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# Case Study Using *CalBack* –Backcalculation Tool for Caltrans ME Design

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# Outline

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- Background
- Case study objectives
- Site description / Field investigation
- CalBack
- Data analysis and results
- Concluding notes

# Background

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- Starting 1996 Caltrans has supported extensive research into developing ME design/analysis tools
  - increased computer performance capabilities
- New software tools will incorporate impact of
  - new materials
  - new construction technologies
  - increased traffic volumes and axle loading, various axle configurations
  - variable climatic conditions



# *Background*

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- Caltrans current design and rehab methods are based on empirical approaches on data collected in 1960s-1970s.
- Empirical procedures performed generally well, but are limited in ability to benefit from
  - emerging new products
  - construction practices
  - design innovations that optimize performance, minimize traffic interruptions, and costly M&R



# Background

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- Two major products - *CalME* and *CalBack*
- Programs will support engineers in design of new and rehab of existing flexible pavements and for performance analysis.
- *CalME* - ME design and analysis program for flexible pavements that parallels *MEPDG* and calibrated for California conditions.





# Case Study Objectives

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- Current field investigation techniques (FWD, material sampling, DCP etc.) used to provide inputs to newly developed ME design and analysis programs:
  - *CalBack* – backcalculation software
  - CalME – design and analysis tool of pavement performance



# Project Location

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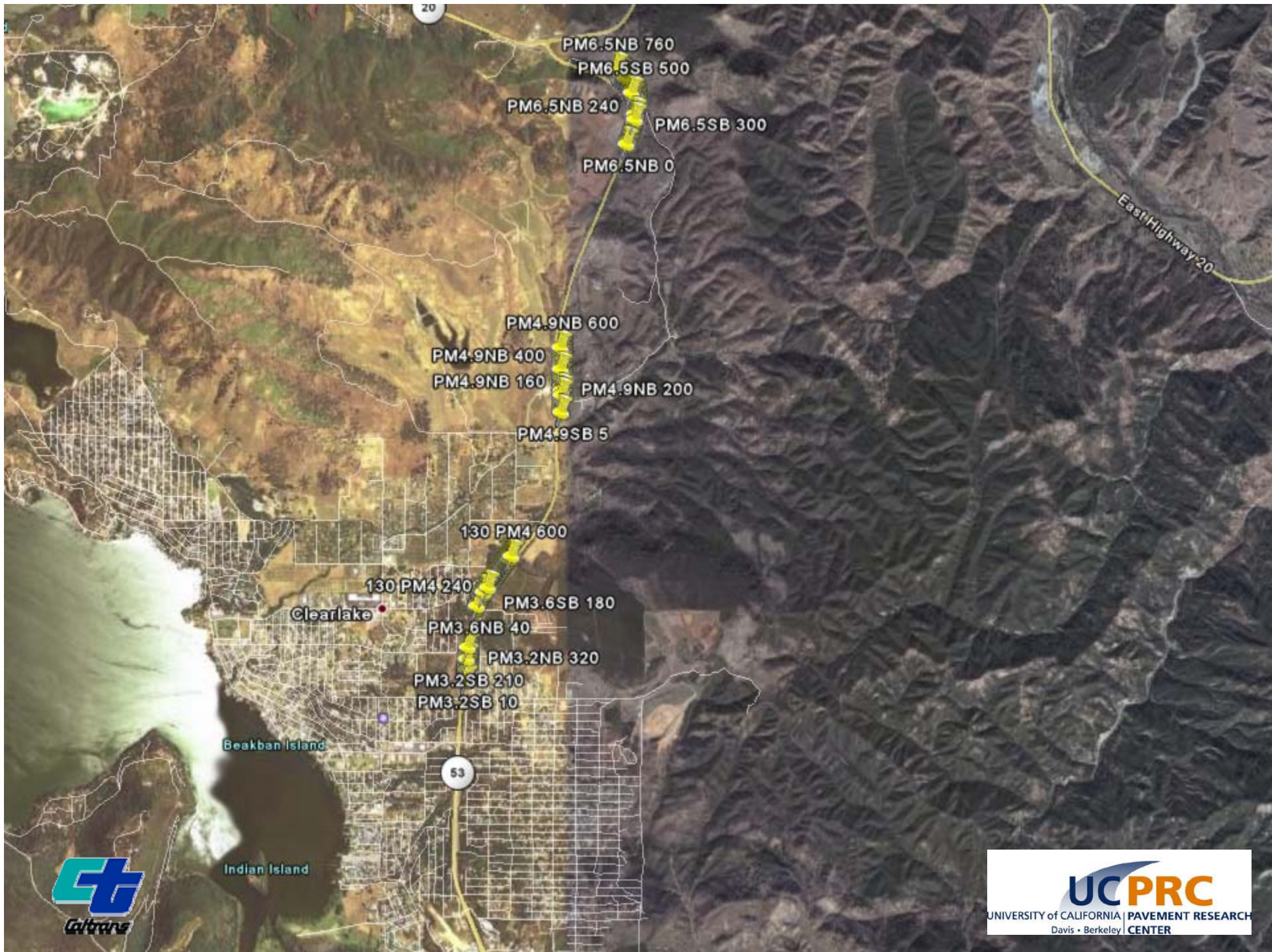
- ❑ Route 53, North of Napa
- ❑ 2 Lane highway, low mountain climate region
- ❑ Frequent changes in cross slope and grade
- ❑ Difficult to obtain closure at certain points along the profile
- ❑ Traffic characterized by commuter and truck traffic



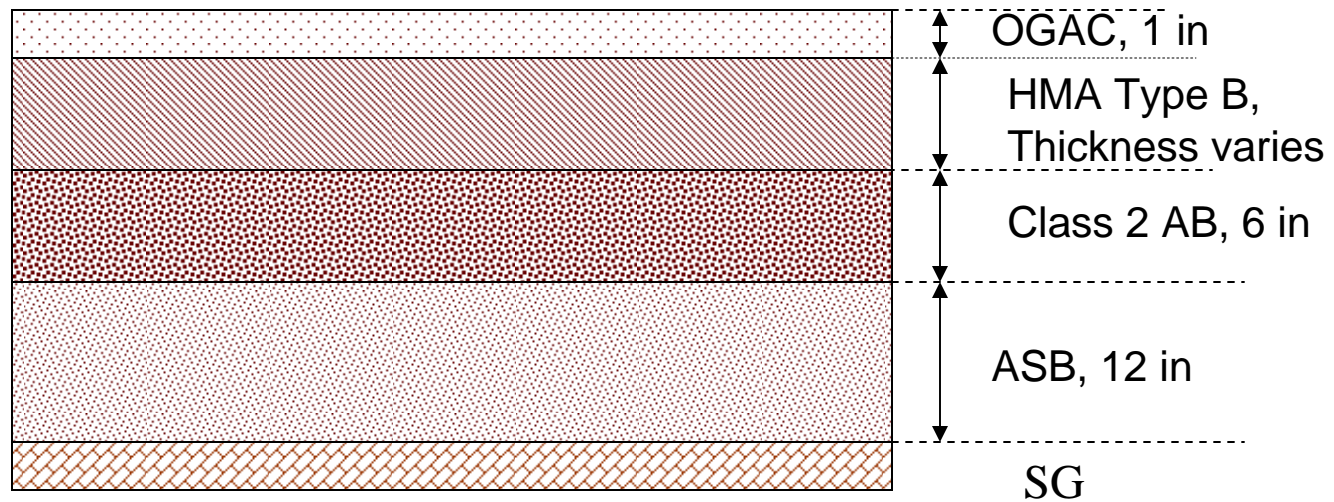
# Weather

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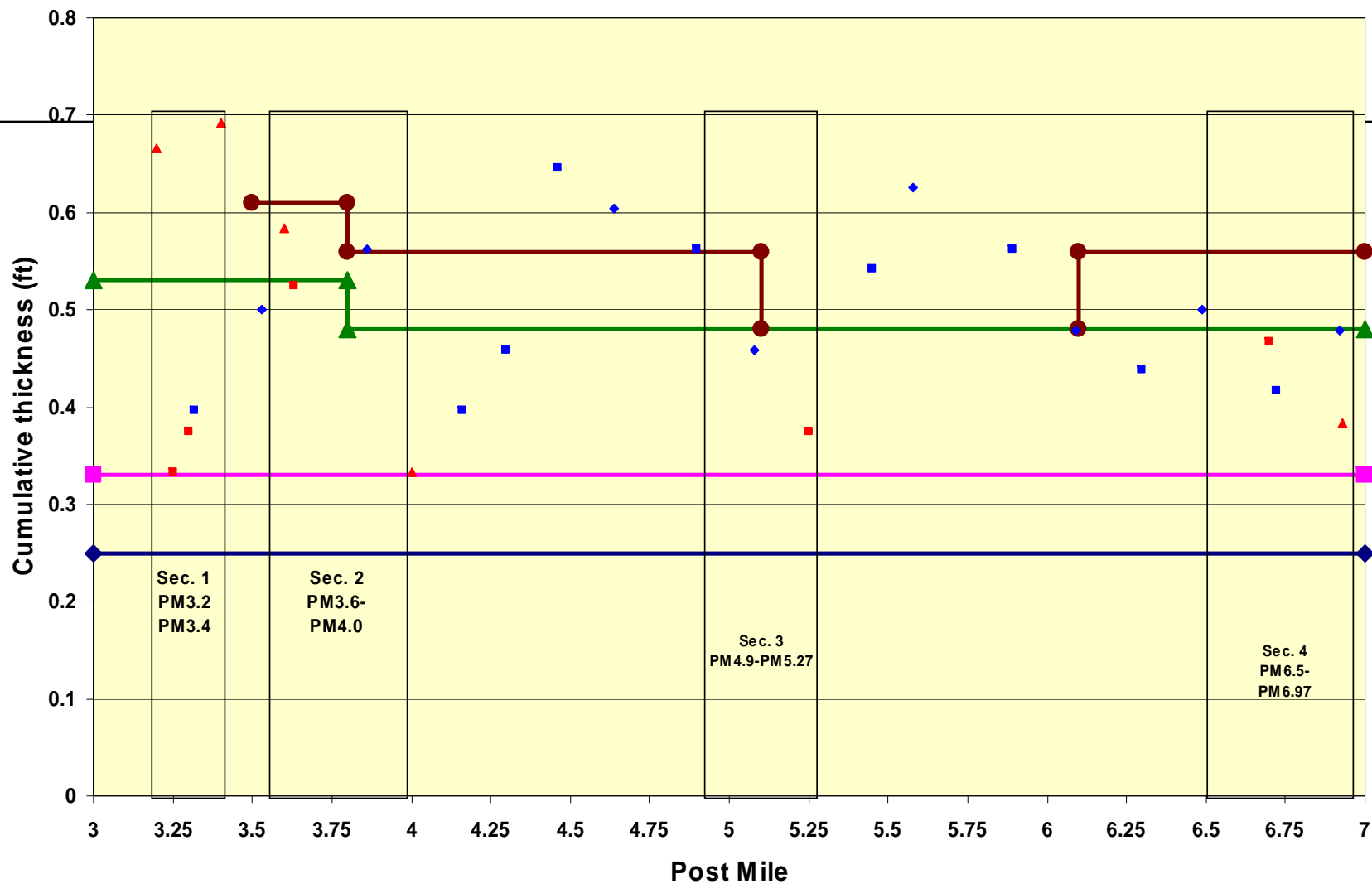
- Temperature:
  - Tmax = 104F (2009)
  - Tmin = 30F (2009)
- Precipitation – 21.75in (Jan 1-Oct 1, 2009)



# Pavement Structure (design plans)



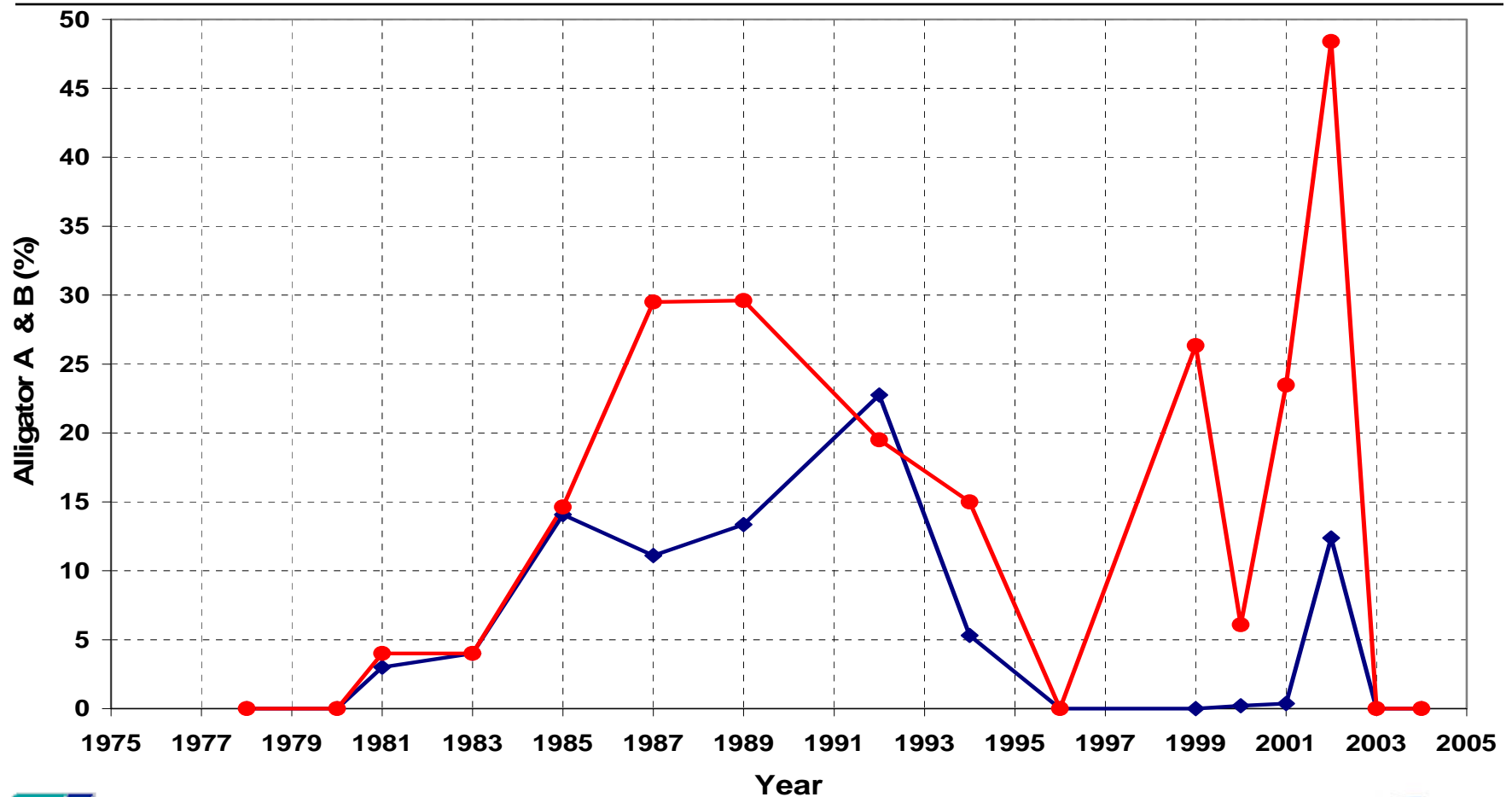
# Maintenance History



◆ 1956  
 ■ 1960  
 ▲ 1978  
 ● 1996  
 ■ SB CT Cores  
 ▲ SB UC Cores  
 ◆ NB CT Cores  
 ■ NB UC Core



# Pavement Condition



—◆— A —●— B



# Pavement condition

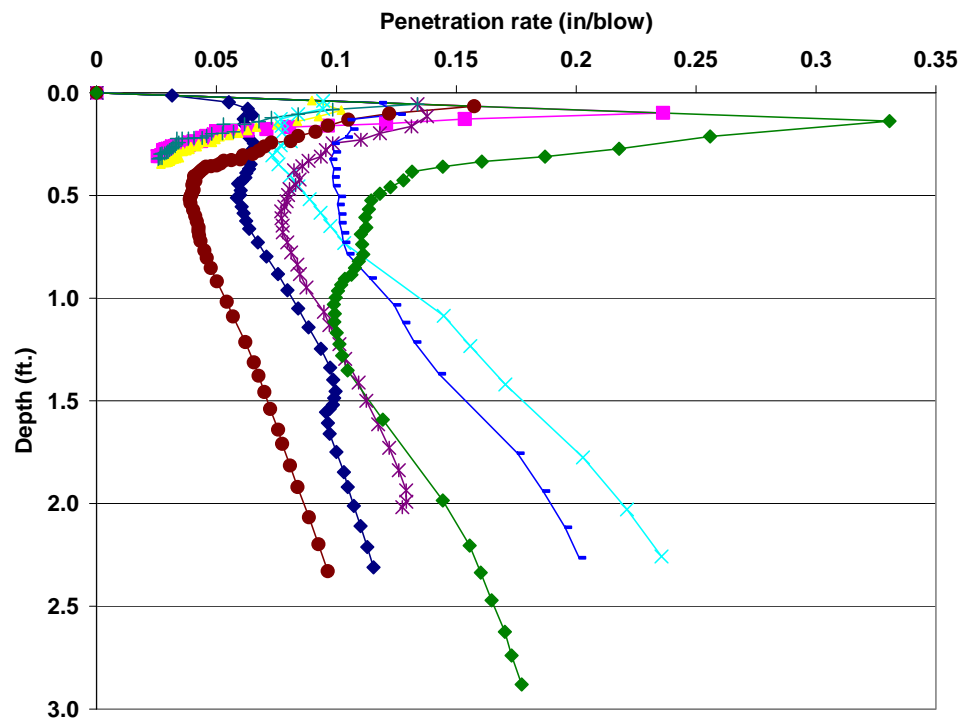
- Longitudinal fatigue and transverse thermal cracking reflected through the open graded course



# Pavement Coring



# DCP and Material Sampling



Station

- ◆ 17160 NB
- 17424 SB
- ▲ 17688 SB
- × 19166 NB
- \* 21120 SB
- 27720 NB
- 35376

- Avg  $E_{AB}$ (DCP) ~ 45,000 psi
- Base: Well Graded Gravel with Silty Clay and Sand (GW-GC)
- SG: Silty Clayey Sand (SC-SM)



# Deflection data

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- Three load levels (8000, 12,000, 20,000 lbs)
- One drop/load level
- Deflection testing staggered across the North and South sections
- Test point spacing: 20ft – 40ft (min 15 test points/section)

# Backcalculation Sub-Sections

Section	HMA thickness	AB thickness
A (North)	0.33 ft - 0.38 ft	1.0 ft
B (South)	0.58 ft – 0.69 ft	1.0 ft
C (North & South)	0.53 ft – 0.58 ft	1.0 ft
D (South)	0.56 ft – 0.58 ft	1.3 ft
E (North)	0.38 ft – 0.48 ft	1.15 ft
F (North & South)	0.38 ft – 0.48 ft	1.0 ft

# Backcalculation Analysis





# *CalBack*

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- ❑ Analyze flexible, rigid, and composite pavements;
- ❑ Automatically imports and analyzes data from FWD output files (JILS, Dynatest, Elmod database).
- ❑ Suspect data flagged and user is notified
- ❑ In one setting, can run an entire project comprising both flexible and rigid pavements
- ❑ Handles multiple deflection basins for long sections and allows division of pavement into “statistically similar” subsections for design purposes

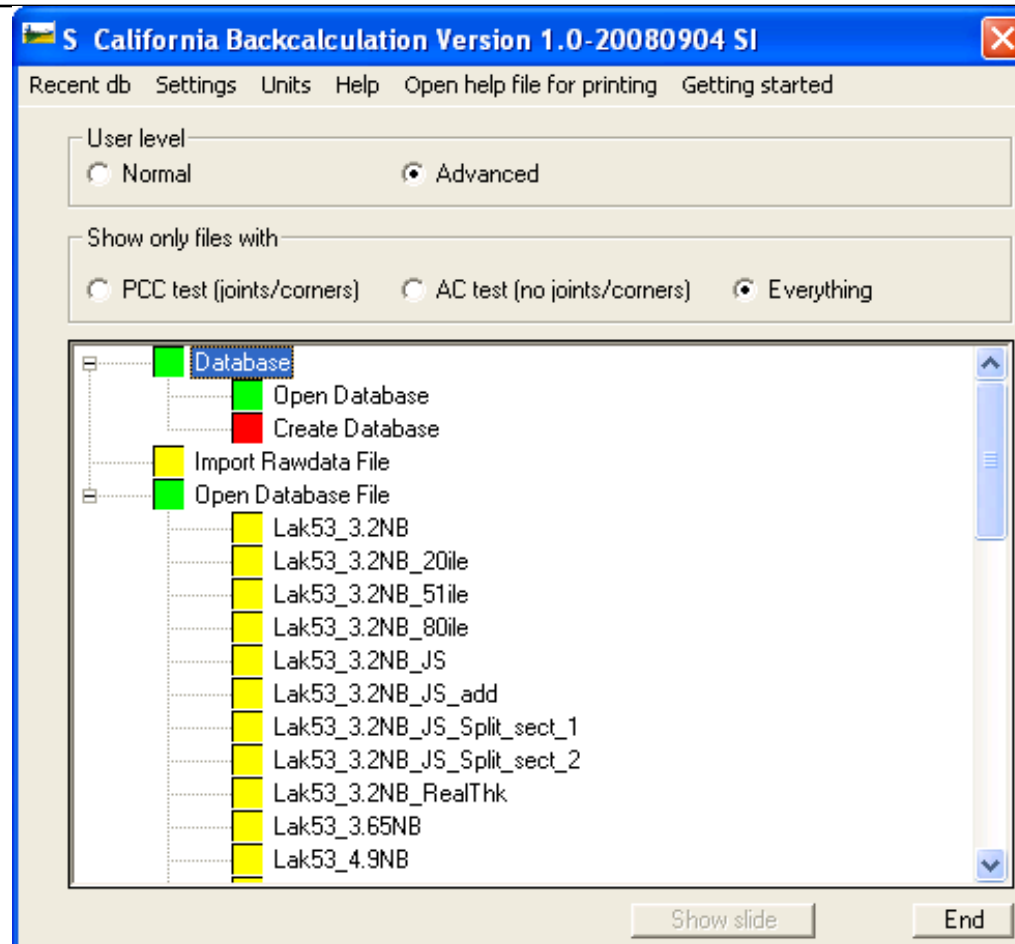




## *CalBack*

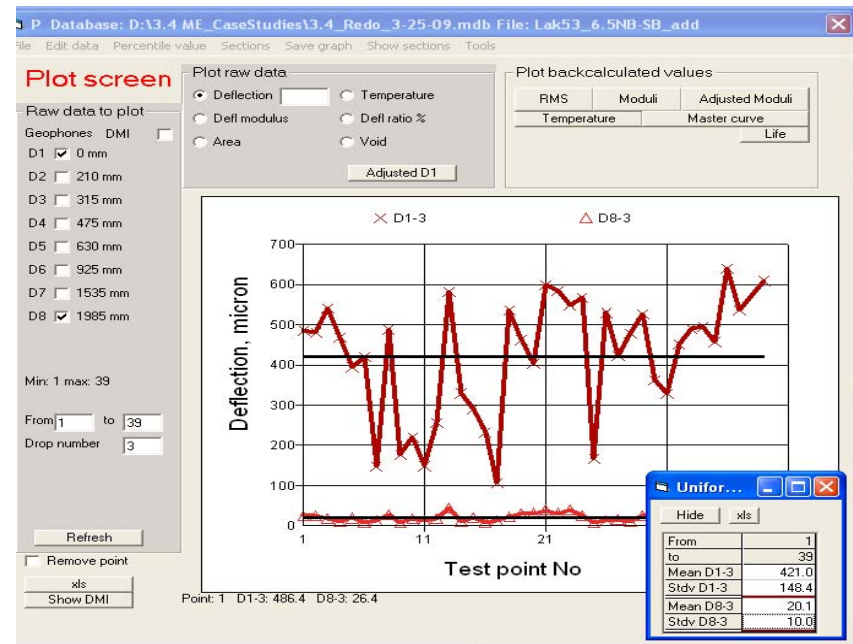
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- ❑ Runs under “normal” or “advanced” mode of analysis.
  - ❑ Contains “library” of extensively characterized materials
  - ❑ Expandable to allow further growth of materials library (real projects)
  - ❑ Remaining service life using AI-ME method (fatigue and rutting performance criteria).

# CalBack main screen



# Analyze imported data

- Allows division of the pavement into “statistically similar” subsections (cumulative difference method AASHTO 1993)



# Analysis criteria

**B Lak53\_6.5NB-SB\_add test point No. 3 of points 1 to 39 Temperature 12.6**

Settings Search parameters Bonding Tools Rules of thumb Hints

### Backcalculation screen

Structural information

Layer	Material type	h mm	E MPa	Ei/Ei+1	Seeds
1	DGAC_Lak53_3-25-09	135	5998.0	✓	5998.0
2	AB-Class 2	300	227.30	✓	227.3
3	SM	0	58.50	✓	58.5
4					
5					

C = 47.87 Store as seed values n = -0.47 Bedrock

Work with test point No. 3

Present station 40 Use drop No 3 Use only first 7 geophones

**Calculate Deflection** **Select Test Point**

Fit basin without saving **Next point** **Previous**

Save moduli for this basin Delete this test point

Work with multiple basins

From test point 1 to test point 39

**Fit and save basins**

Conditions

Saved values as seeds Remove settings from this point all points

Output

RMS relative (%) 2.98 RMS absolute 6.17

Show calculated deflections

Hide graphs Export results to Excel xls summary

Measured Calculated

### Select material 1

Remove layer  
Insert layer

- AB Eref: 210.0 MPa
- AB-Class 2 Eref: 210.0 MPa
- AB-Class 3 Eref: 210.0 MPa
- ACB Type A Eref: 10755.6 MPa
- ACB Type B Eref: 10755.6 MPa
- AS Eref: 210.0 MPa
- AS-Class 1 Eref: 210.0 MPa
- AS-Class 2 Eref: 210.0 MPa
- AS-Class 3 Eref: 210.0 MPa
- AS-Class 4 Eref: 210.0 MPa
- AS-Class 5 Eref: 210.0 MPa
- Asphalt Eref: 10755.6 MPa

### Search Parameters

Search engine

Use Gradient search

Use Kalman filter

Use Genetic search

Response model

Use O-B

Use WES

Use LEAP

Gradient search

Steps 3

Width 3

Alternate 1

Minimize relative difference (%)

n from tail

Get n from tail

3 deflections

2 deflections

**OK**

# CalBack

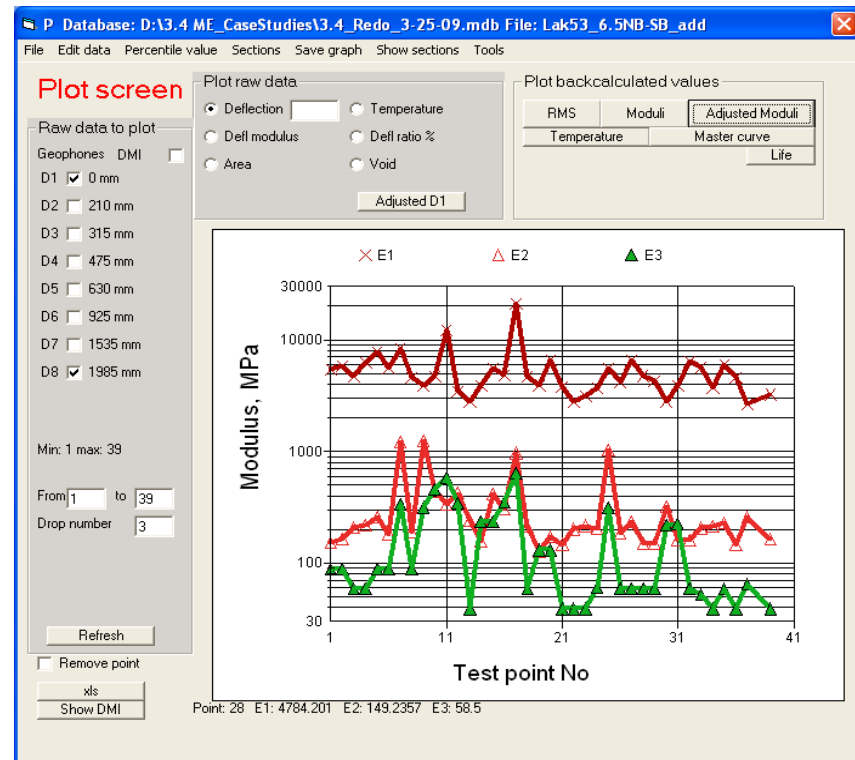
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- Three search engines to determine material moduli:
  - Gradient search (default)
  - Kalman filter
  - Genetic algorithm
- Three response models for analysis of flexible pavements:
  - Odemark-Boussinesq (Ullidtz 1998) (default)
  - WESLEA (Van Cauwelaert et al. 1989)
  - LEAP (Symplectic Engr. Corp. 2004)
- Analysis of PCC pavements based on Westergaard equations
- A maximum of five layers can be defined including SG
- Allows modeling non-linear subgrade material

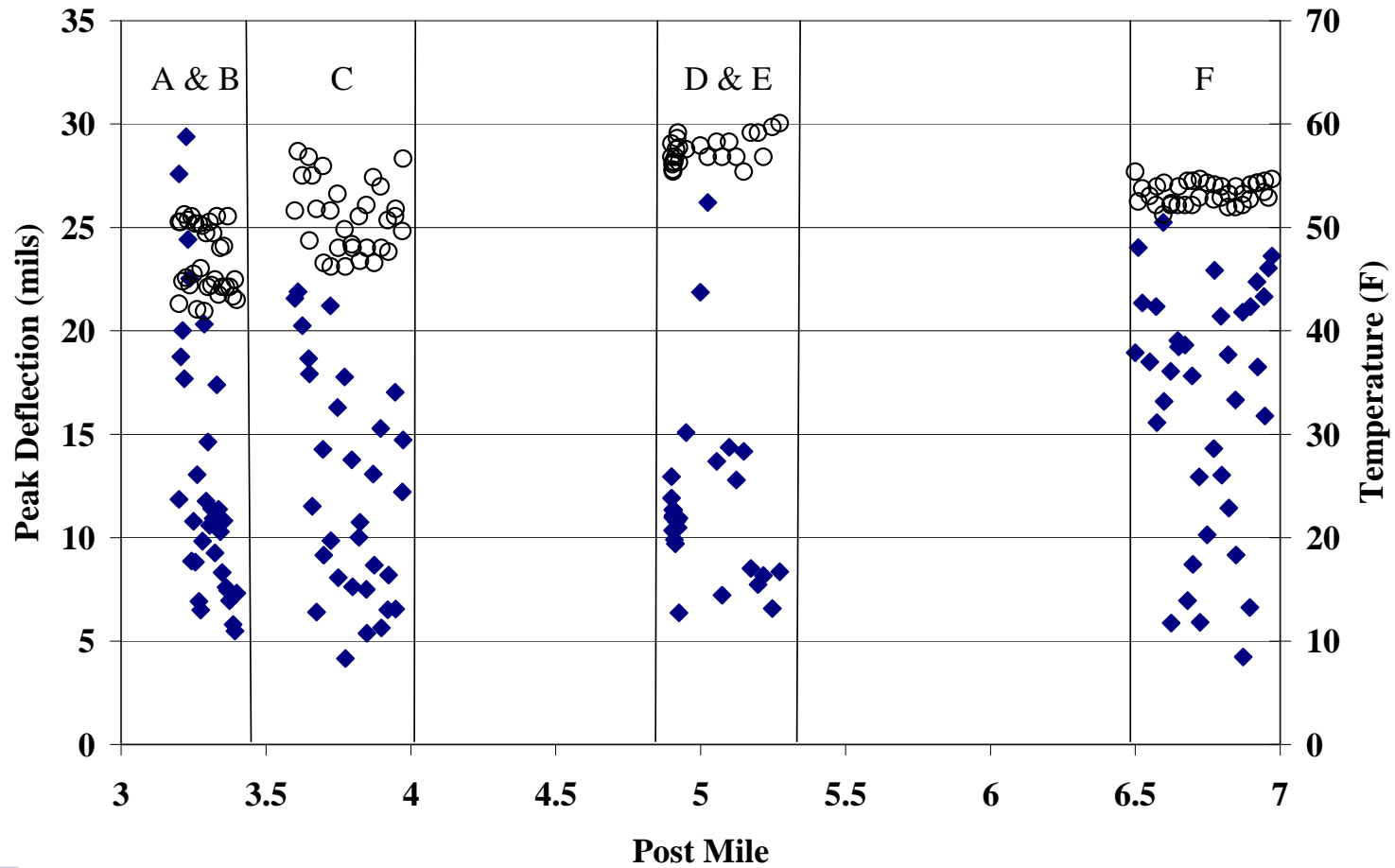


# Review results

- Layer temperature calculated from measured surface temperature using BELLS equation. (Stubstad et al. 1994 and ASTM standard D7228-06a)
- Uses master curve parameters and BELLS temperature to calculate (adjusted) modulus of each pavement layer at a reference temperature, and (unadjusted) moduli at actual temperature



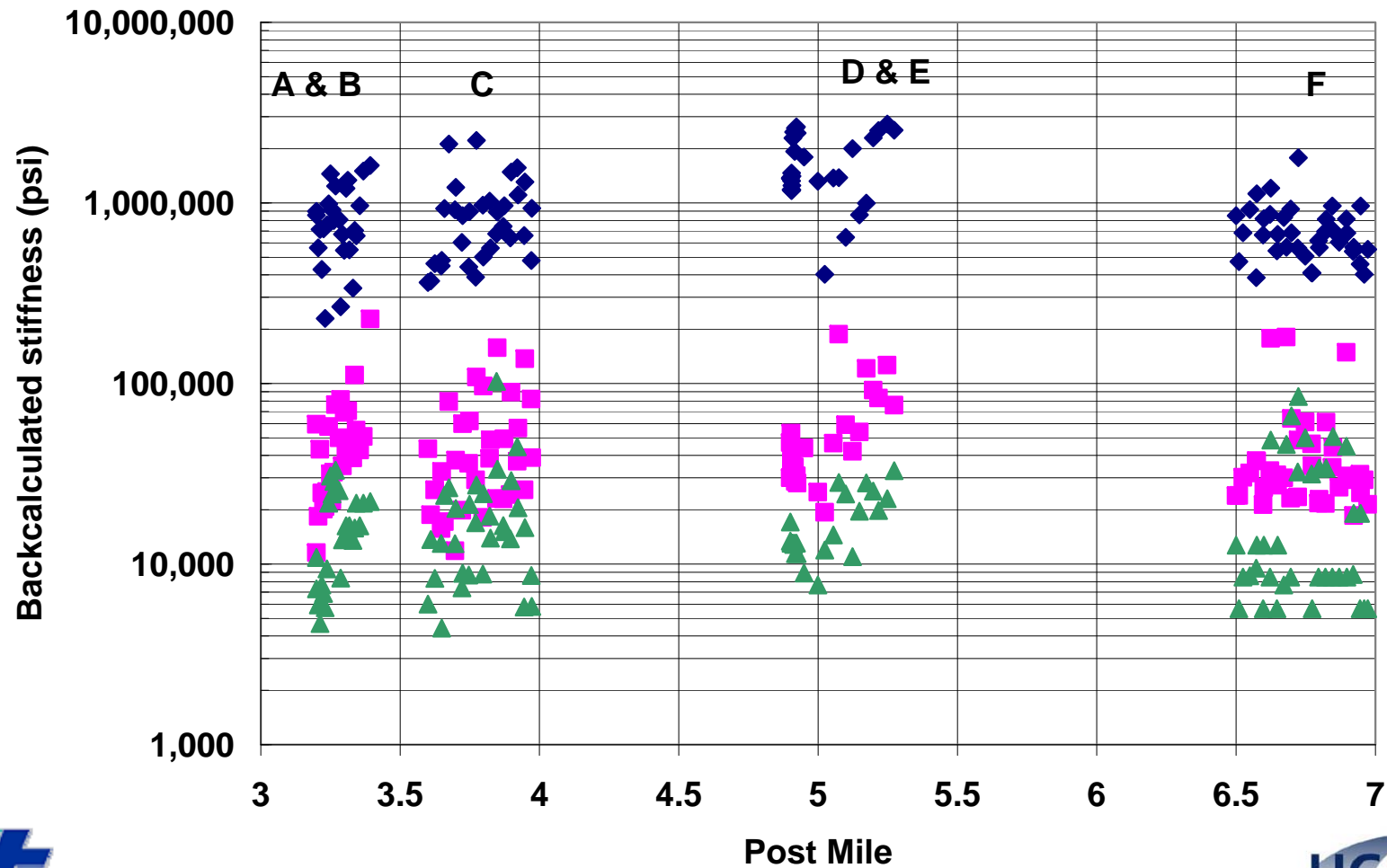
# Deflection data



◆ Deflection ○ Surface Temperature



# Backcalculation Results



◆ HMA    ■ AB    ▲ SG



# Summary results

Section	Section Length (ft.)	Existing Section (backcalculation inputs)				Average Backcalc. Stiffness (temperature corrected)		
		HMA Thickness (ft.)	AB Thickness (ft.)	80th % Defl. (mils)	FWD Avg Air Temp (F)	HMA psi	AB psi	SG psi
North A	1050	0.36	1.0	20	44	814,400	49,600	14,150
South B	1017	0.62	1.0	16.2	50	848,200	54,200	17,300
C (North + South)	1968	0.56	1.0	16.8	51	877,600	49,800	19,200
South D	131	0.57	1.3	11.4	56	1,292,000	38,000	13,500
North E	1968	0.41	1.2	17.1	57	1,215,000	64,500	16,800
F (North + South)	2493	0.44	1.0	21.5	53	719,000	43,300	20,700

# Concluding notes

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- Next step: analyze different rehabilitation options (20 year design life)
- Use CalME with inputs from CalBack (backcalculated moduli), EICM and traffic
  - To check performance of designs based on Caltrans standard design methods
  - To optimize design solutions (analyze performance if new materials are used)



# Concluding notes

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- *CalBack*-versatile backcalculation application
  - Multiple data input/output methods
  - Several analytical modeling methods
  - Numerous user performance options
- *CalBack* and CalME - software to help design engineers incorporate:
  - impact of new products,
  - new construction technologies,
  - increased traffic volumes/axle loading & various axle configurations
  - variable climatic conditions



# Acknowledgements

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# References

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- Popescu, L., Signore J., Steven, B., Harvey, J., Wu, R., Guada, I.; “Rehabilitation design for 439 01-LAK-53, PM 3.1/6.9 using Caltrans ME Design Tools: Findings and Recommendations”
- Lu, Q., Signore, J., Ullidtz, P., Basheer, I., Ghuzlan, K.; “*CalBack*: new backcalculation software for Caltrans mechanistic-empirical design”

