Michigan DOT Pavement Design

Justin Schenkel, P.E.

Michigan Department of Transportation

Outline

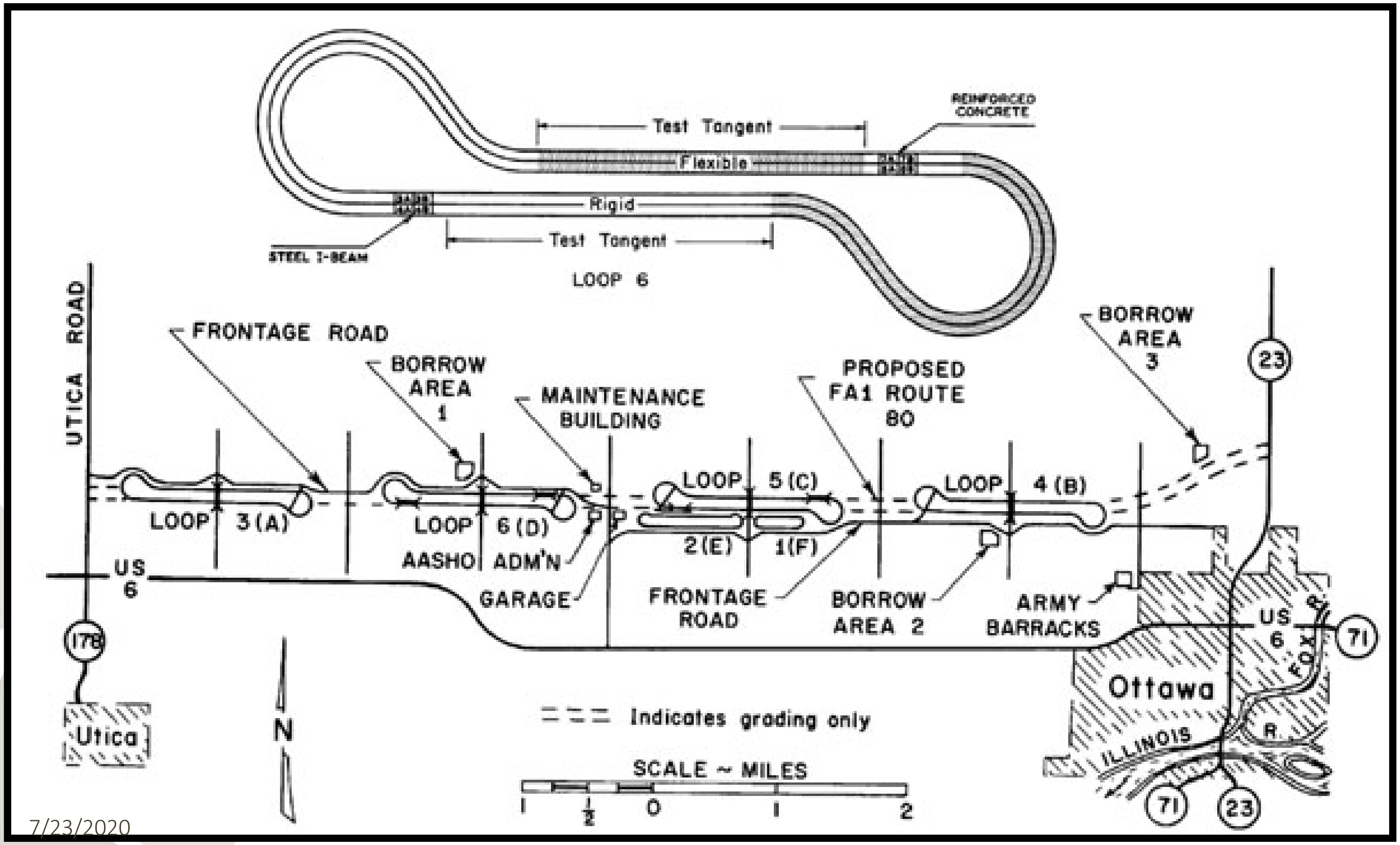
- AASHTO 1993 design method *(OLD)*
- Mechanistic-Empirical (ME) design method *(NEW)*

AASHTO 1993 Design Method *(OLD)*

AASHTO93 Design Method *(OLD)*

- *AASHTO 1993 Guide for Design of Pavement Structures*
  - From AASHO Road Test in 1958-1960 in Ottawa, IL
  - Empirical test
  - Interim design method in 1961
  - Official design method in 1972
  - Updates in 1986, 1993, 1998 (PCC only)

AASHTO93 Design Method *(OLD)*



AASHTO93 Design Method (OLD)

Thickness design from an equation:

- Flexible

$$\log(W_{18}) = Z_R \bullet S_0 + 9.36 \bullet \log(SN+1) - 0.20 + \frac{\log\frac{\Delta PSI}{4.2-1.5}}{0.4+\frac{1094}{(SN+1)^{5.19}}} + 2.32 \bullet \log(M_R) - 8.07$$

- Where:
  - W_{18} = Equivalent single axle loads (ESAL's)
  - Z_R = Reliability
  - S_0 = Standard deviation
  - SN = Structural number (total for all layers)
  - ΔPSI = Change in serviceability
  - M_R = Resilient modulus of the subgrade

- *We are solving for SN (which will be used to determine thickness, see slide # 11)*

AASHTO93 Design Method (OLD)

Thickness design from an equation *(continued)*:

- Rigid

$$\log_{10}(W_{18}) = Z_R S_0 + 7.35\log_{10}(D+1) - 0.06 + \frac{\log_{10}\left(\frac{\Delta PSI}{4.5-1.5}\right)}{1+\frac{1.64\times10^{7}}{(D+1)^{8.46}}} + (4.22 - 0.32\,p_t)\log_{10}\left[\frac{S_c\,C_d\,(D^{0.75}-1.132)}{215.63\,J\left(D^{0.75}-\frac{18.42}{(E_c/k)^{0.25}}\right)}\right]$$

- *We are solving for D (which is thickness)*

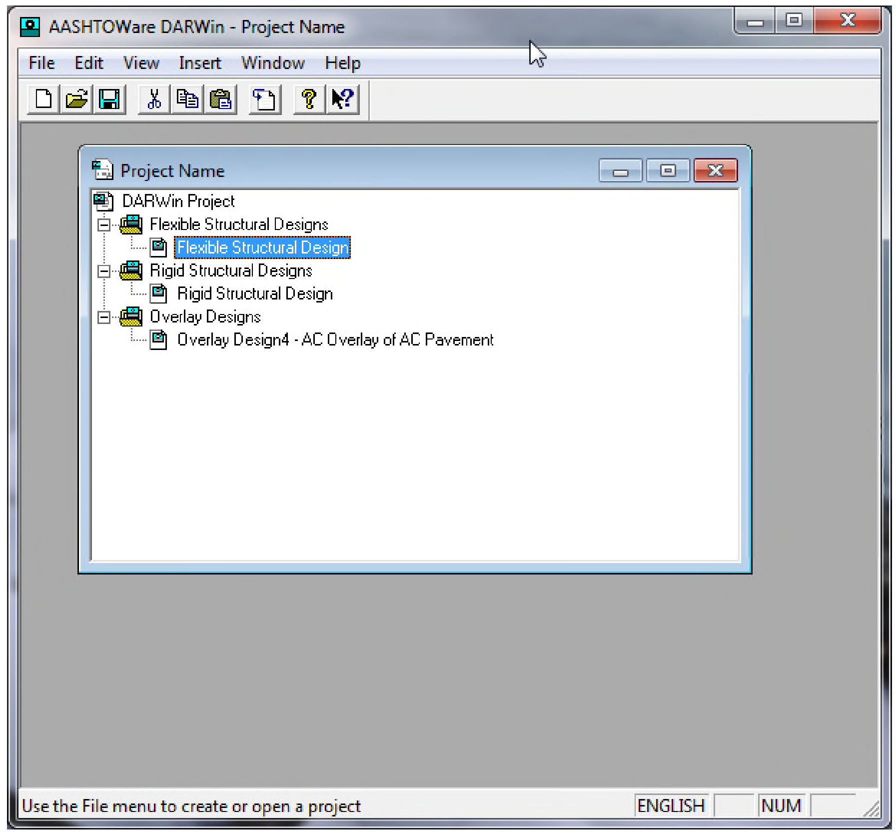
- Where:
  - W_{18} = Equivalent single axle loads (ESAL)
  - Z_R = Reliability
  - S_0 = Standard deviation
  - D = thickness (of the concrete)
  - ΔPSI = Change in serviceability
  - p_t = Terminal serviceability
  - S_C = Modulus of Rupture
  - C_d = Drainage coefficient
  - J = Load transfer coefficient
  - E_c = Modulus of elasticity
  - k = Effective modulus of subgrd reaction

AASHTO93 DESIGN METHOD *(OLD)*

DARWin

(Design, Analysis, and Rehabilitation for Windows)

- 2004 software
- Based on AASHTO93 design method
- Solves for previous equations



AASHTO93 Design Method *(OLD)*

- Typical Hot Mix Asphalt (HMA) inputs
  - Projected ESAL's = Equivalent Single Axle Loads
    - Measure of total damage an axle load does to a pavement in relation to an 18,000 pound axle
    - Is a total derived from the design life (see slide # 20-24)
    - Requested from the Bureau of Transportation Planning.
      - Submit Traffic Analysis Request (TAR) – Form 1730
  - Initial Serviceability = 4.5
  - Terminal Serviceability = 2.5
  - Reliability = 95%
  - Overall Standard Deviation = 0.49

AASHTO93 Design Method *(OLD)*

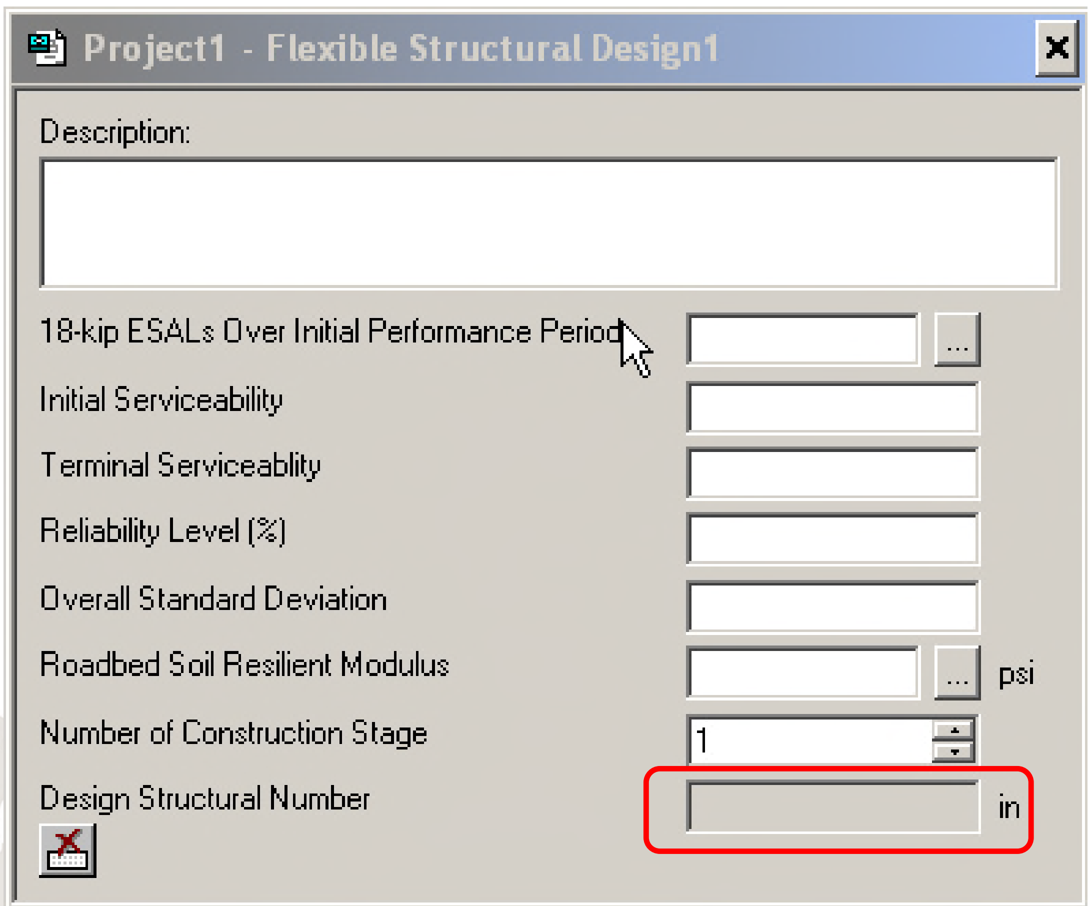
- Typical HMA inputs *(continued)*
  - Roadbed Soil (aka subgrade) M_R = Resilient Modulus
    - Measure of subgrade material stiffness (psi)
      - MDOT typical values: ~3000 to 5000 psi
    - Stress/strain for rapidly applied load
    - Estimated by the Region Soils Engineer from:
      - Falling Weight Deflectometer backcalculation
      - Soils identification and known correlations
  - Stage Construction = 1
- Result is a **Design Structural Number (SN)** that the pavement structure must have to support the projected number of ESAL's over it's life

AASHTO93 Design Method *(OLD)*

- $SN = a_1d_1 + a_2d_2m_2 + \ldots + a_nd_nm_n$
  - Where
    - a = layer structural coeff.
    - d = layer thickness
    - m = layer drainage coeff.

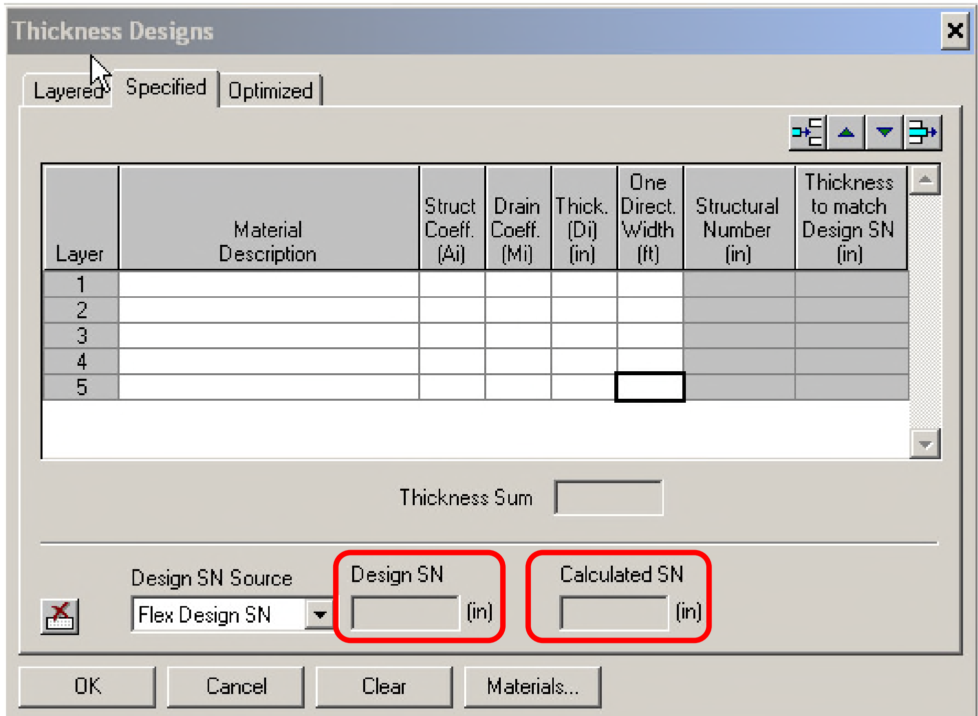
- HMA Structural Coefficients (a)
  - HMA Top & Leveling Course = 0.42
  - HMA Base Course = 0.36
  - Cement Stabilized Base = 0.26
  - ASCRL = 0.30
  - Asphalt/Emulsion Stabilized Base = 0.20
  - Crush and Shaped HMA = 0.20
  - Rubblized Concrete = 0.18
  - Dense-Graded Aggregate Base = 0.14
  - Open-Graded Aggregate Base = 0.13
  - Sand Subbase = 0.10
- Drainage Coefficients (m)
  - All Layers = 1
  - 16” OGDC = 1.1

AASHTO93 Design Method *(OLD)*



- Design SN

AASHTO93 Design Method (OLD)



- Calculated SN must be ≥ Design SN

Additional Notes:

- *Layered*
  - *This approach solves for the structural number of a layer based on the elastic modulus of the underlying layer.*
  - *The elastic modulus is used in the design equation as the resilient modulus.*
  - *Algorithm starts by solving for the thickness of the bottom layer and working up.*
  - *A layer with specified thickness isn't considered as part of elastic layered analysis calcs (for purpose of determining thicknesses).*
- *Specified*
  - *User supplies all inputs for each layer and DARWin calculates the SN contribution of the individual layers & of the total structure.*

AASHTO93 Design Method *(OLD)*

- Typical Concrete (PCC) inputs
  - Projected ESAL's
  - Initial Serviceability = 4.5
  - Terminal Serviceability = 2.5
  - Reliability = 95%
  - Overall Standard Deviation = 0.39
  - 28-day Modulus of Rupture = 670 psi
  - 28-day Elastic Mod. of Slab = 4,200,000 psi
  - Load Transfer Coefficient
    - Tied shoulder, tied curb & gutter, or 14' outside lane = 2.7
    - Untied shoulder = 3.2

AASHTO93 DESIGN METHOD *(OLD)*

- Typical Concrete inputs *(continued)*
  - Drainage Coefficient = 1 to 1.05, (or 1.1 for 16" of OGDC)
  - Effective Modulus of Subgrade Reaction (k-value)
    - Determined from ***Subgrade Resilient Modulus***, ***depth of base/subbase***, and ***Elastic Modulus of base/subbase***
    - Figures 3.3 & 3.6 from *1993 AASHTO Guide for Design of Pavement Structures* is used to obtain the value
    - Loss of support of 0.5 used in Figure 3.6
    - Subgrade M_R comes from Region Soils Engineer

AASHTO93 DESIGN METHOD *(OLD)*

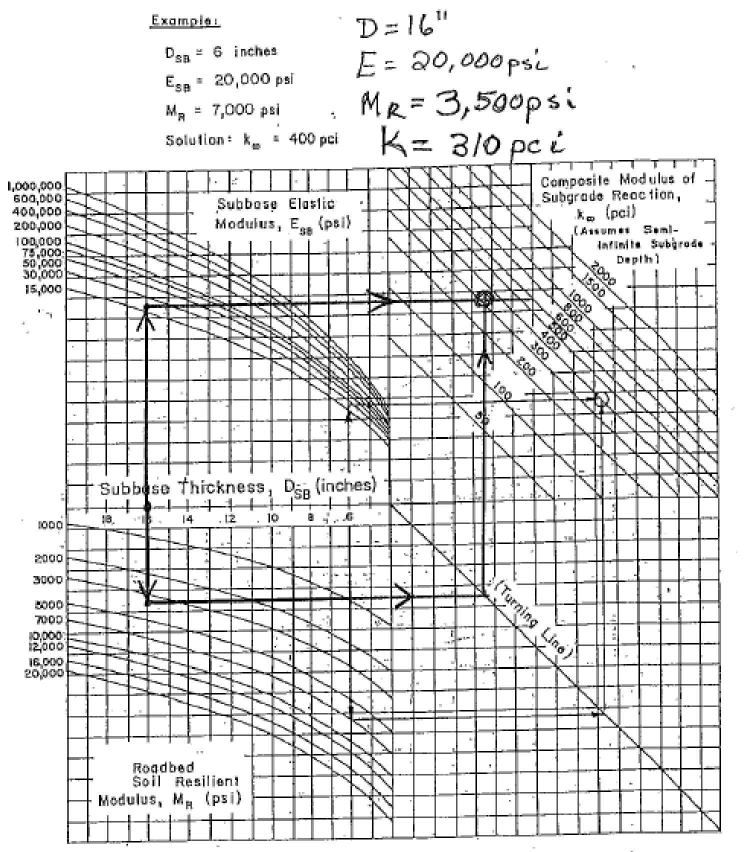


Figure 3.3. Chart for Estimating Composite Modulus of Subgrade Reaction, k_∞, Assuming a Semi-Infinite Subgrade Depth. (For practical purposes, a semi-infinite depth is considered to be greater than 10 feet below the surface of the subgrade.)

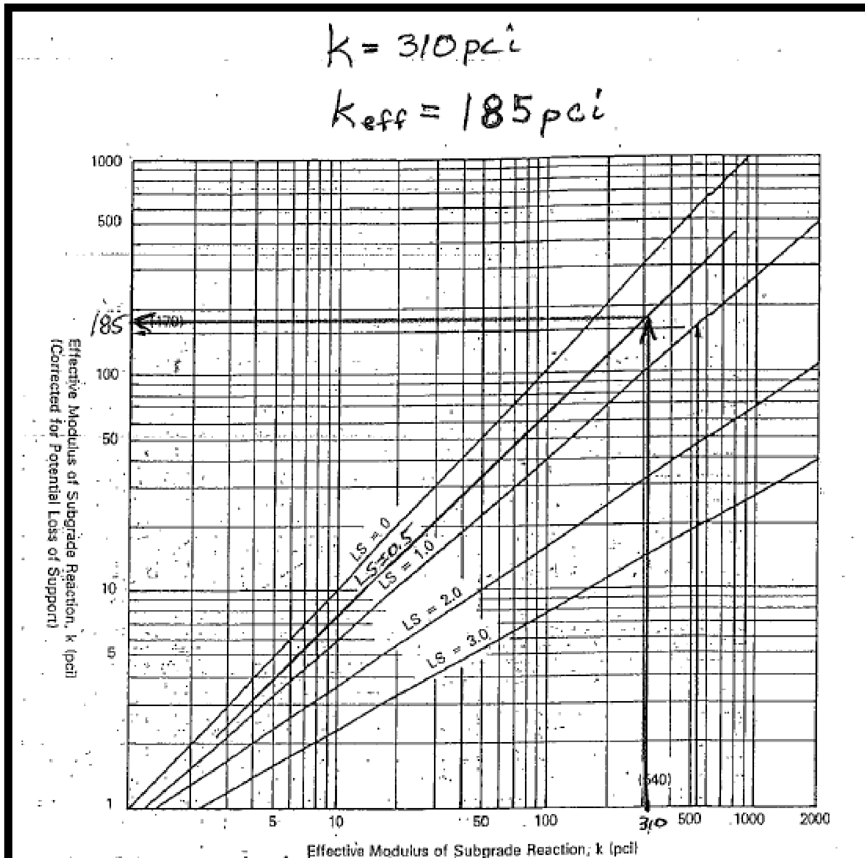


Figure 3.6. Correction of Effective Modulus of Subgrade Reaction for Potential Loss of Subbase Support (6)

AASHTO93 Design Method *(OLD)*

Estimation of Composite Modulus of Subgrade Reaction, Assuming a Semi-Infinite Subgrade
Correction of Effective Modulus of Subgrade Reaction for Potential Loss of Subbase Support

CS	JN	D_{SB} (in)	E_{SB} (psi)	M_R (psi)
		16	20000	3500

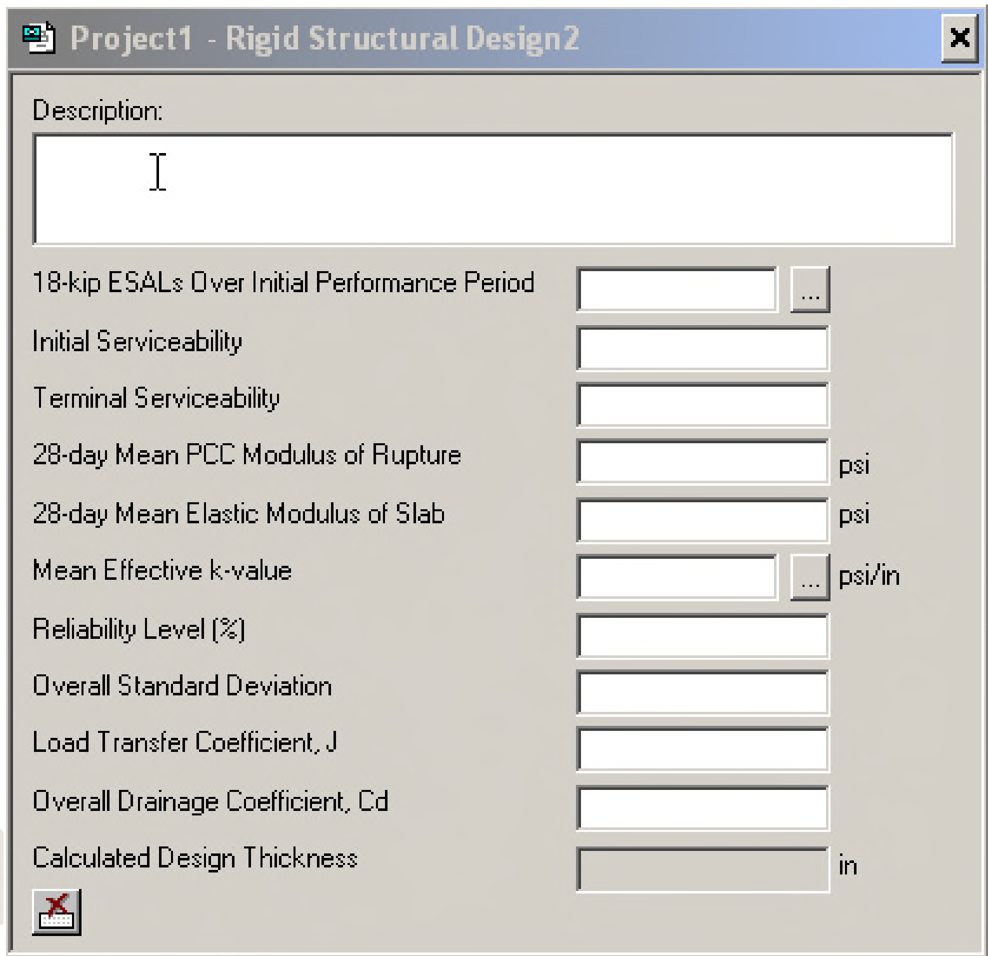
K_∞ (pci)	LS	K_{LS} (pci)
309	0.5	**186**

Per MDOT results using the *AASHTO Guide for Design of Pavement Structures 1993*, Part II Figures 3.3 & 3.6, K_∞ and K_{LS} are calculated from the equations below:

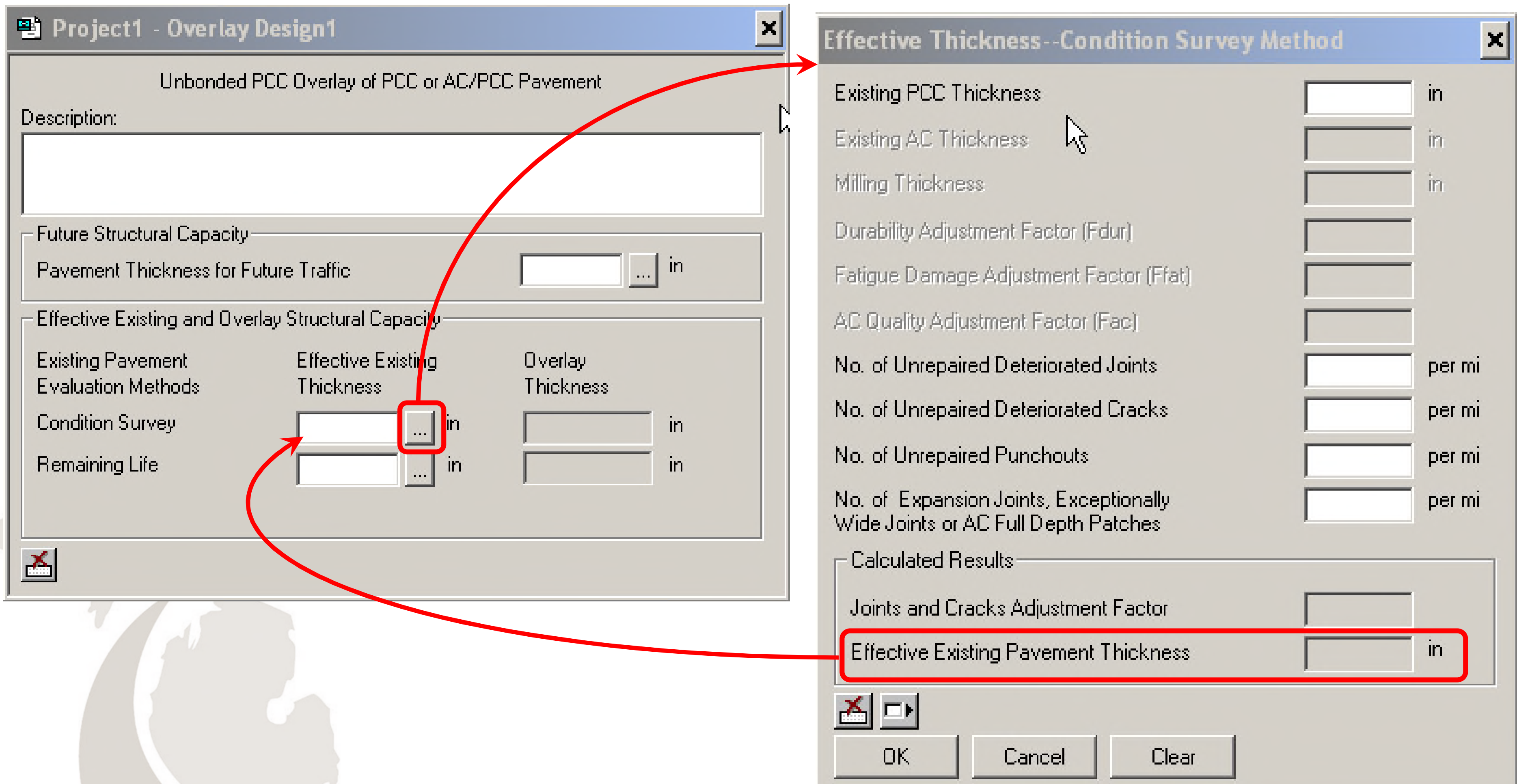
$$\ln K_\infty = \ln(1.09) * (-2.807 + 0.1253(\ln(D_{SB})^2 + 1.062(\ln(M_R)) + 0.1282(\ln(D_{SB}))(\ln(E_{SB})) - 0.4114 (\ln(D_{SB})) - 0.0581(\ln(E_{SB})) - 0.1317(\ln(D_{SB})\ln(M_R))$$

$$\log_{10} K_{LS} = 0.8218 \log_{10} K_\infty + 0.2234$$

AASHTO93 Design Method *(OLD)*



AASHTO93 Design Method *(OLD)*



AASHTO93 Design Method *(OLD)*

- Material Elastic Moduli (psi)
  - HMA Top and Leveling Course = 390,000 to 410,000
  - HMA Base Course = 275,000 to 320,000
  - Cement Stabilized Base = 1,000,000
  - ASCRL = 210,000
  - Asphalt/Emulsion Stabilized Base = 160,000
  - Crush and Shaped HMA = 100,000 to 150,000
  - Rubblized Concrete = 45,000 to 55,000
  - Dense-Graded Aggregate Base = 30,000
  - Open-Graded Aggregate Base = 24,000
  - Sand Subbase = 13,500
- *Elastic Modulus used in HMA layered design or PCC k-value*

AASHTO93 DESIGN METHOD *(OLD)*

- Equivalent Single Axle Loads (ESAL's)
  - Traffic component that is requested at the preliminary planning stages
  - ESAL's = CADT * 365 * DD * LD * TF * GF
    - CADT = truck volume
    - DD = directional distribution
    - LD = lane distribution
    - TF = truck factor
    - GF = growth factor

AASHTO93 Design Method *(OLD)*

- <u>Equivalent Single Axle Loads (ESAL's)</u> *(continued)*
  - Compound growth factor (GF):
    - $GF = ((1+g)^n - 1)/g$
      - g = growth rate expressed as a decimal (e.g. 2% = 0.02)
        - Based on review of historic truck volumes
        - May be adjusted (up or down) based on very limited economic information
      - n = number of years; (use design life)

AASHTO93 Design Method *(OLD)*

- Equivalent Single Axle Loads (ESAL's) *(continued)*
  - Truck factors (TF):
    - Average ESAL per truck
    - Different truck types accounted for
      - Different factor used for each FHWA classifications 5-13
      - Overall TF weighted according to the volume of each class
      - Some routes only have vehicle/medium, truck/heavy-truck percentages rather than classification, so only TF for medium/heavy used.
        - Medium = classes 5 though 8
        - Heavy = classes 9 though 13
  - "Rule of thumb": ESAL's for PCC are typically 1.4 to 1.5 times the ESAL's for HMA

AASHTO93 Design Method *(OLD)*

MDOT uses these truck factors

I. Default values (if no classification counts are available).

Thickness	Rigid	SN	Flexible
9.0"	.85	5	.59
9.5"	.85	6	.57
10.0"	.85		
10.5"	.86		
11.0"	.86		
11.5"	.86		

II. Classification counts available to determine the mix of heavy and medium trucks.

Rigid D = 9		Flexible SN = 5	
Heavy	Medium	Heavy	Medium
1.39	.41	.88	.34

III. Classification counts available to determine mix of vehicles by each vehicle type.

Rigid D = 9			Flexible SN = 5	
Class	Factor		Class	Factor
5	.19	Medium (Under 5 Axles)	5	.19
6	.59		6	.37
7	1.31		7	.80
8	.68		8	.61
9*	1.27	Heavy	9*	.77
10	2.18		10	1.46
11	1.60		11	1.53
12	1.20		12	1.04
13	2.08		13	1.58

*Most common class type

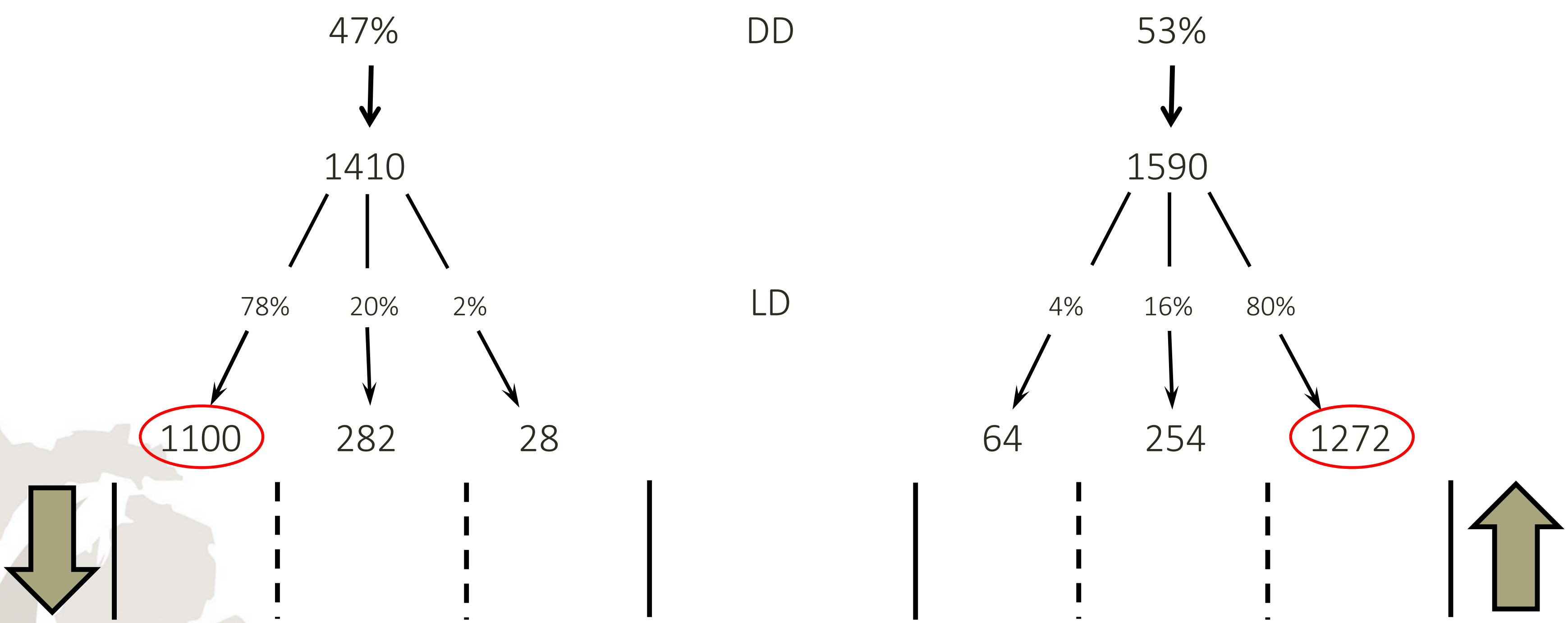
IV. Commercial volumes

Volume	Inches	Rigid	SN	Flexible
<2,000	9.0	0.69	6	0.49
2,000-2,499	9.5	0.81	6	0.75
2,500-3,4999	10.0	1.04	6	0.68
3,500-4,499	10.5	1.08	6	0.68
4,500+	11.0	0.85	6	0.56

AASHTO93 DESIGN METHOD *(OLD)*

<u>Design Lane Example</u>

CADT = 3000

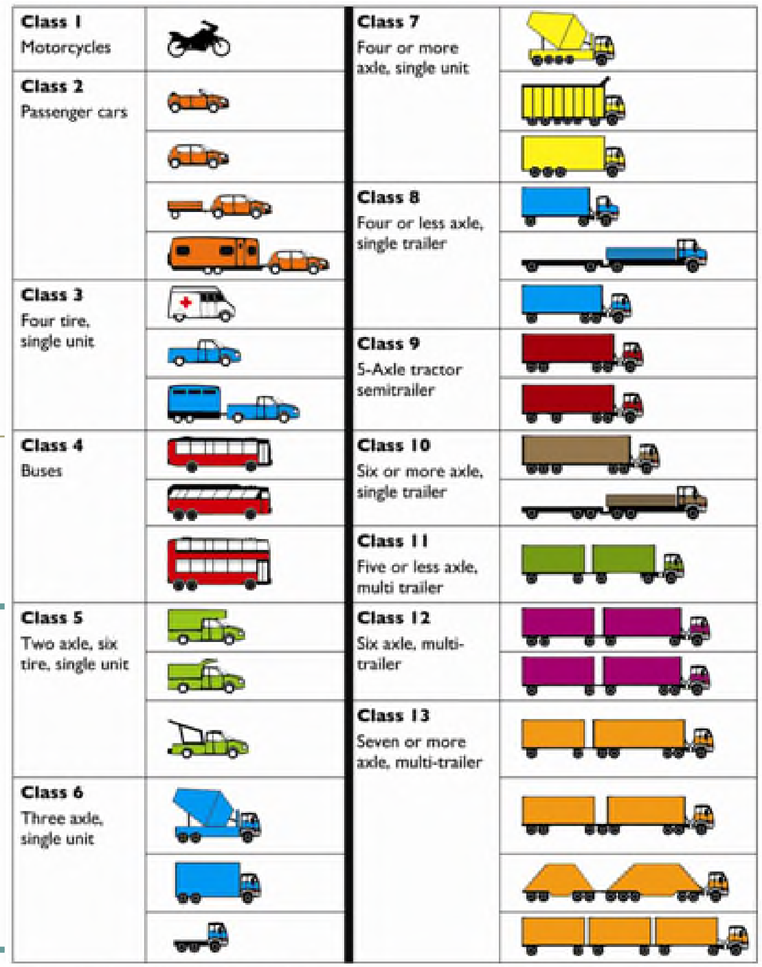


Lane with highest CADT is known as the Design Lane

AASHTO93 Design Method *(OLD)*

(screenshot from FHWA Traffic Monitoring Guide, April 2013, page 1-18)

FIGURE 1-1 FHWA's 13 VEHICLE CATEGORY CLASSIFICATION



Source: Federal Highway Administration.

ME adds Class 4

AASHTO 1993 (ESAL's)

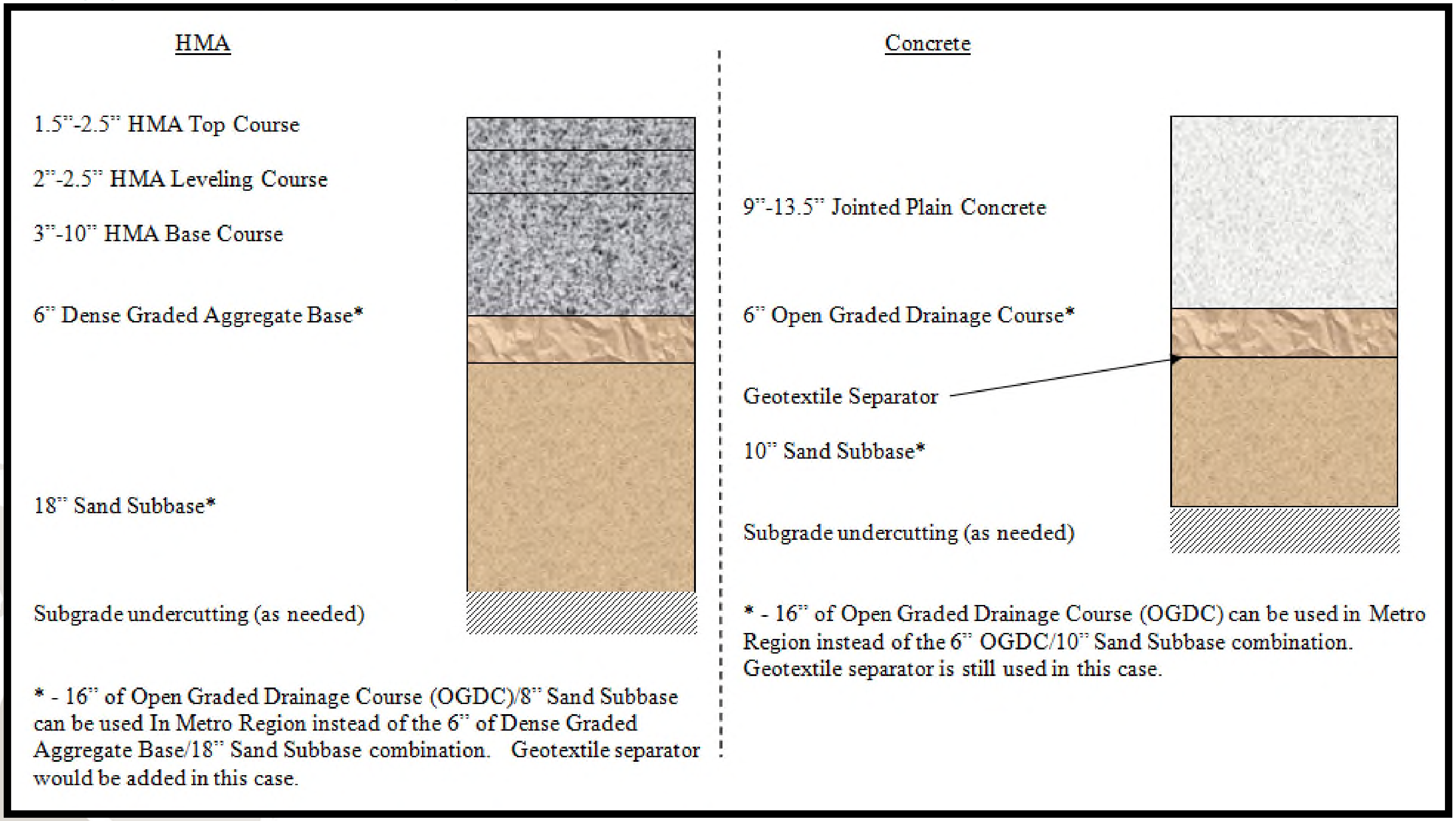
AASHTO 1993 (ESAL's)

AASHTO93 DESIGN METHOD *(OLD)*

- Traffic data generally consists of 2 types:
  - Permanent traffic recorders – embedded in the pavement
    - Weigh-In-Motion sites
    - Classification sites
    - Traffic count sites
    - Speed sites (not used for AASHTO 1993)
  - Short term measurements
    - Classification
    - Traffic count
    - Speed
    - Other (turning movements, etc.)

AASHTO93 Design Method (OLD)

Typical Freeway New/Reconstruct Cross-Sections



AASHTO93 Design Method *(OLD)*

- LCCA Analysis (pavt costs > $1.5 million) – compares PCC vs HMA alternatives:
  - New/reconstruction project
    - PCC = Jointed Plain Concrete Pavement (JPCP)
    - HMA = Full-depth (Superpave mix)
  - Major rehabilitation project
    - PCC = Unbonded concrete overlay of existing PCC
    - HMA = HMA overlay of rubblized concrete

- *Note that there are other types of pavement projects, but the above types are what are used in LCCA.*

ME Design Method *(NEW)*

ME Design Method (*New*)

- Mechanistic-Empirical (ME) Pavement Design
  - *ME Pavement Design Guide (MEPDG)*
    - Original Version - 1st Edition 2007/2008
    - Current Version - 3rd Edition 2020

- Mechanistic – Based on the theories of mechanical properties of materials
- Empirical – Use observed performance measures to calibrate the performance models

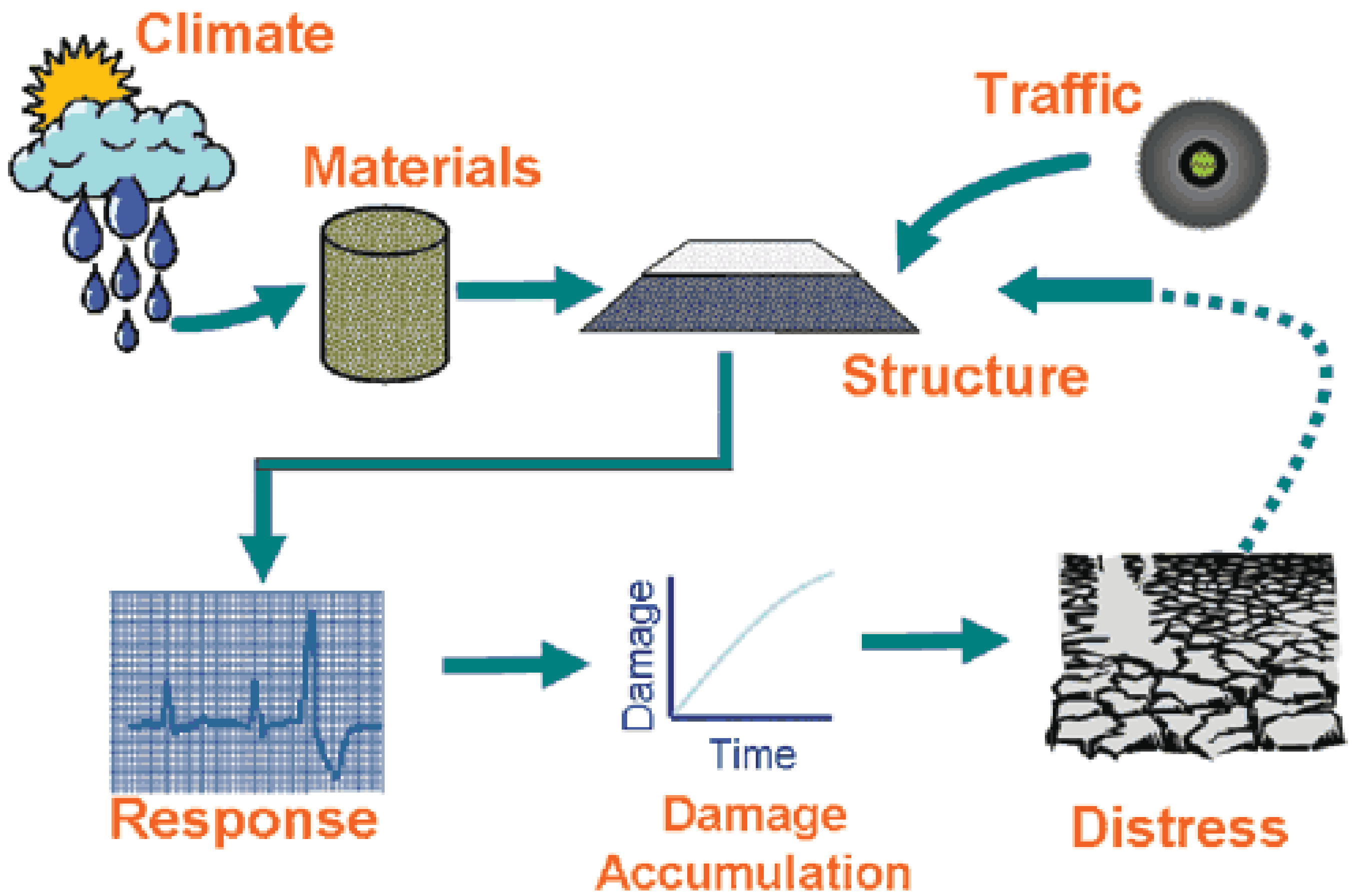
ME DESIGN METHOD (*NEW*)

- It is AASHTO's recommended pavement design method, replacing AASHTO '93
- Software name changed in 2013 from:
  - DARWin-ME to Pavement ME Design

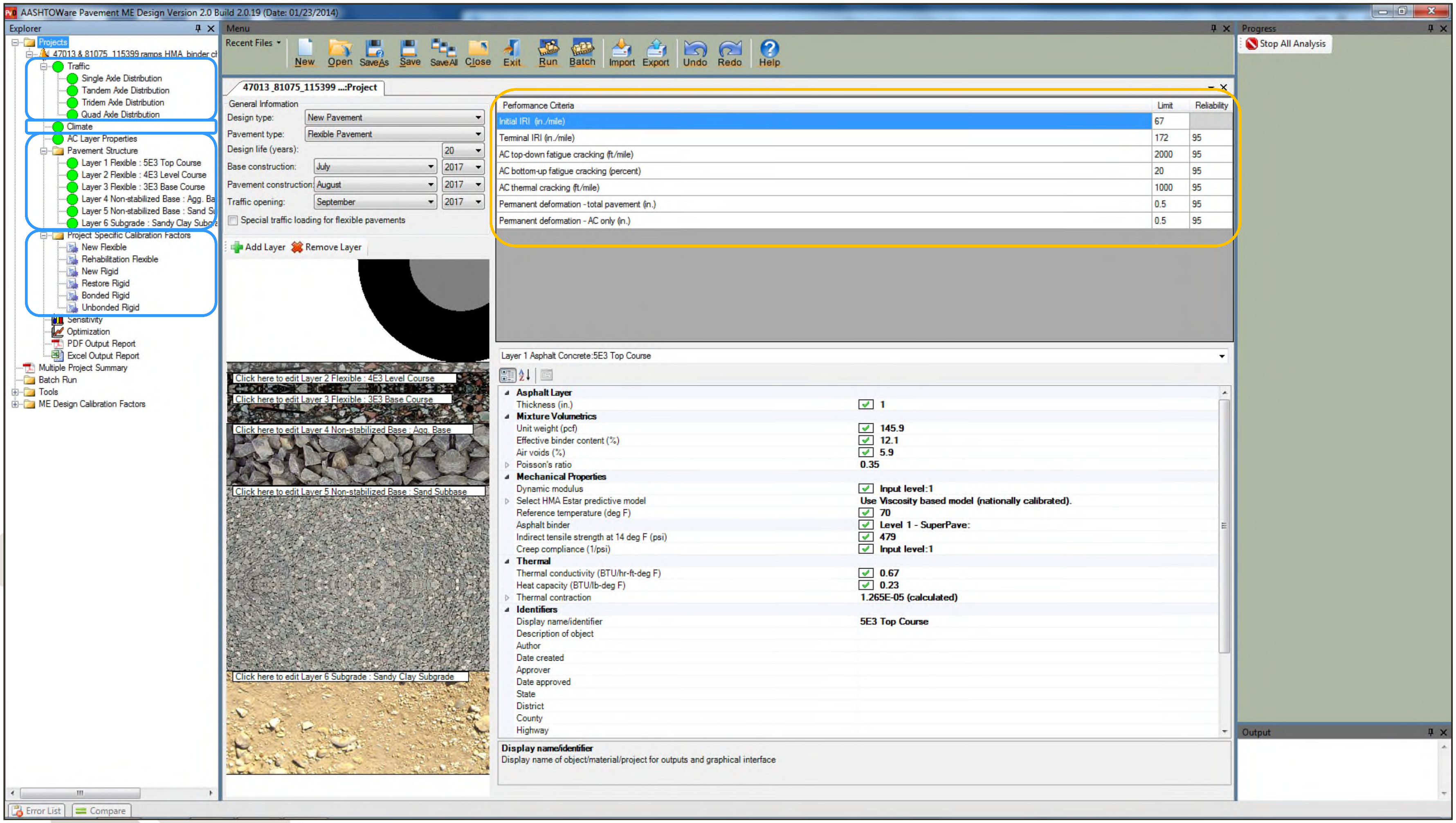
ME DESIGN METHOD (*NEW*)

- Pavement response for every anticipated axle load is calculated and damage is estimated and summed.
- Result is <u>distress prediction</u> (not a pavement cross-section) for the expected design period
  - Concrete distresses:
    - % slabs cracked, faulting, IRI
  - HMA distresses:
    - transverse cracking, longitudinal cracking, % fatigue cracking, rutting, IRI

ME DESIGN METHOD (*NEW*)



ME Design Method (*New*)



ME Design Method (*New*)

- Climate:
  - Data from 39 weather stations in Michigan
    - Recently completed Michigan Tech project added more years of data to existing stations and additional weather stations from the existing 19 (included in ME package).
  - Each weather station over 10 years of monthly climatic data
  - Water table depth is an input

ME Design Method (*New*)

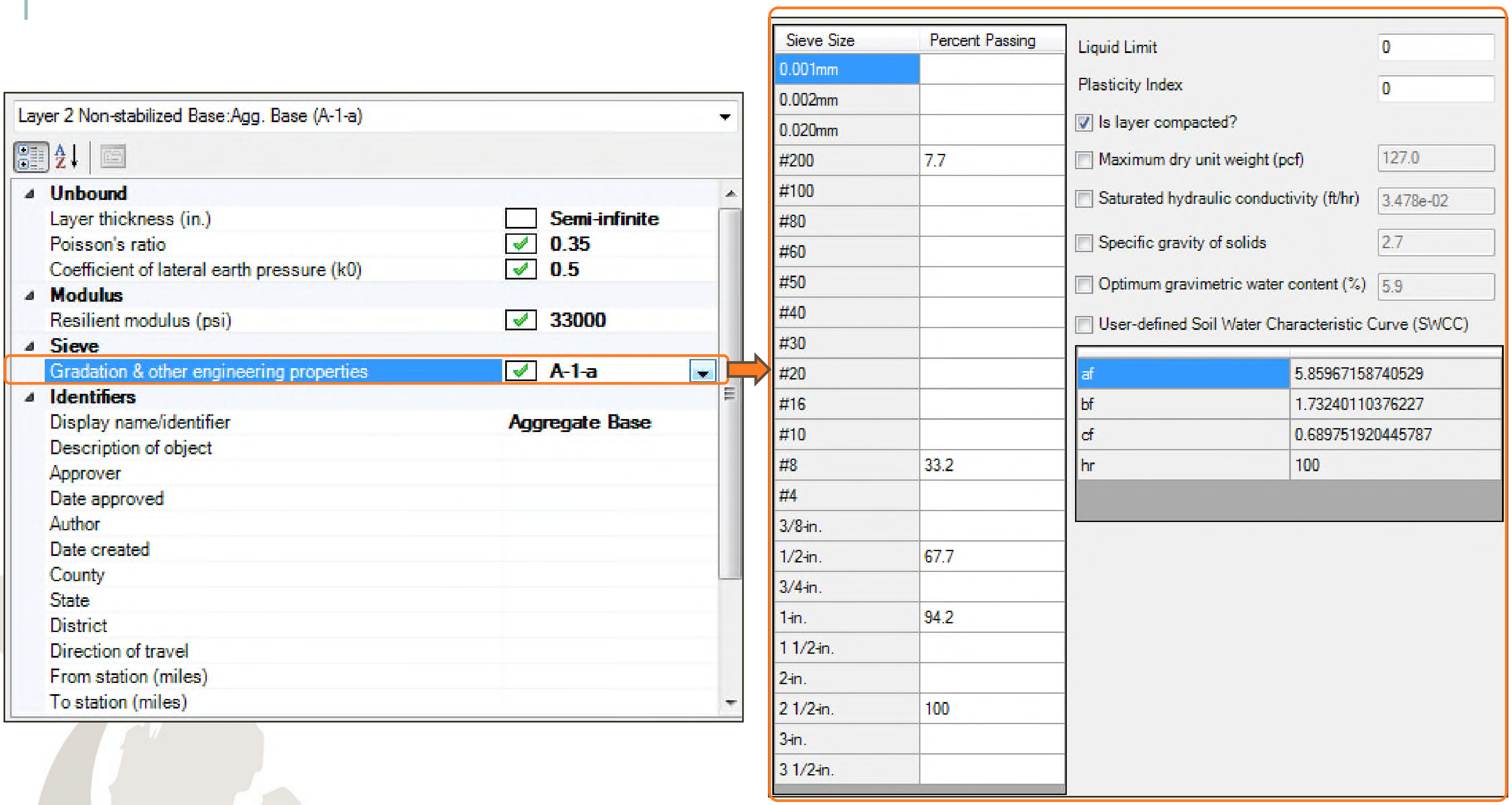
Locations of –

Weather Stations

ME DESIGN METHOD *(NEW)*

- Materials:
  - Many more material inputs
  - Examples:
    - Gradations (for calculating modulus values)
    - Thermal properties of the paved surface (expansion, conductivity, heat capacity)
    - Concrete shrinkage (ultimate, reversible, and time to 50%)
  - A lot more material testing has been occurring
    - This will continue into the future

ME DESIGN METHOD (*NEW*)



ME DESIGN METHOD (*NEW*)

Example of materials inputs – **Concrete Layer**

Layer 1 PCC:JPCP

PropertyGridToolBar

PCC	
Thickness (in.)	**10**
Unit weight (pcf)	**145**
Poisson's ratio	**0.2**
Thermal	
PCC coefficient of thermal expansion (in./in./deg F x 10^-6)	**5.8**
PCC thermal conductivity (BTU/hr-ft-deg F)	**1.25**
PCC heat capacity (BTU/lb-deg F)	**0.28**
Mix	
Cement type	**Type I (1)**
Cementitious material content (lb/yd^3)	**500**
Water to cement ratio	**0.42**
Aggregate type	**Limestone (1)**
PCC zero-stress temperature (deg F)	**Calculated**
Ultimate shrinkage (microstrain)	**530.8 (calculated)**
Reversible shrinkage (%)	**50**
Time to develop 50% of ultimate shrinkage (days)	**35**
Curing method	**Curing Compound**
Strength	
PCC strength and modulus	**Level:3 Compressive(5600)**

ME Design Method (*New*)

Example of materials inputs – **HMA Layer**

Layer 1 Asphalt Concrete:5E3 Top Course

Asphalt Layer	
Thickness (in.)	**1**
Mixture Volumetrics	
Unit weight (pcf)	**145.9**
Effective binder content (%)	**12.1**
Air voids (%)	**5.9**
Poisson's ratio	**0.35**
Mechanical Properties	
Dynamic modulus	**Input level:1**
Select HMA Estar predictive model	**Use Viscosity based model (nationally calibrated).**
Reference temperature (deg F)	**70**
Asphalt binder	**Level 1 - SuperPave:**
Indirect tensile strength at 14 deg F (psi)	**479**
Creep compliance (1/psi)	**Input level:1**
Thermal	
Thermal conductivity (BTU/hr-ft-deg F)	**0.67**
Heat capacity (BTU/lb-deg F)	**0.23**
Thermal contraction	**1.265E-05 (calculated)**

ME DESIGN METHOD (*NEW*)

Layer 1 Asphalt Concrete:HMA Top Course

Asphalt Layer		
Thickness (in.)	✓	1.5
Mixture Volumetrics		
Unit weight (pcf)	✓	146
Effective binder content (%)	✓	11.9
Air voids (%)	✓	7
Poisson's ratio		0.35
Mechanical Properties		
Dynamic modulus	✓	Input level:3
Select HMA Estar predictive model		HMA Top Course
Reference temperature (deg F)	✓	70
Asphalt binder	✓	SuperPave:64-28
Indirect tensile strength at 14 deg F (psi)	✓	400.47
Creep compliance (1/psi)	✓	Input level:3
Thermal		
Thermal conductivity (BTU/hr-ft-deg F)	✓	0.67
Heat capacity (BTU/lb-deg F)	✓	0.23
Thermal contraction		1.32E-05 (calculated)
Identifiers		
Display name/identifier		HMA Top Course

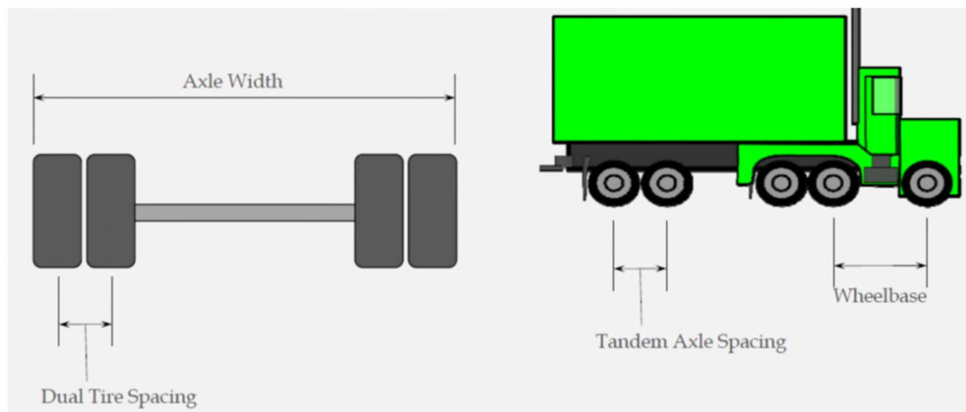
Layer 1 PCC:JPCP

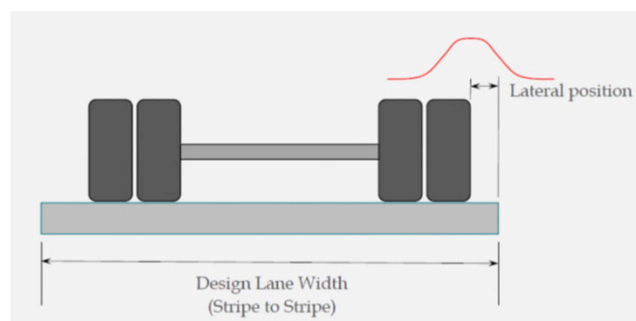
Thickness (in.)	✓	10
Unit weight (pcf)	✓	145
Poisson's ratio	✓	0.2
Thermal		
PCC coefficient of thermal expansion (in./in./deg F x 10^-(	✓	4.5
PCC thermal conductivity (BTU/hr-ft-deg F)	✓	1.25
PCC heat capacity (BTU/lb-deg F)	✓	0.28
Mix		
Cement type		Type I (1)
Cementitious material content (lb/yd^3)	✓	500
Water to cement ratio	✓	0.42
Aggregate type		Limestone (1)
PCC zero-stress temperature (deg F)	☐	Calculated
Ultimate shrinkage (microstrain)	☐	530.8 (calculated)
Reversible shrinkage (%)	✓	50
Time to develop 50% of ultimate shrinkage (days)	✓	35
Curing method		Curing Compound
Strength		
PCC strength and modulus	✓	Level:3 Compressive(5600)
Identifiers		
Display name/identifier		JPCP

HMA vs JPCP
inputs

ME DESIGN METHOD (NEW)

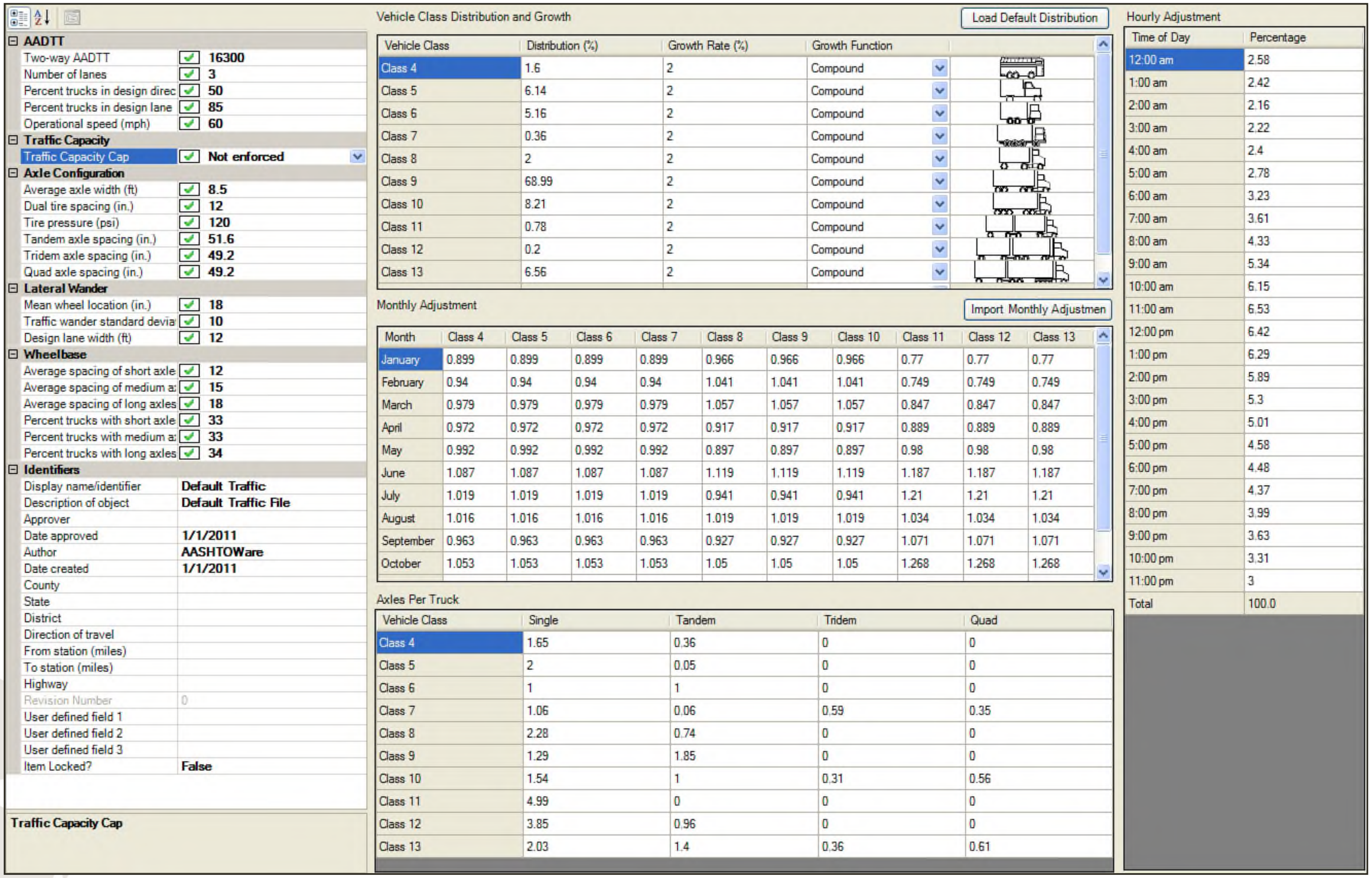
- Traffic:
  - No more ESAL's
  - Axle Load Spectra
  - Inputs include:
    - Average axle spacing,
    - Typical tire pressures,
    - Average distance from shoulder to closest tire,
    - Monthly and hourly distributions,
    - Vehicle class distribution,
    - etc.





ME Design Method (*New*)

Example of – **Traffic Inputs**



AADTT		
Two-way AADTT	✓	16300
Number of lanes	✓	3
Percent trucks in design direc	✓	50
Percent trucks in design lane	✓	85
Operational speed (mph)	✓	60
Traffic Capacity		
Traffic Capacity Cap	✓	Not enforced
Axle Configuration		
Average axle width (ft)	✓	8.5
Dual tire spacing (in.)	✓	12
Tire pressure (psi)	✓	120
Tandem axle spacing (in.)	✓	51.6
Tridem axle spacing (in.)	✓	49.2
Quad axle spacing (in.)	✓	49.2
Lateral Wander		
Mean wheel location (in.)	✓	18
Traffic wander standard devia	✓	10
Design lane width (ft)	✓	12
Wheelbase		
Average spacing of short axle	✓	12
Average spacing of medium a:	✓	15
Average spacing of long axles	✓	18
Percent trucks with short axle	✓	33
Percent trucks with medium a:	✓	33
Percent trucks with long axles	✓	34
Identifiers		
Display name/identifier		Default Traffic
Description of object		Default Traffic File
Approver		
Date approved		1/1/2011
Author		AASHTOWare
Date created		1/1/2011
County		
State		
District		
Direction of travel		
From station (miles)		
To station (miles)		
Highway		
Revision Number		0
User defined field 1		
User defined field 2		
User defined field 3		
Item Locked?		False

Traffic Capacity Cap

Vehicle Class Distribution and Growth — Load Default Distribution

Vehicle Class	Distribution (%)	Growth Rate (%)	Growth Function
Class 4	1.6	2	Compound
Class 5	6.14	2	Compound
Class 6	5.16	2	Compound
Class 7	0.36	2	Compound
Class 8	2	2	Compound
Class 9	68.99	2	Compound
Class 10	8.21	2	Compound
Class 11	0.78	2	Compound
Class 12	0.2	2	Compound
Class 13	6.56	2	Compound

Monthly Adjustment — Import Monthly Adjustmen

Month	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13
January	0.899	0.899	0.899	0.899	0.966	0.966	0.966	0.77	0.77	0.77
February	0.94	0.94	0.94	0.94	1.041	1.041	1.041	0.749	0.749	0.749
March	0.979	0.979	0.979	0.979	1.057	1.057	1.057	0.847	0.847	0.847
April	0.972	0.972	0.972	0.972	0.917	0.917	0.917	0.889	0.889	0.889
May	0.992	0.992	0.992	0.992	0.897	0.897	0.897	0.98	0.98	0.98
June	1.087	1.087	1.087	1.087	1.119	1.119	1.119	1.187	1.187	1.187
July	1.019	1.019	1.019	1.019	0.941	0.941	0.941	1.21	1.21	1.21
August	1.016	1.016	1.016	1.016	1.019	1.019	1.019	1.034	1.034	1.034
September	0.963	0.963	0.963	0.963	0.927	0.927	0.927	1.071	1.071	1.071
October	1.053	1.053	1.053	1.053	1.05	1.05	1.05	1.268	1.268	1.268

Axles Per Truck

Vehicle Class	Single	Tandem	Tridem	Quad
Class 4	1.65	0.36	0	0
Class 5	2	0.05	0	0
Class 6	1	1	0	0
Class 7	1.06	0.06	0.59	0.35
Class 8	2.28	0.74	0	0
Class 9	1.29	1.85	0	0
Class 10	1.54	1	0.31	0.56
Class 11	4.99	0	0	0
Class 12	3.85	0.96	0	0
Class 13	2.03	1.4	0.36	0.61

Hourly Adjustment

Time of Day	Percentage
12:00 am	2.58
1:00 am	2.42
2:00 am	2.16
3:00 am	2.22
4:00 am	2.4
5:00 am	2.78
6:00 am	3.23
7:00 am	3.61
8:00 am	4.33
9:00 am	5.34
10:00 am	6.15
11:00 am	6.53
12:00 pm	6.42
1:00 pm	6.29
2:00 pm	5.89
3:00 pm	5.3
4:00 pm	5.01
5:00 pm	4.58
6:00 pm	4.48
7:00 pm	4.37
8:00 pm	3.99
9:00 pm	3.63
10:00 pm	3.31
11:00 pm	3
Total	100.0

ME Design Method (New)

Month	Class	Total	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000	13000	14000	15000	16000
January	4	100	0	0.02	0.1	0.71	2.7	10.18	15.06	15.67	12.43	11.52	8.92	8.03	5.42	3.18
January	5	100	9.98	12.48	16.19	12.7	13.67	8.34	7.8	4.69	3.97	2.24	2.04	1.59	1.07	1.1
January	6	100	0.36	0.42	0.74	1.13	4.17	7.98	15.11	13.56	16.02	9.81	8.36	5.18	3.19	3.14
January	7	100	1.61	1.9	3.14	2.41	5.92	4.09	6.8	5.92	7.68	7.89	9.58	9.73	7.09	7.53
January	8	100	1.44	2.6	4.15	5.88	10.51	15	20.39	9.77	8.13	5.06	4.4	3.31	2.24	2.37
January	9	100	3.1	1.53	1.23	0.86	1.78	4.84	16.68	23.92	26.41	8.24	2.84	1.47	1.44	2.12
January	10	100	0.02	0.06	0.14	0.42	1.25	4.04	13.07	22.18	27.67	14.45	8.97	3.72	1.45	1.15
January	11	100	0.52	1.86	6.17	5.37	6.61	8.38	17.17	11.65	9.86	6.59	7.21	6.49	4.18	3.45
January	12	100	0.74	2.21	5.57	7.4	10.36	10.77	18.41	11.94	10.12	6.56	5.5	3.2	1.9	1.87
January	13	100	2.03	1.76	2.94	3.66	3.62	2.21	6.59	11.17	15.42	9.11	8.94	7.24	5.33	6.18
February	4	100	0.02	0.02	0.19	0.82	3.12	9.95	14	15.3	12.73	11.89	9.45	7.99	5.34	3.23
February	5	100	10.02	11.73	15.97	13.05	13.79	8.49	7.72	4.67	4.05	2.34	2.15	1.66	1.15	1.13
February	6	100	0.28	0.55	0.84	1.18	5.26	8.38	14.32	13.72	16.18	9.44	8.61	5.15	2.88	3.14
February	7	100	1.24	1.86	5.77	4.54	7.29	4.88	6.94	6.25	8.17	5.84	7.7	8.11	6.12	7.29
February	8	100	1.51	2.44	4.54	6.11	10.73	15.36	19.61	9.62	8.01	4.89	4.49	3.46	2.34	2.3
February	9	100	3.3	1.46	1.17	0.83	1.94	4.96	17.38	24.08	25.04	7.73	3.13	1.75	1.58	2.23
February	10	100	0.01	0.04	0.19	0.31	1.65	3.65	14.18	22.66	26.91	14	8.23	3.91	1.65	1.4
February	11	100	0.53	1.92	6.2	5.15	6.81	8.61	17.41	11.4	9.95	6.75	7.08	6.16	4.15	3.38
February	12	100	0.8	2.4	5.98	7.94	9.8	10.88	18.4	11.27	10.13	6.5	5.46	3.16	1.77	1.91
February	13	100	2.16	2.1	3.2	3.52	3.28	2.09	7.33	11.74	14.32	8.64	8.85	7.03	5.39	6.03
March	4	100	0	0	0.08	0.69	2.86	11.21	14.98	14.68	11.97	11.6	9.13	8.21	4.96	3.61
March	5	100	10.35	11.32	15.34	13.09	13.88	8.49	7.93	4.82	4.11	2.28	2.12	1.67	1.19	1.2
March	6	100	0.24	0.5	0.93	1.7	5.33	9.14	15.23	14.78	17.27	9.6	7.7	4.26	2.17	2.16
March	7	100	1.29	1.83	7.52	6.43	10.67	6.97	7.02	5.64	6.53	4.6	8.01	7.91	6.23	5.89
March	8	100	1.8	2.89	4.4	6.29	10.91	15.82	19.99	9.18	7.57	4.7	4.32	3.38	2.15	2.32
March	9	100	3.55	1.47	1.17	0.79	1.71	4.83	17.58	24.87	25.39	6.73	2.71	1.79	1.75	2.43

→ 41,000

↓ December

1.15% of the class 5 single axles in February are in the 14,000 to 14,999 weight bin

Single Axle Load Spectra
(axle load bin counts)

ME Design Method (New)

JN 88876 & 90076 & 90077 - JPCP

File Name: C:\Users\schenkelj\Documents\My ME Design\LCCA DESIGNS\ME DESIGNS (NEW CALIB COEF)\Testing\JN 88876 & 90076 & 90077 - JPCP.dgpx

Design Inputs

Design Life: 20 years
Design Type: Jointed Plain Concrete Pavement (JPCP)
Existing construction: -
Pavement construction: August, 2016
Traffic opening: September, 2016
Climate Data Sources (Lat/Lon): 43.171, -86.237

Design Structure

Layer type	Material Type	Thickness (in.):
PCC	JPCP	9.5
NonStabilized	OGDC	6.0
NonStabilized	Sand Subbase	10.0
Subgrade	Poorly Graded Sand/Silty Sand Subgrade	Semi-infinite

Joint Design:	
Joint spacing (ft)	14.0
Dowel diameter (in.)	1.25
Slab width (ft)	12.0

Traffic

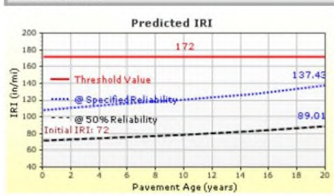
Age (year)	Heavy Trucks (cumulative)
2016 (initial)	2,932
2026 (10 years)	4,530,020
2036 (20 years)	9,435,780

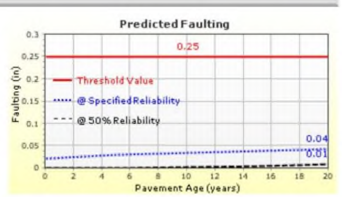
Design Outputs

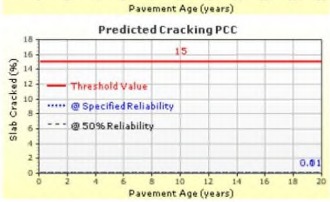
Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in./mile)	172.00	137.43	95.00	99.76	Pass
Mean joint faulting (in.)	0.25	0.04	95.00	100.00	Pass
JPCP transverse cracking (percent slabs)	15.00	0.11	95.00	100.00	Pass

Distress Charts







Report generated on: 1/28/2015 3:51 PM
Created by: J Schenkel on: 6/16/2014 1:41 PM
Approved by: on: 6/16/2014 1:41 PM
Page 1 of 15

JN 88876 & 90076 & 90077 - HMA

File Name: C:\Users\schenkelj\Documents\My ME Design\LCCA DESIGNS\ME DESIGNS (NEW CALIB COEF)\Testing\JN 88876 & 90076 & 90077 - HMA.dgpx

Design Inputs

Design Life: 20 years
Design Type: Flexible Pavement
Base construction: July, 2016
Pavement construction: August, 2016
Traffic opening: September, 2016
Climate Data Sources (Lat/Lon): 43.171, -86.237

Design Structure

Layer type	Material Type	Thickness (in.):
Flexible	5E10 Top Course	1.5
Flexible	3E10 Leveling Course	3.3
Flexible	3E10 Base Course	3.5
NonStabilized	OGDC	6.0
NonStabilized	Sand Subbase	18.0
Subgrade	Poorly Graded Sand/Silty Sand Subgrade	Semi-infinite

Volumetric at Construction:	
Effective binder content (%)	12.1
Air voids (%)	5.9

Traffic

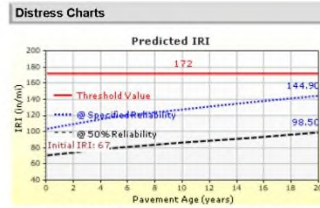
Age (year)	Heavy Trucks (cumulative)
2016 (initial)	2,932
2026 (10 years)	4,530,020
2036 (20 years)	9,435,780

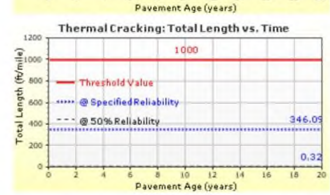
Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in./mile)	172.00	144.94	95.00	99.54	Pass
Permanent deformation - total pavement (in.)	0.50	0.46	95.00	98.38	Pass
AC bottom-up fatigue cracking (percent)	20.00	21.26	95.00	93.40	Fail
AC thermal cracking (ft/mile)	1000.00	346.09	95.00	100.00	Pass
AC top-down fatigue cracking (ft/mile)	2000.00	1427.68	95.00	99.71	Pass
Permanent deformation - AC only (in.)	0.50	0.42	95.00	99.49	Pass

Distress Charts





Report generated on: 1/28/2015 3:55 PM
Created by: J Schenkel on: 9/4/2014 12:00 AM
Approved by: on: 1/1/0001 12:00 AM
Page 1 of 25

ME DESIGN METHOD (*NEW*)

Design Comparison

	AASHTO 1993	Mechanistic-Empirical
Basis	Empirical observation from the 1958-59 AASHTO Road Test	Theories of mechanics
Original Calibration	AASHO Road Test – Ottawa, IL	SHRP test sections from around the country
Traffic Characterization	Equivalent Single Axle Load	Axle load spectra
Materials Inputs	Very few	Many
Climatic Effects	Limited – can change inputs based on season	Integral – weather data from 600+ US weather stations included
Performance Parameter	Present Serviceability Index	Various distresses, IRI
Output	Thickness	Performance prediction (distress prediction)

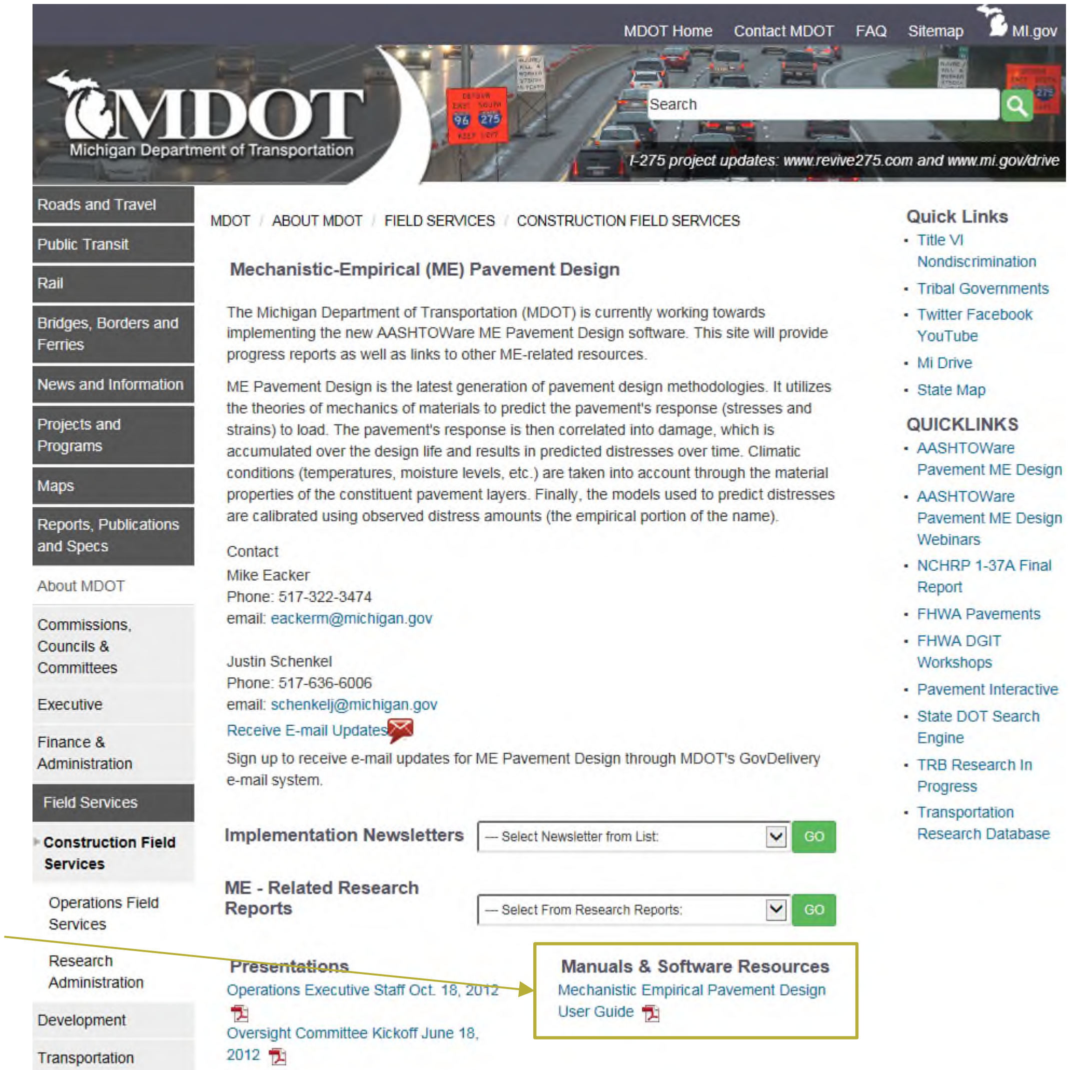
ME Design Method (*New*)

- 1st calibration completed fall of 2014 (Michigan State University project)
- 2nd calibration completed end of 2017 (MSU)
- 3rd calibration to be completed in 2022 (MSU)
- Began phase 1 of transition process March 2015
  - Phase 1: Life-cycled reconstruction projects
  - Phase 2: All reconstruct projects *(currently in this phase)*
  - Phase 3: Life-Cycled rehab projects
  - Phase 4: All rehab projects

ME DESIGN METHOD (*NEW*)

- MDOT ME Website:
  - http://www.michigan.gov/mdot/0,4616,7-151-9623_26663_27303_27336_63969---,00.html

MDOT ME User Guide



QUESTIONS?

- Contact Info:
  - Justin P. Schenkel, P.E.

P: 517-636-6006

E: schenkelj@michigan.gov

Construction Field Services

Michigan Department of Transportation