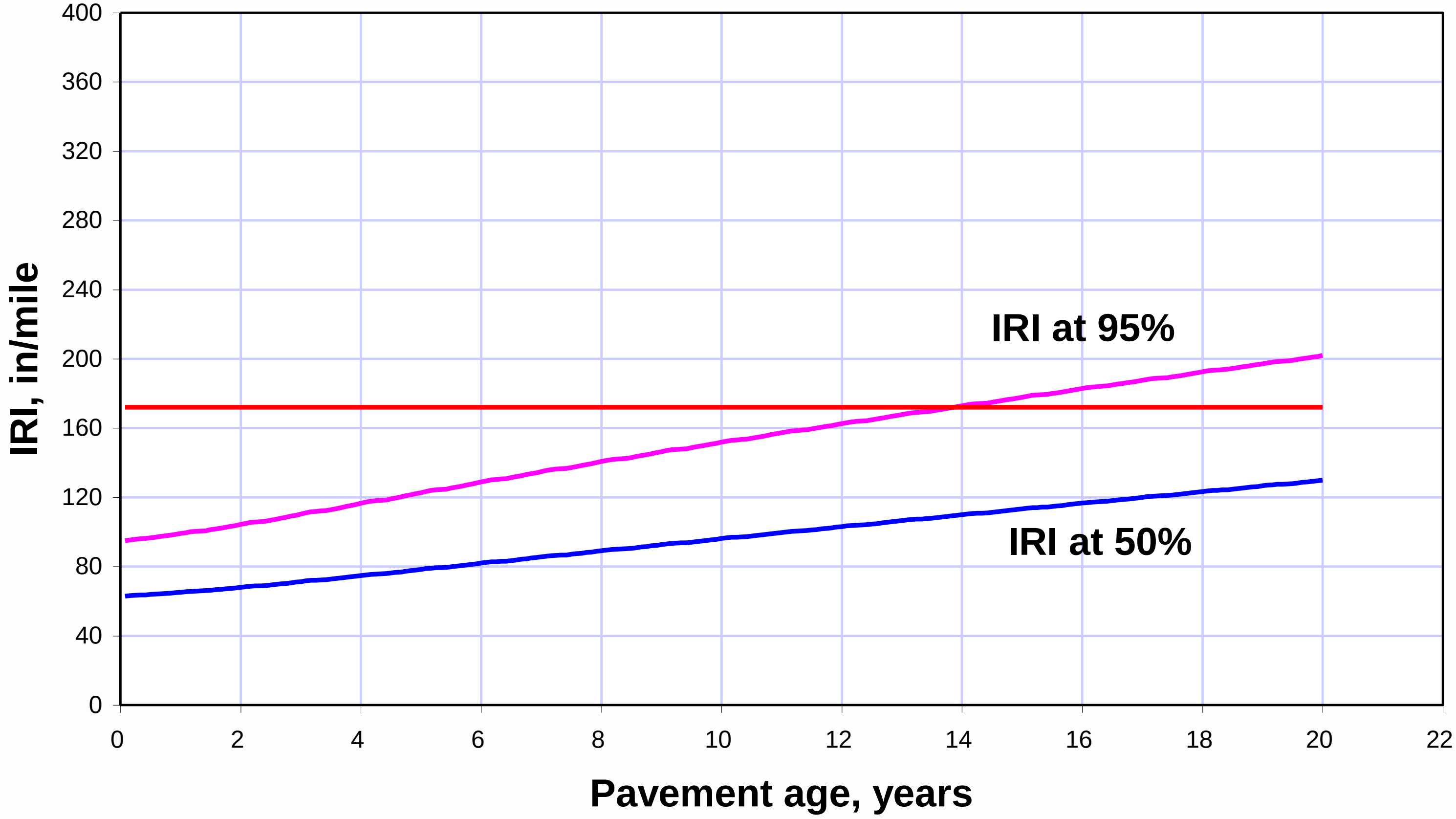

AASHTO DARWin-ME Version 1.0 Build 0.0.44 (Date: 10/18/2010)
GENERAL INFO
PERFORMANCE
EXPLORER WINDOW
PAVEMENT STRUCTURE
LAYER PROPERTIES
RUN PROGRESS
ERROR LIST
Analysis
Limit
Reliability
Initial IRI (m/km)
0.99
Terminal IRI (m/km)
2.71
90
JPCP transverse cracking (percent slabs)
15
90
Mean joint faulting (mm)
3
90
Click here to edit Layer 1 PCC : JPCP
Click here to edit Layer 2 Non-stabilized Base : Crushed stone
Click here to edit Layer 3 Subgrade : A-6
Running Integrated Cli...
Extending climate soluti...
Calculating modulus su...
Preparing PCC Inputs
Preparing thermal gradi...
Calculating Faulting
Calculating Cracking
Calculating JPCP IRI

MEPDG

DARWin-ME Pavement Design Process

1. Trial design selection
2. Estimate inputs
3. Run software
4. Review computed outputs
5. Compare distresses & IRI with criteria
6. Design Reliability met?
7. Modify trial design as needed

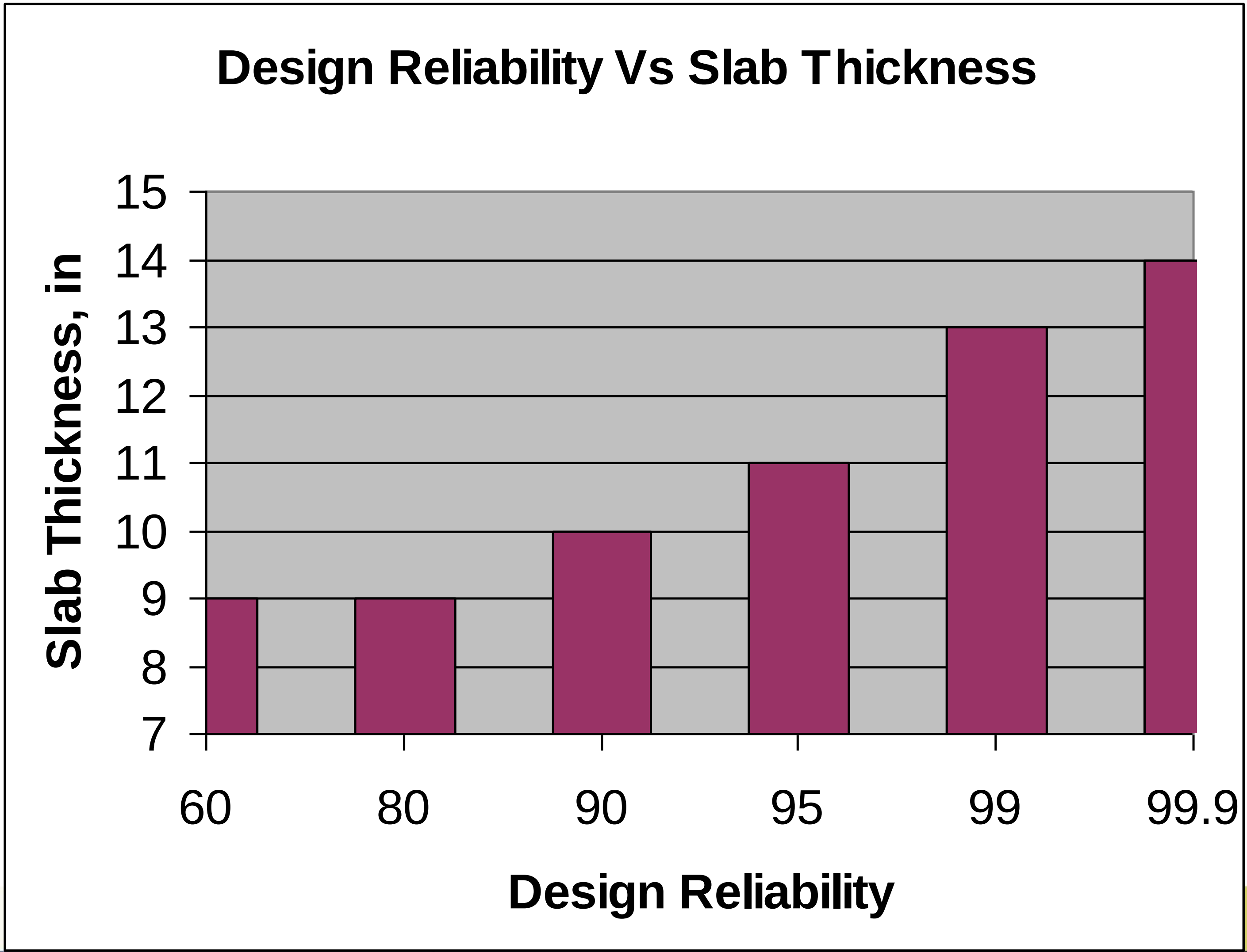
Compare output distress & IRI



Does design meet performance criteria?

Performance Criteria	Distress Target	Reliability Target	Distress Predicted	Reliability Predicted	Acceptable
Terminal IRI (in/mi)	172	95	130	83.15	Fail
Transverse Cracking (% slabs cracked)	15	95	1.6	99.98	Pass
Mean Joint Faulting (in)	0.15	95	0.089	93.13	Fail

Reliability Level Impact for JPCP Project



Recommended Design Reliability Criteria: Arizona

Performance Criteria	Divided Highways, Freeways, Interstates	Non Divided, Non Interstate, 10,000+ ADT	2001 – 10,000 ADT	501-2,000 ADT	< 500 ADT
Design Reliability	97%	95%	90%	80	75

Modify Trial Design as Needed

- Here is where experience and knowledge of fundamental concepts of pavement behavior and performance counts!
- Examples:
  - Too high joint faulting? Increase dowel diameter
  - Too high cracking? Increase thickness, shorter joint spacing, add tied PCC shoulders, treated base
  - Too high IRI? Reduce distress, specify smoother construction

DARWin-ME Analysis Capabilities

- New Design: several alternatives
- Rehabilitation Design: several alternatives
- “What if” questions
- Evaluation: forensic analysis
- Construction deficiencies: impacts on life, $
- Truck size and weight: cost allocation
- Acceptance quality characteristics: impact on performance, $

Key Benefits of DARWin-ME Design

- Allows design for **longer life pavements** (checks for early distress)
- Allows designer to **quantify costs & benefits**
- Allows designer to **optimize the design** (biggest bang for $)

Directly considers Performance