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NCHRP Project 1-41

Models for Predicting Reflection Cracking for Hot-Mix Asphalt Overlays

Overview

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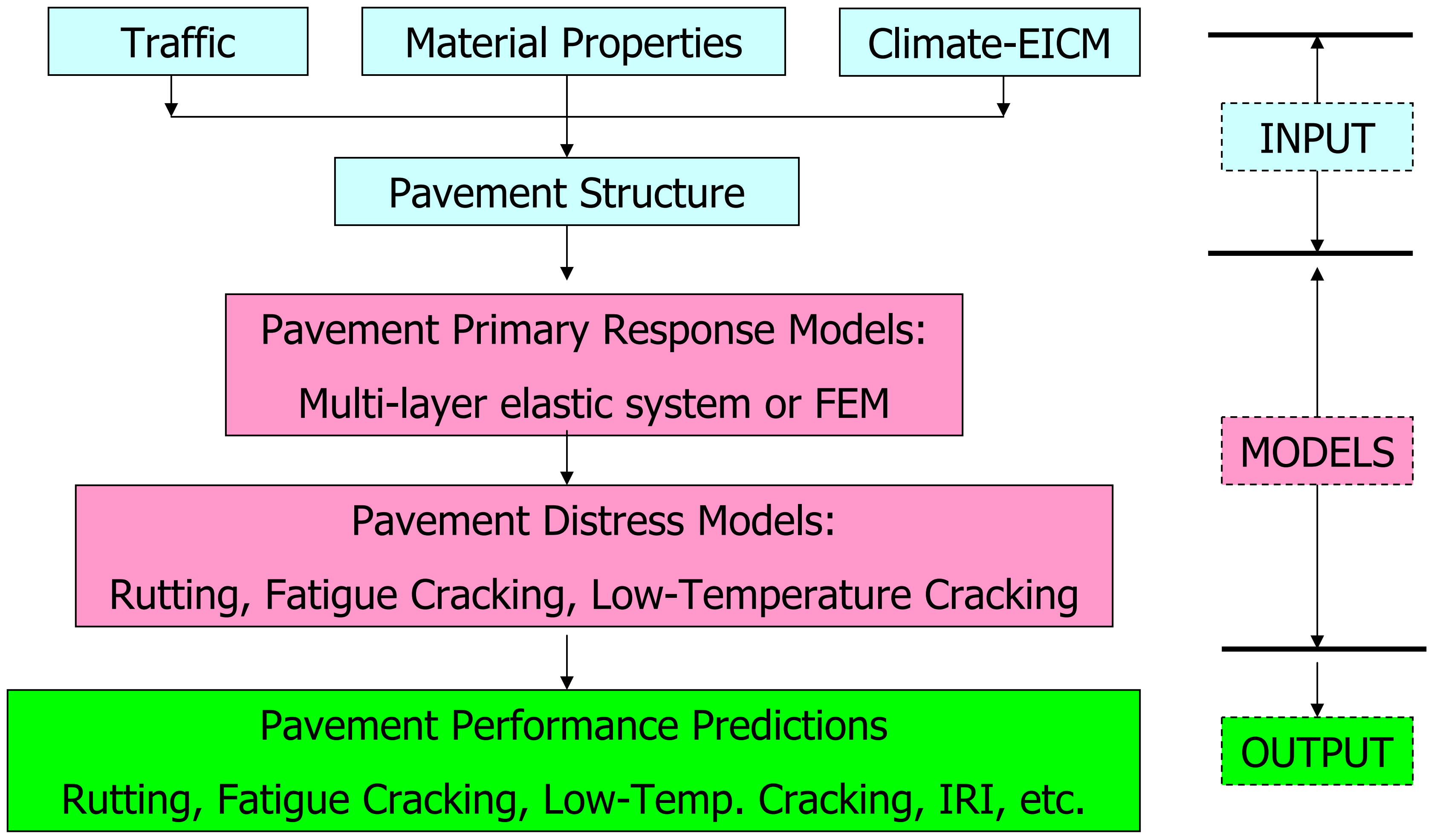
Presentation Outline

- MEPDG
- Relationship: MEPDG to NCHRP1-41
- Reflection Cracking Field Data
- Reflection Cracking Modeling
- Summary and Conclusions

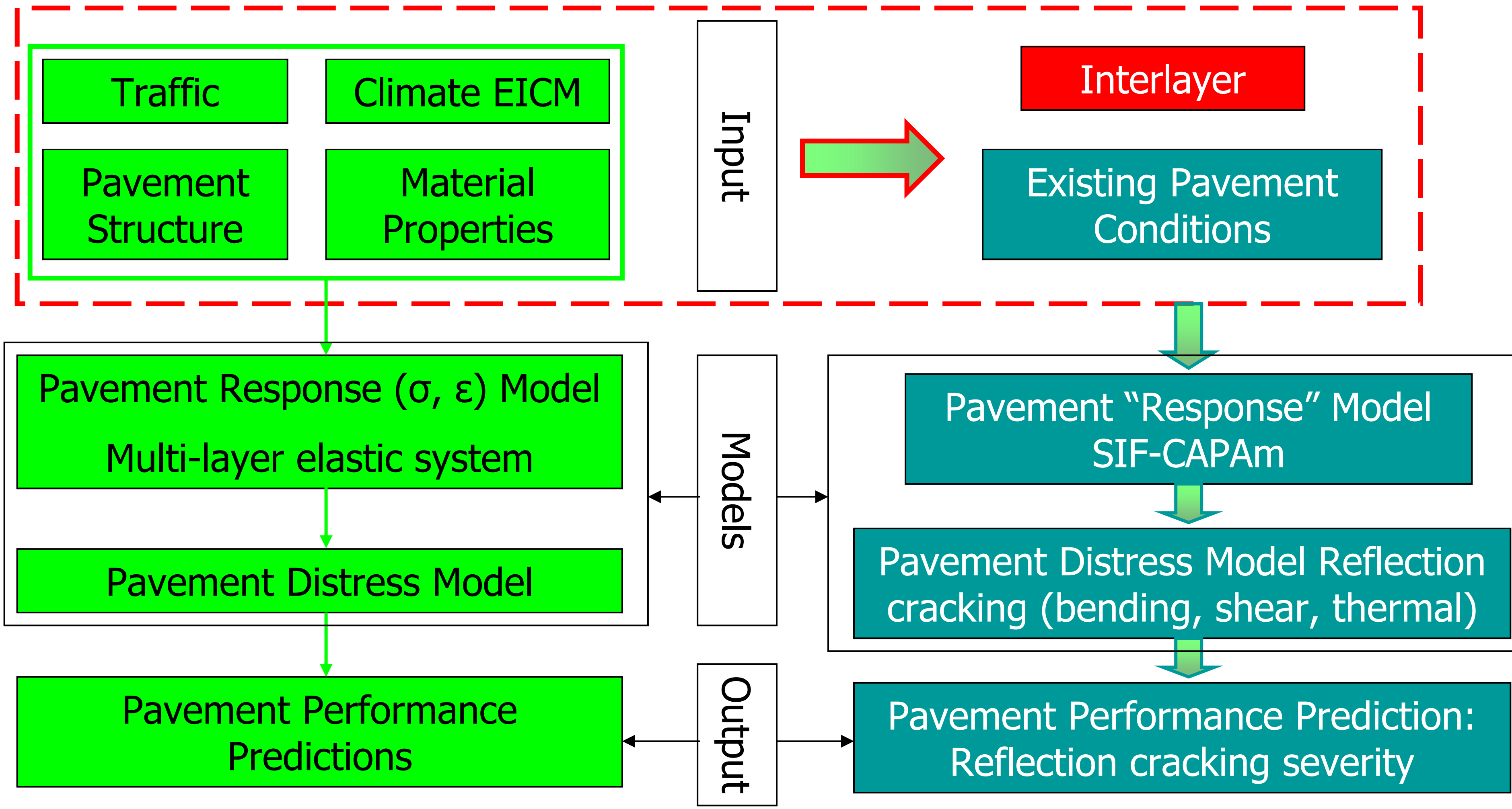
Flow Chart of the MEPDG



Relationship between NCRHP 1-41 and the MEPDG

- How will the asphalt overlay design program be incorporated into the MEPDG?

MEPDG vs. NCHRP 1-41



Reflection Cracking Modeling

- Traffic input
- EICM
- Load Transfer Efficiency
- Fracture Property of Asphalt Mixes (A and n)
- Pavement “Response” Model: (SIF and CAPA-3D/CAPAm)
- Reflection Cracking Models
- Model Calibration and Validation

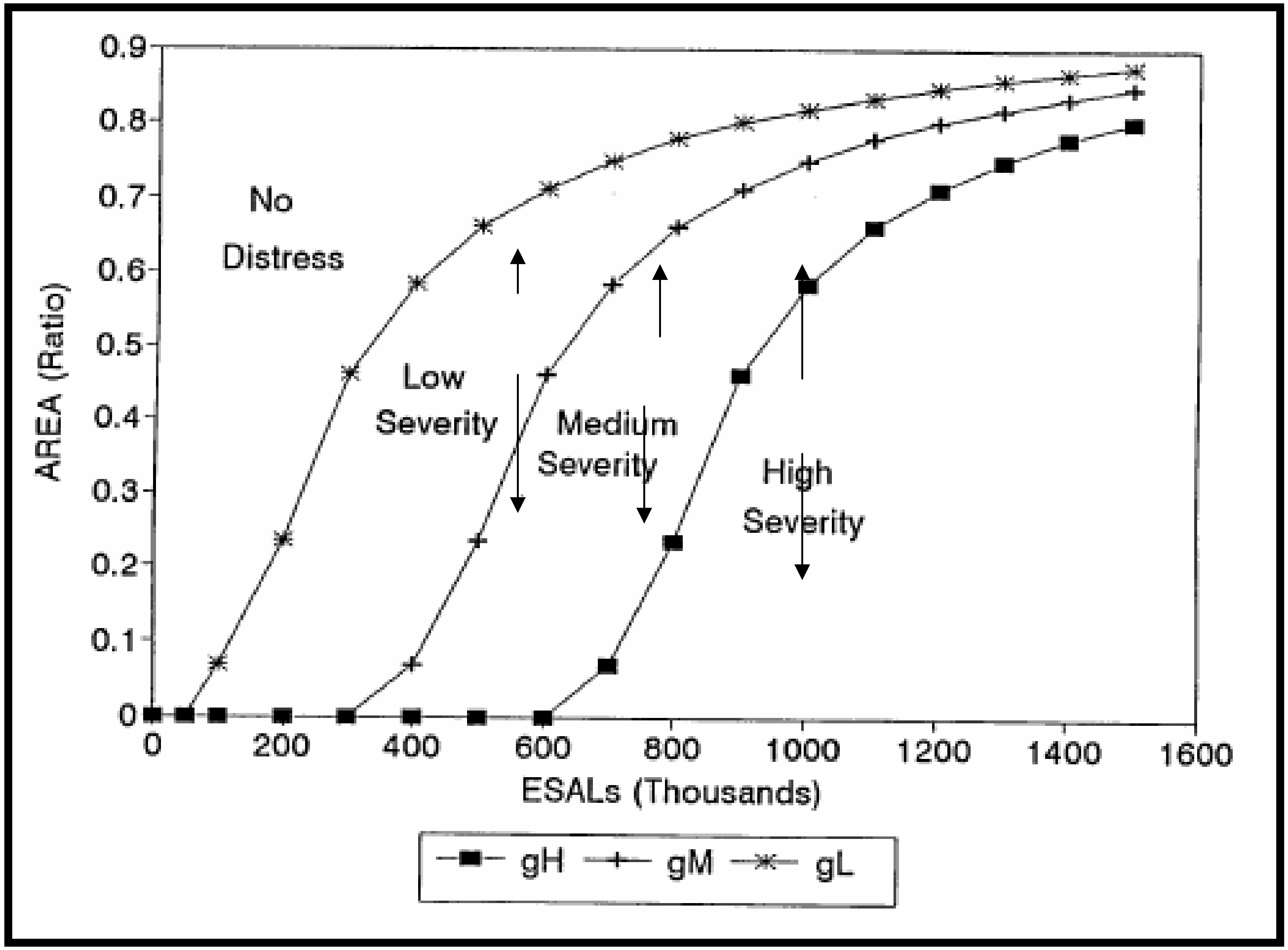
Reflection Cracking Modeling- Data for calibration and validation

- **Data have been collected from:**
  - **LTPP database**
  - **Texas reflection cracking studies**
  - **New York city – ARA reflection cracking study**

Table 20. Realistic AC Overlay Test Sections.

Category	Description	Total test sections	No. of test sections at each climatic zone			
			WF	DF	WNF	DNF
AC/OL	AC, then AC overlay	110	59	16	33	
AC/Mill/OL	AC, then Mill+AC Overlay	133	109			
CRC/OL	CRC, then AC Overlay	26	21			
JPC/OL + JRC/OL	JRC, then AC Overlay	55	54			
Total		19	15			

Figure 55. Pavement Distress vs. Number of Load Repetitions (*106*).



High Severity High+Medium Severity High+Medium+Low Severity

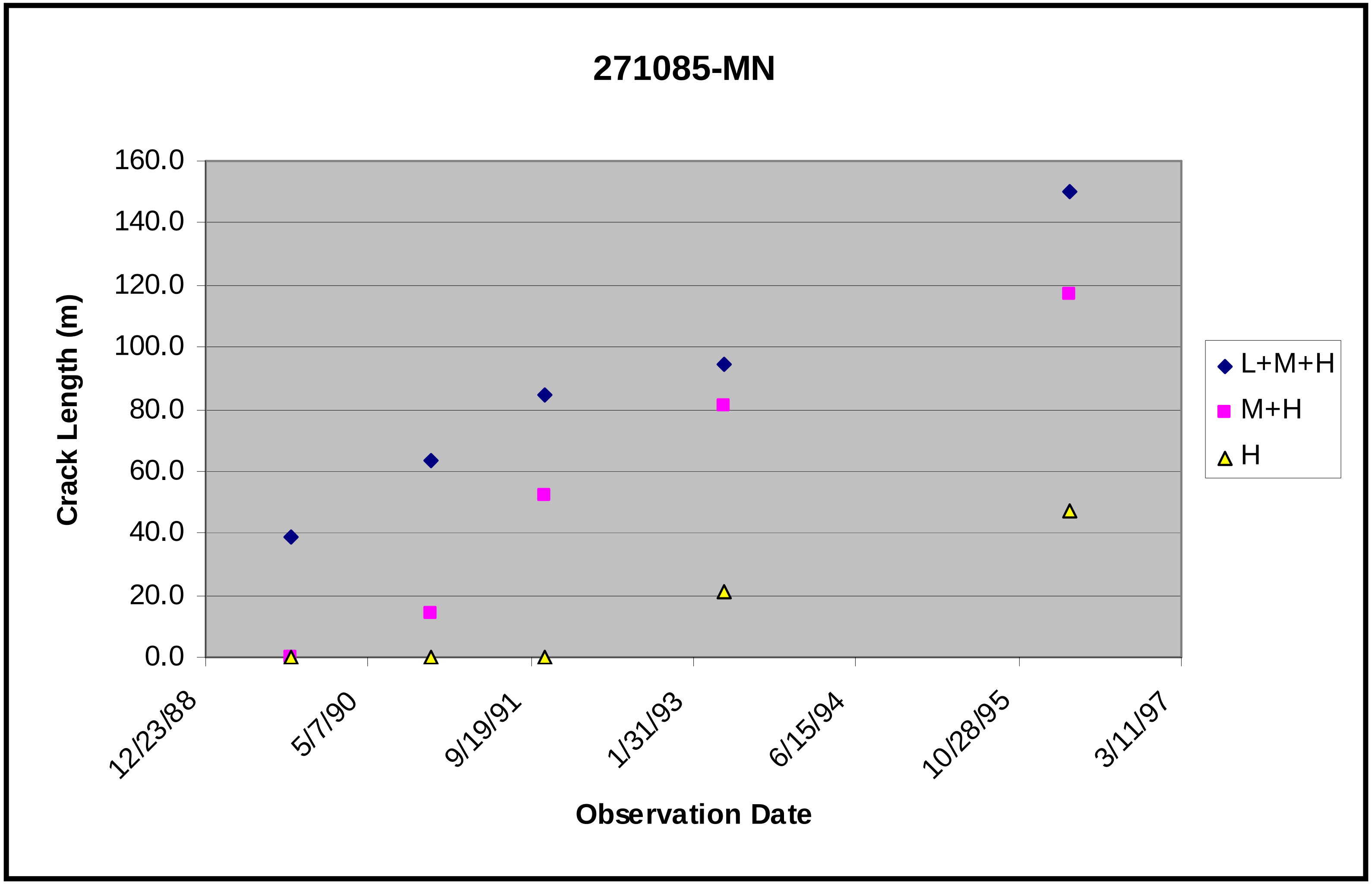


Figure 57. Reflection Cracking of AC/AC Overlay at WF Zone: Case 271085-MN.

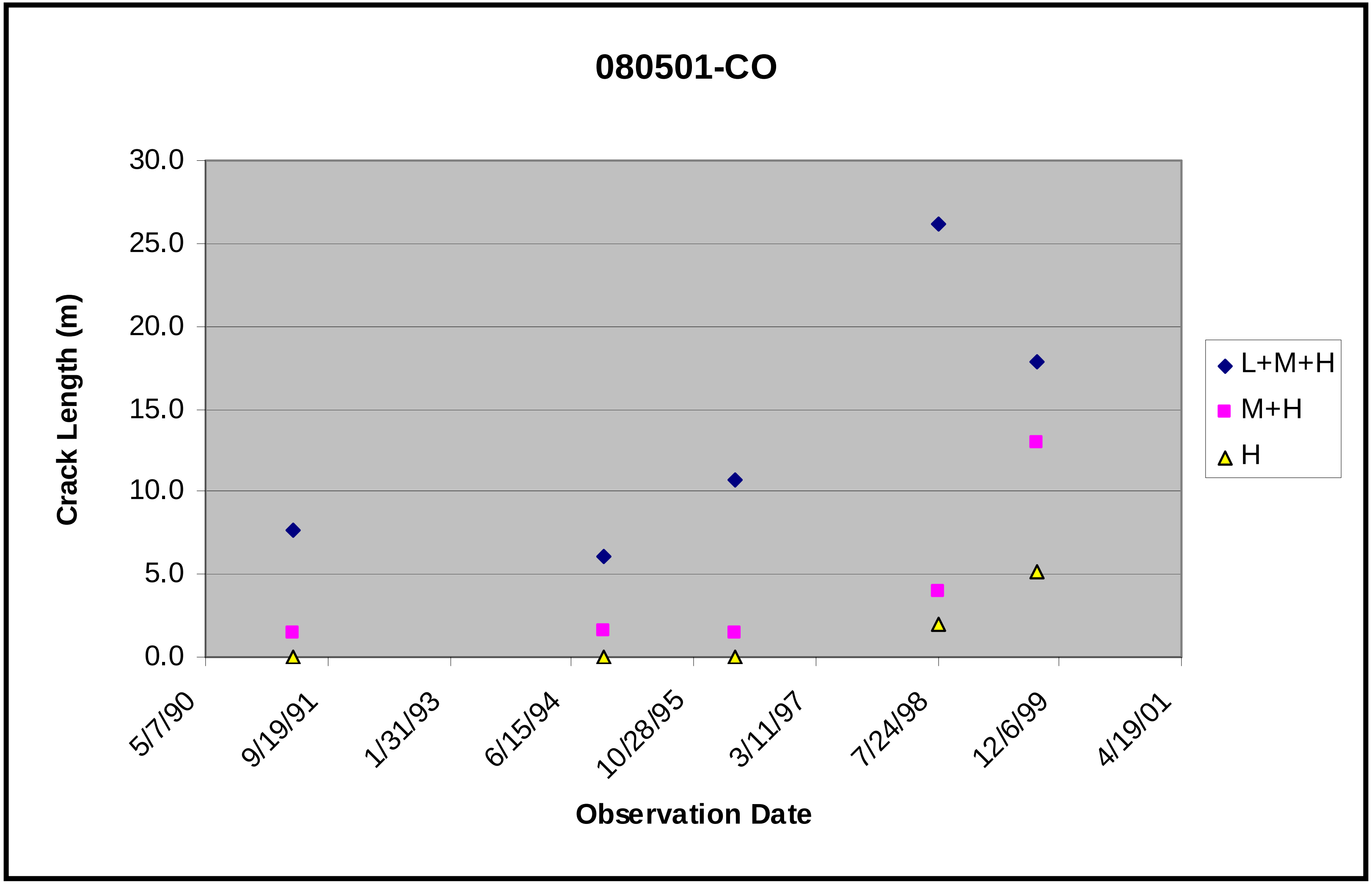


Figure 58. Reflection Cracking of AC/AC Overlay at DF Zone: Case 080501-CO.

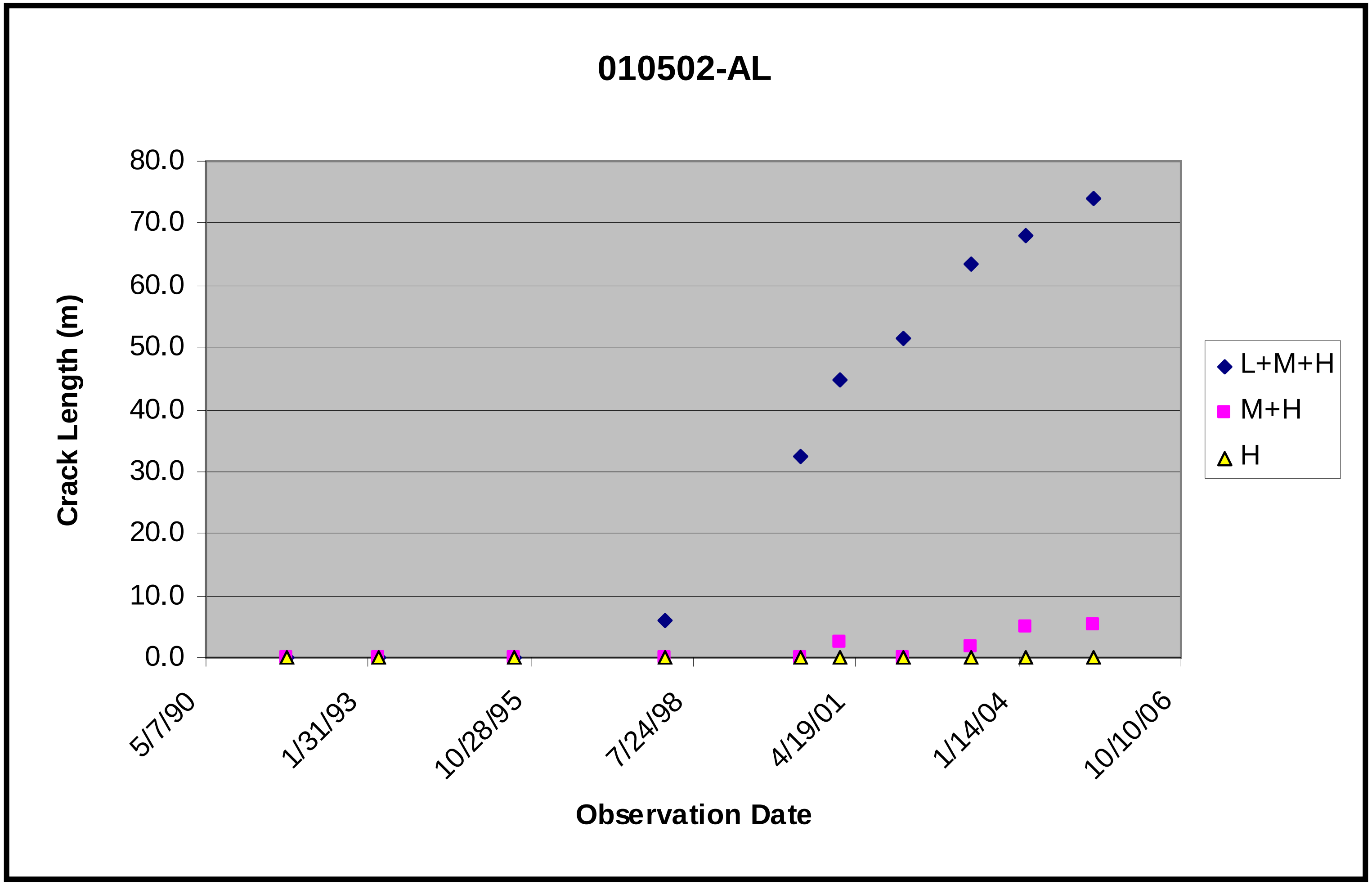


Figure 60. Reflection Cracking of AC/AC Overlay at WNF Zone: Case 010502-AL.

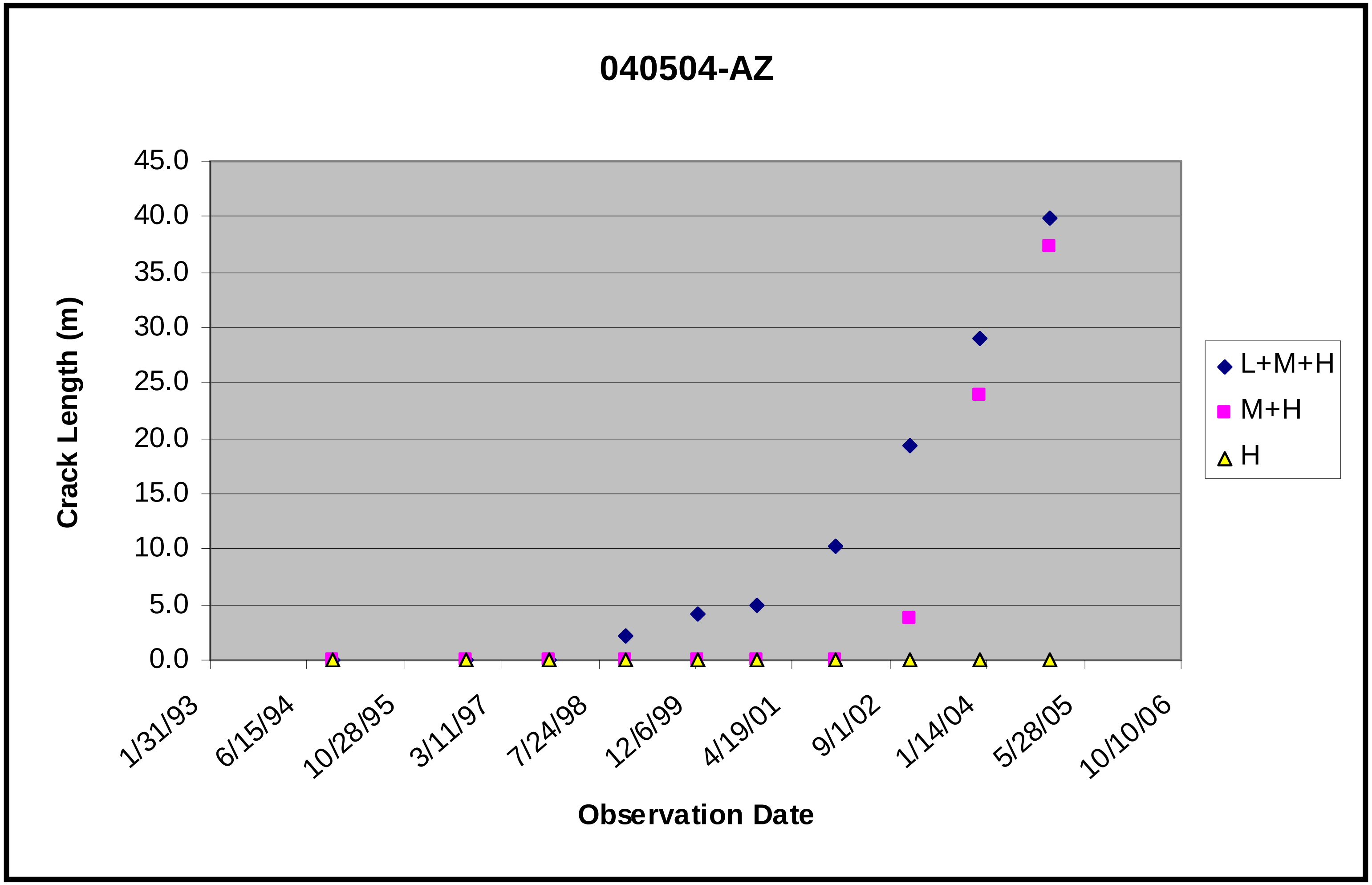


Figure 66. Reflection Cracking of AC/Mill/AC Overlay at DNF Zone: Case 040504-AZ.

Reflection Cracking Modeling- traffic input

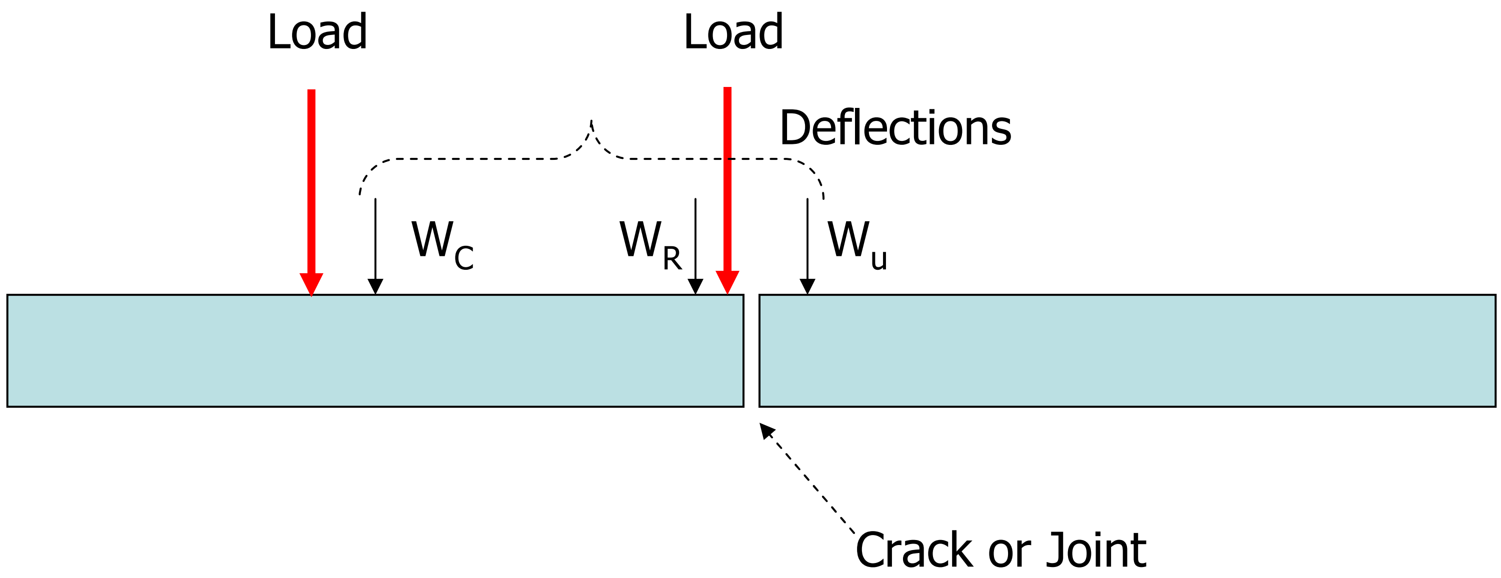
- Traffic input: as indicated previously, traffic input will be the same as the MEPDG. Reflection cracking subroutine program will directly use the MEPDG traffic summary results.
  - No. of single axle load
  - No. of tandem axles load
  - No. of tridem axles load
  - No. of quad axles load

Reflection Cracking Modeling-EICM

- EICM: Reflection cracking subroutine program will directly use the temperature data from ECIM of the MEPDG.
  - Monthly (or half monthly) temperature data for traffic load (bending and shear) reflection cracking
  - Daily temperature data for thermal reflection cracking

Reflection Cracking Modeling- Load transfer efficiency

- Deflection measurement: W_l, W_u, W_c



Reflection Cracking Modeling-Load transfer efficiency (cont'd)

- Load transfer efficiency (LTE):

$$LTE = \frac{W_u}{W_l}$$

- The shear and moment transfer efficiency ratios
  - For shear (p):

$$p = \frac{W_l}{W_l + W_u} = \frac{1}{1 + LTE}$$

  - For moment (f):

$$f = 2 - \frac{(W_u + W_l)}{2W_c} = 2 - \frac{1 + LTE}{2\left(\frac{W_c}{W_l}\right)}$$

Reflection Cracking Modeling-Load transfer efficiency (cont'd)

Ranges of Values of Load Transfer

	Good	Fair	Poor
LTE	0.8-1.0	0.6-0.8	0.0-0.6
Shear (p)	0.56-0.50	0.63-0.56	1.00-0.63
Moment (f)	0.8-1.0	0.67-0.80	0-0.67
Joint/Crack model	Interface Element with Normal and Shear Stiffnesses		

Reflection Cracking Mechanisms

- Three mechanisms of reflection cracking
  - Bending
  - Shearing
  - Thermal

} Load transfer affects these Stress Intensity Factors

Reflection Cracking Modeling- Fracture property of asphalt mixes (A and n)

- Fracture mechanics is necessary (Paris Fracture Model)

$$\frac{dc}{dN} = A(K)^n$$

- Laboratory Test Data (Delft)-Regression Equations

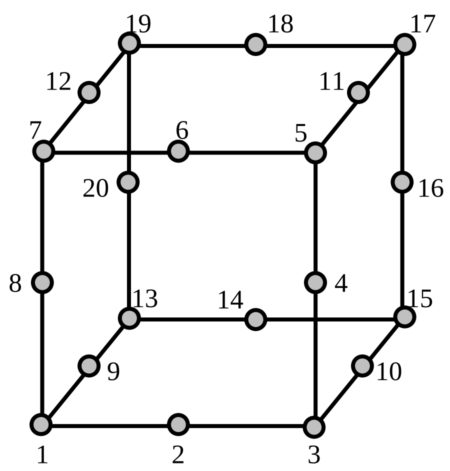
$$\log A = 4.830744 - 2.058768 \log|E^*| - 0.280849 n \log|E^*|$$

$$n = \frac{2}{m\left(0.541 + \frac{0.346}{m} - 0.03524 Va\right)}$$

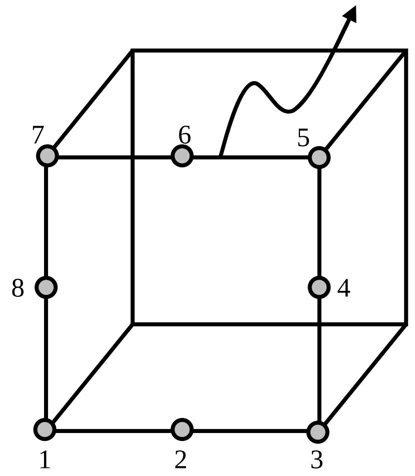
Reflection Cracking Modeling-

Pavement “Response” Model: (SIF and CAPA-3D/CAPAm)

- SIFs: thermal, bending and shear calculated by CAPA-3D/CAPAm.



CAPA-3D



CAPAm

Reflection Cracking Modeling- Calibration

- Reflection cracking model

$$N_f = N_{fT_1}(\alpha_1 - \alpha_2\left(\frac{N_{fT_1}}{N_{fS_1}}\right) - \alpha_3\left(\frac{N_{fT_1}}{N_{fB_1}}\right)) + N_{fT2}(\alpha_4 - \alpha_5\left(\frac{N_{fT_2}}{N_{fS_2}}\right))$$

- Damage model

$$D = \frac{\sum \Delta c}{h}$$

- Reflection cracking amount and severity model

$$RC = \frac{100}{1 + e^{(\alpha_6 + \alpha_7 \log D)}}$$

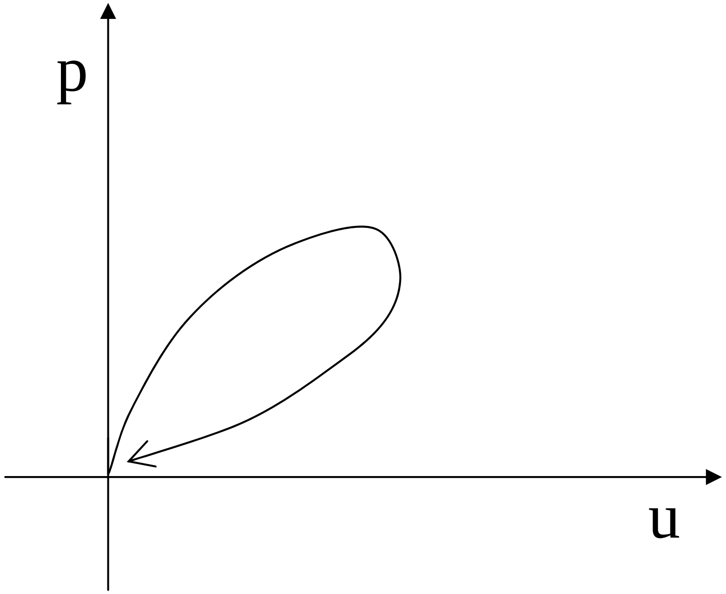
Reflection Cracking Modeling- Calibration (Cont'd)

- Calibration Process
  - 5 coefficients
    - Thermal – 2
    - Shear – 2
    - Bending – 1
  - 10 pavements with good data of all types use SID to determine the 5 coefficients for each climatic zone

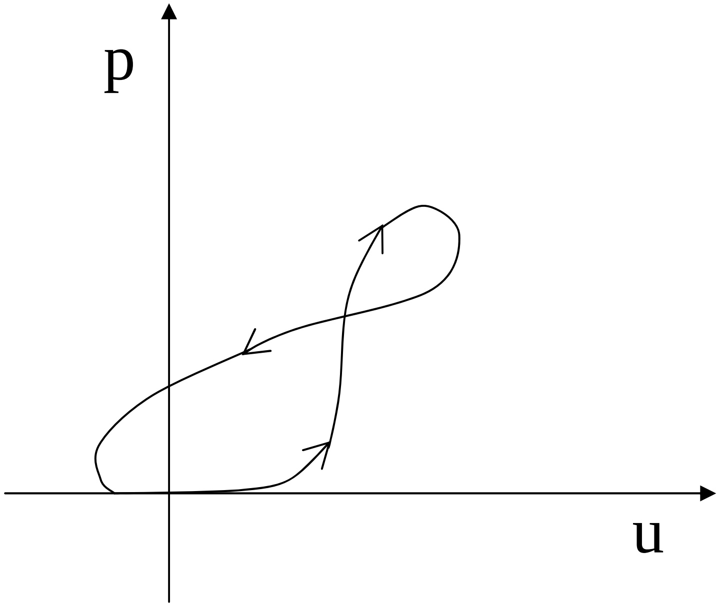
Reflection Cracking Modeling- Calibration (Cont'd)

- Interlayers will require a different set of calibration coefficients:
  - Reinforcement factor
  - Grids
  - Fabrics
  - Interlayers

Reflection Cracking (Cont'd)



Unreinforced



Reinforced

Reflection Cracking Modeling- Validation

- 10 pavements with good condition, structure, materials, and traffic data to use for validation
- Examples for SHRP A-005 using the same process
  - 48 pavement sections – 4 climatic zones, 12 pavements per zone
  - 24 pavement sections – 2 climatic zones, 12 pavements per zone

Reflection Cracking Modeling-
Data for calibration and validation

- Data have been collected from:
  - LTPP database
  - Texas reflection cracking studies
  - New York city – ARA reflection cracking study

Expected Model

- Fast.
- Based on current MEPDG parameter.
- Account for the three cracking mechanisms.
- Easy to calibrate locally.
- Easy to use in design.

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