# Concrete Pavement Design Tools

NWPMA
2017 Conference

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American Concrete Pavement Association, Northwest Chapter

ACPA NORTHWEST CHAPTER

# Concrete Pavement Longevity

- Hallmark of concrete pavements
- >50 year old pavements common…
- SR 522 in Washington
- Built 1917
- Rehab in 2001

# Benefits of Longevity

- Less-frequent reconstruction
- Lower consumption of raw materials
  - Cement, aggregates, steel
- Lower energy consumption
- Congestion

# Benefits of Longevity

- Reduction in pollutants
  - Manufacturing, construction, congestion
- Infrequent construction zones
- Real economic benefits…

# Pavement Design !!

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# PAVEMENT DESIGN

The new pavement will be built in the future, on subgrades often not yet exposed or accessible; using materials not yet manufactured from sources not yet identified; by a contractor who submitted the successful "low dollar" bid, employing unidentified personnel and procedures under climatic conditions that are frequently less than ideal.

NCHRP 1-26 Phase II Final Report

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# Design Procedures

- Empirical Design Procedures
  - Based on observed performance
    - AASHTO 1993 Design Guide – Based on AASHO Road Test
- Mechanistic/Empirical Design Procedures
  - Based on mathematically calculated pavement responses
    - ACPA Design Procedure – StreetPave
    - AASHTO MEPDG

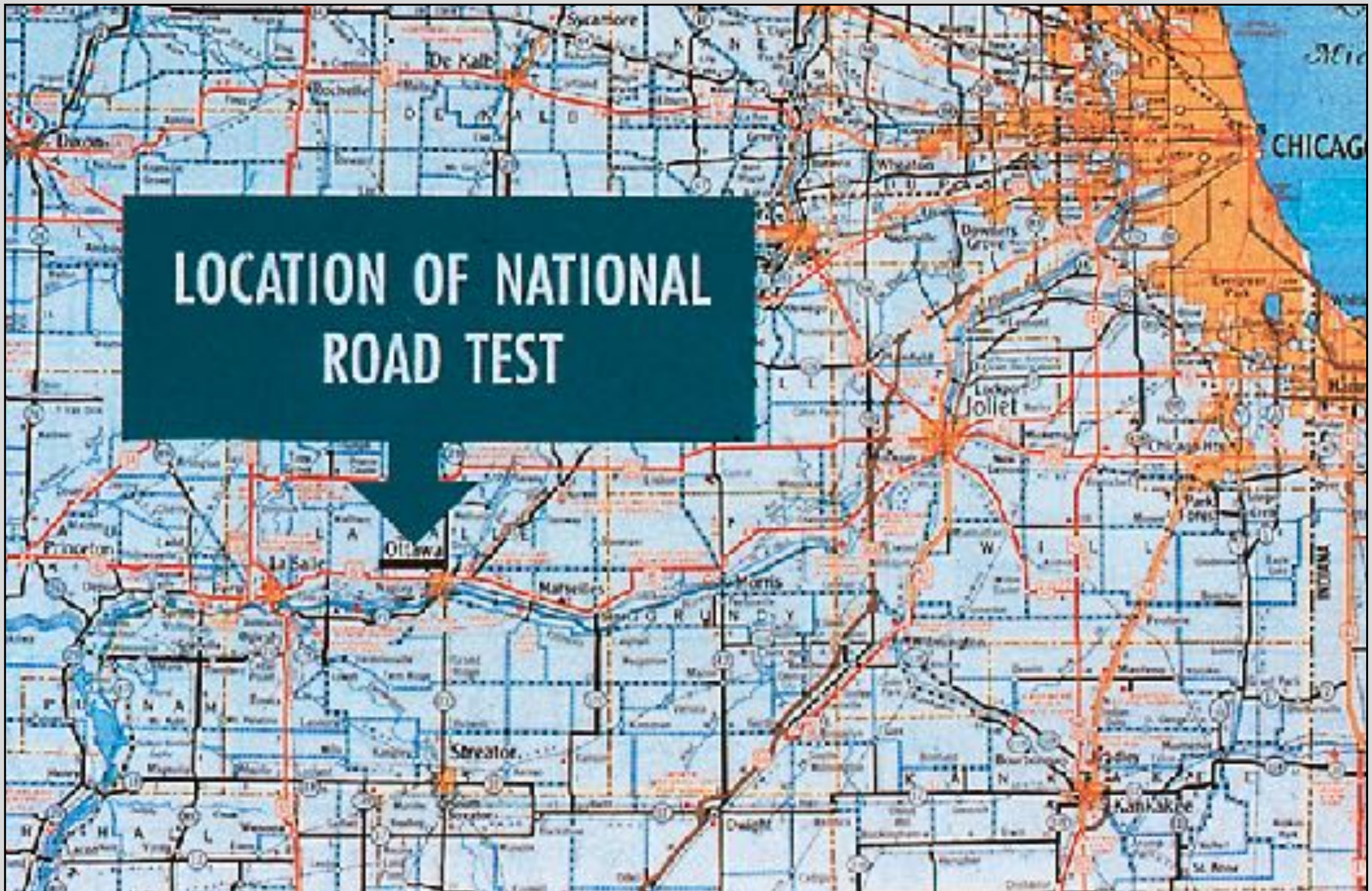
# Concrete Pavement Design Tools

- Roadways
  - AASHTO 93 (WinPAS)
  - StreetPave
  - DarwinME
  - OptiPave
- Overlays
  - StreetPave
  - BCOA-ME
- Industrial
  - AirPave
  - PCASE (Corps of Engineers)

# AASHTO 93 DESIGN Guide
# WinPAS

The AASHO Road Test was conceived and sponsored by the American Association of State Highway Officials to study the  performance of pavement structures of known thickness under moving loads of known magnitude and frequency.

# AASHO Road Test Location

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# Typical AASHO Loop Layout

Test Tangent = 6800 ft.

South tangents & west turnarounds: Rigid

North tangents & east turnarounds: Flexible

Section Length = 100 ft AC

= 240 JRCP

= 120 JPCP

368 rigid test sections

468 flexible test sections

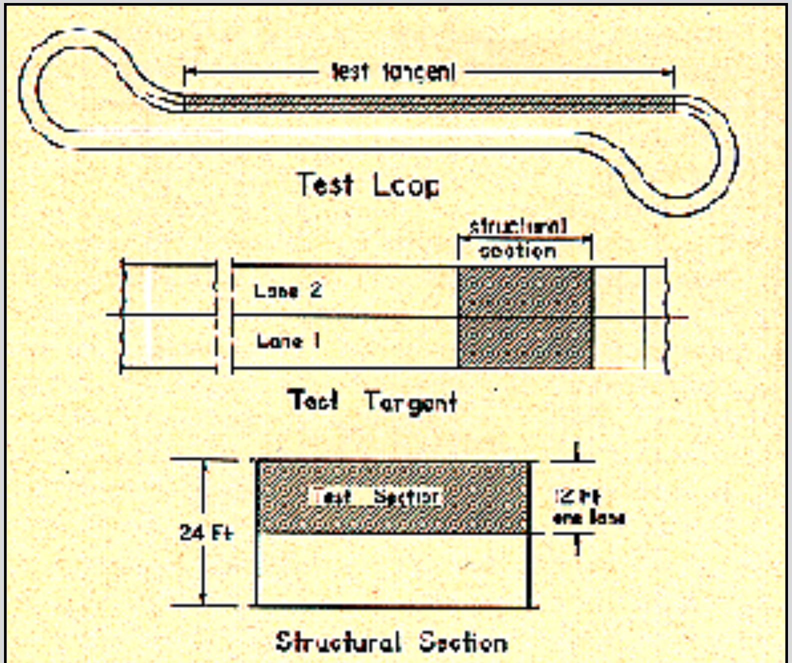
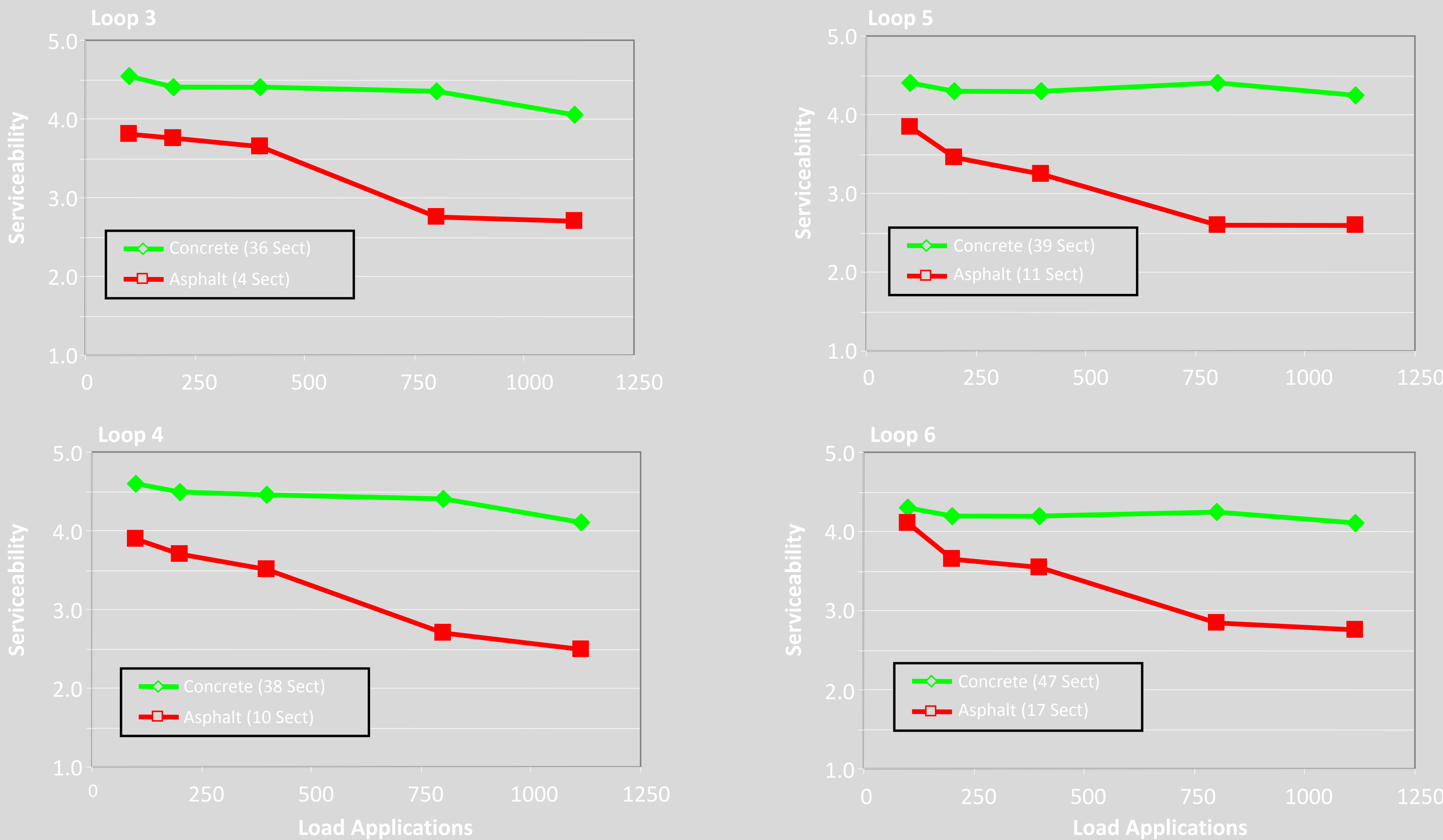


Figure 12. Typical loop layout.

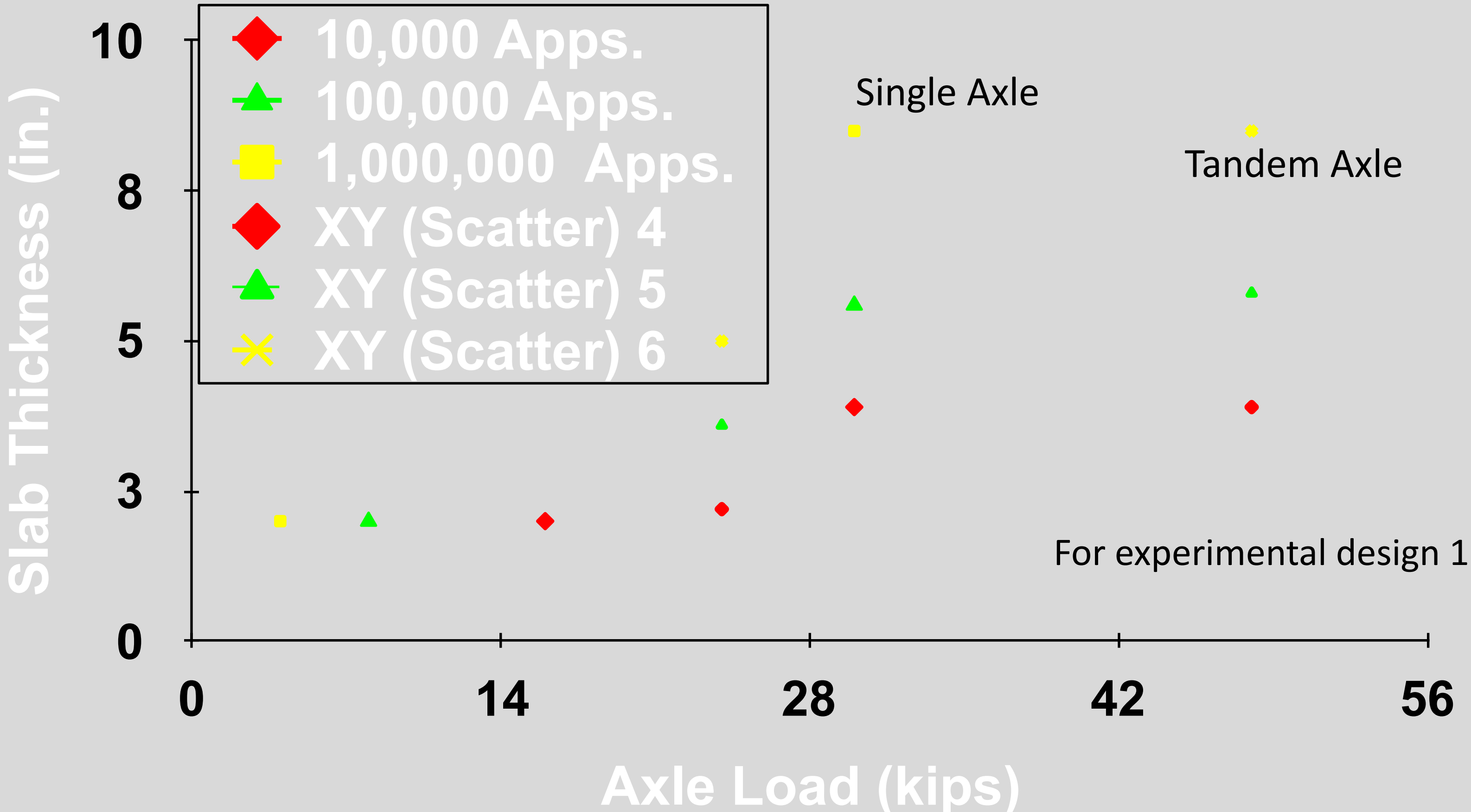
# AASHO Road Test Performance

## Surviving Sections




NORTHWEST CHAPTER

# AASHO Road Test
# Empirical Loop Equation



# AASHO Road Test
# Extended Design Equation

- Empirical Loop Equation only good for conditions at the AASHO Road Test
- Researchers wanted to extend equation to other sites with different:
    - Materials
    - Subgrades
    - Climates
    - Traffic Loadings

# 1986-93 Rigid Pavement Design Equation

$$\text{Log(ESALs)} = Z_R * s_o + 7.35 * \text{Log}(D + 1) - 0.06 + \frac{\text{Log}\left[\dfrac{\Delta PSI}{4.5 - 1.5}\right]}{1 + \dfrac{1.624 * 10^7}{(D + 1)^{8.46}}}$$

$$+ (4.22 - 0.32 p_t) * \text{Log}\left[\frac{S'_c * C_d * \left[D^{0.75} - 1.132\right]}{215.63 * J * \left[D^{0.75} - \dfrac{18.42}{(E_c / k)^{0.25}}\right]}\right]$$

Standard Normal Deviate ($Z_R$)

Overall Standard Deviation ($s_o$)

Depth ($D$)

Change in Serviceability ($\Delta PSI$)

Terminal Serviceability ($p_t$)

Modulus of Rupture ($S'_c$)

Drainage Coefficient ($C_d$)

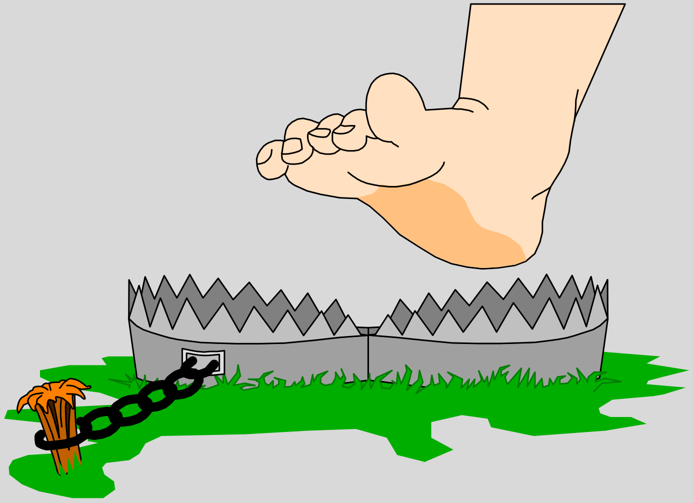
Load Transfer ($J$)

Modulus of Elasticity ($E_c$)

Modulus of Subgrade Reaction ($k$)

# AASHTO DESIGN
## Concrete Properties

Use average, in-field strength for design
(not minimum specified)



**If specify minimum flexural strength at 28-day of 550 psi & allow 10% of beams to fall below minimum:**

**<u>STEP 1</u>**

**Estimate SDEV:**

**9% for typical ready mix.**

**SDEV = 550 * 0.09 = 50 psi**

**<u>STEP 2</u>**

**$S'c_{design} = S'c_{minimum} + z * SDEV$**

**$S'c_{design} = 550 + 1.282 * 50$**

**$S'c_{design} = 614$ psi**

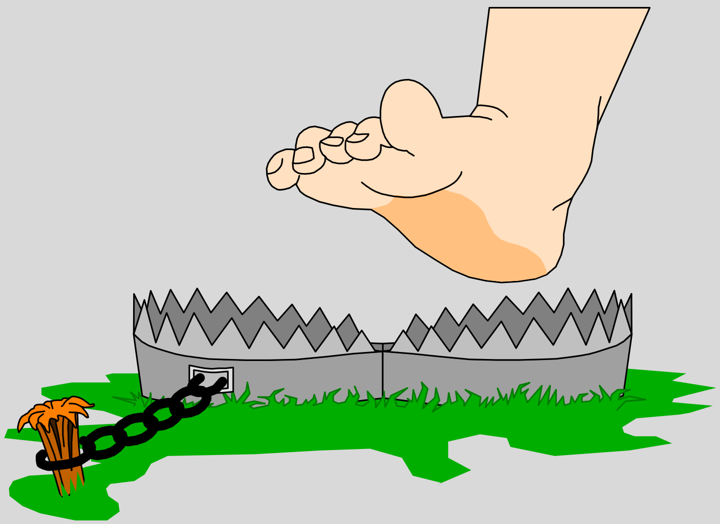
# AASHTO DESIGN

## Subgrade Soil Relationships

Be careful when using the AASHTO Subgrade Soil Relationships

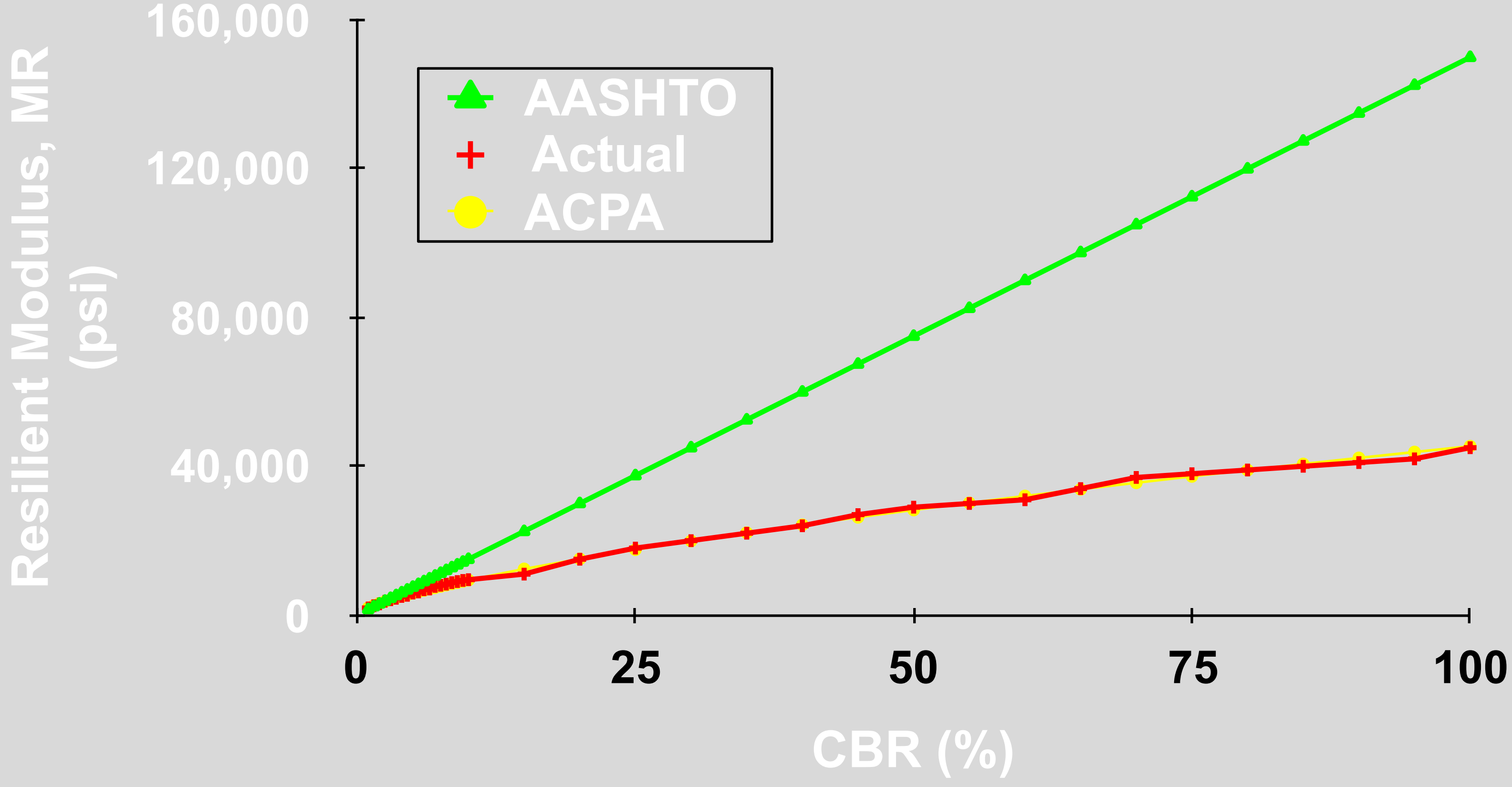
**$M_R$ = 1,500 * CBR**

**$M_R$ = 1,000 + 500 * R**



**These relationships given in the guide between $M_R$ and CBR and R-values over estimates actual $M_R$ values.**

# AASHTO DESIGN
## Subgrade Soil Relationships




Data: NCHRP Report 128.

# AASHTO DESIGN
## k-Value Determination

The relationships between k and $M_R$ (base - no base) give inconsistent results with high in-situ $M_R$ Values.

**For Example,**
**Assume $M_R$ = 12,000 psi**

**with no-base**
**$k = M_R / 19.4 = 619$ psi/in**

**with 6" granular base**
**k = 574 psi/in (from Fig 3.3)**

**As the $M_R$ value increases, the difference becomes greater.**

**Neither value is very realistic. Historical values are 150-250 psi/in.**

# AASHTO DESIGN
# Loss of Support

Reduces k-value due to expected erosion of subgrade.

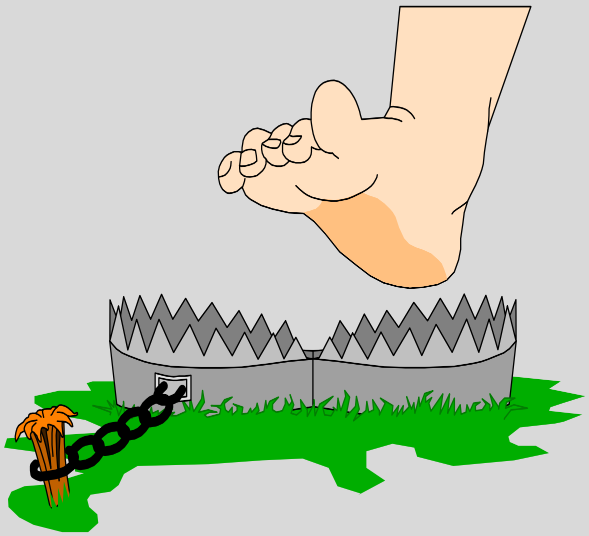
LOS = 0 models conditions at the AASHO road test.

Upper 3 feet were required to be:

- AASHO A-6 (clay)
- Group Index = 9-13
- Plastic Index = 11-15
- Liquid Limit 27-32
- 80-85% passed the #200 Sieve

# AASHTO DESIGN
## Subgrade Strength

Use Loss of Support = 0 (otherwise your using a huge fudge factor)



**All cracking of rigid pavements at the AASHO road test were preceded by the pumping of material from underneath the slab.**

**The primary mode of failure at the road test was loss of support in the poor clay soil.**

**Therefore, AASHTO design equations already account for support loss.**

# AASHTO DESIGN
## Drainage Coefficient

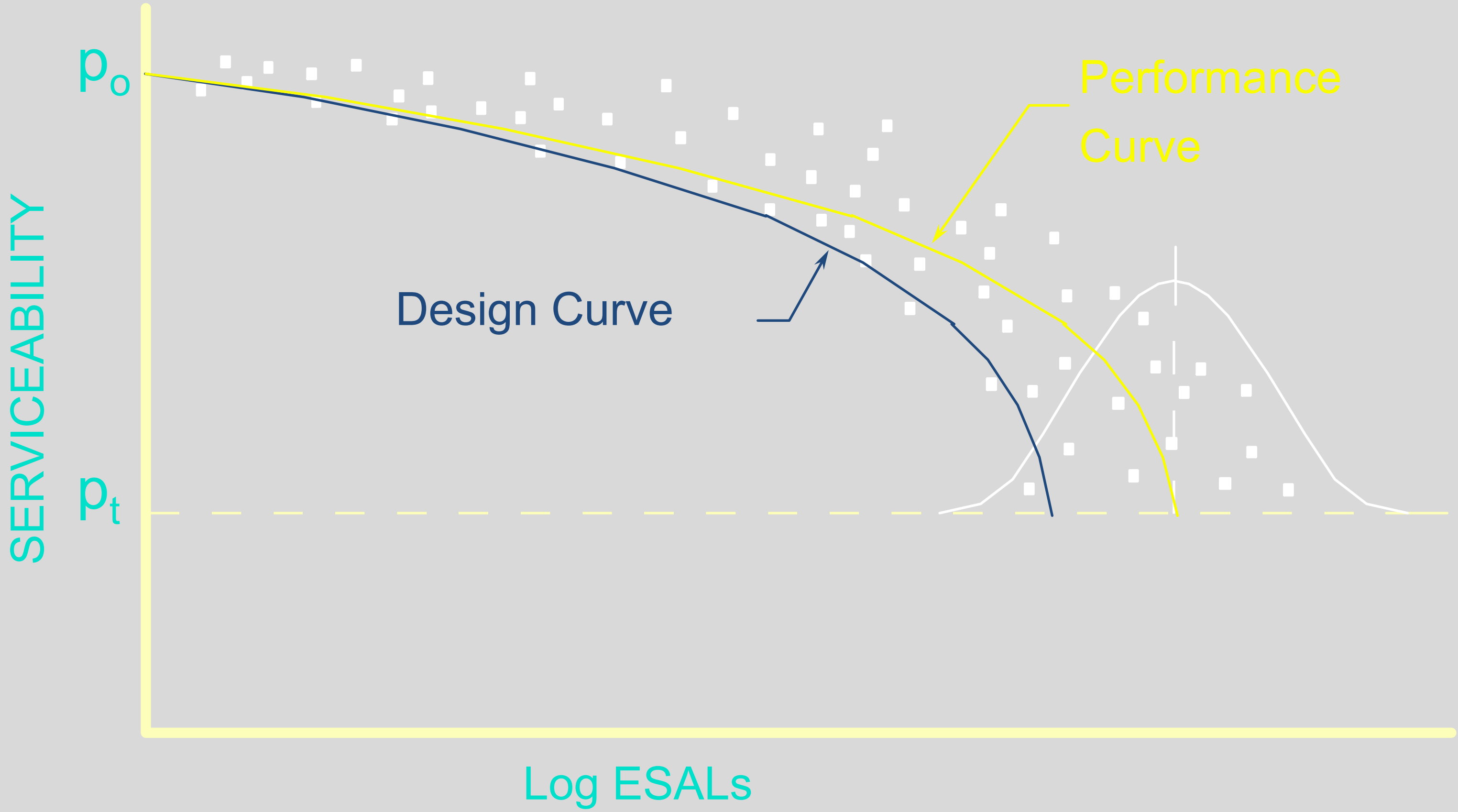
Use Drainage Coeff > 1.0 (otherwise using a huge fudge factor)

**The subgrade soil at the AASHO road test was a very poorly draining clay soil.**

**Therefore the AASHTO design equations already account for a poor drainage condition.**

**Modern open-graded bases and more free-draining soils are design options which can be modeled with Cd > 1.0**

# AASHTO DESIGN
## Reliability

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# AASHTO DESIGN
## Reliability

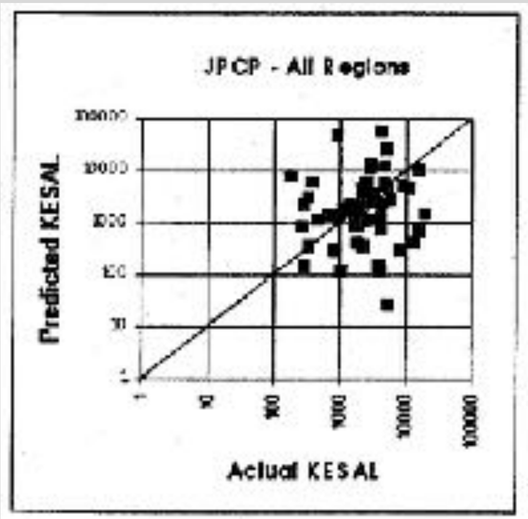
Never compare designs at different reliabilities (reliability = factor of safety)

Another way to think about reliability is to consider that at 90% reliability, only 10% of the pavement will have "failed" by the end of the design period.

If you are comparing a new concrete section to a new asphalt section use the same reliability for each.

Make design evaluations at 50% reliability.

# AASTHO Design Procedure Evaluation - JPCP




- The 1986-93 Equation is an “unbiased” predictor, but it is not accurate
  - Pred/Act ranged from 0.1 to over 10
- If designed with a high reliability, it will yield a conservative design

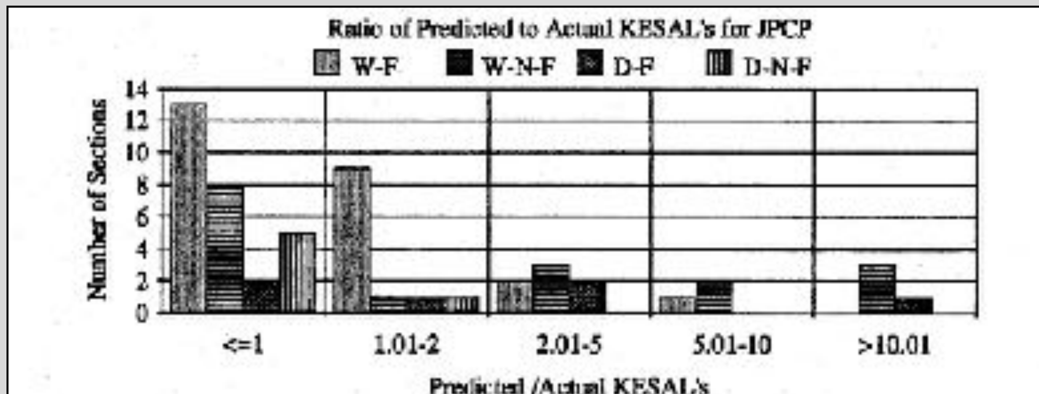



**Figure 6.8. Ratio of Predicted KESALs to Actual KESALs for JPCP Based on the 1993 AASHTO Prediction Model**

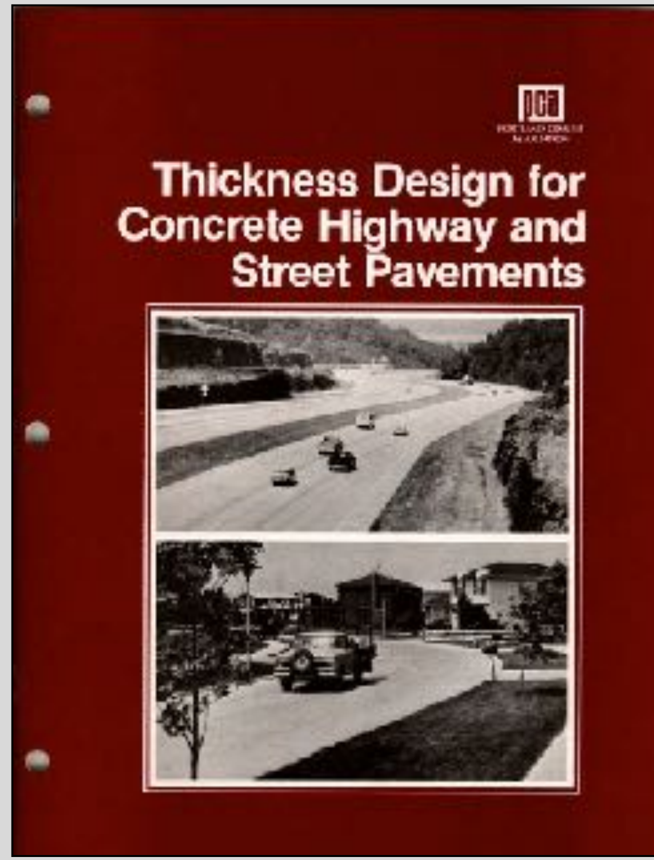
*From: Evaluation of the AASHTO Design Equations and Recommended Improvements SHRP-P-394 (1994)*

# PCAPAV
# DESIGN PROCEDURE

PCAPAV - a mechanistic thickness design procedure.

Based on:

- Theoretical Studies
- Model & Full-scale tests
- Experimental test roads
  - i.e. AASHO Road Test
- Performance of normal pavements

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# StreetPave Thickness Design Procedure

- Pavement design tool geared primarily for roads & streets
- Based on the PCA's pavement thickness design methodology
- Assesses adequacy of concrete thickness using both fatigue and erosion criteria

# StreetPave's Origins

- PCA thickness design methodology for JPCP
  - first published in 1966
    - used slab stress/fatigue as the sole design criterion for determining thickness
  - updated in 1984
    - failure by erosion (pumping)
    - edge support

concrete information

PORTLAND CEMENT ASSOCIATION

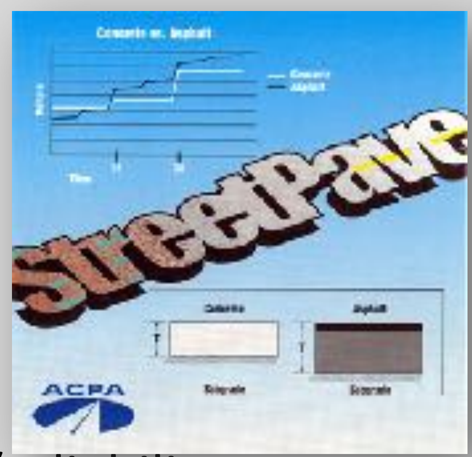
**Thickness Design for Concrete Pavements**

**Introduction**

**Basis for Design**

**Concrete Properties**

# StreetPave's Origins




- StreetPave
  - released in 2005 by ACPA
  - tailored for streets and roads
  - improvements included:
    - enhanced concrete fatigue model w/reliability component
    - ability to analyze tridem axles in the traffic spectrum
    - new recommendations for dowel bars, joint spacing, subgrade/subbase moduli, etc.
    - side-by-side design comparison to asphalt sections

# Fatigue – Total Damage

- Cumulative damage:

$$FD_{total} = FD_{single} + FD_{tandem} + FD_{tridem}$$

where,

$FD_{total}$ = total fatigue damage, %

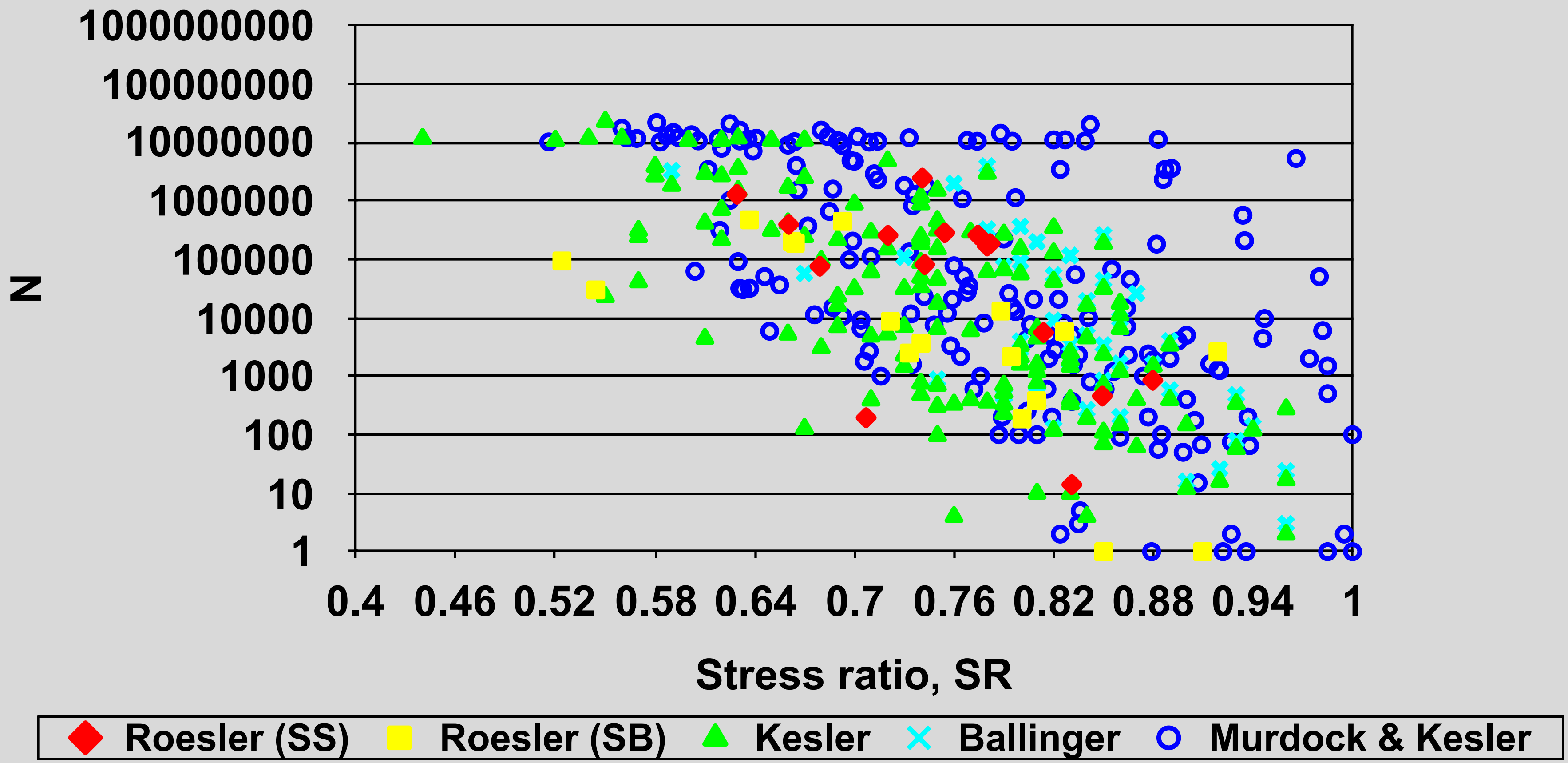
$FD_{single}$ = fatigue damage from single axle loads, %

$FD_{tandem}$ = fatigue damage from tandem axle loads, %

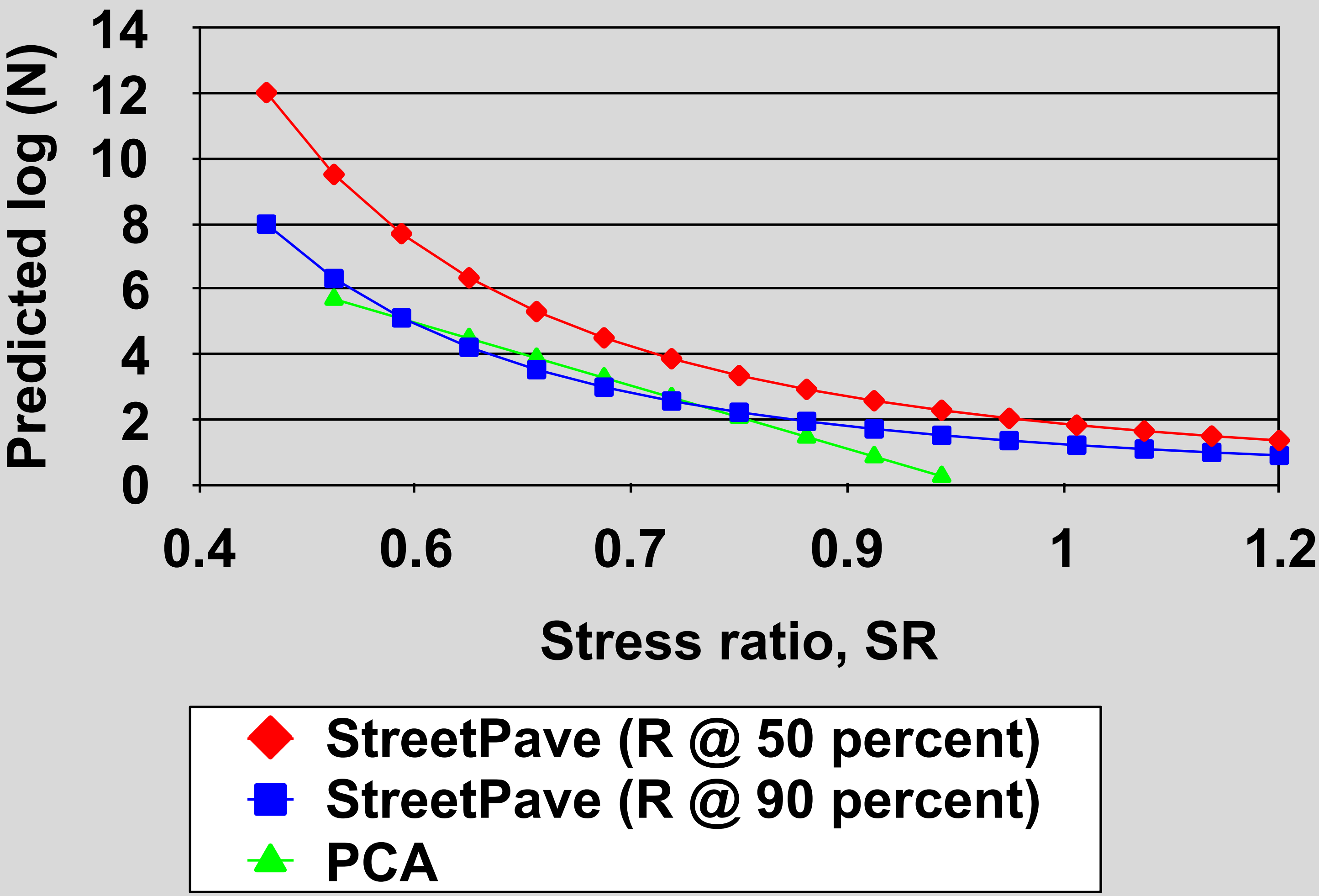
$FD_{tridem}$ = fatigue damage from tridem axle loads, %

**MECHANISTIC DESIGN … but validated**

# Fatigue – Test Data



# Fatigue - Model Comparison



# Faulting – Total Erosion

- Cumulative erosion:

$$ED_{total} = ED_{single} + ED_{tandem} + ED_{tridem}$$

where,

$ED_{total}$ = total erosion damage, %

$ED_{single}$ = erosion damage from single axle loads, %

$ED_{tandem}$ = erosion damage from tandem axle loads, %

$ED_{tridem}$ = erosion damage from tridem axle loads, %

EMPIRICAL DESIGN

# Faulting – Erosion per Load Group

- Erosion damage (*ED*) for each load group is computed per Miner's damage hypothesis:

$$ED = \frac{n}{N_e}$$

where,

$n$ = number of load appl

$N_e$ = allowable applications to **erosion** failure

# Faulting – Power

- Rate or work or power:

$$P = 268.7\left(\frac{k^{1.27} * \delta_{eq}^{2}}{h}\right)$$

where,

$\delta_{eq}$ = equivalent corner deflection, in.

$k$ = composite k-value of subgrade/subbase

- Idea is that, for a unit area, a thinner pavement with a shorter deflection basin (e.g., smaller radius of relative stiffness) will receive a faster punch

# Faulting – Erosion Failure

- Pavement thickness incrementally increased

# StreetPave – Design Inputs

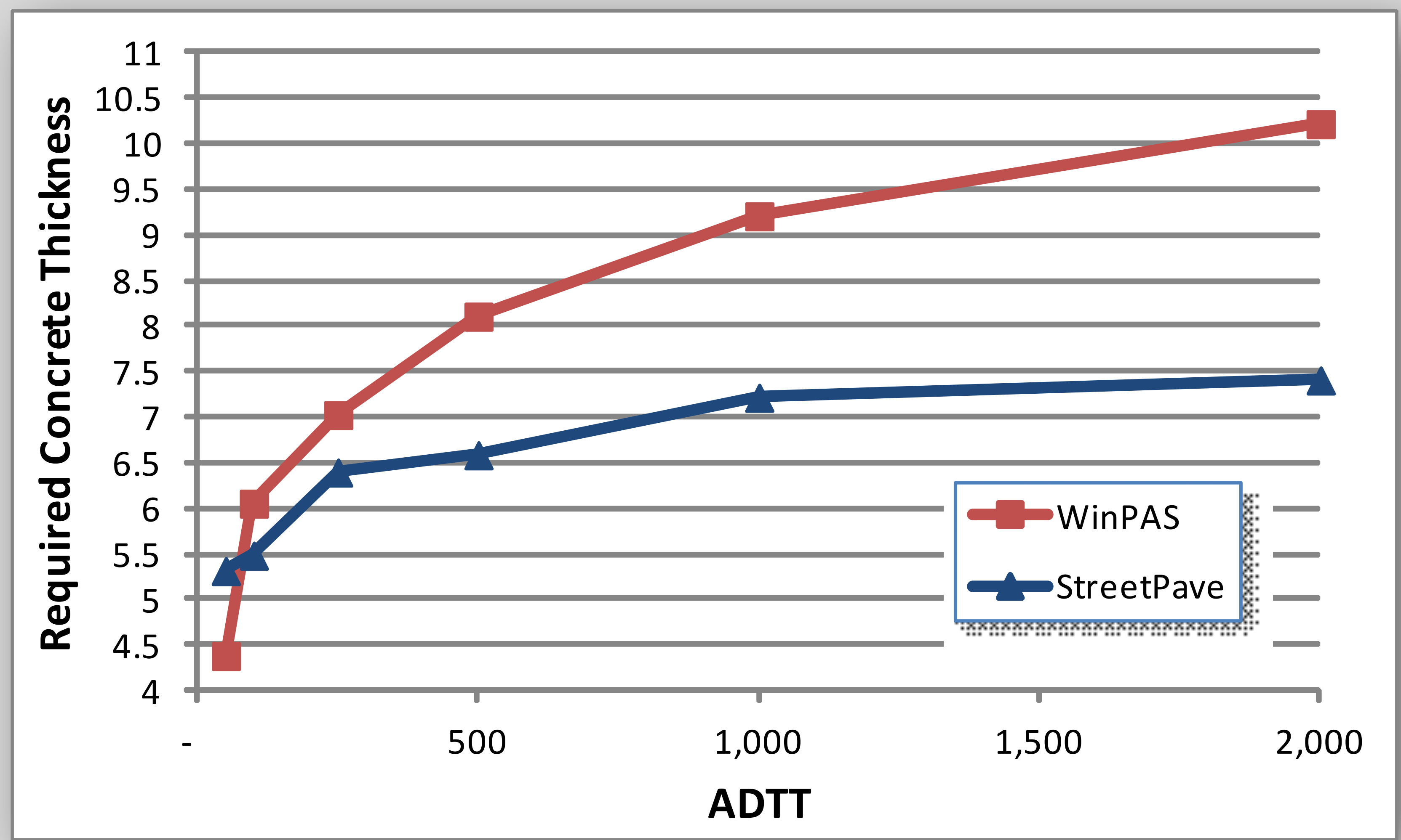
- Design Life
- Reliability
- % Slabs Cracked
- Traffic
  - Volume
  - Load
  - Growth
  - Distribution

- K-value
  - Subgrade & Subbase(s)
    - Thickness
    - Modulus
- Edge Support
- Dowel Bars
- Concrete
  - Strength
  - Modulus of Elasticity

# Controlling Factors

- Fatigue usually controls design of light-traffic pavements
  - Single-axles usually cause more fatigue damage
- Erosion usually controls design of undoweled medium- and heavy-traffic pavements
  - Tandem and tridem axles usually cause more erosion damage

# AASHTO 93 vs. StreetPave




- Traffic spectrum factors in – not just ESALs!

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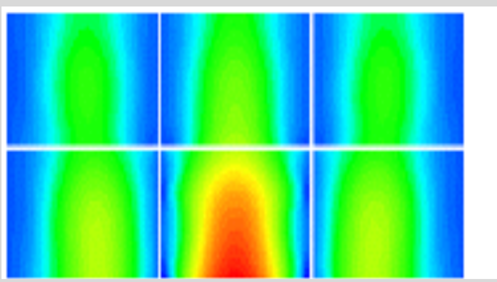
# DARWIN ME

# Mechanistic-Empirical Design



Mechanistic Elements

+

Empirical Elements

=

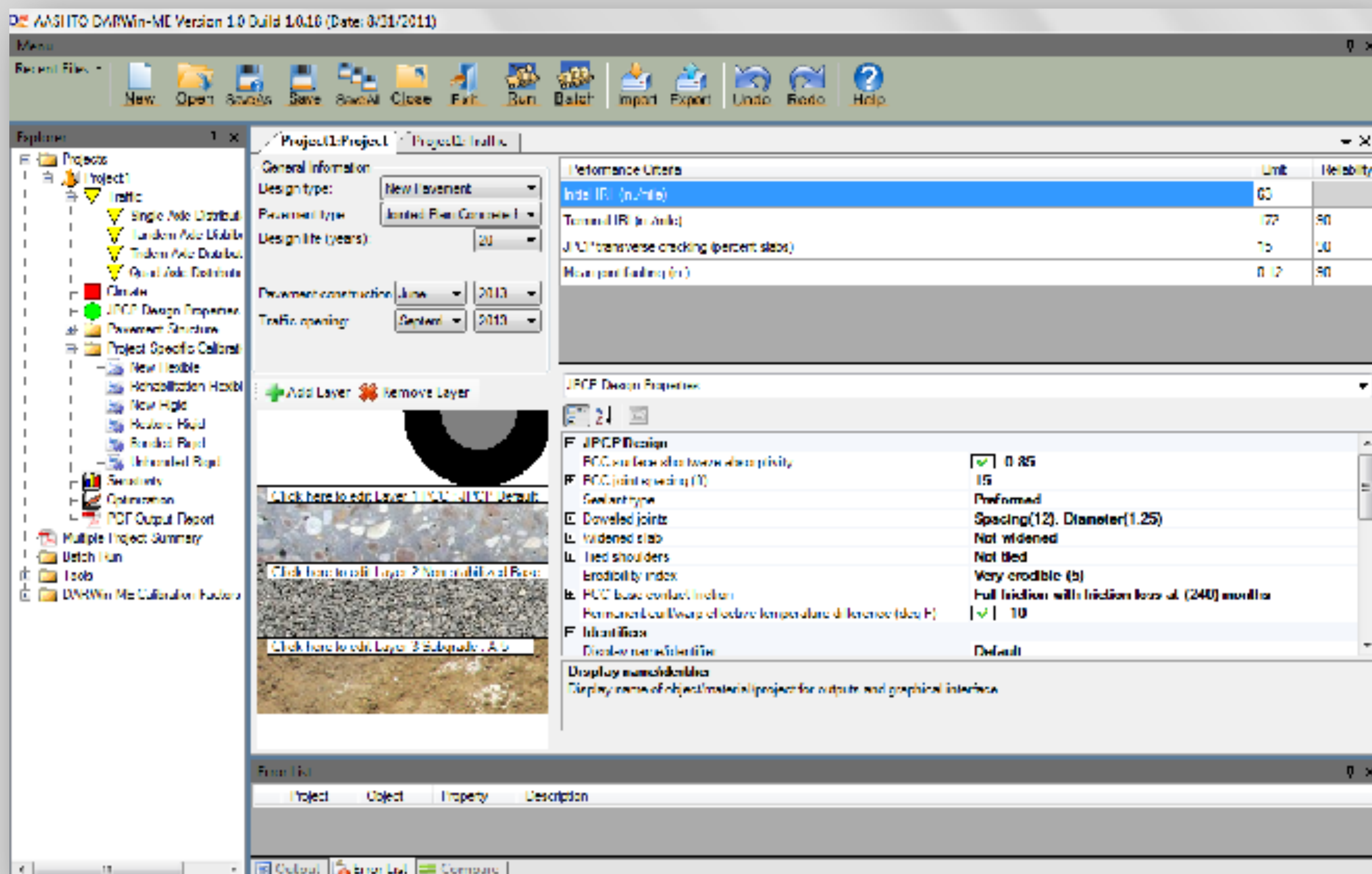
Pavement Performance Prediction

# M-E Design Basics

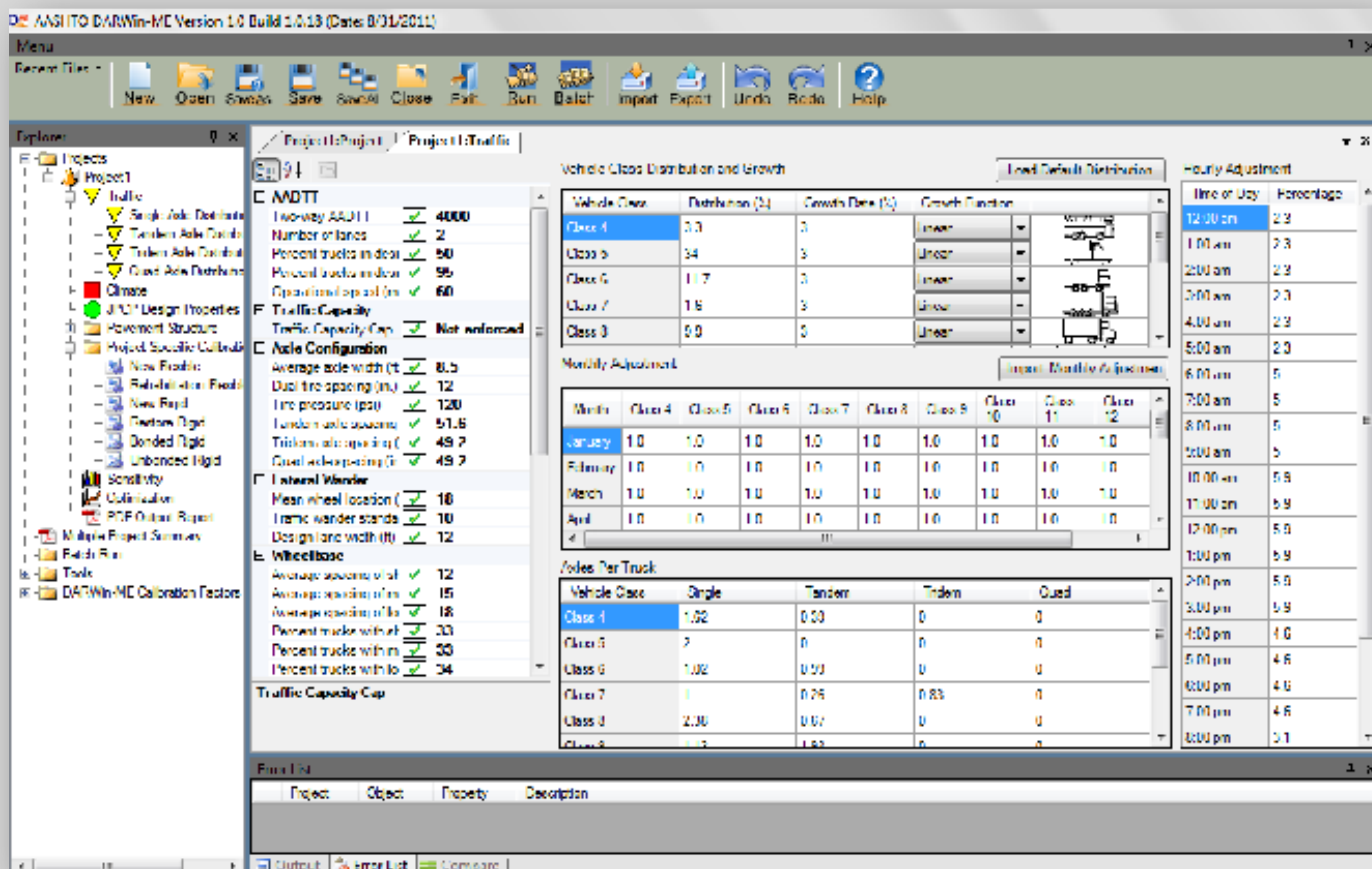
- Mechanistically:
  - Calculate critical pavement response (i.e., stresses, strains, and deflections) due to:
    - Traffic loading.
    - Environmental conditions.
  - Accumulate damage over time.
- Empirically:
  - Relate damage over time to pavement distresses through calibrated models, e.g.:
    - Cracking, Faulting, Roughness in JPCP.
    - Punchouts, Crack Width, Roughness in CRCP.
  - Accumulate damage over time.

**MECHANISTIC + EMPIRICAL DESIGN**

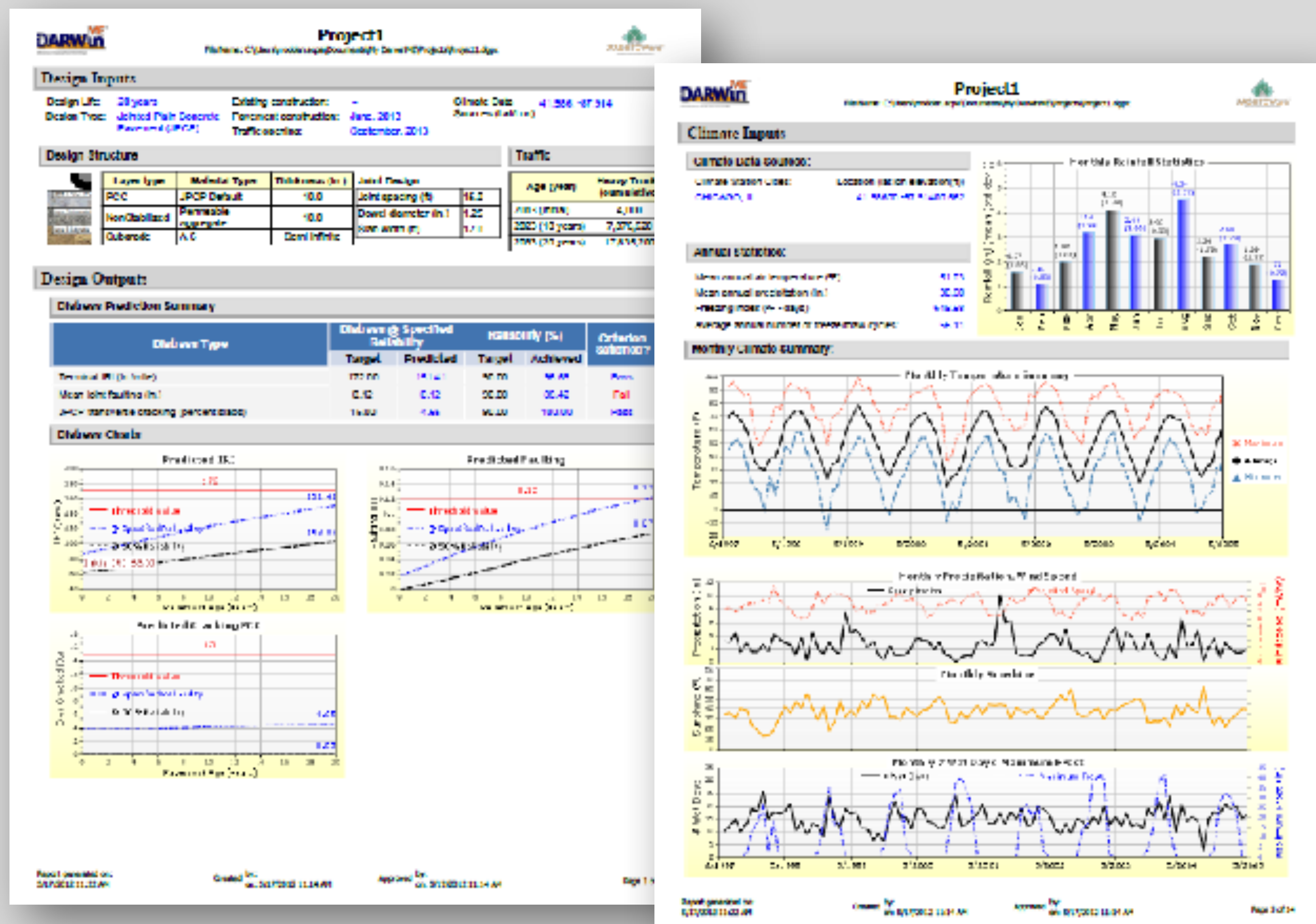
# INPUTS, INPUTS, INPUTS!!!!



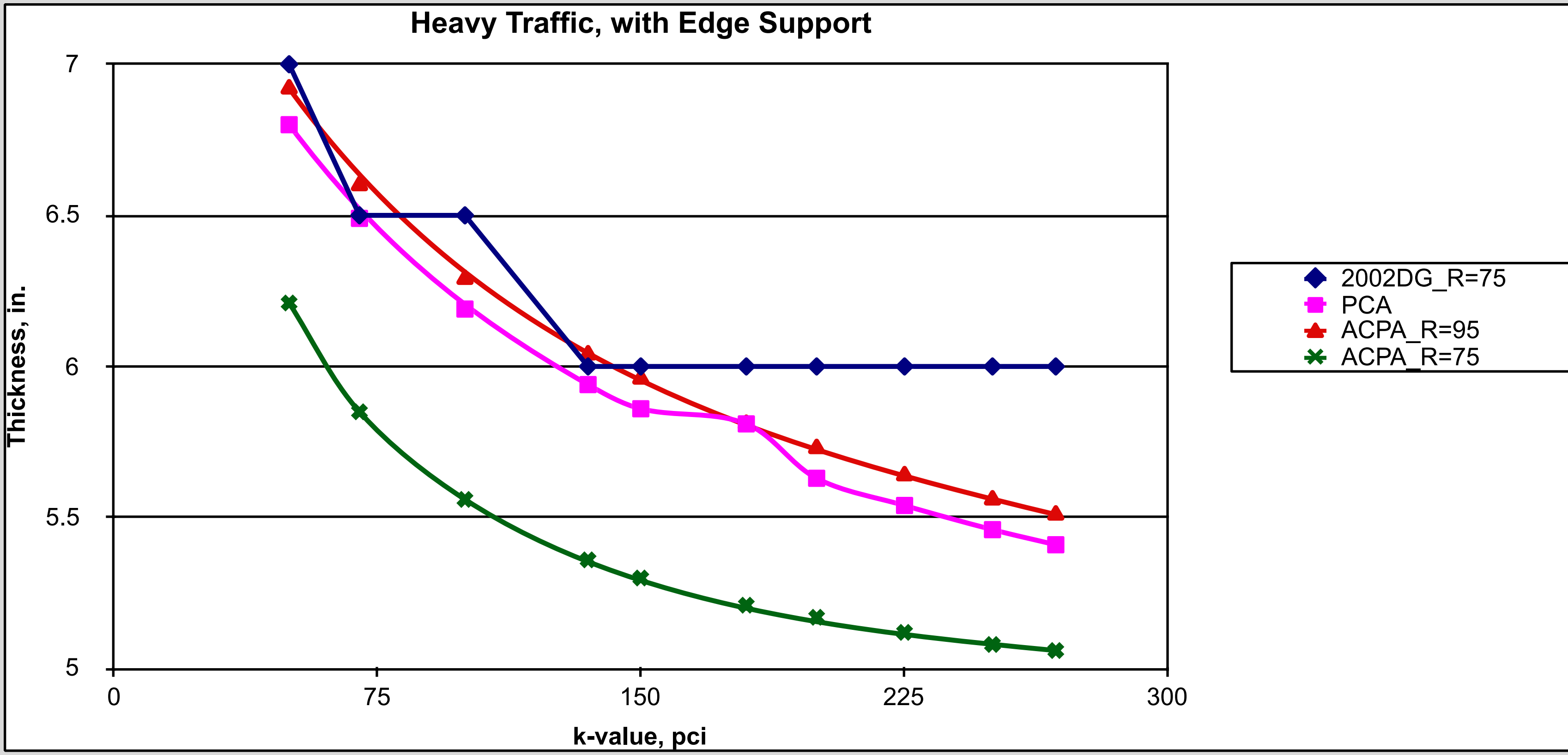
# INPUTS, INPUTS, INPUTS!!!!



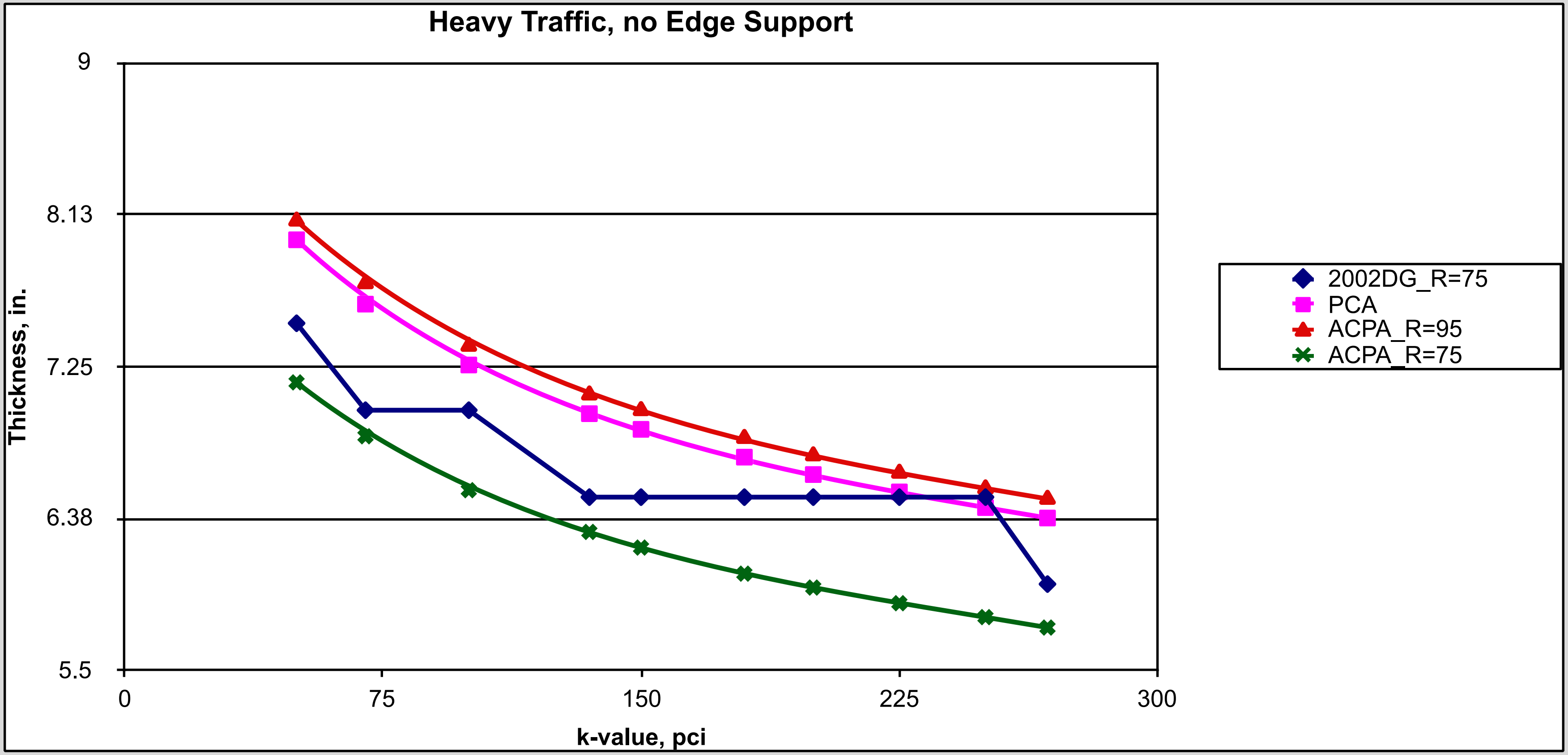
# OUTPUTS, OUTPUTS, OUTPUTS!!!



# Heavy Traffic, w/ Edge Support



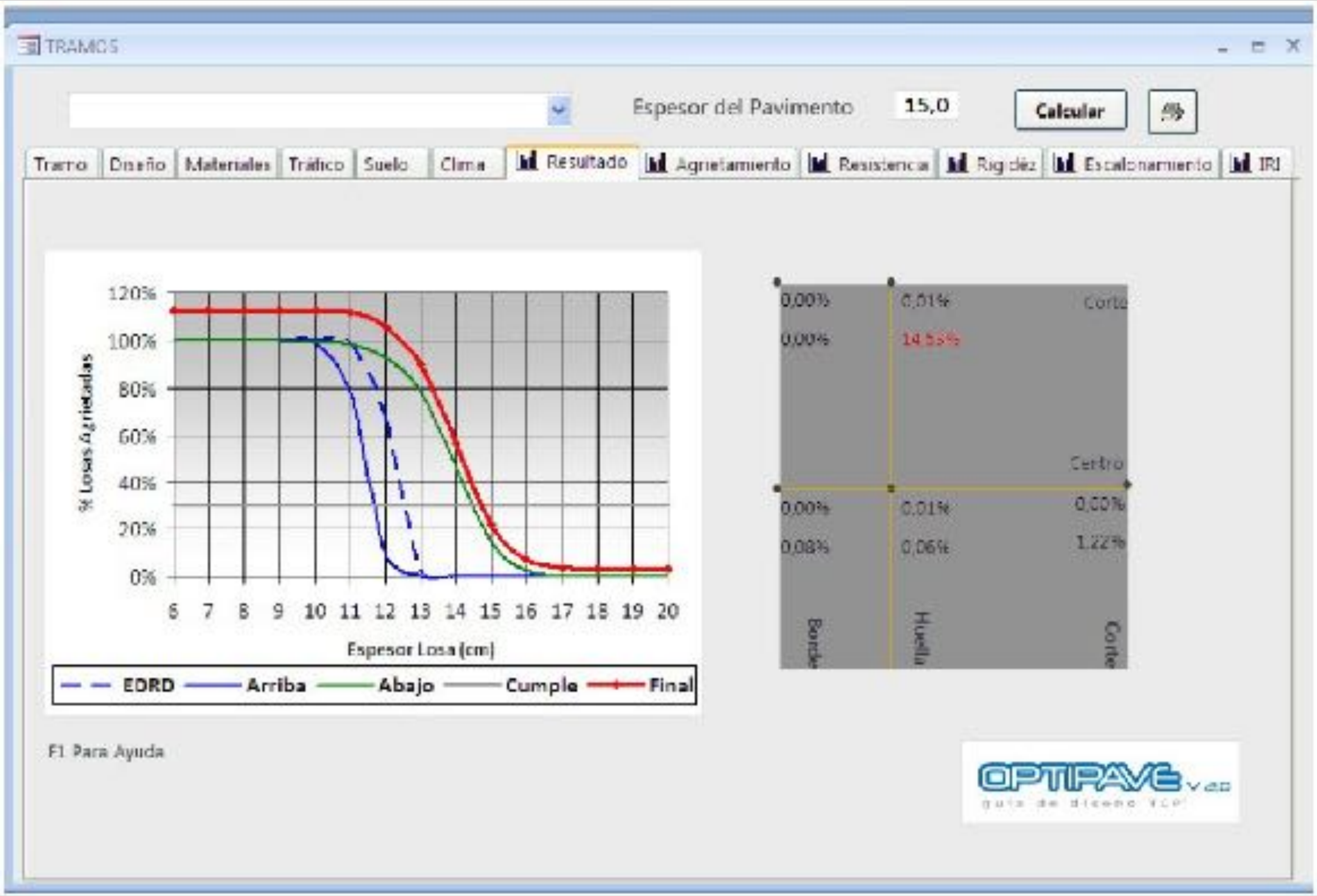
# Heavy Traffic, no Edge Support



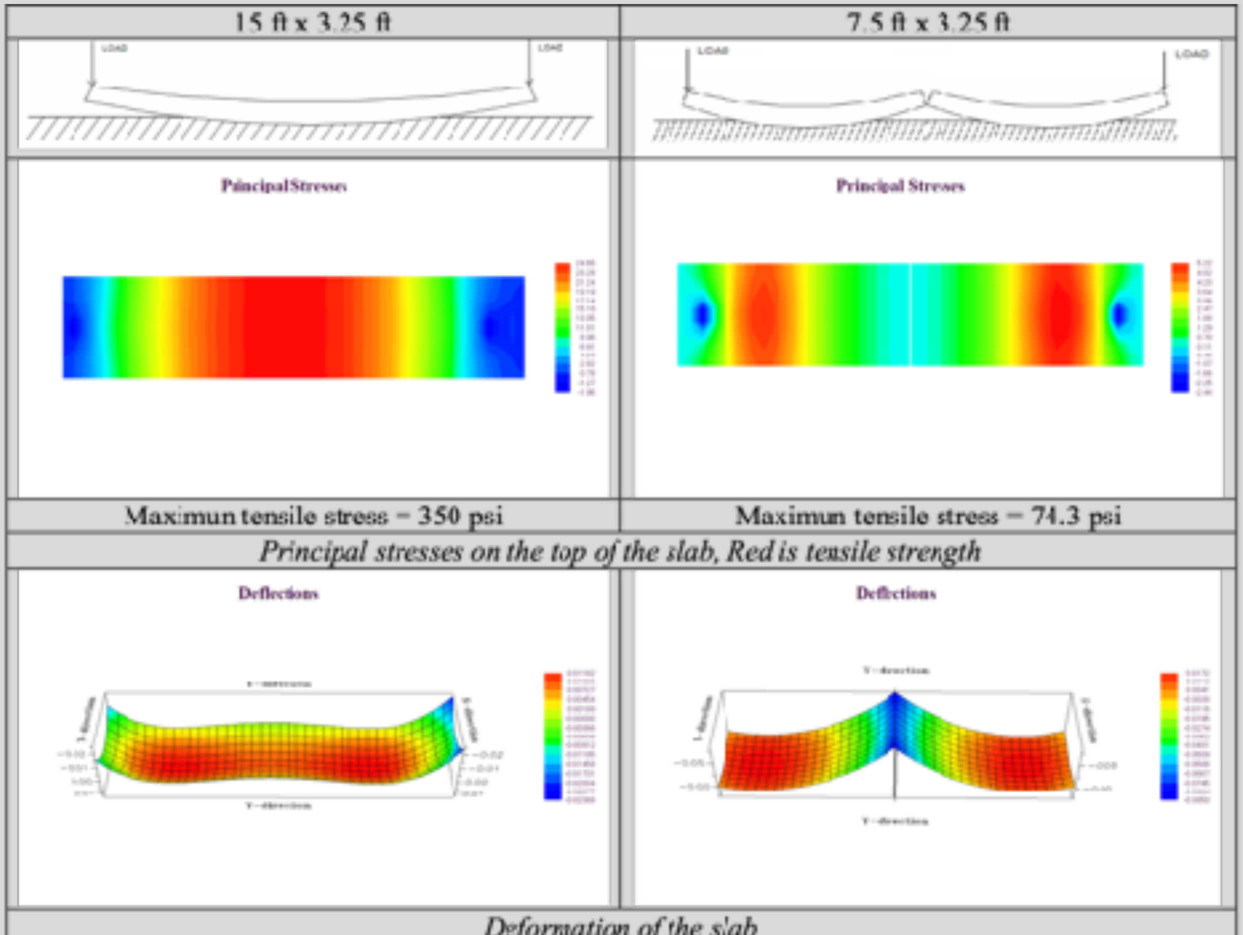
# Summary / Conclusions

- At **heavy** traffic levels:
  - ME Design Guide is still fairly close to PCA and ACPA at 95% reliability
  - ME Design Guide not as sensitive to edge support condition

# Thin Concrete Pavements



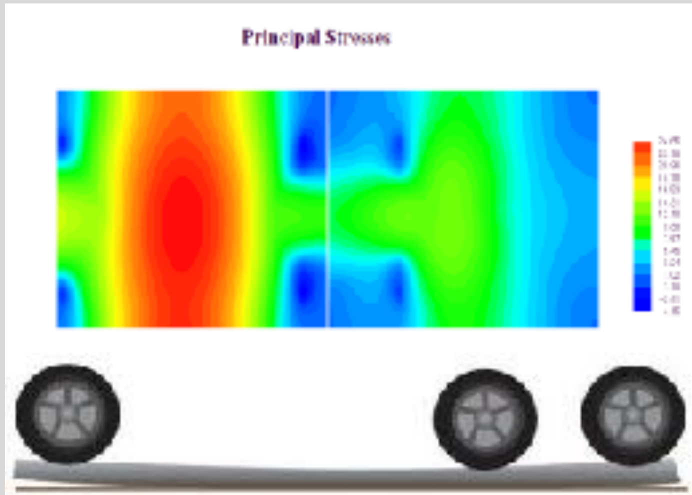
# Influence of Slab Geometry on Stresses



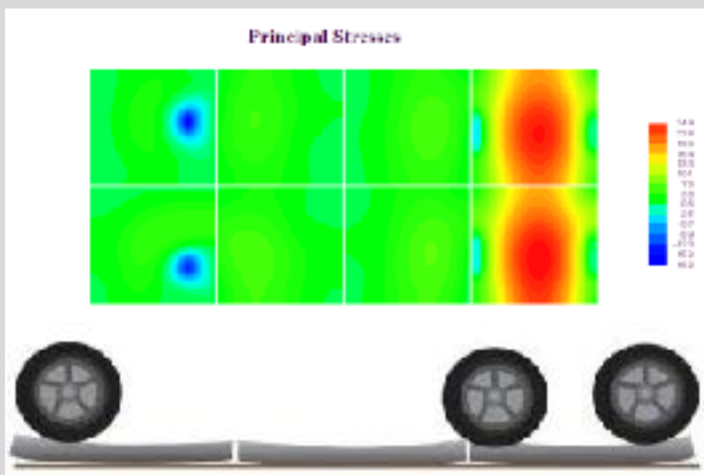
# Position of the Loads and Dimension of the Slabs

TCP® Design
AASHTO Design

# Slabs Sizes and Thickness For Same Top Stress (363 psi)




Concrete Thickness: 10 in.
Slabs: 15 ft x 12 ft




Concrete Thickness: 6.3 in.
Slabs  6 ft x 6 ft

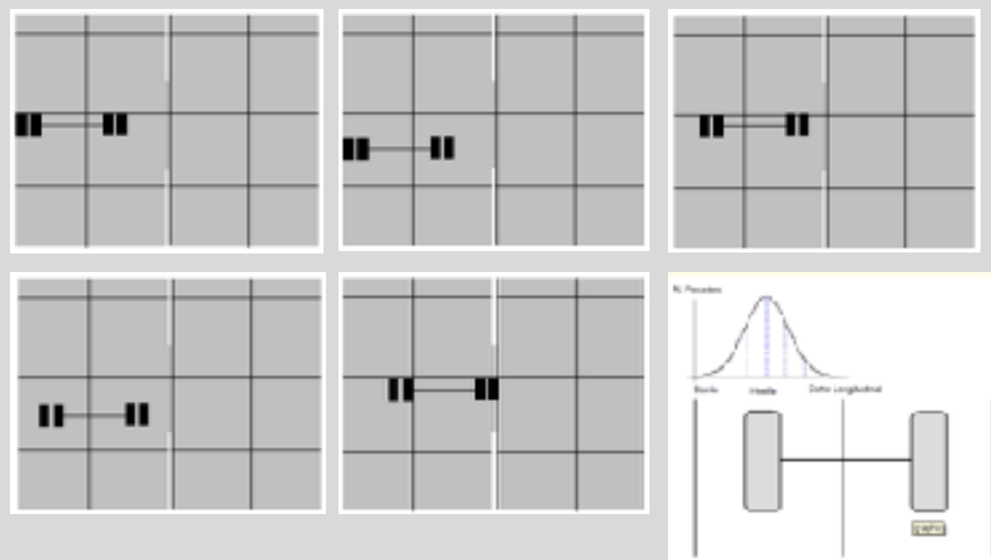
# Characteristics of TCP Design

- Small slabs  (1.4 to 2.4) meters long (5ft-8ft)
  - Less curl/warp; smaller crack width
- Granular base (fines < 8%) 15 cm thick
  - Less pumping/faulting potential
- Normal or fiber reinforced concrete
- Geotextile between the subgrade and base, if needed
- Thin joint cut (<2.5 mm wide)
- No joints sealing
- Optimized dowel bar system or no dowels
- Lateral confinement with curb, shoulder , vertical steel pins or FRC
- Widened outer lane

# TCP Design

- Cumulative fatigue damage, like StreetPave
  - Islab 2000 runs for stresses; NCHRP 1-37 for fatigue
- ESALs used for simplicity
- Environment considered in calculations

**MECHANISTIC DESIGN**
**… but validated**



# Non-Standard Loads

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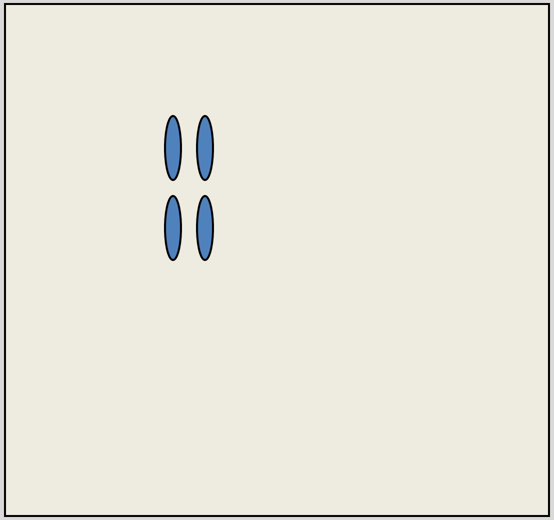
# ACPA AirPave Procedure

- Westergaard Analysis
- Center Loading
- Gear Rotation
- Gear Configuration
- Number of wheels
- Tire contact area
- Tire pressure

## Loading Condition



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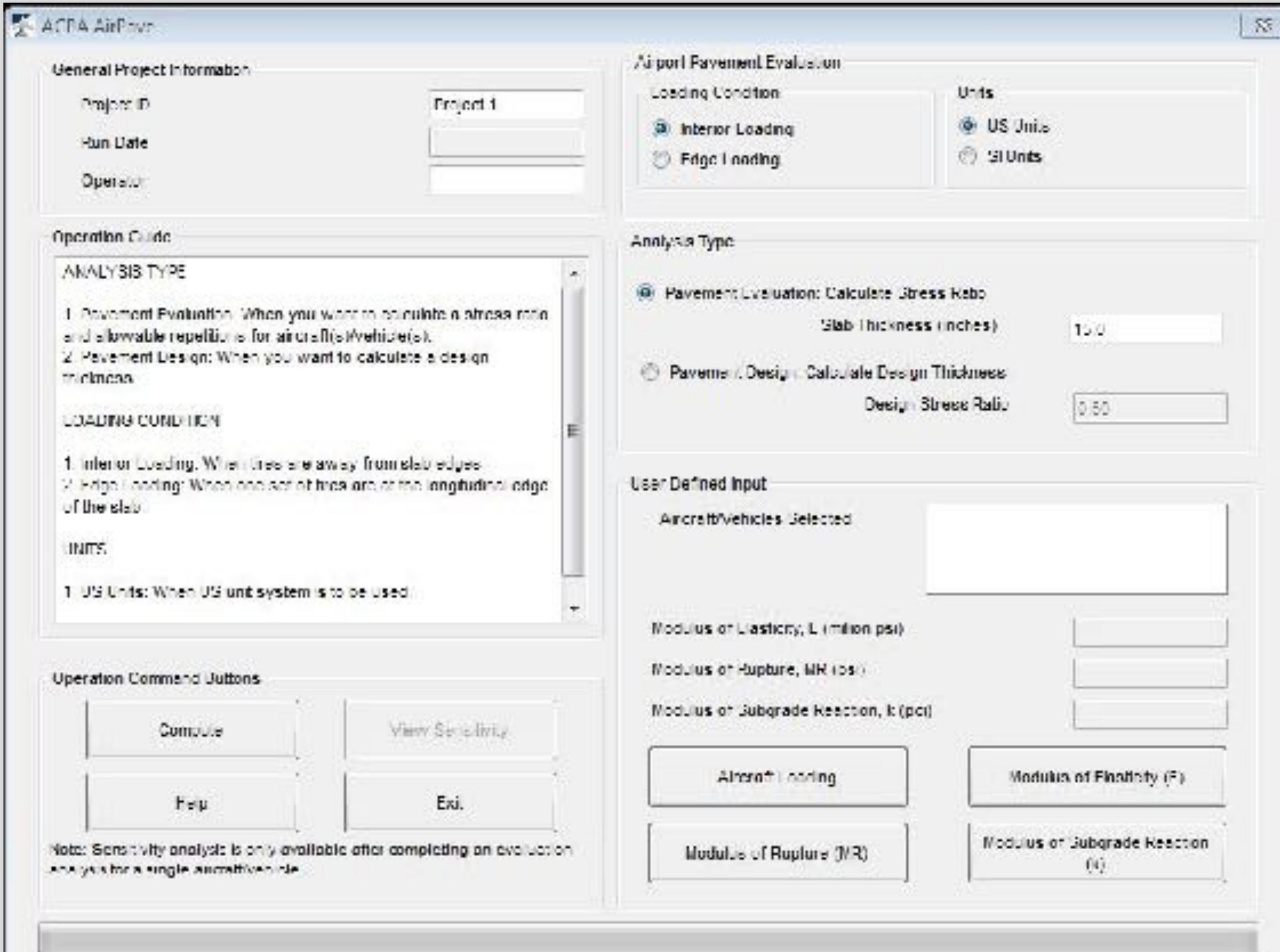
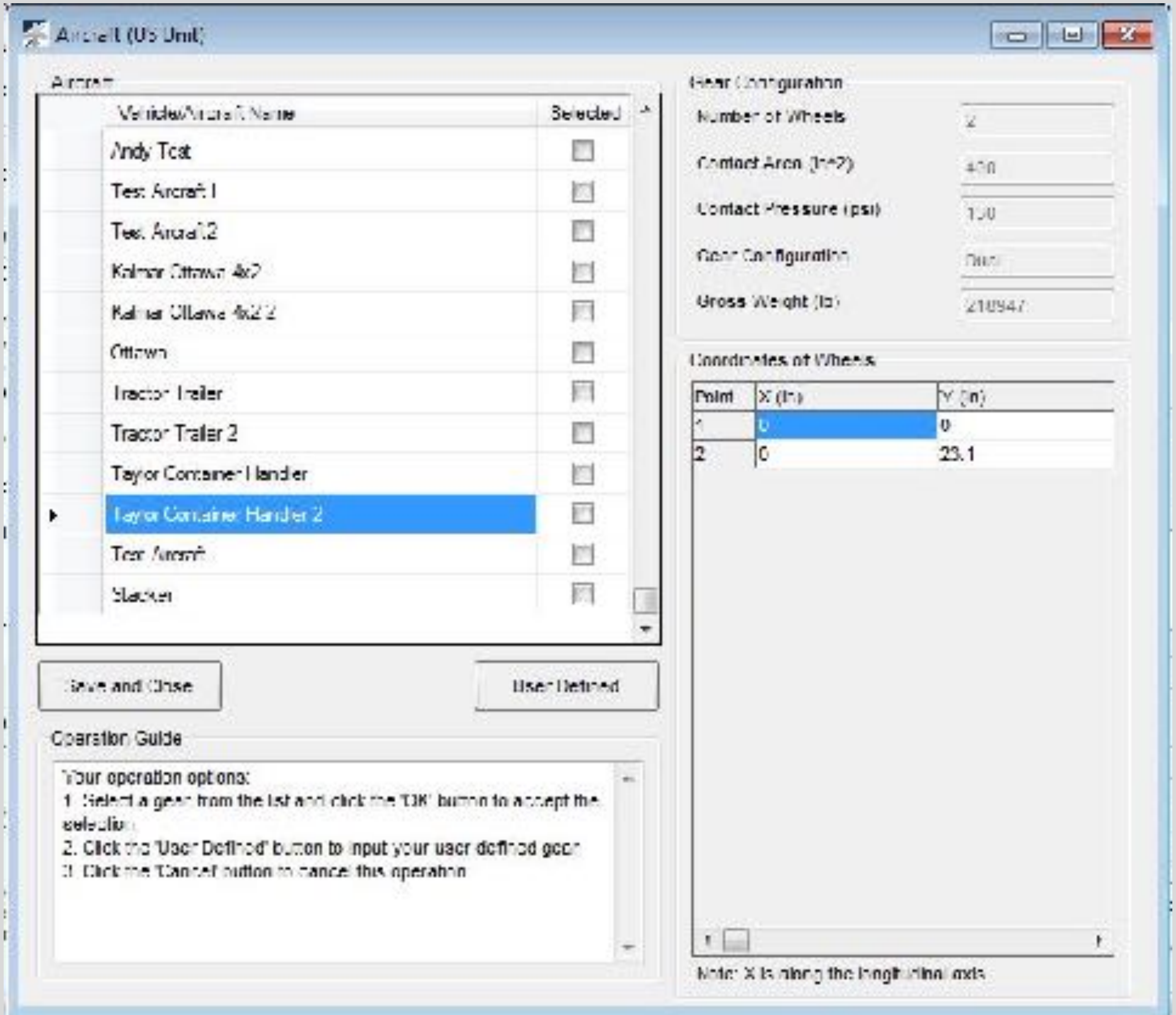
# AirPave


General Project Information
Project ID
Project 1
Run Date
Operation Guide
ANALYSIS TYPE
2. Pavement Design: When you want to calculate a design
UNITS
Operation Command Buttons
Compute
View Sensitivity
Help
Exit
Airport Pavement Evaluation
Loading Condition
Interior Loading
Units
US Units
SI Units
Analysis Type
Slab Thickness (inches)
Design Stress Ratio
User Defined Input
Aircraft/Vehicles Selected
Modulus of Elasticity, E (million psi)
Modulus of Rupture, MR (psi)
Modulus of Subgrade Reaction, k (pci)
Aircraft Loading
Modulus of Elasticity (E)
Modulus of Rupture (MR)
Modulus of Subgrade Reaction (k)

# AirPave


Vehicle/Aircraft Name
Selected
Andy Test
Test Aircraft 1
Test Aircraft 2
Kalmar Ottawa 4x2
Kalmar Ottawa 4x2 2
Ottawa
Tractor Trailer
Tractor Trailer 2
Taylor Container Handler
Taylor Container Handler 2
Test Aircraft
Stacker
Save and Close
User Defined
Operation Guide
Your operation options:
2. Click the 'User Defined' button to input your user defined gear
Gear Configuration
Number of Wheels
Contact Area (in^2)
Contact Pressure (psi)
Gear Configuration
Gross Weight (lb)
Coordinates of Wheels
Point
X (in)
Y (in)
23.1

# AirPave

| Stress* ratio | Allowable repetitions | Stress ratio | Allowable repetitions |
|---|---|---|---|
| 0.51** | 400,000 | 0.63 | 14,000 |
| 0.52 | 300,000 | 0.64 | 11,000 |
| 0.53 | 240,000 | 0.65 | 8,000 |
| 0.54 | 180,000 | 0.66 | 6,000 |
| 0.55 | 130,000 | 0.67 | 4,500 |
| 0.56 | 100,000 | 0.68 | 3,500 |
| 0.57 | 75,000 | 0.69 | 2,500 |
| 0.58 | 57,000 | 0.70 | 2,000 |
| 0.59 | 42,000 | 0.71 | 1,500 |
| 0.60 | 32,000 | 0.72 | 1,100 |
| 0.61 | 24,000 | 0.73 | 850 |
| 0.62 | 18,000 | 0.74 | 650 |

*Load stress divided by modulus of rupture.
**Unlimited repetitions for stress ratios of 0.50 or less.

# AirPave

## ACPA AirPave

### Pavement Evaluation Report

**Summary Information**

GENERAL DESIGN INFORMATION

Project ID: Project 1 Operator: Blank

Run Date: 11/5/2014

GENERAL DESIGN INPUT

Slab Thickness: 15.00in

Unit: US Units

**Aircraft/Vehicle Summary Table**

| Aircraft/Vehicle Name | X Max in | Y Max in | Maximum Angle | Maximum Stress psi | Stress Ratio | Allowable Total Repetitions |
|---|---|---|---|---|---|---|
| Taylor Container Handler 2 | 0.00 | -11.34 | 0.00 | 431.23 | 0.62 | 20,693 |

# AirPave

## ACPA AirPave

### Pavement Evaluation Report

**Detailed Aircraft/Vehicle Report**

**USER DEFINED INPUT**

| | | | | |
|---|---|---|---|---|
| Design Vehicle/Aircraft: | Taylor Container Handler 2 | | | |
| Gear Configuration: | Dual | | Pavement Type: | PCC |
| Modulus of Elasticity(E): | 5 | million psi | | |
| Modulus of Rupture(MR): | 700 | psi | | |
| Modulus of Subgrade Reaction(k): | 200 | pci | | |
| Computation Method: | With Axle Rotation | | Loading Condition: | Interior Loading |
| Number of Wheels: | 2 | | Contact Area: | 400 in^2 |
| Contact Pressure: | 130 | psi | | |
| Total Load: | 104,000 | lb | | |

**WHEEL COORDINATES** in

| | | |
|---|---|---|
| x: | 0.0 | 0.0 |
| y: | 0.0 | 20.1 |

**COMPUTATION RESULT**

| | | |
|---|---|---|
| X Max: | 0.00 | in |
| Y Max: | 11.04 | in |
| Maximum Angle: | 0.0 | Degrees |
| Maximum Stress: | 431.23 | psi |
| Stress Ratio: | 0.616 | |

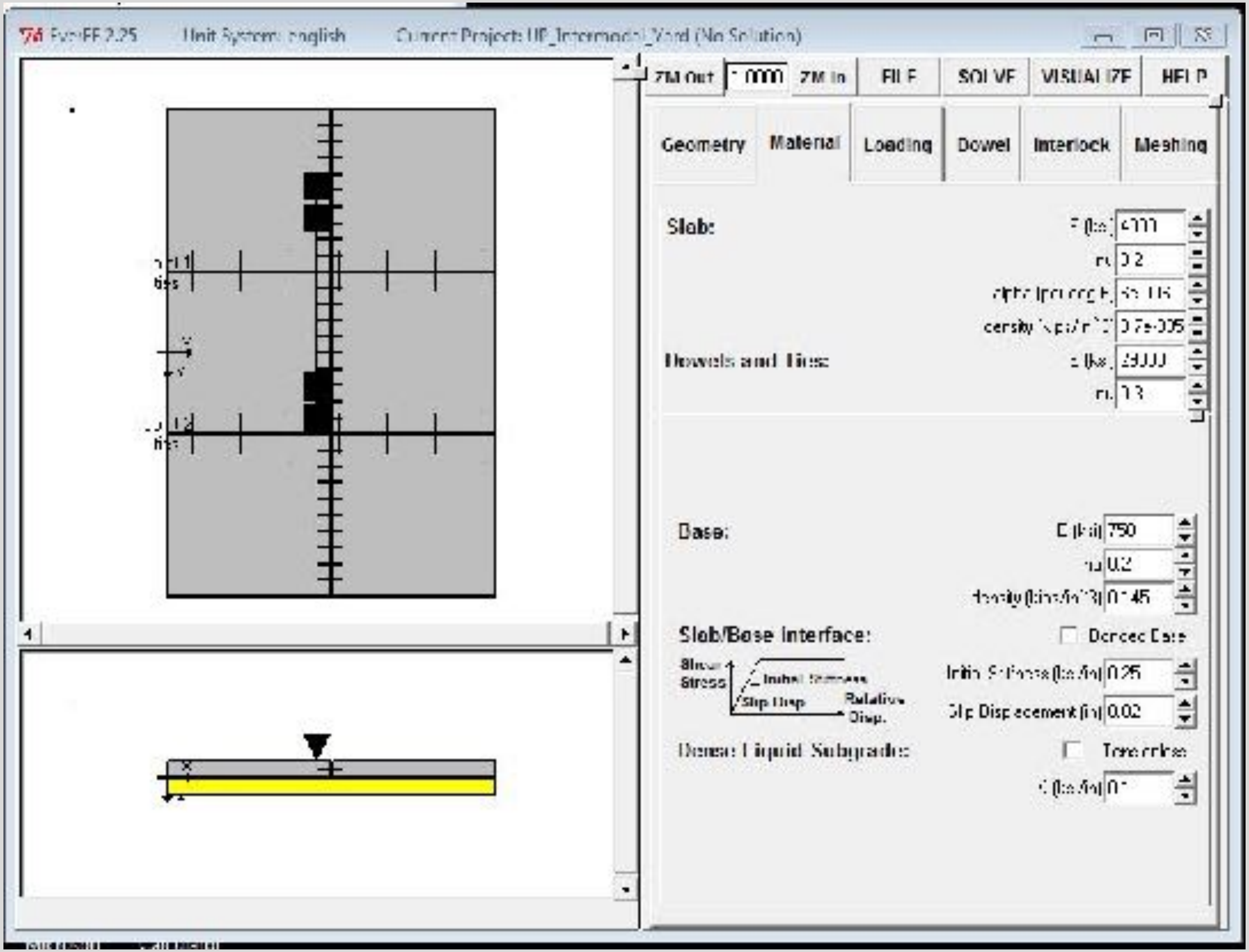
**OUTPUT**

| | |
|---|---|
| Allowable Total Repetitions: | 20,683 |

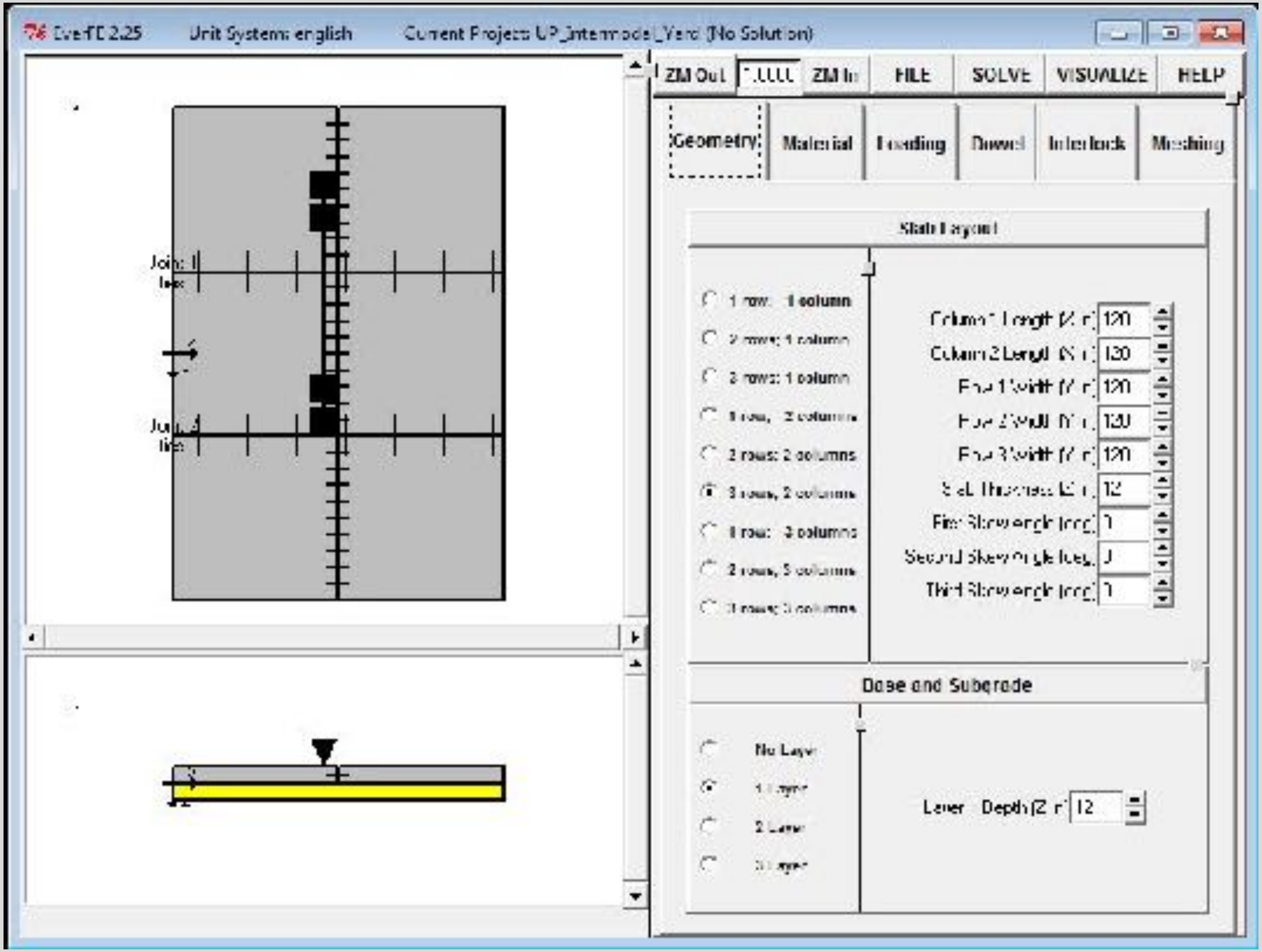
**NOTE**

A stress ratio (stress divided by design strength) greater than 0.75 may be too high to satisfy routine pavement design requirements (the thickness is inadequate), but may be used to evaluate the effect of unexpected heavy loads on an existing pavement.

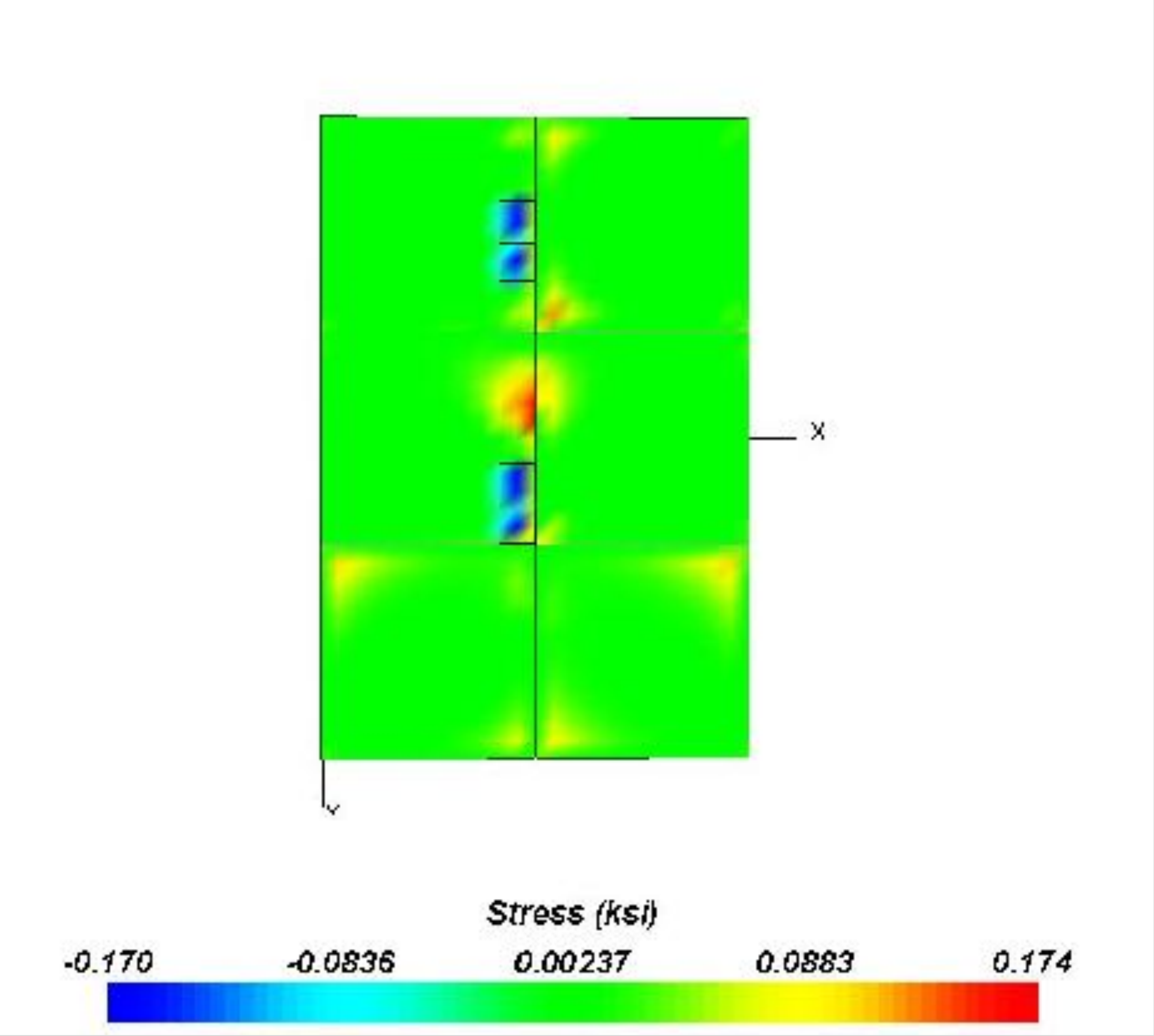
# EverFE


EverFE 2.25
Unit System: english
ZM Out
ZM In
SOLVE
VISUALIZE
HELP
Geometry
Material
Loading
Dowel
Interlock
Meshing
Slab:
Dowels and Ties:
Base:
E (ksi) 750
0.2
Slab/Base Interface:
0.25
Slip Displacement (in) 0.02

# EverFE


EverFE 2.25
Unit System: english
ZM Out
ZM In
FILE
SOLVE
VISUALIZE
HELP
Geometry
Material
Loading
Dowel
Interlock
Meshing
Slab Layout
2 rows: 2 columns
3 rows; 2 columns
Base and Subgrade
No Layer
Layer Depth
120
12

# EverFE



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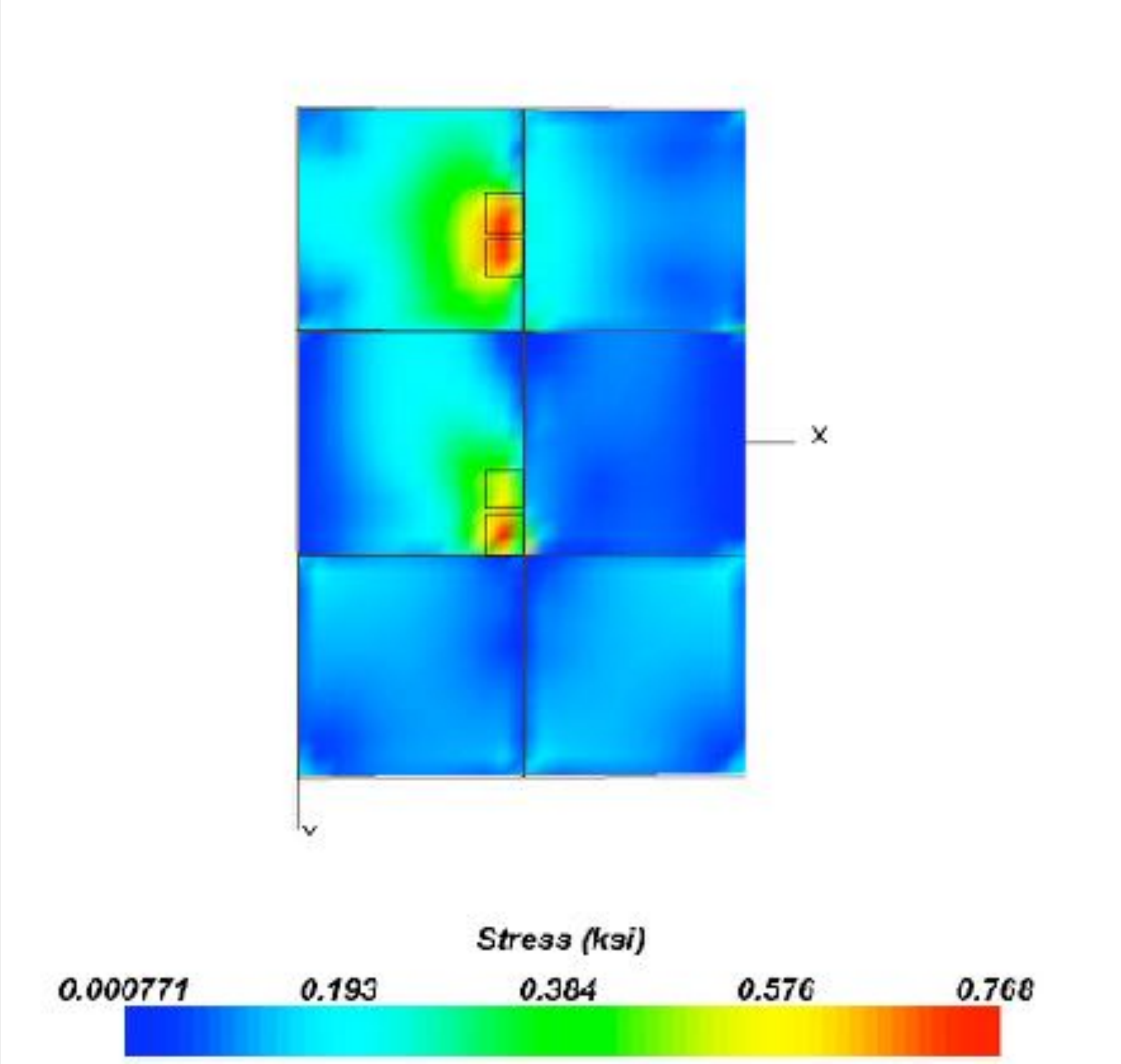
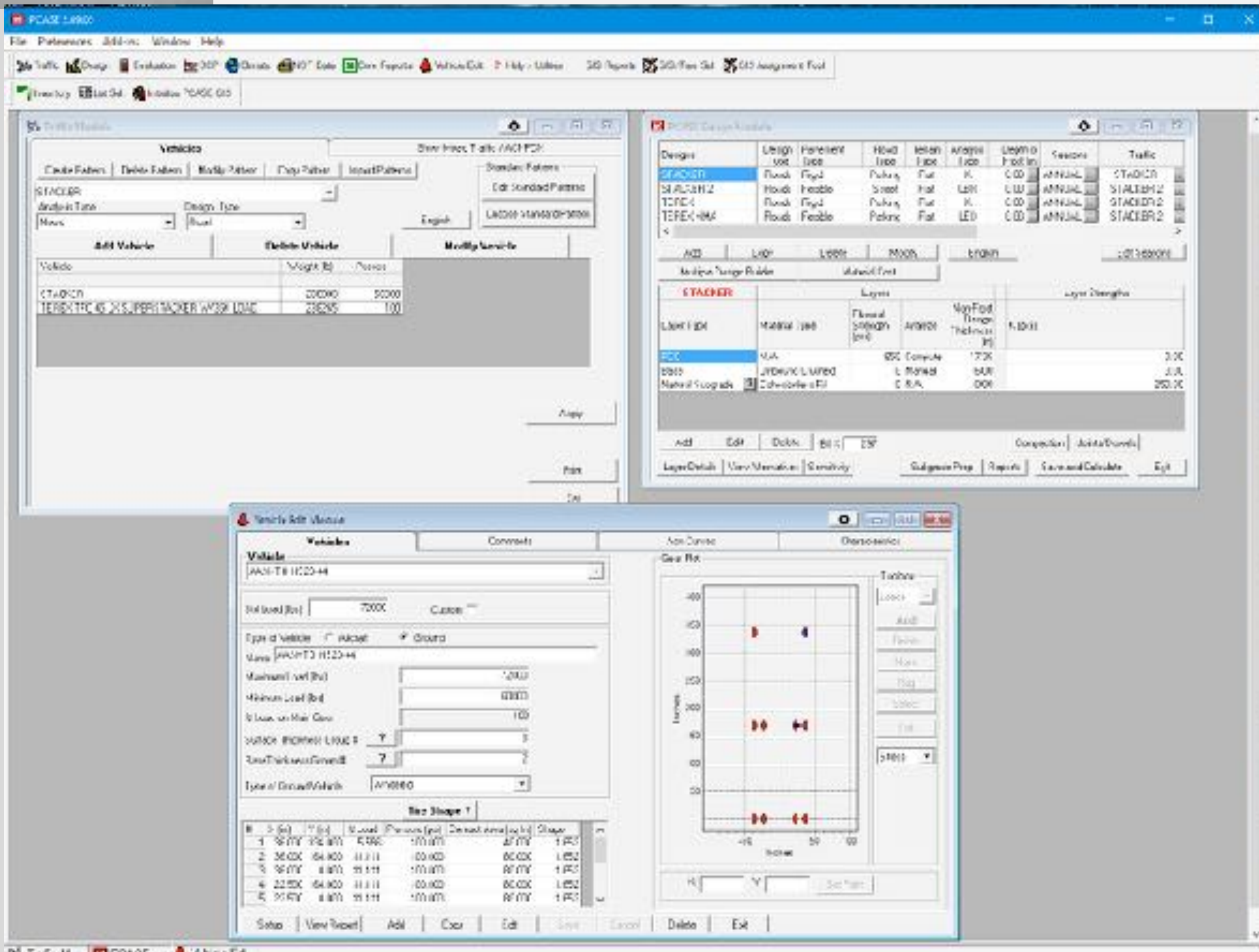


# PCASE



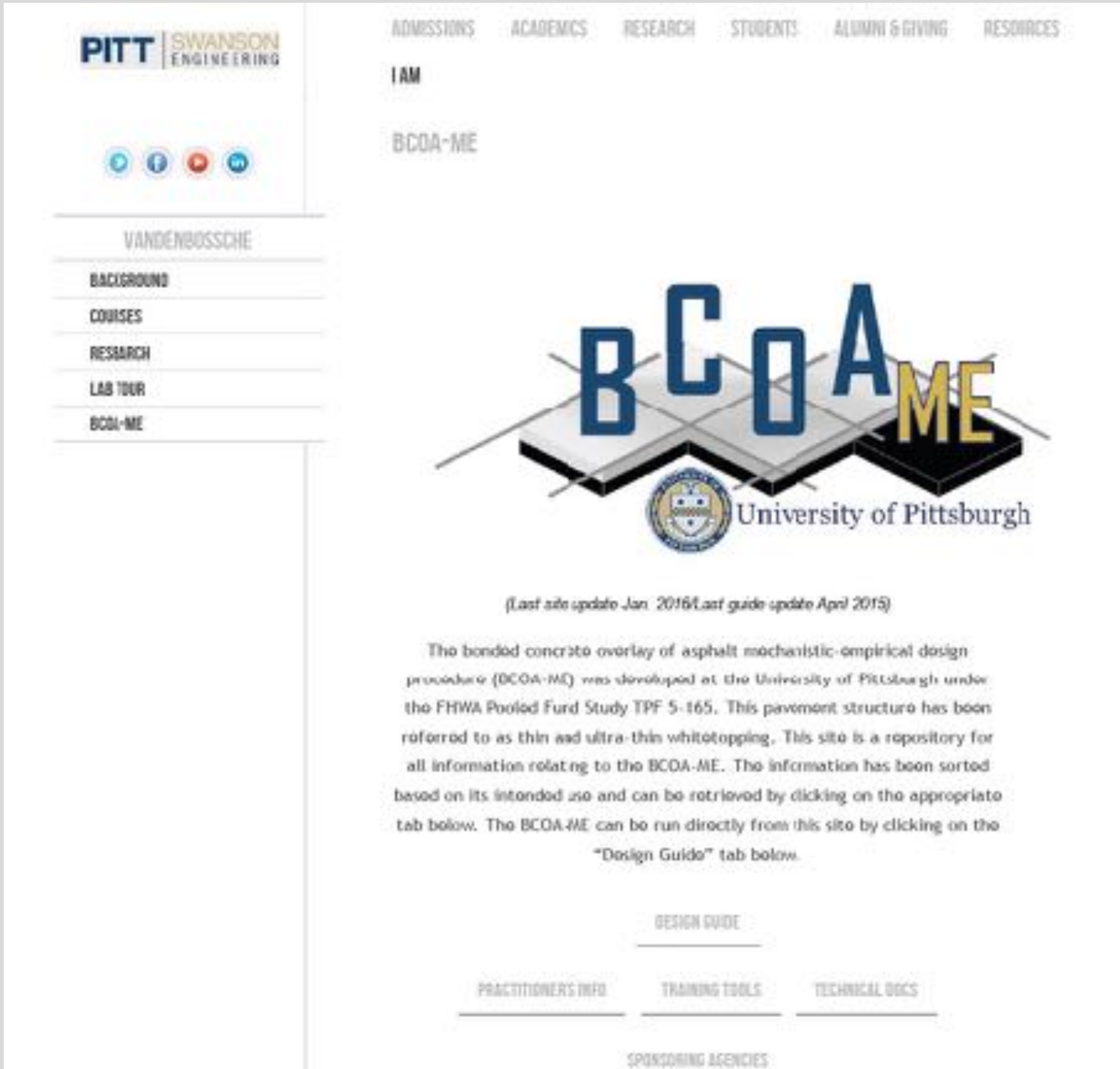
NORTHWEST CHAPTER

# Overlay Experiences

- Spokane, WA
  - 3 sections on I-90, 3”, 4”, 5”
  - Constructed in 2004
  - Eastbound AADT 40,000
  - Excellent performance in 4” and 5” sections
  - Reconstructed in 2011

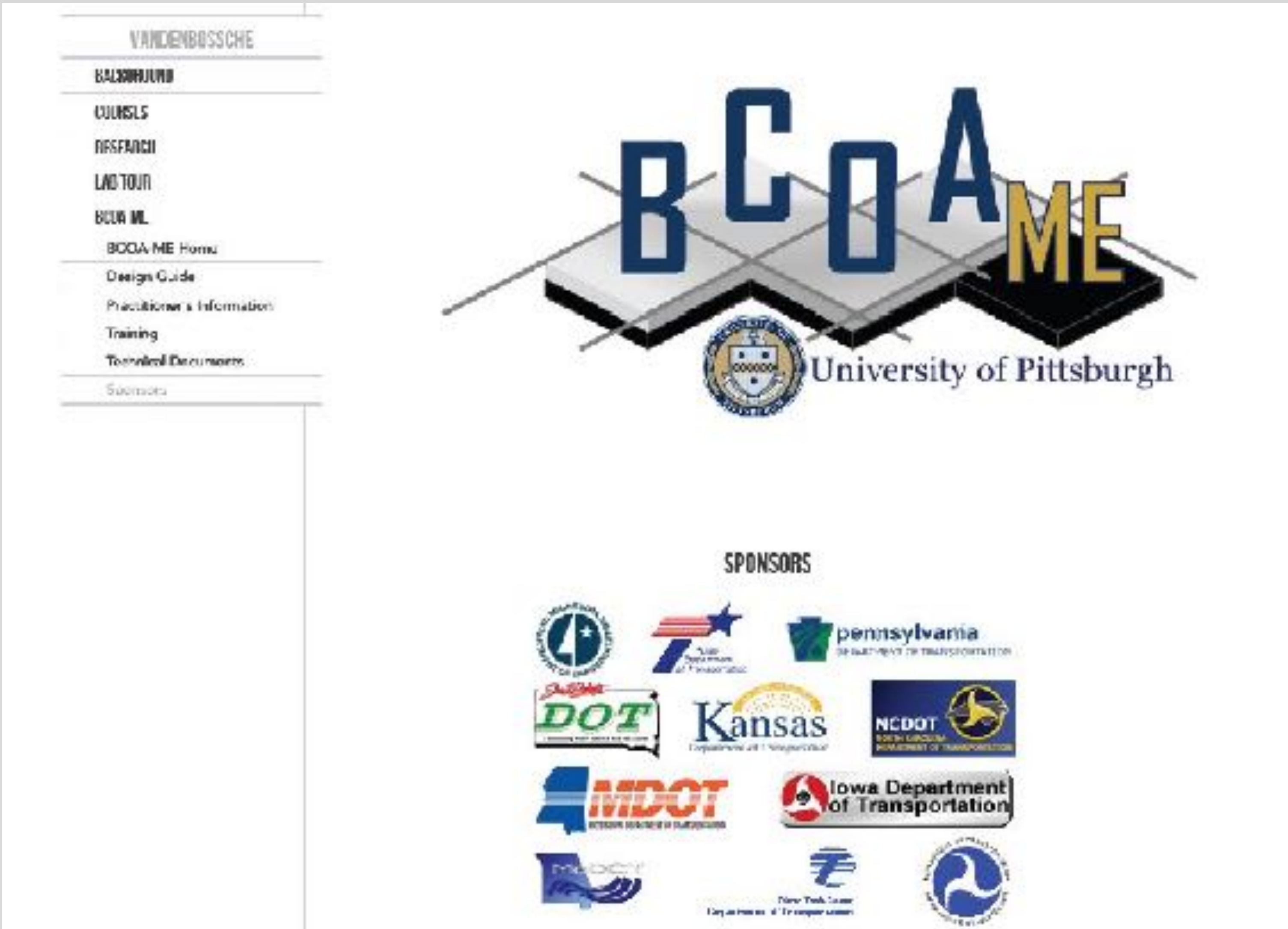

EXIT

# BCOA - ME

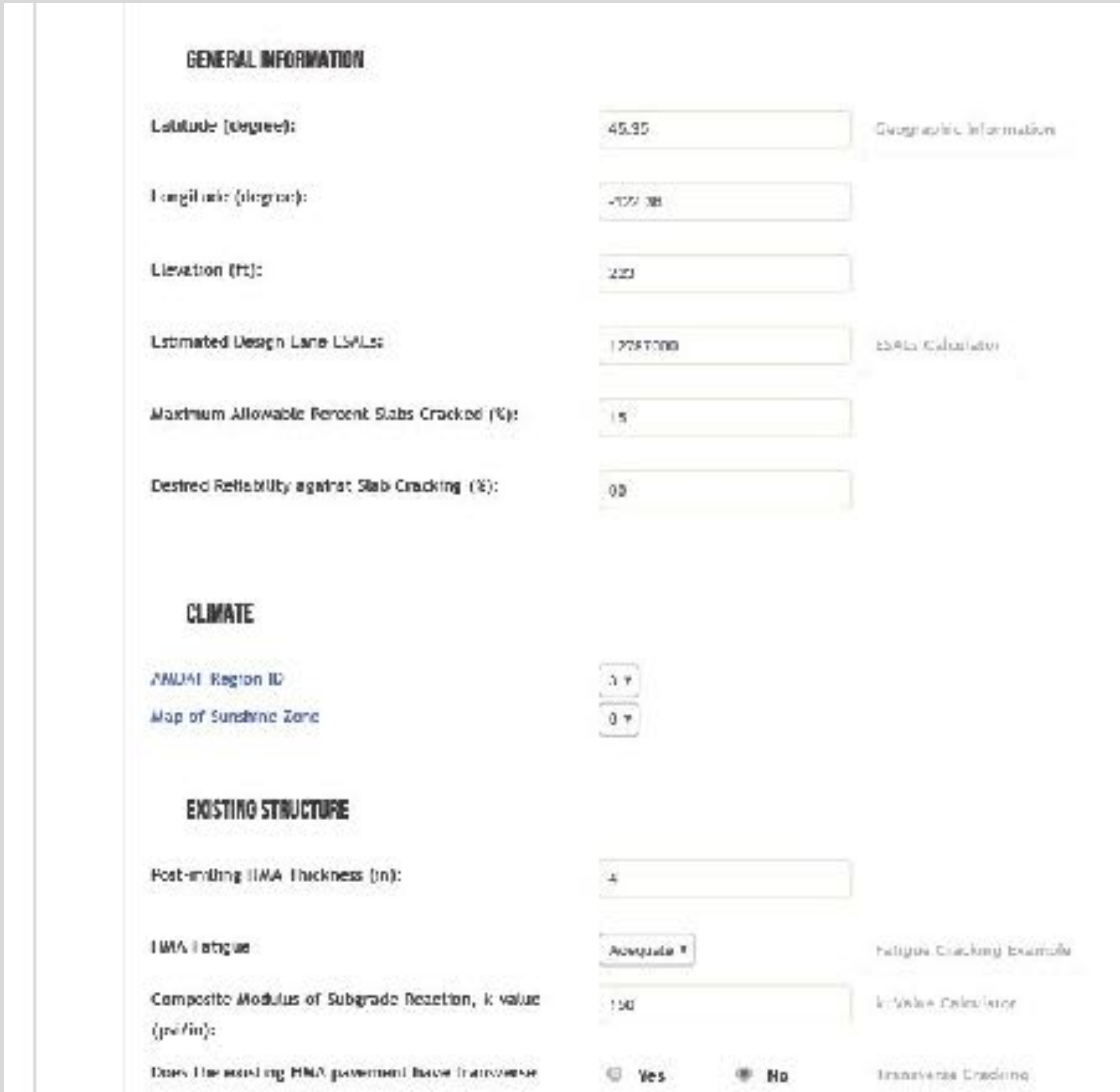



ACPA NORTHWEST CHAPTER

# BCOA ME Sponsors



# BCOA ME
# Main Screen



**GENERAL INFORMATION**

| | | |
|---|---|---|
| Latitude (degree): | 45.95 | Geographic Information |
| Longitude (degree): | -122.38 | |
| Elevation (ft): | 220 | |
| Estimated Design Lane ESALs: | 12257000 | ESALs Calculator |
| Maximum Allowable Percent Slabs Cracked (%): | 15 | |
| Desired Reliability against Slab Cracking (%): | 90 | |

**CLIMATE**

| | |
|---|---|
| AMDAT Region ID | 3 ▾ |
| Map of Sunshine Zone | 0 ▾ |

**EXISTING STRUCTURE**

| | | |
|---|---|---|
| Post-milling HMA Thickness (in): | 4 | |
| HMA Fatigue | Adequate ▾ | Fatigue Cracking Example |
| Composite Modulus of Subgrade Reaction, k value (psi/in): | 150 | k-Value Calculator |
| Does the existing HMA pavement have transverse | ○ Yes ● No | Transverse Cracking |

# BCOA ME
# Traffic

## ESALS ESTIMATION:

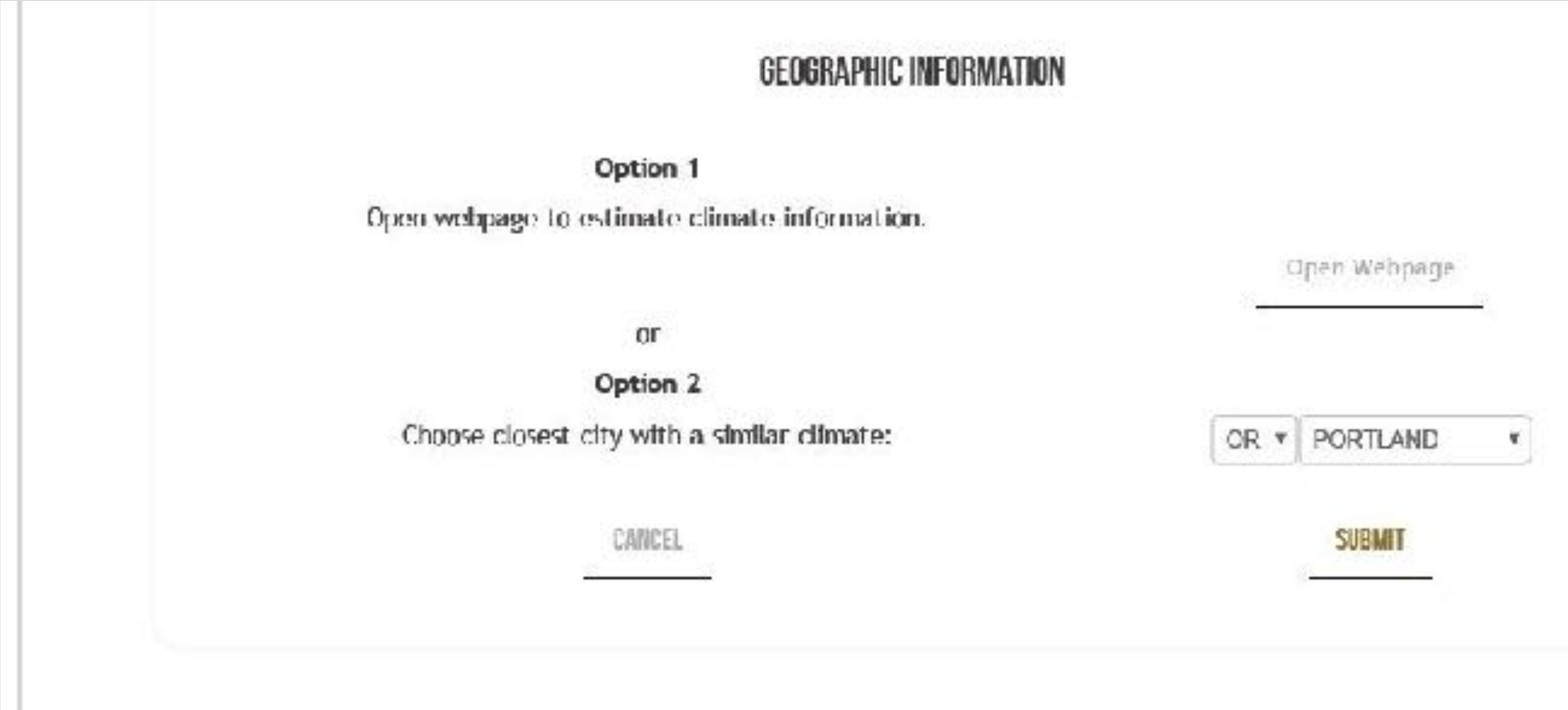
Is One-Way ADT Available? (•) Yes ( ) No

## ESTIMATE ESALS:

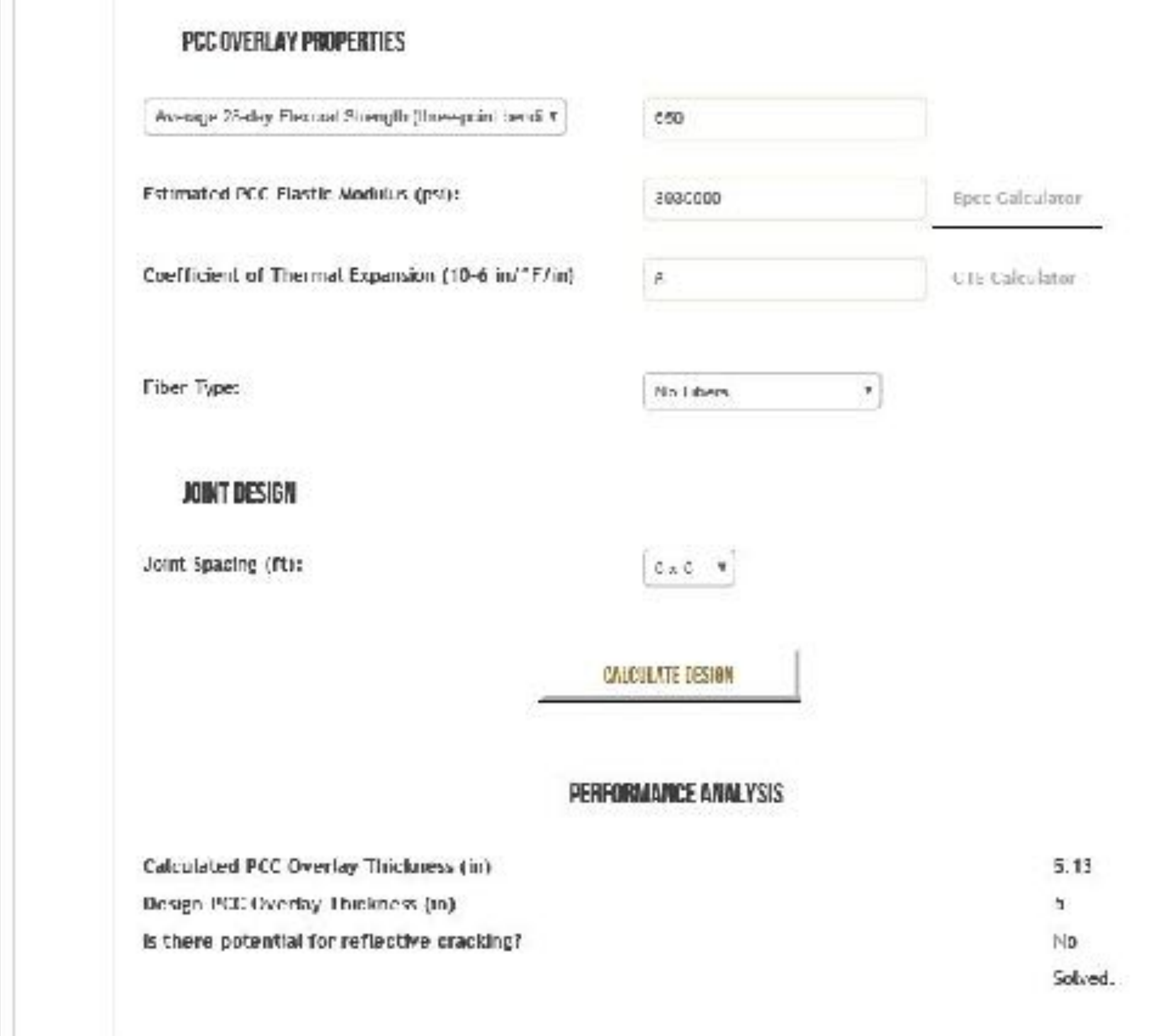
| | |
|---|---|
| Design Life (yrs): | 30 |
| Terminal Serviceability: | 2.5 ▾ |
| Number of Lanes in Each Direction: | 2 ▾ |
| Percent Trucks(%): | 8 |
| ADTT Growth Rate (%): | 2 |
| Traffic Growth Rate Type: | Non linear ▾ |
| Road Category: | Major arterial ▾ |
| One Way Average Daily Traffic (ADT): | 15000 |

CANCEL SUBMIT

# BCOA ME Environment



# BCOA ME
# Main Screen



# Macro Fibers

Table 1. Concrete Mix Proportions and Fresh and Mechanical Concrete Properties

| Materials (kg/m³) | Plain concrete | 0.32% synthetic macrofibers | 0.48% synthetic macrofibers | 0.35% hooked end steel fibers | 0.50% crimped steel fibers |
|---|---|---|---|---|---|
| Coarse aggregate | 995 | 975 | 976 | 965 | 983 |
| Fine aggregate | 823 | 806 | 807 | 796 | 813 |
| Cement | 363 | 360 | 360 | 347 | 363 |
| Water | 178 | 182 | 183 | 163 | 172 |
| Daracem (mL/100 kg) | 925 | 1,116 | 1,117 | 868 | 1,328 |
| Water-to-cement ratio | 0.49 | 0.51 | 0.51 | 0.49 | 0.47 |
| Air content (%) | 1.8 | 2.9 | 2.8 | 6 | 3.2 |
| Slump (mm) | 200 | 150 | 115 | 110 | 190 |
| Compressive (MPa) | 41.1 | 36.1 | 31.8 | 34 | 37.2 |
| Flexural strength (MPa) | 4.73 | 4.69 | 4.82 | 4.68 | 5.28 |
| [a] $R_{e,3}$ = values (%) | 2 | 24 | 39 | 43 | 35 |
| Slab thickness (mm) | 139.7 | 131.8 | 131.8 | 131.8 | 131.8 |

[a] $R_{e,3}$ = equivalent flexural strength ratio at 3-mm deformation.

NORTHWEST CHAPTER

# BCOA ME
# Design w/ Fibers

## PCC OVERLAY PROPERTIES

Average 28 day Flexural Strength (three point bend ▾ | 650

Estimated PCC Elastic Modulus (psi): 3900000 | Epcc Calculator

Coefficient of Thermal Expansion (10^-6 in/°F/in): 6 | CTE Calculator

Fiber Type: Synthetic Structural Fibers ▾

Fiber Content (lb/yd3): 3

## JOINT DESIGN

Joint Spacing (ft): 6 x 6 ▾

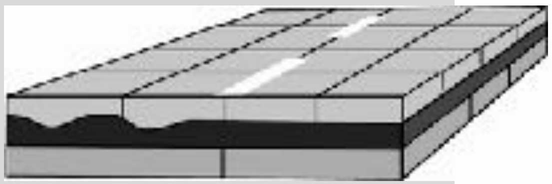
CALCULATE DESIGN

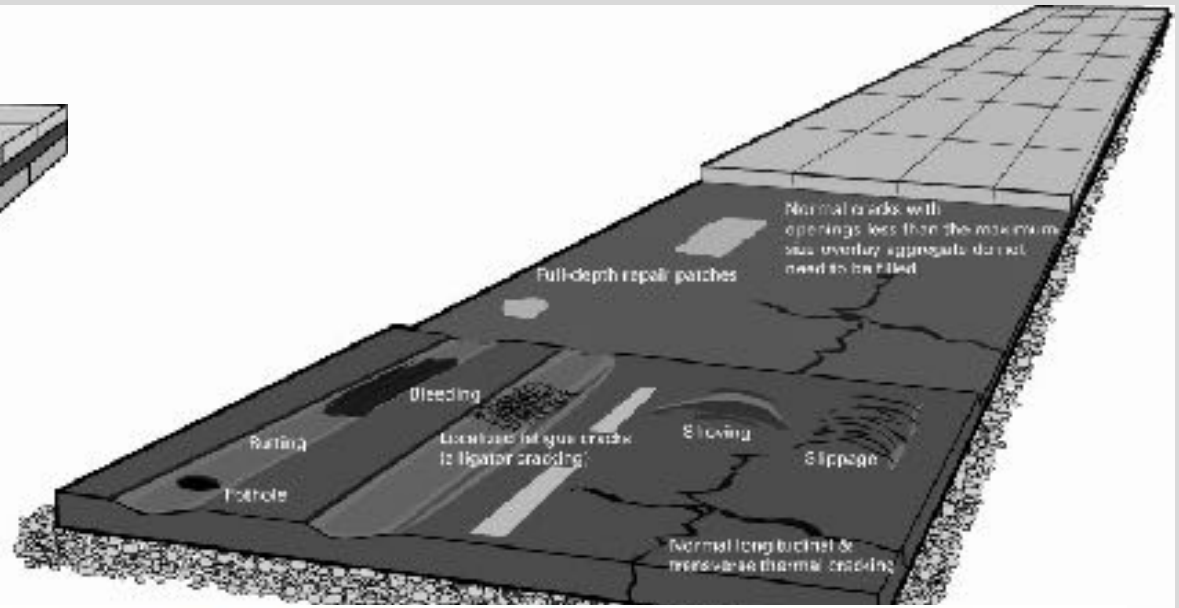
## PERFORMANCE ANALYSIS

| | |
|---|---|
| Calculated PCC Overlay Thickness (in) | 4.16 |
| Design PCC Overlay Thickness (in) | **4.5** |
| Is there potential for reflective cracking? | No |
| | Solved. |

NORTHWEST CHAPTER

# Repairs-Bonded Resurfacing of Asphalt or Composite Pavement






| Existing pavement distress | Spot repairs to consider |
|---|---|
| Fatigue cracking | Full-depth repair patch |
| Pothole | Full-depth repair patch |
| Deep rutting | Milling |
| Shoving, slippage | Milling |
| Thermal cracking | None |

# Milling: Bonded Resurfacing of Asphalt or Composite Pavements

The three main objectives of milling:

1. to remove significant surface distortions that contain soft asphalt material, resulting in an inadequate bonding surface
2. to reduce high spots to help ensure minimum resurfacing depth and reduce the quantity of concrete needed to fill low spots; and
3. to roughen a portion of the surface to enhance bond development between the new concrete overlay and the existing asphalt. (don’t leave a thin lift)

# Milling: Bonded Resurfacing of Asphalt or Composite Pavements

- Complete removal of ruts is not needed when rutting in the existing asphalt pavement does not exceed 2”.
- Any ruts in the existing pavement are filled with concrete, resulting in a thicker concrete overlay above the ruts.

- A minimum of 3"–4" of asphalt should be left after milling because of the reliance on the asphalt pavement to carry a portion of the load.

# Pre-Paving

- Surface cleaning
  - Power sweeping
  - Air blasting

# Construction

- Place concrete when surface temperature is <120°F.
- Conventional fixed-form or slip form placement used.
- Shotblast or mill (if needed) and clean surface thoroughly.
- Grout or epoxy bonding agents are not required (however local conditions and experience will dictate).
- Texture Pavement for friction.
- Curing material must be placed as soon as possible (<30 minutes). Full coverage is essential.
- Begin sawing as soon as possible (use of early entry saw is recommended).
- Test mix throughout placement for QC.

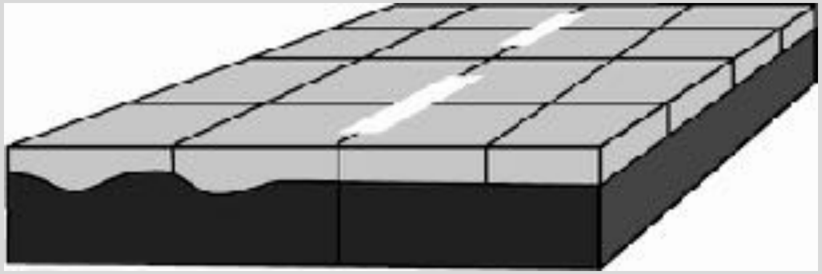
# Paving

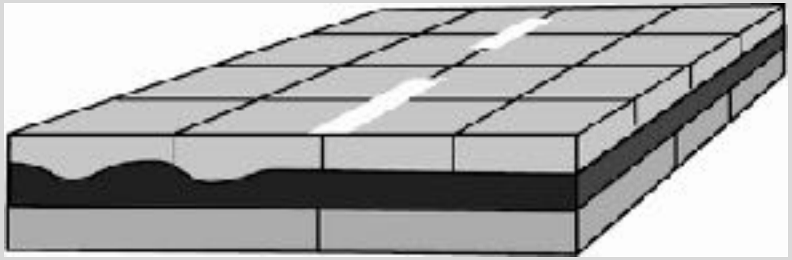
- Maintenance of traffic
  - Depends on concrete overlay thickness
    - If edge drop-off criteria is exceeded, then MOT is just like full depth PCC reconstruction
    - Otherwise, similar to MOT for asphalt projects
  - Options include:
    - Construction adjacent to traffic (lane at a time)
    - Positive separation or cones
    - Pilot car operation for two lane roadways
    - Crossovers and construct full width
    - Staged intersections or full closure with accelerated opening (48 to 72 hr)
  - All concrete overlays are accelerated construction!

# Curing of Overlays

- Cure as soon as practical
- Even and complete coverage
- Consistent operating speed
- Edge covered also
- Even and complete cover
- Adjust  for dry and/or wind
- Clean/adjust nozzles
- Keep it wet, keep it warm: for durability

# Important Elements-Bonded Resurfacing of Asphalt/Composite Pavement





- Clean Surface/Bond is important for good performance
- Thin milling may be required to eliminate significant surface distortions of 2” or more and provide good bond.
- Leave at least 3” remaining asphalt after milling.

- Control surface temperature of existing asphalt to below 120ºF.
- Try to keep joints out of wheel paths.
- Curing should be timely and adequate.
- Small joint spacing to minimize bonding shear stress

# Unbonded on Concrete

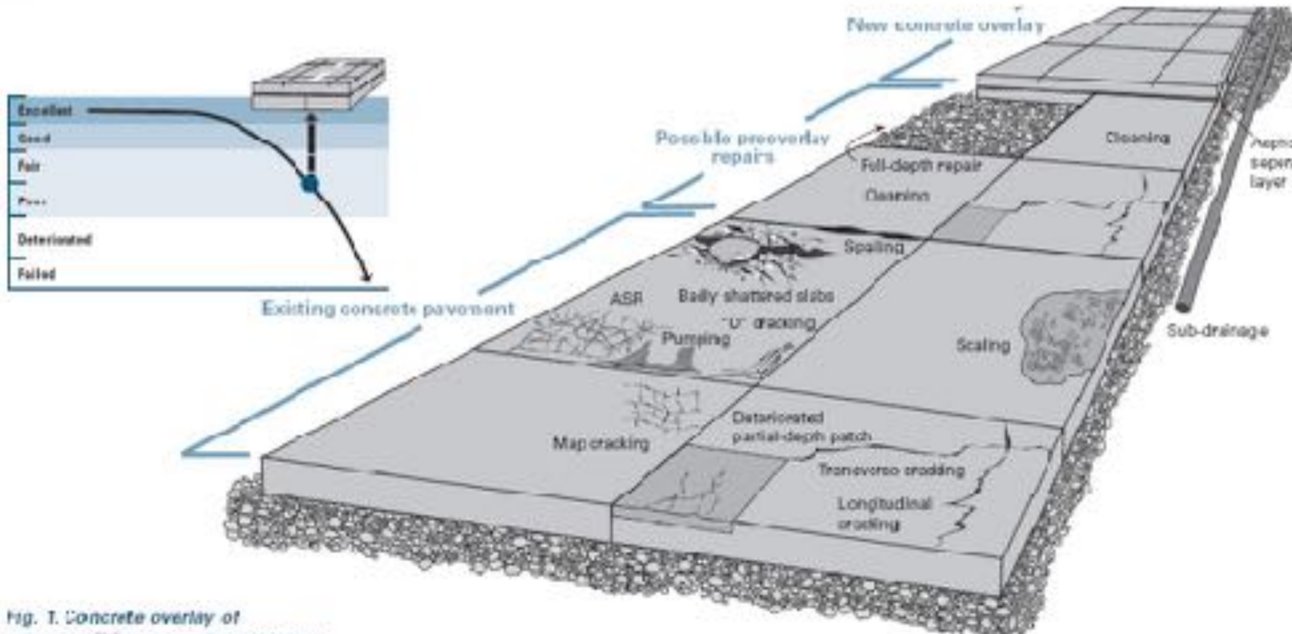



*Fig. 1. Concrete overlay of poor condition concrete pavement*

- If the movement is confined to isolated areas, full depth repairs can solve the problem.
- For faulted pavements, if the subgrade is stable, the overlay has proven to be adequate.
- Minor faulting is generally not a concern when a separator layer of 1" or greater is used.

## Separation for Unbonded Overlays

- Separation required for good performance.
  - Isolate overlay from existing pavement:
    - Prevent reflection cracking.
    - Prevent bonding/mechanical interlocking.
    - Provide level surface for overlay construction.
  - Traditional – 1 in dense HMA.
  - New – Nonwoven Geotextile fabric (MO, ND, VA, KS…)

NORTHWEST CHAPTER

# Nonwoven Fabric Interlayer

NORTHWEST CHAPTER

# Nonwoven Fabric Interlayer

# Nonwoven Fabric Interlayer

ACPA NORTHWEST CHAPTER

## Benefits of Geotextile Interlayer

- Provides adequate separation
- Avoids another paving operation:
  - Saves on mobilization
  - Avoids materials availability/cost issues
- Reduces overhead clearance issues
- Reduces materials for shoulder fills
- Reduces project costs

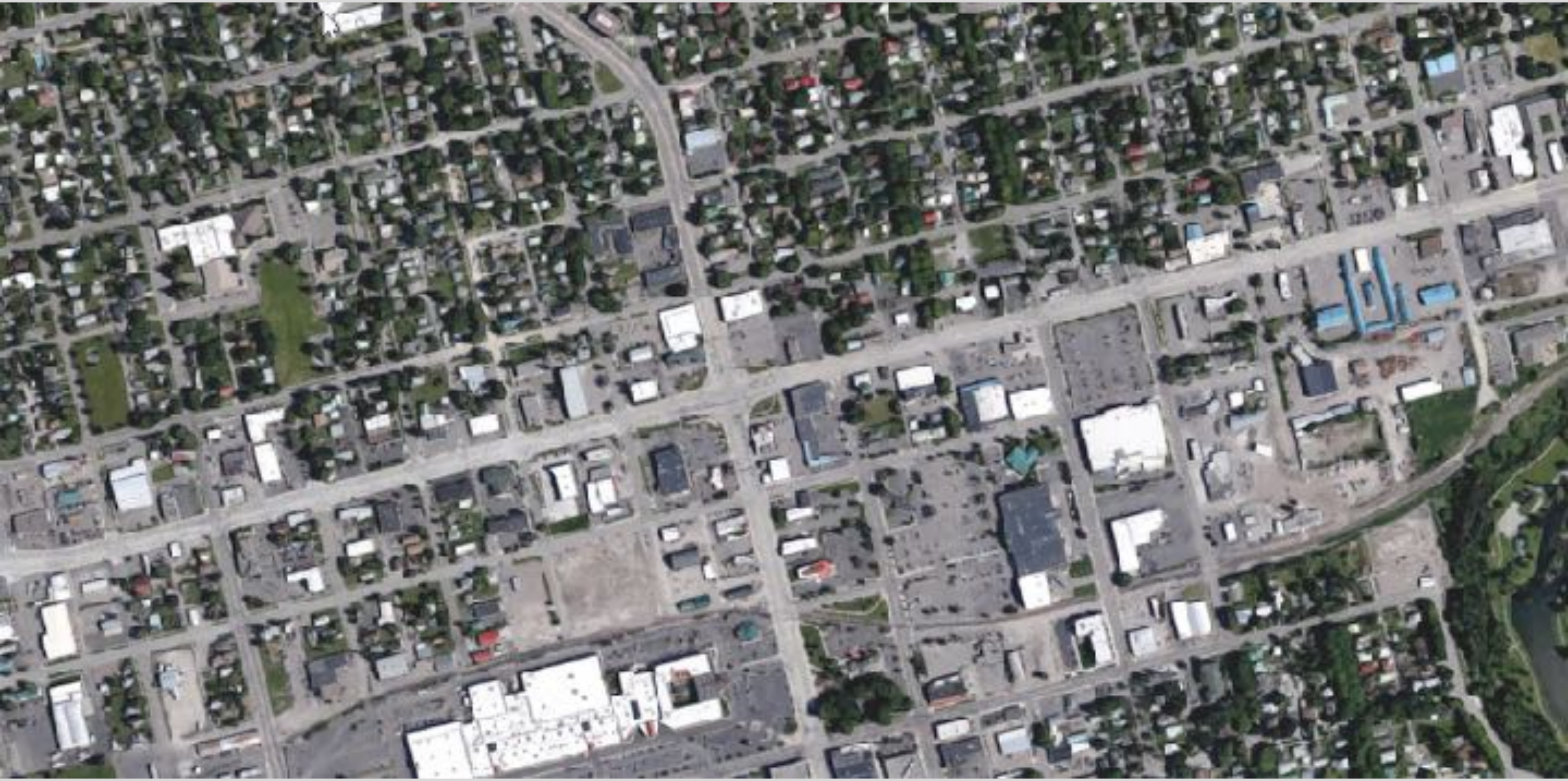
NORTHWEST CHAPTER

# Overlay Experiences

- Kalispell
  - 5” on ?”-5” of HMA
  - 6’ joint spacing
  - 18,000 ADT in 2000
  - 30% Trucks
  - Built in 2000
  - Performing very well

NORTHWEST CHAPTER

NORTHWEST CHAPTER



# Overlay Experiences

- Bellevue
  - 3” PCC on 3” AC
  - Built 1998
  - Still in service
  - Cracking in edge panels due to lack of support.  Edge panels have been replaced.

# Overlay Experiences

- US 20/26 & Middleton Road
- Built in 2005
- 4” on 4”
- Still in service
- Excellent performance


09/08/2010

# Other NW Projects

- Portland
  - NE Columbia Blvd.
    - 4” – 6” PCC on 0” – 4” Asphalt
  - N. Denver Avenue
    - 2.5” PCC on Variable Sections
- Eugene
  - Coburg Rd.
  - 6” PCC on 4” Asphalt
- Yakima
  - 40th and Knob Hill
  - 6” PCC on 2” – 4” Asphalt

NORTHWEST CHAPTER

# Portland

# Yakima

# QUESTIONS?