Heavy Duty Pavement Design Using CalME

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Master Class
New Directions Heavy Duty Pavement Design
Wednesday 1 pm

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UCPRC
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Caltrans context for heavy duty pavement design

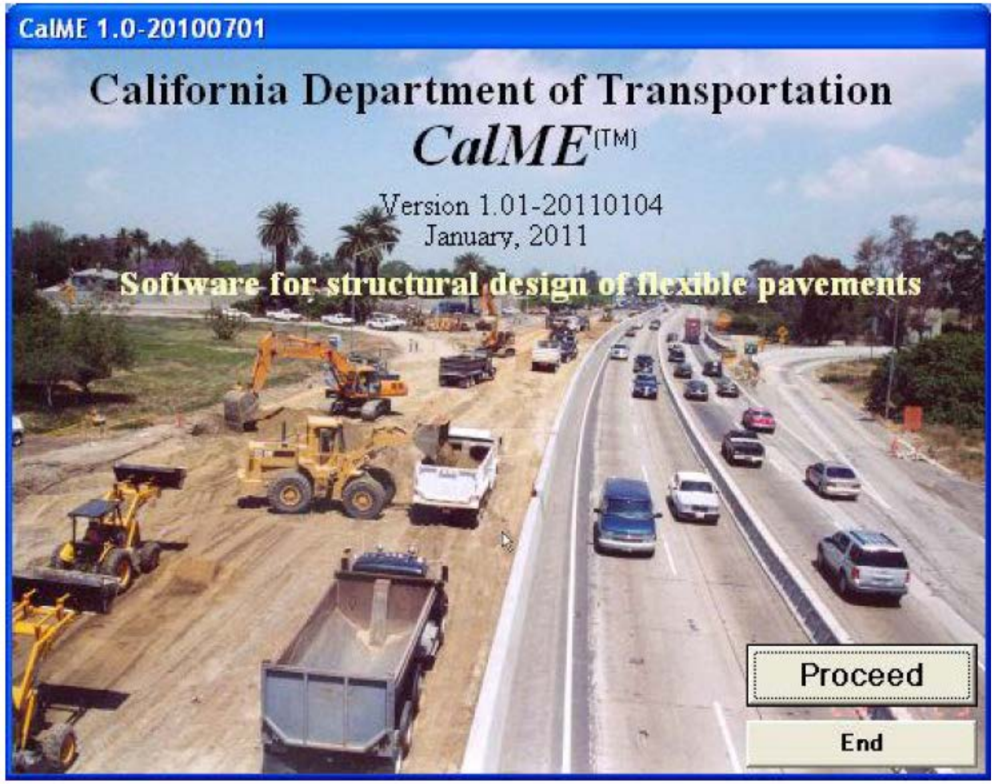
- Old pavement
  - 1/3 concrete pavement, urban high-volume freeways, 30-50 years old
  - 2/3 asphalt surfaced: composite, semi-rigid, full-depth and conventional flexible structures, original structures 20-90 years old
- 90 % of work is overlays, crack PCC/seat/overlay, mill & overlay, recycling, reconstruction

Drivers for Heavy Duty Design Method

- Cost and Constructability
  - Urban reconstruction, rehabilitation, preservation work done at night, 55 hour weekends, or 24/7 closures
  - Rural projects have more time
  - Need thinner structures to carry same load, to get faster construction, reduced cost
- Materials
  - PMB and RHMA surfaces
  - High RAP contents
  - Varying bitumen supplies
  - Performance related specs
- Consider construction compaction and variability

CalME Overview

- Introduced in 2006
- Focus on heavy duty rehabilitation and preservation
- Incremental – Recursive approach
  - Simulation runs one increment of axle loads/temperatures at a time (4 hour period of one day per month)
  - Calculates damage and permanent deformation
  - Adjusted stiffnesses are used as input for the next increment
  - Calculations continued through simulation of entire life of pavement
  - Can include simulation of pavement preservation treatments



CalME Overview

- Response calculation engines
  - Layer elastic calculations of critical stresses, strains
  - Regression models for reflection cracking strains
- Damage models
  - Asphalt fatigue damage
  - Asphalt permanent shear strain
  - Cemented soil fatigue, crushing
  - Full-depth reclamation damage (foamed asphalt done, cemented, engineered emulsion in progress)
  - Cold In-Place Recycling damage
- Distress models
  - Asphalt fatigue cracking
  - Asphalt rutting
  - Unbound layers rutting

CalME Overview

- Aging and rest period models for asphalt
- Transfer functions, shift factors calibration:
  - 27 original Heavy Vehicle Simulator (HVS) test sections
  - 26 Westrack sections; NCAT, MnROAD, CEDEX track validation
  - 4 California field sections
- Monte Carlo simulation for reliability
  - Within project variability
  - Uses FWD back-calculated stiffnesses for variability of existing layers

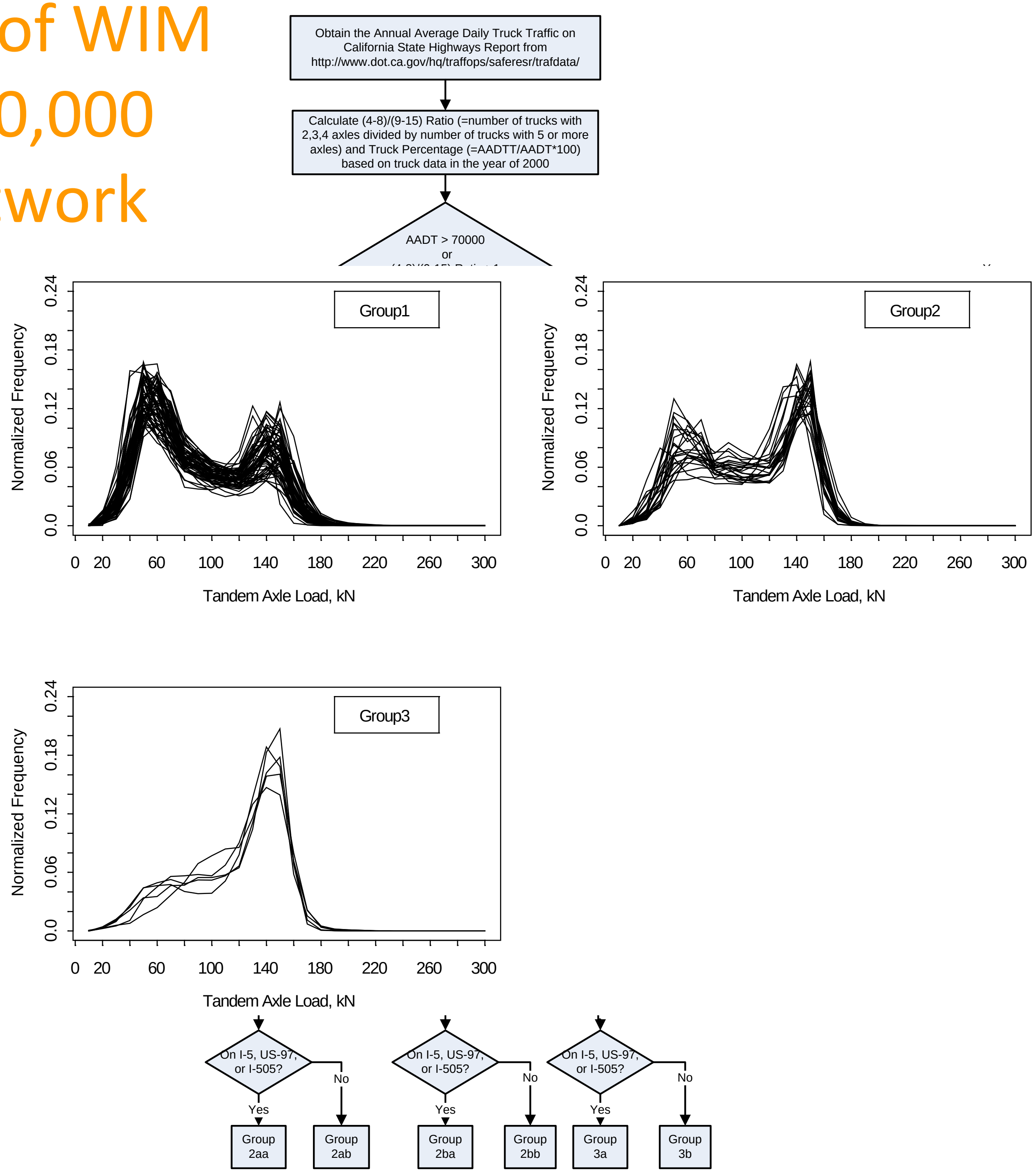
- Sensitivity analysis for between project/contractor

CalME Model Framework

- Mechanistic models
  - Linear elastic solid mechanics:
    Openpave layer elastic, Odemark-Boussinesq,
  - For calculating the primary response (stress, strain, displacement)
- Empirical models
  - Relating the calculated response to pavement performance (fatigue damage, cracking, rutting)
- Both components must be verified against reality in two step process using APT data

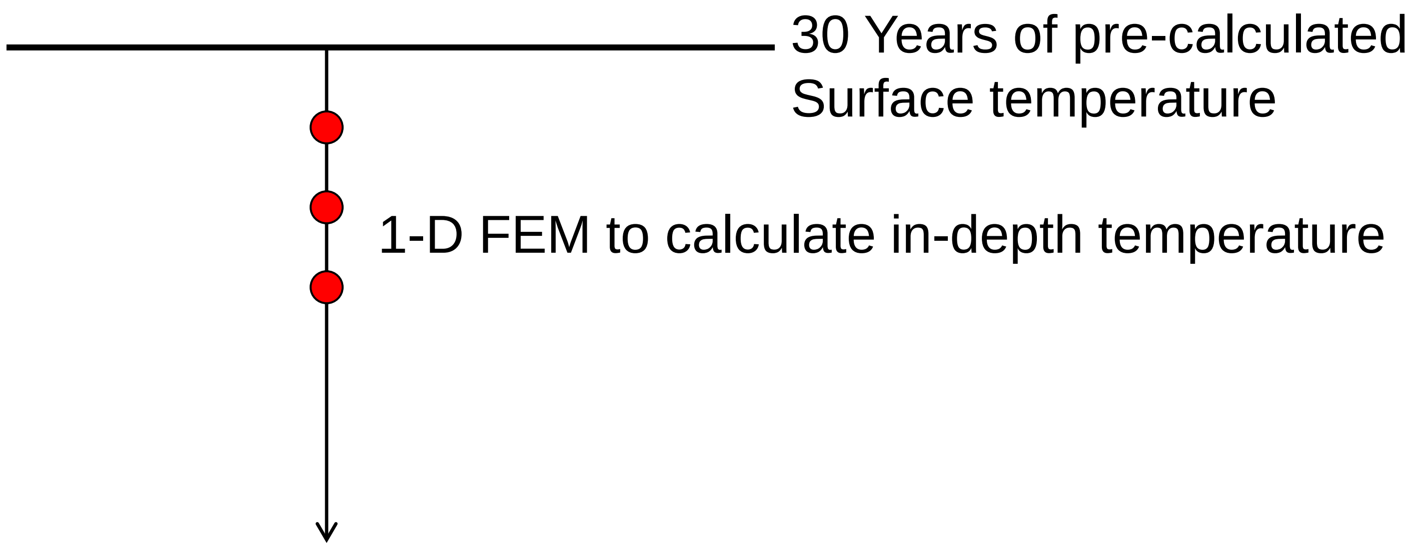
Extrapolation of WIM spectra to 80,000 lane-km network

- Excellent WIM data since 1995
- 115 stations
- Assignment tree uses truck classification data to estimate axle load spectra for every km of entire state network



Pavement Temperature

- California is divided into six climate zones
- 30-year hourly surface temperature database developed based on EICM climate model runs
- In-depth temperatures calculated with 1-D FEM on the fly for every hour and different years

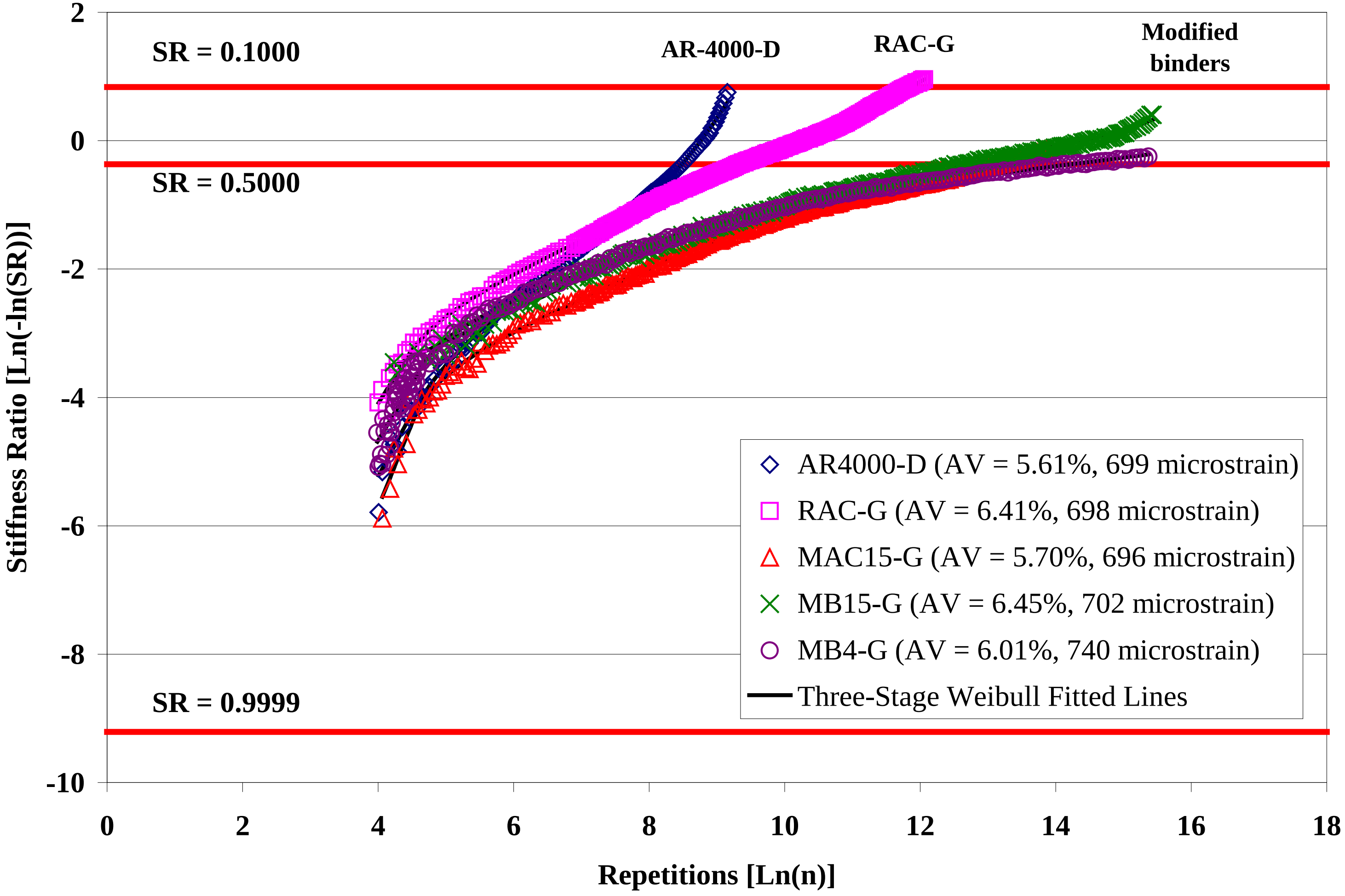


Incremental-Recursive Process vs Linear Sum of Cycles

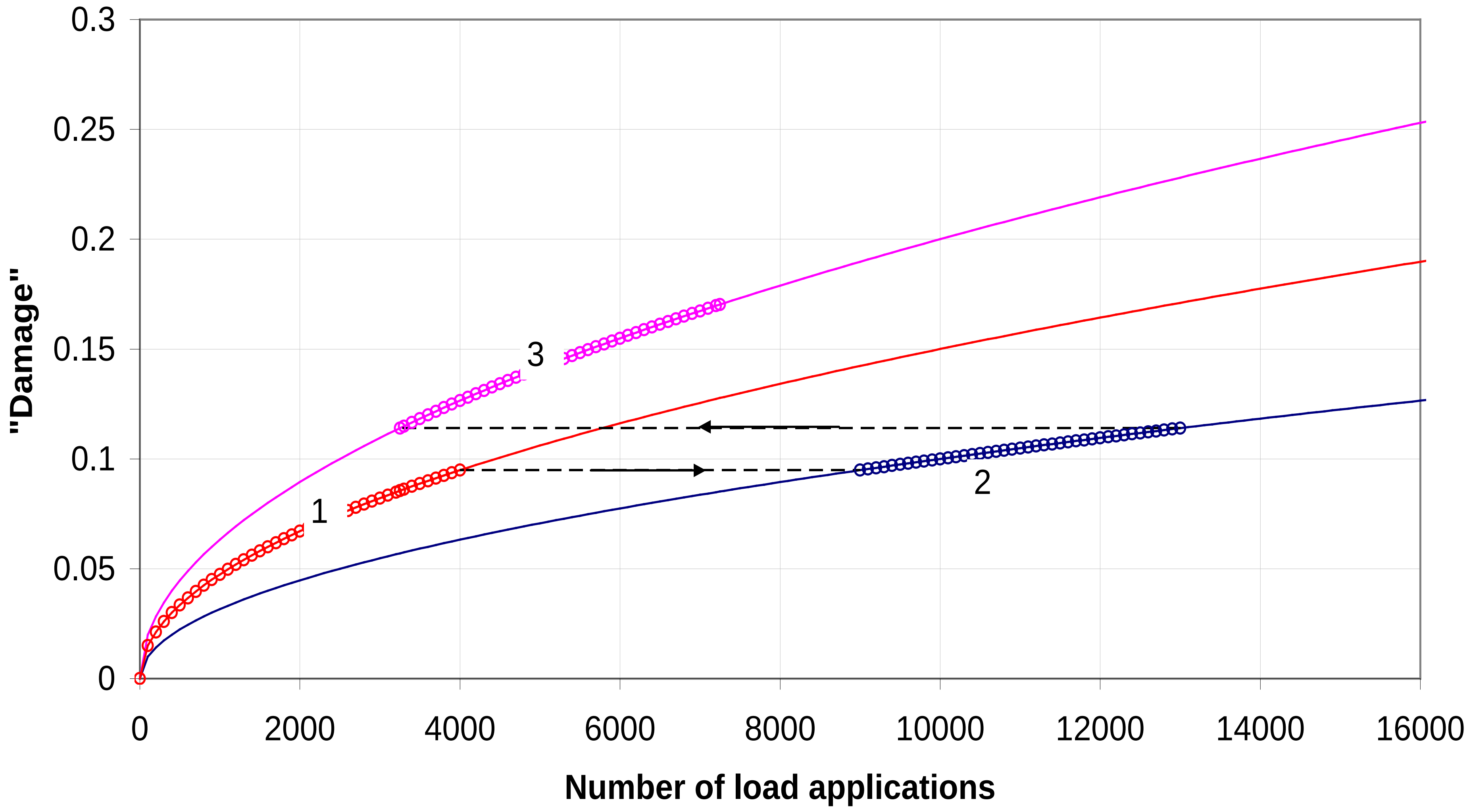
- Using: Incremental-recursive
  - Characterize material in terms of entire damage process from start to end for different strain/stress/temperature levels
  - Simulate damage process each step of entire life
  - Correlation of damage to distress
  - Calibrate using data from entire damage process
- Not Using: Linear sum of cycles (Miner's Law)
  - Characterize material in terms of repetitions to failure (distress) for different strain/stress/temp levels for first year
  - Sum up damage as $n_{actual}/N_{failure}$
  - Calibrate initial state and final distress state

Incremental-Recursive: Use Entire Damage Process from Lab Characterization Test

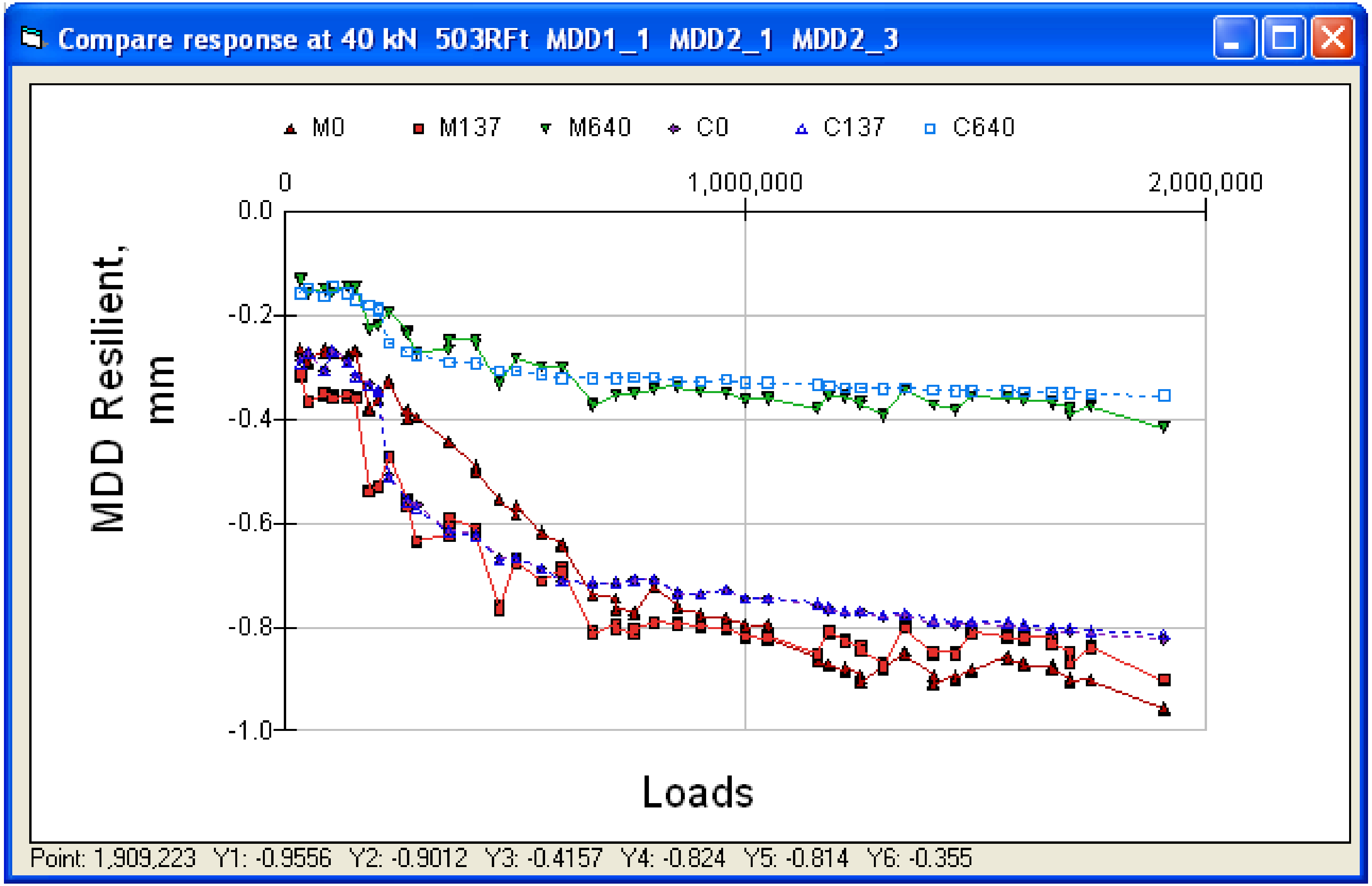
- Example for asphalt fatigue shown
- Considers damage and crack propagation in test



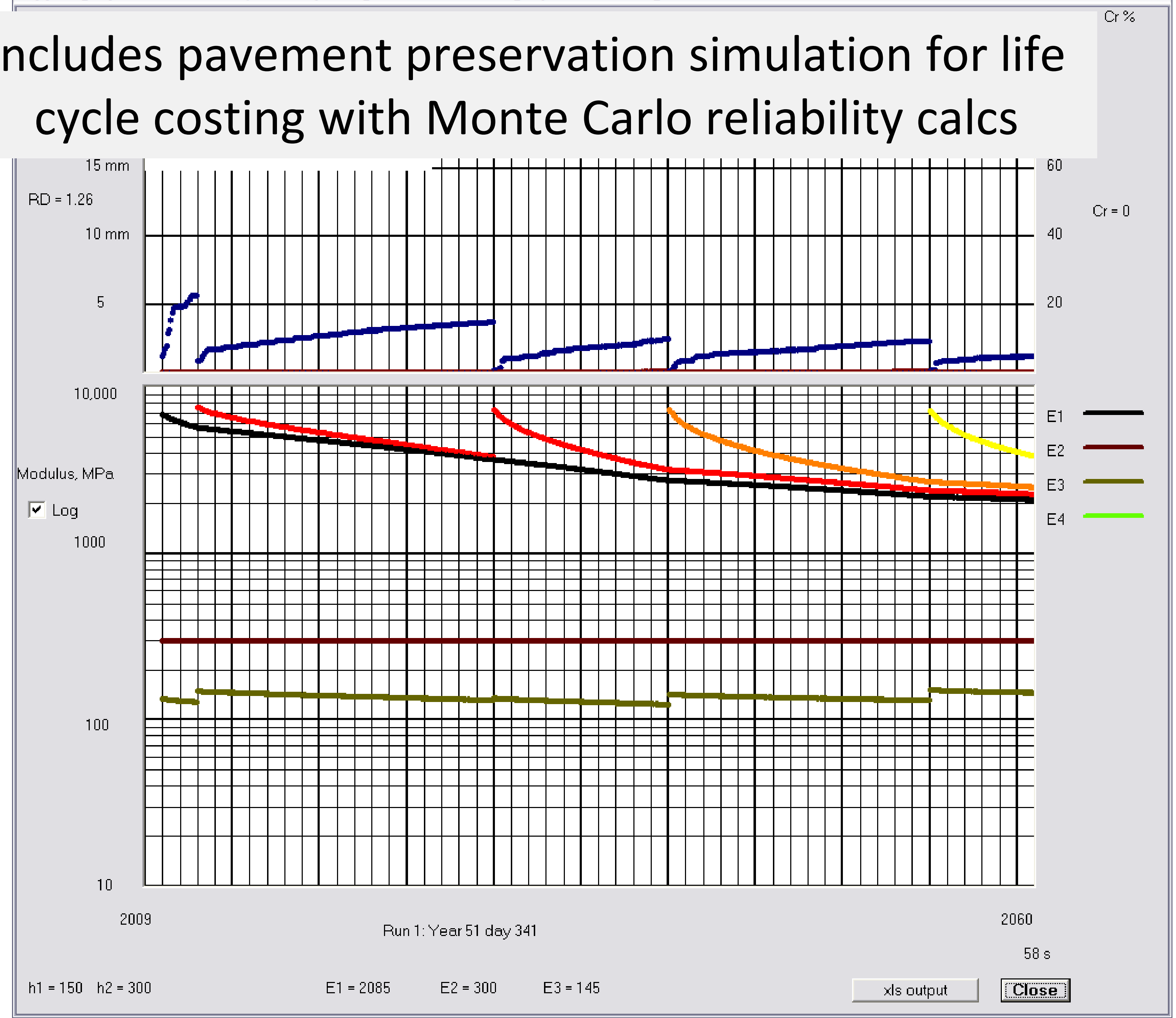
Stepping through time: Time hardening process



Calibration using entire damage process not just end state of percent of wheelpath cracked



Includes pavement preservation simulation for life cycle costing with Monte Carlo reliability calcs



Use to Date and Next Steps

- Use to Date:
  - California
    - Official state design method for flexible surfaces as of 2013, training and implementation underway
    - Major issue: lab testing capability for performance related specs
    - Used on 3 long life rehab/reconstruct Interstate projects in last 4 years, 40 year design lives, approximately $100M total work
  - Approx. 20 evaluation, teaching and APT use licenses; Skanska use in design/build projects in Sweden and eastern Europe
- Improvements for late 2016
  - Web based version
  - Fatigue, stiffness, rutting data for high RAP Superpave mixes
  - Improved models for <u>aging</u>, consideration of <u>thixotropy (rest periods)</u>, stabilized full-depth reclamation
  - Initial models for consideration of interlayers, raveling

References: technical reports

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- Calibration of the CalME Rutting Model Using 2000 NCAT Data
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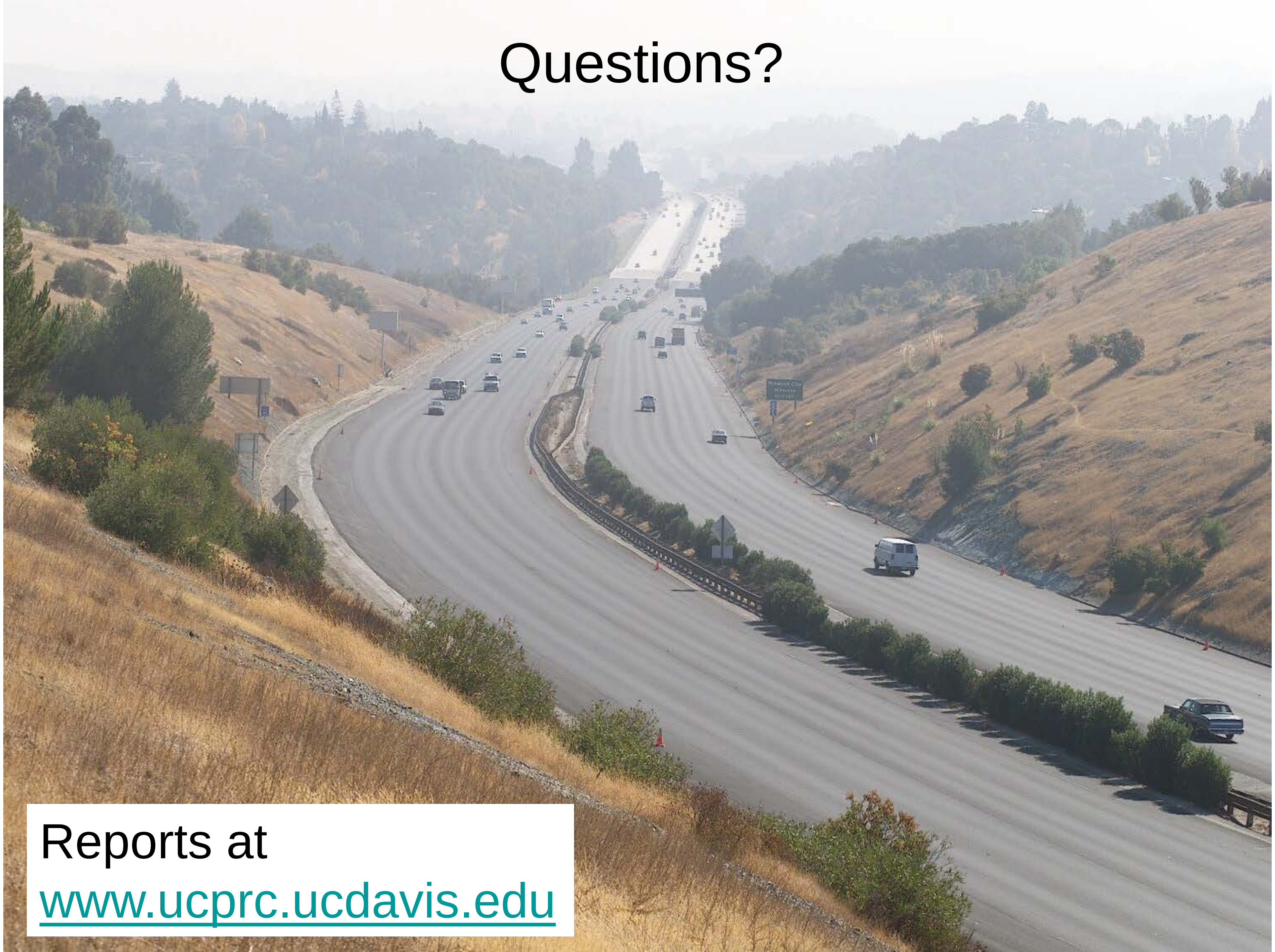
Questions?



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