

# **TxME for Flexible Pavement Design**



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# Presentation Outline



- Introduction
- TxME for New Pavement Design Check
- TxME for Asphalt Overlay Design Check
- TxME Application: Case Studies
- Summary

# What is Mechanistic Empirical (ME) Pavement Design



- Mechanistic
  - ▣ Computes Stresses and Strains with pavement structure for each design load
  - ▣ Changes materials properties for each month of year
- Models
  - ▣ Uses models to predict rutting and cracking damage in all pavement layers
- Empirical
  - ▣ Compares model predictions to measured field performance
  - ▣ Introduces calibration factors to ensure predictions are reasonable

# Introduction: Flexible Pavement Design

## New Construction and *Asphalt Overlay*

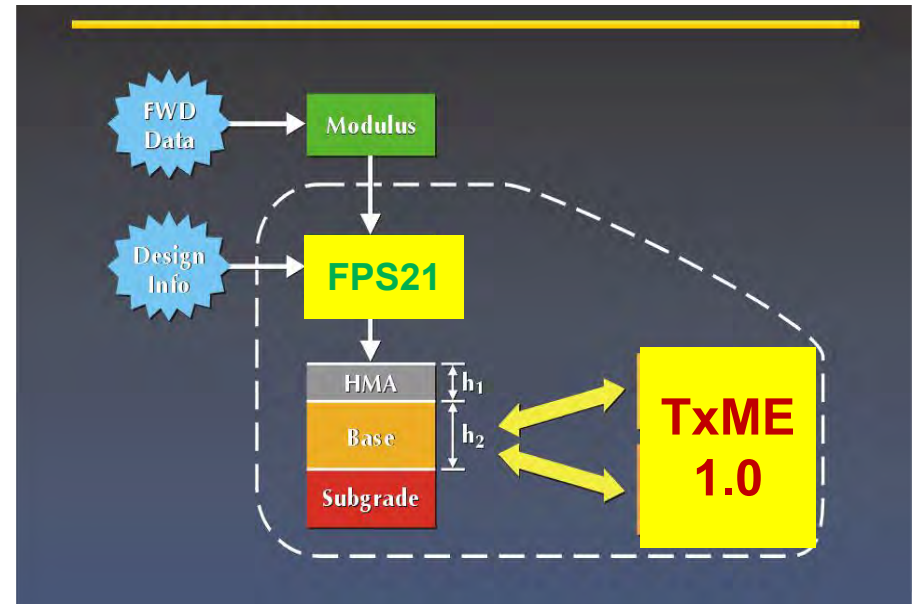
- New Construction
  - ▣ Surface treatment
  - ▣ Conventional AC
  - ▣ Perpetual pavement
  
- Asphalt Overlays for Cracked pavements
  - ▣ Existing cracks before overlay



# Texas Pavement Design and ME Check Concept

- Pavement design: FPS21
  - ▣ Pavement structure alternatives
  
- M-E check for overlay and new pavements
  - Mix type (Binder,....)
  - Traffic
  - Climate
  - ...

## Future TxDOT's Flexible Pavement Design System



# Texas Pavement Design and ME Check Concept

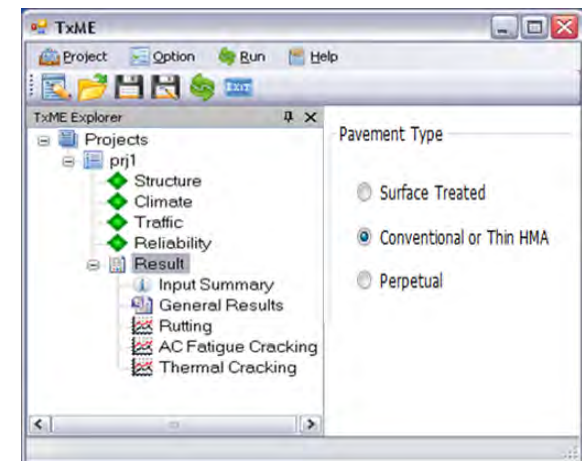
## □ FPS21 Design options

Best Design No.	Design: 1	Design: 2	Design: 3	Design: 4
Material Arrangement	ABC	ABC	ABC	ABC
Total Cost	23.21	23.29	24.89	24.97
No. of Layers	3	3	3	3
Layer Depths (inches)	2.0 5.5 6.0	2.0 7.0 6.0	2.0 5.0 9.5	2.0 6.5 9.5
No. of Perf. Periods	2	1	2	1
Perf. Time (years)	10.20	16	10.19	15
Overlay Policy (inches)	2.0		2.0	



## □ TxME: Mechanistic Check

- **Specific** layer material properties
- **Specific** climatic conditions
- **Specific** traffic (load spectrum)
- **Specific** variability: Inputs



# New Asphalt Pavement Design

- New Construction
  - ▣ Surface treatment
  - ▣ Conventional AC
  - ▣ Perpetual pavement



# TxME for New Pavements: Overview

The screenshot displays the TxME software interface with several key components:

- Project Explorer:** A tree view on the left showing the project structure: Project1 > Structure > Climate > Traffic > Reliability.
- Project1:Structure\* Tab:** Contains the 'Pavement Type' section with radio buttons for 'Surface Treated', 'Conventional or Thin HMA', and 'Perpetual'. It also includes 'Design/Analysis Life (years): 20' and 'Project Location' dropdowns for 'District: 01 Paris' and 'County: 60 DELTA'.
- Material Selection Panels:** Three panels on the right allow for selecting 'AC Layer Material', 'Base Material', and 'Subbase Layer Material' from various material options.
- Pavement Structure View:** A central view showing a cross-section of the pavement layers: 'Type D, PG 64-22' (top), 'Subbase', and 'Subgrade'. A tooltip indicates: 'To remove this layer, click the mouse right button and select the popup menu. To insert a new layer above, drag one material icon and drop on this layer.'
- Material Property Table:** A detailed table for 'Layer 1, Type D, PG 64-22' showing the following properties:

Layer Information	
Layer Number	1
Layer Thickness (inches)	4
Material Information	
Binder Type	PG 64-22
Gradation	Type D
RAS %	0
Material Properties	
Dynamic Modulus	Level 2 input : default value
Fracture Property	@77 F: A=4.2081E-06, n=3.9531
Rutting Property	@104 F: alpha=0.7465, mu=0.8102
Poisson Ratio	0.35
Thermal Coefficient of Expansion (1e-6 in/in/F)	13.5



# TxME for New Pavements:

## Specific material properties

Layer Information		
Layer Number	1	
Layer Thickness (inches)	4	
Material Information		
Binder Type	PG 64-22	PG 64-22
Gradation	Type D	PG 76-22
RAP %	0	PG 70-22
RAS %	0	PG 70-28
	Type A	PG 64-22
	Type B	PG 64-28
	Type C	PG 64-22
	Type D	PG 64-28
Material Properties		
Dynamic Modulus	Level 2 input : default value	
Fracture Property	@77 F: A=4.2081E-06, n=3.9531	
Rutting Property	@104 F: alpha=0.7465, mu=0.8102	
Poisson Ratio	0.35	
Thermal Coefficient of Expansion (1e-6 in/in/F):	13.5	

# TxME for New Pavements:

## Specific climatic condition

Climatic data for a specific weather station       Interpolate climatic data for a given location

Seasonal

Select Weather Station

- ABILENE, TX
- ALICE, TX
- AMARILLO, TX
- ANGLETON/LAKE JACKSON, TX
- ARLINGTON, TX
- AUSTIN/BERGSTROM, TX
- AUSTIN/CITY, TX
- BEAUMONT/PORT ARTHUR, TX
- BORGER, TX
- BROWNSVILLE, TX
- BURNET, TX
- CHILDRESS, TX
- COLLEGE STATION, TX
- CONROE, TX
- CORSICANA, TX
- CORPUS CHRISTI, TX

Station Location:  
MUNICIPAL AIRPORT

Available Data Months: 116

32.25 Latitude (degrees.minutes)  
-99.41 Longitude (degrees.minutes)  
1789 Elevation (ft)

Depth Of Water Table (ft)  
Annual Average 10

- #1 0.0 miles, ABILENE, TX, MUNICIPAL AIRPORT, Lat. 32.25, Lon. -99.41, Ele. 1789, Months. 116
- #2 87.3 miles, SAN ANGELO, TX, MATHIS FIELD, Lat. 31.21, Lon. -100.29, Ele. 1891, Months. 116
- #3 97.4 miles, MINERAL WELLS, TX, MINERAL WELLS AIRPORT, Lat. 32.47, Lon. -98.04, Ele. 933, Months. 63
- #4 128.5 miles, WICHITA FALLS, TX, SHEPPARD AIR FORCE BASE, Lat. 33.59, Lon. -98.29, Ele. 1010, Months. 116
- #5 131.3 miles, JUNCTION, TX, KIMBLE COUNTY AIRPORT, Lat. 30.31, Lon. -99.46, Ele. 1704, Months. 106
- #6 137.6 miles, FORT WORTH, TX, MEACHAM INTL AIRPORT, Lat. 32.49, Lon. -97.22, Ele. 702, Months. 103

Temperature (deg F)	Wind Speed (mph)	Sunshine (%)	Precipitation (in.)	Humidity (%)
78.1	7.0	100.0	0.0	56.0
78.1	7.0	100.0	0.0	56.0
75.9	8.0	100.0	0.0	60.0
75.0	7.0	100.0	0.0	62.0
75.9	8.0	100.0	0.0	60.0
77.0	7.0	100.0	0.0	56.0
78.1	6.0	100.0	0.0	58.0
82.0	9.0	100.0	0.0	53.0
84.9	9.0	100.0	0.0	51.0
89.1	6.0	100.0	0.0	47.0
91.0	3.0	100.0	0.0	42.0
91.9	3.0	75.0	0.0	40.0
93.9	3.0	100.0	0.0	36.0
95.0	6.0	100.0	0.0	36.0
93.9	0.0	100.0	0.0	35.0
93.9	3.0	50.0	0.0	33.0
95.0	10.0	50.0	0.0	32.0
95.0	7.0	50.0	0.0	34.0
93.0	9.0	50.0	0.0	34.0
89.1	6.0	75.0	0.0	39.0
84.9	7.0	100.0	0.0	48.0
82.9	7.0	100.0	0.0	51.0

# TxME for New Pavements:

## Specific traffic (load spectrum)



Traffic Input

Level 2: ESALs
  Level 1: Load Spectra

Level 1: Load Spectra

General Traffic Information

Traffic Two-way AADTT: 500

Number of Lanes in Design Direction: 2

Percent of Trucks in Design Lane (%): 95.0

Operation Speed (mph): 60

Axle Configuration

Axle Tire

Single Tire Pressure (psi): 100

Dual Tire Pressure (psi): 100

Dual Tire Spacing (in): 12

Axle spacing

Tandem Axle (in): 51.6

Tridem Axle (in): 49.2

Quad Axle (in): 49.2

Vehicle Class Distribution and Growth

Vehicle Class	Pictorial View	Distribution (%)	Growth Rate (%)	Growth Function
Class 4		1.8	4	Compound
Class 5		24.6	4	Compound
Class 6		7.6	4	Compound
Class 7		0.5	4	Compound
Class 8		0.5	4	Compound
Class 9		31.3	4	Compound
Class 10		9.8	4	Compound
Class 11		0.8	4	Compound
Class 12		3.3	4	Compound
Class 13		15.3	4	Compound
Sum of Distribution (%):		100.0		

Axles Per Truck

Vehicle Class	Steering Axle	Other Single Axle	Tandem Axles	Tridem Axles	Quad Axles
Class 4	0	1.62	0.39	0	0
Class 5	0	2	0	0	0
Class 6	0	1.02	0.99	0	0
Class 7	0	1	0.26	0.83	0
Class 8	0	2.38	0.67	0	0
Class 9	0	1	1	1	0
Class 10	0	1.19	1.09	0.89	0
Class 11	0	4.29	0.26	0.06	0
Class 12	0	3.52	1.14	0.06	0
Class 13	0	2.15	2.13	0.35	0

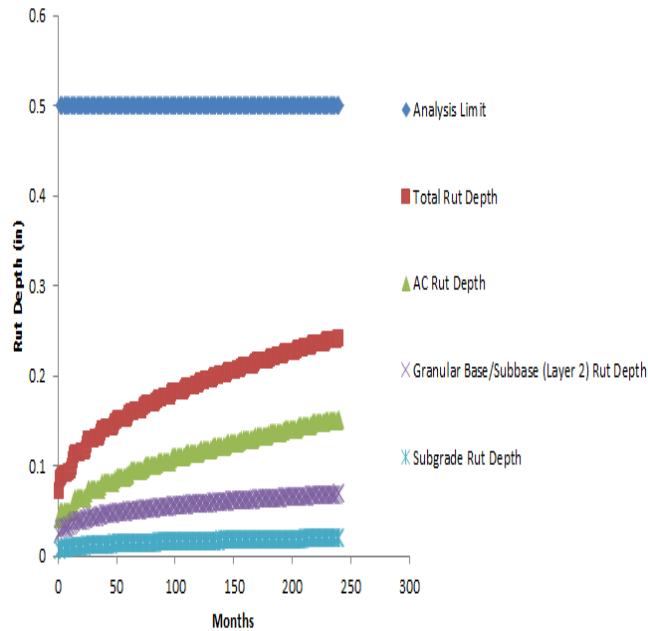
Note: Steering Axle -- Single axle, single tire; Other Single Axle -- Single axle, dual tires.

# TxME for New Pavements: Output

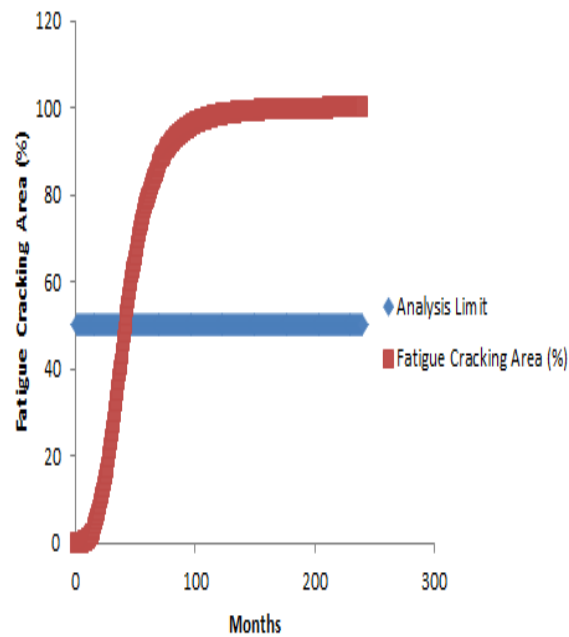
Whether or not the design meets requirements



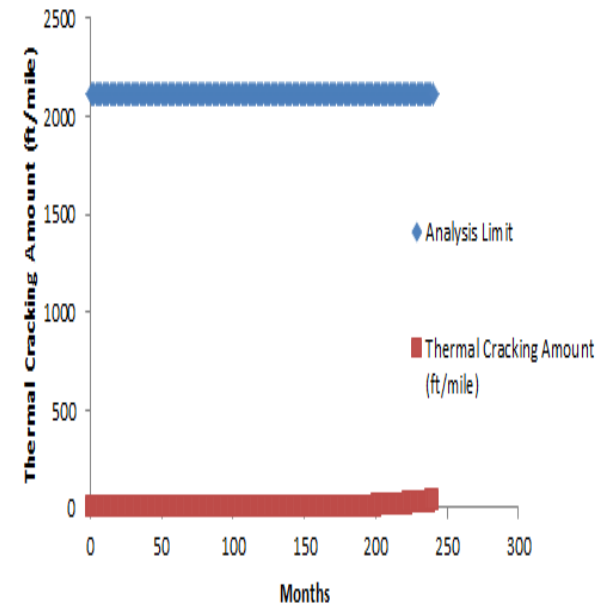
### Rutting



### AC Fatigue Cracking



### Thermal Cracking



# TxME for Asphalt Overlays

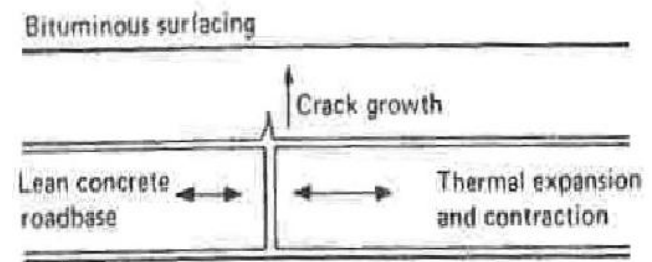
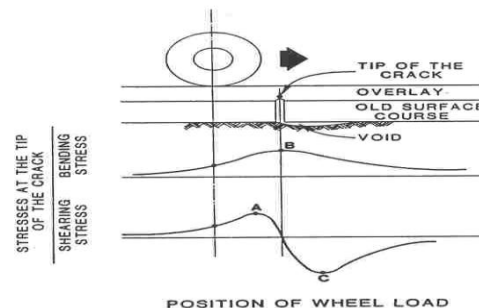
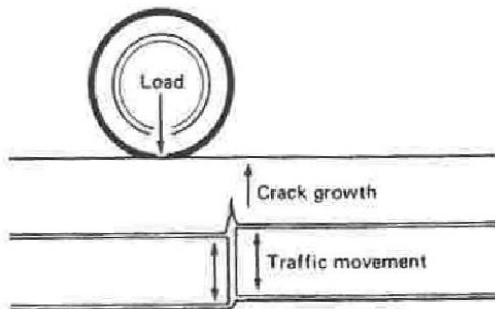
## □ Rutting:

- HMA layer only
- Controlled by mix design

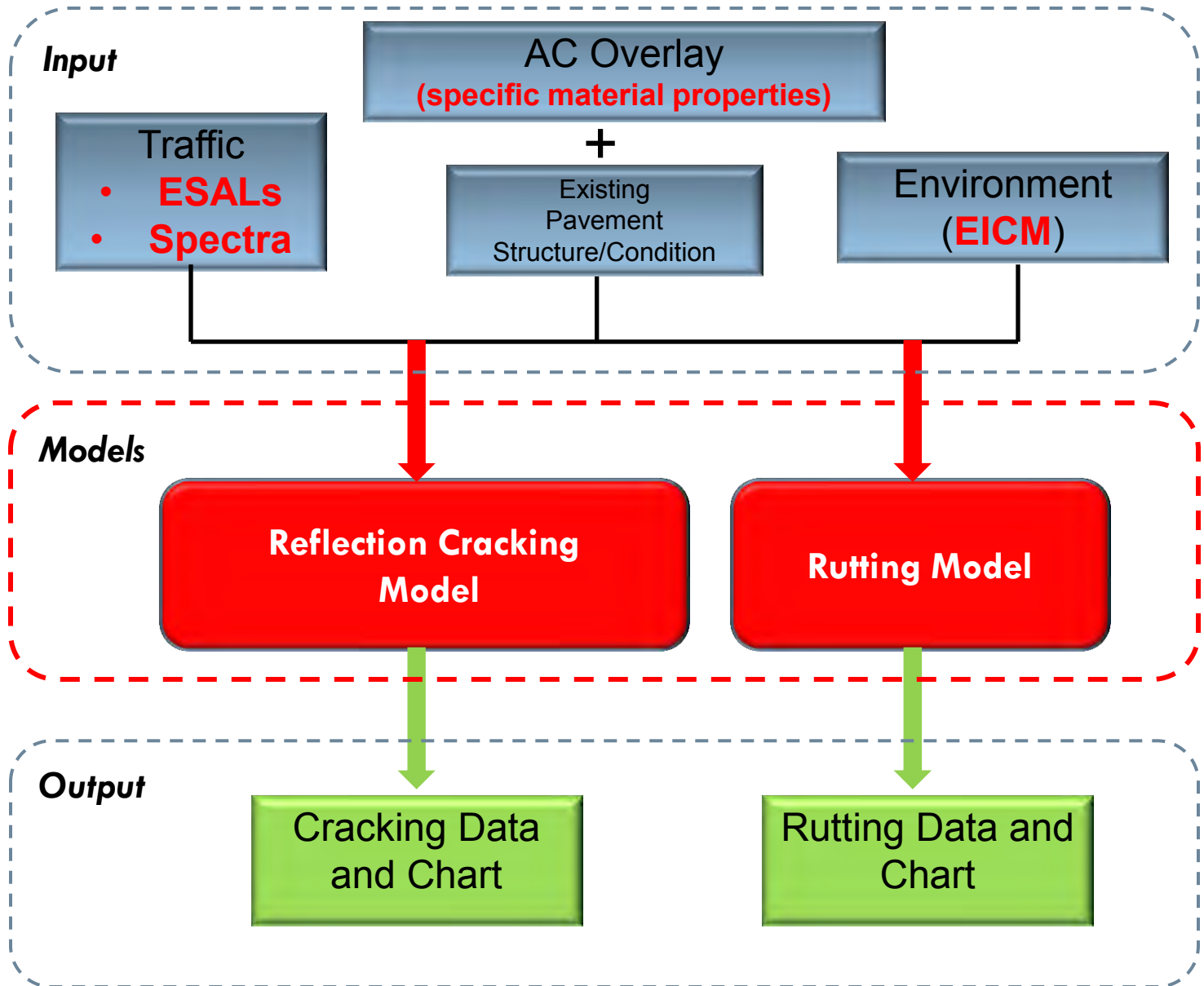


## □ Reflective Cracking

- Impacted by thickness, ...
- Three mechanisms: shearing, bending, and thermal stress



# TxME for Asphalt Overlays



# Advanced Asphalt Overlay Design Program

**Advanced Asphalt Concrete Overlay Design and Analysis System**

File Option Help

- Project [AC-PCC]
  - General Information
  - Project Identification
  - Analysis Parameters & Criteria
- Inputs
  - Traffic
  - Climate
  - Structure & Material Properties
- Results
  - Input Summary
    - General Information
    - Traffic
    - Climate
    - Structure & Material Properties
  - Output Summary
    - General Results Summary Table
    - Reflective Cracking Plot
    - AC Rutting Plot

**General information**

**Key inputs**

**Outputs**

**Analysis**

**Run analysis**

# TxME Applications: Case Studies

## Case 1:

### Pavement structure

- 3" TyD/8" CTB/subgrade

### Climate: Austin

### Traffic:

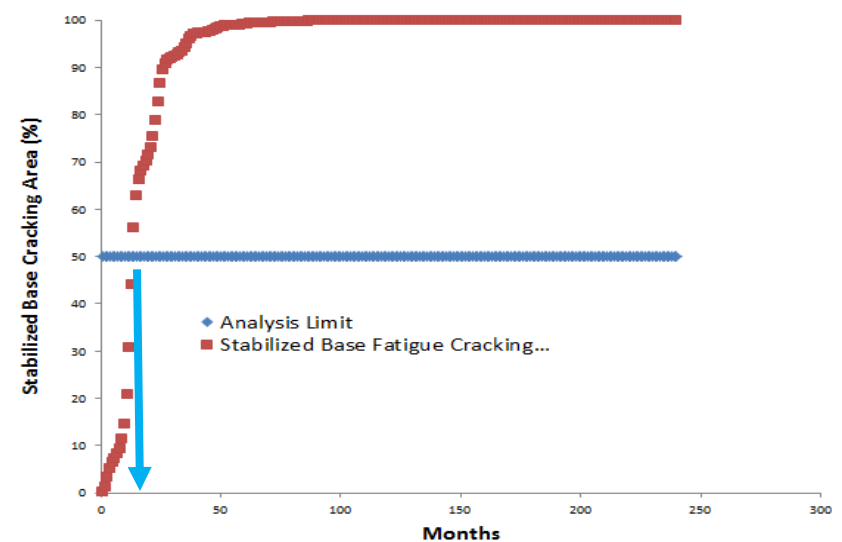
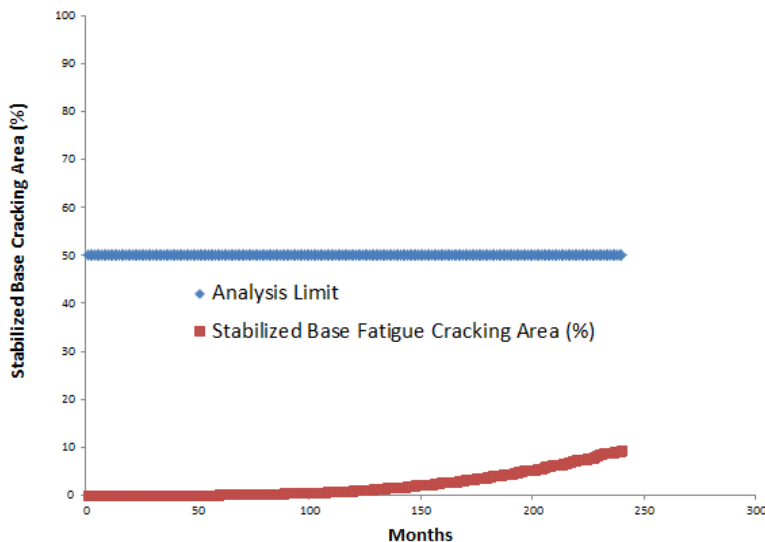
- 100 trucks/day; 100 trucks/day, half with traffic load 30% heavier



Axle 3  
34kips

Axle 2  
34kips

Axle 1  
12kips





# TxME Applications: Case Studies

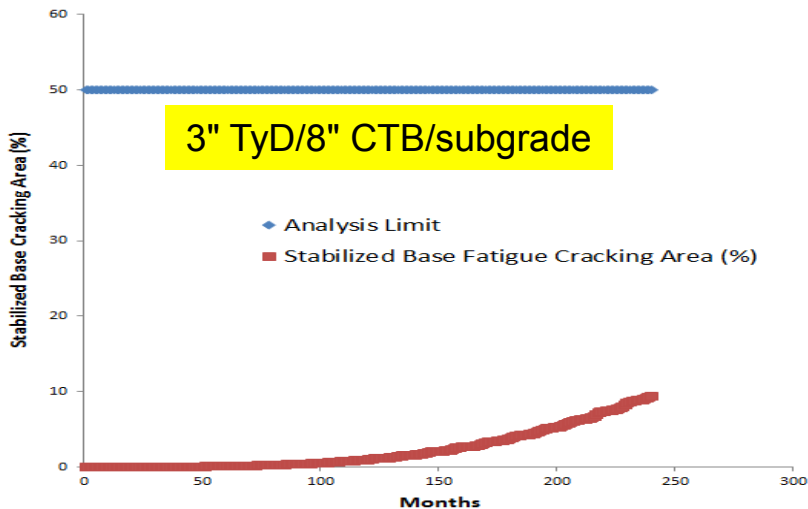
## Case 2:

- Pavement structure
- Climate: Austin
- Traffic:

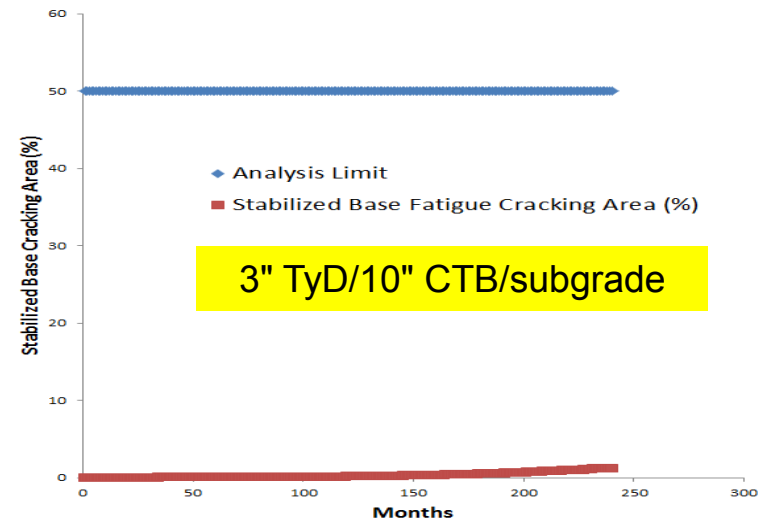
- 100 trucks/day; 100 trucks/day, half with traffic load 30% heavier



Stabilized Base Fatigue Cracking



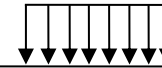
Stabilized Base Fatigue Cracking



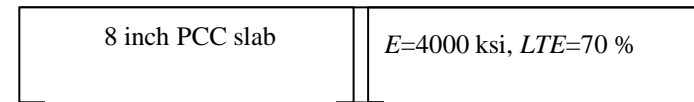
# TxME Applications: Case Studies

## Case 3: Mix Type

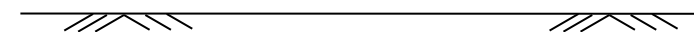
Climate: Austin, Texas      10 million ESALs, 20 YR



3 inch Asphalt Overlay, Type D, PG76-22 binder

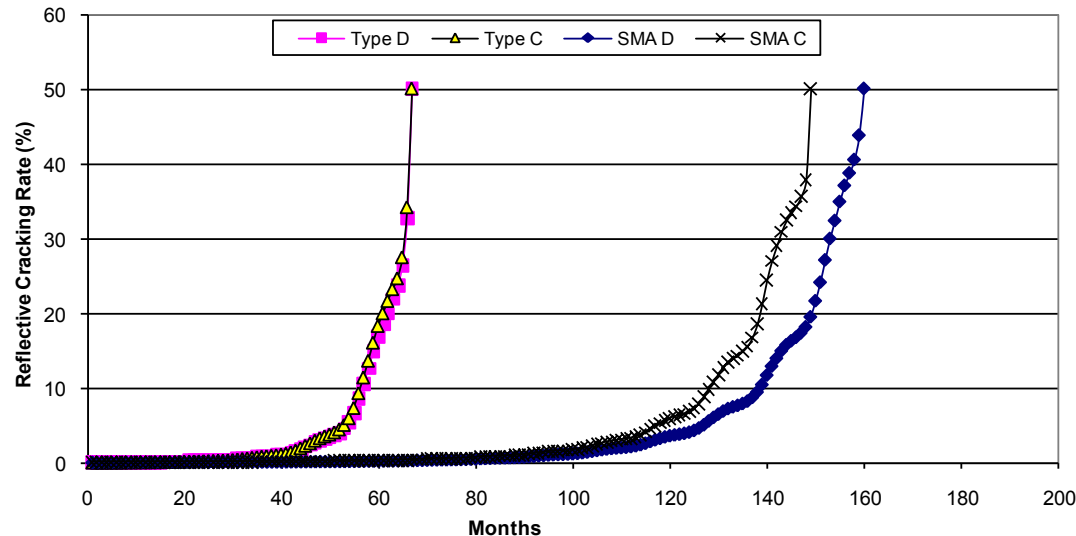


4 inch asphalt base layer, 300 ksi



Subgrade,  $E=8$  ksi

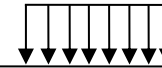
Influence of Overlay Mix Type on Reflective Cracking



# TxME Applications: Case Studies

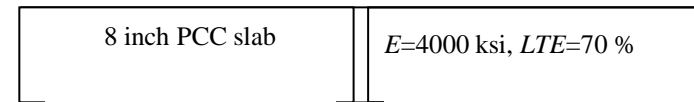
## Case 4: Climate impact

Climate: Austin, Texas

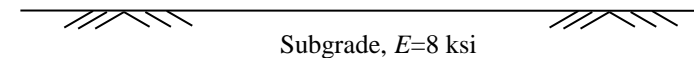


10 million ESALs, 20 YR

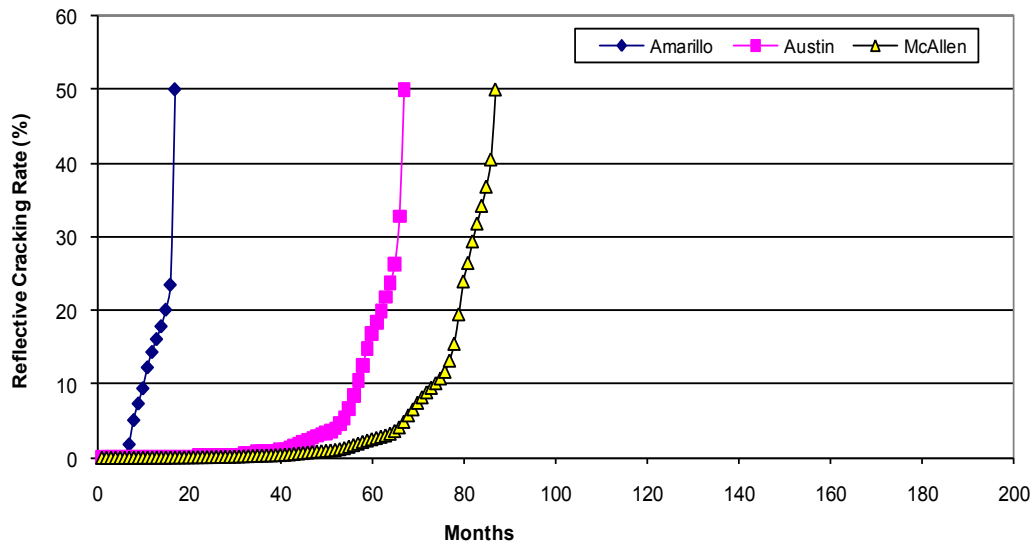
3 inch Asphalt Overlay, Type D, PG76-22 binder




4 inch asphalt base layer, 300 ksi




Influence of Climate on Reflective Cracking



# Benefits of TxME approach

- 
- When to use Performance mixes
  - Allows design of stabilized layers to minimize the risk of fatigue damage
  - Can evaluate the impact of overloaded trucks on proposed design
  - Better accounting to environment in pavement design
  - Based on real materials properties rather than only modulus

# Summary

- 
- TxME is available for both new and overlay pavement design check
  - TTI is working with Joe Leidy and RTI to start a pilot implementation project
  - TTI welcomes each District to participate
  - TTI will assist each participating District in material characterization and pavement design.



Thank You All!

# Reflection Cracking Model



- Reflection Cracking Model
  - Paris' law-based crack propagation model
  - Considered 3 mechanisms: bend, shear, and thermal stress
- Lab test procedure: Overlay Test
  - Validated through field test sections and HVS test
  - Two-step test: 1)  $E^*$  test and 2) A and n test
- Model calibration and validation studies
  - Calibration: Field test sections
  - Validation: SPS5 Sections on US175, Texas

# Asphalt Overlay Rutting

- **Asphalt overlay rutting model**
  - Asphalt overlay rutting only
  - VESYS layer model
- **Lab test procedure: Repeated Load Test**
  - Test condition: 40C/20psi/10000 cycles
  - Validated through SPS1 and NCAT test track
- **Model calibration and validation**
  - Calibration: NCAT: Phases III, SPS5 on US175
  - Validation: NCAT: Phases I

