OPTIMIZING DESIGN USING AASHTO PAVEMENT ME

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Arizona Pavement and Materials Conference
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OUTLINE

1. AASHTO Pavement ME

2. How to Establish Inputs

3. Optimize the Design

PAVEMENT ME IS THE MOST ADVANCED DESIGN PROCEDURE

Covers a wide range of applications, including nearly all new & rehabilitation options
Can account of new and diverse materials and various failure mechanisms

New Pavement

- **Asphalt Concrete (AC)**
- **Jointed Plain Concrete Pavement (JPCP)**
- **Continuously Reinforced Concrete Pavement (CRCP)**
- **Semi-Rigid Pavement**

Overlays

- **AC over AC (w/ & w/o seal coat/interlayer)**
- **AC over Semi-Rigid**
- **AC over JPCP (w/ & w/o fracture)**
- **AC over CRCP**
- **Bonded PCC over JPCP**
- **Bonded PCC over CRCP**
- **Unbound PCC over JPCP**
- **Unbound PCC over CRCP**
- **JPCP over AC**
- **CRCP over AC**
- **SJPCP over AC**

Restoration

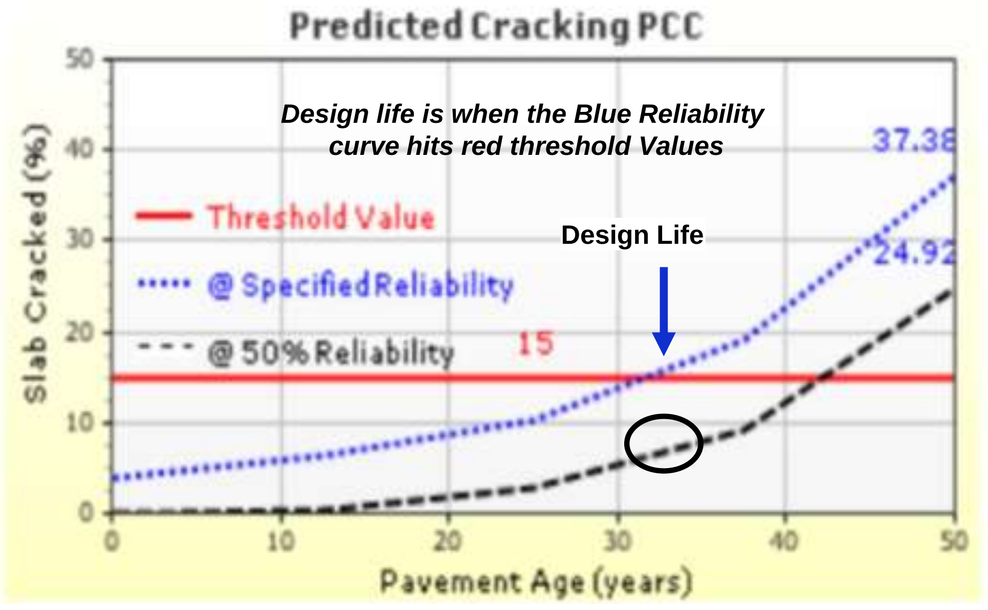
- **JPCP Restoration**

Most Recent Version 2.3.1(Revision 66, as of Oct 2016)
Available from AASHTO
http://www.aashtoware.org/Pavement/Pages/default.aspx
Individual License Cost = $5,500 / year
Site License Costs = $22,000 to $44,000 / year

PAVEMENT ME PROVIDES PERFORMANCE ESTIMATES

All other procedures (e.g. StreetPave) only provide thickness

Pavement ME Performance Curve



Red Line - <u>Defined Distress Limit</u>. When major rehabilitation is needed (i.e. patching & DG or overlay).

Black Dashed Line - The actual (most likely) level of distresses predicted

Blue Dotted Line - The predicted distresses at the given reliability level (i.e. 90%). Designs are based on when this line hits the defined distress limit

Design life is when the Blue Reliability curve hits red Predefined Distress level

Pavement ME Concrete Distresses Predicted

Bottom up & Top Down Cracking (JPCP Only)

Faulting (JPCP Only)

Punchout (CRCP Only)

- **International Roughness index (IRI) – Smoothness**

Other precursors to distresses

- **Cumulative damage → Cracking**
- **Load transfer → Faulting (JPCP) or punchouts (CRCP)**
- **Crack Spacing → Punchouts**

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PAVEMENT ME CONTAINS OVER 200 INPUT VARIABLES

broken down into five basic categories (most can use default values)

Design Categories

1. General information
   - Site/project Identification
   - Analysis parameters
2. Traffic
3. Climate
4. Design features
   - Layer definition & material properties
   - Drainage & surface properties
5. Calibration

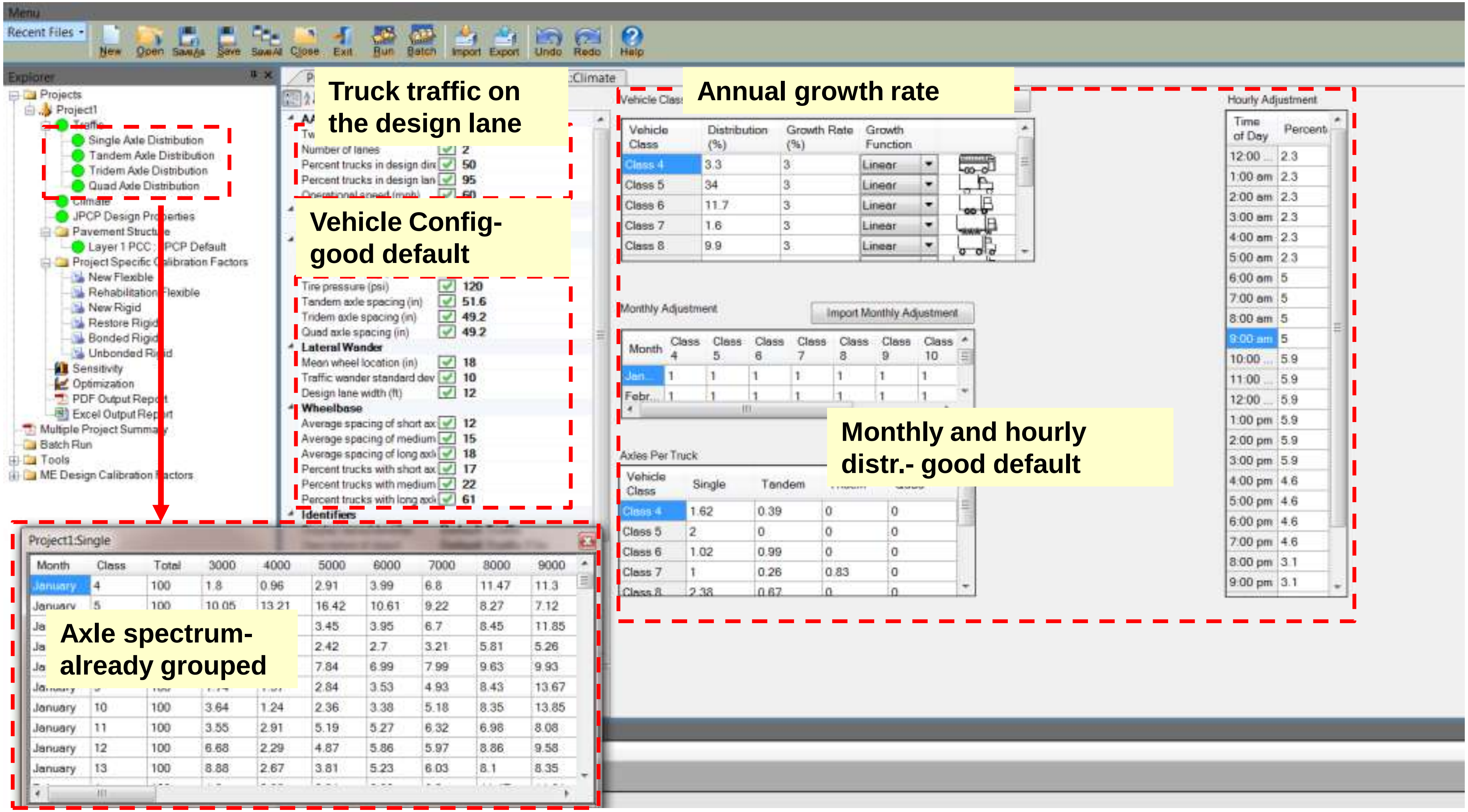
Inputs are based on a Hierarchical levels (Level 1, 2 or 3)

Level	Input Values	Knowledge of Parameters
1	Segment or Project Specific Data (AVC, WIM, vehicle counts, soil properties, concrete and other material properties, etc)	Good
2	Regional/Statewide Data	Fair
3	National Data, Educated Guess based on local experience	Poor

It also helps knowing which inputs are the most sensitive/important and the difference between design variables and semi-constants

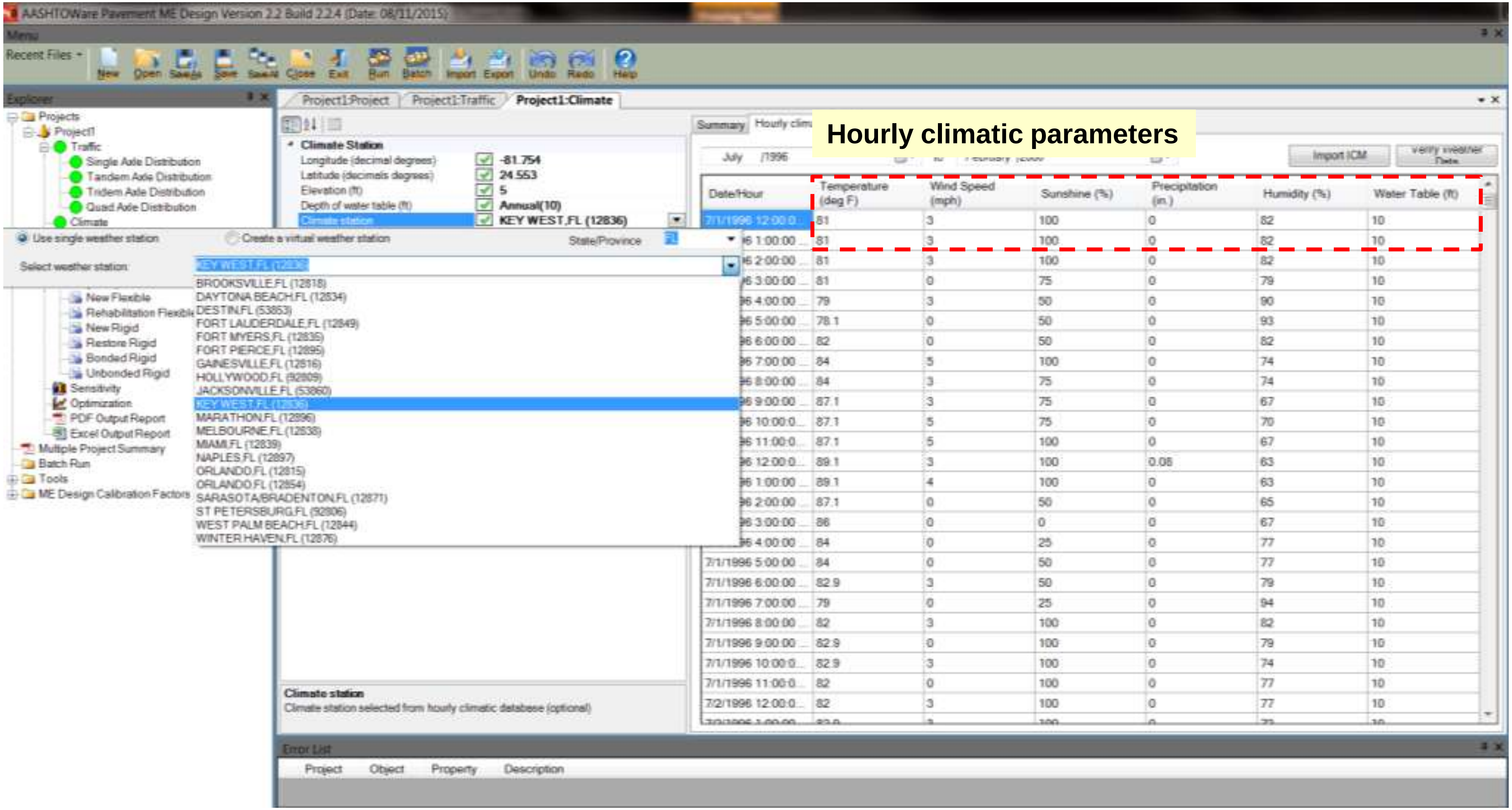
2 Traffic

KEY TRAFFIC INPUTS ARE TRUCK TRAFFIC, GROWTH RATE AND TTC GROUPS



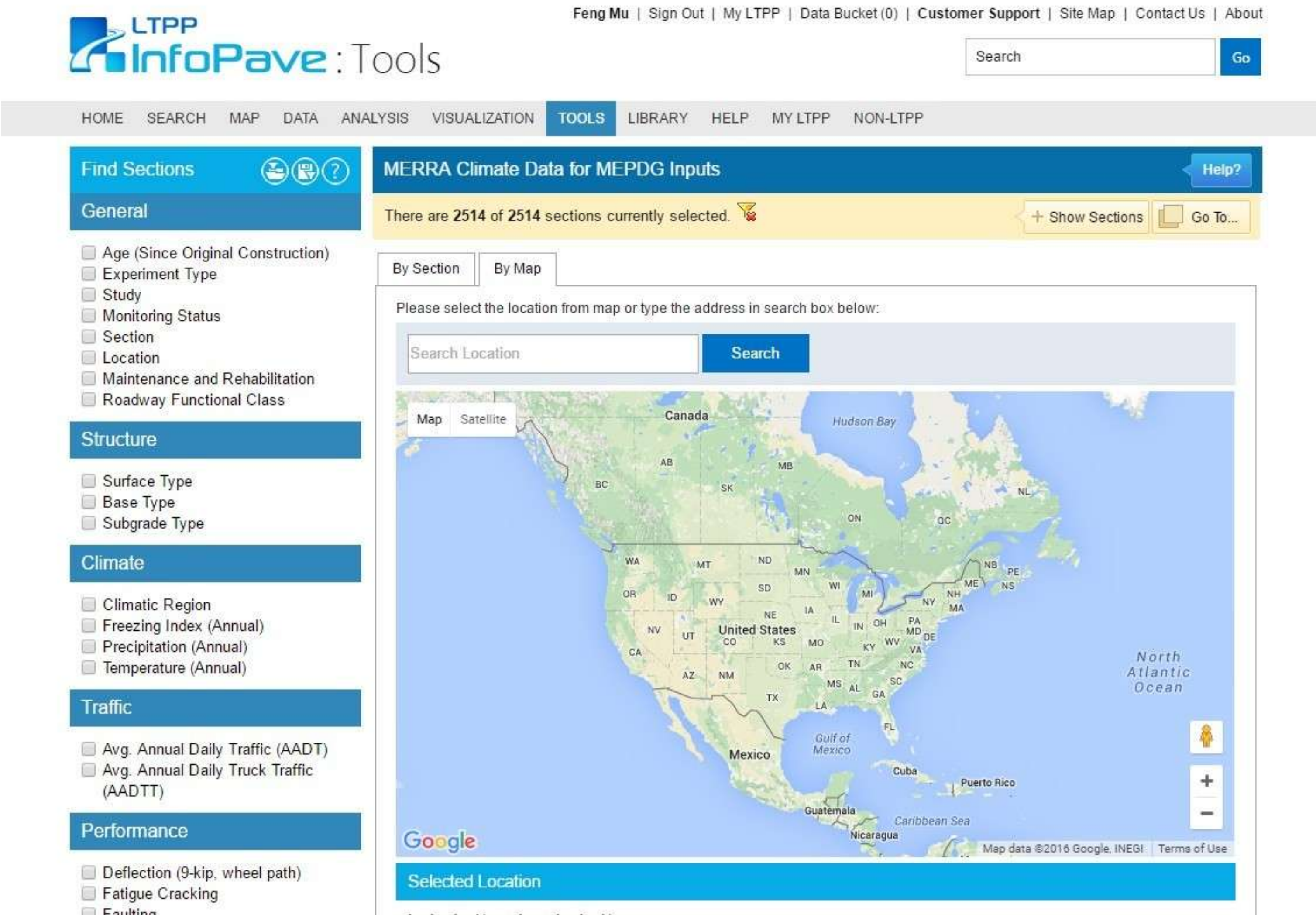
THREE OPTIONS FOR CLIMATIC INPUTS

1. Drop-down options for major US and Canadian cities



OPTION 2. WEATHER FILES FOR 2514 LTPP PROJECTS

From LTTP InfoPave (US and Canada only)

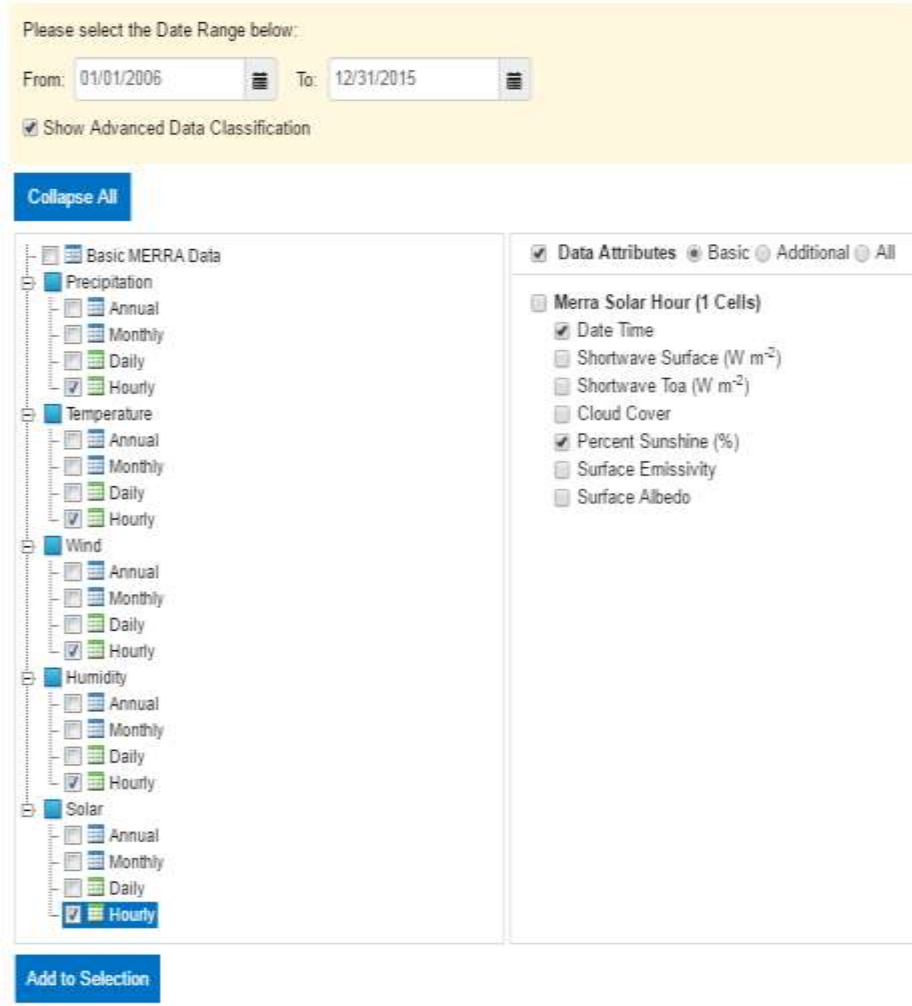


OPTION 3. MAKE WEATHER FILES BASED ON NASA MERRA DATA

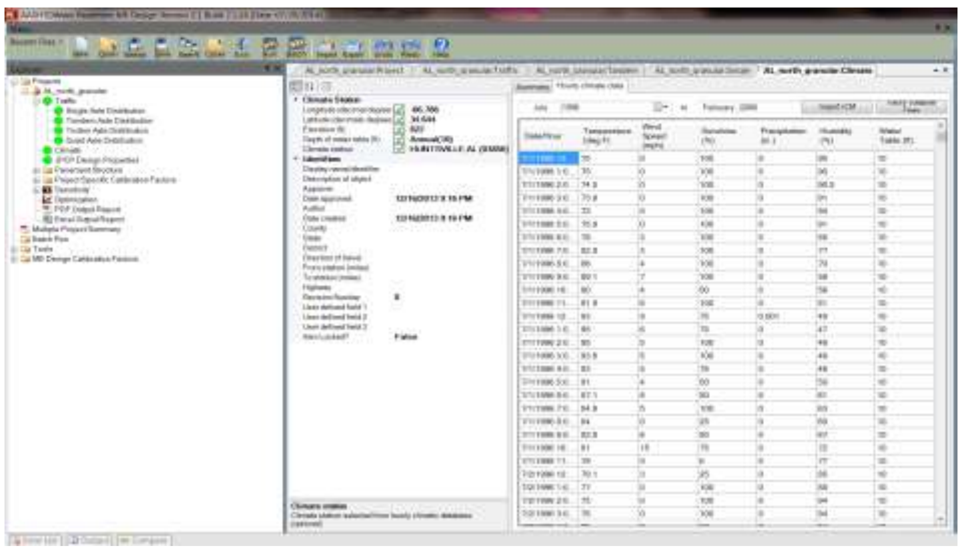
Also from LTTP InfoPave (available soon worldwide)

Select Location in ~30 mile× ~40 mile grids

Download No-gap hourly Precipitation, Temperature, Wind, Sunshine , & Relative humidity since 1979



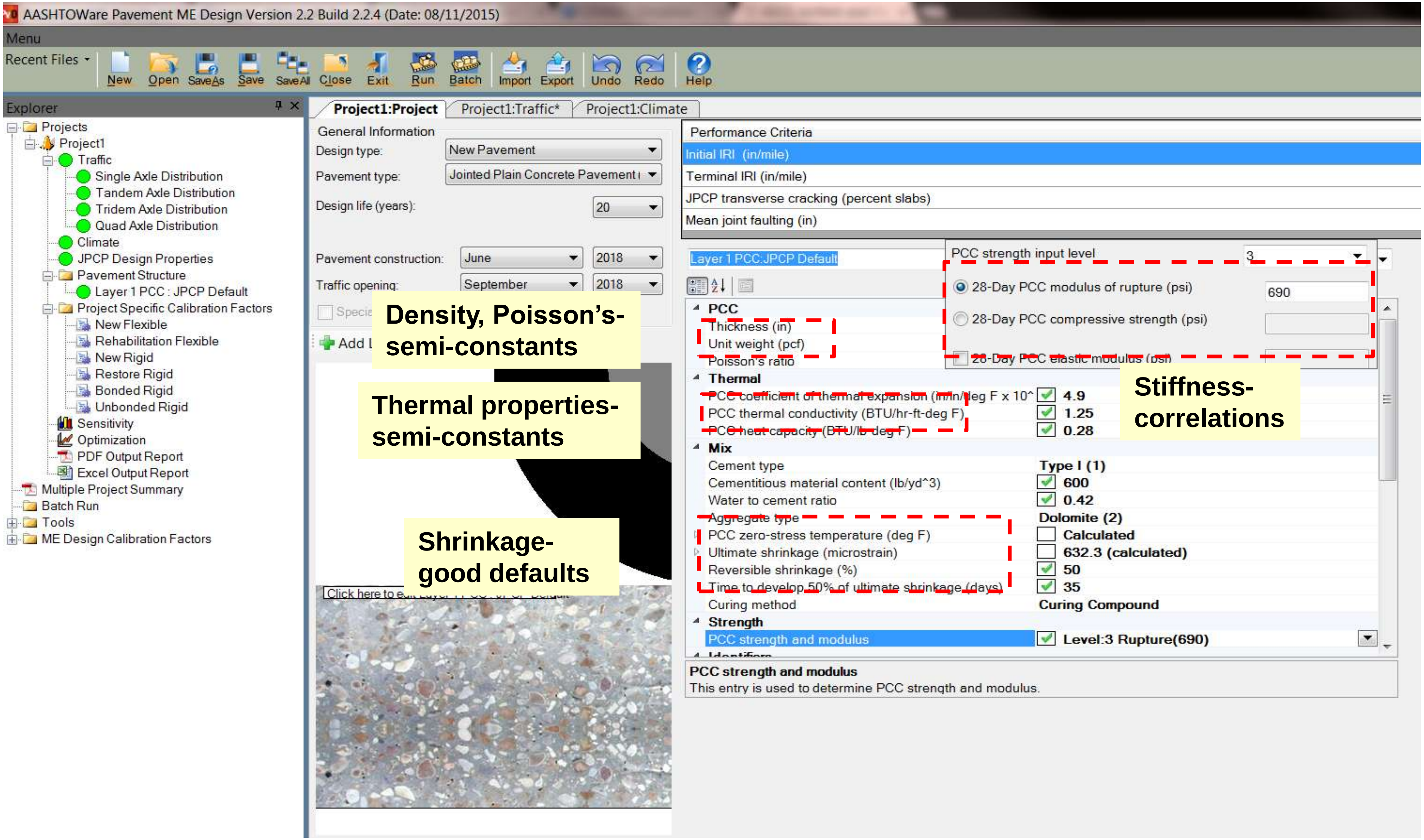
Fill the data in Pavement ME



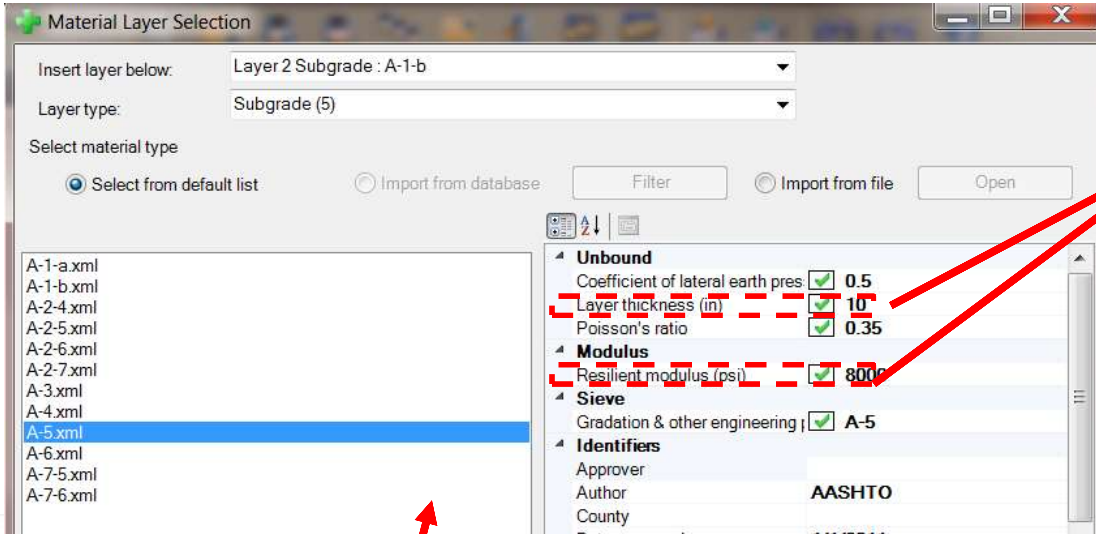
4 Design features

ONLY THREE SENSITIVE INPUTS FOR PCC LAYER

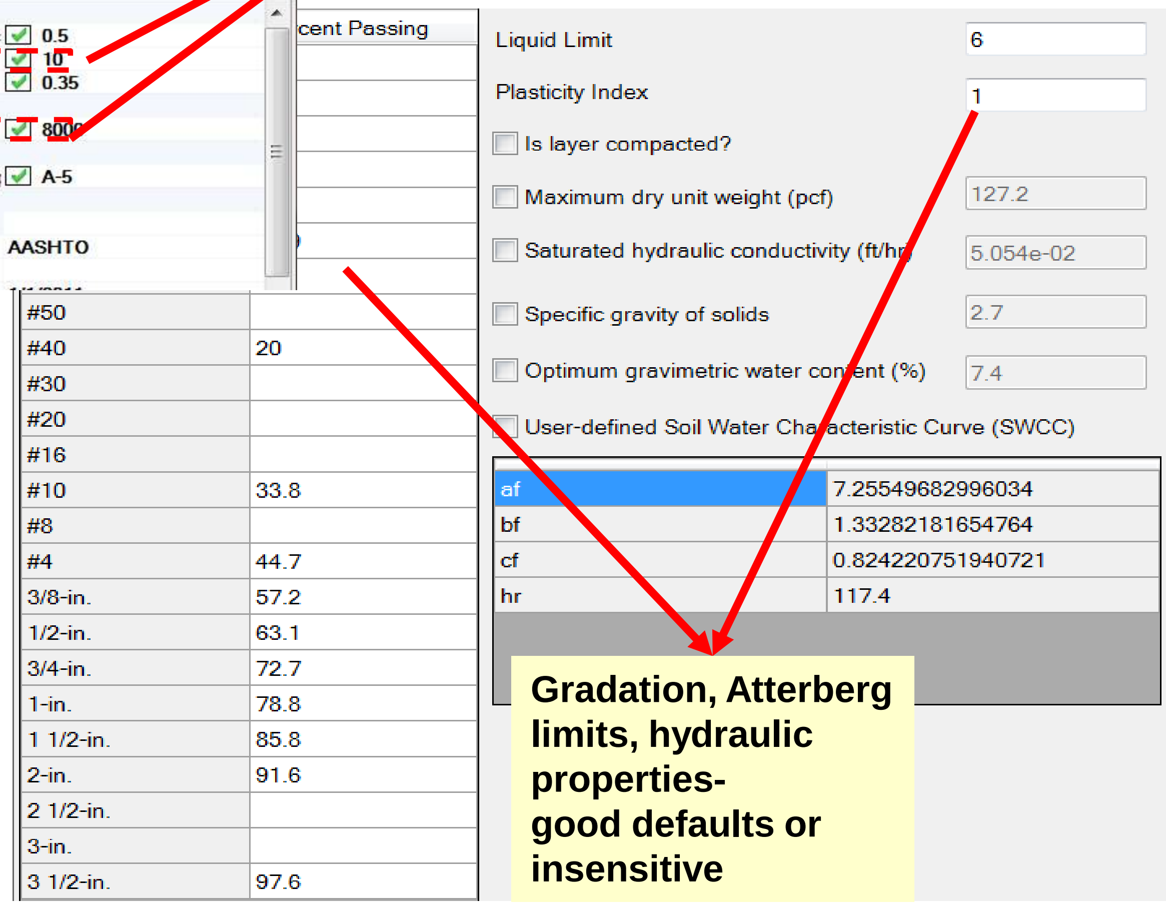
Thickness, CTE and Strength



BASE/SUBGRADE MATERIAL PROPERTIES



Coefficient of earth pressure, Poisson's-semi-constants

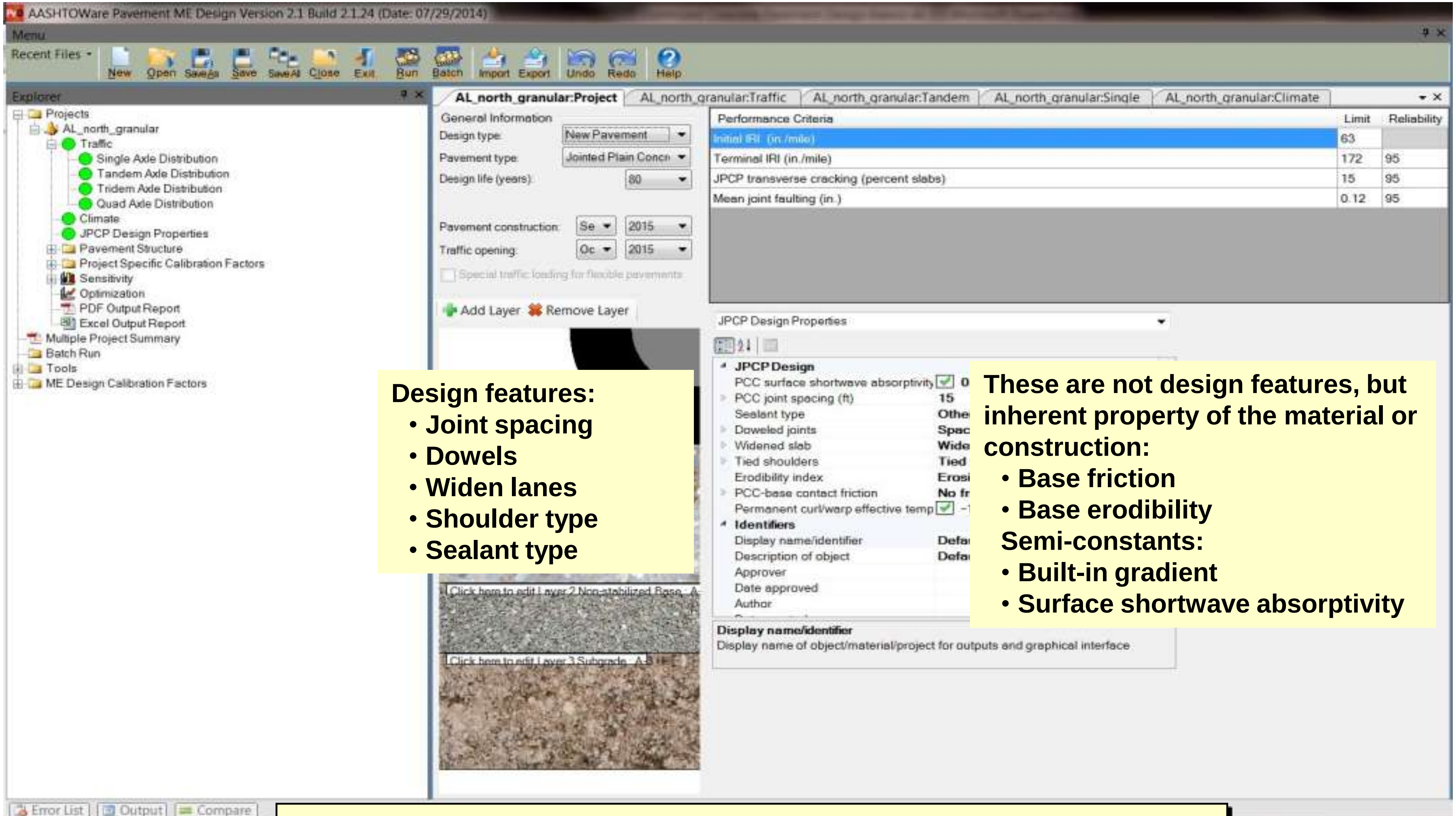


Gradation, Atterberg limits, hydraulic properties-
good defaults or insensitive

Bound/Unbound subbase/subgradematerials

Typical unbound materials are provided in groups; the only user inputs are thickness and resilient modulus.

PAVEMENT ME ALSO ACCOUNT FOR MANY DESIGN FEATURES



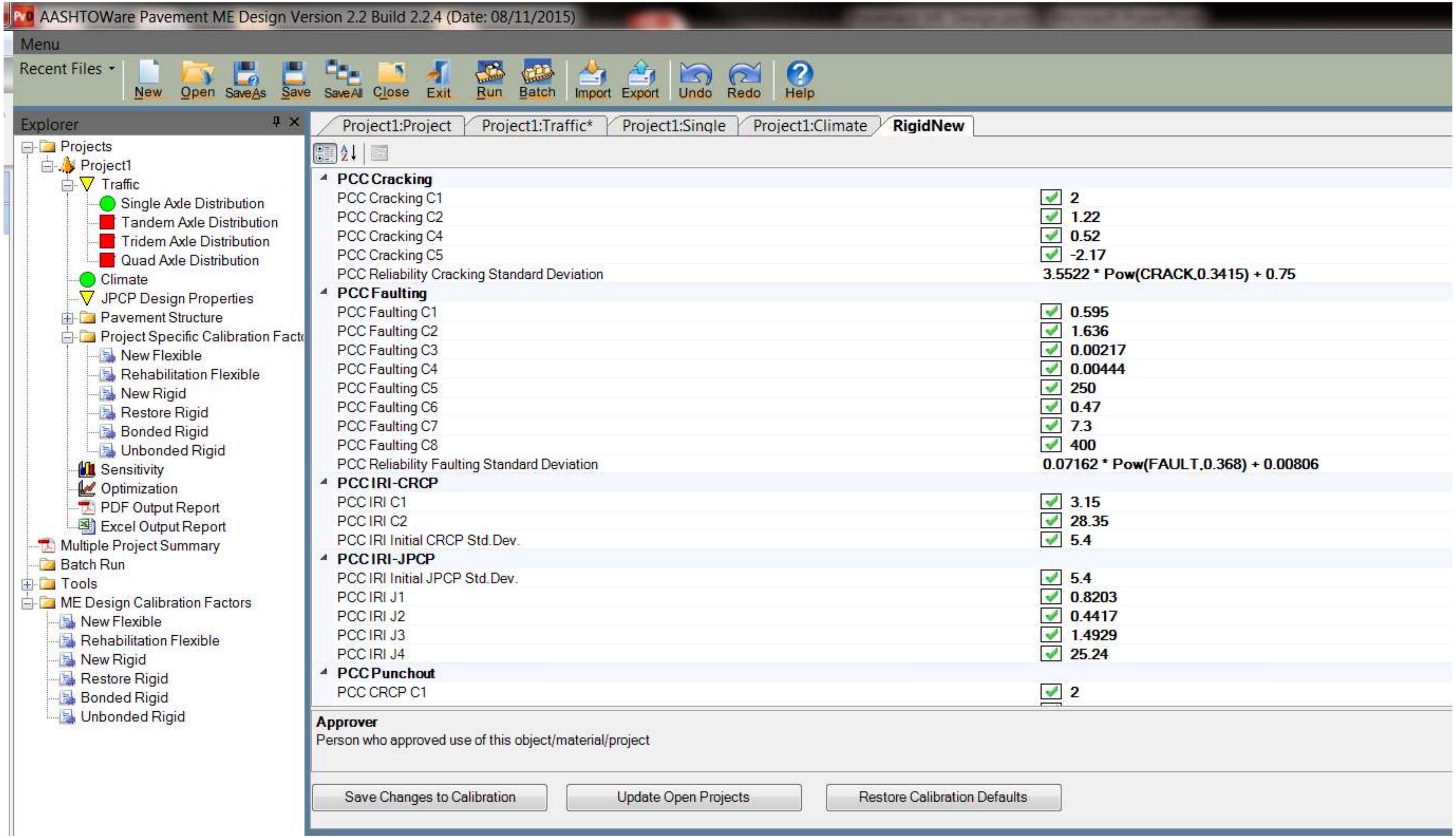
Design features:
- **Joint spacing**
- **Dowels**
- **Widen lanes**
- **Shoulder type**
- **Sealant type**

These are not design features, but inherent property of the material or construction:
- **Base friction**
- **Base erodibility**

Semi-constants:
- **Built-in gradient**
- **Surface shortwave absorptivity**

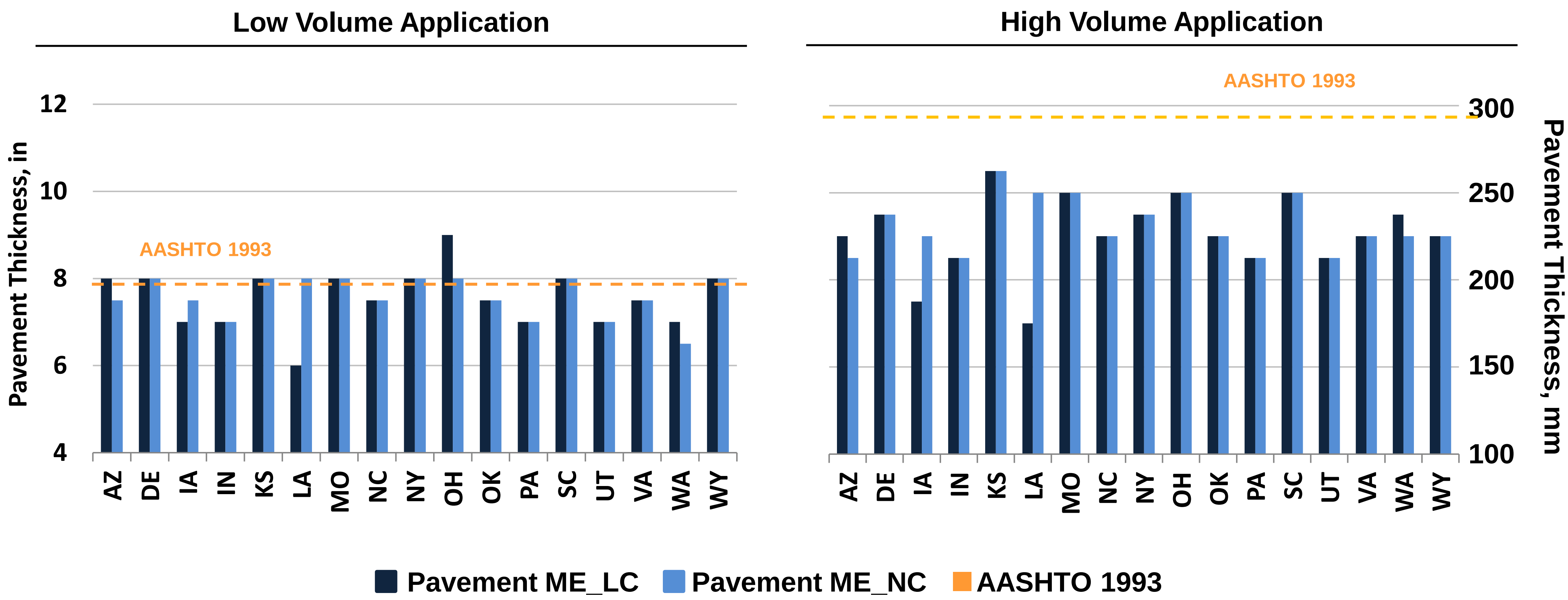
There is no such thing as one-size-fits-all design. Each project is unique.

PAVEMENT ME ALLOWS AGENCIES TO DEVELOP AND USE LOCAL CALIBRATION COEFFICIENTS



You can save your local calibration coefficients as default or restore the national as default at one click

LOCAL CALIBRATION RESULT IN ½-IN OR LESS DIFFERENCE IN REQUIRED THICKNESS vs. NATIONAL CALIBRATION



However, using Pavement ME result in ~2-3 in thinner JPCPs when compared to the AASHTO 93 guide.

THREE NATIONAL CALIBRATIONS FOR NEW JPCP SO FAR

Most JPCP designs have been done using the 2nd Calibration

Cal. 1
(NCHRP 1-37)

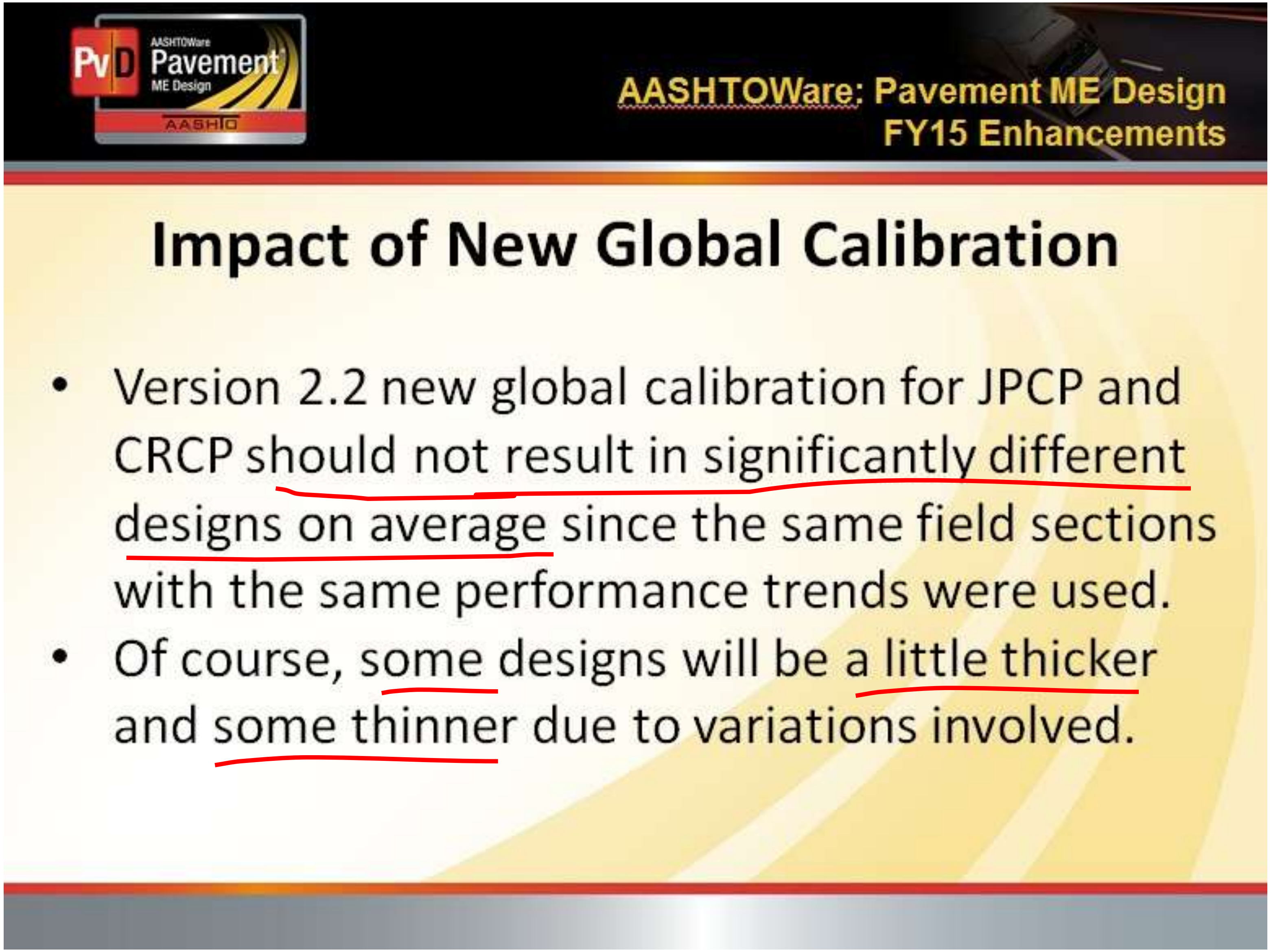
Cal. 2 (NCHRP 1-40D)
- **Models updated**
- **Cal. database expanded**

Cal. 2.5 (NCHRP 20-07 Task 288)
- **To correct CTE testing**

Cal. 3 (NCHRP 20-07 Task 327)
- **To validate Task 288**

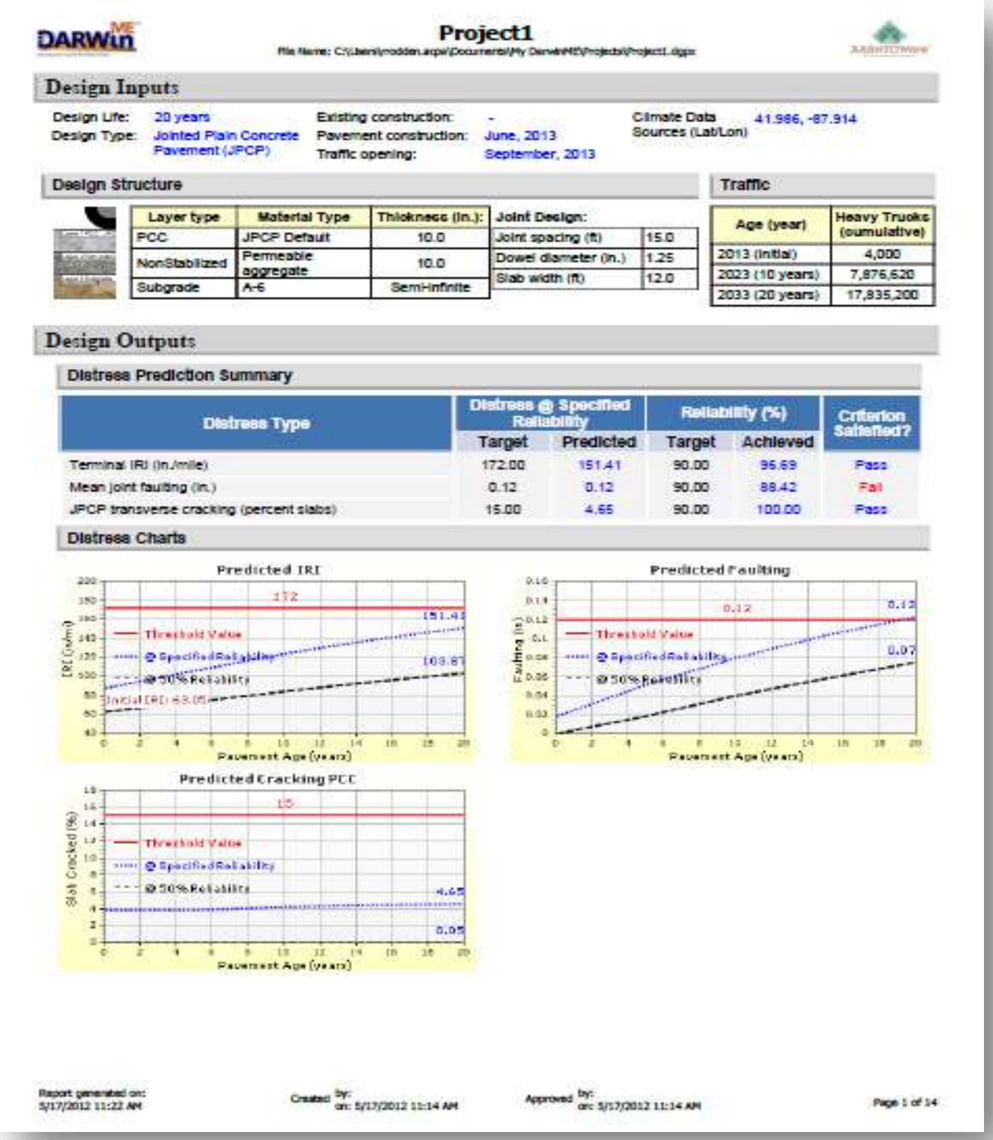
MEPDG 0.7	**MEPDG 1.0 - Pavement ME 2.1**		**Pavement ME 2.2**
2004	**2007**	**2011**	**August, 2015**

CAL. 2 AND CAL.3 NOT SUPPOSED TO CHANGE DESIGNS ON AVERAGE



15-25 PAGES OF REPORT SUMMERIZES ALL THE INPUTS AND OUTPUTS

Many more intermediate outputs are also available for in-depth analysis



Project1

File Name: C:\Users\rodden.arpa\Documents\My DarwinME\Projects\Project1.dgpx

Design Inputs

Design Life: 20 years
Design Type: Jointed Plain Concrete Pavement (JPCP)
Existing construction: -
Pavement construction: June, 2013
Traffic opening: September, 2013
Climate Data Sources (Lat/Lon): 41.986, -87.914

Design Structure

Layer type	Material Type	Thickness (in.):
PCC	JPCP Default	10.0
NonStabilized	Permeable aggregate	10.0
Subgrade	A-6	Semi-infinite

Joint Design:

Joint spacing (ft)	15.0
Dowel diameter (in.)	1.25
Slab width (ft)	12.0

Traffic

Age (year)	Heavy Trucks (cumulative)
2013 (initial)	4,000
2023 (10 years)	7,876,620
2033 (20 years)	17,835,200

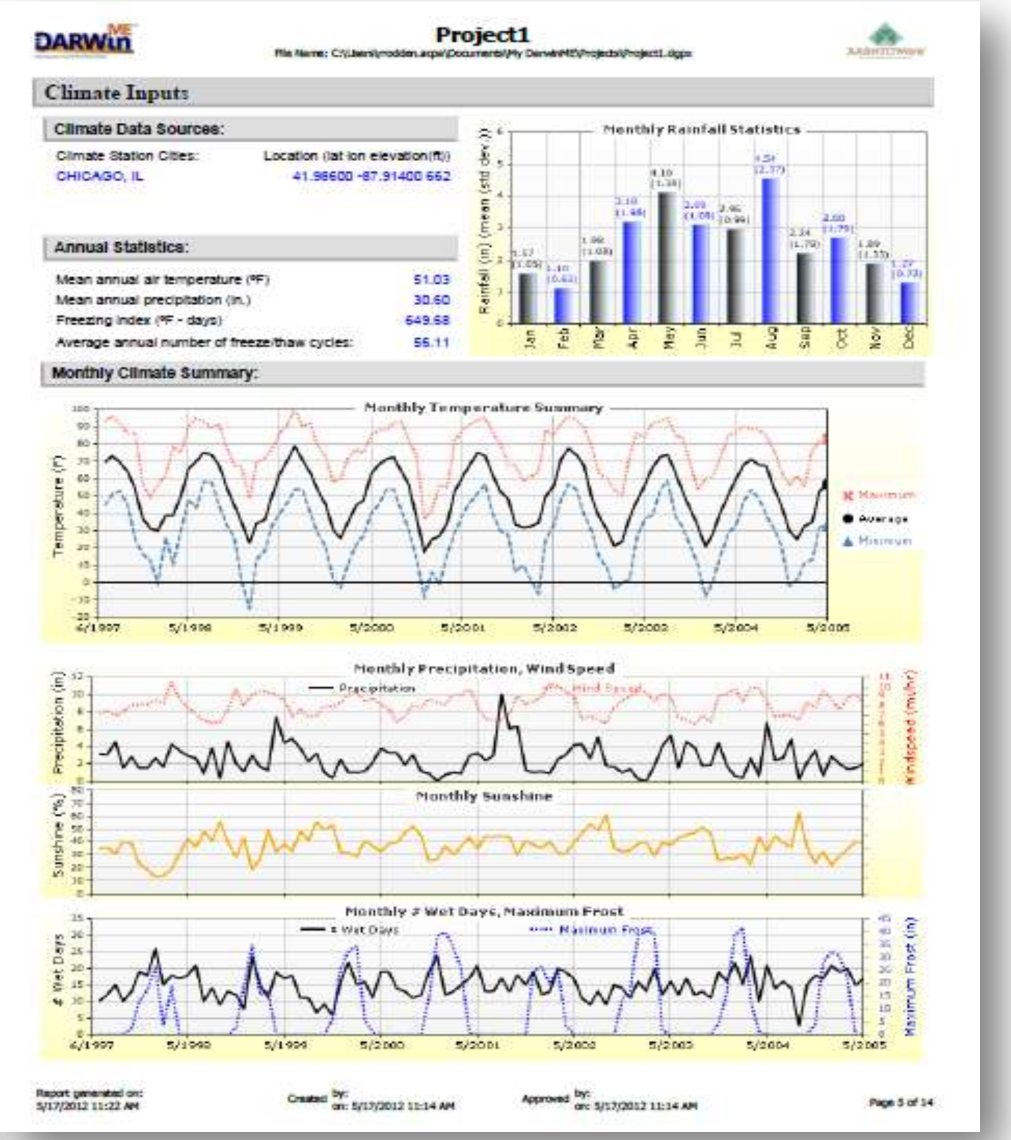
Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in./mile)	172.00	151.41	90.00	96.69	Pass
Mean joint faulting (in.)	0.12	0.12	90.00	88.42	Fail
JPCP transverse cracking (percent slabs)	15.00	4.65	90.00	100.00	Pass

Distress Charts

Report generated on: 5/17/2012 11:22 AM
Created by: on: 5/17/2012 11:14 AM
Approved by: on: 5/17/2012 11:14 AM
Page 1 of 14



Project1

File Name: C:\Users\rodden.arpa\Documents\My DarwinME\Projects\Project1.dgpx

Climate Inputs

Climate Data Sources:

Climate Station Cities:	Location (lat lon elevation(ft))
CHICAGO, IL	41.98600 -87.91400 662

Annual Statistics:

Mean annual air temperature (ºF)	51.03
Mean annual precipitation (in.)	30.60
Freezing index (ºF - days)	649.68
Average annual number of freeze/thaw cycles:	56.11

Monthly Climate Summary:

Report generated on: 5/17/2012 11:22 AM
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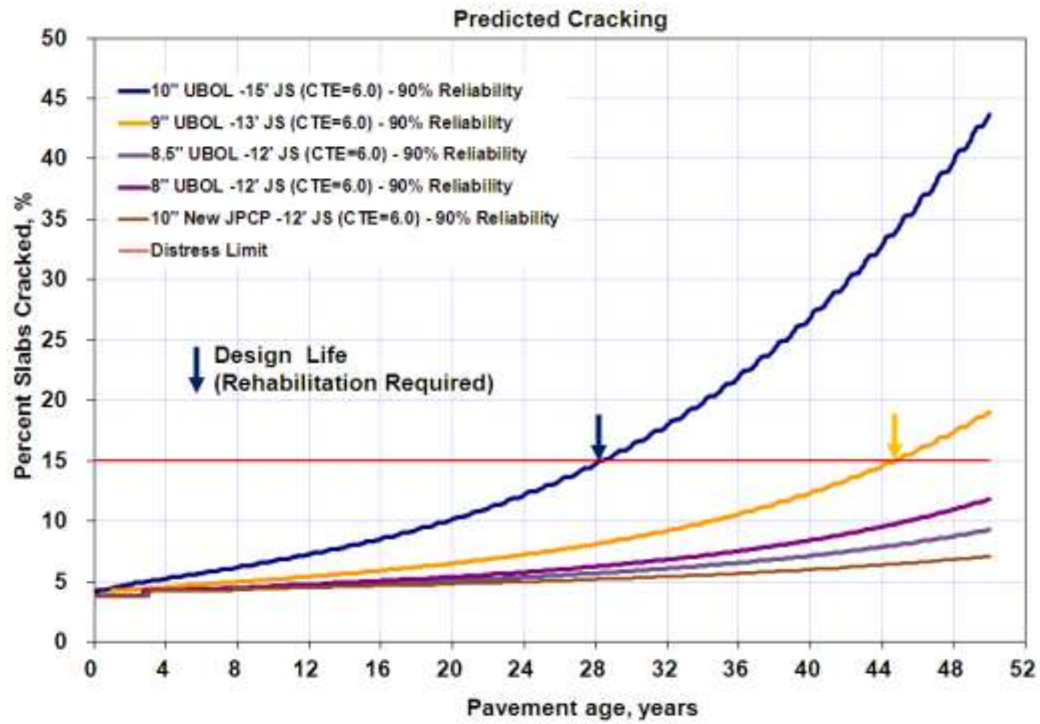
PAVEMENT-ME ALLOWS FOR COMPARISONS OF DIFFERENT DESIGNS

Predicted Performance Curves & Pavement Designs

- Many pavement designs will meet the design criteria
  - Pavement-ME predicts what the actual performance could be
  - Allows for comparisons and evaluation of different design features / thickness
- Performance estimates help determine the "when" and "what" rehabilitation activities to perform



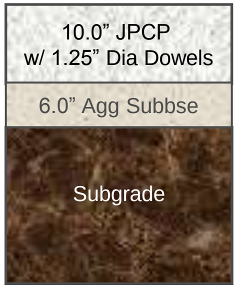
Comparing Designs

- Pavement-ME is for 50 years to give long term performance for each design
- Pavement design must the "design criteria" (eg less than 10% cracking at year 30)

Combining Performance Results with the LCCA finds the design that best balances the initial costs, life cycle costs and performance

COMBINING PAVMENT ME AND LCCA INTO THE DESIGN PROCESS
finds the optimum design in terms of initial, long-term cost and performance

Develop Pavement Structure
Layers
Traffic
Climate



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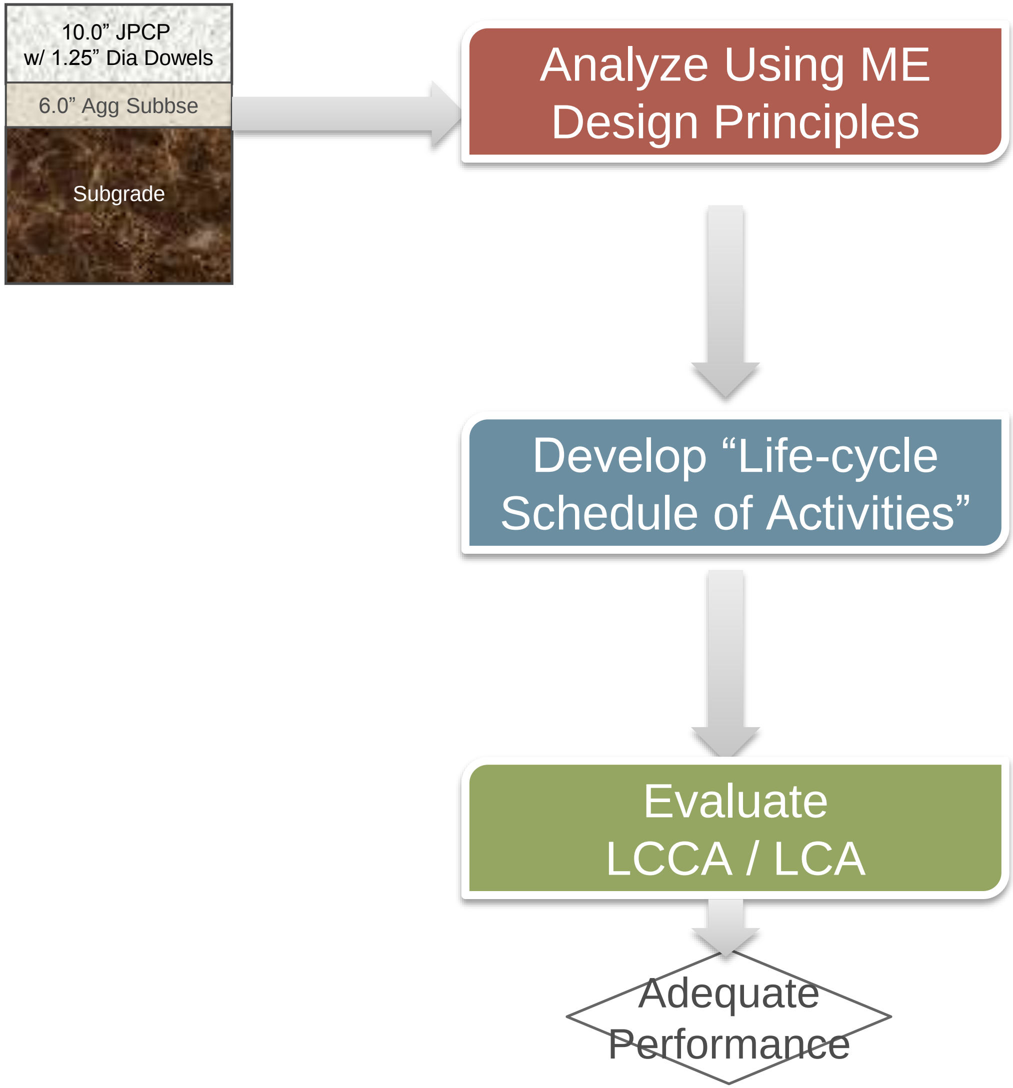

Slide: Courtesy of MIT Concrete Sustainability Hub

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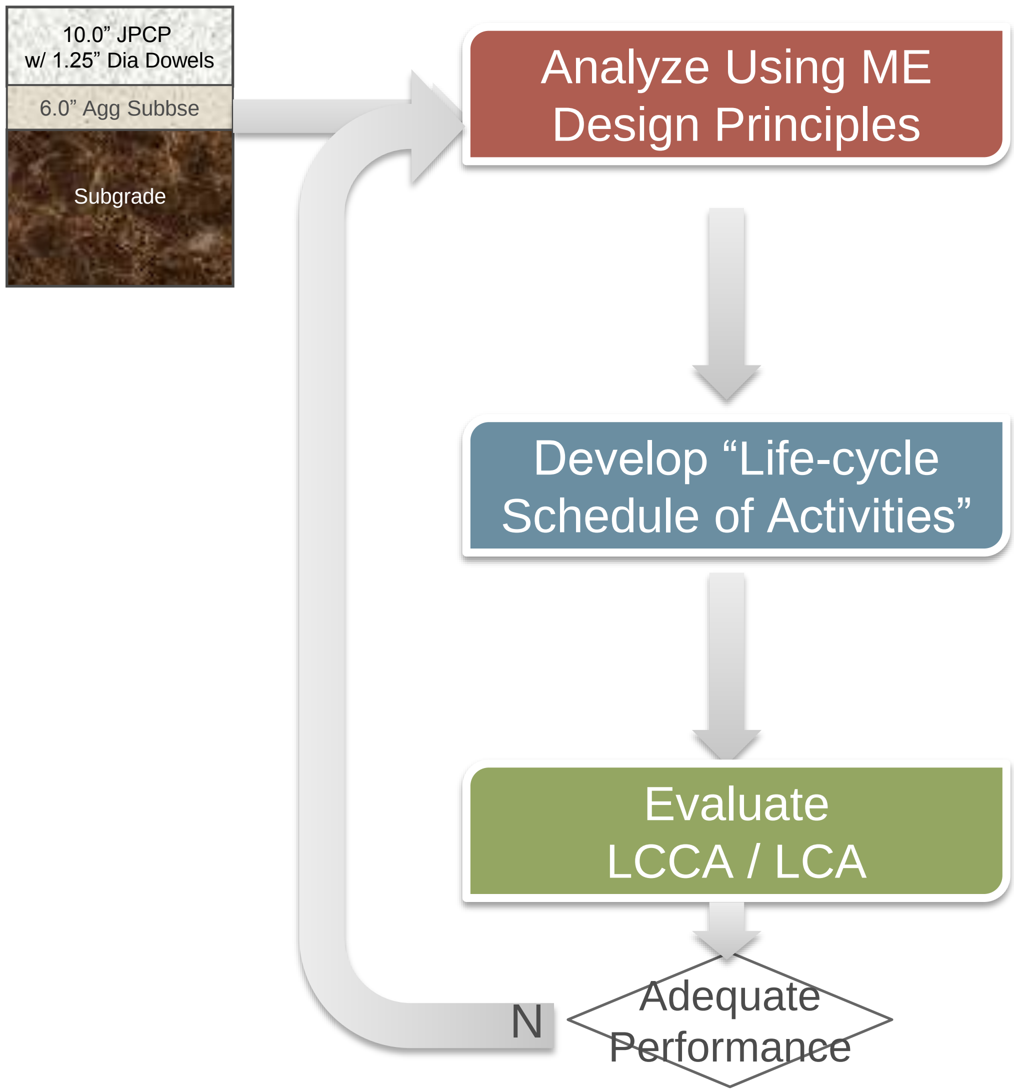

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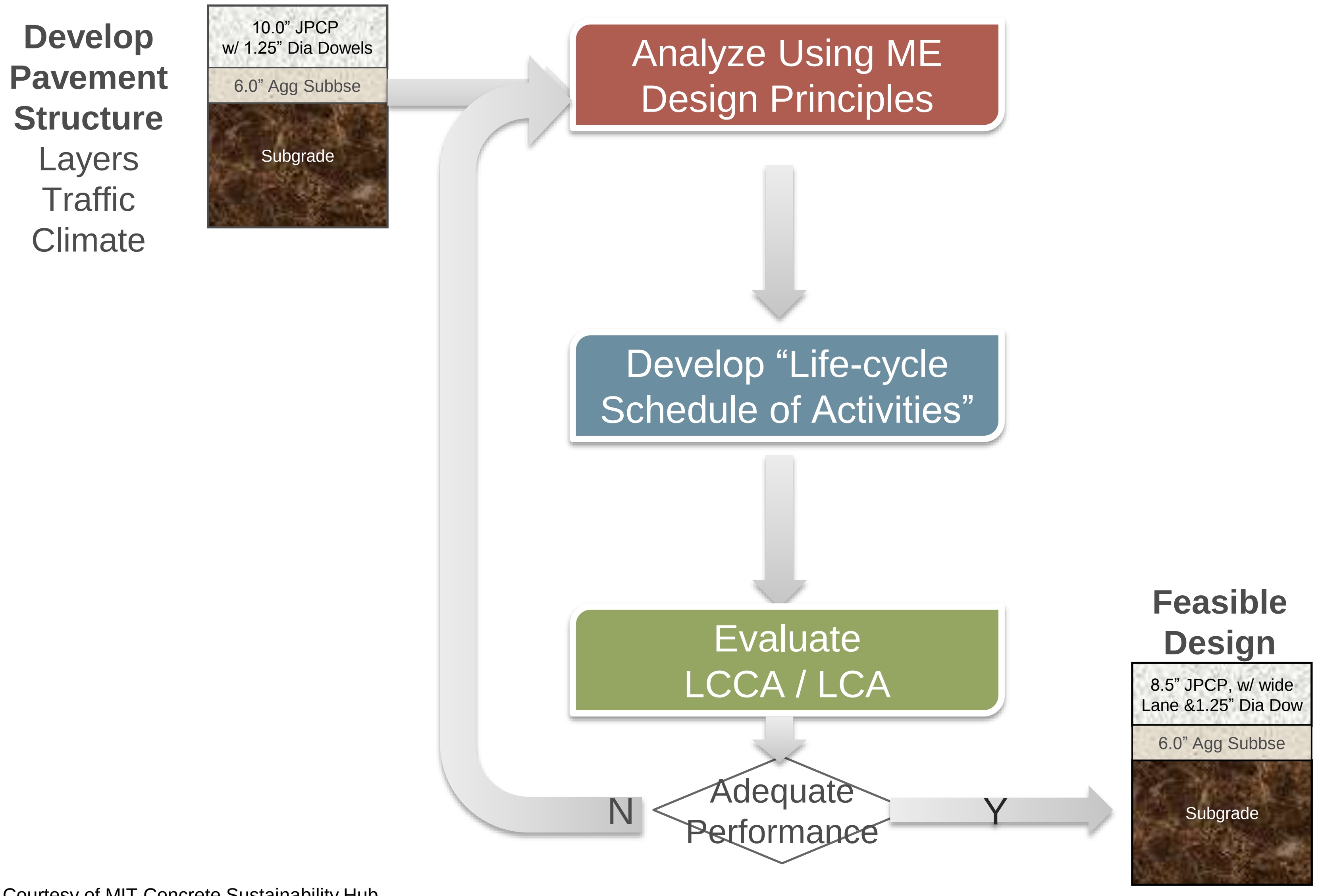

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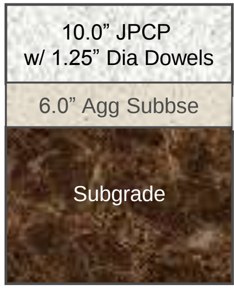
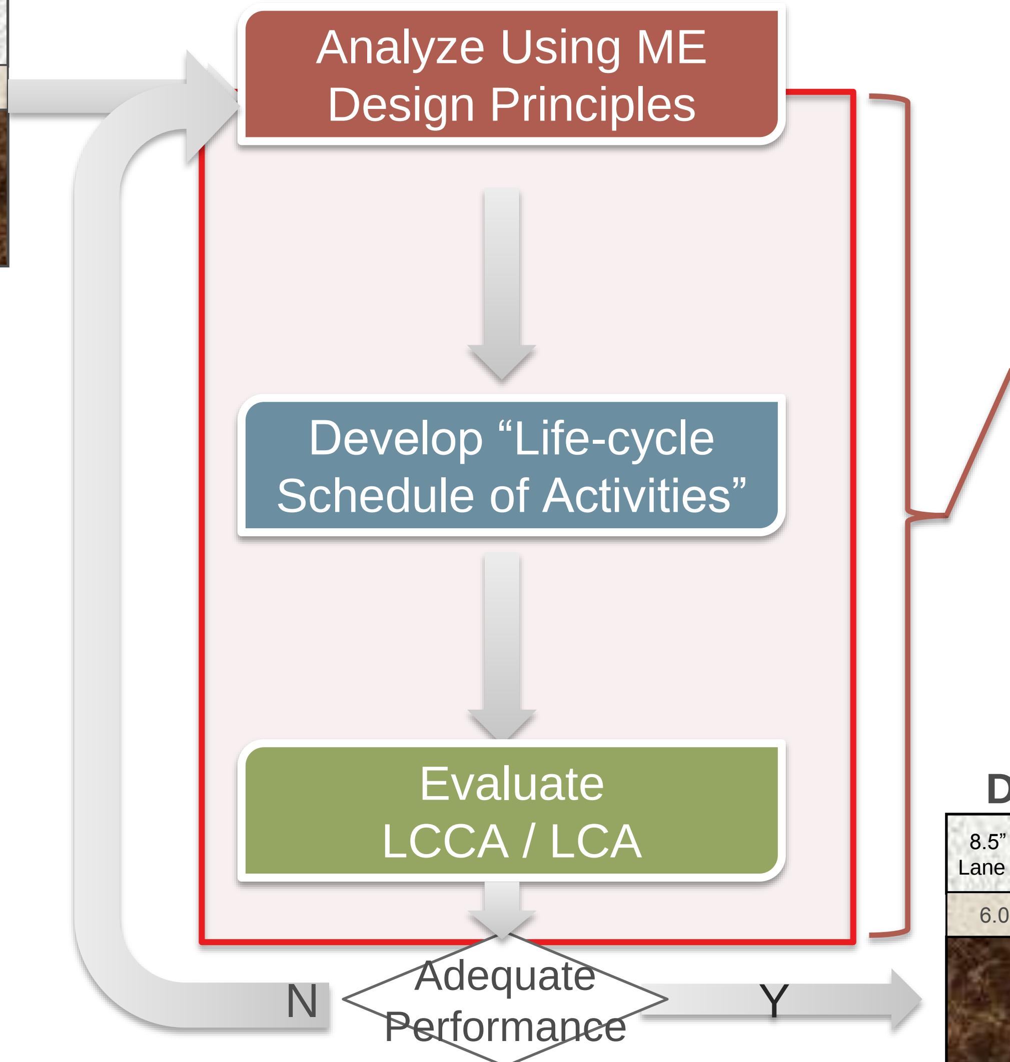
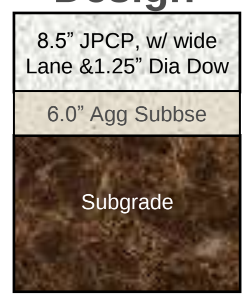




Designing pavements in an iterative procedure provides a Feedback Loop

- **Improves performance**
- **Lowers cost**
- **Lowers environmental impacts**

Final Design

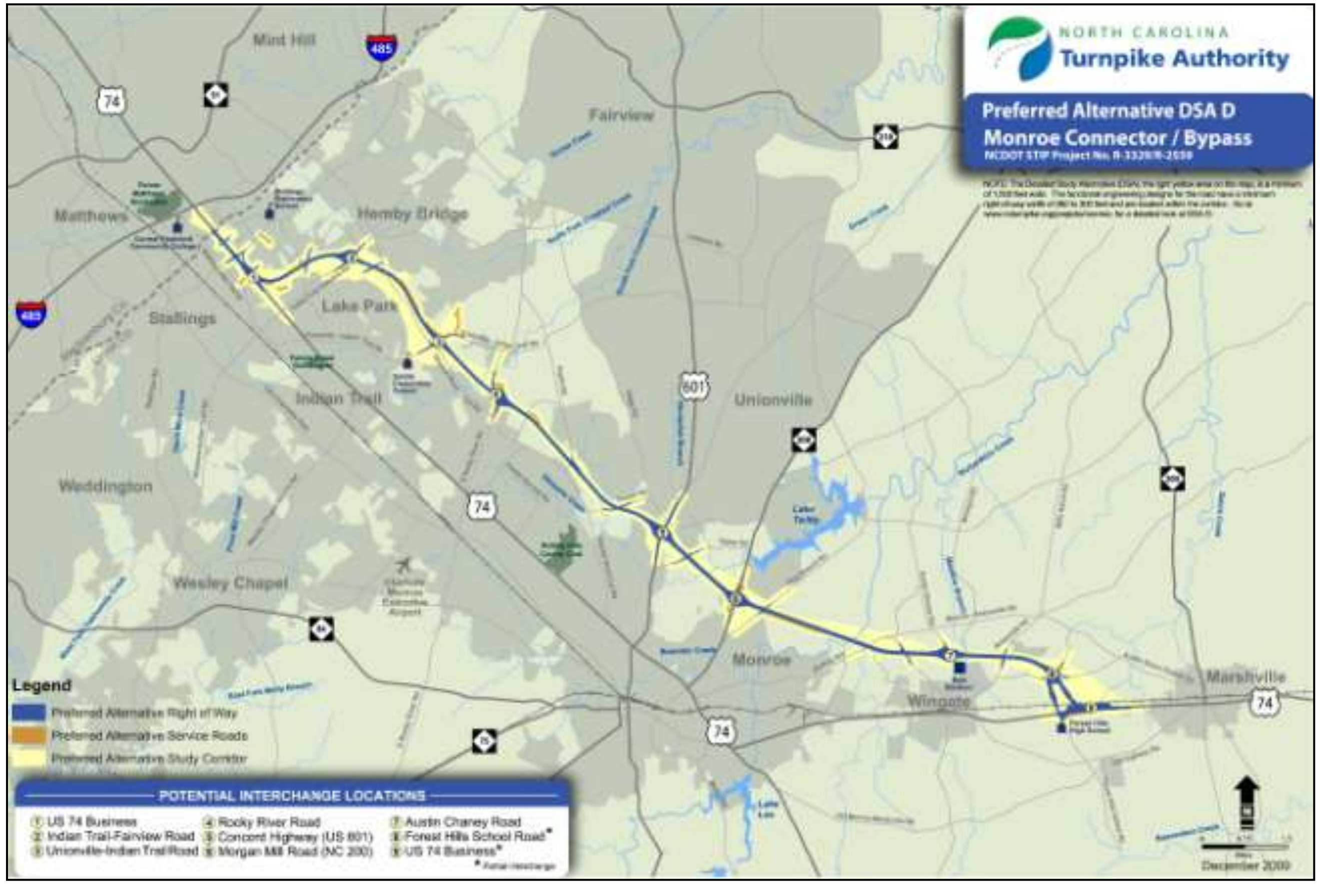


Slide: Courtesy of MIT Concrete Sustainability Hub

MONROE PARKWAY IS NEW ROAD NEAR CHARLOTTE NC

From US 74 at I-485 in eastern Mecklenburg County to US 74 near the Town of Marshville

- **Project owner: North Carolina Turnpike Authority (NCTA)**
- **Preliminary cost estimate ~ $520 M Project was let as Design-Build with alternate pavement designs (asphalt or concrete)**
- **Length is approximately 21 miles**
- **Estimated Traffic:[1],**
  - **Yr 2015 – ADT = 35,600**
  - **Yr 2030 –ADT = 56,600**
    - **% Duals = 1 % TTST = 2%**
    - **Growth = 3.14%**
  - **20-yr F-ESALS[2] = 7.74 M**
  - **30-yr R-ESALS[2] = 18.0 M**



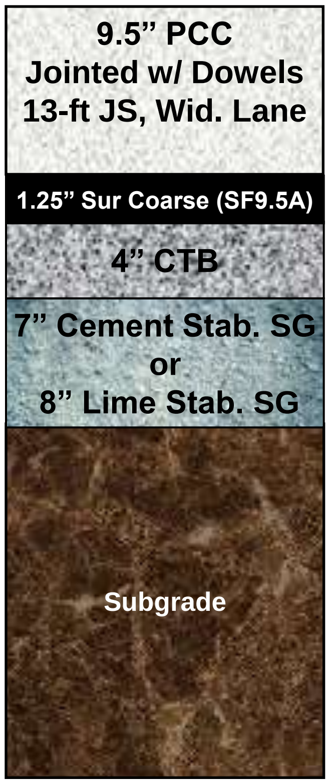
1. NCTA – Proposed Monroe Connector/Bypass Preliminary Traffic and Revenue Study – 2009 Update
2. F-ESALS based on Dual TF = 0.35, TTST TF = 1.15, Lane Distribution Factor = 0.8 (3 lanes / direction)
   R-ESALS based on Dual TF = 0.3, TTST TF = 1.6, Lane Distribution Factor = 0.8 (3 lanes / direction)

PAVEMENT-ME SHOWS OTHER CONCRETE SECTIONS MEET THE 30-YEAR DESIGN CRITERIA

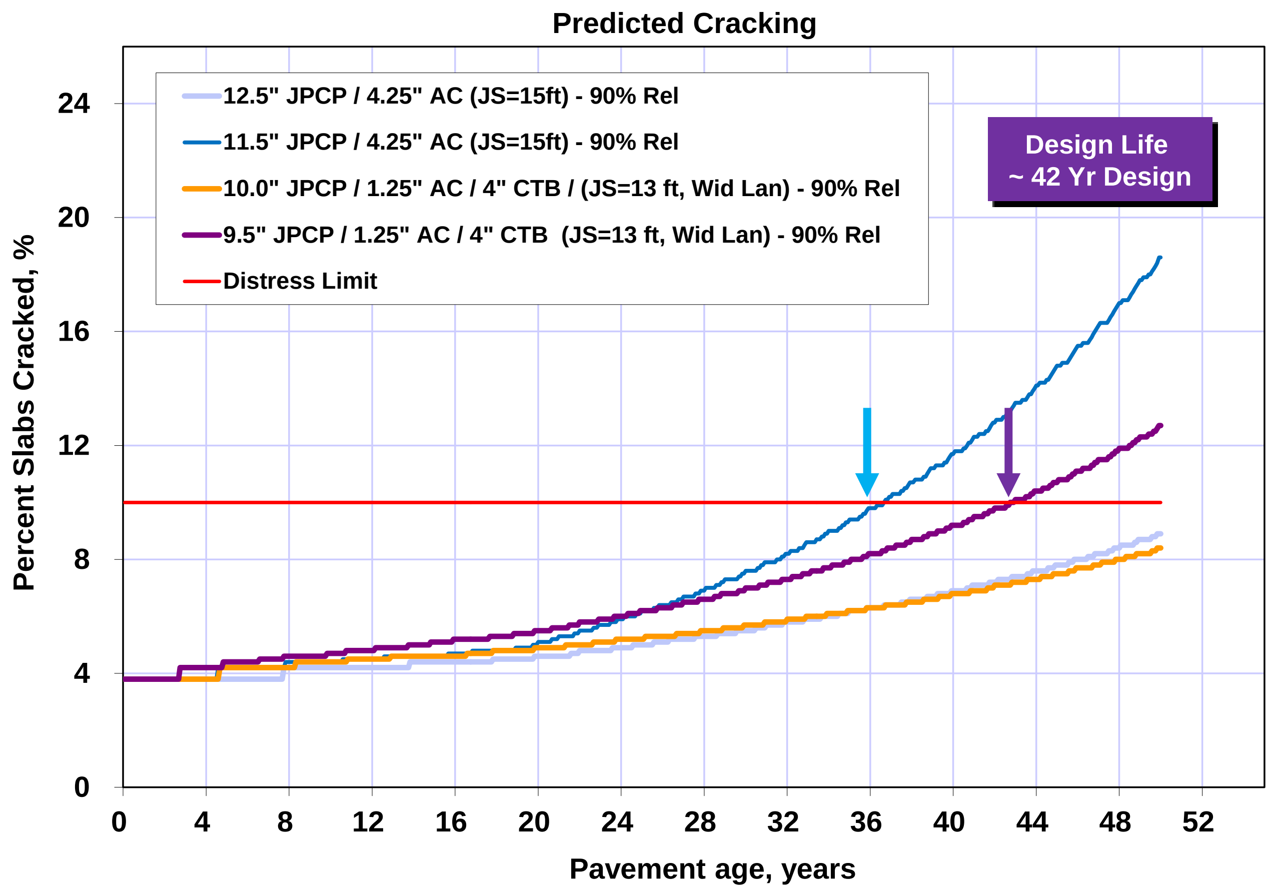
Changing designs also changed the controlling distress

Standard Concrete

Pavement-ME Concrete



Pavement-ME Predicted Performance

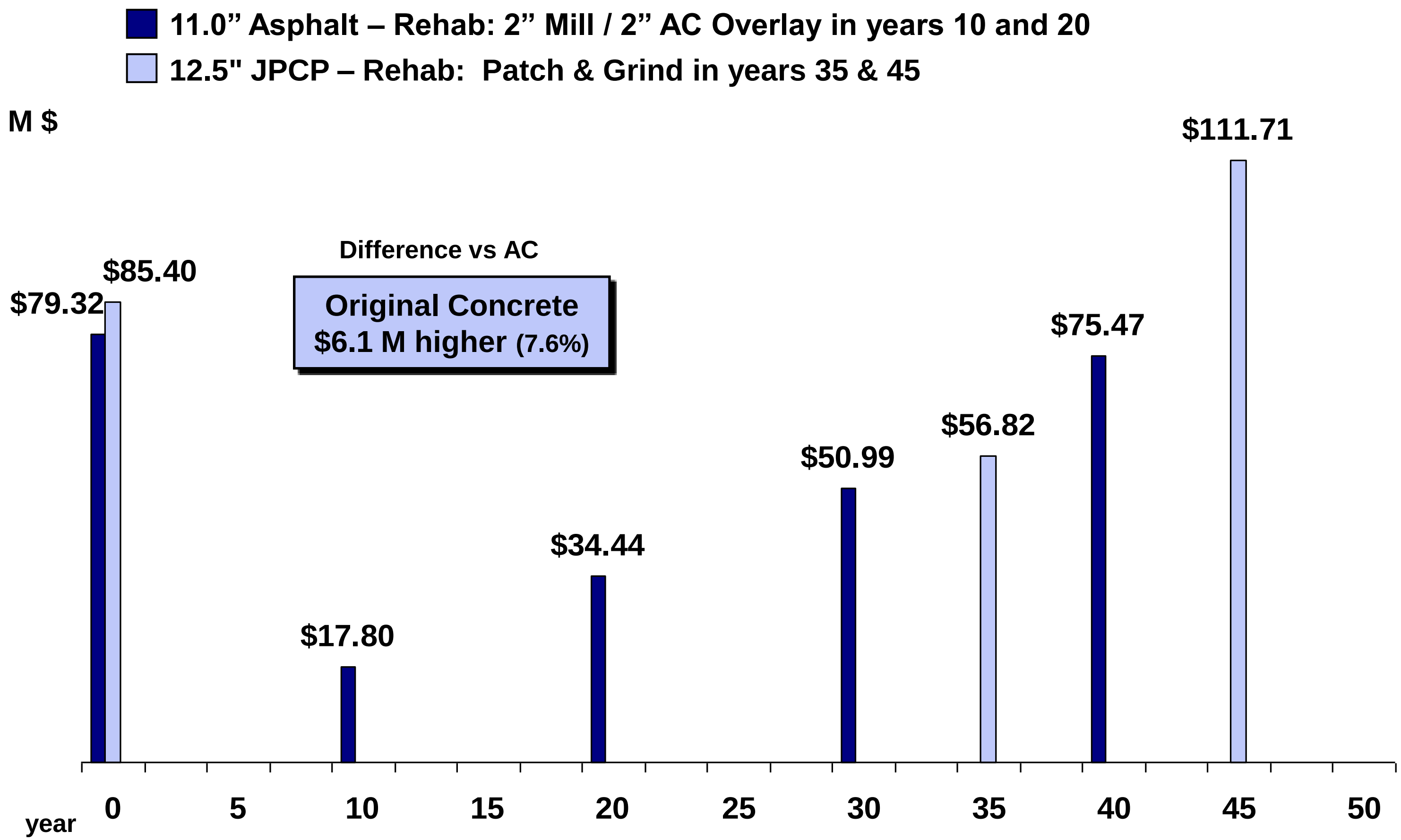


9.5" Jointed Pavement with Widened Lanes & 13-ft joint spacing is a 42-Year design

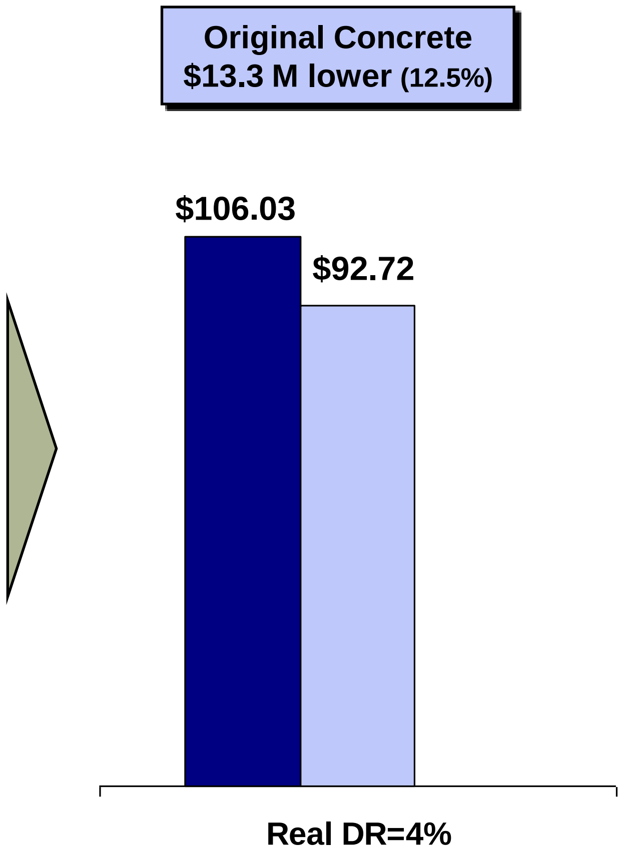
THE ORGINAL CONCRETE PAVEMENT HAS HIGHER INITIAL COST BUT LOWER LIFE CYCLE COST

Makes pavement type selection difficult

Nominal Expenditures by Pavement Type ($ M)



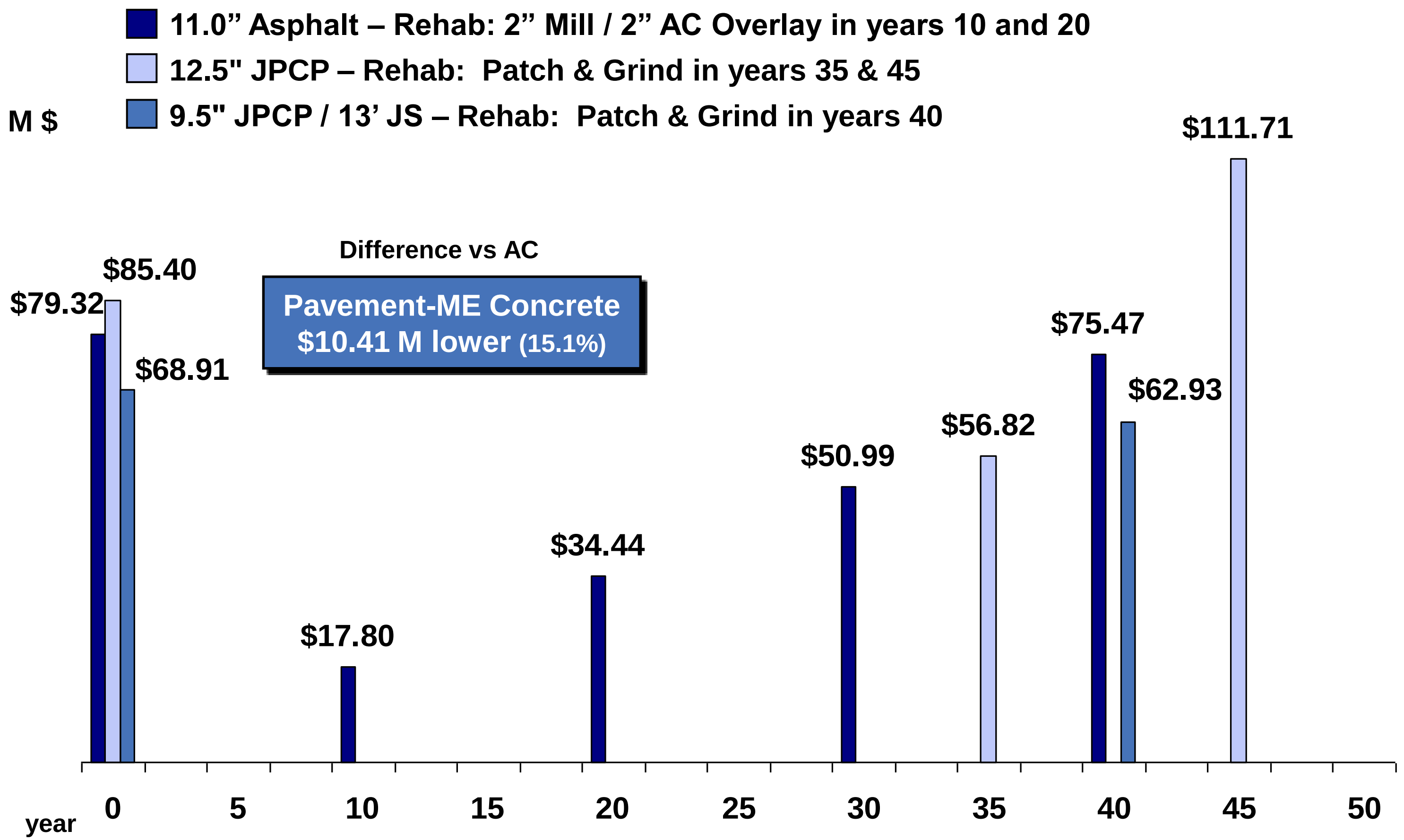
LCC Net Present Value ($ M)



Costs for 21 miles, 3 lanes plus Shoulders. Initial Costs include Pavement, base, and subgrade stabilization materials and labor
Rehabilitation costs – AC Activities based on NCDOT Schedules with same activities continued throughout 50 year analysis
Concrete activities based on Pavement-ME (no salvage) – 3% Patch & 100% Grind in yr 35, 5% Patch & 100% Grind in yr 35

THE OPTIMIZED PAVEMENT HAS BOTH LOWEST INITIAL COSTS & FUTURE REHABILITATION COSTS

Nominal Expenditures by Pavement Type ($ M)



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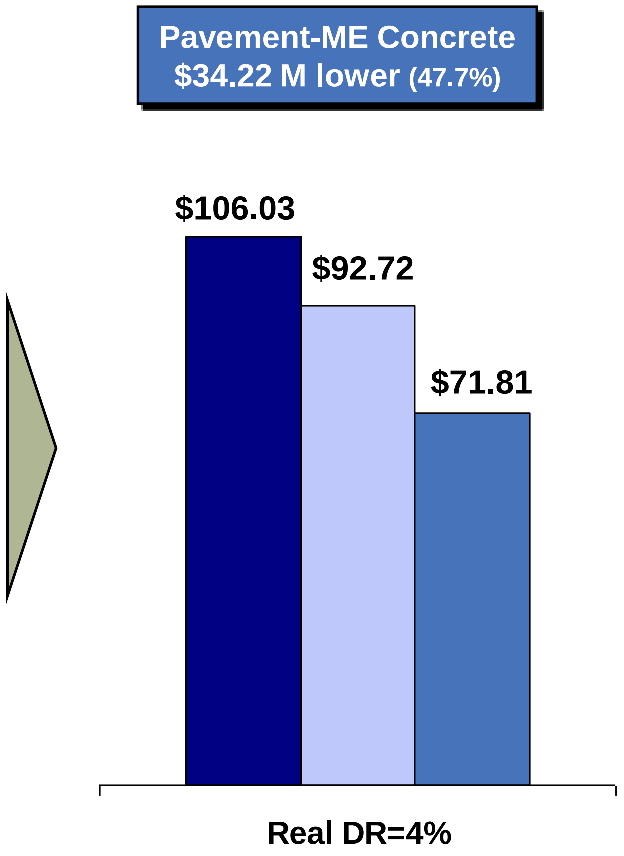

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SUMMARY

1. Pavement ME is a powerful tool for pavement performance prediction
   - Covers a wide range of applications
   - Determines when and how the pavement will fail
   - No longer just a thickness design procedure

2. For design, Pavement ME only needs a handful of important and necessary inputs
   - Three levels of input determination
   - Many inputs are semi-constants
   - Even more inputs are not sensitive
   - Be aware which are the design variables

3. Combine Pavement ME and LCCA to find the optimum design
   - No one-size-fits-all design. Each project is unique.
   - Use Pavement ME to generate many feasible designs
   - Use LCCA to decide the final design