Integration of Pavement Cracking Prediction Model with Asset Management and Vehicle-Infrastructure Interaction

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Project Details

- Advisor: Professor William Buttlar
- Graduate Student Advisor: Md Shahidul Islam

- Research in asphalt binders and asphalt pavements
- Emphasis on thermal cracking, IRI and relation to user costs

Outline

- Internship Goals
- Background Information
- Testing Procedures
- Results
- Conclusions

Goals of Internship

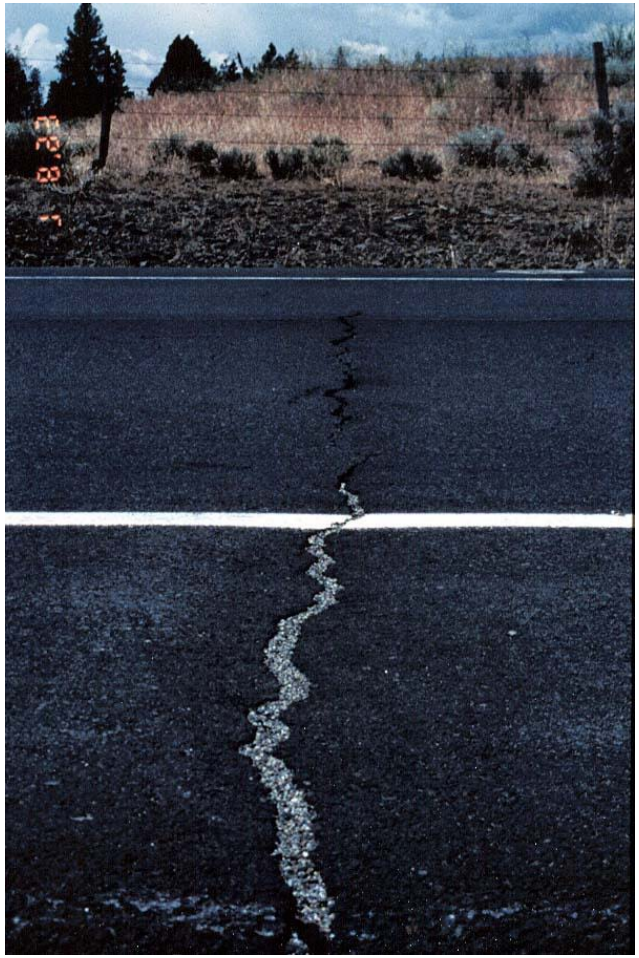
- Evaluate predictions of the Mechanistic-Empirical Pavement Design Guide (MEPDG)
- Determine when/where asphalt binders reach threshold of thermal cracking
- Evaluate default MEPDG asphalt binder data
- Provide data for Md Shahidul Islam's research
- Update the University of Illinois' IDT database

Asphalt Pavements

- *Superpave* Performance Grading System
- Distresses
  - Thermal (Transverse) Cracking
  - Rutting
  - Longitudinal Cracking
  - Alligator (Fatigue) Cracking

Thermal (Transverse) Cracking

- Occurs during low temperatures
- Most severe in coldest climates
- Contraction of asphalt binders leads to stresses in pavement and crack formation



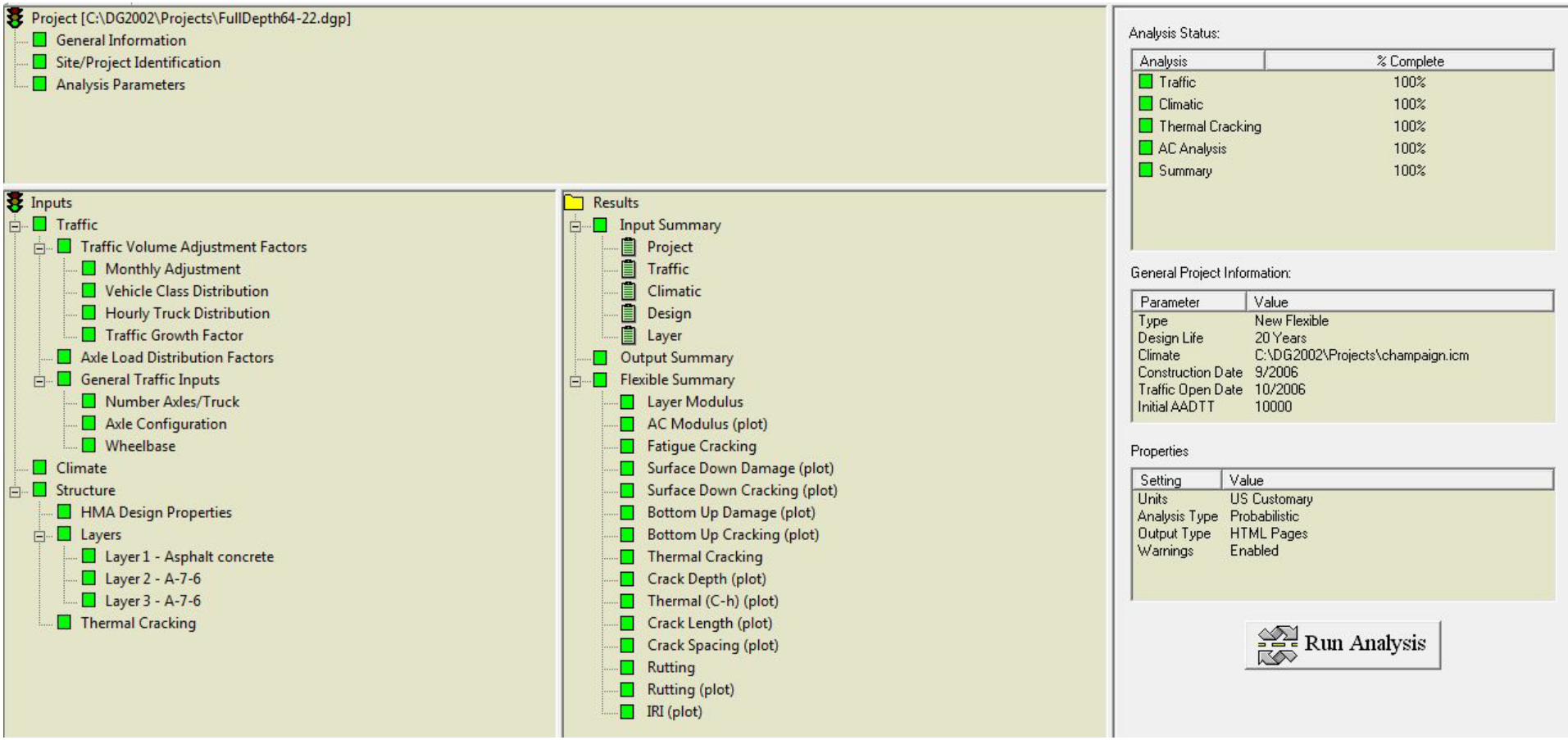
Transverse Cracking (From: *Pavement Interactive*)

MEPDG

- Mechanistic-Empirical Pavement Design Guide
- **Inputs**: Traffic, Climate, Materials, Pavement Structure
- **Outputs**: Predicted level of distresses, IRI

- TC MODEL
- EICM

MEPDG Input Screen



Levels of Analysis

- Level 1
  - User-input creep compliance and tensile strength
  - Data directly obtained from experiments
  - Most accurate output
- Level 3
  - Default MEPDG creep compliance and tensile strength
  - Least accurate outputs

Level 1 Inputs

Thermal Cracking

Level 1
Level 2
Level 3

Average tensile strength at 14 °F (psi): 483.61

Loading Time sec	Creep Compliance (1/psi)		
	Low Temp (°F)	Mid Temp (°F)	High Temp (°F)
	-4	14	32
1	2.47222E-07	3.12229E-07	4.71791E-07
2	2.50177E-07	3.34883E-07	5.28918E-07
5	2.63967E-07	3.70341E-07	6.42187E-07
10	2.76771E-07	4.06784E-07	7.8008E-07
20	2.9253E-07	4.46182E-07	9.50477E-07
50	3.20109E-07	5.26948E-07	1.2893E-06
100	3.40793E-07	6.14609E-07	1.67441E-06

Import

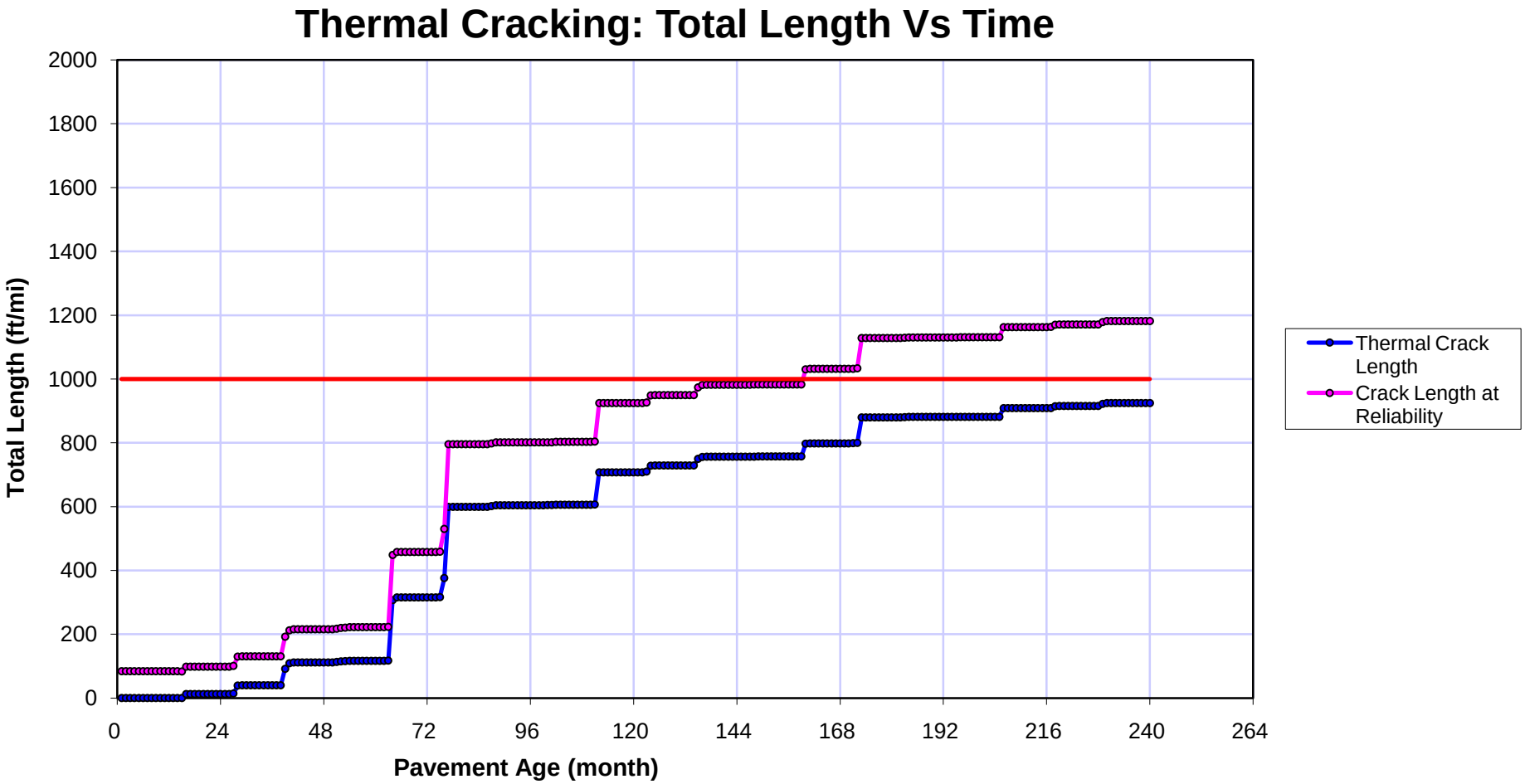
Export

- Data obtained from *Superpave* Indirect Tension Test (IDT)
- Experimental data from testing at the University of Illinois

Test Parameters

- 3 Climates
  - International Falls, MN (cold)
  - Champaign, IL (intermediate)
  - Flagstaff, AZ (warm)
- Asphalt Binders
  - PG 64-22, 58-28, 70-16, 52-34, 76-16, 46-40
- Pavement Structure
  - Full depth, thick, medium, and thin pavements

MEPDG Thermal Cracking Output



Full Depth, 15” AC Pavement: PG 64-22, Intermediate Climate

Level 3 Analysis Results

International Falls, MN (Cold)

Project	Binder	Cracking @ 1 Year	Cracking @ 10 Years	Cracking @ 20 Years
InternationalFalls1.1	**PG 64-22**	3.149	155.543	163.043
InternationalFalls1.2	**PG 58-28**	0.0172	115.742	128.589
InternationalFalls1.3	**PG 70-16**	16.147	165.932	171.650
InternationalFalls1.4	**PG 52-34**	0.000	0.365	2.620
InternationalFalls1.5	**PG 76-10**	2.720	157.478	164.813
InternationalFalls1.6	**PG 46-40**	0.000	0.000	0.000

Champaign, IL (Intermediate)

Project	Binder	Cracking @ 1 Year	Cracking @ 10 Years	Cracking @ 20 Years
Champaign1.1	**PG 64-22**	0.000	0.638	5.818
Champaign1.2	**PG 58-28**	0.000	0.0033	0.022
Champaign1.3	**PG 70-16**	0.000	4.266	31.170
Champaign1.4	**PG 52-34**	0.000	0.000	0.000
Champaign1.5	**PG 76-10**	0.000	0.575	6.237
Champaign1.6	**PG 46-40**	0.000	0.000	0.000

15” AC Pavement on A-7-6 Subgrade
Cracking Units: ft/500 ft

Level 1 Analysis Results

International Falls, MN (Cold)

Project	Binder	Cracking @ 5 Years	Cracking @ 10 Years	Cracking @ 15 Years	Cracking @ 20 Years
InternationalFalls64-22	**PG 64-22**	157.746	177.045	180.136	182.813
InternationalFalls70-22	**PG 70-22**	Max out: 200 @ 3.419186 months			
InternationalFalls64-28	**PG 64-28**	0.044	2.494	9.249	22.94111

Champaign, IL (Intermediate)

Project	Binder	Cracking @ 5 Years	Cracking @ 10 Years	Cracking @ 15 Years	Cracking @ 20 Years
Champaign64-22	PG 64-22	11.067	67.022	83.291	87.552
Champaign70-22	**PG 70-22**	Max out: 200 @ 15.32058 months			
Champaign64-28	**PG 64-28**	0.000	0.001	0.002	0.004

Flagstaff, AZ (Warm)

Project	Binder	Cracking @ 5 Years	Cracking @ 10 Years	Cracking @ 15 Years	Cracking @ 20 Years
Flagstaff64-22	PG 64-22	0.004	0.041	0.159	0.405
Flagstaff70-22	PG 70-22	72.154	92.194	96.704	102.4796
Flagstaff64-28	PG 64-28	0.000	0.000	0.000	0

15” AC Pavement on A-7-6 Subgrade
Cracking Units: ft/500 ft

Level 3 vs. Level 1 TC Results

USING MEPDG DEFAULT CREEP COMPLIANCE DATA

Project	Binder	Cracking @ 5 Years	Cracking @ 10 Years	Cracking @ 15 Years	Cracking @ 20 Years
Champaign64-22.1	PG 64-22	0.245	4.077	12.572	23.917
Champaign70-22.1	PG 70-22	0.072	1.212	3.735	7.290
Champaign76-22.1	PG 76-22	0.019	0.337	1.022	1.972
Champaign64-28.1	PG 64-28	0.002	0.028	0.079	0.149
Champaign70-28.1	PG 70-28	0.000	0.009	0.026	0.050
Champaign76-28.1	PG 76-28	0.000	0.004	0.013	0.024

USING IDT DATABASE DATA

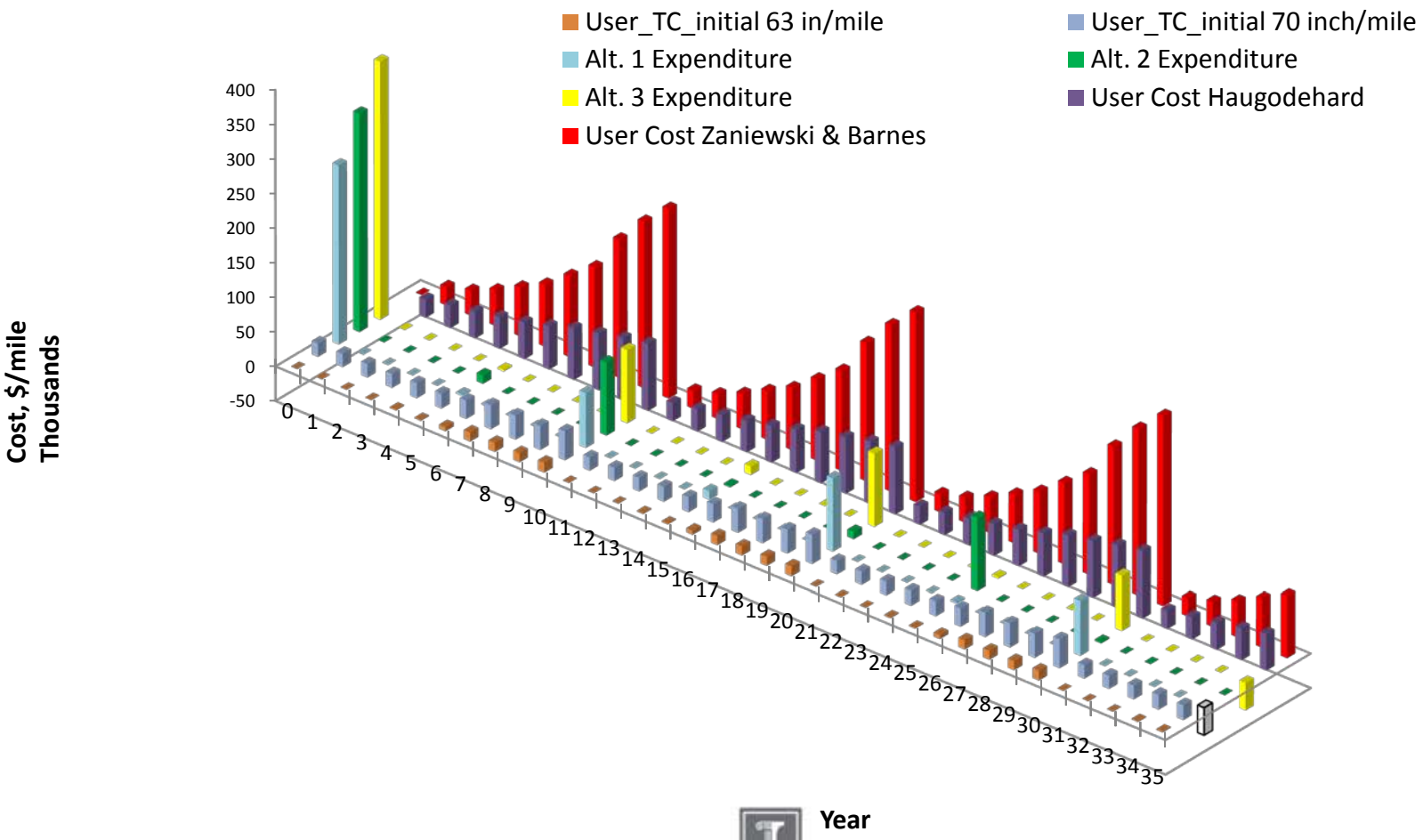
Project	Binder	Cracking @ 5 Years	Cracking @ 10 Years	Cracking @ 15 Years	Cracking @ 20 Years
Champaign64-22	PG 64-22	38.199	145.688	172.767	177.920
Champaign70-22	PG 70-22	Max out: 200 @ 15.32058 months		-	
Champaign76-22	PG 76-22	-	-	-	-
Champaign64-28	PG 64-28	0.000	0.001	0.002	0.004
Champaign70-28	PG 70-28	-	-	-	-
Champaign76-28	PG 76-28	-	-	-	-

15” AC Pavement on A-7-6 Subgrade
Cracking Units: ft/500 ft

Tests for Shahidul's Project

- IRI vs. time (in regards to thermal cracking)
- Climate: Champaign, IL
- 3 Pavement Structures
  - Full depth AC, 1.5" AC overlay, 2" AC overlay
- Asphalt binders: PG 64-22, PG 70-22, PG 76-22, PG 64-28

Shahidul's Preliminary Results: User Cost



Conclusions

- MEPDG is a powerful tool for transportation engineers to predict pavement distresses
- MEPDG default creep compliance and tensile strength values are unconservative
- Default MEPDG creep compliance and tensile strength data must be verified with more tests
- MEPDG should be calibrated regionally, rather than nationally

Possible Further Steps

- Use of full MEPDG software
- Perform indirect tension tests for additional binders

Acknowledgments

- Professor William Buttlar
- Graduate Students Md Shahidul Islam and Behzad Behnia

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Questions?