TTI: 0-6839

Texas A&M Transportation Institute

Designing Pavements to Support the Heavy Loads in the Energy Development Areas

Technical Report 0-6839-P1 & P2

Cooperative Research Program

TEXAS A&M TRANSPORTATION INSTITUTE
COLLEGE STATION, TEXAS

in cooperation with the
Federal Highway Administration and the Texas
Department of Transportation
http://tti.tamu.edu/documents/0-6839-P1-P2.pdf

TxDOT Project 0-6839 Workshop:

Designing Pavements to Support the Heavy Loads in the Energy Development Areas

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Texas A&M Transportation Institute

Project 0-6839 Research Team

Austin, Tx; February 26, 2018

Outline

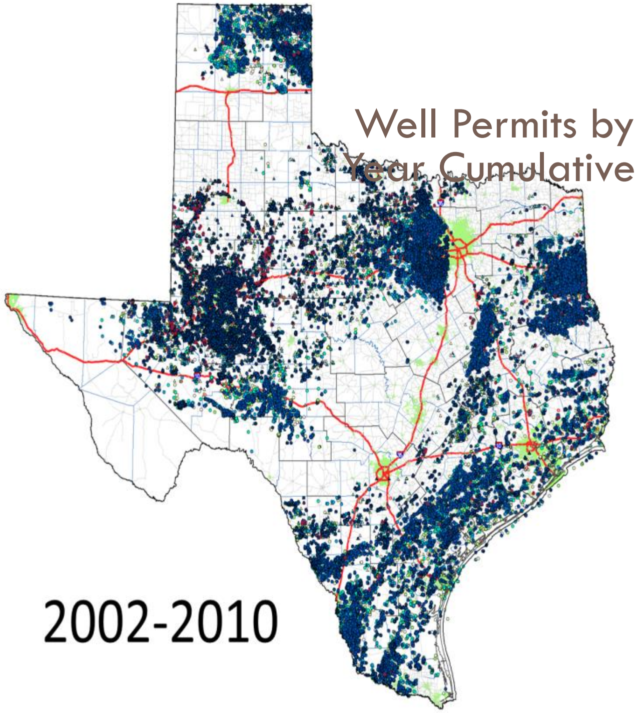
- Project overview and objectives
- Concrete pavement options
- Flexible pavement options
- Implementation plan

Project Overview

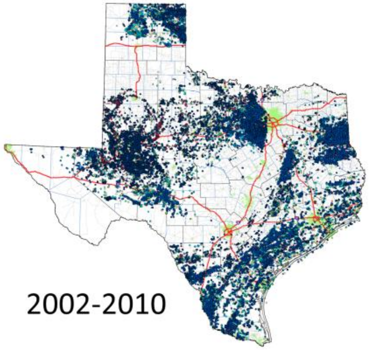
- Energy development areas
  - Heavy traffic and sever failure







Project Overview



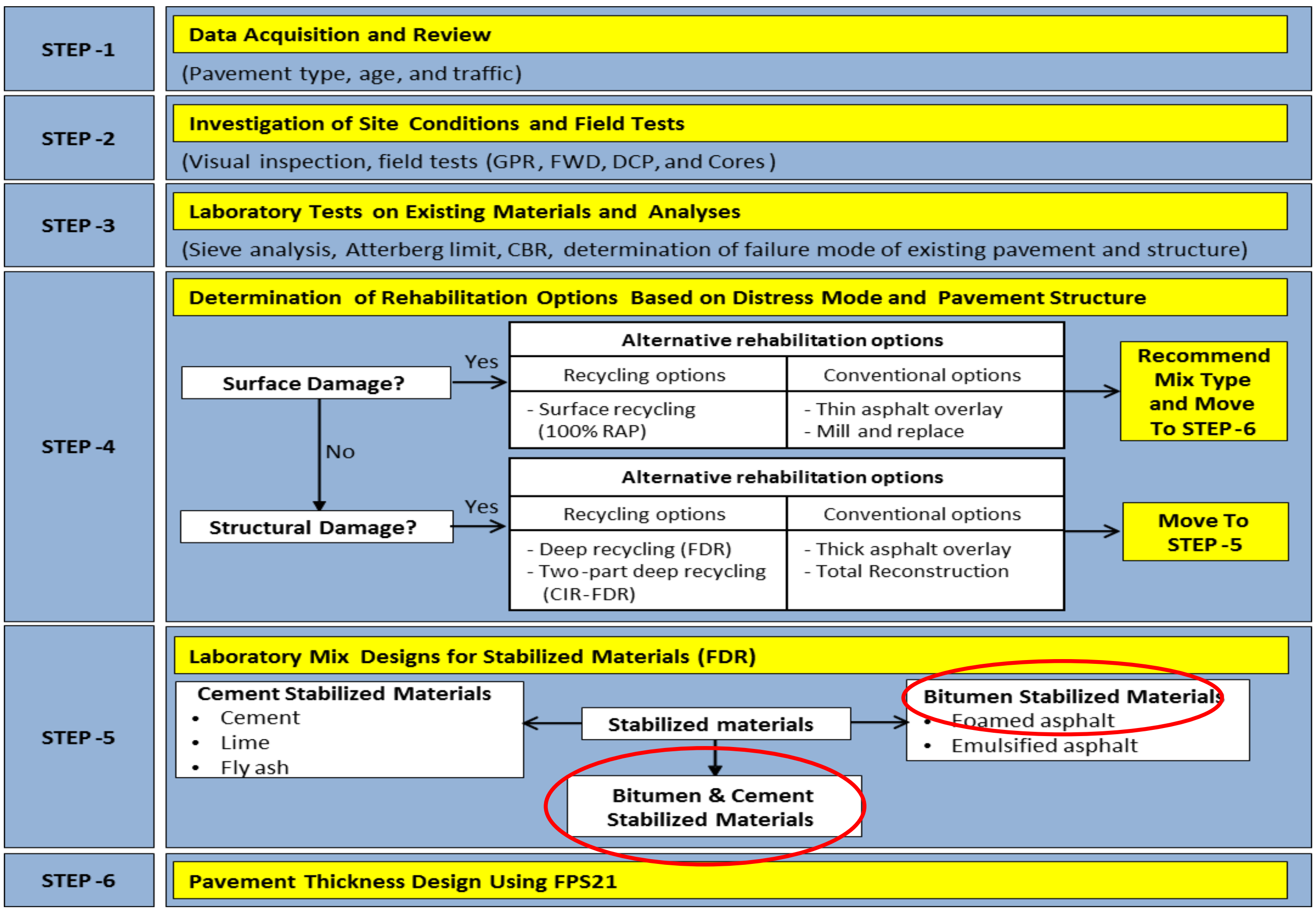
- "Features" and challenges of pavement design
  - Early opening requirements (no detours; end of day)
  - Weak/thin existing materials (most FM roads)
  - Excessive traffic loads (50-60% overload)
  - Available funds (limited fund vs. miles and miles)

Project Main Objectives

- Develop materials options suitable for early trafficking
- Recommend pavement designs that are structurally adequate for overloaded vehicles
- Work with Districts to design, construct, and monitor test sections with new materials and design approaches

Selecting rehabilitation options

- 6 steps

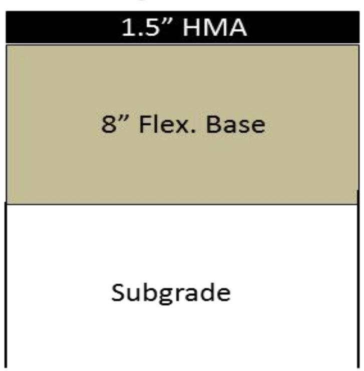


Selecting rehabilitation options: case study

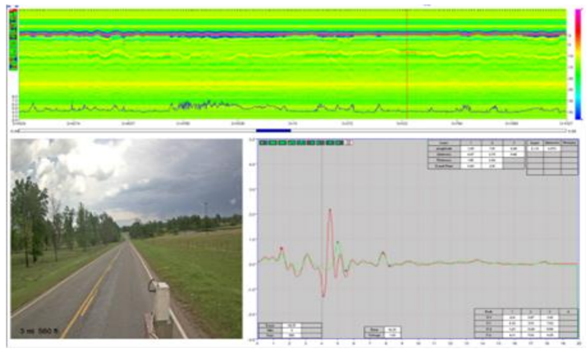
Case Study: FM906 in Paris District, Texas

Project Info. (Step-1)

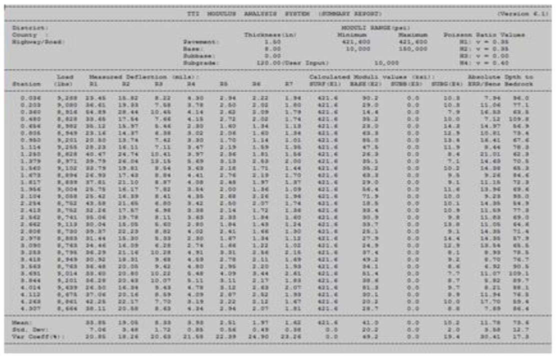
- From FM 196 to US 271
- 4.5 miles long (net)
- AADT (2015): 904
- Future AADT (2035): 1,810
- Truck Percent: 4.3
- Speed Limit: 55 MPH
- Number of Lanes: 2
- Existing Structure



Field Survey and Test (Step-2)



GPR Survey



FWD Test

Test Pit

Selecting rehabilitation options: case study

Material Collection and Laboratory Test (Step-3)

Sieve Analysis / Plastic Index / Proctor Test

Gradation % Passing		
Sieve	**Existing Base**	**New Base**
1 ¾ "	100	100
1 ¼ "	99.0	95.4
¾ "	90.5	78.5
3/8 "	66.0	57.7
# 4	55.3	44.1
# 40	29.0	28.2
Plasticity Index	**7**	**4**
Combined Materials	OMC (%)	Dry Density (pcf)
75% Existing Base & 25% RAP	5.4	133.0
42% Existing Base, 33% New Base, & 25% RAP	6.0	131.1

Selecting rehabilitation options: case study

Rehabilitation Method Selection (Step-4): We select FDR for this study

Laboratory Mix Designs on FDR Mixes (Step-5)

Design #	Material %	%RAP	Foamed % (PG64-22)	Emulsion % (CSS-1H)	Additive
1	75% EB	25%	2.4	-	0%
2	75% EB	25%	2.4	-	1% Cement
3	42% EB 33% NB	25%	2.4	-	0%
4	42% EB 33% NB	25%	2.4	-	1% Cement
5	75% EB	25%	-	4	0%
6	75% EB	25%	-	4	1% Cement
7	42% EB 33% NB	25%	-	4	0%
8	42% EB 33% NB	25%	-	4	1% Cement

8 FDR Mixes

Moisture Conditioning

Design #	Material %	%RAP	Foamed % (PG64-22)	Emulsion % (CSS-1H)	Additive	Dry IDT (psi)	Wet IDT (psi)
1	75% EB	25%	2.4	-	0%	78.9	1.7
2	**75% EB**	**25%**	**2.4**	**-**	**1% Cement**	**73.3**	**33.5**
3	42% EB 33% NB	25%	2.4	-	0%	71.3	2.9
4	42% EB 33% NB	25%	2.4	-	1% Cement	49.3	37.9
5	**75% EB**	**25%**	**-**	**4**	**0%**	**76.4**	**50.2**
6	75% EB	25%	-	4	1% Cement	53.2	41.1
7	42% EB 33% NB	25%	-	4	0%	67.5	42.7
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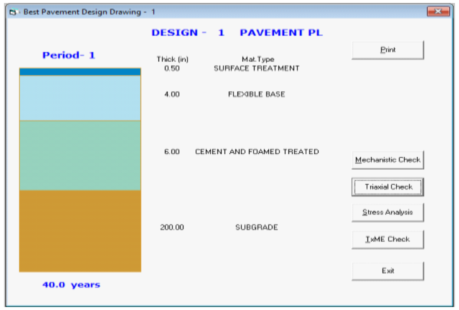
Selecting rehabilitation options: case study

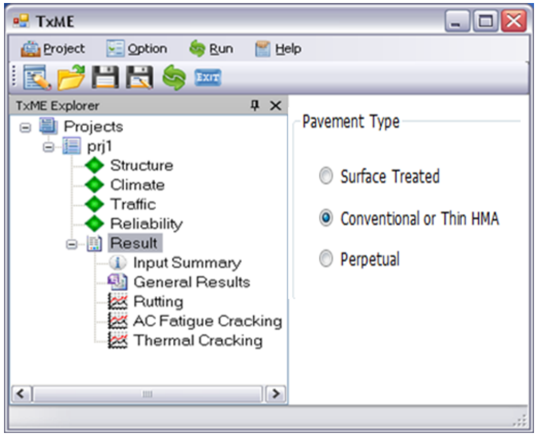
Pavement Thickness Design using FPS 21(Step-6)

	FM 99	FM 906	FM 541
AADT (2015)	3,352	904	697
Future AADT (2035)	6,710	1,810	1,400
Truck Percent (%)	4.9	4.3	22.8
Speed Limit (MPH)	60	55	55
Number of Lanes	2	2	2
18 kip ESAL for 20-year (millions)	**1.144**	**0.271**	**1.111**
Variables used for ESAL calculation	Design years=20 Dir. Distribution=0.5 Lane Distribution=1.0 Growth Rate (%)=3.50 Truck Factor= 1.35	Design years=20 Dir. Distribution=0.5 Lane Distribution=1.0 Growth Rate (%)=3.53 Truck Factor= 1.35	Design years=20 Dir. Distribution=0.5 Lane Distribution=1.0 Growth Rate (%)=3.54 Truck Factor= 1.35
Subgrade Modulus (ksi)	19.5	10	14.3

Pavement structural design

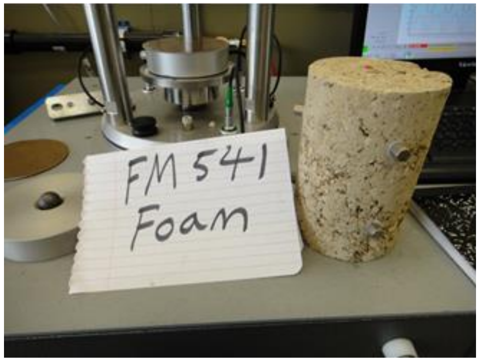
- FPS21
  - Modulus
  - Traffic: ESALs
  - Design life
- Texas Triaxial check
  - One pass shear failure
- TxME check
  - Load spectra
  - Rutting
  - Cracking

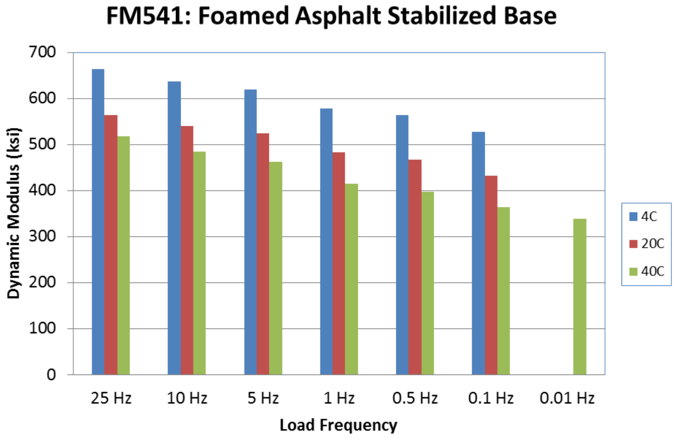


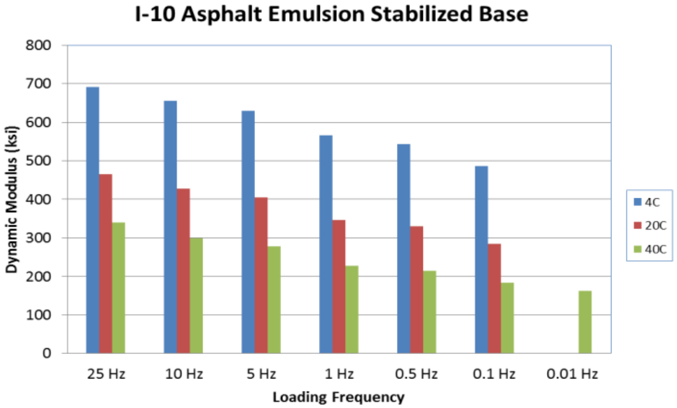


Pavement structural design

- FDR materials moduli: laboratory measurement

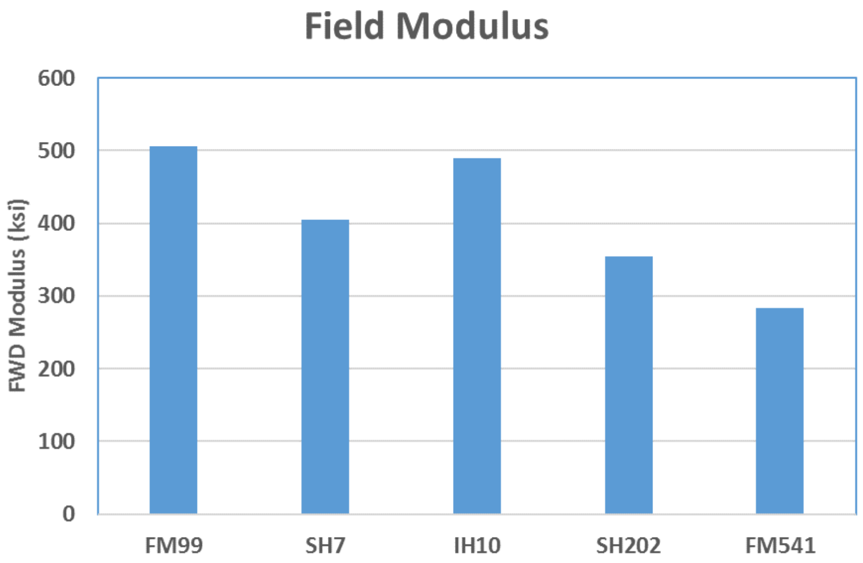


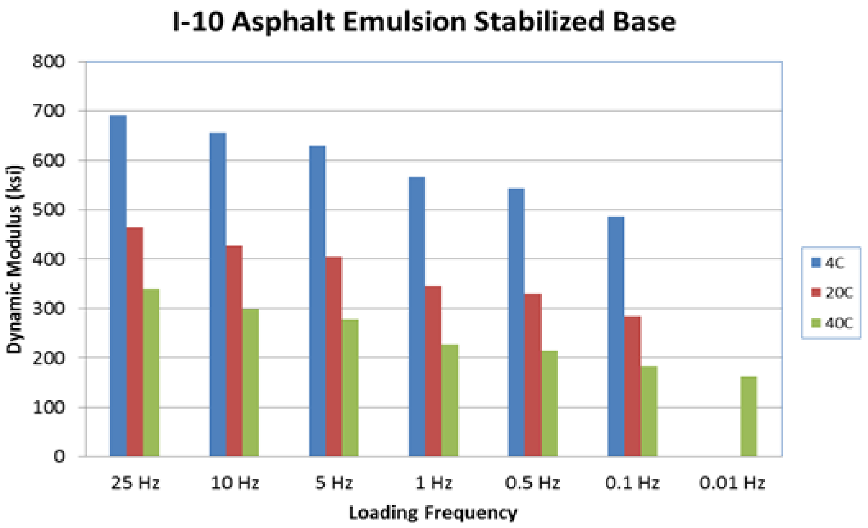




Pavement structural design

- FDR materials moduli: lab vs. FWD (field)





Recommended modulus: 300 ksi

Pavement structural design

- Traffic: load spectrum; Case study: FM468

Vehicle Class Distribution & Growth

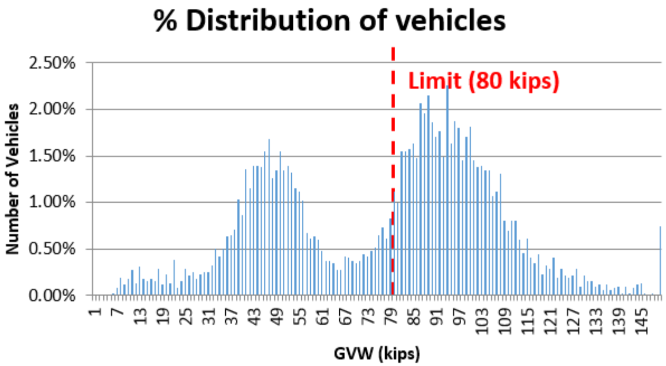
Vehicle Class	Pictorial View	Distribution (%)
Class04		0.94
Class05		3.24
Class06		2.87
Class07		0.40
Class08		2.51
Class09		86.88
Class10		2.97
Class11		0.00
Class12		0.08
Class13		0.11
	Sum of Distribution =	**100.00%**

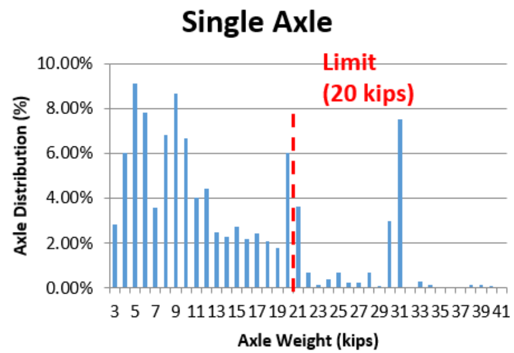
Pavement structural design

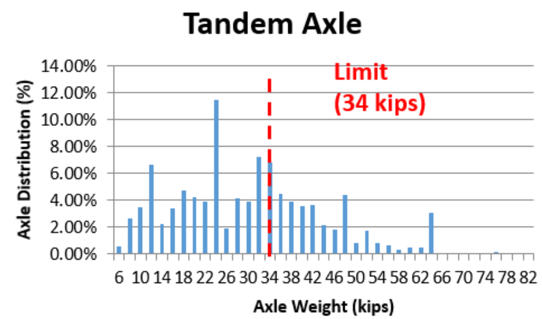
- Traffic: load spectrum; Case study: FM468

GVW & Axle Load Distribution

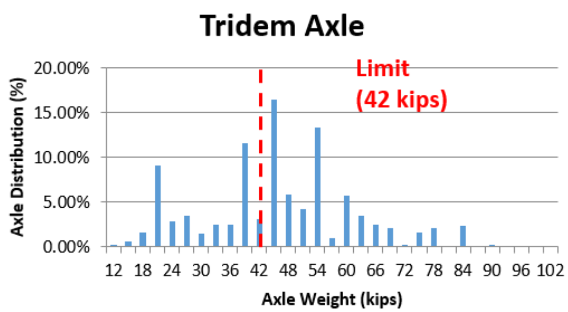
Portable WIM | 16-Days Traffic Data Collection | GVW = Gross Vehicle Weight

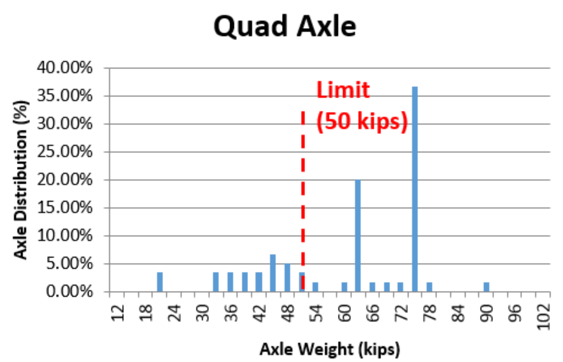






Axle Type	Daily Count
Steering Axles	326
Non-steering Single Axles	32
Tandem Axles	588
Tridem Axles	10
Quad Axles	2



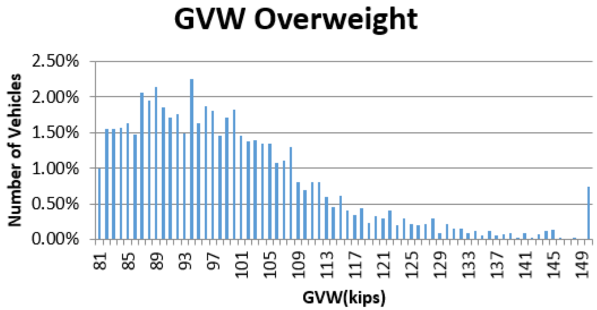


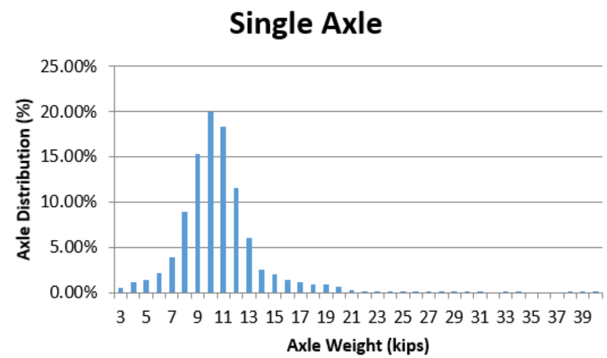
Pavement structural design

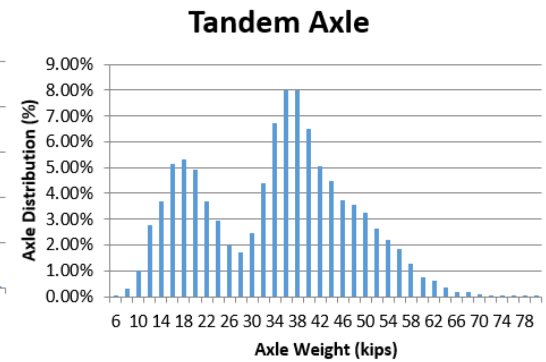
- Traffic: load spectrum; Case study: FM468

Overloading & Overweight Data

Portable WIM | 16-Days Traffic Data Collection







55.75 % Overloaded Trucks Daily (GVW ≥ 80 kips)

1.39 % Overloaded Trucks Daily (Single Axle Weight ≥20 kips)

52.92 % Overloaded Trucks Daily (Tandem Axle Weight ≥34 kips)

Over-Weight Summary	Daily Overweight Count (% of Total)	Maximum Overweight Recorded	Legal Limit	%age Overweight
GVW Overweight (≥ 80 kips)	182(55.75%)	411 kips	80 kips	414%
Single Axles (≥ 20 kips)	5(1.39%)	41kips	20 kips	105%
Tandem Axles (≥ 34 kips)	311(52.92%)	80 kips	34 kips	135.3%
Tridem Axles (≥ 42 kips)	4(41.03%)	90 kips	42 kips	114.3%
Quad Axles (≥ 50 kips)	1(48.48%)	90 kips	50 kips	80%

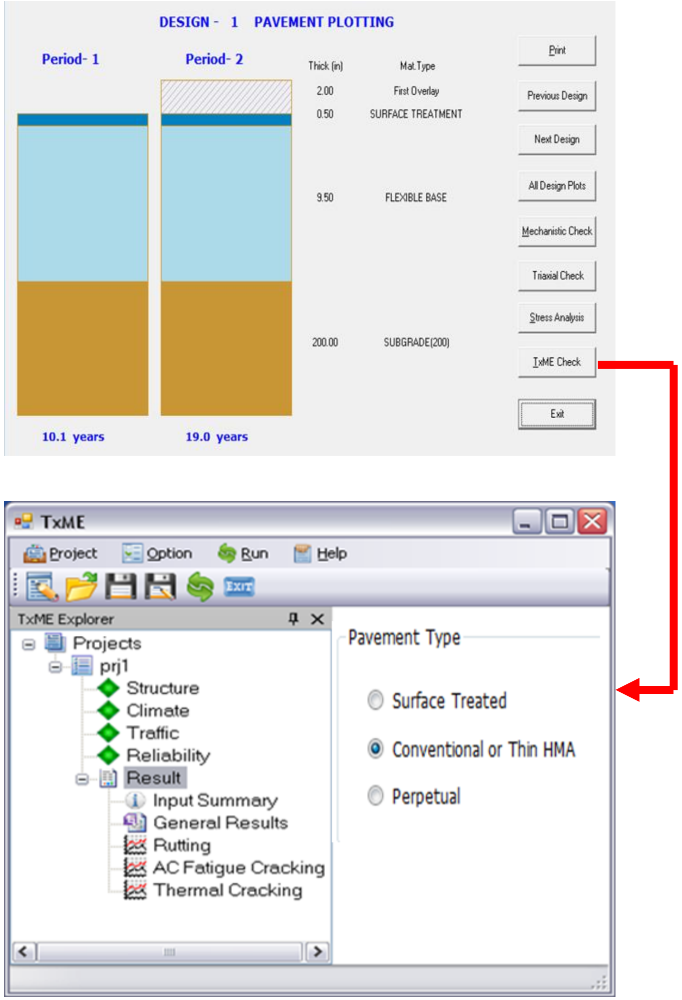
Pavement structural design

- Traffic: load spectrum vs. ESAL

Highway ID	Station ID	AADTT	ESAL from TxME Load Spectra (20 years)
I35	513	10,867	49,650,718
I10	502	8,005	32,748,557
I20	526	7,704	50,529,653
I45	539	6,834	37,354,536
I35	531	6,299	26,717,107
I20	544	5,767	28,243,048
US287	506	4,182	36,010,559
US287	528	3,247	17,228,683
SH114	527	2,656	13,479,223
SH130	532	2,269	7,682,393
US59	535	2,000	5,656,394
US82	530	919	3,120,864
US96	142	846	4,337,616
SH121	546	550	1,976,022
SH6	Portable WIM	474	1,830,420
US82	543	372	1,310,763
FM468	Portable WIM	1,062	11,437,641
FM3129	541	251	1,652,034
FM2223	800	142	516,928

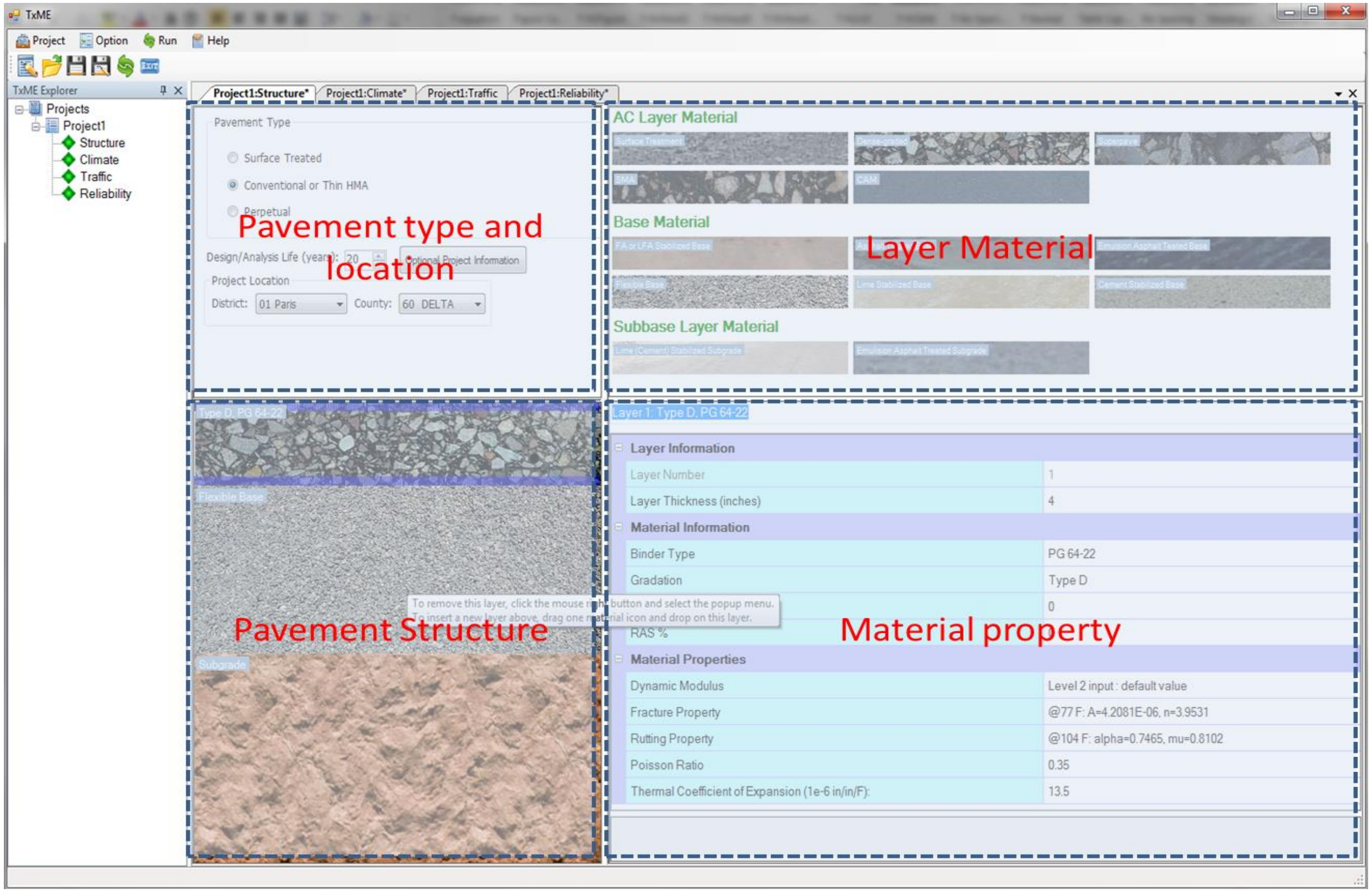
Pavement structural design

- TxME check
  - load spectrum



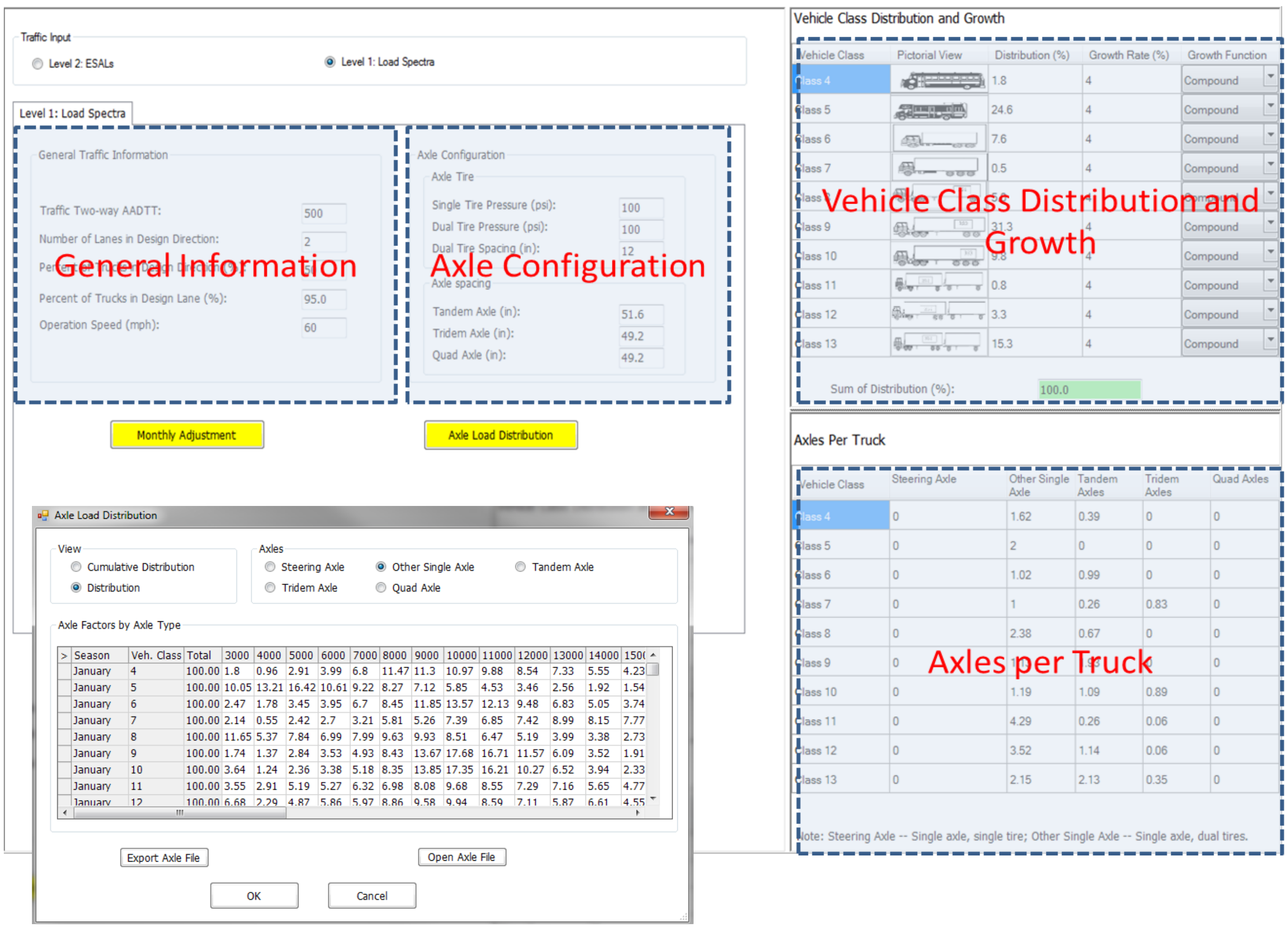
Pavement structural design

- TxME check



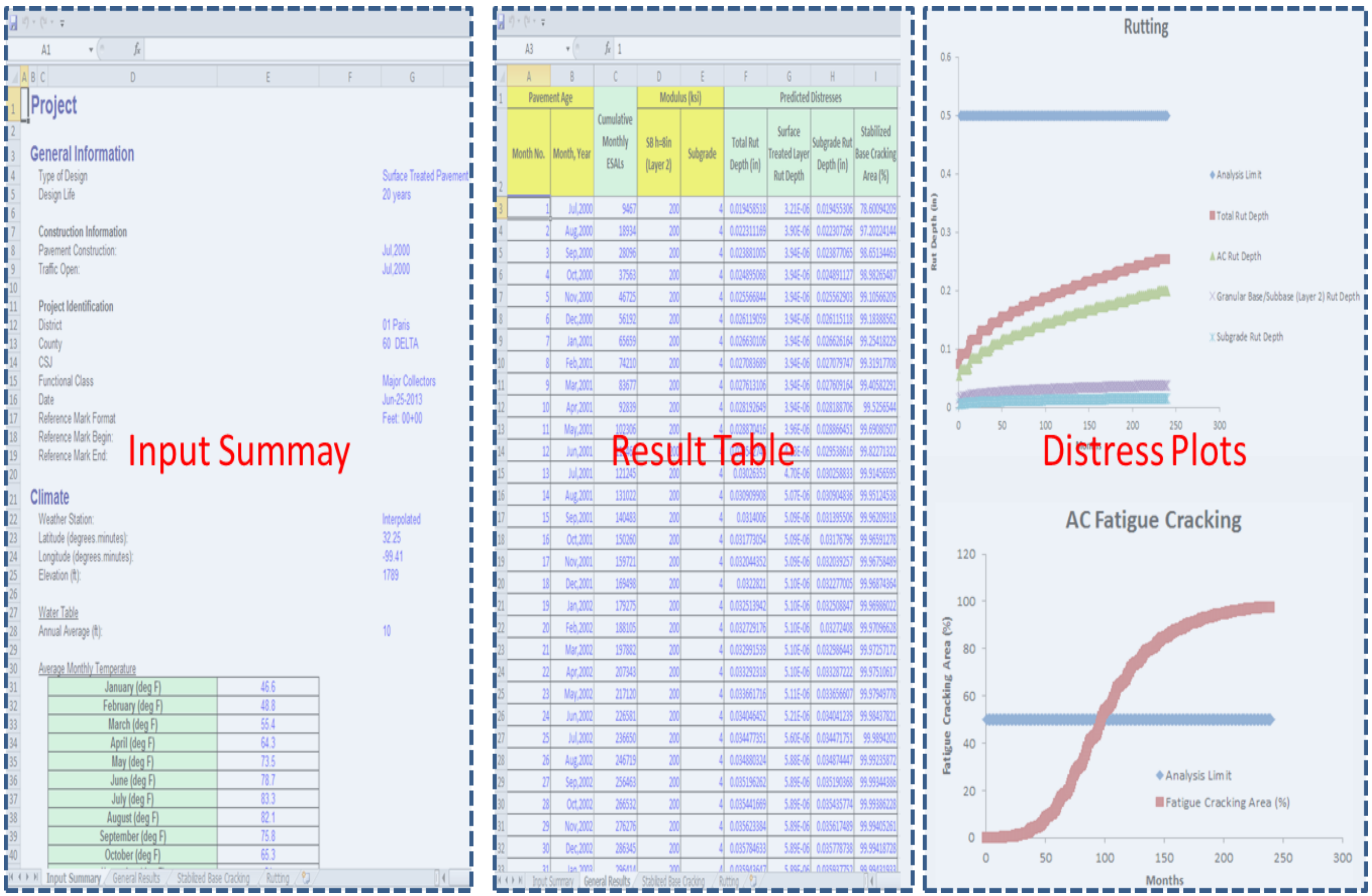
Pavement structural design

- TxME check: load spectrum



Pavement structural design

- TxME check: performance prediction



Pavement structural design

- TxME check

Influence of Material Properties

Variable inputs

- Fracture properties of dense grade type-D: 20, **40**, and 100 overlay cycles
- FDR Modulus (ksi): 300, **150**, 75

Fixed inputs

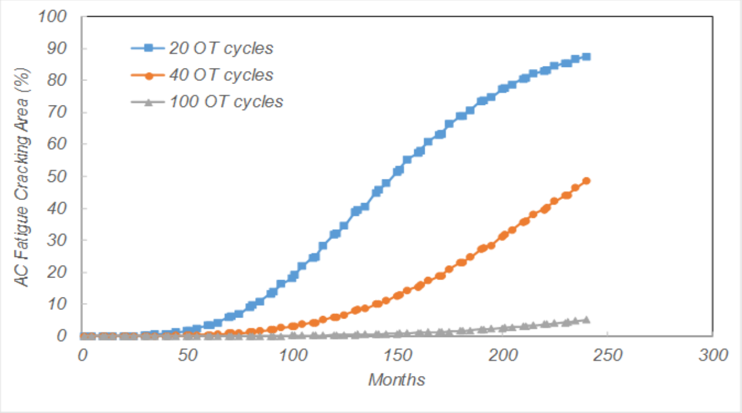
- **Traffic: Traffic spectra from Station 535**
- Subgrade Modulus (ksi): 14.3.
- Climate: San Antonio, TX

FM541 Design #3

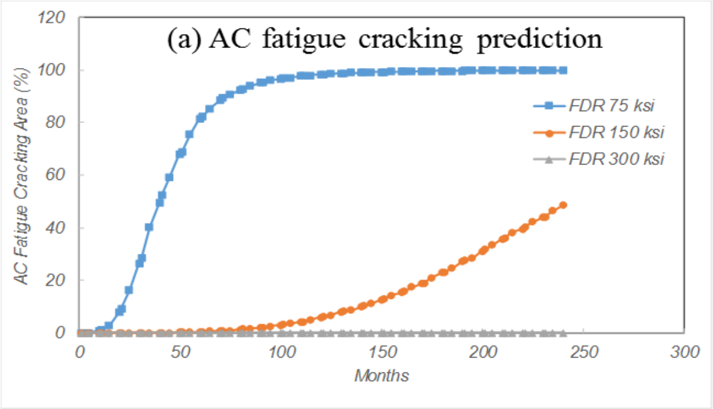
Pavement structural design

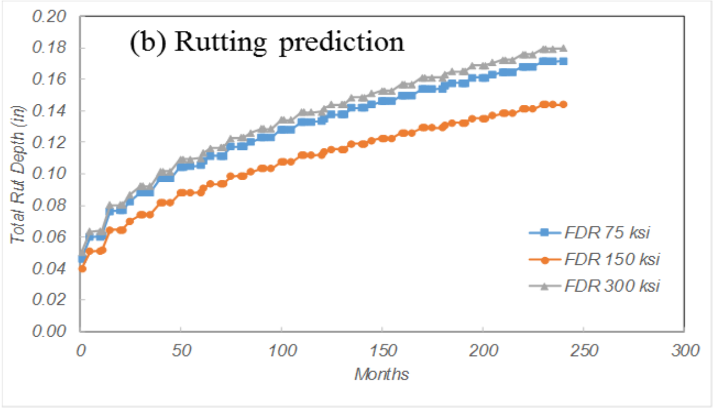
- TxME check

AC fatigue cracking prediction



Influence of Fracture Property of Mix





Influence of Modulus of FDR Mix

Field test sections

- FM541: foamed asphalt stabilization
- SH202: foamed asphalt stabilization
- I10: asphalt emulsion stabilization
- SH7: foamed asphalt stabilization
- FM99: foamed asphalt stabilization
- US281/SH123: concrete pavement

Field test sections

- FM541: foamed asphalt stabilization








After 2 years: no cracking; average rut depth: 2.9 mm

Field test sections

- SH202: foamed asphalt stabilization







After 1.5 years: no cracking; average rut depth: 5.4 mm

Field test sections

- I10: asphalt emulsion stabilization

After 1.5 years: no cracking; average rut depth: 6.4 mm

Field test sections

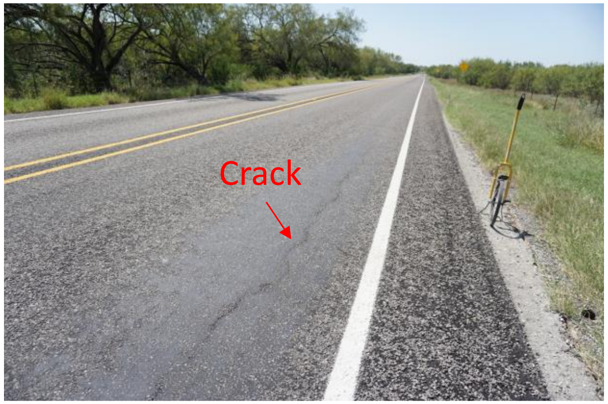
- SH7: foamed asphalt stabilization

After 1.5 years: no cracking AND no rutting

Field test sections

- FM99: foamed asphalt stabilization

After 3.5 years: limited longitudinal cracking; rut depth: 4 mm



Implementation plan

- Develop and teach workshops
  - Rehabilitation options
  - Mix design
  - Structural design
- Construct sections: foamed vs. emulsion
- Continue to monitor existing field test sections
- Document US281/SH123 construction

Thank You All!

Questions???