RED ROCK CONSULTING

Pavement Design Report

I-35
MCCLAIN COUNTY, OKLAHOMA

35589(04)

Prepared For:

Olsson Associates
11600 Broadway Extension, Suite 300
Oklahoma City, Oklahoma 73114
Attention: Mr. Russell Beaty, PE

Prepared By:

Red Rock Consulting, LLC
PO Box 30591
Edmond, Oklahoma 73003
(405) 562-3328

August 28, 2023
Project No. 22119

RED ROCK
CONSULTING

August 28, 2023

Olsson Associates
11600 Broadway Extension, Suite 300
Oklahoma City, Oklahoma 73114

Attention: Mr. Russell Beaty, PE

Re: Pavement Design Report
I-35
McClain County, Oklahoma
35589(04)
RRC Project No. 22119

Dear Mr. Beaty,

We are pleased to submit herewith this report entitled "Pavement Design Report, I-35, McClain County, Oklahoma, 35589(04)".

In an effort to provide a more environmentally friendly service, this report has been provided electronically.

If you have any questions regarding the contents of this report, please contact Red Rock Consulting. It has been our pleasure to assist you with this project.

Yours very truly,
RED ROCK CONSULTING, LLC
CA No. 5707 Exp. 06/30/25

REGISTERED PROFESSIONAL ENGINEER
JEREMY BASLER
8-28-2023
20233
OKLAHOMA

Jeremy Basler, PE
Geotechnical Manager
Oklahoma PE No 20233

PAVEMENT DESIGN REPORT

I-35
MCCLAIN COUNTY, OKLAHOMA

35589(04)

PROJECT NO. 22119

PAVEMENT DESIGN REPORT

I-35
MCCLAIN COUNTY, OKLAHOMA

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INTRODUCTION

General

This report presents the results for the typical asphalt overlay and asphalt and concrete section recommendations for I-35 from 1.0 mile south of Ladd Road extending north approximately 4.7 miles in McClain County, Oklahoma.

Proposed Construction

The project includes the widening of the existing pavement of I-35 in the center median and outside lanes to accommodate adding one lane of traffic in each direction. The project also includes the potential overlay or reconstruction of the existing pavement of the I-35 mainline and the construction of a portion of nine ramps to tie into the existing ramps at the Ladd Road and SH 74 interchanges.

Scope of Work

The scope of this investigation includes the following:

1. Review of previous geotechnical and geological information of sites near this site. This was augmented with data obtained during the field investigation phase of the Shoulder Soils Survey and the Pavement and Subgrade Survey.

2. Pavement design recommendations for the mill and overlay section.

3. Pavement design recommendations for the new asphalt and concrete pavement sections.

PAVEMENT RECOMMENDATIONS

Recommendations for designing mill and overlay using a 15 year design life and new asphalt and concrete pavement using a 30-year design life were requested by ODOT. The asphalt pavement design analysis was performed using the mechanistic-empirical (ME) pavement design computer software AASHTOWare Pavement ME Design 2.6.2.2. Information considered in the design is discussed briefly below.

The climate summary for the nearest climate station US, OK 138373 (35.15, -97.47), is as follows:

Mean annual air temperature (°F)	61.13
Mean annual precipitation (in)	34.17
Freezing index (°F – days)	102.07
Average annual number of freeze/thaw cycles	61.02

The functional performance of asphalt pavement with a target of 90% reliability is expressed in terms of the pavement distresses below. The design criteria or threshold values used fall within the typical values recommended by the pavement ME design program.

Terminal international roughness index (IRI)	172 inches/mile
Permanent deformation – total pavement	0.75 inches
AC total fatigue cracking: bottom up + reflective	25% lane area
AC total transverse cracking: thermal + reflective	2,500 feet/mile
Permanent deformation – AC only	0.25 inches
AC bottom-up fatigue cracking	25% lane area
AC thermal cracking	1,000 feet/mile
AC top-down fatigue cracking	25% lane area

The functional performance of concrete pavement with a target of 95% reliability is expressed in terms of the pavement distresses below. The design criteria or threshold values used fall within the typical values recommended by the pavement ME design program.

Terminal International Roughness Index (IRI)	172 in/mile
Mean joint faulting	0.12 inches
Jointed Plain Concrete Pavement (JPCP) transverse cracking	15% slabs

The annual average daily traffic (AADT) by vehicle classification was provided by Olsson Associates to use to calculate the traffic data for the asphalt and concrete pavement designs for this project. A summary of the traffic data is provided in Tables 1 and 2.

Table 1 – Mainline Traffic Data

Parameter	Value	Parameter	Value
AADT (2022):	53,300	Design Res. Mod. (psi):	5,600
AADT (2027):	57,974	Heavy Trucks (T_3):	21%
AADT (2042):	74,600	D (Directional Dist.):	55%
15 Year Flex ESALs:	38,860,000	L (Lane Dist.):	70%
20 Year Flex ESALs:	54,600,000	Design Speed (mph):	65
30 Year Flex ESALs:	91,170,000		
30 Year Rigid ESALs:	135,660,000		
Design PI:	13		

Table 2 – Ramps Traffic Data

Parameter	Value	Parameter	Value
AADT (2025):	4,900	Design Res. Mod. (psi):	5,600
AADT (2027):	5,603	Heavy Trucks (T_3):	4%
AADT (2045):	6,800	D (Directional Dist.):	100%
30 Year Flex ESALs:	4,460,000	L (Lane Dist.):	100%
20 Year Flex ESALs:	2,670,000	Design Speed (mph):	45
30 Year Rigid ESALs:	6,410,000		
Design PI:	13		

The hot mixed asphalt (HMA) courses recommended include PG 76-28 and PG 64-22 binders, as per typical sections/plans provided by Olsson Associates. The jointed plain concrete pavement (JPCP) should have 12 foot slabs with approximate 15 foot joints, 1 ½” to 1 ¾” diameter dowels and 12” dowel spacing. The material for the base course is assumed to be ODOT Type ‘A’ Aggregate Base.

Resilient modulus results from the Shoulder Soils Survey associated with this project were used to determine the resilient modulus for the existing subgrade layer. A Mr value of 5,600 psi was used for the subgrade. Mix design and laboratory testing were not conducted for the stabilized subgrade, aggregate base or cement treated base layers. Mr values of 15,000, 25,000 and 700,000 psi were assumed for the stabilized subgrade, aggregate base and cement treated base layers, respectively.

Milling of the existing I-35 pavement with an asphalt overlay is being considered for this project. Mill and overlay can be used for the areas of the existing pavement that have adequate drainage, sufficient subgrade support and exhibits only minor pavement distress in the surface course only. Minor pavement distress was observed in the surface of the existing asphalt pavement during the Pavement and Subgrade Survey field investigation. If the pavement distress exceeds the 5 inch milling depth recommended below, the pavement should be filled with suitable crack filler for the remainder of the crack depth following milling**. If pavement damage is not removed, the remaining damage will reflect through the asphalt overlay in a relatively short amount of time.** If cracks extend from the pavement surface all the way to the subgrade, the pavement should be reconstructed for the full depth.

The recommended mill and overlay pavement section for a 15-year design life is shown in Table 3. The design requires at least 5 inches total asphalt pavement overlay following 5 inches of milling of the existing asphalt pavement. All materials and construction procedures should meet Oklahoma Department of Transportation (ODOT) specifications. The AASHTOWare Pavement ME design is provided in Appendix A.

Table 3 – *Mainline Mill and Overlay Pavement Section

Layer	Depth
Superpave Type S4 (PG 76-28 OK)	2"
Superpave Type S3 (PG 76-28 OK)	3"

*This pavement section represents mainline paving and not the shoulders. For shoulders replace the PG 76-28 OK layers with PG 64-22 OK

A new asphalt pavement section is proposed for the widening adjacent to the existing pavement, areas of realignment and if it is determined the existing pavement will be reconstructed. A new concrete pavement section for the mainline was also requested for comparison. The recommended full depth asphalt and concrete pavement sections for a 30-year design life are shown in Tables 4-7. Our 30 year analysis/design of the asphalt pavement sections would create a Terminal International Roughness Index (IRI) in (in/mile) higher than the target/typical. If ODOT relaxes the aforementioned distress requirement and allows up to 174.97 in/mile for the mainline and 174.64 for the Ramps, the designed thicknesses would be sufficient, otherwise, the pavement thicknesses should increase or additional maintenance should be expected. All materials and construction procedures should meet applicable ODOT standard specifications. The AASHTOWare Pavement ME designs are provided in Appendix A.

Table 4 – *Mainline Reconstruction/Lane Widening Full Depth Pavement Section

Layer	Depth
Superpave Type S4 (PG 76-28 OK)	2"
Superpave Type S3 (PG 76-28 OK)	3"
Superpave Type S3 (PG 64-22 OK)	3"
Superpave Type S3 (PG 64-22 OK)	3”
Superpave Type S3 (PG 64-22 OK)	3”
Aggregate Base	8”
Geotextile Reinforcement	
Stabilized Subgrade	8"

*This pavement section represents mainline paving and not the shoulders. For shoulders replace the PG 76-28 OK layers with PG 64-22 OK. Fabric reinforcement should be placed 2-ft either side of the longitudinal saw joint

Table 5 – *Mainline Reconstruction/Lane Widening Concrete Pavement Section

Material	Thickness
Portland Cement 1 ¾" Dowel Jointed Concrete	12"
Separator Fabric	
Cement Treated Base	4"
Aggregate Base	8"
Geotextile Reinforcement	
Stabilized Subgrade	8"

*This pavement section also represents the Tied PC shoulders

Table 6 – *Ramps Full Depth Pavement Section

Layer	Depth
Superpave Type S4 (PG 76-28 OK)	2"
Superpave Type S3 (PG 76-28 OK)	3"
Superpave Type S3 (PG 64-22 OK)	2.5"
Superpave Type S3 (PG 64-22 OK)	2.5"
Stabilized Subgrade	8"

*This pavement section represents mainline paving and not the shoulders. For shoulders replace the PG 76-28 OK layers with PG 64-22 OK

Table 7 – *Ramps Concrete Pavement Section

Material	Thickness
Portland Cement 1 ½" Dowel Jointed Concrete	9"
Separator Fabric	
Cement Treated Base	4"
Stabilized Subgrade	8"

*This pavement section also represents the Tied PC shoulders

The subgrade preparation, compaction, aggregate base, separator fabric, stabilized subgrade and cement treated base for the new pavement construction must meet applicable ODOT Standard Specifications.

The pavement subgrade will benefit from the use of stabilization. A soil-stabilizing agent mix design should be conducted as per OHD L-50 Soil Stabilization Mix Design Procedure prior to construction to determine the type appropriate for the soil classification and percent of stabilizing agent necessary. Chemical analysis of the soil and stabilizing agent should also be conducted. The subgrade preparation, compaction and stabilization must meet applicable ODOT Standard Specifications.

Asphalt mixes are sensitive to environmental interference during construction. Pavement should be placed only at appropriate temperatures and during dry weather without severe wind.

Minimizing subgrade saturation is an important factor in maintaining subgrade strength both during construction and after construction. Water allowed to pond on or adjacent to pavements could saturate the subgrade and cause premature pavement deterioration. Concrete pavement joints should be sealed as soon as possible following construction. The pavement should be sloped to provide rapid surface drainage and positive surface drainage should be maintained away from the edge of the paved areas. Design alternatives that could reduce the risk of subgrade saturation and improve long-term pavement performance includes crowning the pavement subgrade to drain toward the edges rather than to the center of the pavement and installing surface drains next to any areas where surface water could pond. Properly designed and constructed subsurface drainage will reduce the time subgrade soils are saturated and can also improve subgrade strength and performance.

Periodic maintenance extends the service life of the pavement and should include crack sealing, surface sealing and patching of any deteriorated areas. Thicker pavement sections could be used to reduce the required maintenance and extend the service life of the pavement.

CLOSURE

The data presented in this report are based on the negotiated scope for this project and site conditions as they existed at the time of the field exploration. The conditions encountered in the exploratory borings are representative subsurface conditions within the study area.

This report was prepared for the exclusive use of Olsson Associates, ODOT and their agents and consultants. It should be made available to prospective contractors for information and factual data only and not as a warranty of subsurface conditions or discussions presented herein.

APPENDIX A

22119.Overlay.Mill5Fill5 with Agg Base

File Name: C:\Users\kkb\OneDrive\Documents\My ME Design\Projects\2022\22119\22119.Overlay.Mill5Fill5 with Agg Base.dgpx

Design Inputs

Design Life: 15 years
Design Type: AC_AC

Existing construction: June, 2005
Pavement construction: May, 2025
Traffic opening: May, 2027

Climate Data Sources (Lat/Lon): 35, -97.5

Design Structure

Layer type	Material Type	Thickness (in)
Flexible (OL)	Default asphalt concrete	5.0
Flexible (existing)	Default asphalt concrete	4.0
NonStabilized	Crushed stone	6.0
Subgrade	A-6	24.0
Subgrade	A-6	Semi-infinite

Volumetric at Construction:	
Effective binder content (%)	10.7
Air voids (%)	7.0

Traffic

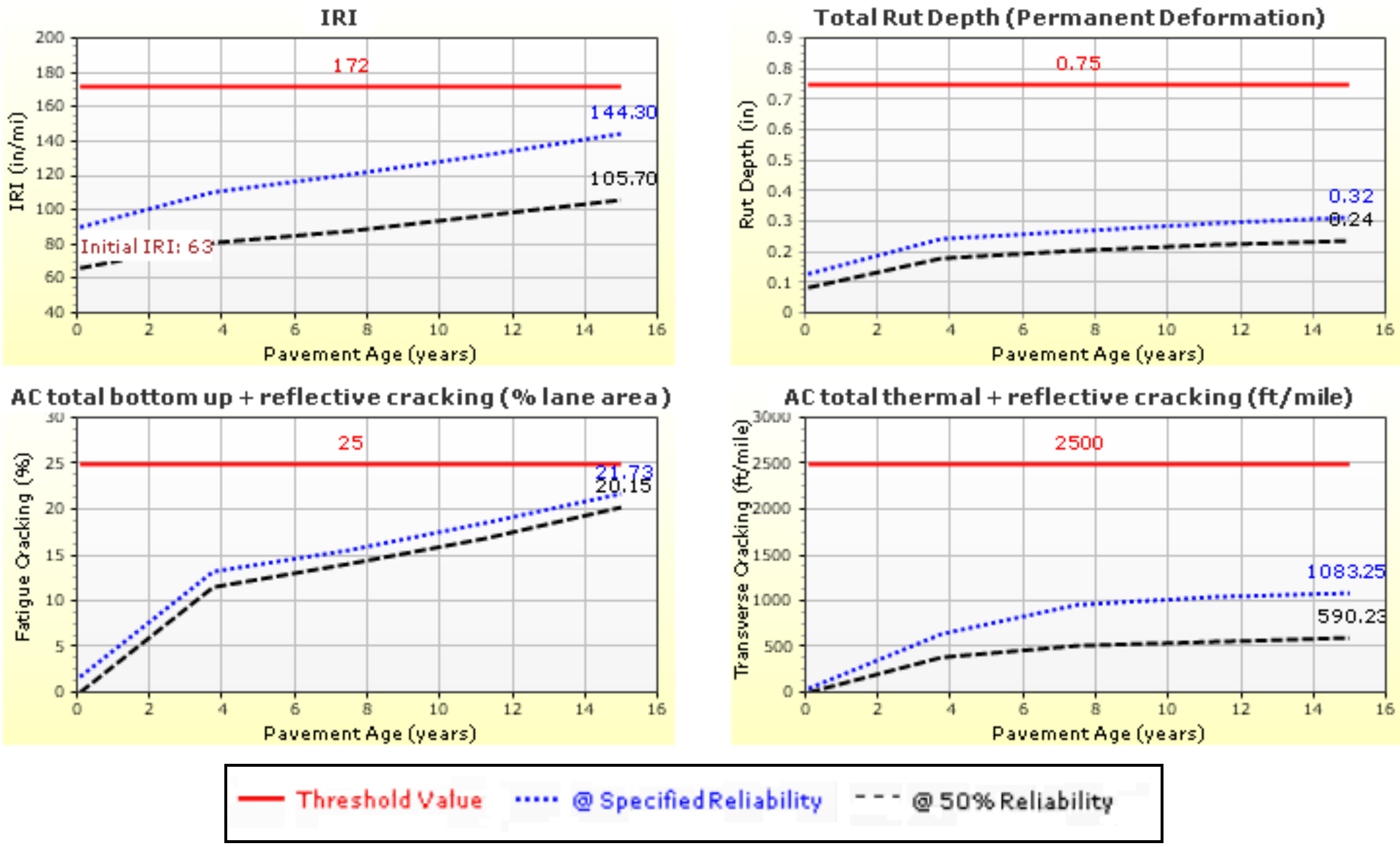
Age (year)	Heavy Trucks (cumulative)
2027 (initial)	13,914
2034 (7 years)	15,669,700
2042 (15 years)	33,836,400

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	172.00	144.34	90.00	98.61	Pass
Permanent deformation - total pavement (in)	0.75	0.32	90.00	100.00	Pass
AC total fatigue cracking: bottom up + reflective (% lane area)	25.00	21.73	90.00	100.00	Pass
AC total transverse cracking: thermal + reflective (ft/mile)	2500.00	1083.25	90.00	100.00	Pass
Permanent deformation - AC only (in)	0.25	0.15	90.00	100.00	Pass
AC bottom-up fatigue cracking (% lane area)	25.00	0.00	50.00	100.00	Pass
AC thermal cracking (ft/mile)	1000.00	215.42	50.00	100.00	Pass
AC top-down fatigue cracking (% lane area)	25.00	13.32	90.00	99.95	Pass

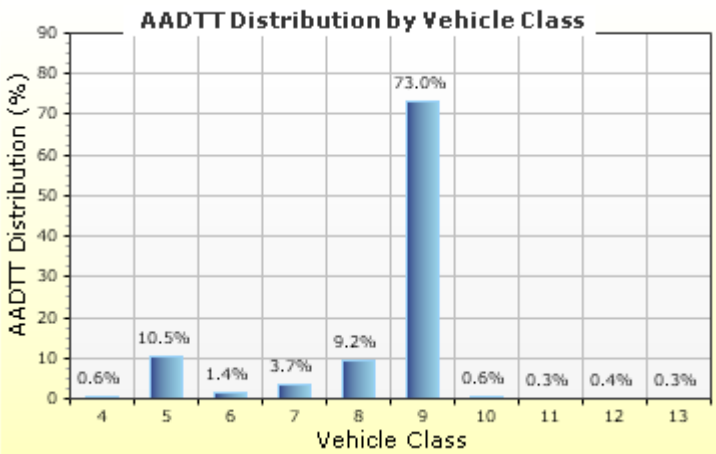
Distress Charts

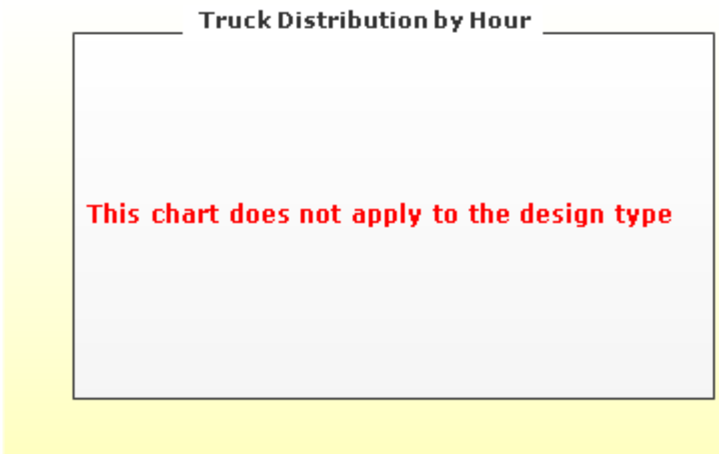


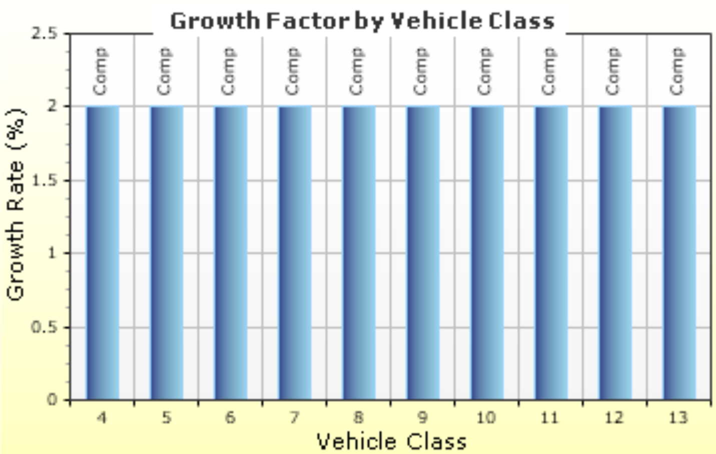
Traffic Inputs

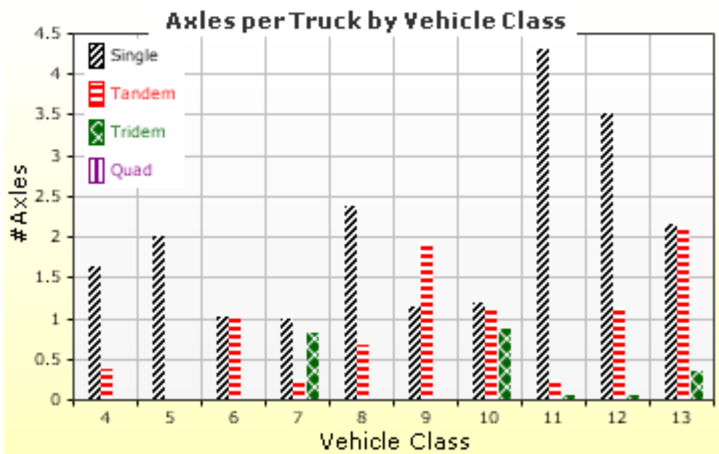
Graphical Representation of Traffic Inputs

Initial two-way AADTT:	13,914	Percent of trucks in design direction (%):	55.0
Number of lanes in design direction:	3	Percent of trucks in design lane (%):	70.0
		Operational speed (mph)	65.0

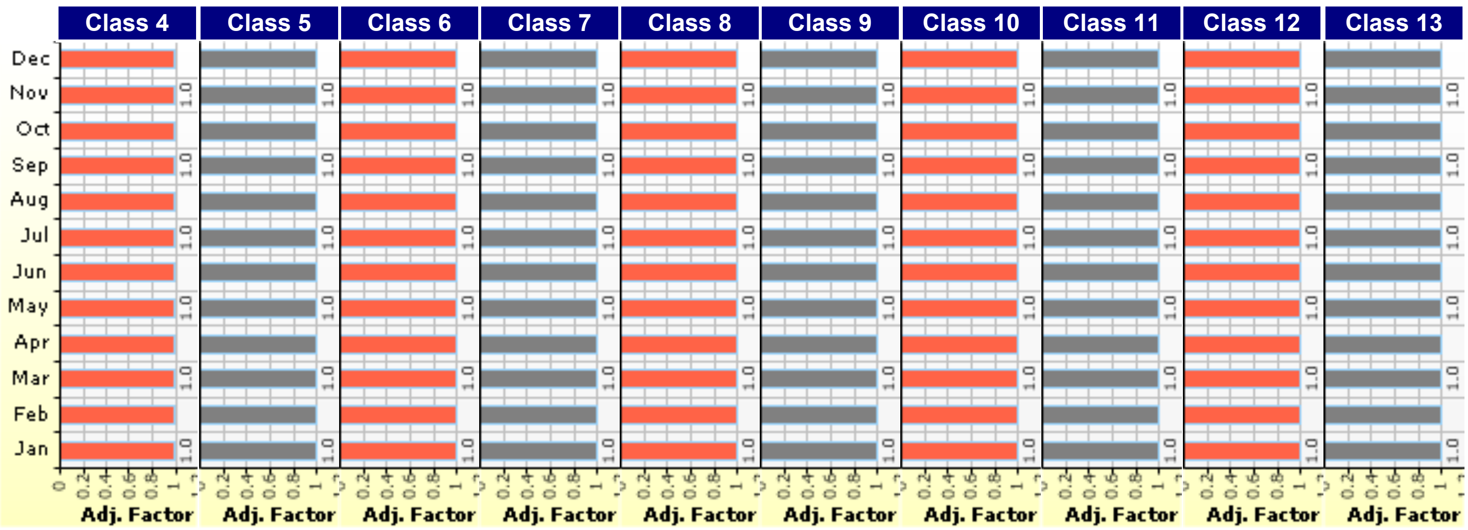








Traffic Volume Monthly Adjustment Factors



Tabular Representation of Traffic Inputs

Volume Monthly Adjustment Factors

Level 3: Default MAF

Month	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
January	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
February	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
March	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
April	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
May	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
June	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
July	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
August	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
September	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
October	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
November	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
December	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Distributions by Vehicle Class

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor	
		Rate (%)	Function
Class 4	0.6%	2%	Compound
Class 5	10.5%	2%	Compound
Class 6	1.4%	2%	Compound
Class 7	3.7%	2%	Compound
Class 8	9.2%	2%	Compound
Class 9	73%	2%	Compound
Class 10	0.6%	2%	Compound
Class 11	0.3%	2%	Compound
Class 12	0.4%	2%	Compound
Class 13	0.3%	2%	Compound

Truck Distribution by Hour does not apply

Axle Configuration

Traffic Wander	
Mean wheel location (in)	18.0
Traffic wander standard deviation (in)	10.0
Design lane width (ft)	12.0

Axle Configuration	
Average axle width (ft)	8.5
Dual tire spacing (in)	12.0
Tire pressure (psi)	120.0

Average Axle Spacing	
Tandem axle spacing (in)	51.6
Tridem axle spacing (in)	49.2
Quad axle spacing (in)	49.2

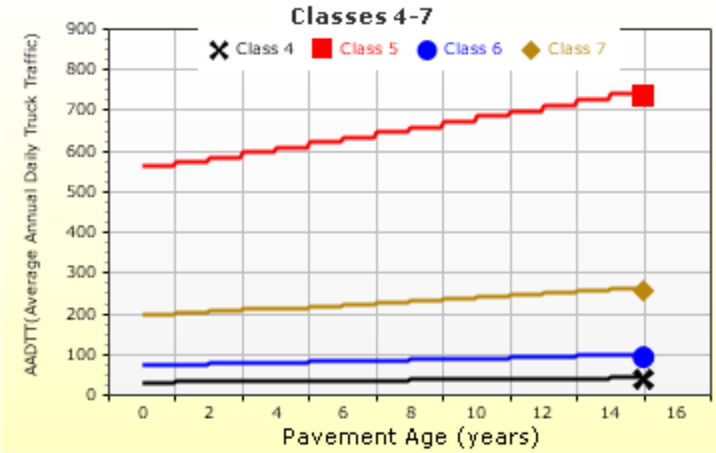
Wheelbase does not apply

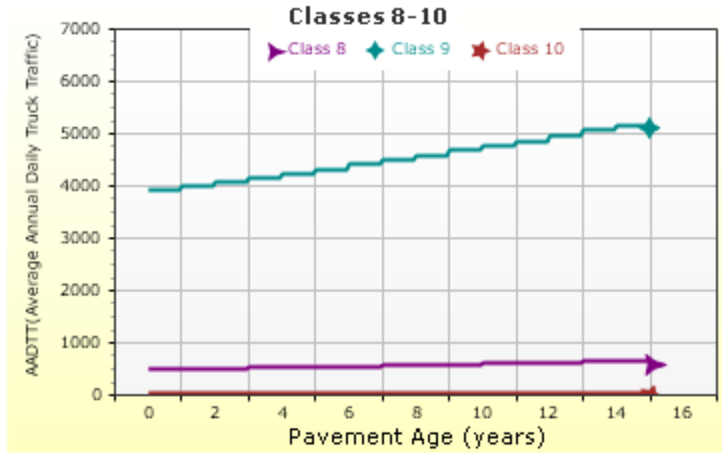
Number of Axles per Truck

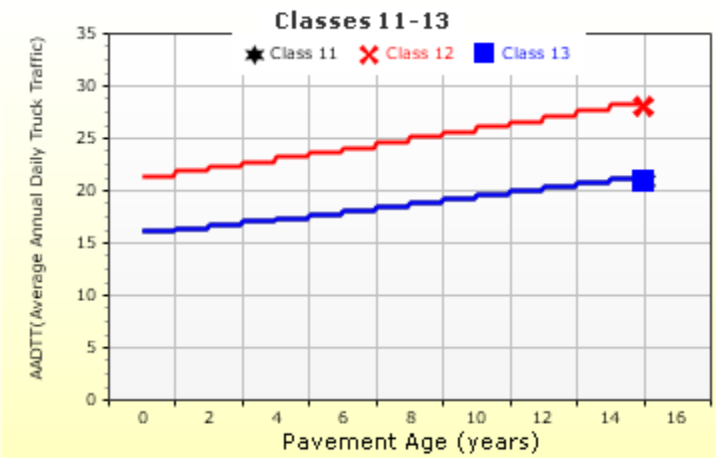
Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.62	0.39	0	0
Class 5	2	0	0	0
Class 6	1.02	0.99	0	0
Class 7	1	0.26	0.83	0
Class 8	2.38	0.67	0	0
Class 9	1.13	1.93	0	0
Class 10	1.19	1.09	0.89	0
Class 11	4.29	0.26	0.06	0
Class 12	3.52	1.14	0.06	0
Class 13	2.15	2.13	0.35	0

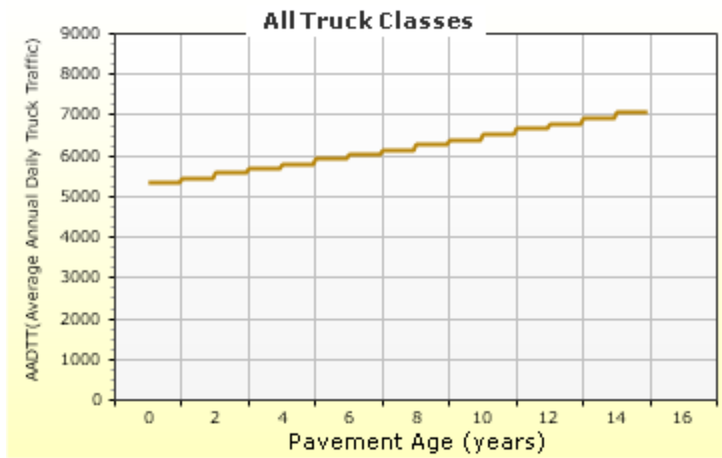
AADTT (Average Annual Daily Truck Traffic) Growth

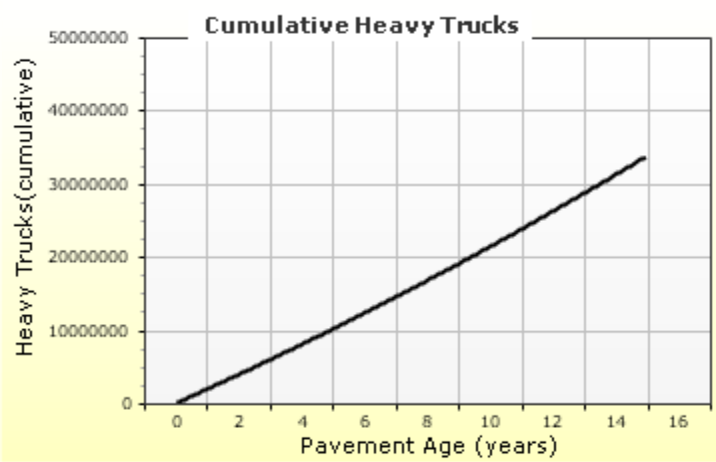
*** Traffic cap is not enforced**







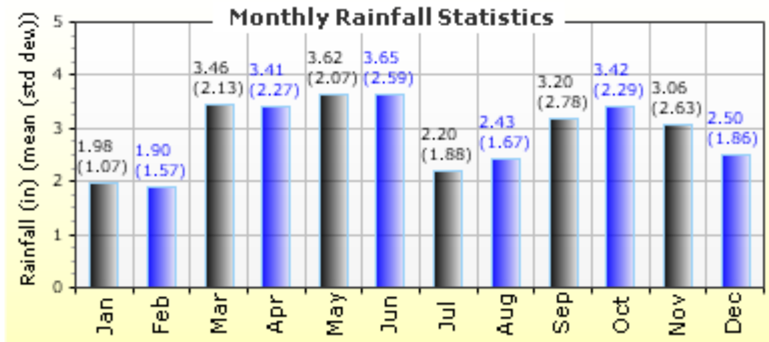




Climate Inputs

Climate Data Sources:

Climate Station Cities:	Location (lat lon elevation(ft))
US, OK	35.00000 -97.50000 1109

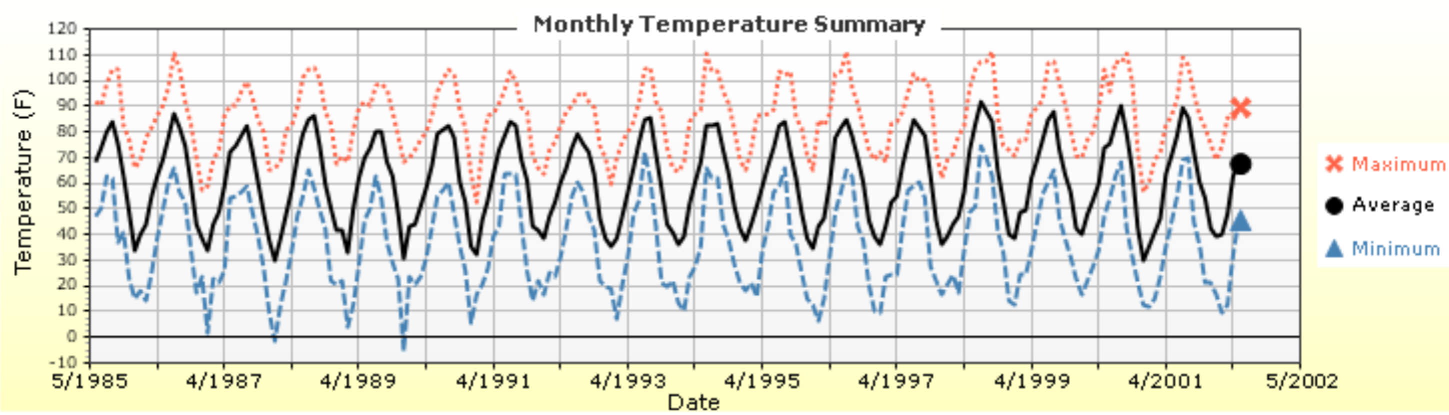


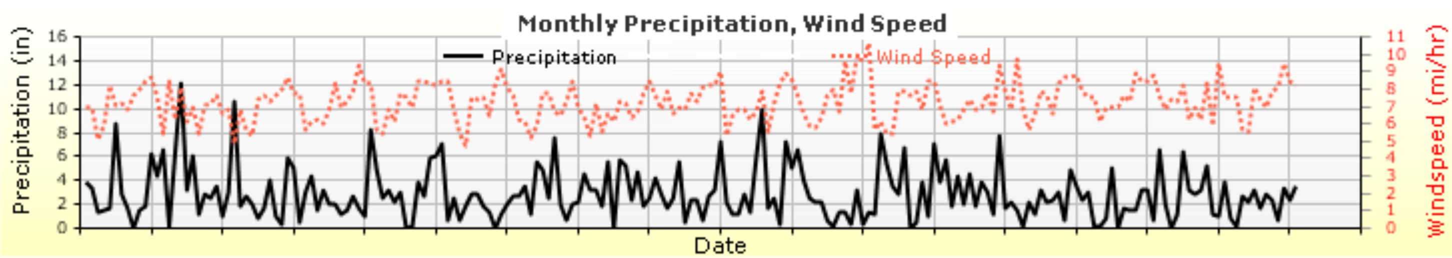
Annual Statistics:

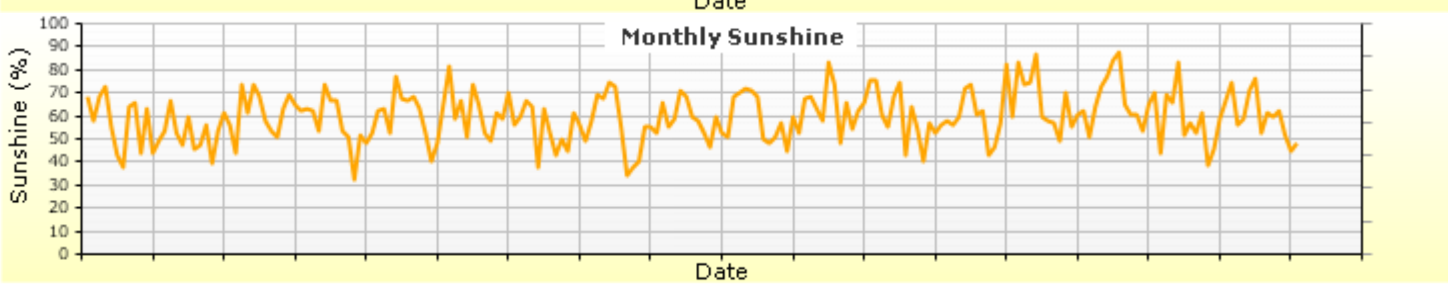
Mean annual air temperature (ºF)	60.51
Mean annual precipitation (in)	34.87
Freezing index (ºF - days)	111.02
Average annual number of freeze/thaw cycles:	61.02

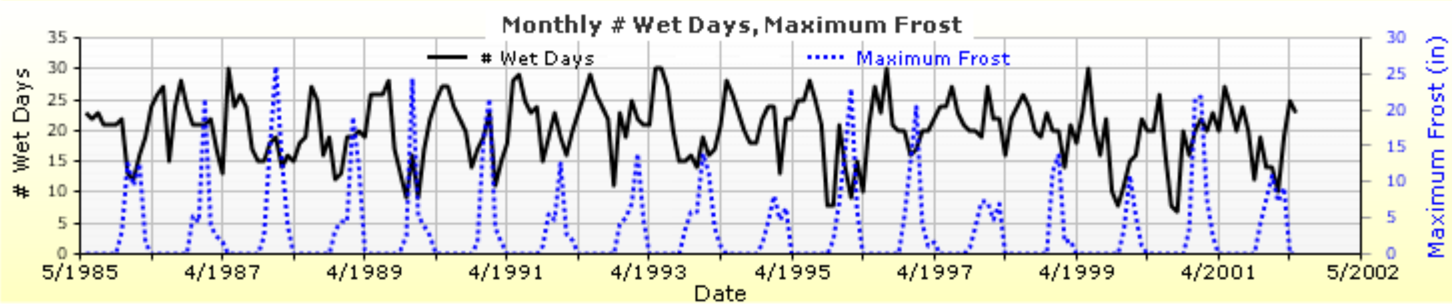
Water table depth (ft)	51.00

Monthly Climate Summary:

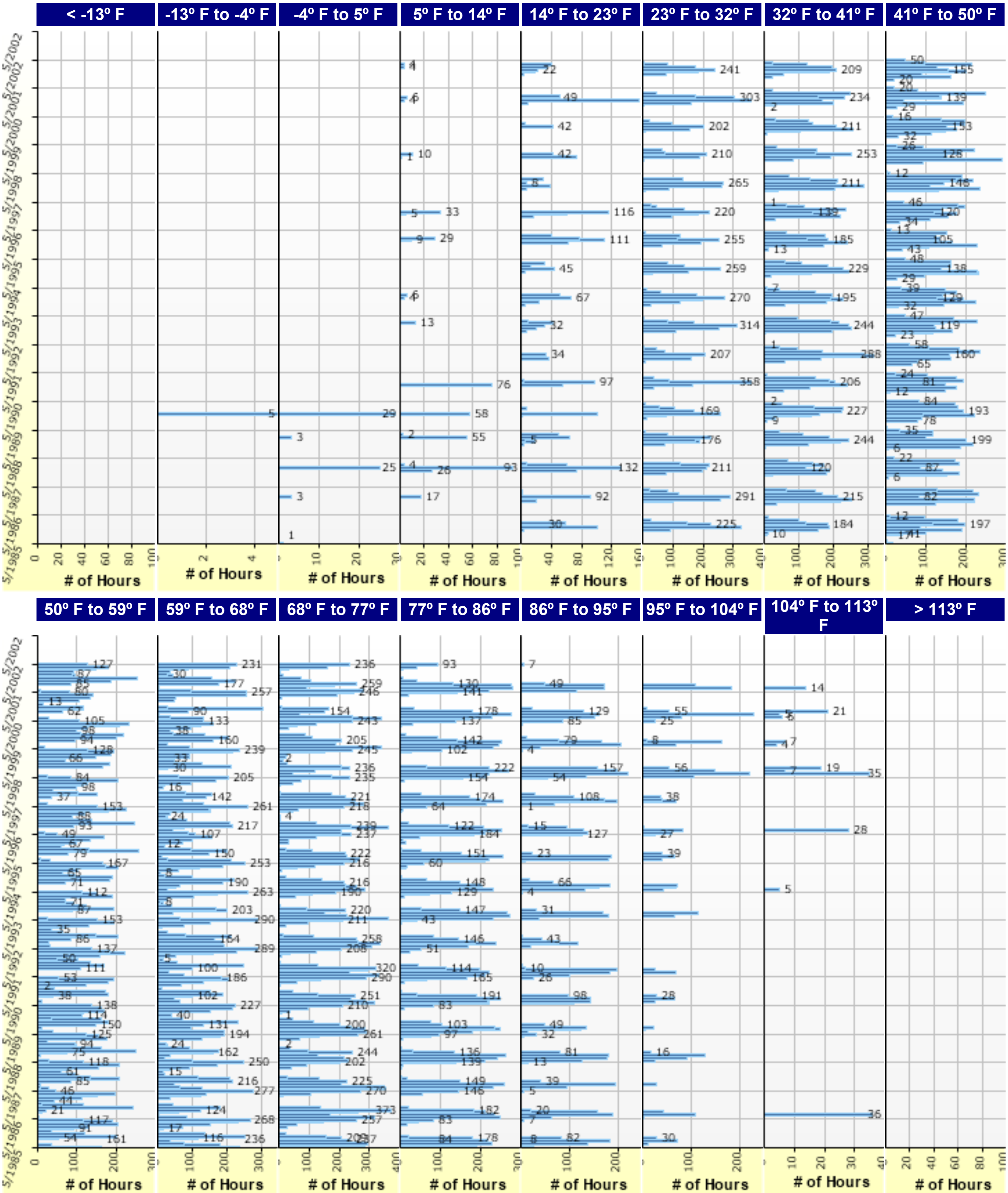








Hourly Air Temperature Distribution by Month:



Design Properties

HMA Design Properties

Use Multilayer Rutting Model	False
Using G* based model (not nationally calibrated)	False
Is NCHRP 1-37A HMA Rutting Model Coefficients	True
Endurance Limit	-
Use Reflective Cracking	True

Structure - ICM Properties	
AC surface shortwave absorptivity	0.85

Layer Name	Layer Type	Interface Friction
Layer 1 Flexible : Default asphalt concrete	Flexible (1)	1.00
Layer 2 Flexible : Default asphalt concrete(existing)	Flexible (1)	1.00
Layer 3 Non-stabilized Base : Crushed stone	Non-stabilized Base (4)	1.00
Layer 4 Subgrade : A-6	Subgrade (5)	1.00
Layer 5 Subgrade : A-6	Subgrade (5)	-

HMA Rehabilitation (Input Level: 2)

Milled thickness (in)	5.00
Fatigue cracking amount (%)	10.00
Fatigue cracking severity	Medium
Fatigue cracking LTE	0.4
Transverse cracking amount (ft/mile)	500.00
Transverse cracking severity	Medium
Transverse cracking LTE	0.4
Total rut depth (in)	-

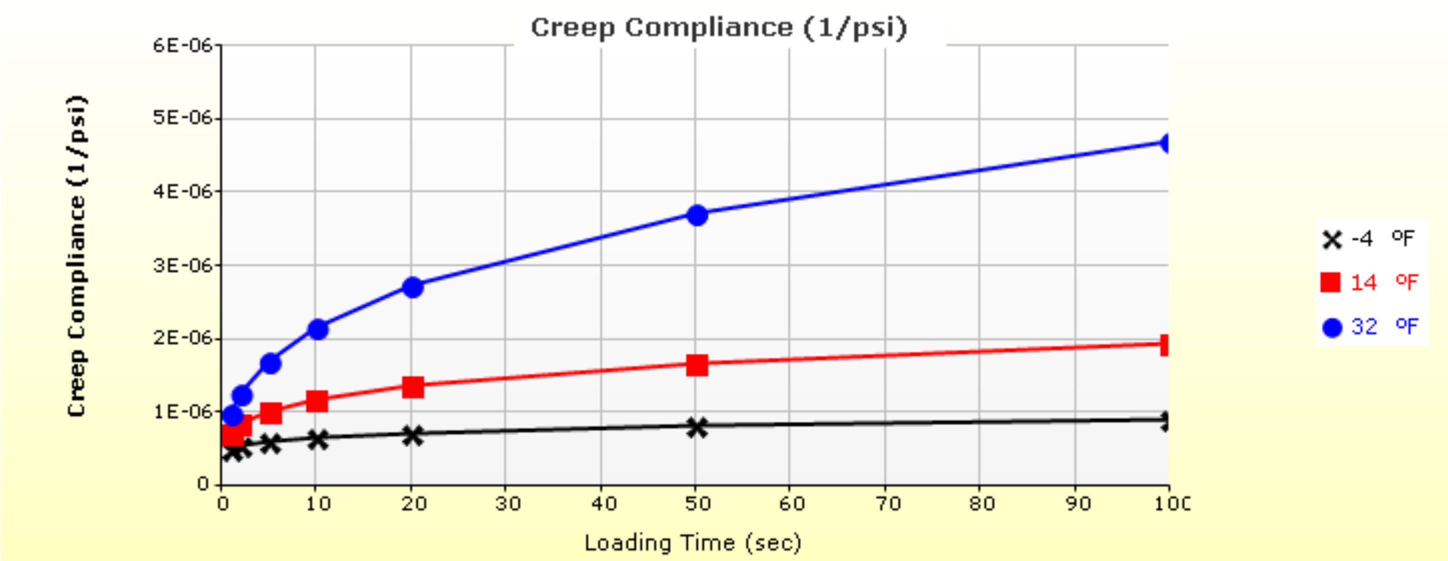
Layer Name	Layer Type	Rut Depth (in)
Layer 1 Flexible : Default asphalt concrete	Flexible (1)	-
Layer 2 Flexible : Default asphalt concrete(existing)	Flexible (1)	0.00
Layer 3 Non-stabilized Base : Crushed stone	Non-stabilized Base (4)	0.00
Layer 4 Subgrade : A-6	Subgrade (5)	0.00
Layer 5 Subgrade : A-6	Subgrade (5)	0.00

Thermal Cracking

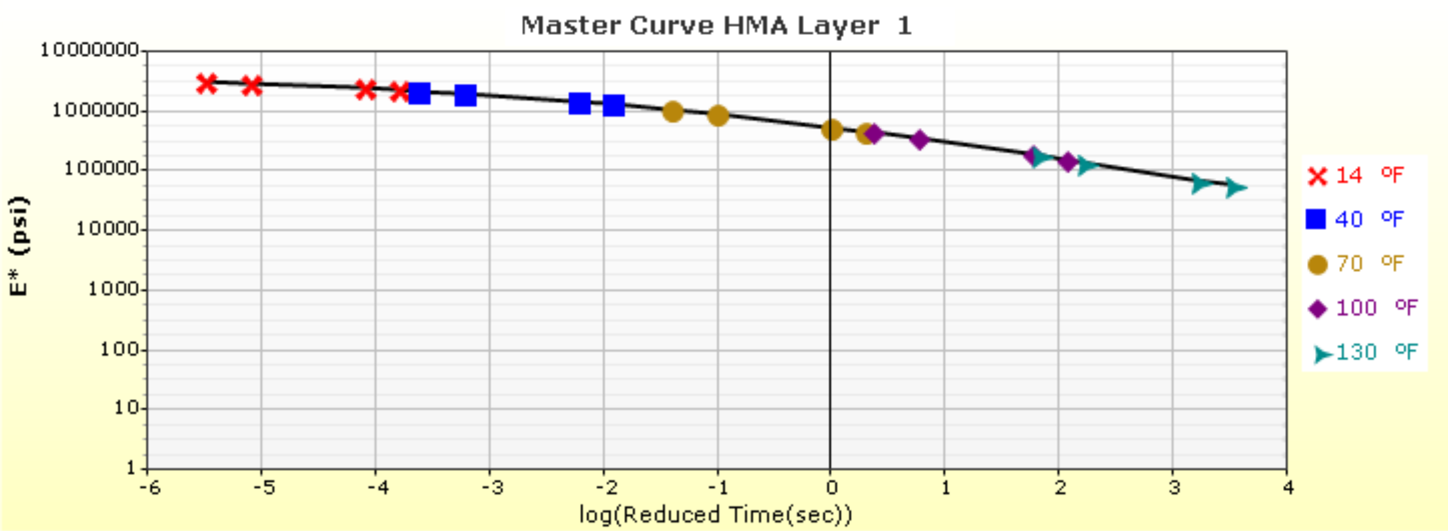
Thermal Contraction	
Is thermal contraction calculated?	True
Mix coefficient of thermal contraction (in/in/ºF)	-
Aggregate coefficient of thermal contraction (in/in/ºF)	5.0e-006
Voids in Mineral Aggregate (%)	17.7

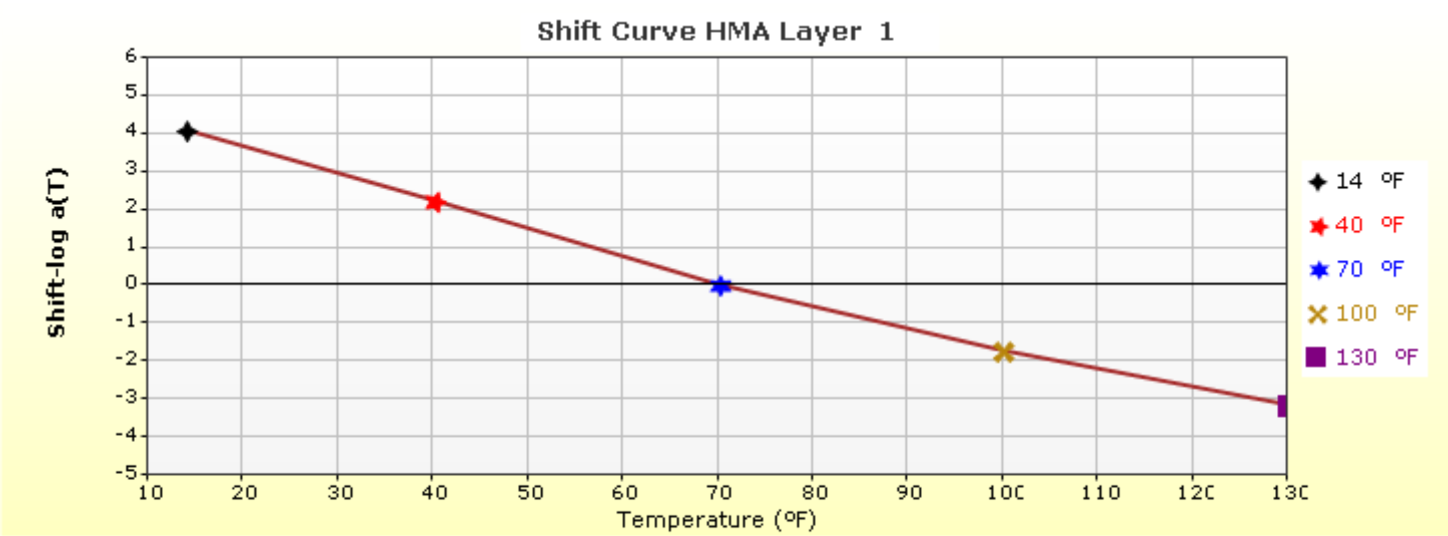
Indirect Tensile Strength (Input Level: 3)	
Test Temperature (ºF)	Indirect Tensilte Strength (psi)
14.0	482.98

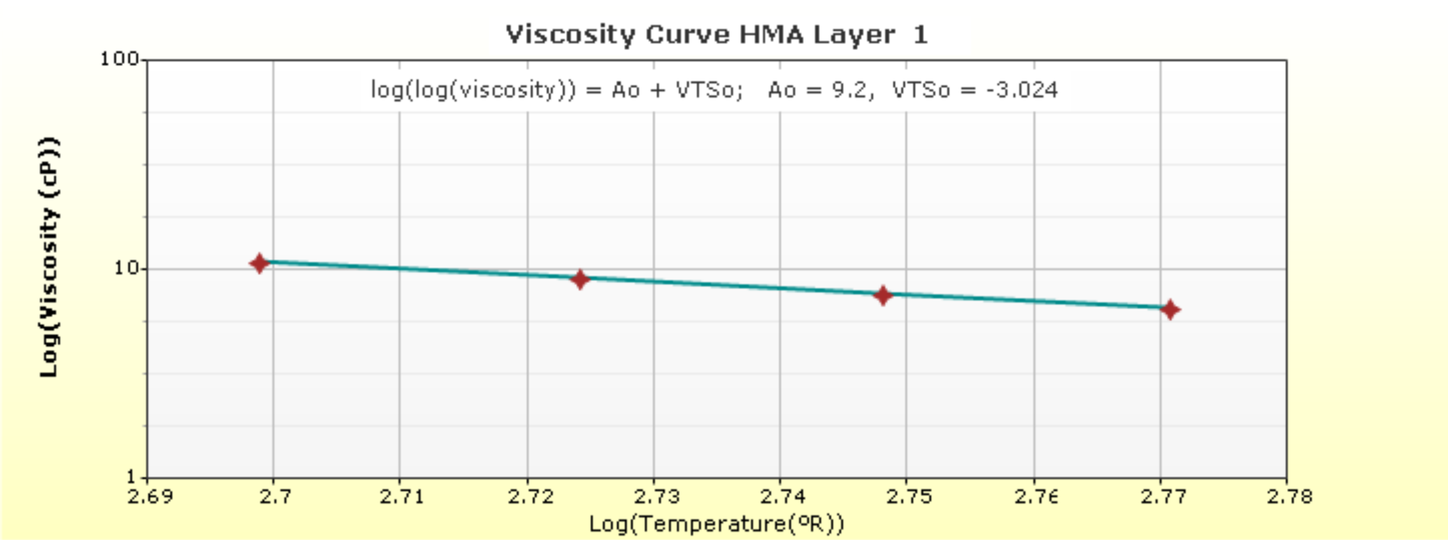
Creep Compliance (1/psi) (Input Level: 3)			
Loading time (sec)	-4 ºF	14 ºF	32 ºF
1	5.01e-007	7.30e-007	9.96e-007
2	5.48e-007	8.47e-007	1.26e-006
5	6.16e-007	1.03e-006	1.71e-006
10	6.73e-007	1.20e-006	2.17e-006
20	7.35e-007	1.39e-006	2.73e-006
50	8.26e-007	1.69e-006	3.72e-006
100	9.03e-007	1.96e-006	4.70e-006



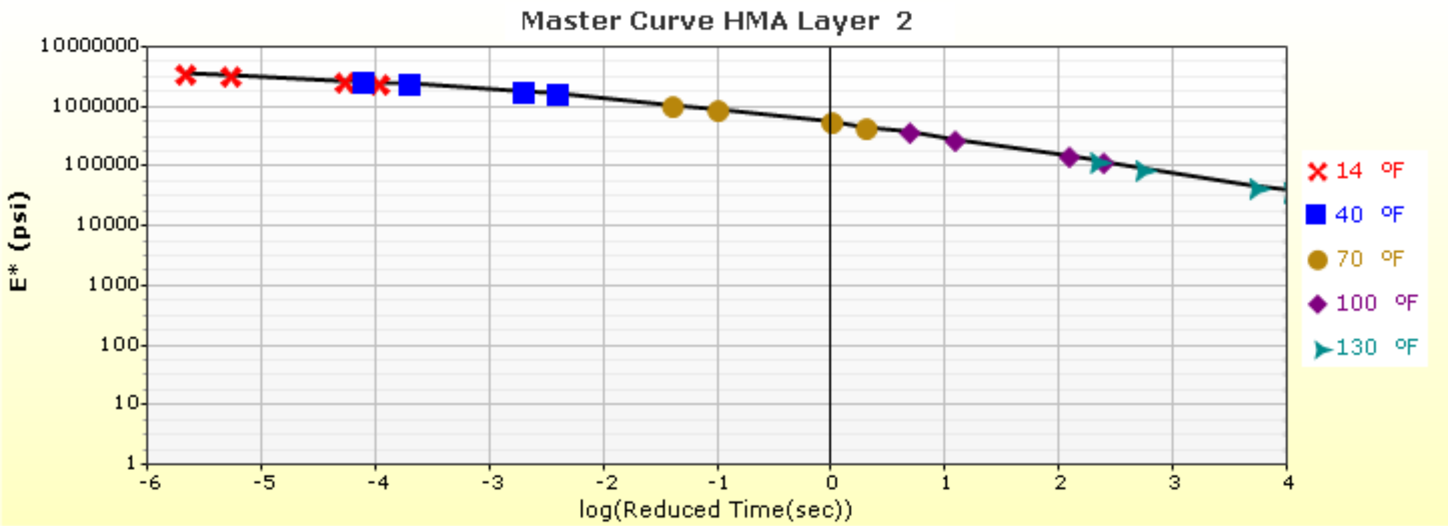
HMA Layer 1: Layer 1 Flexible : Default asphalt concrete

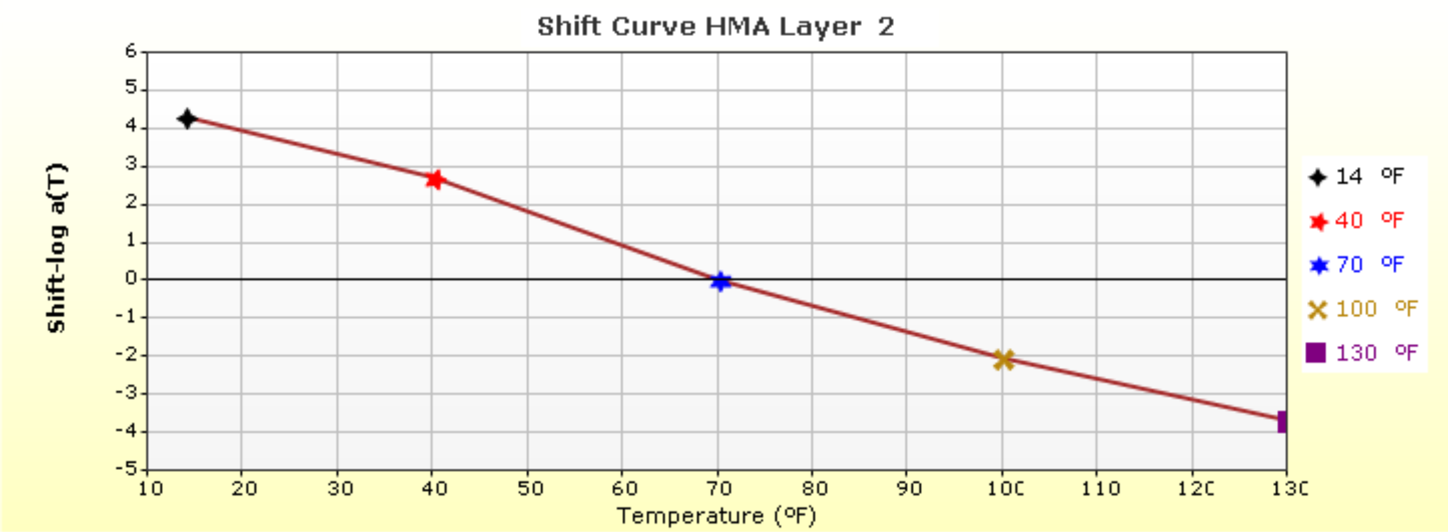


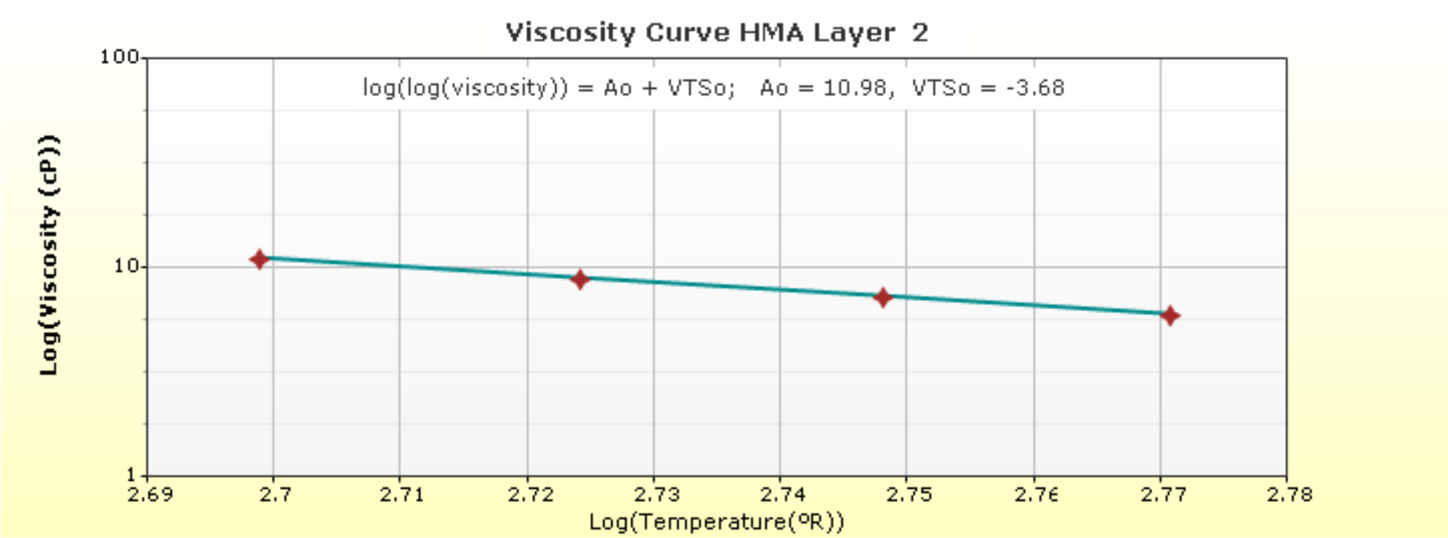




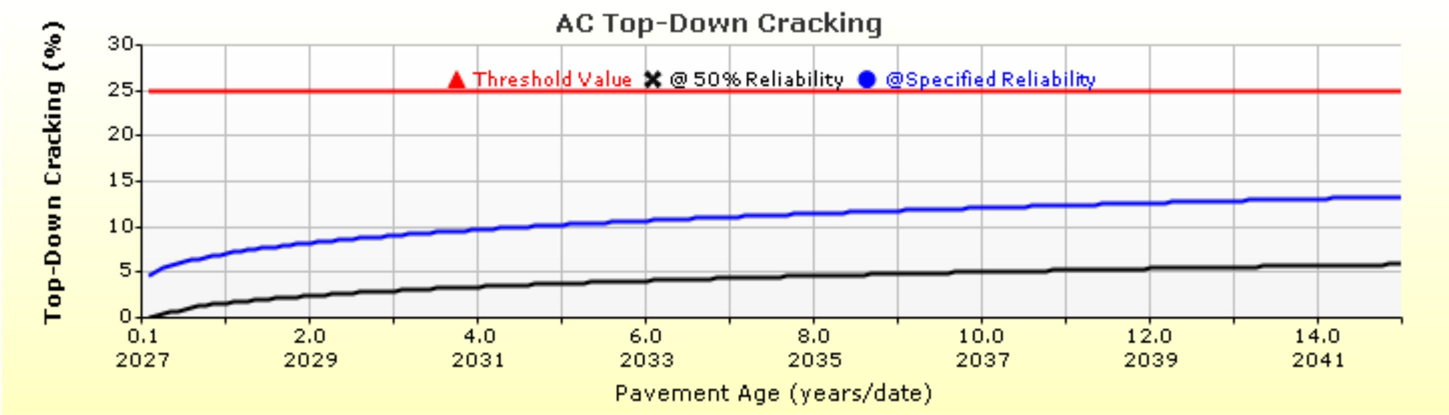
HMA Layer 2: Layer 2 Flexible : Default asphalt concrete(existing)

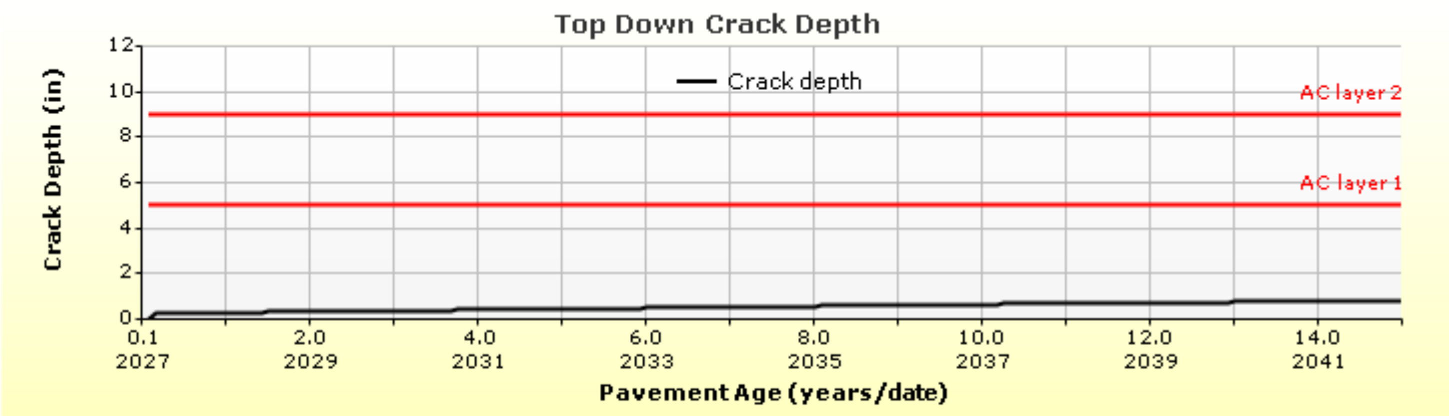


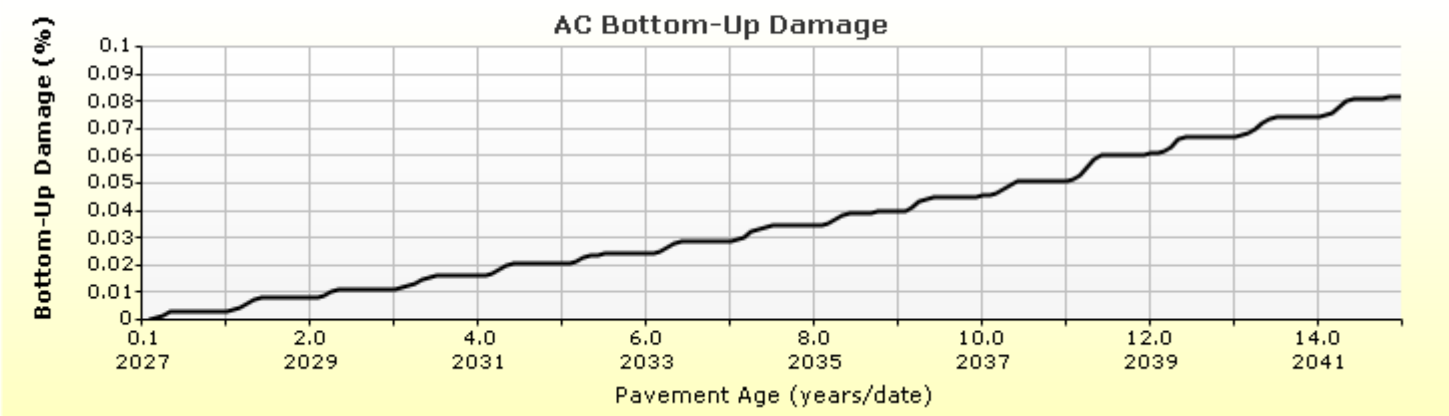


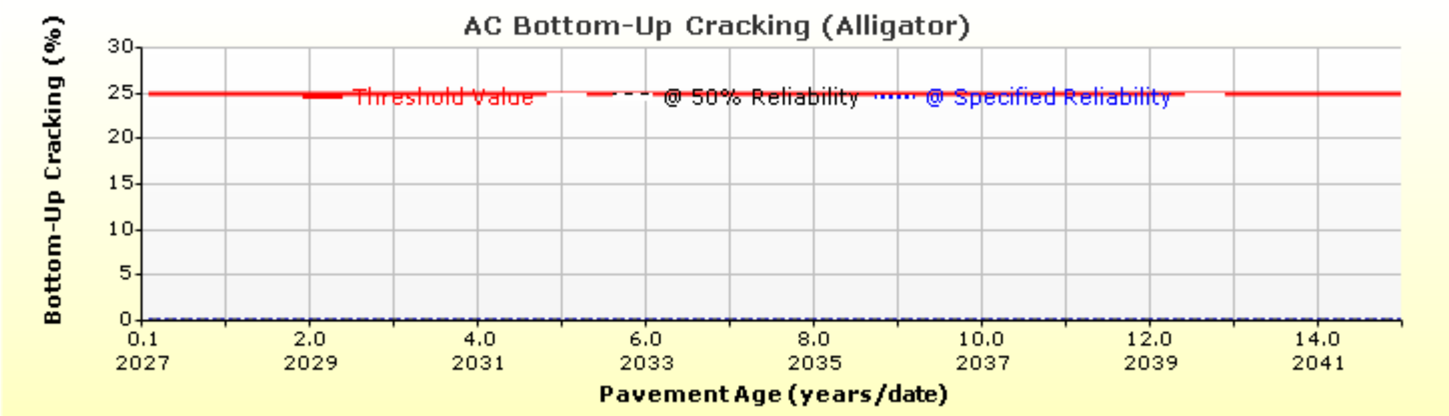


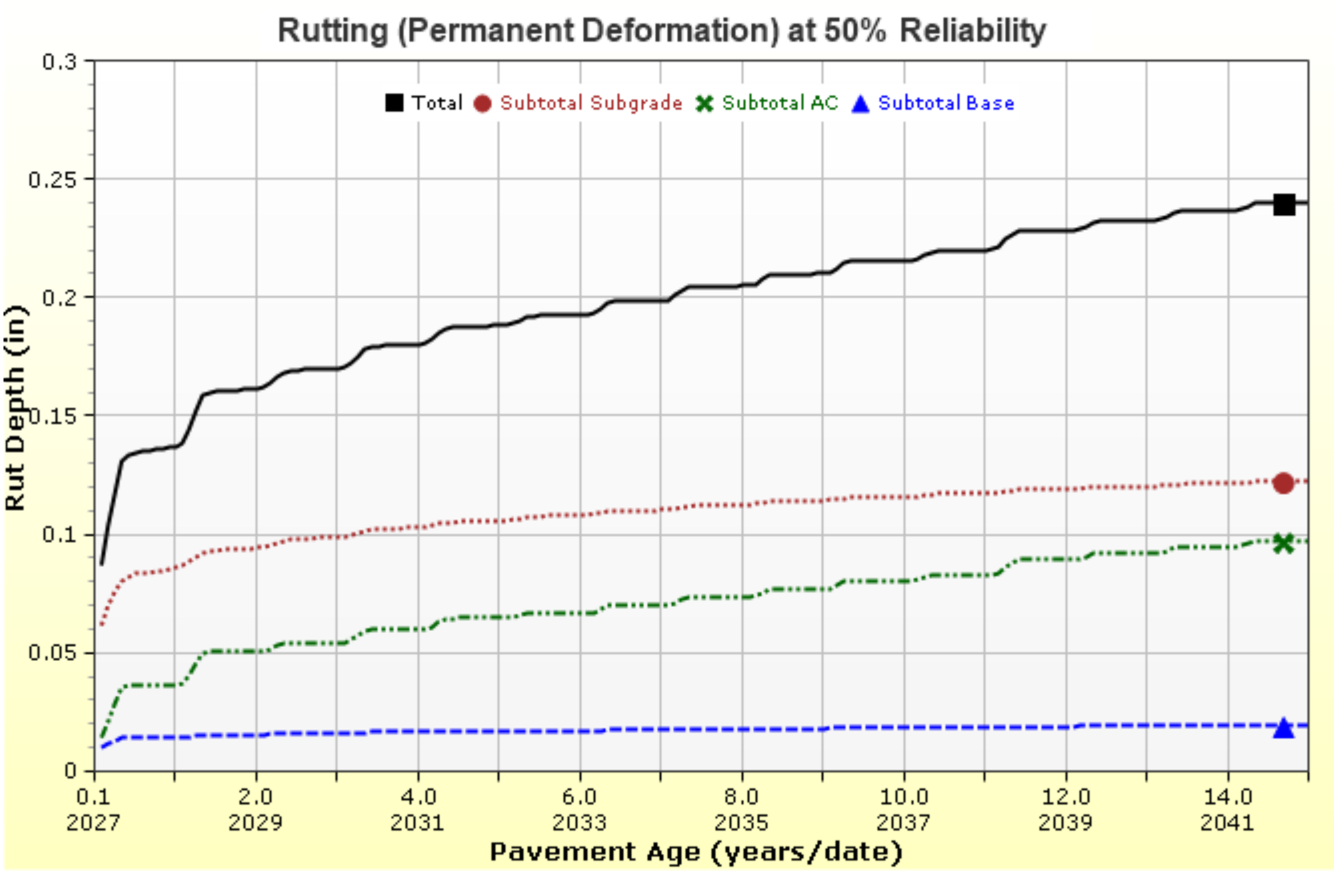
Analysis Output Charts

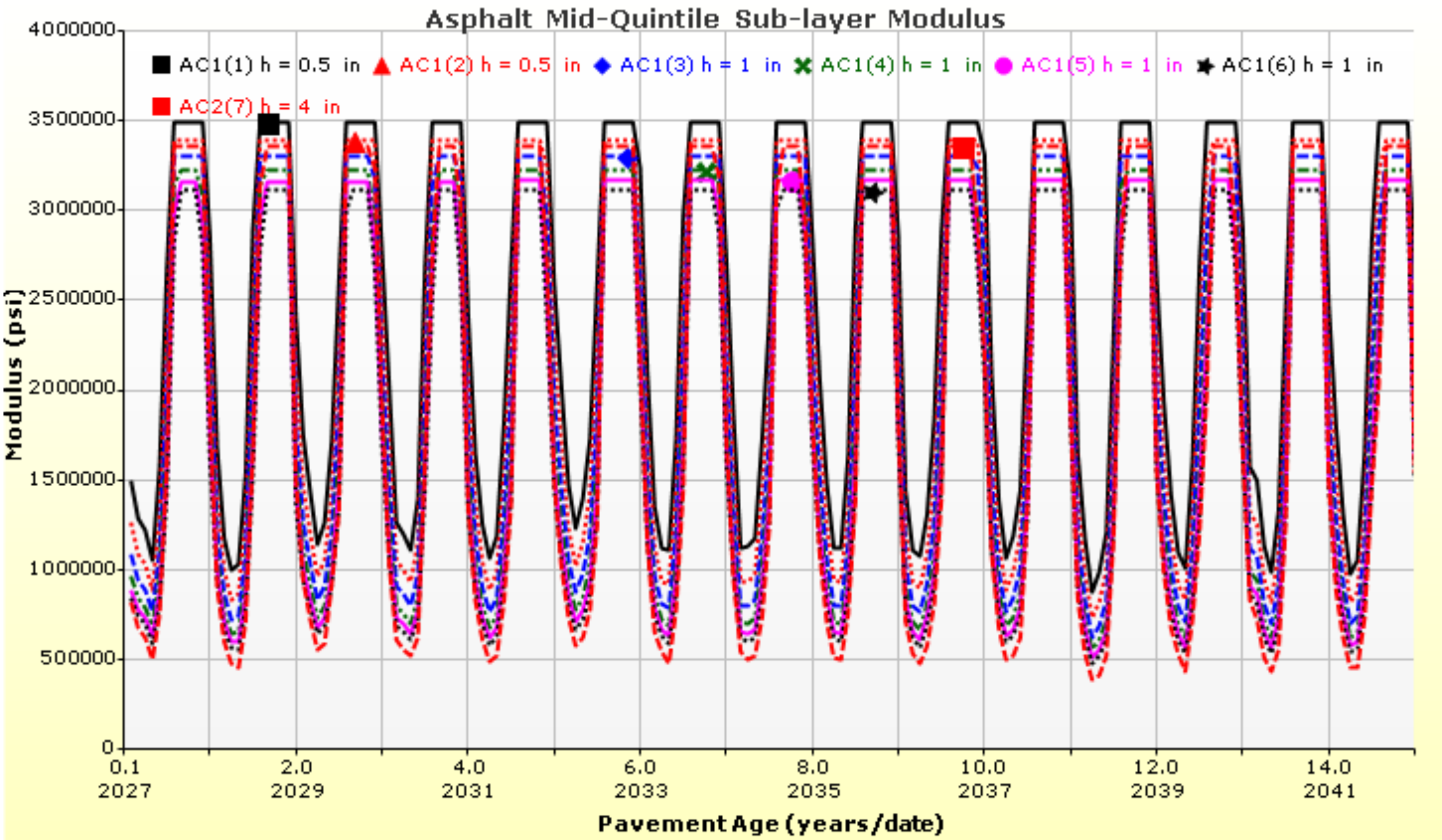

AC Top-Down Cracking
Threshold Value
@ 50% Reliability
@Specified Reliability
Top-Down Cracking (%)
Pavement Age (years/date)

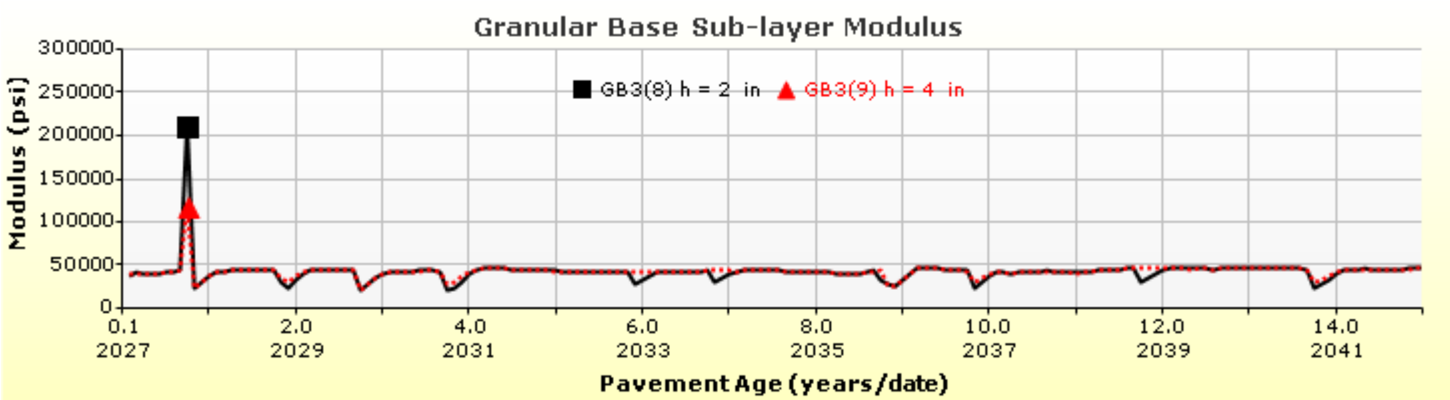

Top Down Crack Depth
Crack depth
AC layer 2
AC layer 1
Crack Depth (in)
Pavement Age (years/date)

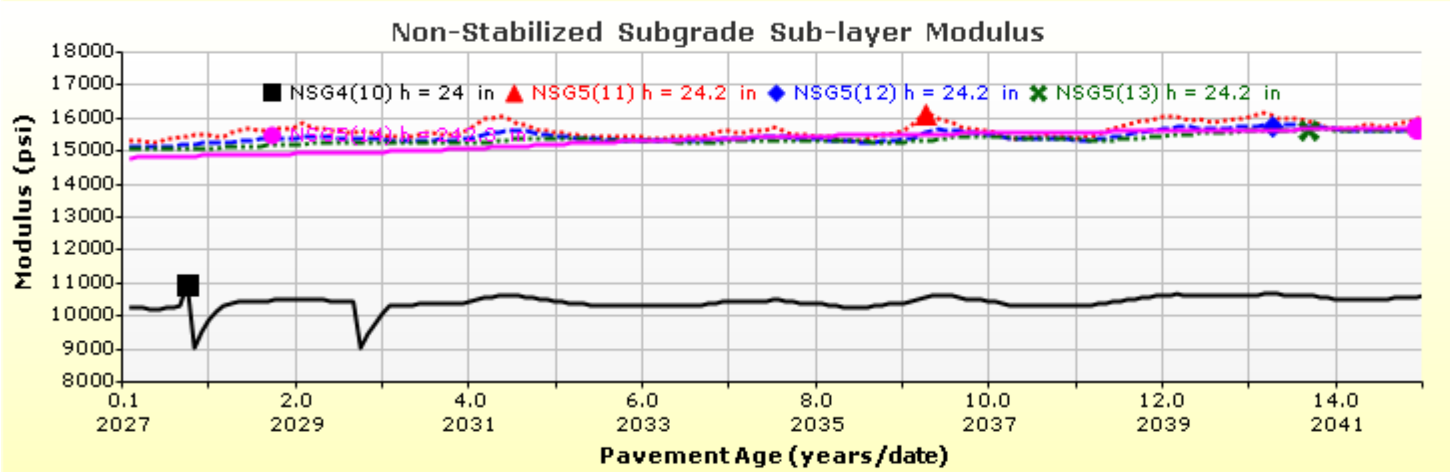

AC Bottom-Up Damage
Bottom-Up Damage (%)
Pavement Age (years/date)


AC Bottom-Up Cracking (Alligator)
Threshold Value
@ 50% Reliability
@ Specified Reliability
Bottom-Up Cracking (%)
Pavement Age (years/date)


Rutting (Permanent Deformation) at 50% Reliability
Total
Subtotal Subgrade
Subtotal AC
Subtotal Base
Rut Depth (in)
0.3
0.25
0.2
0.15
0.1
0.05
0
0.1 2027
2.0 2029
4.0 2031
6.0 2033
8.0 2035
10.0 2037
12.0 2039
14.0 2041
Pavement Age (years/date)


Asphalt Mid-Quintile Sub-layer Modulus
AC1(1) h = 0.5 in
AC1(2) h = 0.5 in
AC1(3) h = 1 in
AC1(4) h = 1 in
AC1(5) h = 1 in
AC1(6) h = 1 in
AC2(7) h = 4 in
Modulus (psi)
Pavement Age (years/date)


Granular Base Sub-layer Modulus
GB3(8) h = 2 in
GB3(9) h = 4 in
Modulus (psi)
Pavement Age (years/date)


Non-Stabilized Subgrade Sub-layer Modulus
NSG4(10) h = 24 in
NSG5(11) h = 24.2 in
NSG5(12) h = 24.2 in
NSG5(13) h = 24.2 in
Modulus (psi)
Pavement Age (years/date)

Layer Information

Layer 1 Flexible : Default asphalt concrete

Asphalt		
Thickness (in)	5.0	
Unit weight (pcf)	150.0	
Poisson's ratio	Is Calculated?	False
	Ratio	0.35
	Parameter A	-
	Parameter B	-

Asphalt Dynamic Modulus (Input Level: 3)

Gradation	Percent Passing
3/4-inch sieve	100
3/8-inch sieve	77
No.4 sieve	60
No.200 sieve	6

Asphalt Binder

Parameter	Value
Grade	Superpave Performance Grade
Binder Type	76-28
A	9.2
VTS	-3.024

General Info

Name	Value
Reference temperature (ºF)	70
Effective binder content (%)	10.7
Air voids (%)	7
Thermal conductivity (BTU/hr-ft-ºF)	0.67
Heat capacity (BTU/lb-ºF)	0.23
Asphalt content by weight (%)	6
Aggregate parameter	0.4021

Identifiers

Field	Value
Display name/identifier	Default asphalt concrete
Description of object	
Author	
Date Created	10/30/2010 12:00:00 AM
Approver	
Date approved	10/30/2010 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Layer 2 Flexible : Default asphalt concrete(existing)

Asphalt		
Thickness (in)	4.0	
Unit weight (pcf)	150.0	
Poisson's ratio	Is Calculated?	False
	Ratio	0.35
	Parameter A	-
	Parameter B	-

Asphalt Dynamic Modulus (Input Level: 3)

Gradation	Percent Passing
3/4-inch sieve	95
3/8-inch sieve	79
No.4 sieve	57
No.200 sieve	6

Asphalt Binder

Parameter	Value
Grade	Superpave Performance Grade
Binder Type	64-22
A	10.98
VTS	-3.68

General Info

Name	Value
Reference temperature (ºF)	70
Effective binder content (%)	11.2
Air voids (%)	5
Thermal conductivity (BTU/hr-ft-ºF)	0.67
Heat capacity (BTU/lb-ºF)	0.23
Asphalt content by weight (%)	-
Aggregate parameter	-

Identifiers

Field	Value
Display name/identifier	Default asphalt concrete
Description of object	
Author	
Date Created	10/30/2010 12:00:00 AM
Approver	
Date approved	10/30/2010 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Layer 3 Non-stabilized Base : Crushed stone

Unbound	
Layer thickness (in)	6.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
31000.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Crushed stone
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	6.0
Plasticity Index	1.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	127.2
Saturated hydraulic conductivity (ft/hr)	False	5.054e-02
Specific gravity of solids	False	2.7
Water Content (%)	False	7.4

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	7.2555
bf	1.3328
cf	0.8242
hr	117.4000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	8.7
#100	
#80	12.9
#60	
#50	
#40	20.0
#30	
#20	
#16	
#10	33.8
#8	
#4	44.7
3/8-in.	57.2
1/2-in.	63.1
3/4-in.	72.7
1-in.	78.8
1 1/2-in.	85.8
2-in.	91.6
2 1/2-in.	
3-in.	
3 1/2-in.	97.6

Layer 4 Subgrade : A-6

Unbound	
Layer thickness (in)	24.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
7800.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	A-6
Description of object	Average Values
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	26.0
Plasticity Index	12.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	True	115.3
Saturated hydraulic conductivity (ft/hr)	False	1.563e-05
Specific gravity of solids	False	2.7
Water Content (%)	True	18

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	103.4254
bf	0.7138
cf	0.2488
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	72.4
#100	
#80	
#60	
#50	
#40	93.0
#30	
#20	
#16	
#10	97.0
#8	
#4	99.0
3/8-in.	100.0
1/2-in.	100.0
3/4-in.	100.0
1-in.	100.0
1 1/2-in.	100.0
2-in.	100.0
2 1/2-in.	
3-in.	
3 1/2-in.	100.0

Layer 5 Subgrade : A-6

Unbound	
Layer thickness (in)	Semi-infinite
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
12100.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	A-6
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	26.0
Plasticity Index	12.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	True	115.3
Saturated hydraulic conductivity (ft/hr)	False	1.563e-05
Specific gravity of solids	False	2.7
Water Content (%)	True	18

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	103.4254
bf	0.7138
cf	0.2488
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	72.4
#100	
#80	
#60	
#50	
#40	93.0
#30	
#20	
#16	
#10	97.0
#8	
#4	99.0
3/8-in.	100.0
1/2-in.	100.0
3/4-in.	100.0
1-in.	100.0
1 1/2-in.	100.0
2-in.	100.0
2 1/2-in.	
3-in.	
3 1/2-in.	100.0

Calibration Coefficients

AC Fatigue	
$N_f = 0.00432 * C * \beta_{f1} k_1 \left(\frac{1}{\varepsilon_1}\right)^{k_2 \beta_{f2}} \left(\frac{1}{E}\right)^{k_3 \beta_{f3}}$	k1: 3.75
	k2: 2.87
$C = 10^M$	k3: 1.46
	Bf1: (5.014 * Pow(hac,-3.416)) * 1 + 0
$M = 4.84\left(\frac{V_b}{V_a + V_b} - 0.69\right)$	Bf2: 1.38
	Bf3: 0.88

AC Rutting

$$\frac{\varepsilon_p}{\varepsilon_r} = k_z \beta_{r1} 10^{k_1} T^{k_2 \beta_{r2}} N^{k_3 B_{r3}}$$

$$k_z = (C_1 + C_2 * depth) * 0.328196^{depth}$$

$$C_1 = -0.1039 * H_\alpha^2 + 2.4868 * H_\alpha - 17.342$$

$$C_2 = 0.0172 * H_\alpha^2 - 1.7331 * H_\alpha + 27.428$$

Where:

H_{ac} = total AC thickness(in)

ε_p = plastic strain(in/in)
ε_r = resilient strain(in/in)
T = layer temperature(°F)
N = number of load repetitions

acRuttingStandardDeviation	0.24 * Pow(RUT,0.8026) + 0.001	
AC Layer 1	K1:-2.45 K2:3.01 K3:0.22	Br1:0.4 Br2:0.52 Br3:1.36
AC Layer 2	K1:-2.45 K2:3.01 K3:0.22	Br1:0.4 Br2:0.52 Br3:1.36

Thermal Fracture

$$C_f = \beta_{t1} N\left[\frac{1}{\sigma_d} log\left(\frac{C}{h_{AC}}\right)\right]$$

$$\Delta C = A(\Delta K)^n$$

$$A = k_t \beta_t 10^{[4.389 - 2.52 \log(E_{HMA} \sigma_m n)]}$$

Cf = Observed amount of thermal cracking, ft. / 500ft.
β_{t1} = Regression coefficient determined through global calibration (400)
N[z] = Standard normal distribution evaluated at [z]
σ_d = Standard deviation of the logarithm of crack depth in the pavement (0.769), in.
C = Crack depth, in.
h_{AC} = Thickness of asphalt layer, in.
ΔC = Change in the crack depth due to a cooling cycle
ΔK = Change in the stress intensity factor due to a cooling cycle
A, n = Fracture parameters for the asphalt mixture
E = Asphalt mixture stiffness, MPa
σ_m = Undamaged mixture tensile strength, MPa
k_t = Regression coefficient determined through field calibration
β_t = Calibration parameter

Level 1 K: (0.13 * Pow(MAAT,2) - 11.68 * MAAT + 244.14) * 1 + 0	
Level 2 K: (0.13 * Pow(MAAT,2) - 11.68 * MAAT + 244.14) * 1 + 0	
Level 3 K: (0.13 * Pow(MAAT,2) - 11.68 * MAAT + 244.14) * 1 + 0	

CSM Fatigue

$$N_f = 10^{\left(\frac{k_1 \beta_{c1}\left(\frac{\sigma_s}{M_r}\right)}{k_2 \beta_{c2}}\right)}$$

N_f = number of repetitions to fatigue cracking
σ_s = Tensile stress(psi)
M_r = modulus of rupture(psi)

k1: 0.972	k2: 0.0825	Bc1: 1	Bc2:1

Unbound Layer Rutting

$$\delta_a(N) = \beta_{s_1} k_1 \varepsilon_v h \left(\frac{\varepsilon_0}{\varepsilon_r}\right) \left| e^{-\left(\frac{\rho}{N}\right)^{\beta}} \right|$$

δ_a = permanent deformation for the layer
N = number of repetitions
ε_v = average veritcal strain(in/in)
$\varepsilon_0, \beta, \rho$ = material properties
ε_r = resilient strain(in/in)

Base Rutting		Subgrade Rutting	
k1: 0.965	Bs1: 1	k1: 0.675	Bs1: 1
Standard Deviation (BASERUT) 0.1477 * Pow(BASERUT,0.6711) + 0.001		Standard Deviation (BASERUT) 0.1235 * Pow(SUBRUT,0.5012) + 0.001	

AC Cracking

AC Top Down Cracking

$$L(t) = L_{Max} e^{-\left(\frac{C_1 \rho}{t - C_3 t_o}\right)^{C_2 \beta}}$$

$$t_0(\text{Days}) = \frac{k_{L1}}{1 + e^{(k_{L2} \times 100 \times a_0 / 2A_0) + (k_{L3} \times HT) + (k_{L4} \times LT) + (k_{L5} \times \log_{10} AADTT)}}$$

c1: 2.5219	c2: 0.8069	c3: 1
kL1: 64271618	kL2: 0.2855	kL3: 0.011
kL4: 0.01488	kL5: 3.266	

acCrackingTopStandardDeviation

0.3657 * TOP + 3.6563

AC Bottom Up Cracking

$$FC = \left(\frac{6000}{1 + e^{\left(C_1 * C_1' + C_2 * C_2' \log_{10}(D * 100)\right)}}\right) * \left(\frac{1}{60}\right)$$

$$C_2' = -2.40874 - 39.748 * (1 + h_{ac})^{-2.856}$$

$$C_1' = -2 * C_2'$$

c1: 1.31	c2: (0.867 + 0.2583 * hac) * 1 + 0	c3: 6000

acCrackingBottomStandardDeviation

1.13 + 13/(1+exp(7.57-15.5*LOG10(BOTTOM+0.0001)))

CSM Cracking

$$FC_{ctb} = C_1 + \frac{C_2}{1 + e^{C_3 - C_4 * \log_{10}(Damage)}}$$

C1: 0	C2: 75	C3: 2	C4: 2

csmCrackingStandardDeviation

CTB*11

IRI Flexible Pavements

C1 - Rutting
C2 - Fatigue Crack
C3 - Transverse Crack
C4 - Site Factors

C1: 40	C2: 0.4	C3: 0.008	C4: 0.015

Reflective Cracking

$$\Delta C = k_1 \Delta_{bending} + k_2 \Delta_{shaering} + k_3 \Delta_{thermal}$$

$$\Delta D = \frac{C_1 k_1 \Delta_{bending} + C_2 k_2 \Delta_{shearing} + C_3 k_3 \Delta_{thermal}}{h_{OL}}$$

$$\Delta_{Bending} = A(SIF)_B^n$$

$$\Delta_{Shearing} = A(SIF)_S^n$$

$$\Delta_{Thermal} = A(SIF)_T^n$$

$$D = \sum_{i=1}^{N} \Delta D$$

$$RCR = \left(\frac{100}{C4 + e^{C5 \log D}}\right) * EX\_CRK$$

Where

- ΔC = Crack length increment, in
- ΔD = Incremental damage ratio
- $k_1, k_2, k_3, C_1, C_2, C_3, C_4, C_5$ = Calibration factors (local and global)
- $\Delta_{bending}, \Delta_{shearing}, \Delta_{thermal}$ = Crack length increments caused by bending, shearing, and thermal loading
- A, n = HMA material fracture properties
- N = Total number of days
- $(SIF)_B, (SIF)_S, (SIF)_T$ = Stress intensity factors caused by bending, shearing, and thermal loading
- D = Damage ratio
- h_{OL} = Overlay thickness, in
- RCR = Cracks in the underlying layers reflected, %
- EX_CRK = Transverse cracking in underlying pavement layers, ft/mile (transverse cracking)
  Alligator cracking in underlying pavement layers, % lane area (alligator cracking)

Pavement Type	Distress Type	k1	k2	k3	C1	C2	C3	C4	C5	Standard Deviation
AC over AC	Transverse	0.012	0.005	1	3.22	25.7	0.1	133.4	-72.4	70.98 * Pow (TRANSVERSE,0.2994) + 30.12
AC over AC	Fatigue	0.012	0.005	1	0.38	1.66	2.72	105.4	-7.02	1.1097 * Pow (FATIGUE,0.6804) + 1.23

22119.Overlay.Mill5Fill5 with Stab Subgrade

File Name: C:\Users\kkb\OneDrive\Documents\My ME Design\Projects\2022\22119\22119.Overlay.Mill5Fill5 with Stab Subgrade.dgpx

Design Inputs

Design Life: 15 years
Design Type: AC_AC

Existing construction: June, 2005
Pavement construction: May, 2025
Traffic opening: May, 2027

Climate Data Sources (Lat/Lon): 35, -97.5

Design Structure

Layer type	Material Type	Thickness (in)
Flexible (OL)	Default asphalt concrete	5.0
Flexible (existing)	Default asphalt concrete	4.0
Subgrade	Cement Stabilized Subgrade	6.0
Subgrade	A-6	24.0
Subgrade	A-6	Semi-infinite

Volumetric at Construction:	
Effective binder content (%)	10.7
Air voids (%)	7.0

Traffic

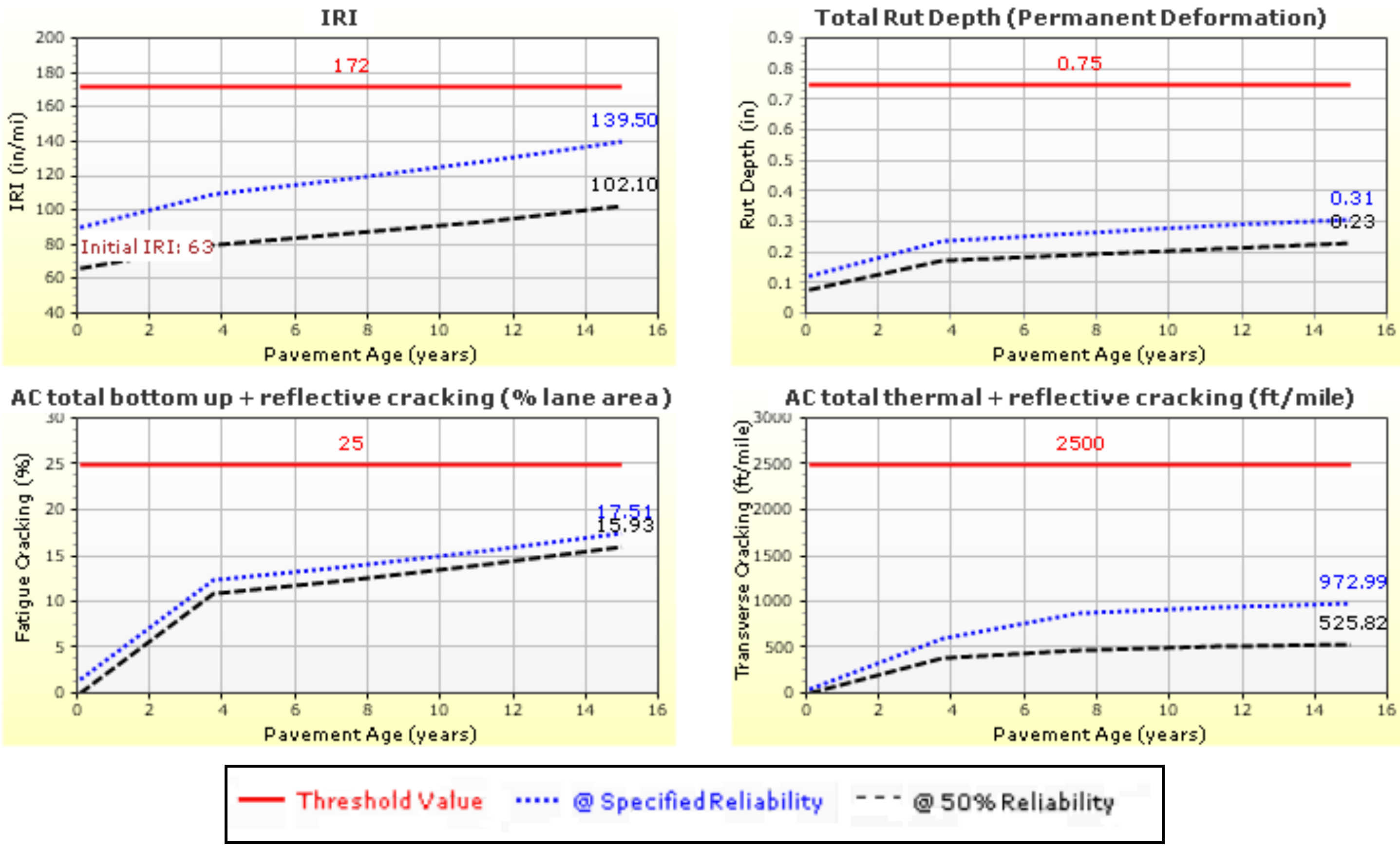
Age (year)	Heavy Trucks (cumulative)
2027 (initial)	13,914
2034 (7 years)	15,669,700
2042 (15 years)	33,836,400

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	172.00	139.54	90.00	99.16	Pass
Permanent deformation - total pavement (in)	0.75	0.31	90.00	100.00	Pass
AC total fatigue cracking: bottom up + reflective (% lane area)	25.00	17.51	90.00	100.00	Pass
AC total transverse cracking: thermal + reflective (ft/mile)	2500.00	972.99	90.00	100.00	Pass
Permanent deformation - AC only (in)	0.25	0.15	90.00	99.99	Pass
AC bottom-up fatigue cracking (% lane area)	25.00	0.00	50.00	100.00	Pass
AC thermal cracking (ft/mile)	1000.00	151.01	50.00	100.00	Pass
AC top-down fatigue cracking (% lane area)	25.00	13.32	90.00	99.95	Pass

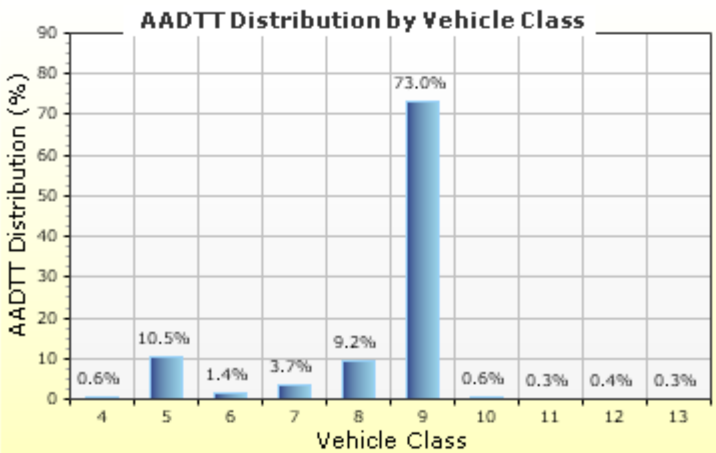
Distress Charts

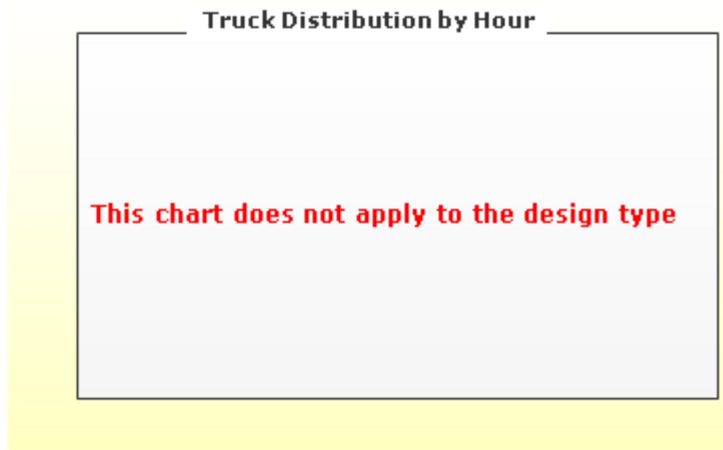


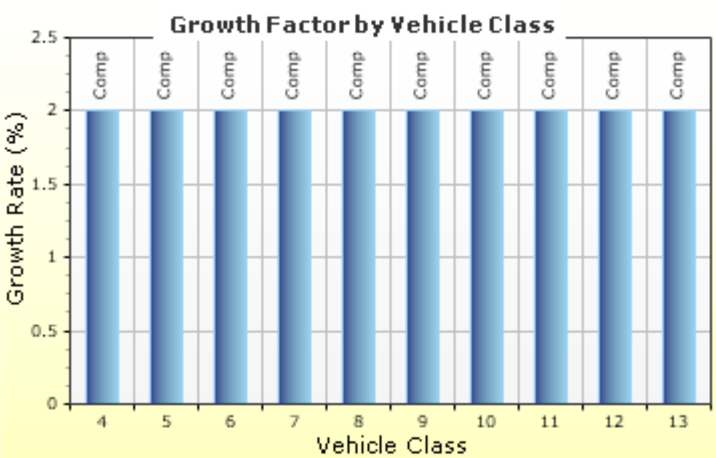
Traffic Inputs

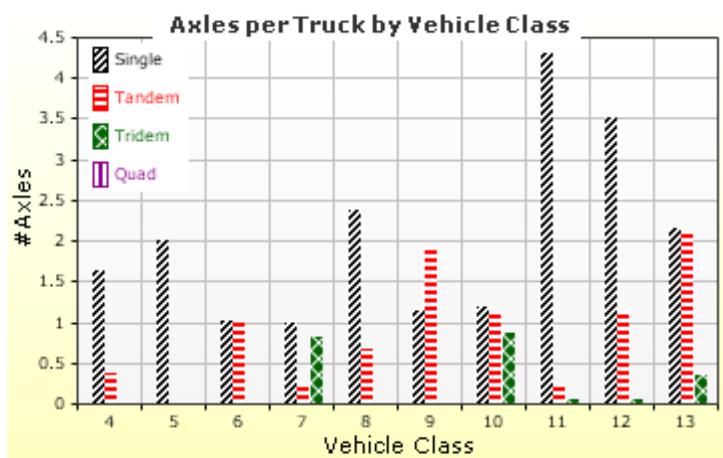
Graphical Representation of Traffic Inputs

Initial two-way AADTT:	13,914	Percent of trucks in design direction (%):	55.0
Number of lanes in design direction:	3	Percent of trucks in design lane (%):	70.0
		Operational speed (mph)	65.0

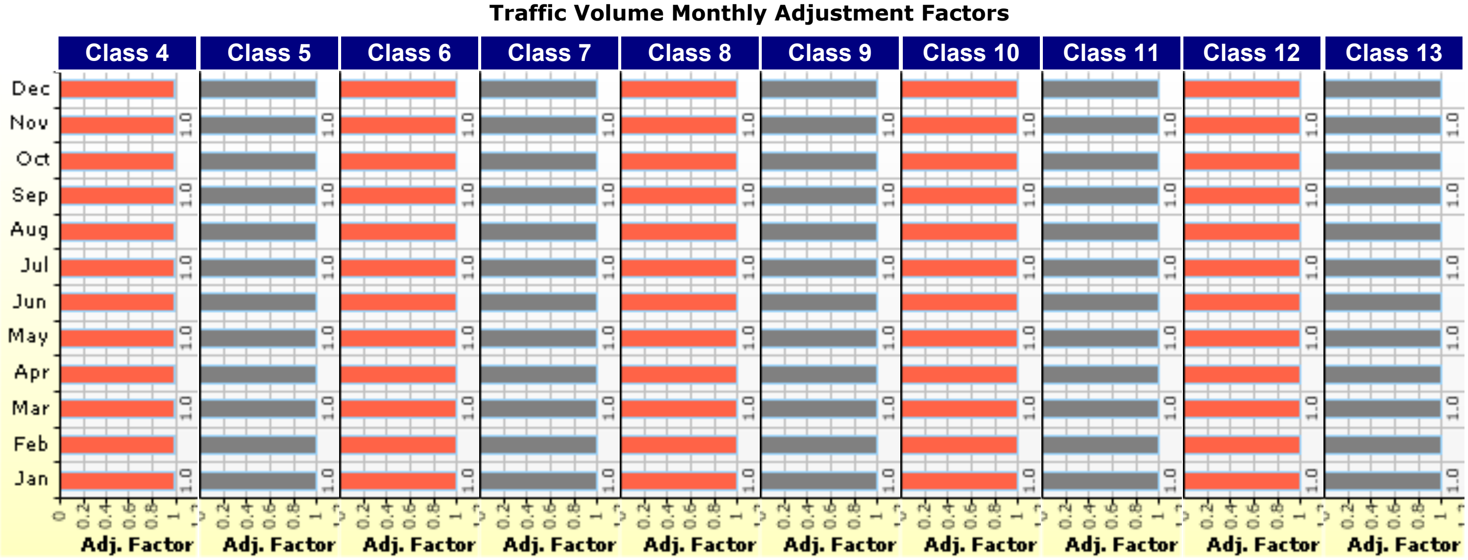








Traffic Volume Monthly Adjustment Factors



Tabular Representation of Traffic Inputs

Volume Monthly Adjustment Factors

Level 3: Default MAF

Month	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
January	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
February	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
March	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
April	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
May	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
June	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
July	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
August	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
September	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
October	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
November	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
December	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Distributions by Vehicle Class

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor	
		Rate (%)	Function
Class 4	0.6%	2%	Compound
Class 5	10.5%	2%	Compound
Class 6	1.4%	2%	Compound
Class 7	3.7%	2%	Compound
Class 8	9.2%	2%	Compound
Class 9	73%	2%	Compound
Class 10	0.6%	2%	Compound
Class 11	0.3%	2%	Compound
Class 12	0.4%	2%	Compound
Class 13	0.3%	2%	Compound

Truck Distribution by Hour does not apply

Axle Configuration

Traffic Wander	
Mean wheel location (in)	18.0
Traffic wander standard deviation (in)	10.0
Design lane width (ft)	12.0

Axle Configuration	
Average axle width (ft)	8.5
Dual tire spacing (in)	12.0
Tire pressure (psi)	120.0

Average Axle Spacing	
Tandem axle spacing (in)	51.6
Tridem axle spacing (in)	49.2
Quad axle spacing (in)	49.2

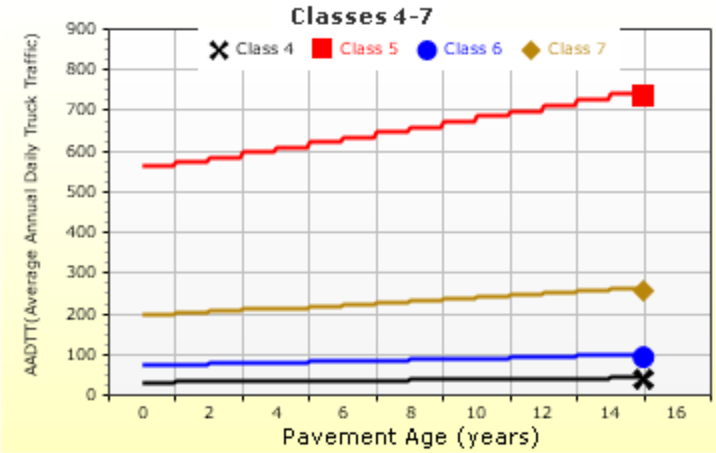
Wheelbase does not apply

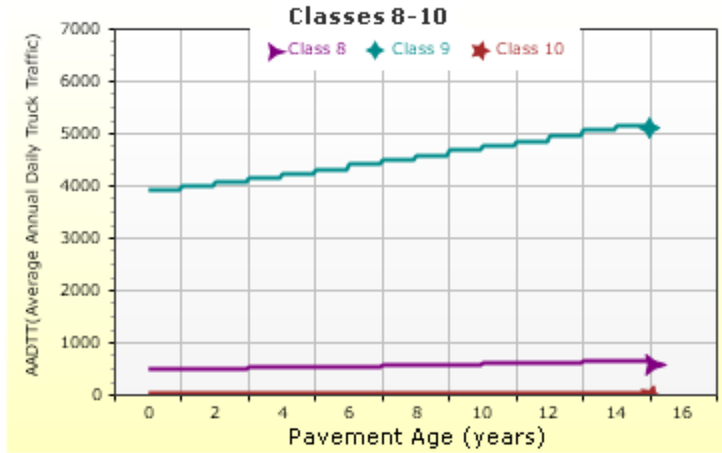
Number of Axles per Truck

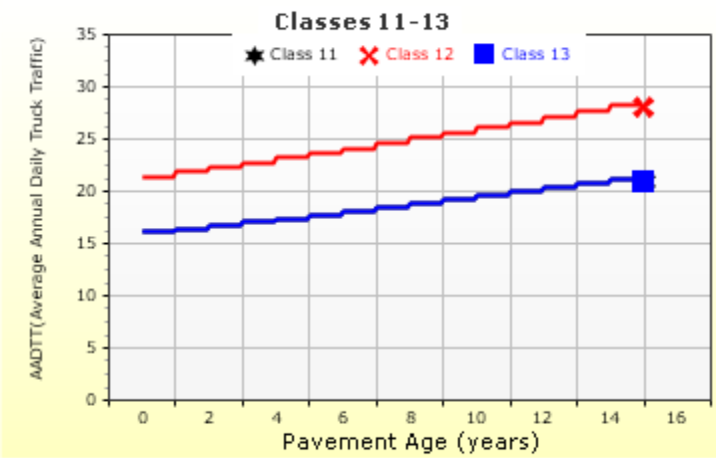
Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.62	0.39	0	0
Class 5	2	0	0	0
Class 6	1.02	0.99	0	0
Class 7	1	0.26	0.83	0
Class 8	2.38	0.67	0	0
Class 9	1.13	1.93	0	0
Class 10	1.19	1.09	0.89	0
Class 11	4.29	0.26	0.06	0
Class 12	3.52	1.14	0.06	0
Class 13	2.15	2.13	0.35	0

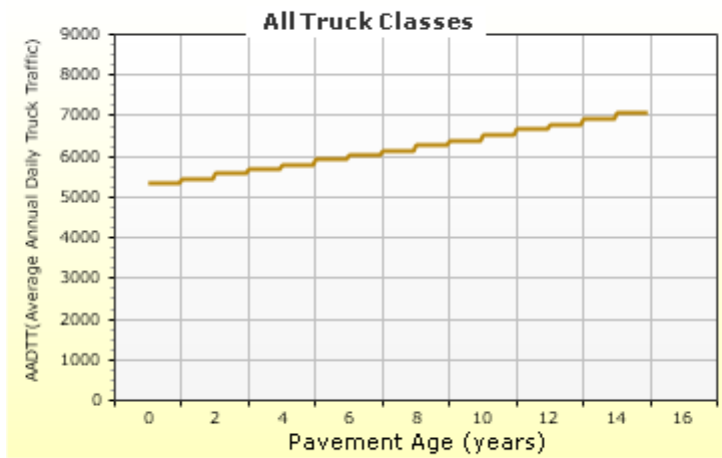
AADTT (Average Annual Daily Truck Traffic) Growth

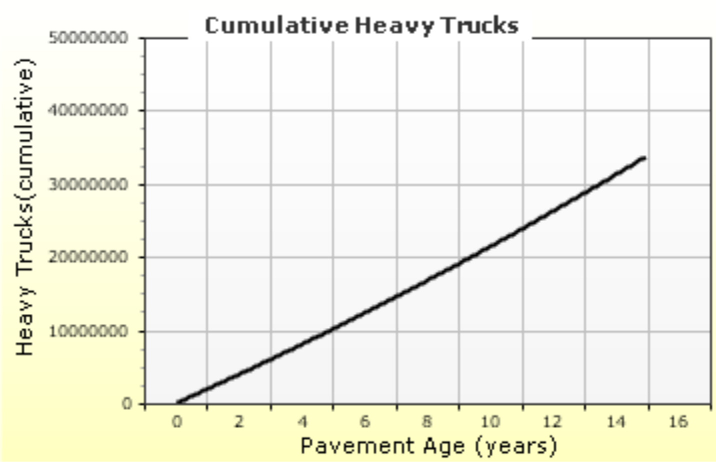
*** Traffic cap is not enforced**







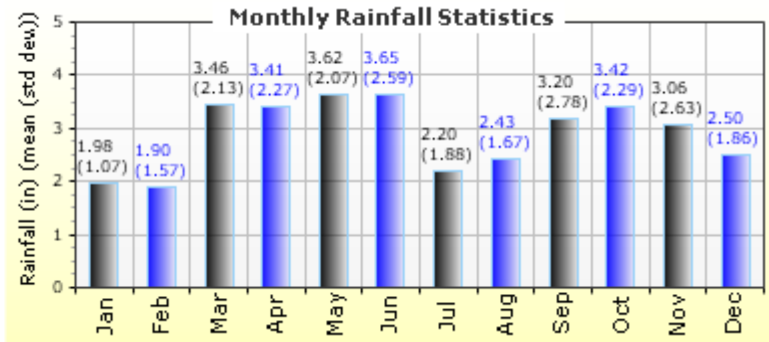




Climate Inputs

Climate Data Sources:

Climate Station Cities:	Location (lat lon elevation(ft))
US, OK	35.00000 -97.50000 1109

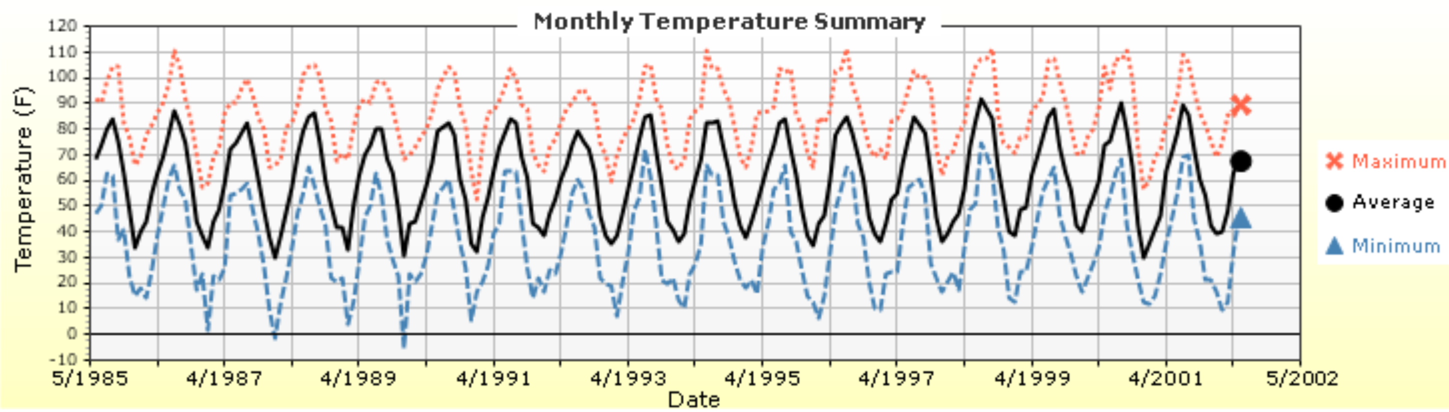


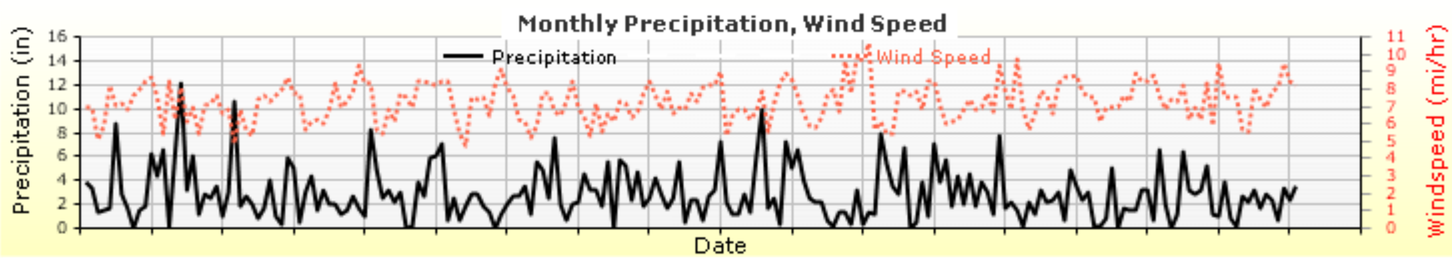
Annual Statistics:

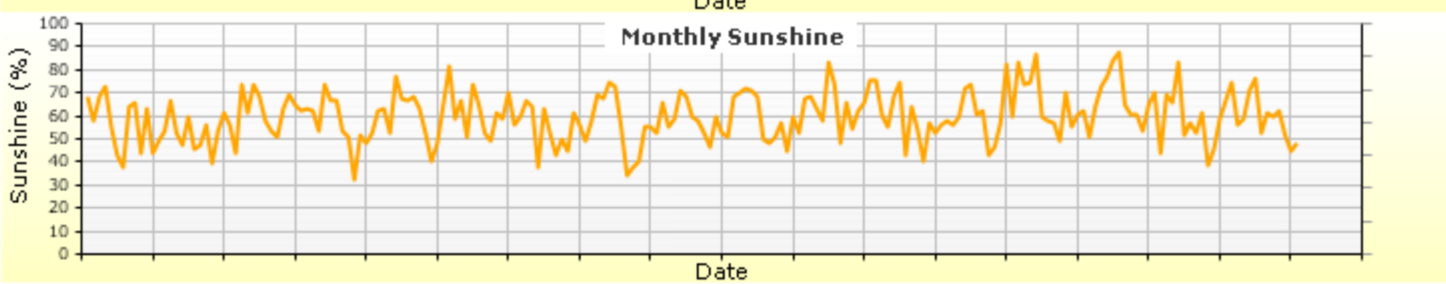
Mean annual air temperature (ºF)	60.51
Mean annual precipitation (in)	34.87
Freezing index (ºF - days)	111.02
Average annual number of freeze/thaw cycles:	61.02

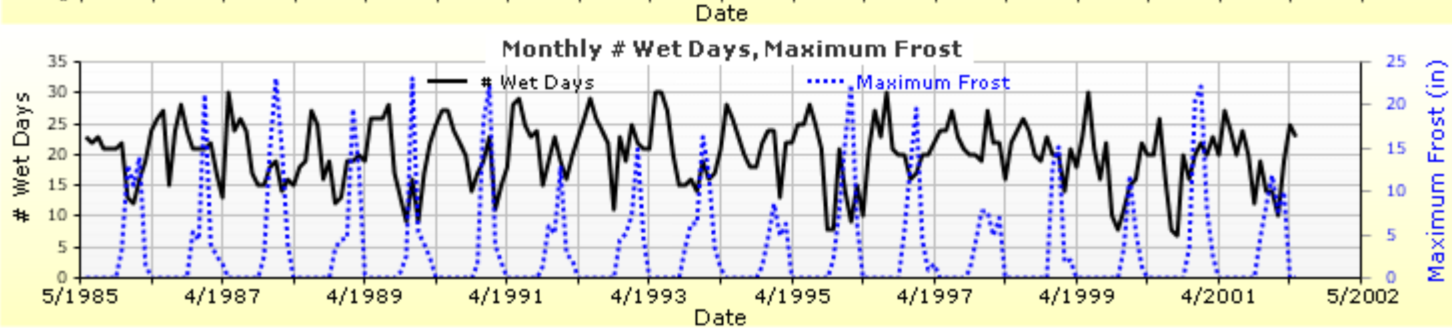
Water table depth (ft)	51.00

Monthly Climate Summary:

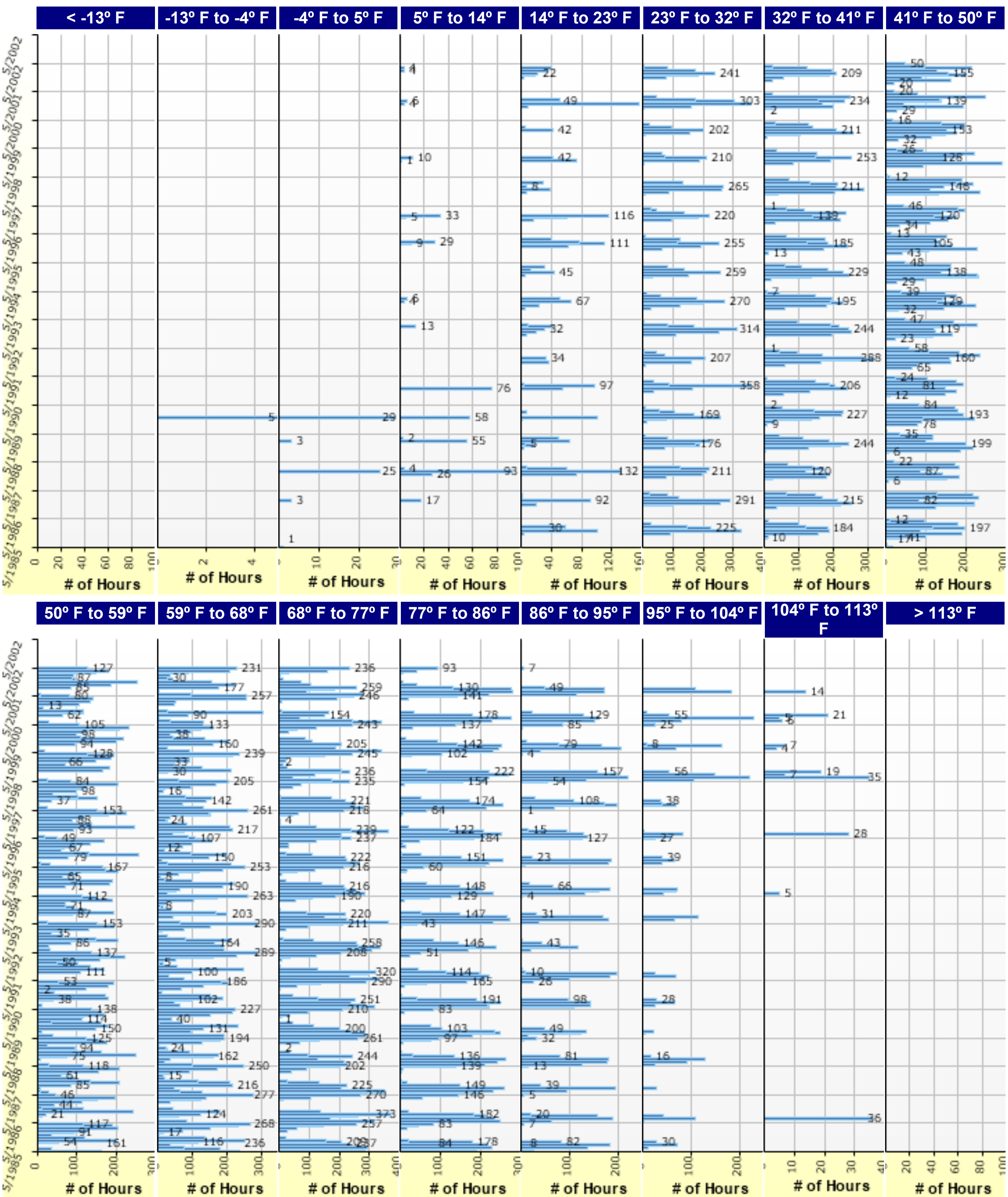








Hourly Air Temperature Distribution by Month:



Design Properties

HMA Design Properties

Use Multilayer Rutting Model	False
Using G* based model (not nationally calibrated)	False
Is NCHRP 1-37A HMA Rutting Model Coefficients	True
Endurance Limit	-
Use Reflective Cracking	True

Structure - ICM Properties	
AC surface shortwave absorptivity	0.85

Layer Name	Layer Type	Interface Friction
Layer 1 Flexible : Default asphalt concrete	Flexible (1)	1.00
Layer 2 Flexible : Default asphalt concrete(existing)	Flexible (1)	1.00
Layer 3 Subgrade : Cement Stabilized Subgrade	Subgrade (5)	1.00
Layer 4 Subgrade : A-6	Subgrade (5)	1.00
Layer 5 Subgrade : A-6	Subgrade (5)	-

HMA Rehabilitation (Input Level: 2)

Milled thickness (in)	5.00
Fatigue cracking amount (%)	10.00
Fatigue cracking severity	Medium
Fatigue cracking LTE	0.4
Transverse cracking amount (ft/mile)	500.00
Transverse cracking severity	Medium
Transverse cracking LTE	0.4
Total rut depth (in)	-

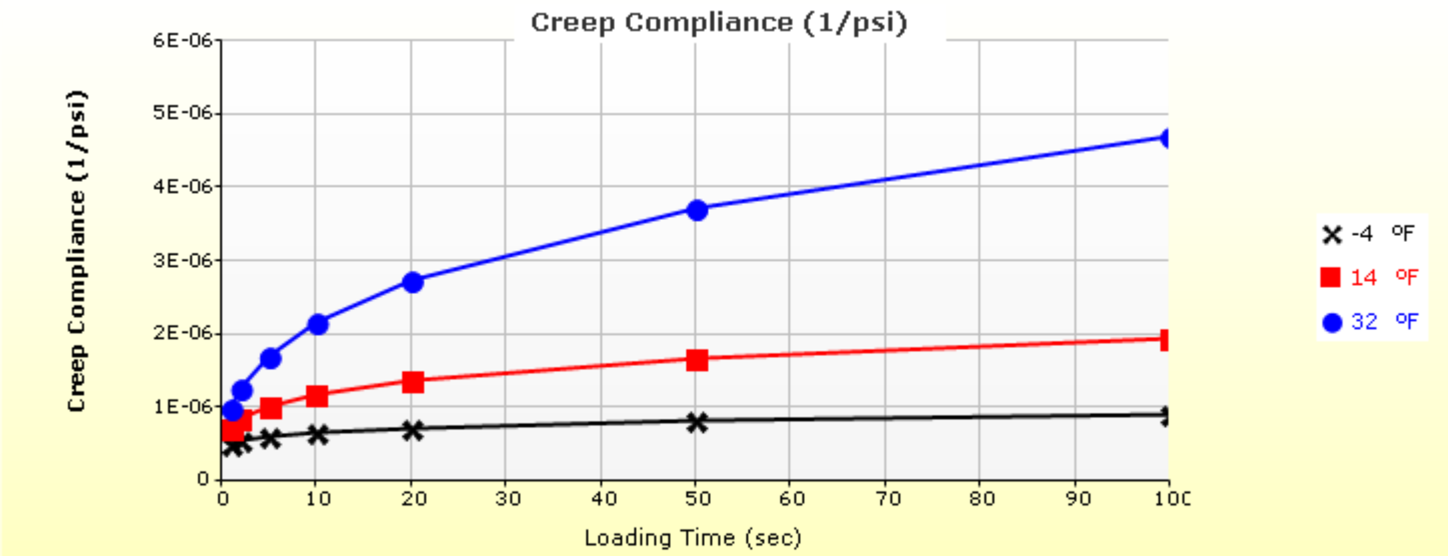
Layer Name	Layer Type	Rut Depth (in)
Layer 1 Flexible : Default asphalt concrete	Flexible (1)	-
Layer 2 Flexible : Default asphalt concrete(existing)	Flexible (1)	0.00
Layer 3 Subgrade : Cement Stabilized Subgrade	Subgrade (5)	0.00
Layer 4 Subgrade : A-6	Subgrade (5)	0.00
Layer 5 Subgrade : A-6	Subgrade (5)	0.00

Thermal Cracking

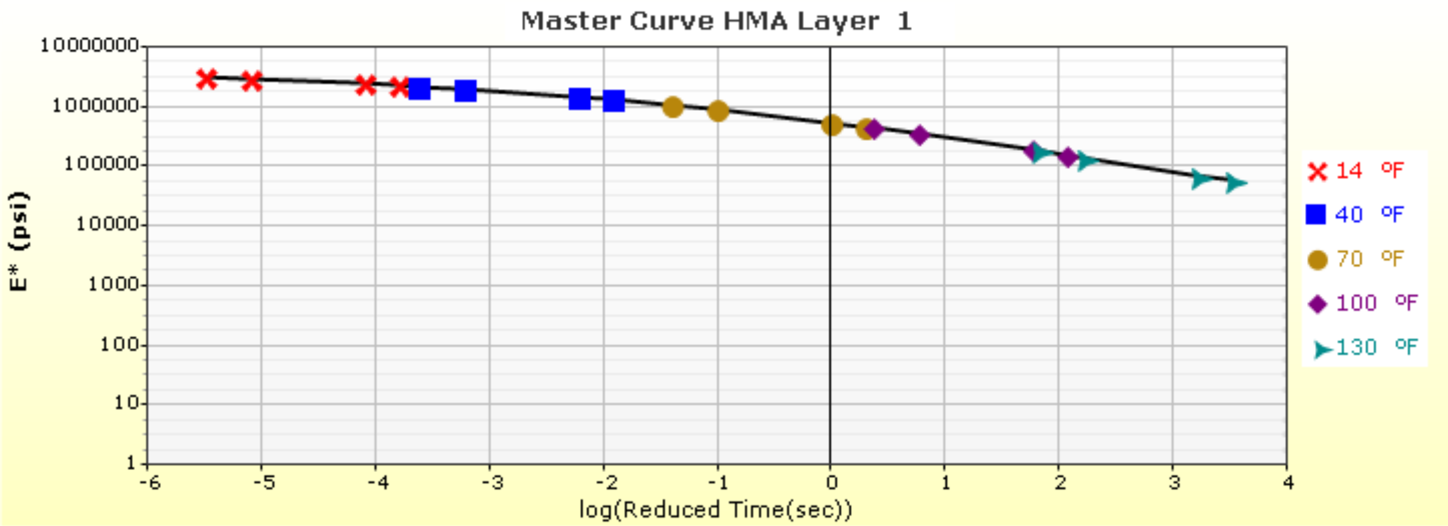
Thermal Contraction	
Is thermal contraction calculated?	True
Mix coefficient of thermal contraction (in/in/ºF)	-
Aggregate coefficient of thermal contraction (in/in/ºF)	5.0e-006
Voids in Mineral Aggregate (%)	17.7

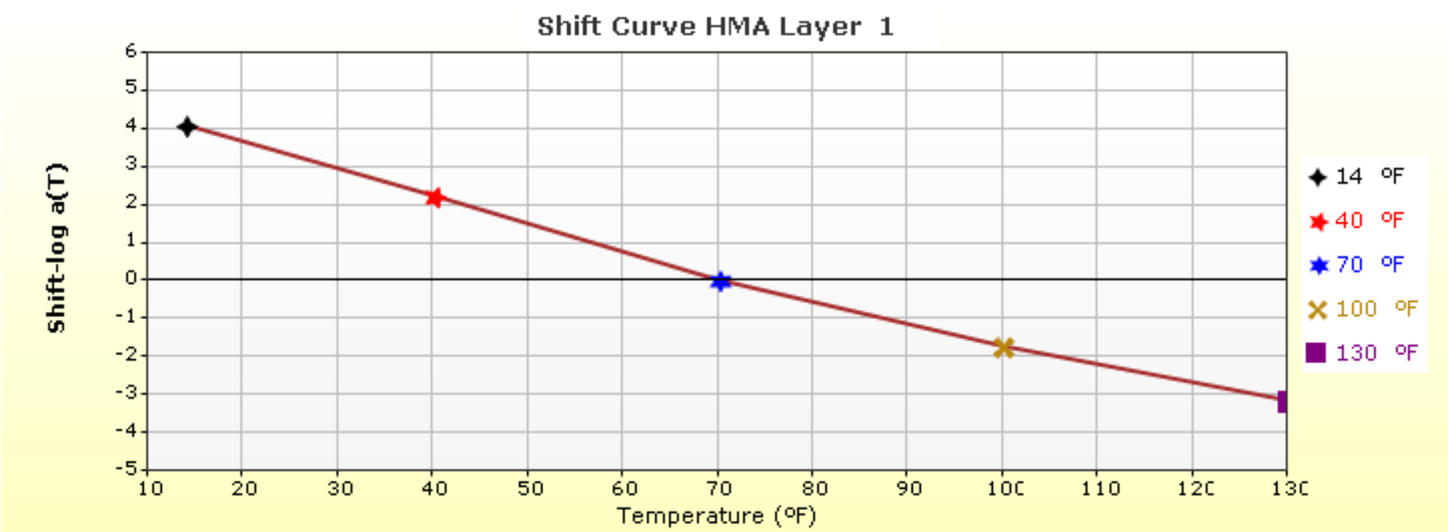
Indirect Tensile Strength (Input Level: 3)	
Test Temperature (ºF)	Indirect Tensilte Strength (psi)
14.0	482.98

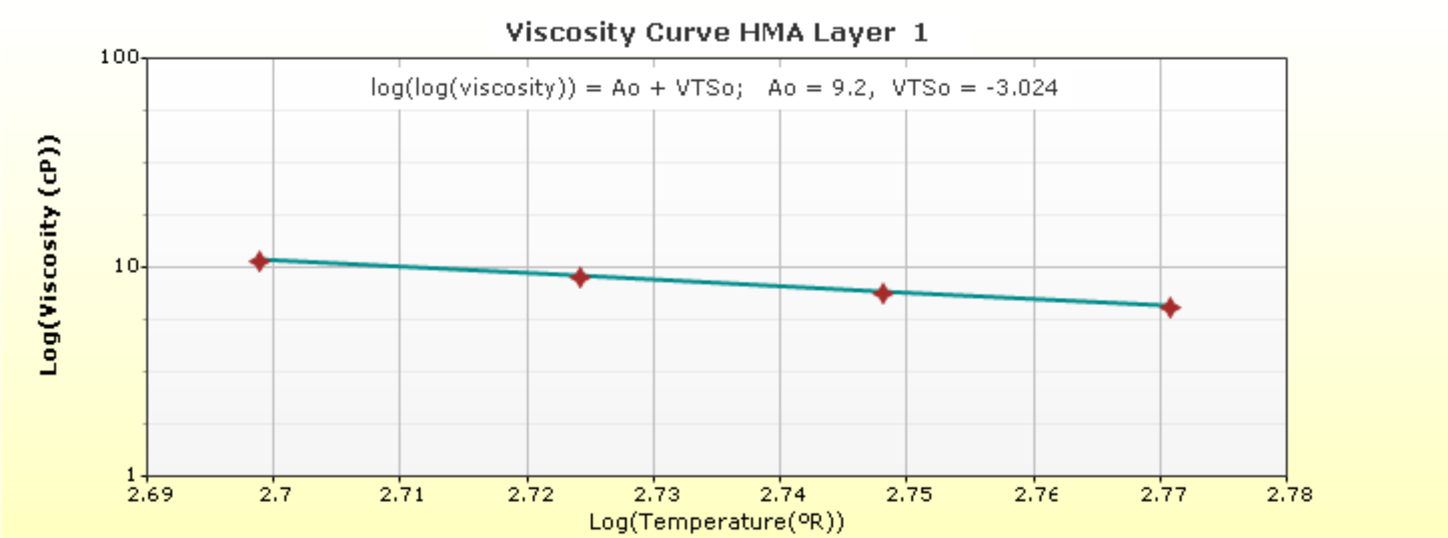
Creep Compliance (1/psi) (Input Level: 3)			
Loading time (sec)	-4 ºF	14 ºF	32 ºF
1	5.01e-007	7.30e-007	9.96e-007
2	5.48e-007	8.47e-007	1.26e-006
5	6.16e-007	1.03e-006	1.71e-006
10	6.73e-007	1.20e-006	2.17e-006
20	7.35e-007	1.39e-006	2.73e-006
50	8.26e-007	1.69e-006	3.72e-006
100	9.03e-007	1.96e-006	4.70e-006



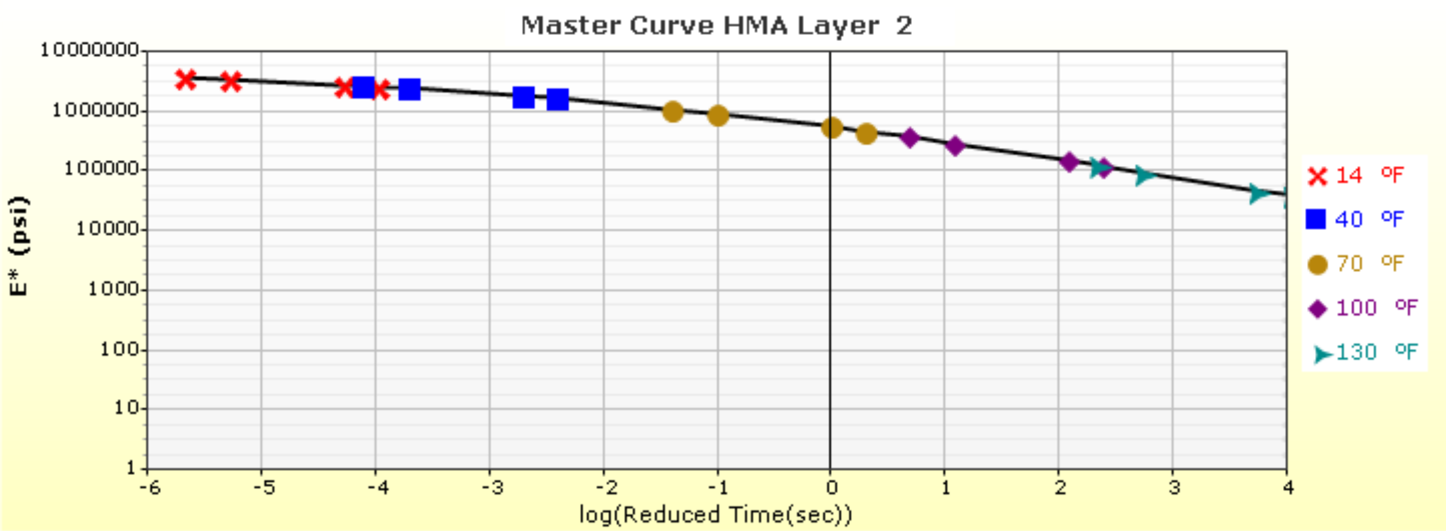
HMA Layer 1: Layer 1 Flexible : Default asphalt concrete

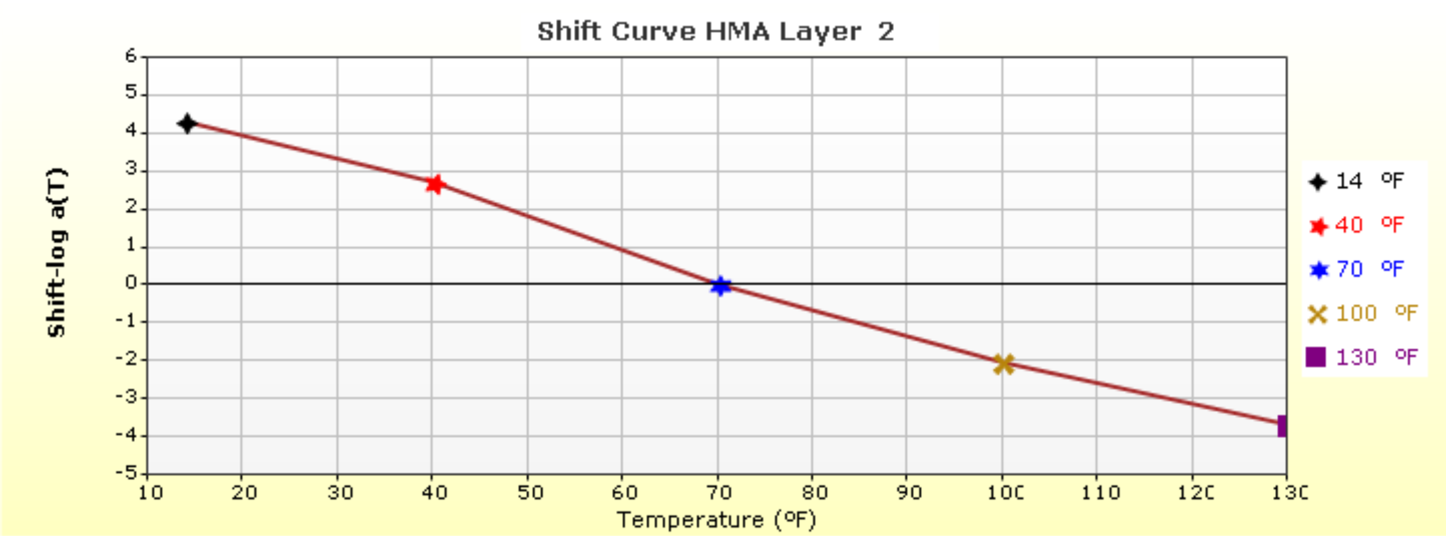


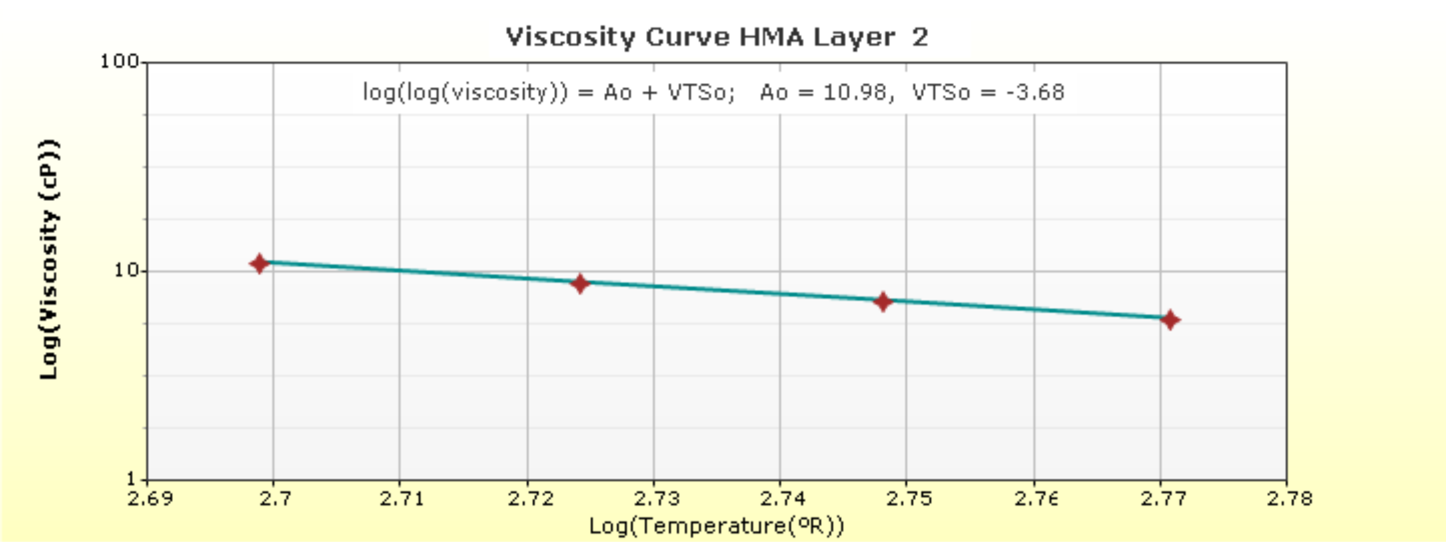




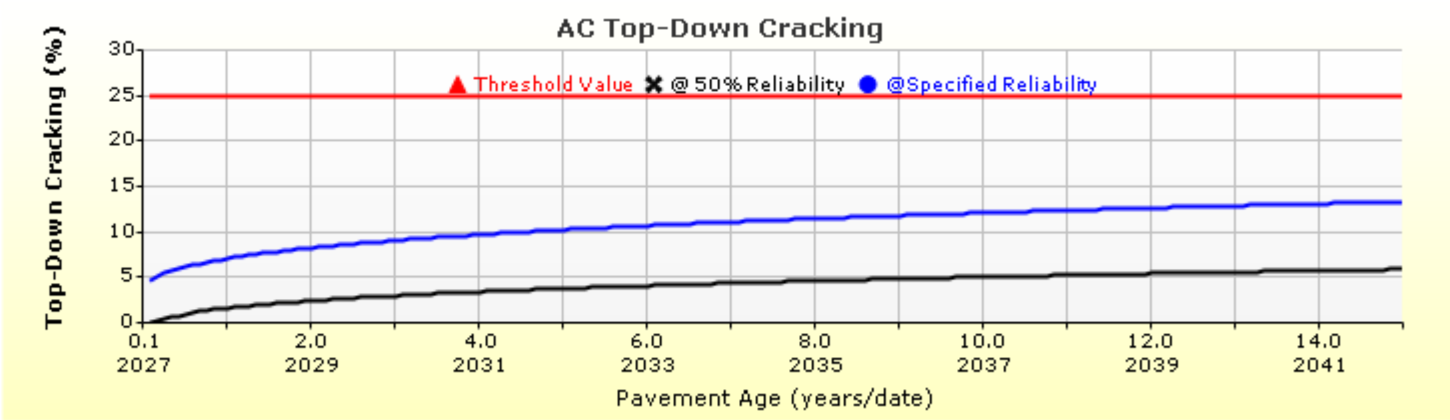
HMA Layer 2: Layer 2 Flexible : Default asphalt concrete(existing)

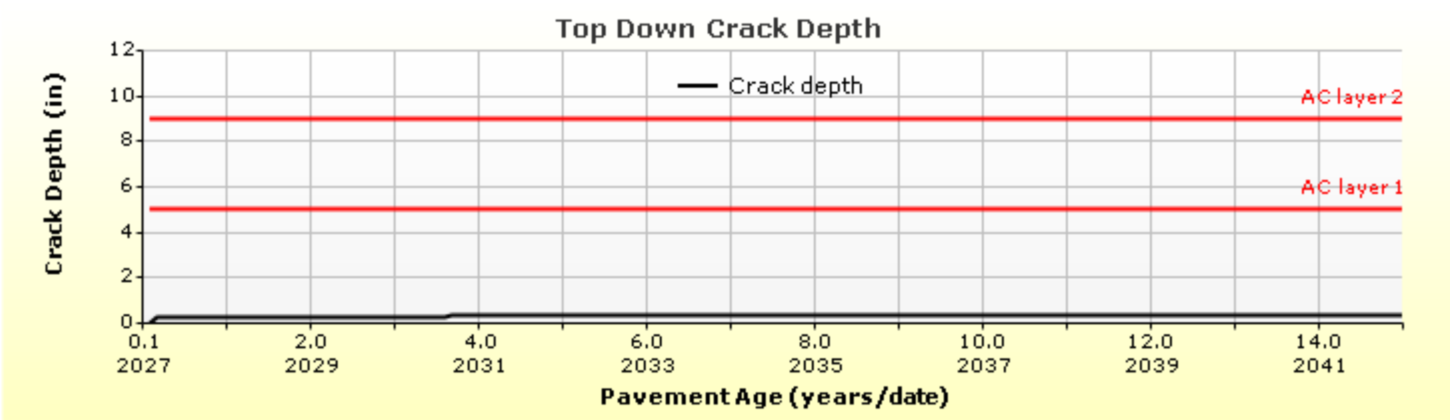


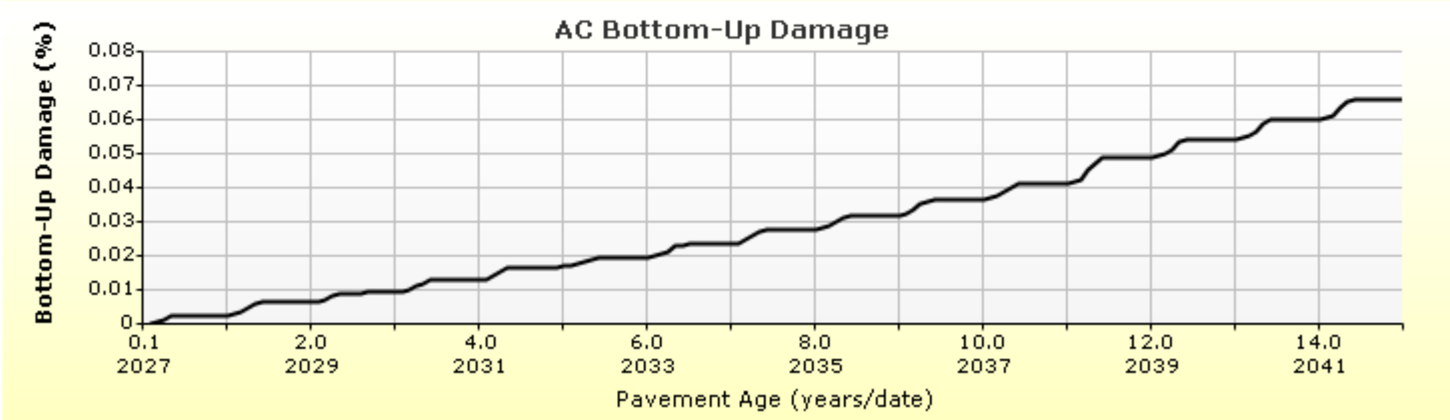


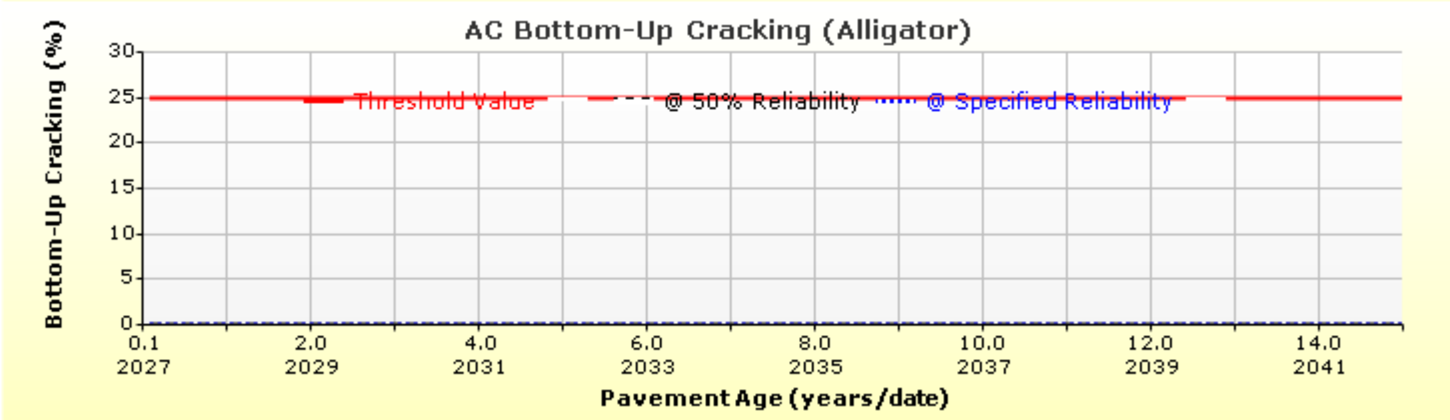


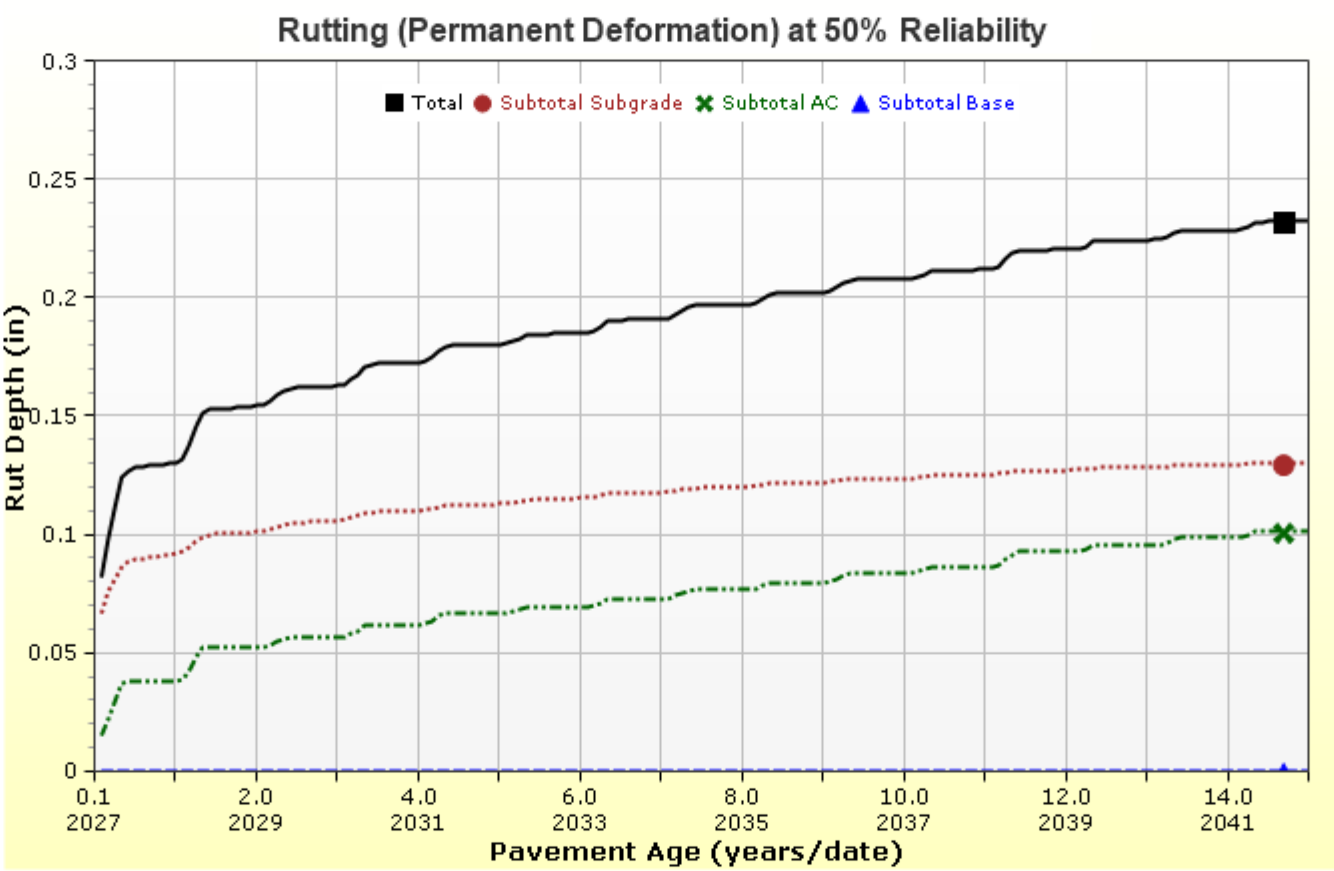
Analysis Output Charts

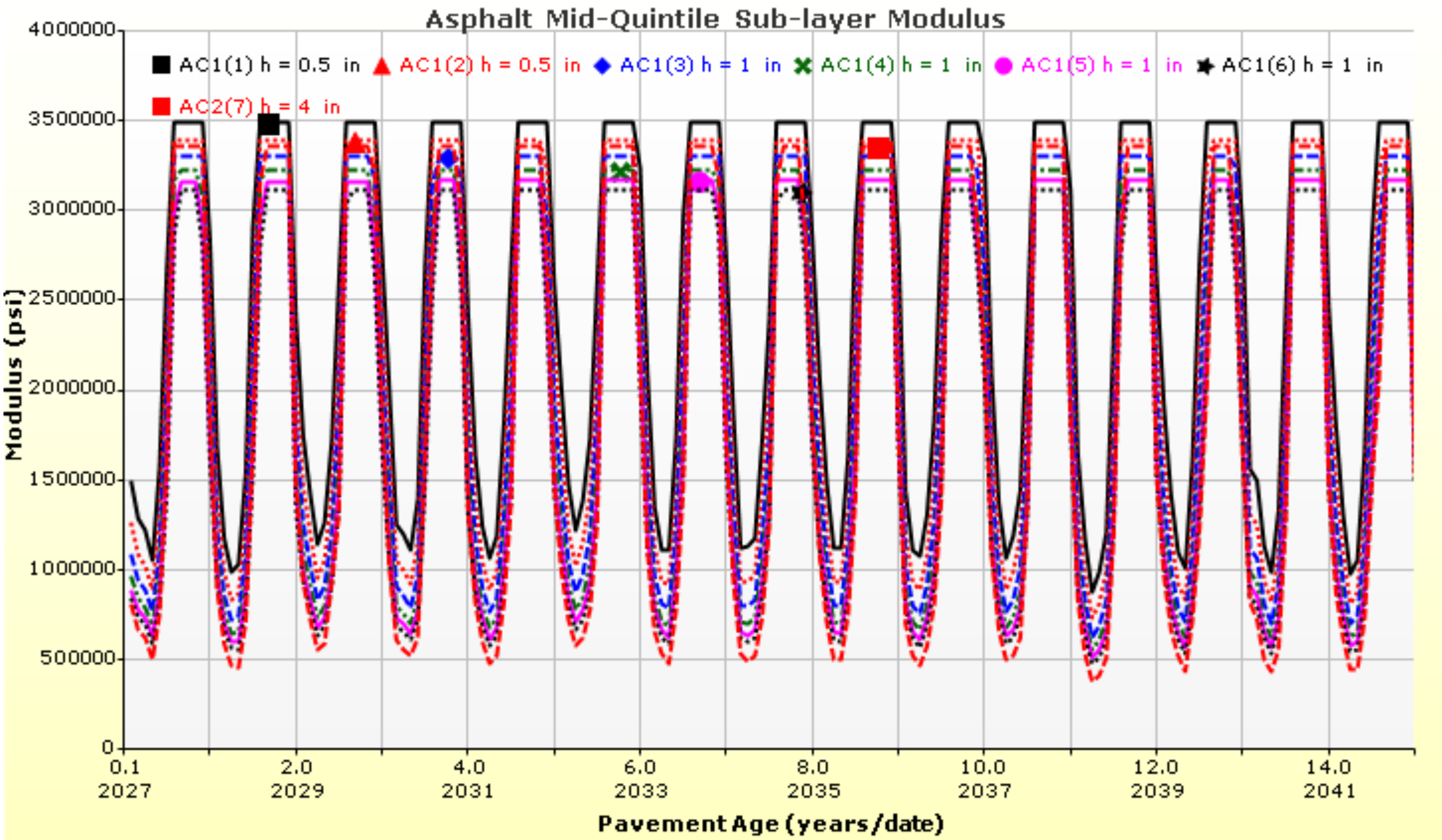

AC Top-Down Cracking
Threshold Value
@ 50% Reliability
@Specified Reliability
Top-Down Cracking (%)
30
25
20
15
10
5
0
0.1 2027
2.0 2029
4.0 2031
6.0 2033
8.0 2035
10.0 2037
12.0 2039
14.0 2041
Pavement Age (years/date)


Top Down Crack Depth
Crack depth
AC layer 2
AC layer 1
Crack Depth (in)
12
10
8
6
4
2
0
0.1 2027
2.0 2029
4.0 2031
6.0 2033
8.0 2035
10.0 2037
12.0 2039
14.0 2041
Pavement Age (years/date)

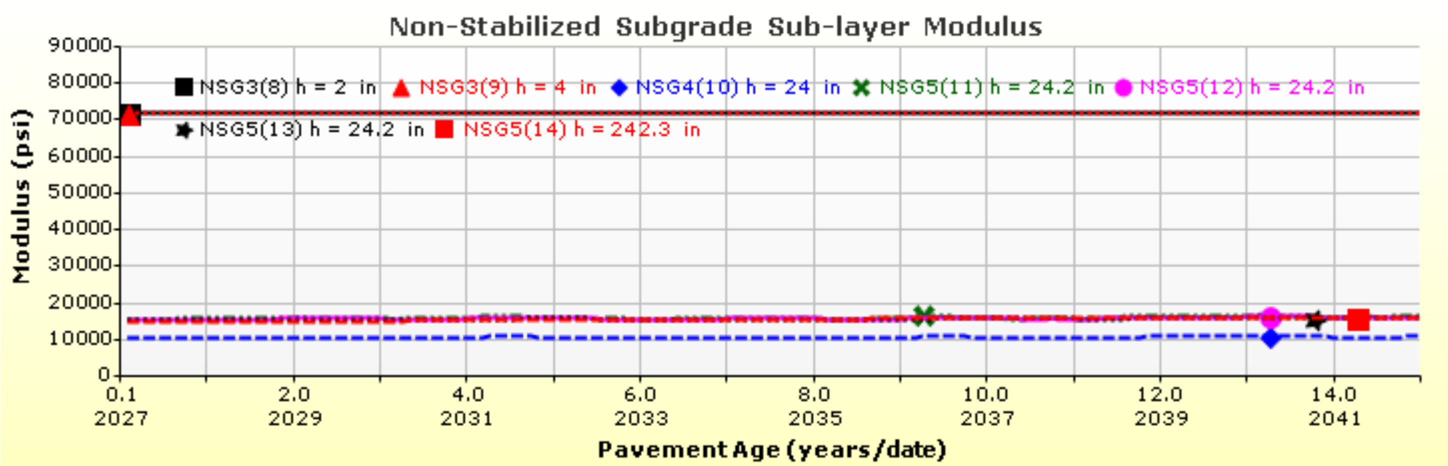

AC Bottom-Up Damage
Bottom-Up Damage (%)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.1 2027
2.0 2029
4.0 2031
6.0 2033
8.0 2035
10.0 2037
12.0 2039
14.0 2041
Pavement Age (years/date)


AC Bottom-Up Cracking (Alligator)
Threshold Value
@ 50% Reliability
@ Specified Reliability
Bottom-Up Cracking (%)
30
25
20
15
10
5
0
0.1 2027
2.0 2029
4.0 2031
6.0 2033
8.0 2035
10.0 2037
12.0 2039
14.0 2041
Pavement Age (years/date)


Rutting (Permanent Deformation) at 50% Reliability
Total
Subtotal Subgrade
Subtotal AC
Subtotal Base
Rut Depth (in)
0.3
0.25
0.2
0.15
0.1
0.05
0
0.1
2027
2.0
2029
4.0
2031
6.0
2033
8.0
2035
10.0
2037
12.0
2039
14.0
2041
Pavement Age (years/date)



Asphalt Mid-Quintile Sub-layer Modulus
AC1(1) h = 0.5 in
AC1(2) h = 0.5 in
AC1(3) h = 1 in
AC1(4) h = 1 in
AC1(5) h = 1 in
AC1(6) h = 1 in
AC2(7) h = 4 in
Modulus (psi)
4000000
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
0.1 2027
2.0 2029
4.0 2031
6.0 2033
8.0 2035
10.0 2037
12.0 2039
14.0 2041
Pavement Age (years/date)



Non-Stabilized Subgrade Sub-layer Modulus
NSG3(8) h = 2 in
NSG3(9) h = 4 in
NSG4(10) h = 24 in
NSG5(11) h = 24.2 in
NSG5(12) h = 24.2 in
NSG5(13) h = 24.2 in
NSG5(14) h = 242.3 in
Modulus (psi)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0.1 2027
2.0 2029
4.0 2031
6.0 2033
8.0 2035
10.0 2037
12.0 2039
14.0 2041
Pavement Age (years/date)

Layer Information

Layer 1 Flexible : Default asphalt concrete

Asphalt		
Thickness (in)	5.0	
Unit weight (pcf)	150.0	
Poisson's ratio	Is Calculated?	False
	Ratio	0.35
	Parameter A	-
	Parameter B	-

General Info

Name	Value
Reference temperature (ºF)	70
Effective binder content (%)	10.7
Air voids (%)	7
Thermal conductivity (BTU/hr-ft-ºF)	0.67
Heat capacity (BTU/lb-ºF)	0.23
Asphalt content by weight (%)	6
Aggregate parameter	0.4021

Asphalt Dynamic Modulus (Input Level: 3)

Gradation	Percent Passing
3/4-inch sieve	100
3/8-inch sieve	77
No.4 sieve	60
No.200 sieve	6

Asphalt Binder

Parameter	Value
Grade	Superpave Performance Grade
Binder Type	76-28
A	9.2
VTS	-3.024

Identifiers

Field	Value
Display name/identifier	Default asphalt concrete
Description of object	
Author	
Date Created	10/30/2010 12:00:00 AM
Approver	
Date approved	10/30/2010 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Layer 2 Flexible : Default asphalt concrete(existing)

Asphalt		
Thickness (in)	4.0	
Unit weight (pcf)	150.0	
Poisson's ratio	Is Calculated?	False
	Ratio	0.35
	Parameter A	-
	Parameter B	-

Asphalt Dynamic Modulus (Input Level: 3)

Gradation	Percent Passing
3/4-inch sieve	95
3/8-inch sieve	79
No.4 sieve	57
No.200 sieve	6

Asphalt Binder

Parameter	Value
Grade	Superpave Performance Grade
Binder Type	64-22
A	10.98
VTS	-3.68

General Info

Name	Value
Reference temperature (ºF)	70
Effective binder content (%)	11.2
Air voids (%)	5
Thermal conductivity (BTU/hr-ft-ºF)	0.67
Heat capacity (BTU/lb-ºF)	0.23
Asphalt content by weight (%)	-
Aggregate parameter	-

Identifiers

Field	Value
Display name/identifier	Default asphalt concrete
Description of object	
Author	
Date Created	10/30/2010 12:00:00 AM
Approver	
Date approved	10/30/2010 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Layer 3 Subgrade : Cement Stabilized Subgrade

Unbound	
Layer thickness (in)	6.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Annual representative values
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
72000.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Cement Stabilized Subgrade
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	32.0
Plasticity Index	15.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	121.9
Saturated hydraulic conductivity (ft/hr)	False	7.651e-06
Specific gravity of solids	False	2.7
Water Content (%)	False	10

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	75.5741
bf	0.9351
cf	0.4315
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	24.8
#100	
#80	32.4
#60	
#50	
#40	43.5
#30	
#20	
#16	
#10	59.4
#8	
#4	67.2
3/8-in.	78.8
1/2-in.	83.3
3/4-in.	90.4
1-in.	94.5
1 1/2-in.	97.7
2-in.	99.4
2 1/2-in.	
3-in.	
3 1/2-in.	99.9

Layer 4 Subgrade : A-6

Unbound	
Layer thickness (in)	24.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
7800.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	A-6
Description of object	Average Values
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	26.0
Plasticity Index	12.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	True	115.3
Saturated hydraulic conductivity (ft/hr)	False	1.563e-05
Specific gravity of solids	False	2.7
Water Content (%)	True	18

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	103.4254
bf	0.7138
cf	0.2488
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	72.4
#100	
#80	
#60	
#50	
#40	93.0
#30	
#20	
#16	
#10	97.0
#8	
#4	99.0
3/8-in.	100.0
1/2-in.	100.0
3/4-in.	100.0
1-in.	100.0
1 1/2-in.	100.0
2-in.	100.0
2 1/2-in.	
3-in.	
3 1/2-in.	100.0

Layer 5 Subgrade : A-6

Unbound	
Layer thickness (in)	Semi-infinite
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
12100.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	A-6
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	26.0
Plasticity Index	12.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	True	115.3
Saturated hydraulic conductivity (ft/hr)	False	1.563e-05
Specific gravity of solids	False	2.7
Water Content (%)	True	18

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	103.4254
bf	0.7138
cf	0.2488
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	72.4
#100	
#80	
#60	
#50	
#40	93.0
#30	
#20	
#16	
#10	97.0
#8	
#4	99.0
3/8-in.	100.0
1/2-in.	100.0
3/4-in.	100.0
1-in.	100.0
1 1/2-in.	100.0
2-in.	100.0
2 1/2-in.	
3-in.	
3 1/2-in.	100.0

Calibration Coefficients

AC Fatigue

$$N_f = 0.00432 * C * \beta_{f1} k_1 \left(\frac{1}{\varepsilon_1}\right)^{k_2 \beta_{f2}} \left(\frac{1}{E}\right)^{k_3 \beta_{f3}}$$

$$C = 10^M$$

$$M = 4.84\left(\frac{V_b}{V_a + V_b} - 0.69\right)$$

k1: 3.75
k2: 2.87
k3: 1.46
Bf1: (5.014 * Pow(hac,-3.416)) * 1 + 0
Bf2: 1.38
Bf3: 0.88

AC Rutting

$$\frac{\varepsilon_p}{\varepsilon_r} = k_z \beta_{r1} 10^{k_1} T^{k_2 \beta_{r2}} N^{k_3 \beta_{r3}}$$

$$k_z = (C_1 + C_2 * depth) * 0.328196^{depth}$$

$$C_1 = -0.1039 * H_\alpha^2 + 2.4868 * H_\alpha - 17.342$$

$$C_2 = 0.0172 * H_\alpha^2 - 1.7331 * H_\alpha + 27.428$$

Where:

H_{ac} = total AC thickness(in)

ε_p = plastic strain(in/in)

ε_r = resilient strain(in/in)

T = layer temperature(°F)

N = number of load repetitions

acRuttingStandardDeviation	0.24 * Pow(RUT,0.8026) + 0.001	
AC Layer 1	K1:-2.45 K2:3.01 K3:0.22	Br1:0.4 Br2:0.52 Br3:1.36
AC Layer 2	K1:-2.45 K2:3.01 K3:0.22	Br1:0.4 Br2:0.52 Br3:1.36

Thermal Fracture

$$C_f = \beta_{t1} N\left[\frac{1}{\sigma_d} log\left(\frac{C}{h_{AC}}\right)\right]$$

$$\Delta C = A(\Delta K)^n$$

$$A = k_t \beta_t 10^{[4.389 - 2.52\log(E_{HMA}\sigma_m n)]}$$

Cf = Observed amount of thermal cracking, ft. / 500ft.
β_{t1} = Regression coefficient determined through global calibration (400)
N[z] = Standard normal distribution evaluated at [z]
σ_d = Standard deviation of the logarithm of crack depth in the pavement (0.769), in.
C = Crack depth, in.
h_{AC} = Thickness of asphalt layer, in.
ΔC = Change in the crack depth due to a cooling cycle
ΔK = Change in the stress intensity factor due to a cooling cycle
A, n = Fracture parameters for the asphalt mixture
E = Asphalt mixture stiffness, MPa
σ_m = Undamaged mixture tensile strength, MPa
k_t = Regression coefficient determined through field calibration
β_t = Calibration parameter

Level 1 K: (0.13 * Pow(MAAT,2) - 11.68 * MAAT + 244.14) * 1 + 0	
Level 2 K: (0.13 * Pow(MAAT,2) - 11.68 * MAAT + 244.14) * 1 + 0	
Level 3 K: (0.13 * Pow(MAAT,2) - 11.68 * MAAT + 244.14) * 1 + 0	

CSM Fatigue

$$N_f = 10^{\left(\frac{k_1 \beta_{c1}\left(\frac{\sigma_s}{M_r}\right)}{k_2 \beta_{c2}}\right)}$$

N_f = number of repetitions to fatigue cracking
σ_s = Tensile stress(psi)
M_r = modulus of rupture(psi)

k1: 0.972	k2: 0.0825	Bc1: 1	Bc2:1

Unbound Layer Rutting

$$\delta_a(N) = \beta_{s_1} k_1 \varepsilon_v h \left(\frac{\varepsilon_0}{\varepsilon_r}\right) \left| e^{-\left(\frac{\rho}{N}\right)^\beta} \right|$$

δ_a = permanent deformation for the layer
N = number of repetitions
ε_v = average veritcal strain(in/in)
$\varepsilon_0, \beta, \rho$ = material properties
ε_r = resilient strain(in/in)

Base Rutting		Subgrade Rutting	
k1: 0.965	Bs1: 1	k1: 0.675	Bs1: 1
Standard Deviation (BASERUT) 0.1477 * Pow(BASERUT,0.6711) + 0.001		Standard Deviation (BASERUT) 0.1235 * Pow(SUBRUT,0.5012) + 0.001	

AC Cracking

AC Top Down Cracking

$$L(t) = L_{Max} e^{-\left(\frac{C_1 \rho}{t - C_3 t_o}\right)^{C_2 \beta}}$$

$$t_0(\text{Days}) = \frac{k_{L1}}{1 + e^{(k_{L2} \times 100 \times a_0/2A_0) + (k_{L3} \times HT) + (k_{L4} \times LT) + (k_{L5} \times \log_{10} AADTT)}}$$

c1: 2.5219	c2: 0.8069	c3: 1
kL1: 64271618	kL2: 0.2855	kL3: 0.011
kL4: 0.01488	kL5: 3.266	

acCrackingTopStandardDeviation

0.3657 * TOP + 3.6563

AC Bottom Up Cracking

$$FC = \left(\frac{6000}{1 + e^{(C_1 * C_1' + C_2 * C_2' \log_{10}(D*100))}}\right) * \left(\frac{1}{60}\right)$$

$$C_2' = -2.40874 - 39.748 * (1 + h_{ac})^{-2.856}$$

$$C_1' = -2 * C_2'$$

c1: 1.31	c2: (0.867 + 0.2583 * hac) * 1 + 0	c3: 6000

acCrackingBottomStandardDeviation

1.13 + 13/(1+exp(7.57-15.5*LOG10(BOTTOM+0.0001)))

CSM Cracking

$$FC_{ctb} = C_1 + \frac{C_2}{1 + e^{C_3 - C_4 * \log_{10}(Damage)}}$$

C1: 0	C2: 75	C3: 2	C4: 2

csmCrackingStandardDeviation

CTB*11

IRI Flexible Pavements

C1 - Rutting
C2 - Fatigue Crack
C3 - Transverse Crack
C4 - Site Factors

C1: 40	C2: 0.4	C3: 0.008	C4: 0.015

Reflective Cracking

$$\Delta C = k_1 \Delta_{bending} + k_2 \Delta_{shaering} + k_3 \Delta_{thermal}$$

$$\Delta D = \frac{C_1 k_1 \Delta_{bending} + C_2 k_2 \Delta_{shearing} + C_3 k_3 \Delta_{thermal}}{h_{OL}}$$

$$\Delta_{Bending} = A(SIF)_B^n$$

$$\Delta_{Shearing} = A(SIF)_S^n$$

$$\Delta_{Thermal} = A(SIF)_T^n$$

$$D = \sum_{i=1}^{N} \Delta D$$

$$RCR = \left(\frac{100}{C4 + e^{C5 \log D}}\right) * EX\_CRK$$

Where

ΔC	=	Crack length increment, in
ΔD	=	Incremental damage ratio
$k_1, k_2, k_3, C_1, C_2, C_3, C_4, C_5$	=	Calibration factors (local and global)
$\Delta_{bending}, \Delta_{shearing}, \Delta_{thermal}$	=	Crack length increments caused by bending, shearing, and thermal loading
A, n	=	HMA material fracture properties
N	=	Total number of days
$(SIF)_B, (SIF)_S, (SIF)_T$	=	Stress intensity factors caused by bending, shearing, and thermal loading
D	=	Damage ratio
h_{OL}	=	Overlay thickness, in
RCR	=	Cracks in the underlying layers reflected, %
EX_CRK	=	Transverse cracking in underlying pavement layers, ft/mile (transverse cracking) Alligator cracking in underlying pavement layers, % lane area (alligator cracking)

Pavement Type	Distress Type	k1	k2	k3	C1	C2	C3	C4	C5	Standard Deviation
AC over AC	Transverse	0.012	0.005	1	3.22	25.7	0.1	133.4	-72.4	70.98 * Pow (TRANSVERSE,0.2994) + 30.12
AC over AC	Fatigue	0.012	0.005	1	0.38	1.66	2.72	105.4	-7.02	1.1097 * Pow (FATIGUE,0.6804) + 1.23

22119 New Mainline AC 14

File Name: C:\Users\kkb\OneDrive\Documents\My ME Design\Projects\2022\22119\22119 New Mainline AC 14.dgpx

Design Inputs

Design Life: 30 years
Design Type: FLEXIBLE

Base construction: May, 2025
Pavement construction: May, 2026
Traffic opening: May, 2027

Climate Data Sources (Lat/Lon): 35, -97.5

Design Structure

Layer type	Material Type	Thickness (in)
Flexible	Default asphalt concrete	5.0
Flexible	Default asphalt concrete	9.0
NonStabilized	Crushed stone	8.0
Subgrade	Stabilized Subgrade	8.0
Subgrade	A-6	Semi-infinite

Volumetric at Construction:	
Effective binder content (%)	11.0
Air voids (%)	6.5

Traffic

Age (year)	Heavy Trucks (cumulative)
2027 (initial)	13,914
2042 (15 years)	33,836,400
2057 (30 years)	79,375,700

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	172.00	174.97	90.00	88.43	Fail
Permanent deformation - total pavement (in)	0.75	0.26	90.00	100.00	Pass
AC bottom-up fatigue cracking (% lane area)	25.00	1.77	90.00	100.00	Pass
AC thermal cracking (ft/mile)	1000.00	844.96	90.00	95.09	Pass
AC top-down fatigue cracking (% lane area)	25.00	15.67	90.00	99.69	Pass
Permanent deformation - AC only (in)	0.25	0.09	90.00	100.00	Pass

22119 New Mainline AC 14

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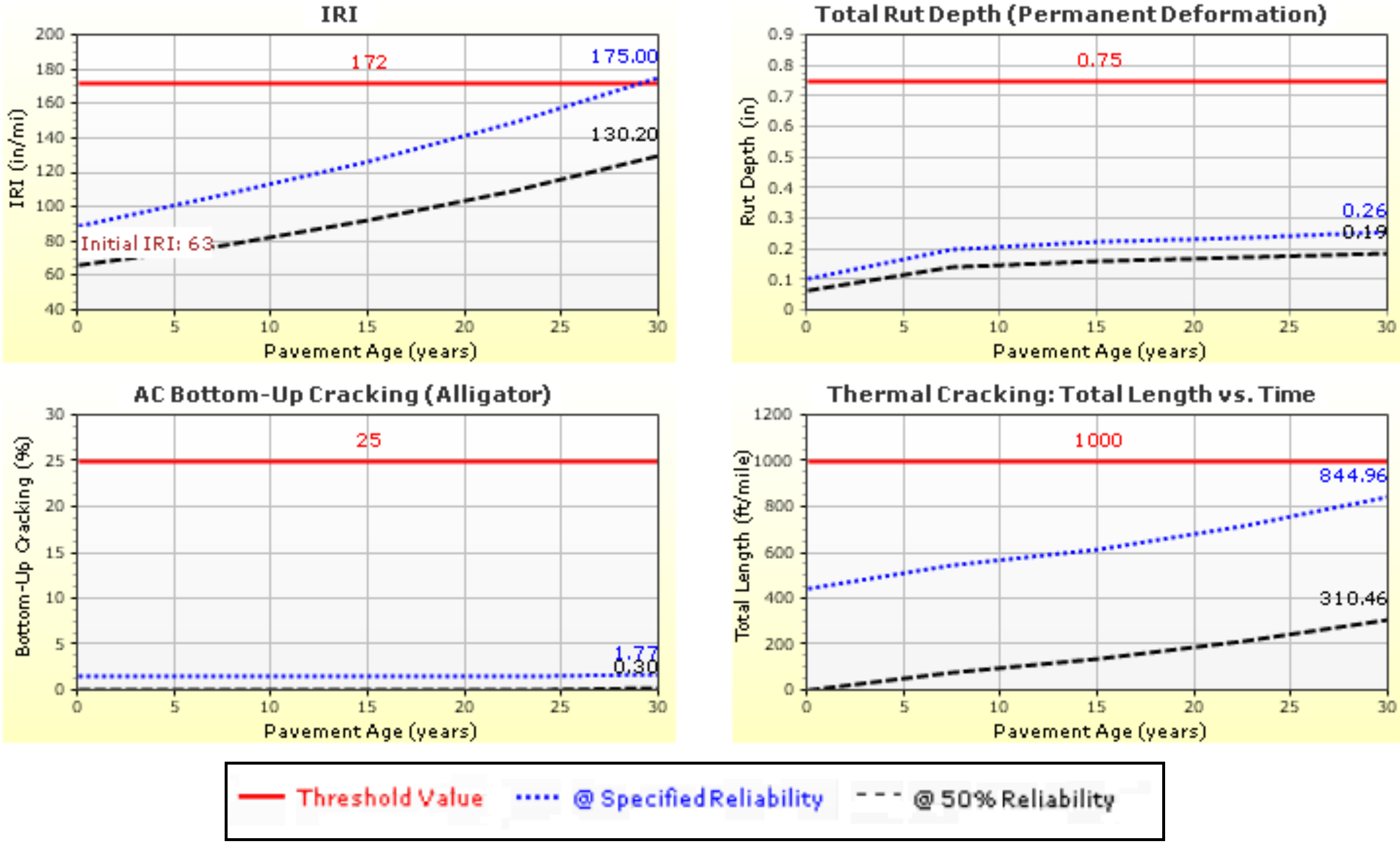
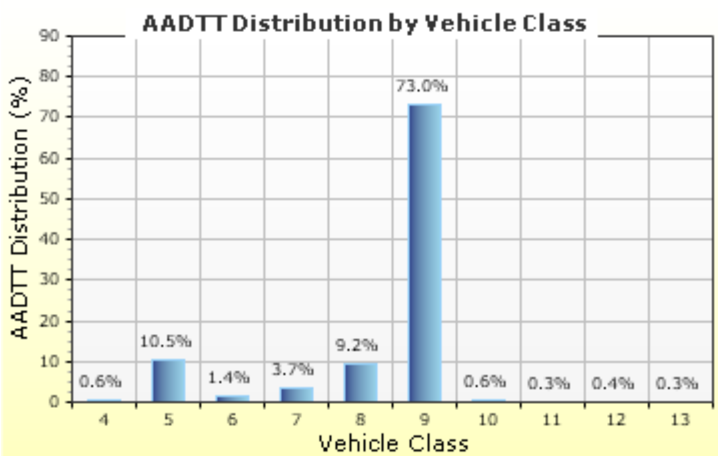
Distress Charts

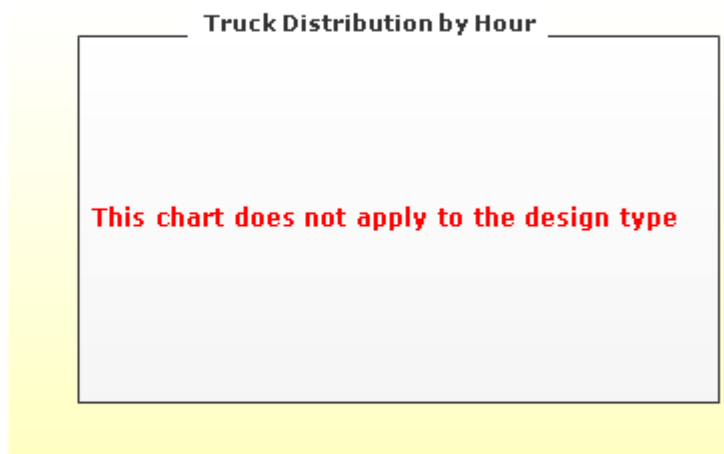


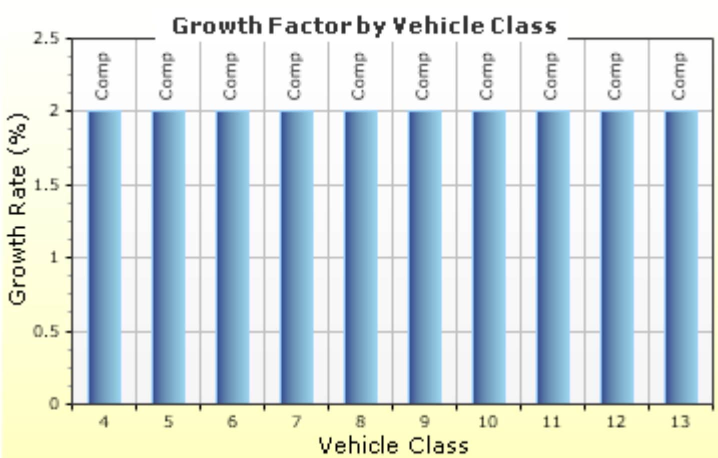
Traffic Inputs

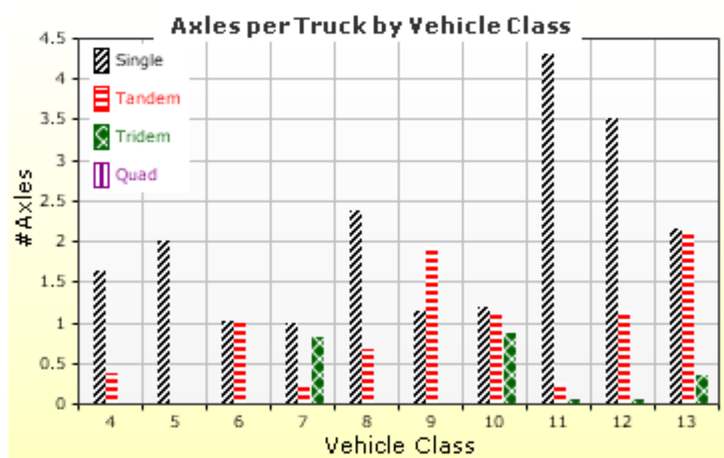
Graphical Representation of Traffic Inputs

Initial two-way AADTT:	13,914	Percent of trucks in design direction (%):	55.0
Number of lanes in design direction:	3	Percent of trucks in design lane (%):	70.0
		Operational speed (mph)	65.0

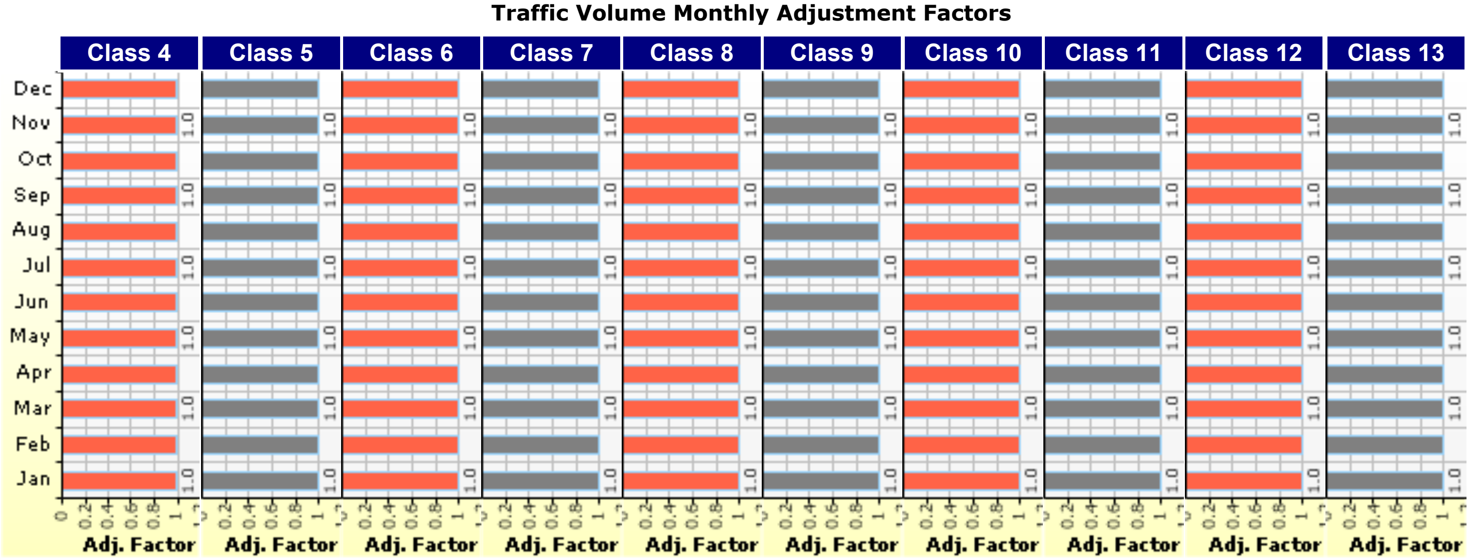








Traffic Volume Monthly Adjustment Factors



Tabular Representation of Traffic Inputs

Volume Monthly Adjustment Factors

Level 3: Default MAF

Month	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
January	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
February	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
March	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
April	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
May	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
June	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
July	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
August	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
September	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
October	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
November	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
December	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Distributions by Vehicle Class

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor	
		Rate (%)	Function
Class 4	0.6%	2%	Compound
Class 5	10.5%	2%	Compound
Class 6	1.4%	2%	Compound
Class 7	3.7%	2%	Compound
Class 8	9.2%	2%	Compound
Class 9	73%	2%	Compound
Class 10	0.6%	2%	Compound
Class 11	0.3%	2%	Compound
Class 12	0.4%	2%	Compound
Class 13	0.3%	2%	Compound

Truck Distribution by Hour does not apply

Axle Configuration

Traffic Wander	
Mean wheel location (in)	18.0
Traffic wander standard deviation (in)	10.0
Design lane width (ft)	12.0

Axle Configuration	
Average axle width (ft)	8.5
Dual tire spacing (in)	12.0
Tire pressure (psi)	120.0

Average Axle Spacing	
Tandem axle spacing (in)	51.6
Tridem axle spacing (in)	49.2
Quad axle spacing (in)	49.2

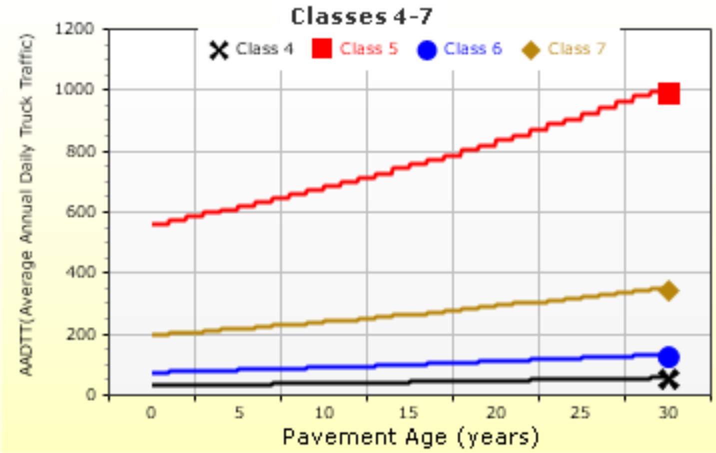
Wheelbase does not apply

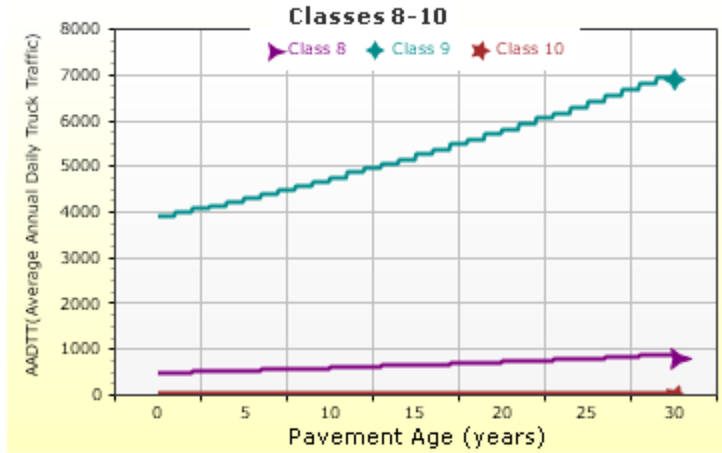
Number of Axles per Truck

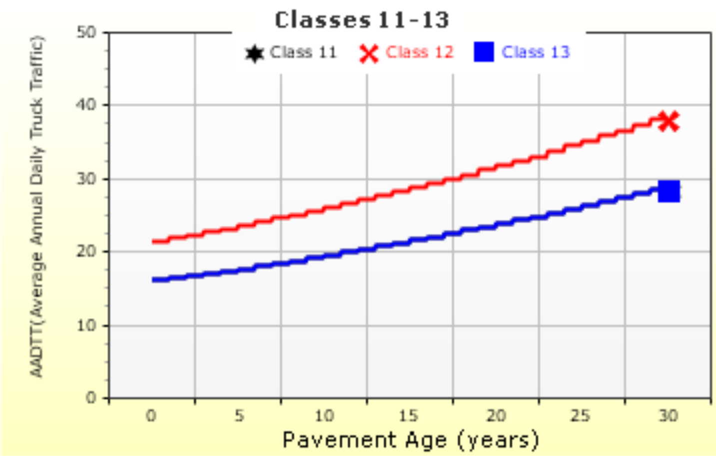
Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.62	0.39	0	0
Class 5	2	0	0	0
Class 6	1.02	0.99	0	0
Class 7	1	0.26	0.83	0
Class 8	2.38	0.67	0	0
Class 9	1.13	1.93	0	0
Class 10	1.19	1.09	0.89	0
Class 11	4.29	0.26	0.06	0
Class 12	3.52	1.14	0.06	0
Class 13	2.15	2.13	0.35	0

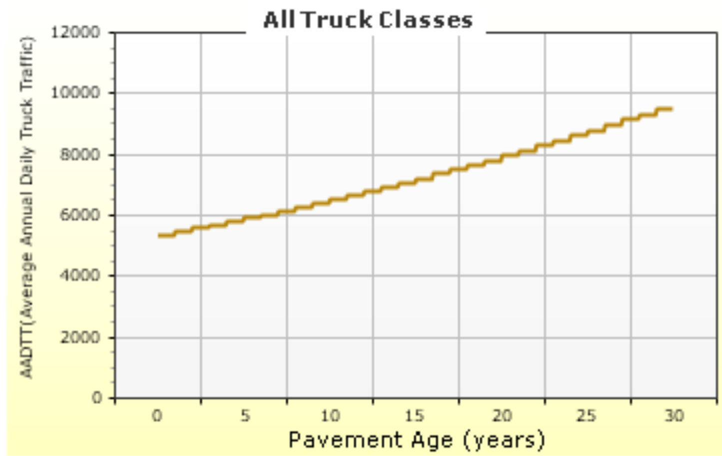
AADTT (Average Annual Daily Truck Traffic) Growth

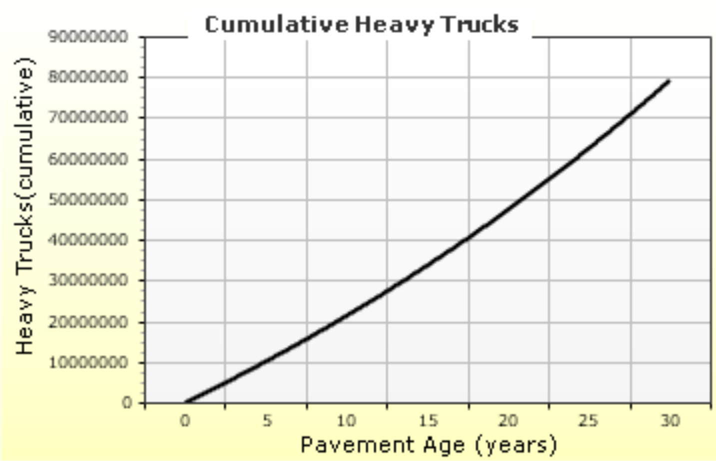
*** Traffic cap is not enforced**







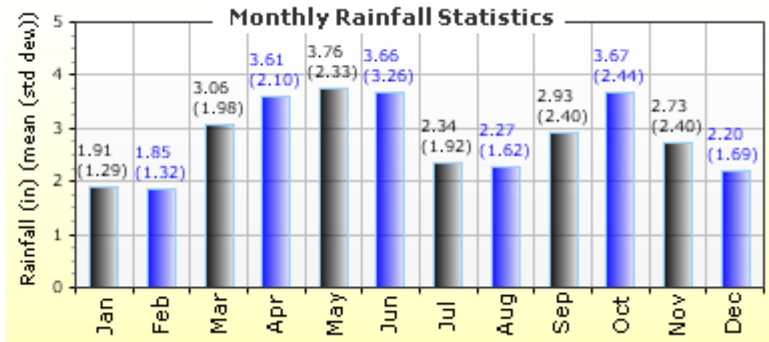




Climate Inputs

Climate Data Sources:

Climate Station Cities:	Location (lat lon elevation(ft))
US, OK	35.00000 -97.50000 1109

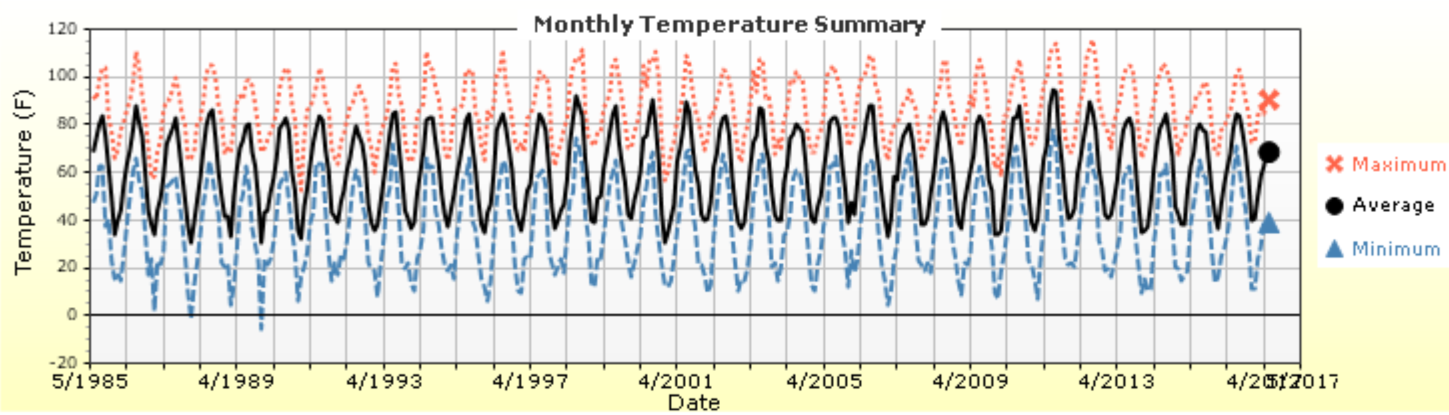


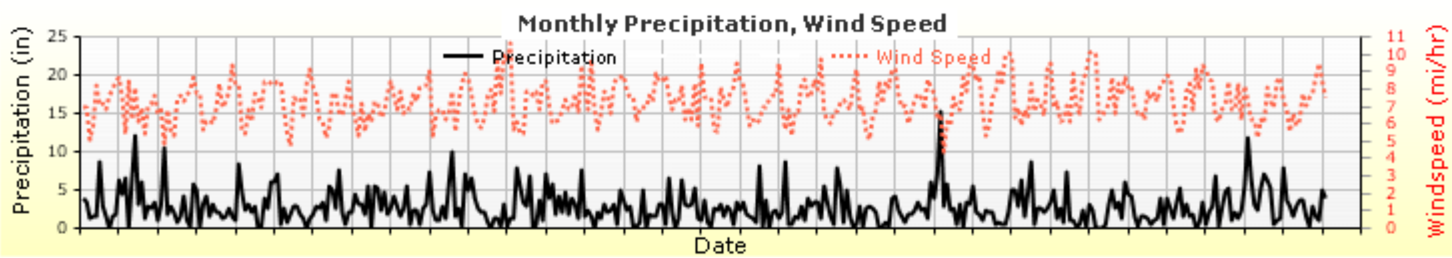
Annual Statistics:

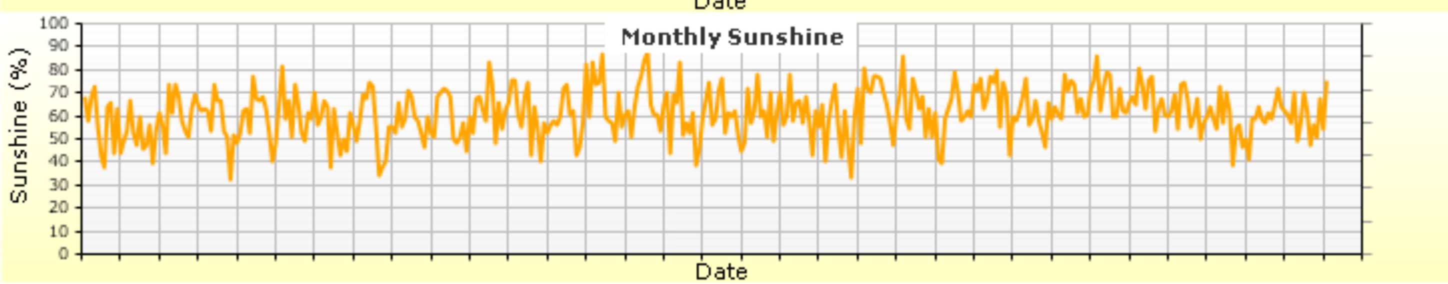
Mean annual air temperature (ºF)	61.10
Mean annual precipitation (in)	34.02
Freezing index (ºF - days)	102.06
Average annual number of freeze/thaw cycles:	61.02

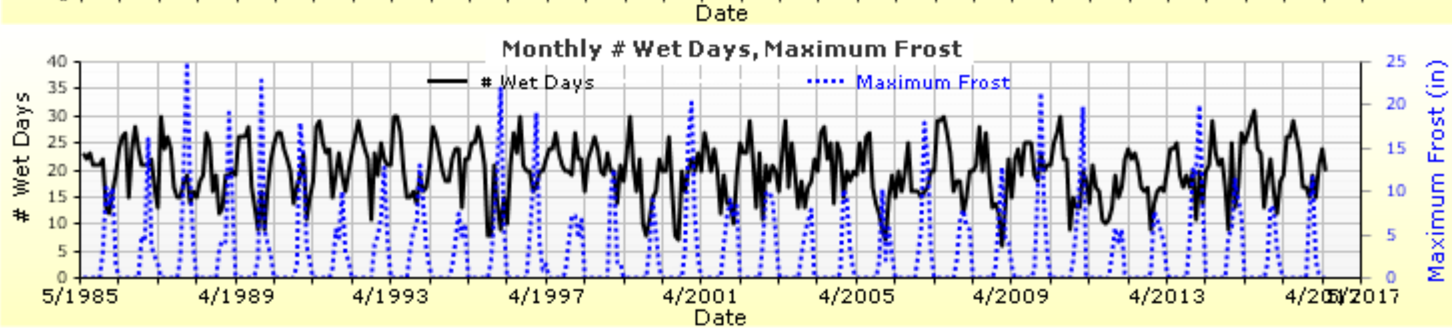
Water table depth (ft)	51.00

Monthly Climate Summary:

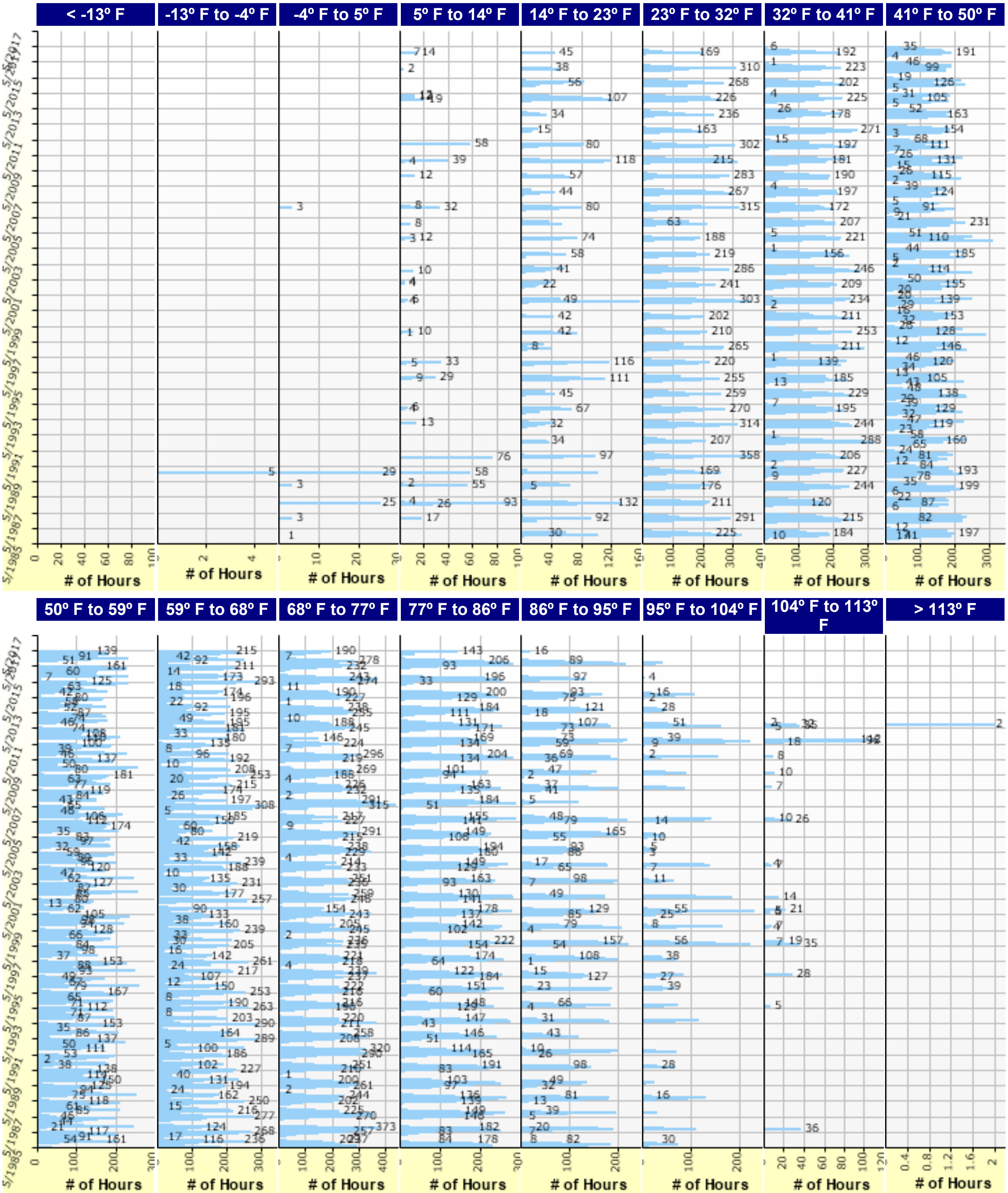








Hourly Air Temperature Distribution by Month:



Design Properties

HMA Design Properties

Use Multilayer Rutting Model	False
Using G* based model (not nationally calibrated)	False
Is NCHRP 1-37A HMA Rutting Model Coefficients	True
Endurance Limit	-
Use Reflective Cracking	True

Structure - ICM Properties	
AC surface shortwave absorptivity	0.85

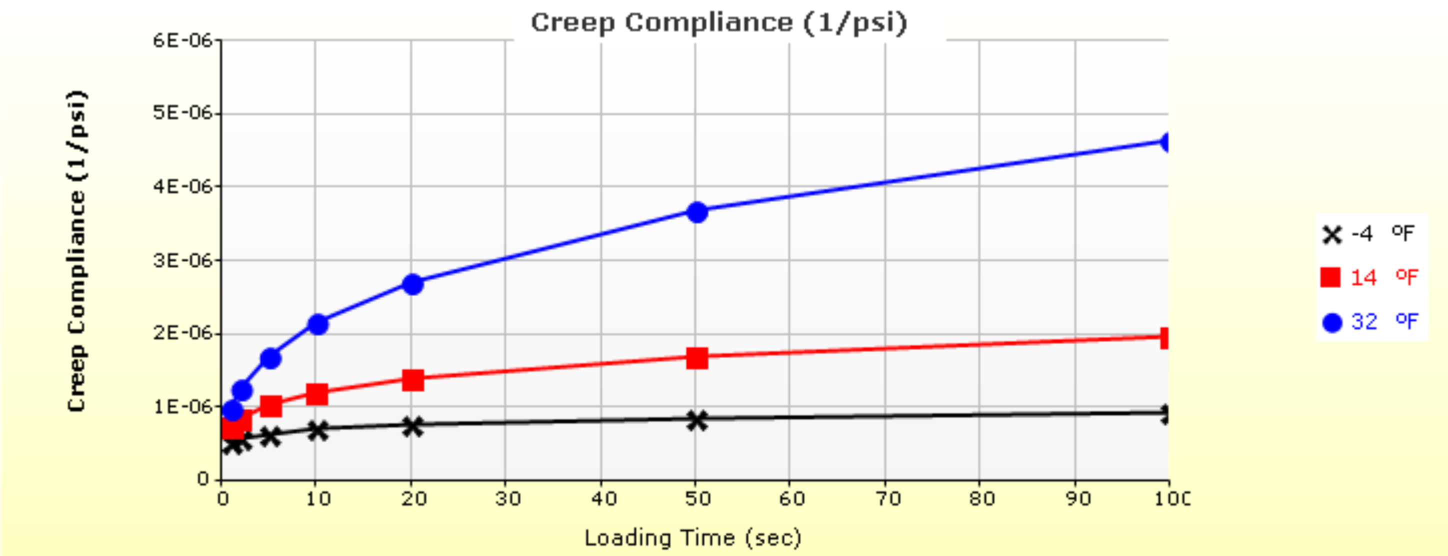
Layer Name	Layer Type	Interface Friction
Layer 1 Flexible : Default asphalt concrete	Flexible (1)	1.00
Layer 2 Flexible : Default asphalt concrete	Flexible (1)	1.00
Layer 3 Non-stabilized Base : Crushed stone	Non-stabilized Base (4)	1.00
Layer 4 Subgrade : Stabilized Subgrade	Subgrade (5)	1.00
Layer 5 Subgrade : A-6	Subgrade (5)	-

Thermal Cracking

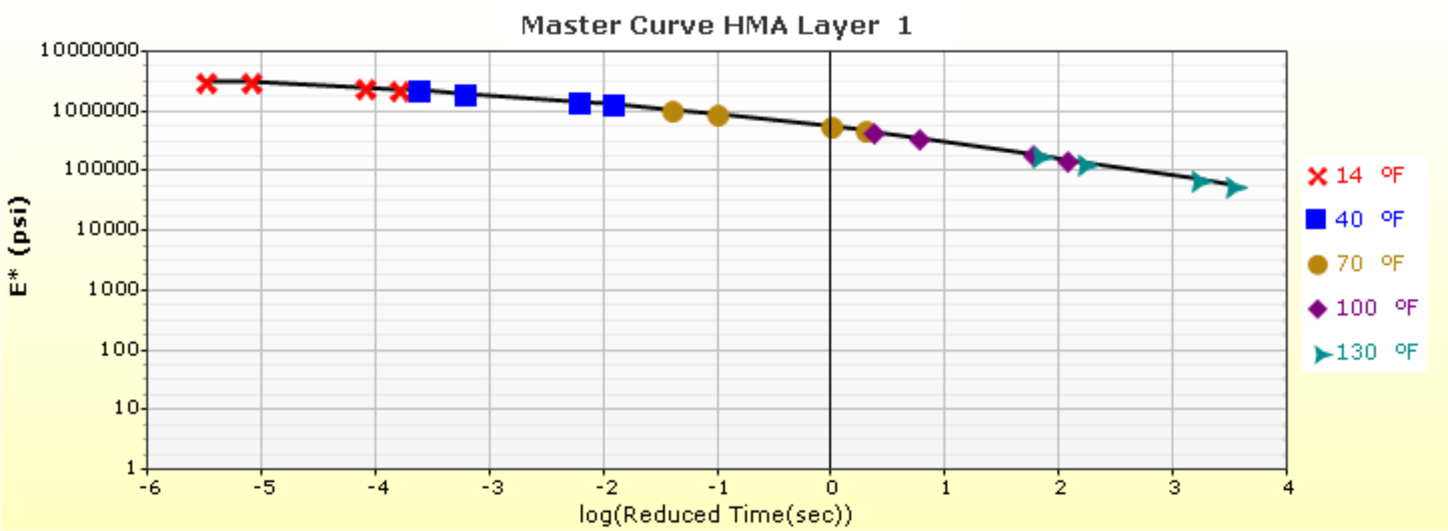
Thermal Contraction	
Is thermal contraction calculated?	True
Mix coefficient of thermal contraction (in/in/ºF)	-
Aggregate coefficient of thermal contraction (in/in/ºF)	5.0e-006
Voids in Mineral Aggregate (%)	17.5

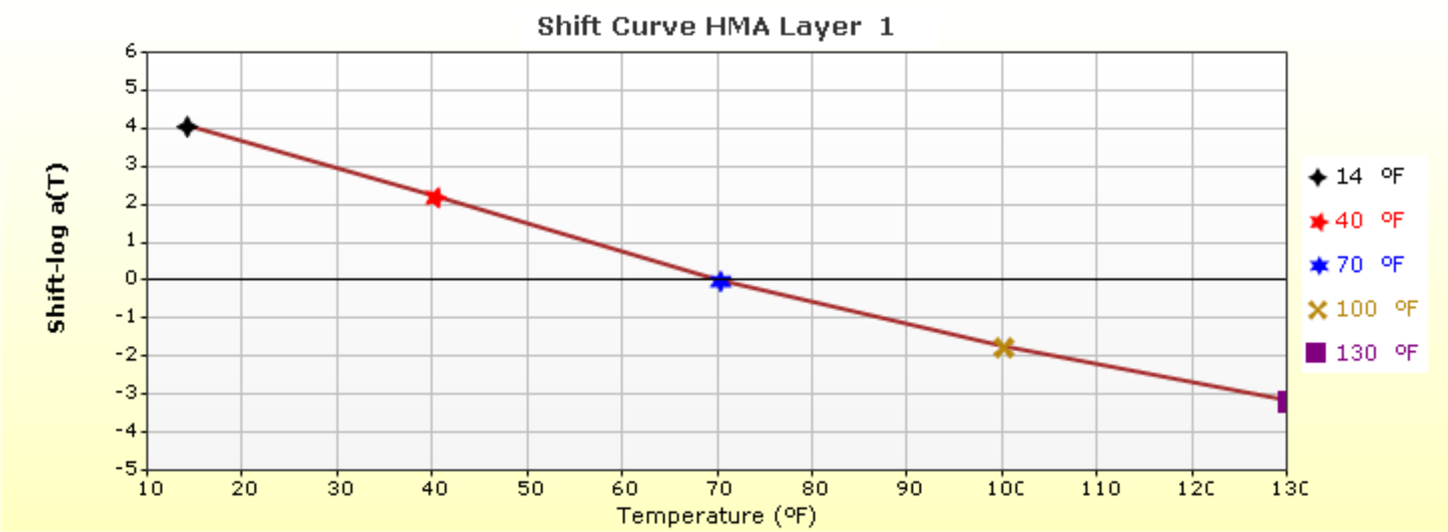
Indirect Tensile Strength (Input Level: 3)	
Test Temperature (ºF)	Indirect Tensilte Strength (psi)
14.0	466.68

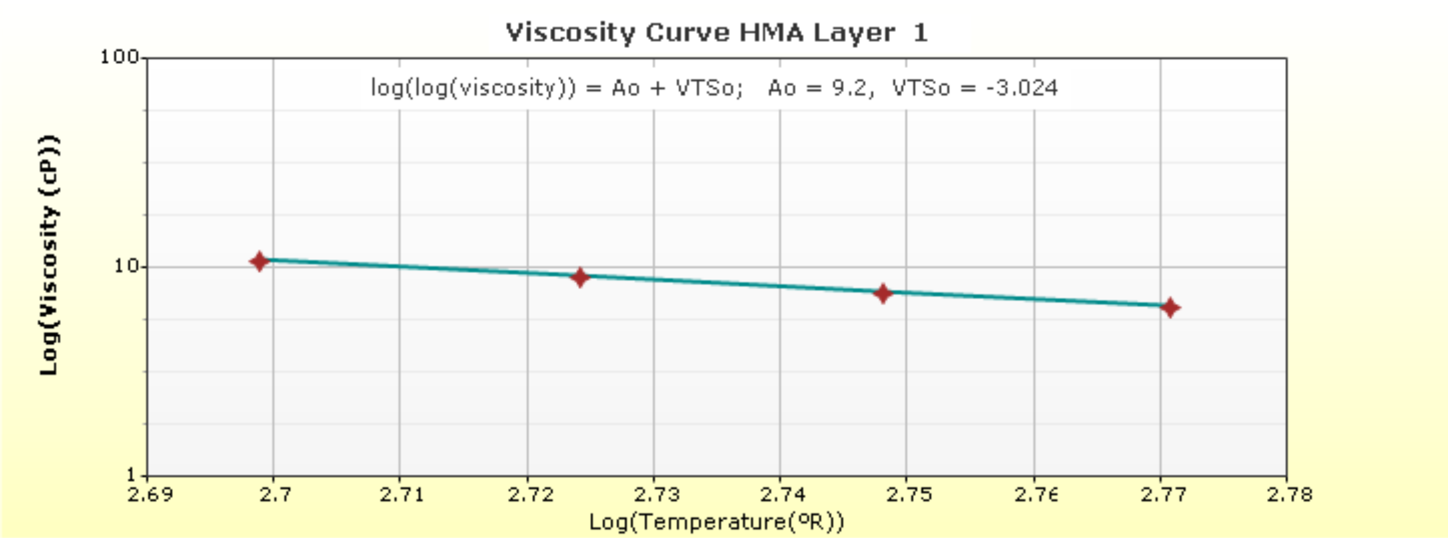
Creep Compliance (1/psi) (Input Level: 3)			
Loading time (sec)	-4 ºF	14 ºF	32 ºF
1	5.34e-007	7.47e-007	1.00e-006
2	5.82e-007	8.66e-007	1.26e-006
5	6.53e-007	1.05e-006	1.71e-006
10	7.12e-007	1.22e-006	2.16e-006
20	7.76e-007	1.41e-006	2.72e-006
50	8.70e-007	1.71e-006	3.70e-006
100	9.49e-007	1.98e-006	4.66e-006



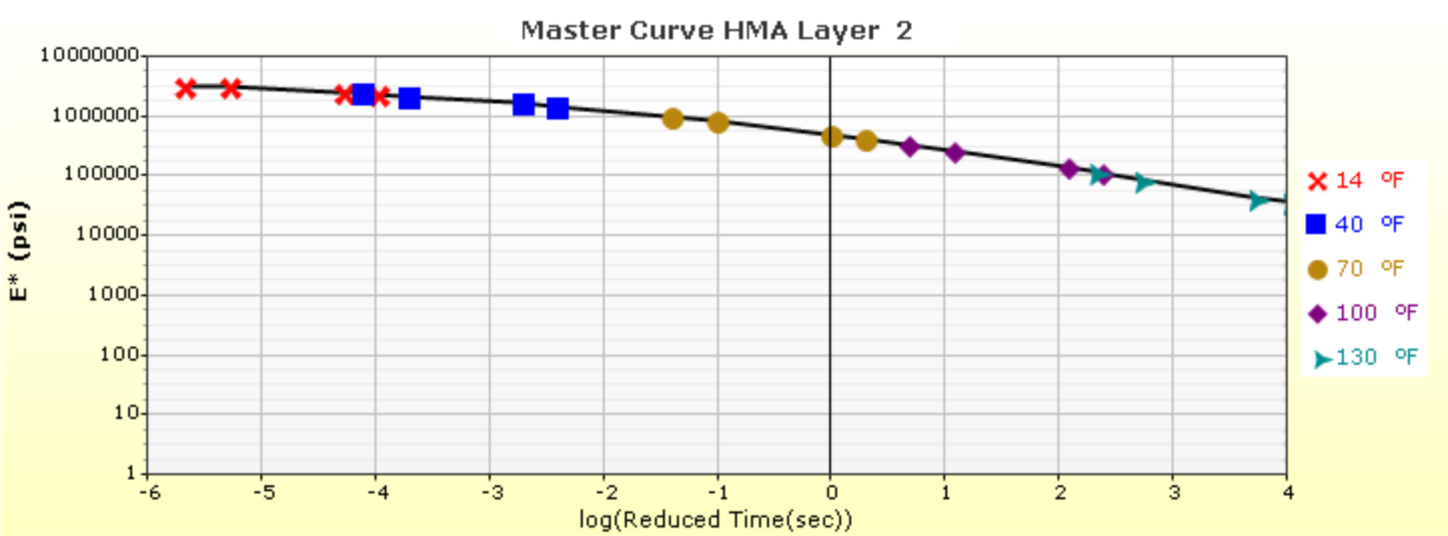
HMA Layer 1: Layer 1 Flexible : Default asphalt concrete

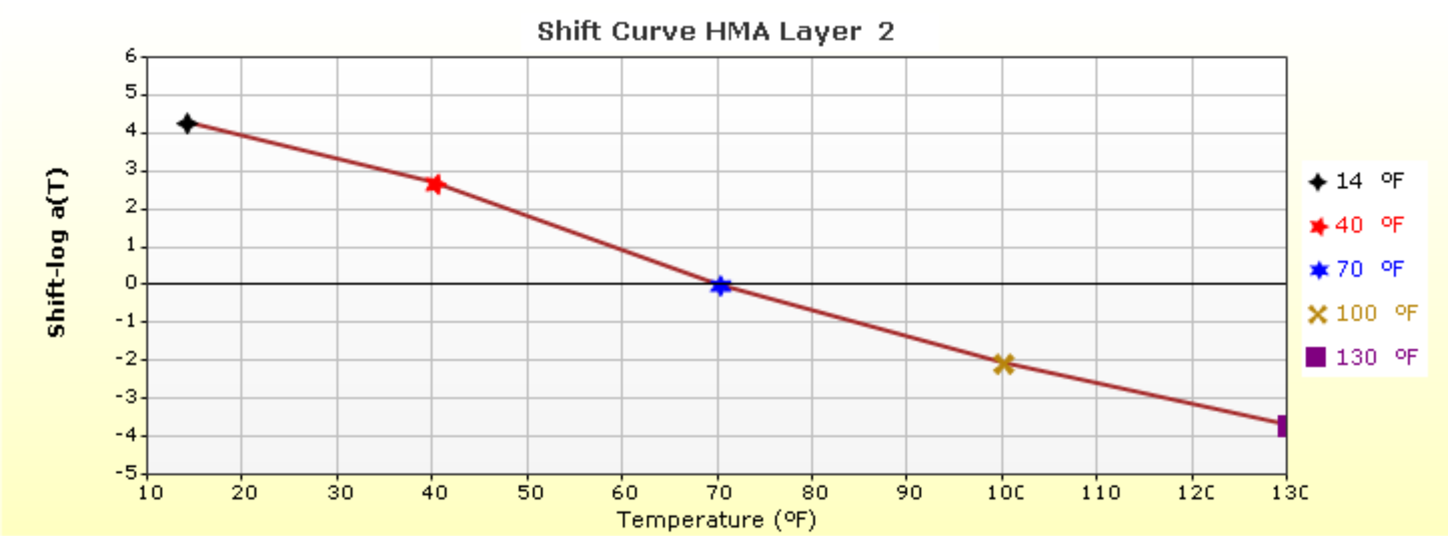


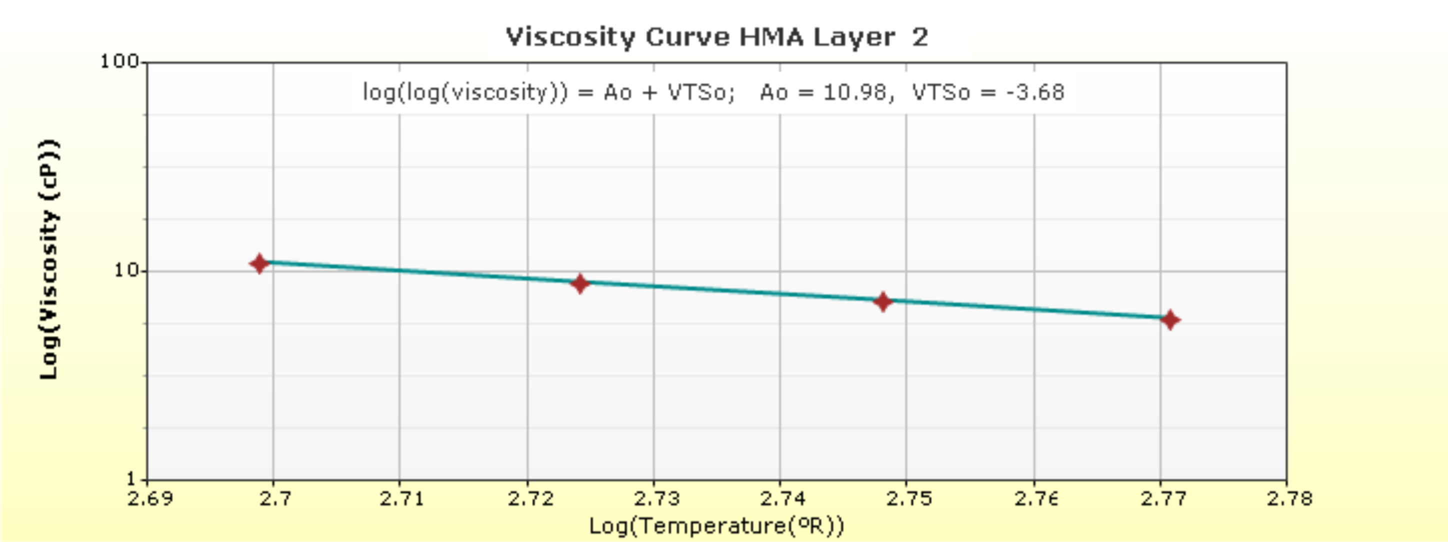




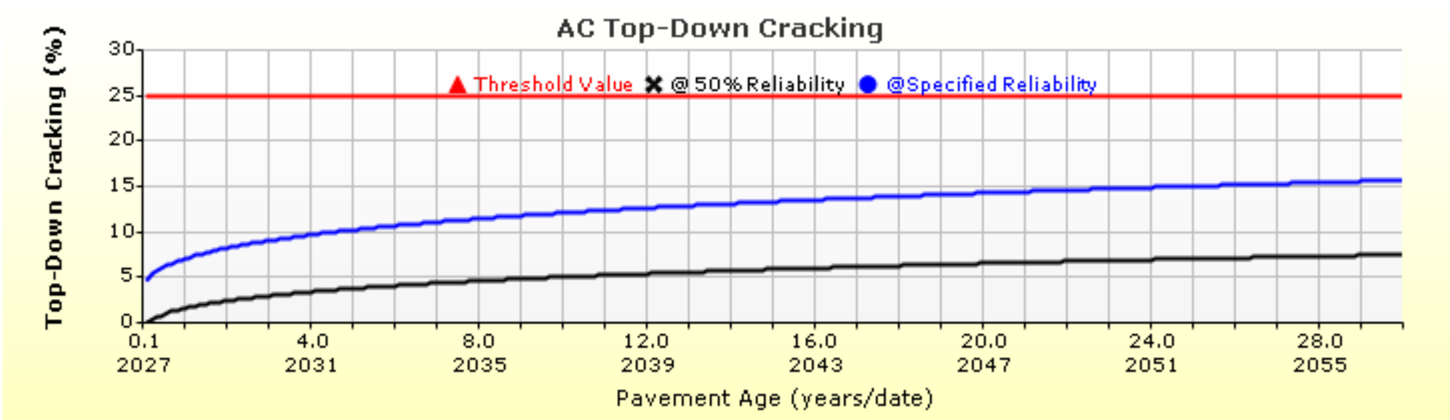
HMA Layer 2: Layer 2 Flexible : Default asphalt concrete



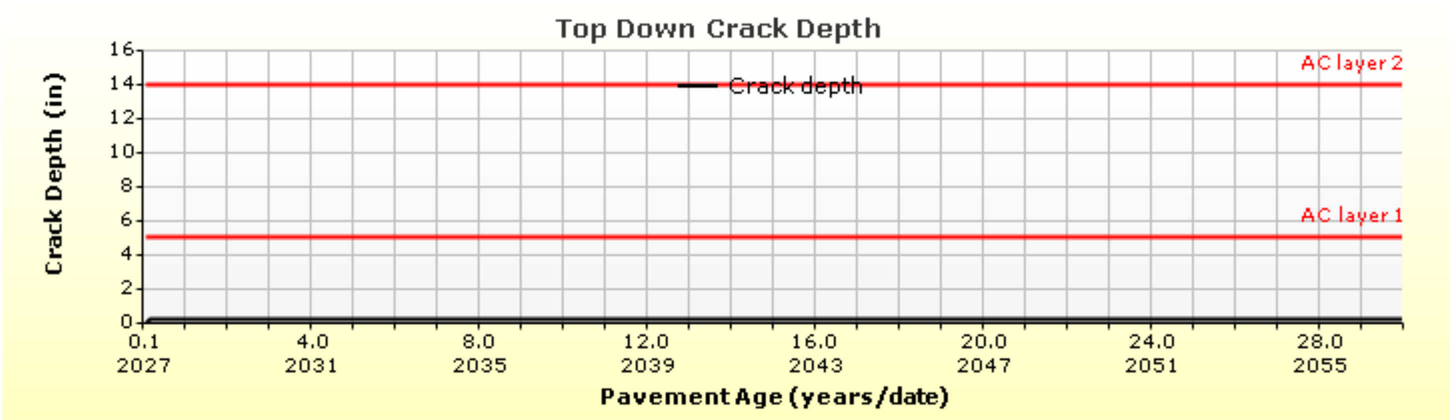




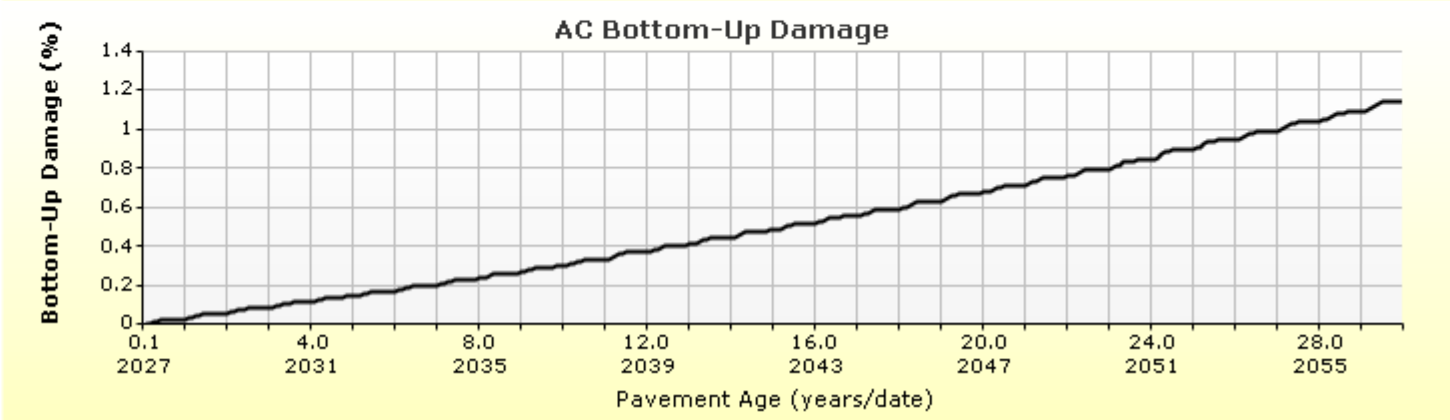
Analysis Output Charts



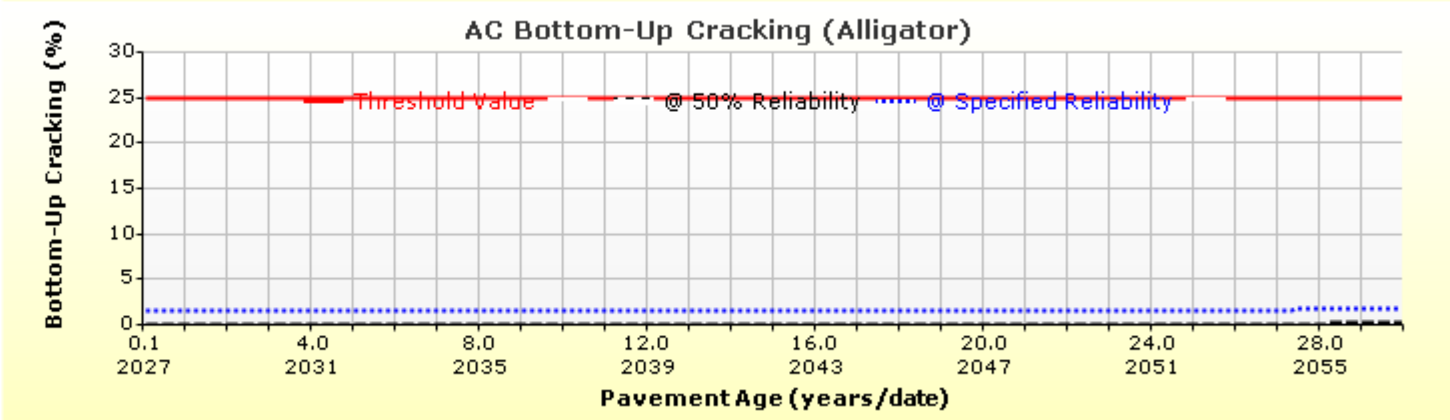
AC Top-Down Cracking
Threshold Value
@ 50% Reliability
@Specified Reliability
Top-Down Cracking (%)
Pavement Age (years/date)



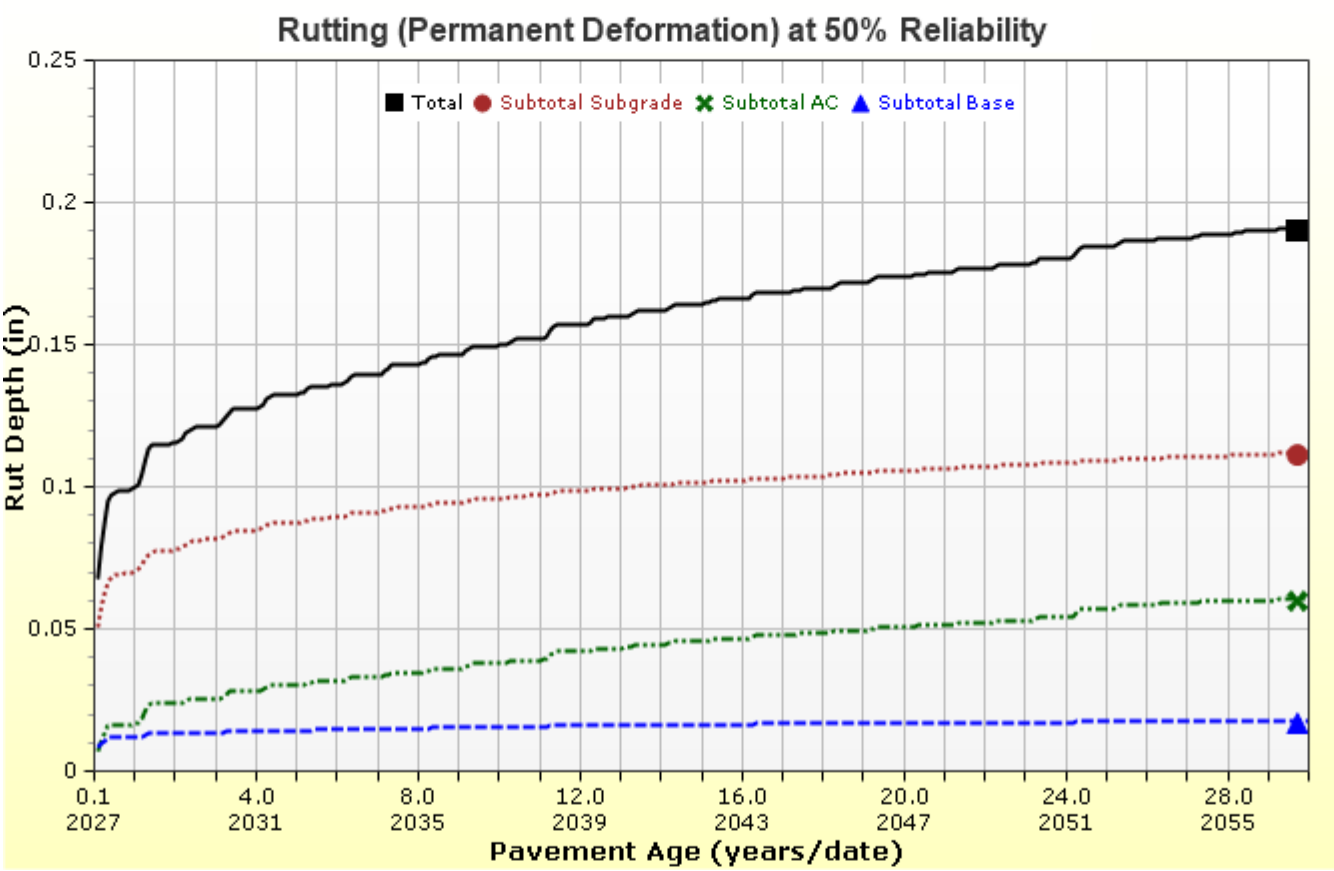
Top Down Crack Depth
AC layer 2
Crack depth
AC layer 1
Crack Depth (in)
Pavement Age (years/date)



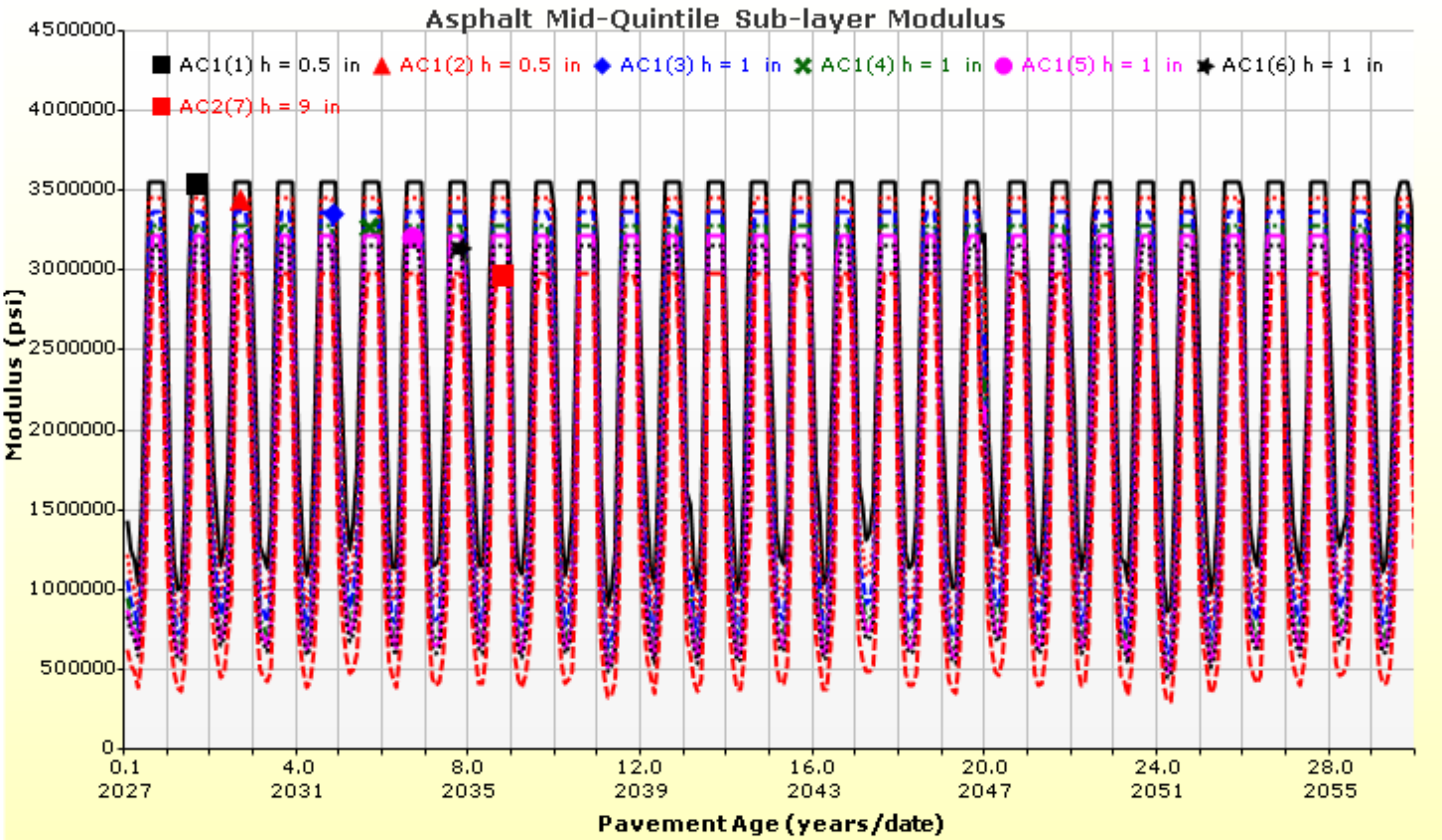
AC Bottom-Up Damage
Bottom-Up Damage (%)
Pavement Age (years/date)



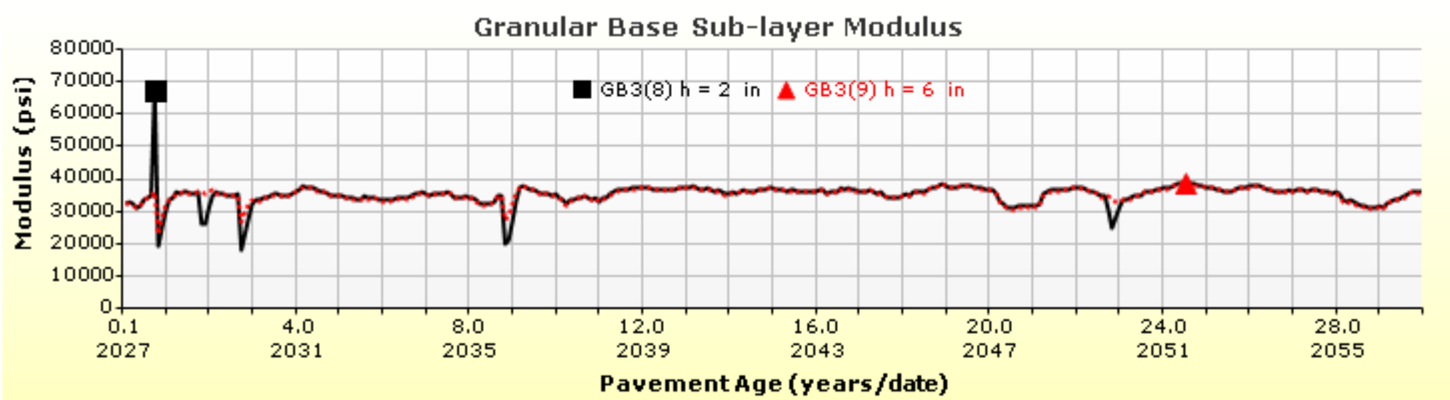
AC Bottom-Up Cracking (Alligator)
Threshold Value
@ 50% Reliability
@ Specified Reliability
Bottom-Up Cracking (%)
Pavement Age (years/date)



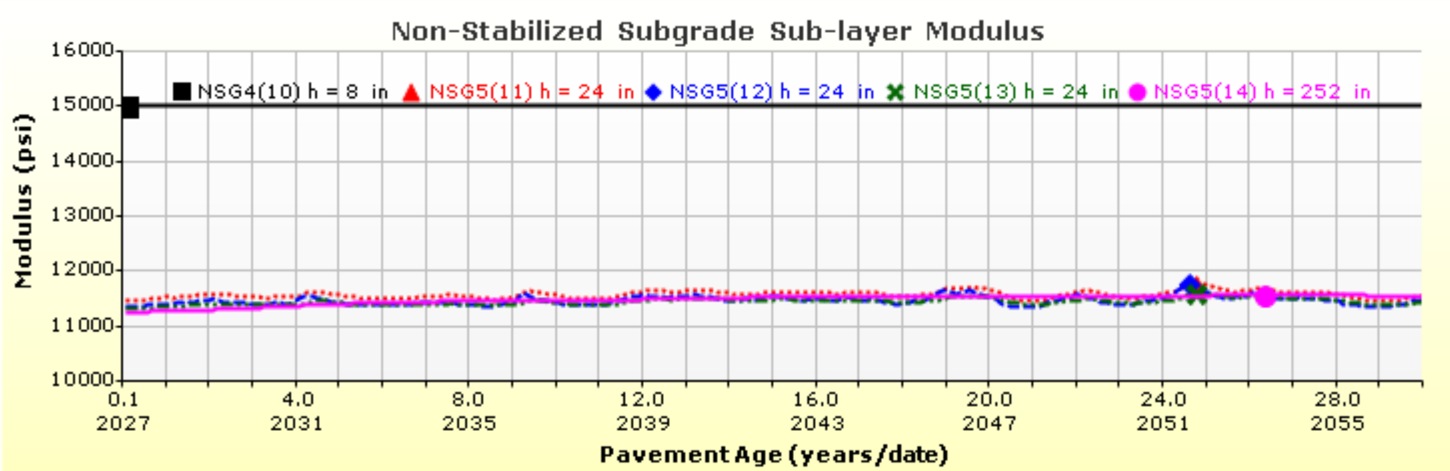
Rutting (Permanent Deformation) at 50% Reliability
Total
Subtotal Subgrade
Subtotal AC
Subtotal Base
Rut Depth (in)
0.25
0.2
0.15
0.1
0.05
0
0.1
2027
4.0
2031
8.0
2035
12.0
2039
16.0
2043
20.0
2047
24.0
2051
28.0
2055
Pavement Age (years/date)



Asphalt Mid-Quintile Sub-layer Modulus
AC1(1) h = 0.5 in
AC1(2) h = 0.5 in
AC1(3) h = 1 in
AC1(4) h = 1 in
AC1(5) h = 1 in
AC1(6) h = 1 in
AC2(7) h = 9 in
Modulus (psi)
Pavement Age (years/date)



Granular Base Sub-layer Modulus
GB3(8) h = 2 in
GB3(9) h = 6 in
Modulus (psi)
Pavement Age (years/date)



Non-Stabilized Subgrade Sub-layer Modulus
NSG4(10) h = 8 in
NSG5(11) h = 24 in
NSG5(12) h = 24 in
NSG5(13) h = 24 in
NSG5(14) h = 252 in
Modulus (psi)
Pavement Age (years/date)

Layer Information

Layer 1 Flexible : Default asphalt concrete

Asphalt		
Thickness (in)	5.0	
Unit weight (pcf)	150.0	
Poisson's ratio	Is Calculated?	False
	Ratio	0.35
	Parameter A	-
	Parameter B	-

Asphalt Dynamic Modulus (Input Level: 3)

Gradation	Percent Passing
3/4-inch sieve	100
3/8-inch sieve	77
No.4 sieve	60
No.200 sieve	6

Asphalt Binder

Parameter	Value
Grade	Superpave Performance Grade
Binder Type	76-28
A	9.2
VTS	-3.024

General Info

Name	Value
Reference temperature (ºF)	70
Effective binder content (%)	11
Air voids (%)	6.5
Thermal conductivity (BTU/hr-ft-ºF)	0.67
Heat capacity (BTU/lb-ºF)	0.23
Asphalt content by weight (%)	6
Aggregate parameter	0.4021

Identifiers

Field	Value
Display name/identifier	Default asphalt concrete
Description of object	
Author	
Date Created	10/30/2010 12:00:00 AM
Approver	
Date approved	10/30/2010 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Layer 2 Flexible : Default asphalt concrete

Asphalt		
Thickness (in)	9.0	
Unit weight (pcf)	150.0	
Poisson's ratio	Is Calculated?	False
	Ratio	0.35
	Parameter A	-
	Parameter B	-

Asphalt Dynamic Modulus (Input Level: 3)

Gradation	Percent Passing
3/4-inch sieve	100
3/8-inch sieve	77
No.4 sieve	60
No.200 sieve	6

Asphalt Binder

Parameter	Value
Grade	Superpave Performance Grade
Binder Type	64-22
A	10.98
VTS	-3.68

General Info

Name	Value
Reference temperature (ºF)	70
Effective binder content (%)	11
Air voids (%)	6.5
Thermal conductivity (BTU/hr-ft-ºF)	0.67
Heat capacity (BTU/lb-ºF)	0.23
Asphalt content by weight (%)	-
Aggregate parameter	-

Identifiers

Field	Value
Display name/identifier	Default asphalt concrete
Description of object	
Author	
Date Created	10/30/2010 12:00:00 AM
Approver	
Date approved	10/30/2010 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Layer 3 Non-stabilized Base : Crushed stone

Unbound	
Layer thickness (in)	8.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
25000.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Crushed stone
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	6.0
Plasticity Index	1.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	127.2
Saturated hydraulic conductivity (ft/hr)	False	5.054e-02
Specific gravity of solids	False	2.7
Water Content (%)	False	7.4

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	7.2555
bf	1.3328
cf	0.8242
hr	117.4000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	8.7
#100	
#80	12.9
#60	
#50	
#40	20.0
#30	
#20	
#16	
#10	33.8
#8	
#4	44.7
3/8-in.	57.2
1/2-in.	63.1
3/4-in.	72.7
1-in.	78.8
1 1/2-in.	85.8
2-in.	91.6
2 1/2-in.	
3-in.	
3 1/2-in.	97.6

Layer 4 Subgrade : Stabilized Subgrade

Unbound	
Layer thickness (in)	8.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Annual representative values
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
15000.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Stabilized Subgrade
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	32.0
Plasticity Index	15.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	True	121.9
Saturated hydraulic conductivity (ft/hr)	False	7.663e-06
Specific gravity of solids	False	2.7
Water Content (%)	True	10

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	75.5741
bf	0.9351
cf	0.4315
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	24.8
#100	
#80	32.4
#60	
#50	
#40	43.5
#30	
#20	
#16	
#10	59.4
#8	
#4	67.2
3/8-in.	78.8
1/2-in.	83.3
3/4-in.	90.4
1-in.	94.5
1 1/2-in.	97.7
2-in.	99.4
2 1/2-in.	
3-in.	
3 1/2-in.	99.9

Layer 5 Subgrade : A-6

Unbound	
Layer thickness (in)	Semi-infinite
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
5600.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	A-6
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	26.0
Plasticity Index	13.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	True	115.3
Saturated hydraulic conductivity (ft/hr)	False	1.709e-05
Specific gravity of solids	False	2.7
Water Content (%)	True	22

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	106.0536
bf	0.6958
cf	0.2316
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	72.4
#100	
#80	
#60	
#50	
#40	93.0
#30	
#20	
#16	
#10	97.0
#8	
#4	99.0
3/8-in.	100.0
1/2-in.	100.0
3/4-in.	100.0
1-in.	100.0
1 1/2-in.	100.0
2-in.	100.0
2 1/2-in.	
3-in.	
3 1/2-in.	100.0

Calibration Coefficients

AC Fatigue

$$N_f = 0.00432 * C * \beta_{f1} k_1 \left(\frac{1}{\varepsilon_1}\right)^{k_2 \beta_{f2}} \left(\frac{1}{E}\right)^{k_3 \beta_{f3}}$$

$$C = 10^M$$

$$M = 4.84\left(\frac{V_b}{V_a + V_b} - 0.69\right)$$

k1: 3.75	
k2: 2.87	
k3: 1.46	
Bf1: 0.001032	
Bf2: 1.38	
Bf3: 0.88	

AC Rutting

$$\frac{\varepsilon_p}{\varepsilon_r} = k_z \beta_{r1} 10^{k_1} T^{k_2 \beta_{r2}} N^{k_3 \beta_{r3}}$$

$$k_z = (C_1 + C_2 * depth) * 0.328196^{depth}$$

$$C_1 = -0.1039 * H_\alpha^2 + 2.4868 * H_\alpha - 17.342$$

$$C_2 = 0.0172 * H_\alpha^2 - 1.7331 * H_\alpha + 27.428$$

Where:

$H_{ac} = total\ AC\ thickness (in)$

$\varepsilon_p = plastic\ strain (in/in)$

$\varepsilon_r = resilient\ strain (in/in)$

$T = layer\ temperature (°F)$

$N = number\ of\ load\ repetitions$

acRuttingStandardDeviation	0.24 * Pow(RUT,0.8026) + 0.001	
AC Layer 1	K1:-2.45 K2:3.01 K3:0.22	Br1:0.4 Br2:0.52 Br3:1.36
AC Layer 2	K1:-2.45 K2:3.01 K3:0.22	Br1:0.4 Br2:0.52 Br3:1.36

Thermal Fracture

$$C_f = \beta_{t1} N \left[\frac{1}{\sigma_d} log\left(\frac{C}{h_{AC}}\right)\right]$$

$$\Delta C = A(\Delta K)^n$$

$$A = k_t \beta_t 10^{[4.389 - 2.52\log(E_{HMA} \sigma_m n)]}$$

Cf = Observed amount of thermal cracking, ft. / 500ft.
β_{t1} = Regression coefficient determined through global calibration (400)
N[z] = Standard normal distribution evaluated at [z]
σ_d = Standard deviation of the logarithm of crack depth in the pavement (0.769), in.
C = Crack depth, in.
h_{AC} = Thickness of asphalt layer, in.
ΔC = Change in the crack depth due to a cooling cycle
ΔK = Change in the stress intensity factor due to a cooling cycle
A, n = Fracture parameters for the asphalt mixture
E = Asphalt mixture stiffness, MPa
σ_m = Undamaged mixture tensile strength, MPa
k_t = Regression coefficient determined through field calibration
β_t = Calibration parameter

Level 1 K: (0.13 * Pow(MAAT,2) - 11.68 * MAAT + 244.14) * 1 + 0	Level 1 Standard Deviation: 0.14 * THERMAL + 343
Level 2 K: (0.13 * Pow(MAAT,2) - 11.68 * MAAT + 244.14) * 1 + 0	Level 2 Standard Deviation: 0.20 * THERMAL + 343
Level 3 K: (0.13 * Pow(MAAT,2) - 11.68 * MAAT + 244.14) * 1 + 0	Level 3 Standard Deviation: 0.2386 * THERMAL + 343

CSM Fatigue

$$N_f = 10^{\left(\frac{k_1 \beta_{c1} \left(\frac{\sigma_s}{M_r}\right)}{k_2 \beta_{c2}}\right)}$$

$N_f = number\ of\ repetitions\ to\ fatigue\ cracking$

$\sigma_s = Tensile\ stress (psi)$

$M_r = modulus\ of\ rupture (psi)$

k1: 0.972	k2: 0.0825	Bc1: 1	Bc2:1

Unbound Layer Rutting

$$\delta_a(N) = \beta_{s_1} k_1 \varepsilon_v h \left(\frac{\varepsilon_0}{\varepsilon_r}\right) \left| e^{-\left(\frac{\rho}{N}\right)^{\beta}} \right|$$

δ_a = permanent deformation for the layer
N = number of repetitions
ε_v = average veritcal strain(in/in)
$\varepsilon_0, \beta, \rho$ = material properties
ε_r = resilient strain(in/in)

Base Rutting		**Subgrade Rutting**	
k1: 0.965	Bs1: 1	k1: 0.675	Bs1: 1
Standard Deviation (BASERUT) 0.1477 * Pow(BASERUT,0.6711) + 0.001		Standard Deviation (BASERUT) 0.1235 * Pow(SUBRUT,0.5012) + 0.001	

AC Cracking

AC Top Down Cracking

$$L(t) = L_{Max} e^{-\left(\frac{C_1 \rho}{t - C_3 t_o}\right)^{C_2 \beta}}$$

$$t_0(\text{Days}) = \frac{k_{L1}}{1 + e^{(k_{L2} \times 100 \times a_0/2A_0) + (k_{L3} \times HT) + (k_{L4} \times LT) + (k_{L5} \times \log_{10} AADTT)}}$$

c1: 2.5219	c2: 0.8069	c3: 1
kL1: 64271618	kL2: 0.2855	kL3: 0.011
kL4: 0.01488	kL5: 3.266	
acCrackingTopStandardDeviation		
0.3657 * TOP + 3.6563		

AC Bottom Up Cracking

$$FC = \left(\frac{6000}{1 + e^{(C_1 * C_1' + C_2 * C_2' \log_{10}(D * 100))}}\right) * \left(\frac{1}{60}\right)$$

$$C_2' = -2.40874 - 39.748 * (1 + h_{ac})^{-2.856}$$

$$C_1' = -2 * C_2'$$

c1: 1.31	c2: 3.9666	c3: 6000
acCrackingBottomStandardDeviation		
1.13 + 13/(1+exp(7.57-15.5*LOG10(BOTTOM+0.0001)))		

CSM Cracking

$$FC_{ctb} = C_1 + \frac{C_2}{1 + e^{C_3 - C_4 * \log_{10}(Damage)}}$$

C1: 0	C2: 75	C3: 2	C4: 2
csmCrackingStandardDeviation			
CTB*1			

IRI Flexible Pavements

C1 - Rutting
C2 - Fatigue Crack
C3 - Transverse Crack
C4 - Site Factors

C1: 40	C2: 0.4	C3: 0.008	C4: 0.015

22119 New Mainline PCC 12

File Name: C:\Users\kkb\OneDrive\Documents\My ME Design\Projects\2022\22119\22119 New Mainline PCC 12.dgpx

Design Inputs

Design Life: 30 years

Design Type: JPCP

Existing construction: -

Pavement construction: May, 2025

Traffic opening: May, 2027

Climate Data Sources (Lat/Lon): 35.389, -97.6

Design Structure

Layer type	Material Type	Thickness (in)
PCC	JPCP Default	12.0
Cement_Base	Cement Treated Base	4.0
NonStabilized	Crushed stone	8.0
Subgrade	Stabilized Subgrade	8.0
Subgrade	A-6	Semi-infinite

Joint Design:	
Joint spacing (ft)	15.0
Dowel diameter (in)	1.75
Slab width (ft)	12.0

Traffic

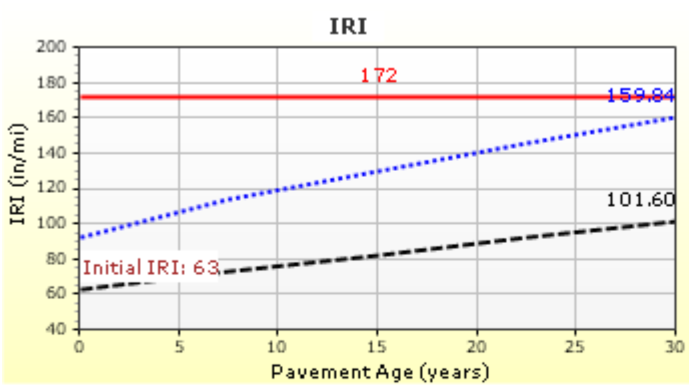
Age (year)	Heavy Trucks (cumulative)
2027 (initial)	13,914
2042 (15 years)	33,836,400
2057 (30 years)	79,375,700

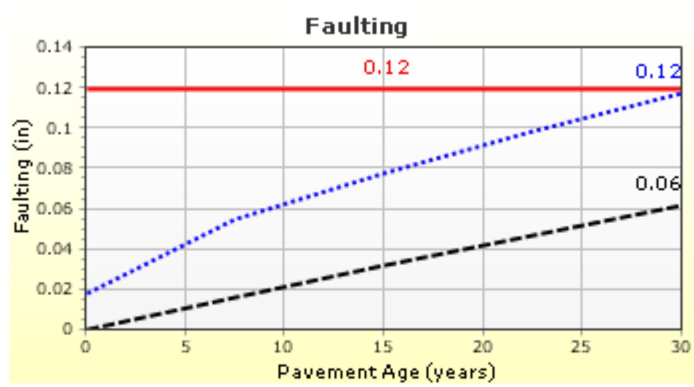
Design Outputs

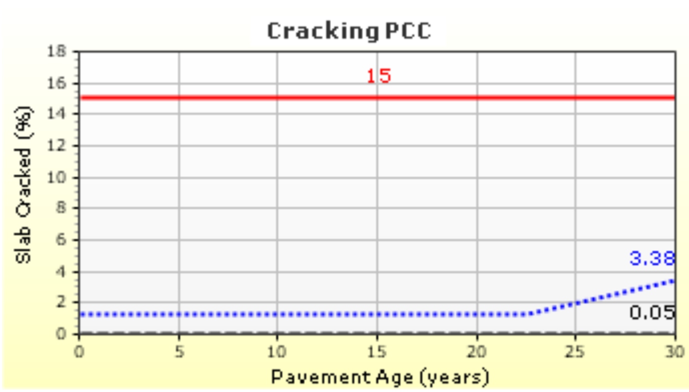
Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	172.00	159.84	95.00	97.66	Pass
Mean joint faulting (in)	0.12	0.12	95.00	95.69	Pass
JPCP transverse cracking (percent slabs)	15.00	3.38	95.00	100.00	Pass

Distress Charts



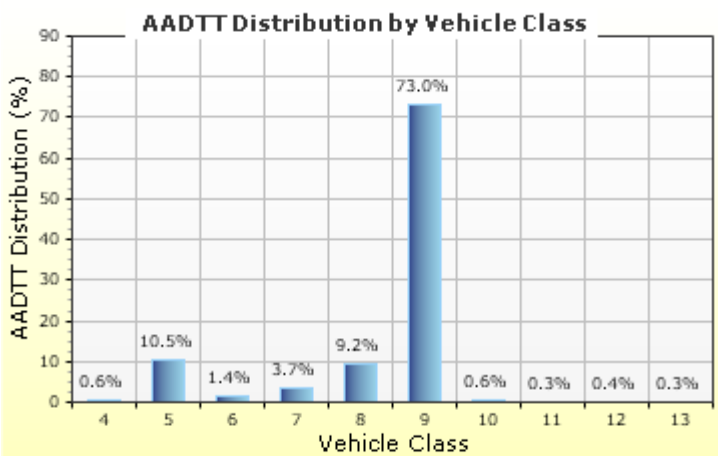


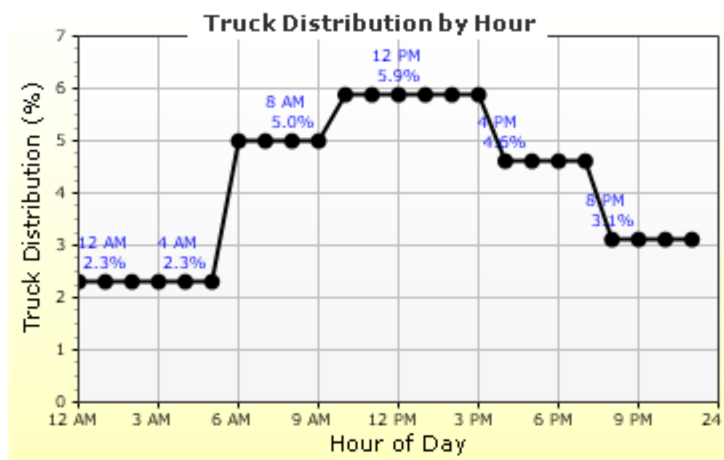


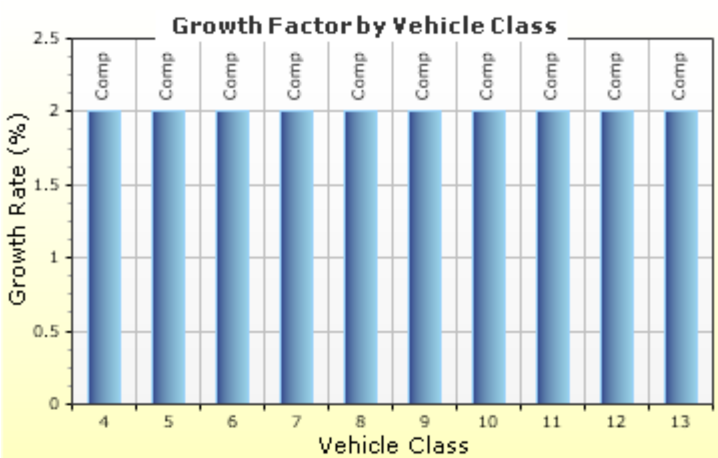
Traffic Inputs

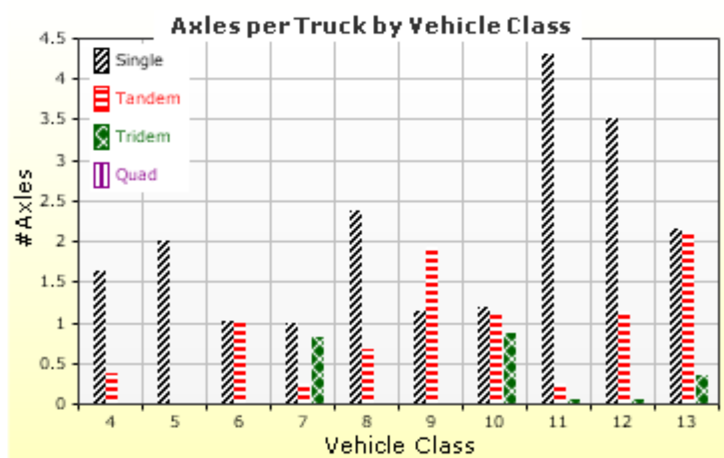
Graphical Representation of Traffic Inputs

Initial two-way AADTT:	13,914	Percent of trucks in design direction (%):	55.0
Number of lanes in design direction:	3	Percent of trucks in design lane (%):	70.0
		Operational speed (mph)	65.0

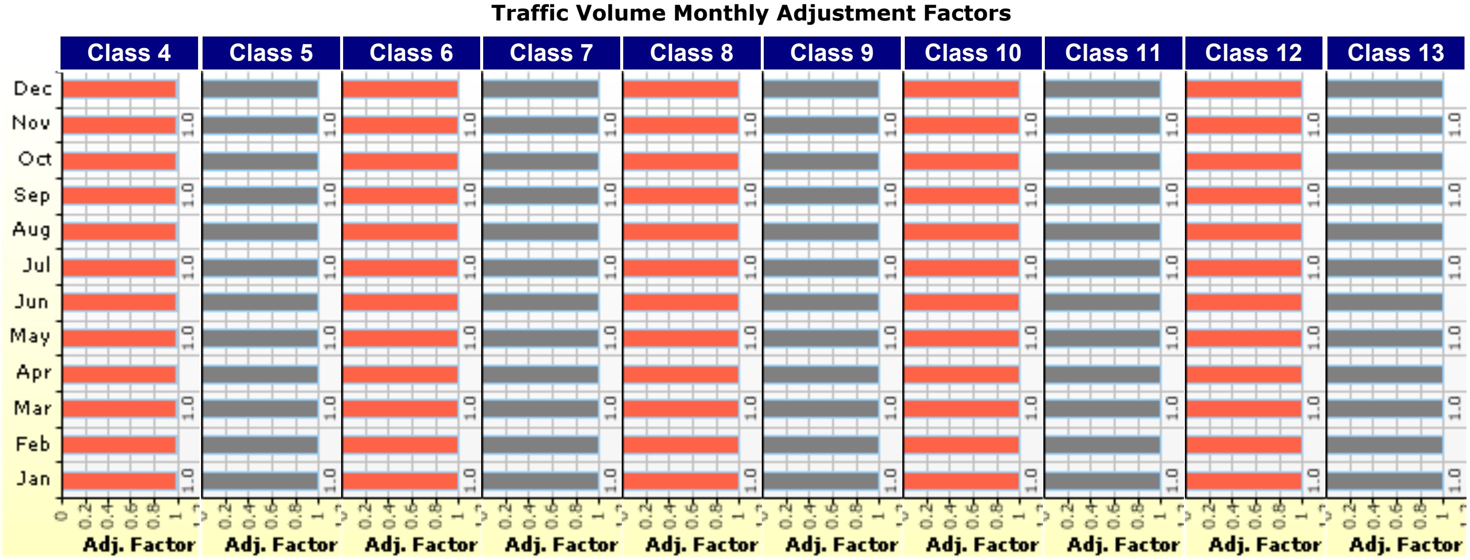








Traffic Volume Monthly Adjustment Factors



Tabular Representation of Traffic Inputs

Volume Monthly Adjustment Factors

Level 3: Default MAF

Month	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
January	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
February	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
March	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
April	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
May	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
June	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
July	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
August	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
September	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
October	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
November	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
December	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Distributions by Vehicle Class

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor	
		Rate (%)	Function
Class 4	0.6%	2%	Compound
Class 5	10.5%	2%	Compound
Class 6	1.4%	2%	Compound
Class 7	3.7%	2%	Compound
Class 8	9.2%	2%	Compound
Class 9	73%	2%	Compound
Class 10	0.6%	2%	Compound
Class 11	0.3%	2%	Compound
Class 12	0.4%	2%	Compound
Class 13	0.3%	2%	Compound

Truck Distribution by Hour

Hour	Distribution (%)	Hour	Distribution (%)
12 AM	2.3%	12 PM	5.9%
1 AM	2.3%	1 PM	5.9%
2 AM	2.3%	2 PM	5.9%
3 AM	2.3%	3 PM	5.9%
4 AM	2.3%	4 PM	4.6%
5 AM	2.3%	5 PM	4.6%
6 AM	5%	6 PM	4.6%
7 AM	5%	7 PM	4.6%
8 AM	5%	8 PM	3.1%
9 AM	5%	9 PM	3.1%
10 AM	5.9%	10 PM	3.1%
11 AM	5.9%	11 PM	3.1%
		Total	100%

Axle Configuration

Traffic Wander	
Mean wheel location (in)	18.0
Traffic wander standard deviation (in)	10.0
Design lane width (ft)	12.0

Axle Configuration	
Average axle width (ft)	8.5
Dual tire spacing (in)	12.0
Tire pressure (psi)	120.0

Average Axle Spacing	
Tandem axle spacing (in)	51.6
Tridem axle spacing (in)	49.2
Quad axle spacing (in)	49.2

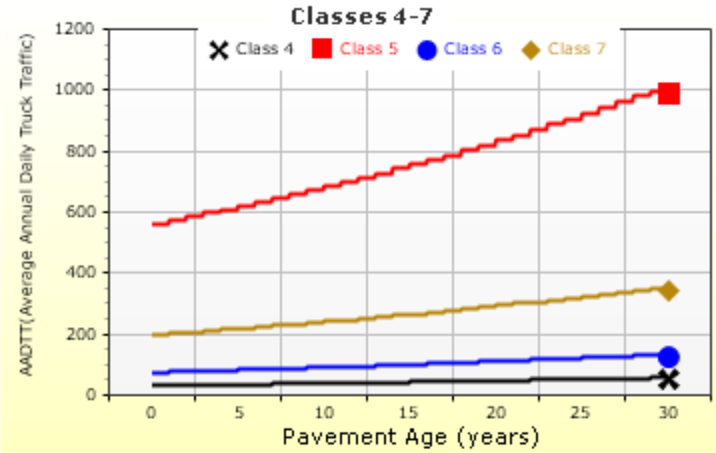
Wheelbase			
Value Type / Axle Type	Short	Medium	Long
Average spacing of axles (ft)	12.0	15.0	18.0
Percent of Trucks (%)	17.0	22.0	61.0

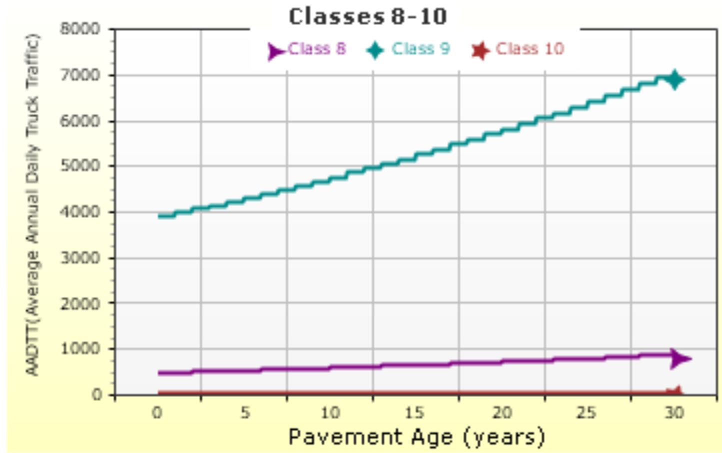
Number of Axles per Truck

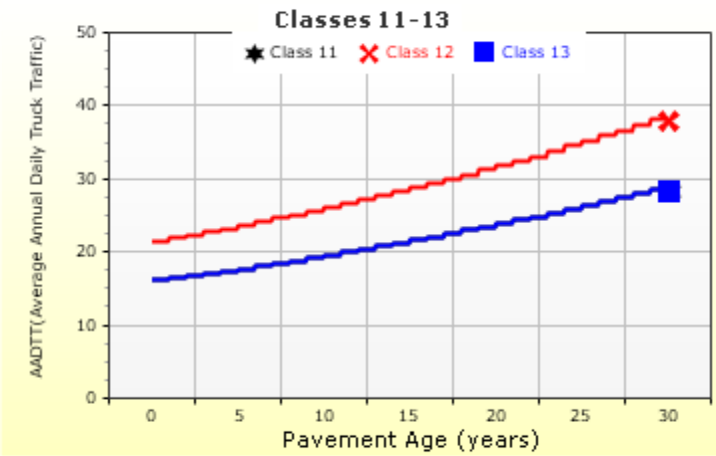
Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.62	0.39	0	0
Class 5	2	0	0	0
Class 6	1.02	0.99	0	0
Class 7	1	0.26	0.83	0
Class 8	2.38	0.67	0	0
Class 9	1.13	1.93	0	0
Class 10	1.19	1.09	0.89	0
Class 11	4.29	0.26	0.06	0
Class 12	3.52	1.14	0.06	0
Class 13	2.15	2.13	0.35	0

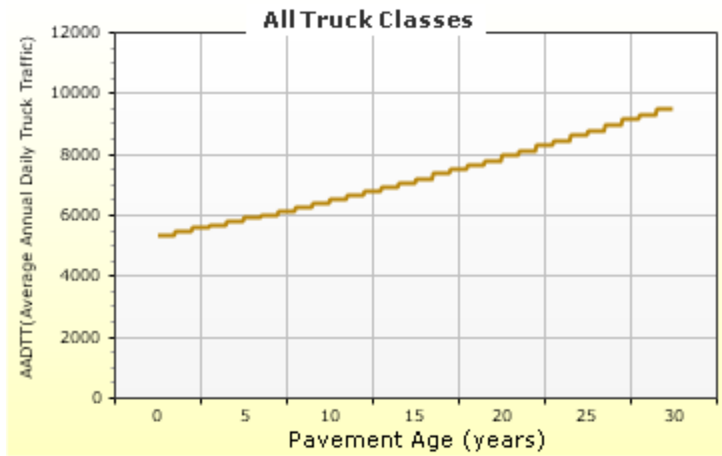
AADTT (Average Annual Daily Truck Traffic) Growth

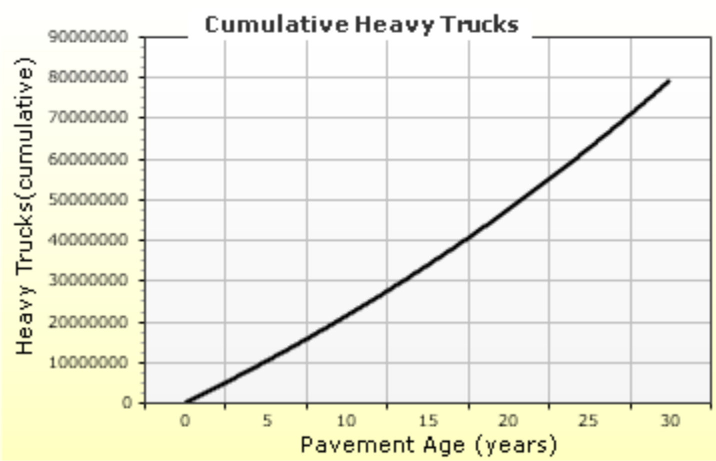
*** Traffic cap is not enforced**











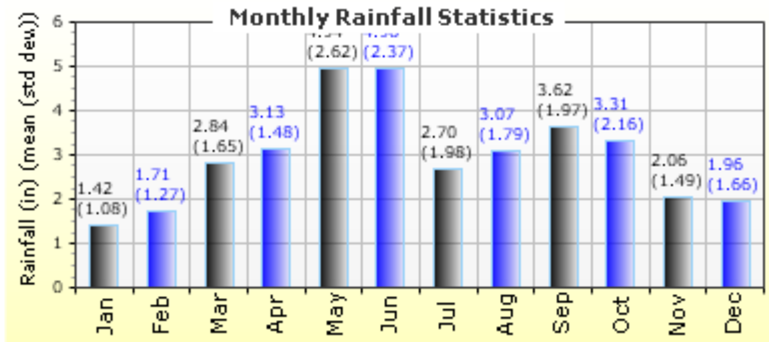
Climate Inputs

Climate Data Sources:

Climate Station Cities:	Location (lat lon elevation(ft))
OKLAHOMA CITY_NARR	35.38900 -97.60000 1274

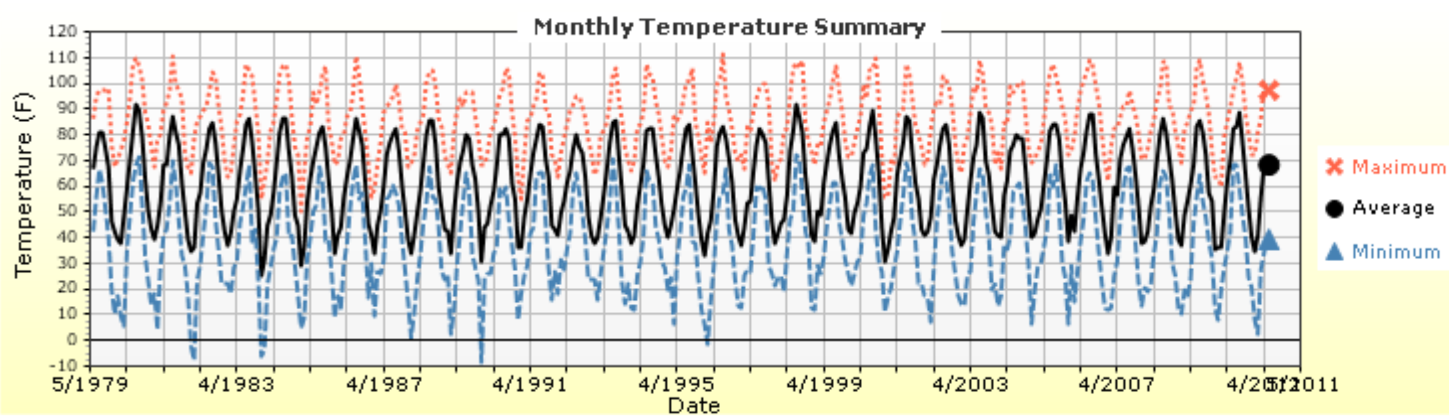
Annual Statistics:

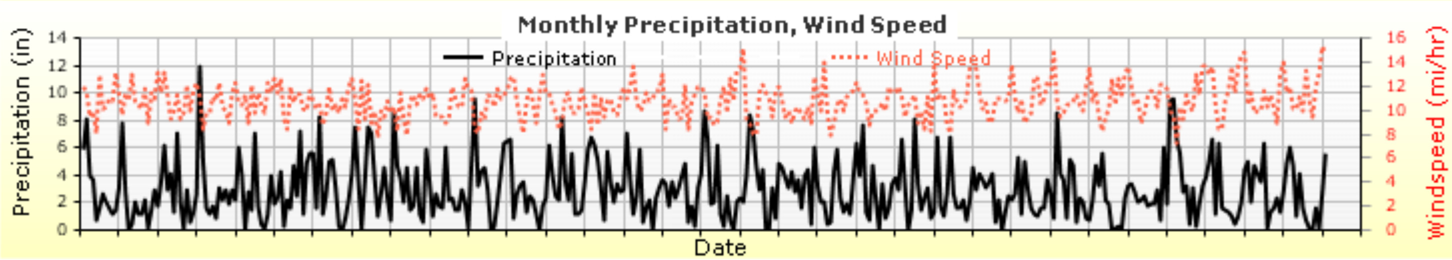
Mean annual air temperature (ºF)	61.19
Mean annual precipitation (in)	35.80
Freezing index (ºF - days)	130.68
Average annual number of freeze/thaw cycles:	41.56

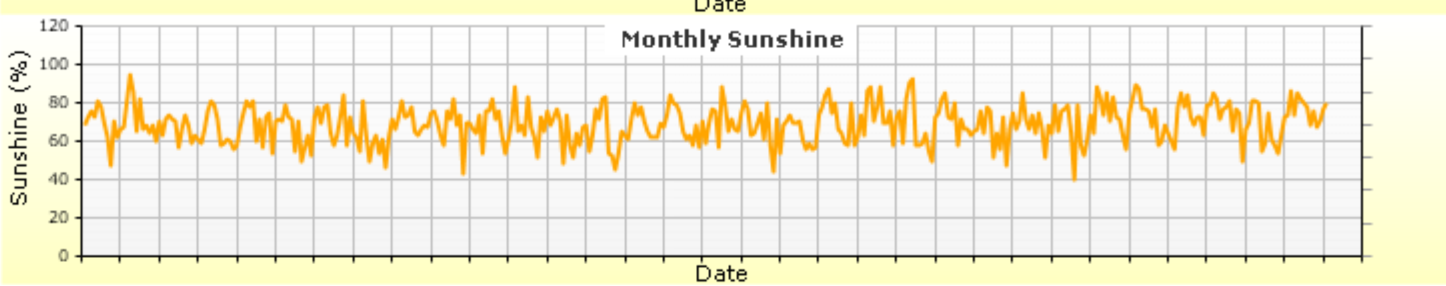


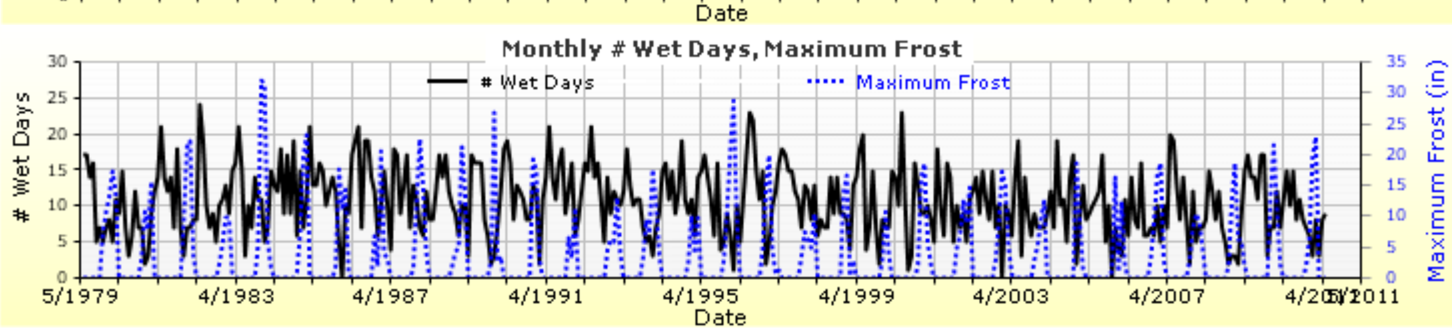
Water table depth (ft) 24.00

Monthly Climate Summary:

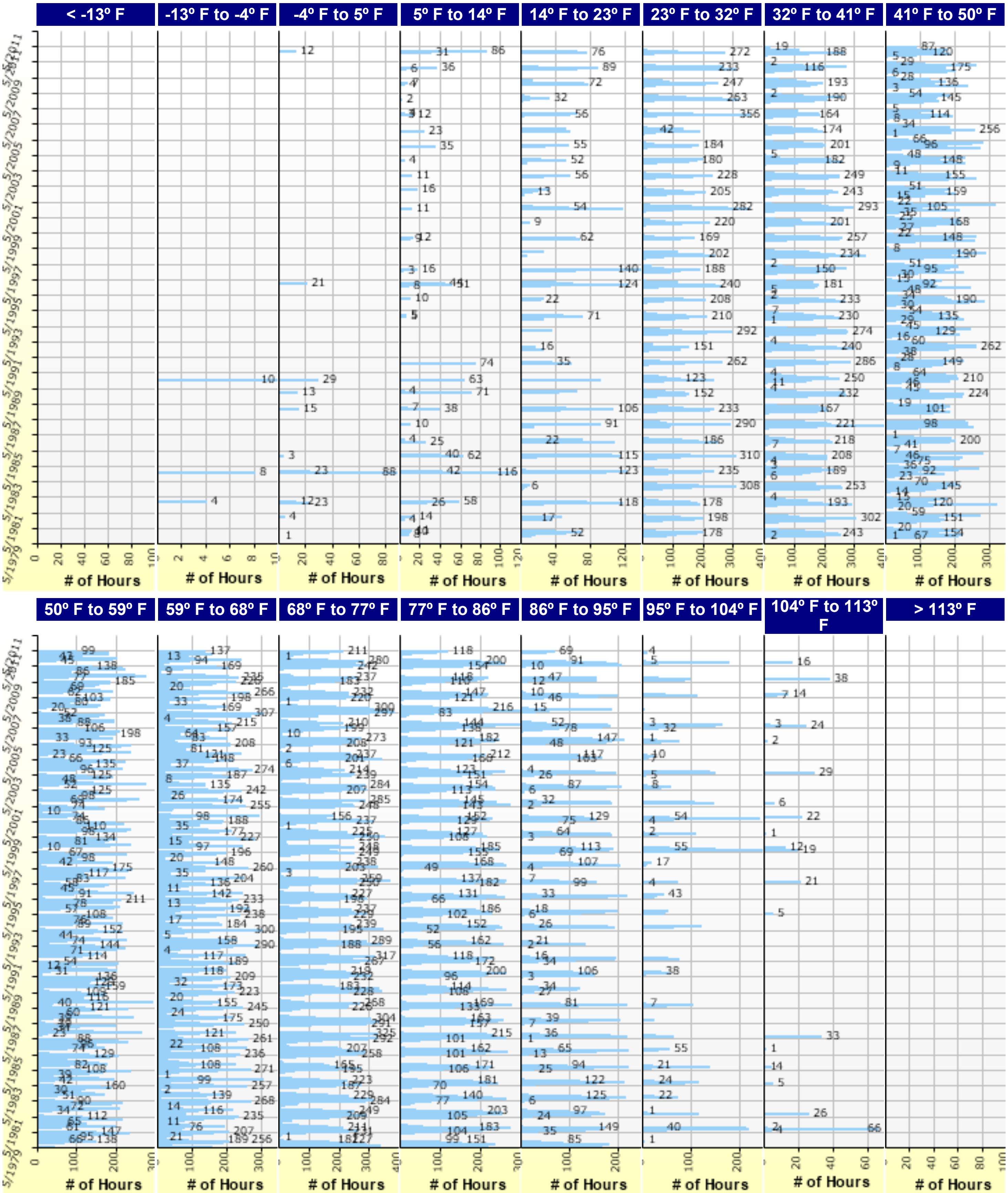








Hourly Air Temperature Distribution by Month:



Design Properties

JPCP Design Properties

Structure - ICM Properties	
PCC surface shortwave absorptivity	0.85

Doweled Joints	
Is joint doweled ?	True
Dowel diameter (in)	1.75
Dowel spacing (in)	12.00

Tied Shoulders	
Tied shoulders	False
Load transfer efficiency (%)	-

PCC joint spacing (ft)	
Is joint spacing random ?	False
Joint spacing (ft)	15.00

Widened Slab	
Is slab widened ?	False
Slab width (ft)	12.00

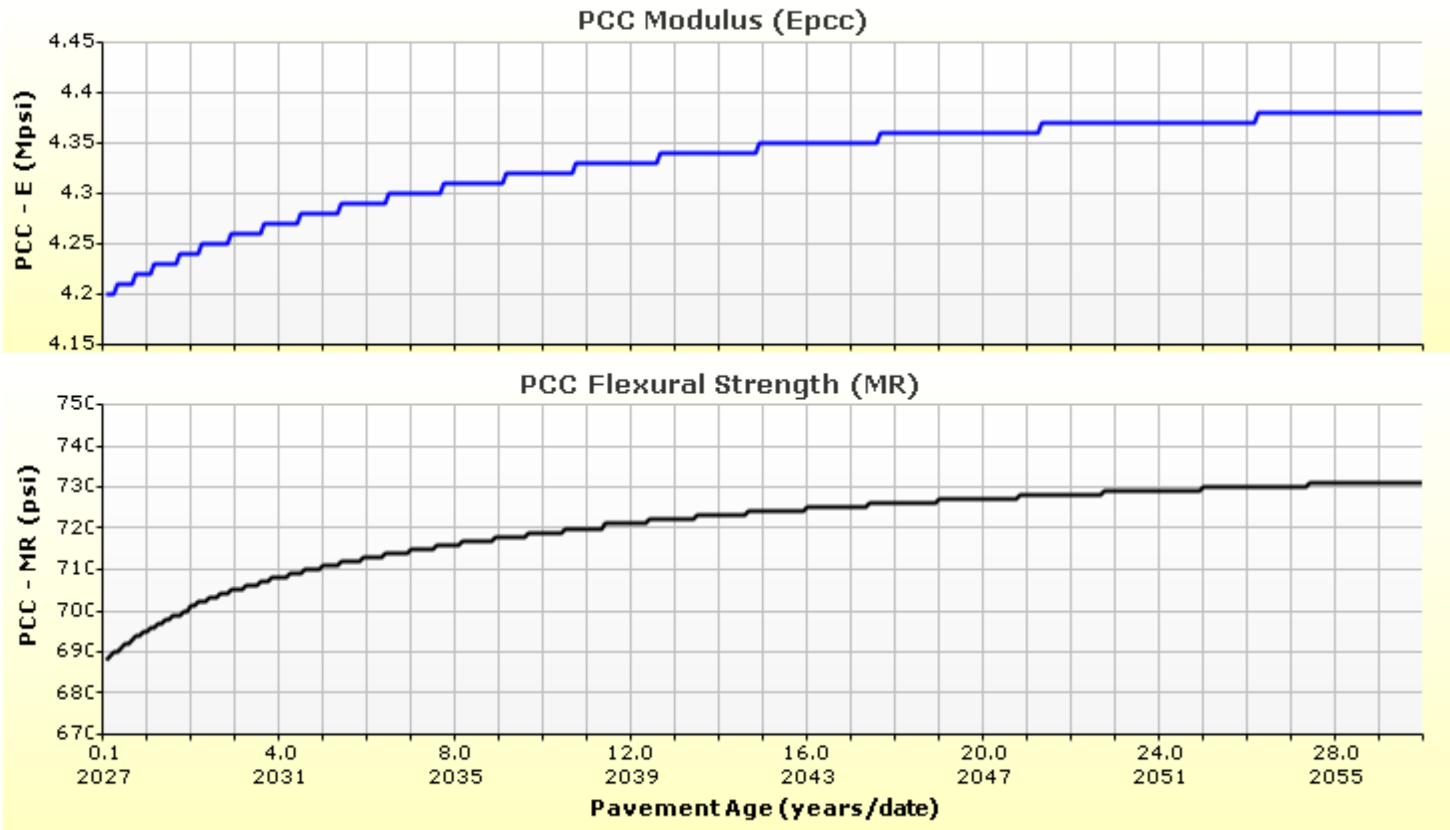
PCC-Base Contact Friction	
PCC-Base full friction contact	True
Months until friction loss	240.00

Sealant type	Preformed

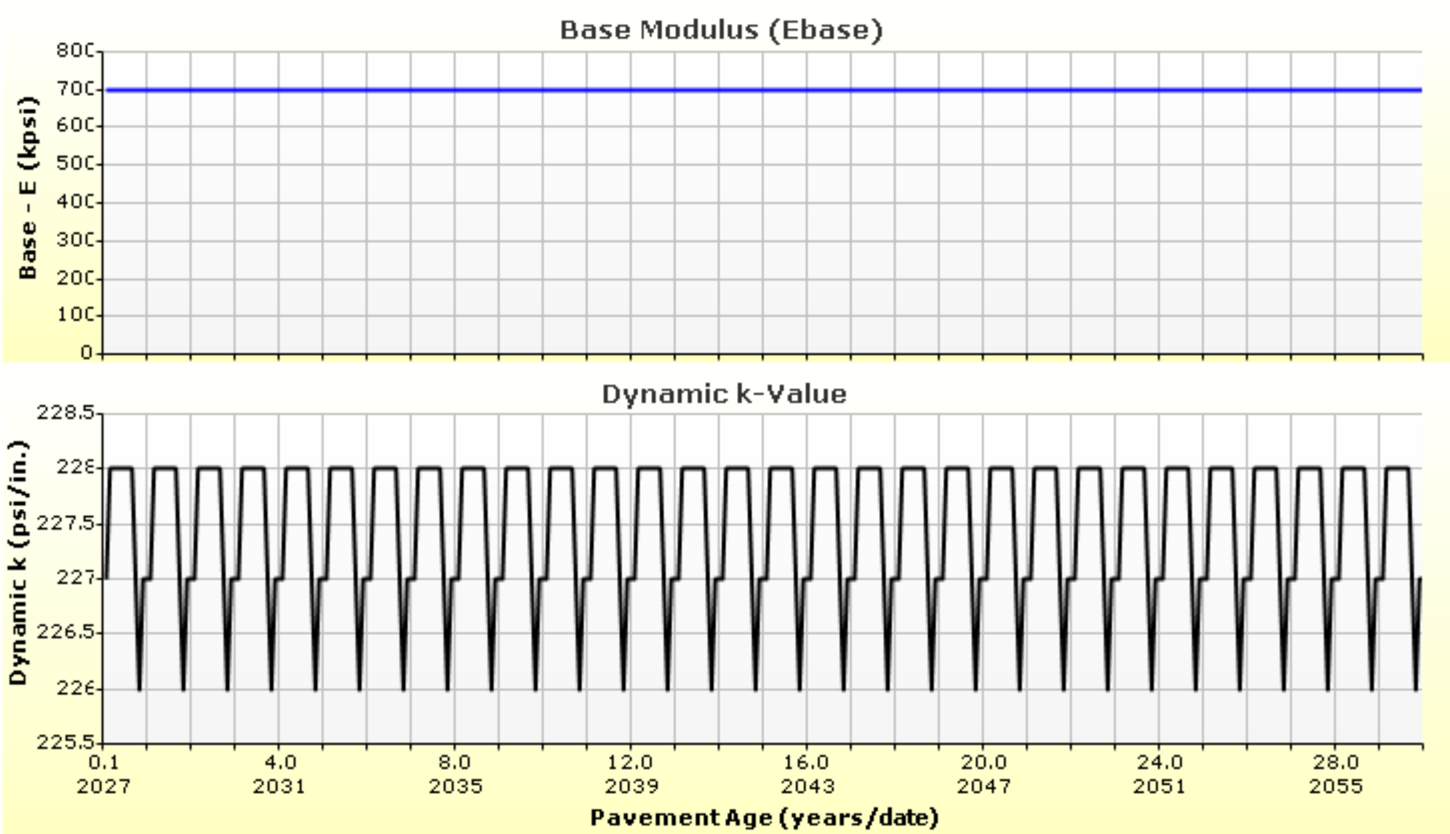
Erodibility index	4

Permanent curl/warp effective temperature difference (ºF)	-10.00

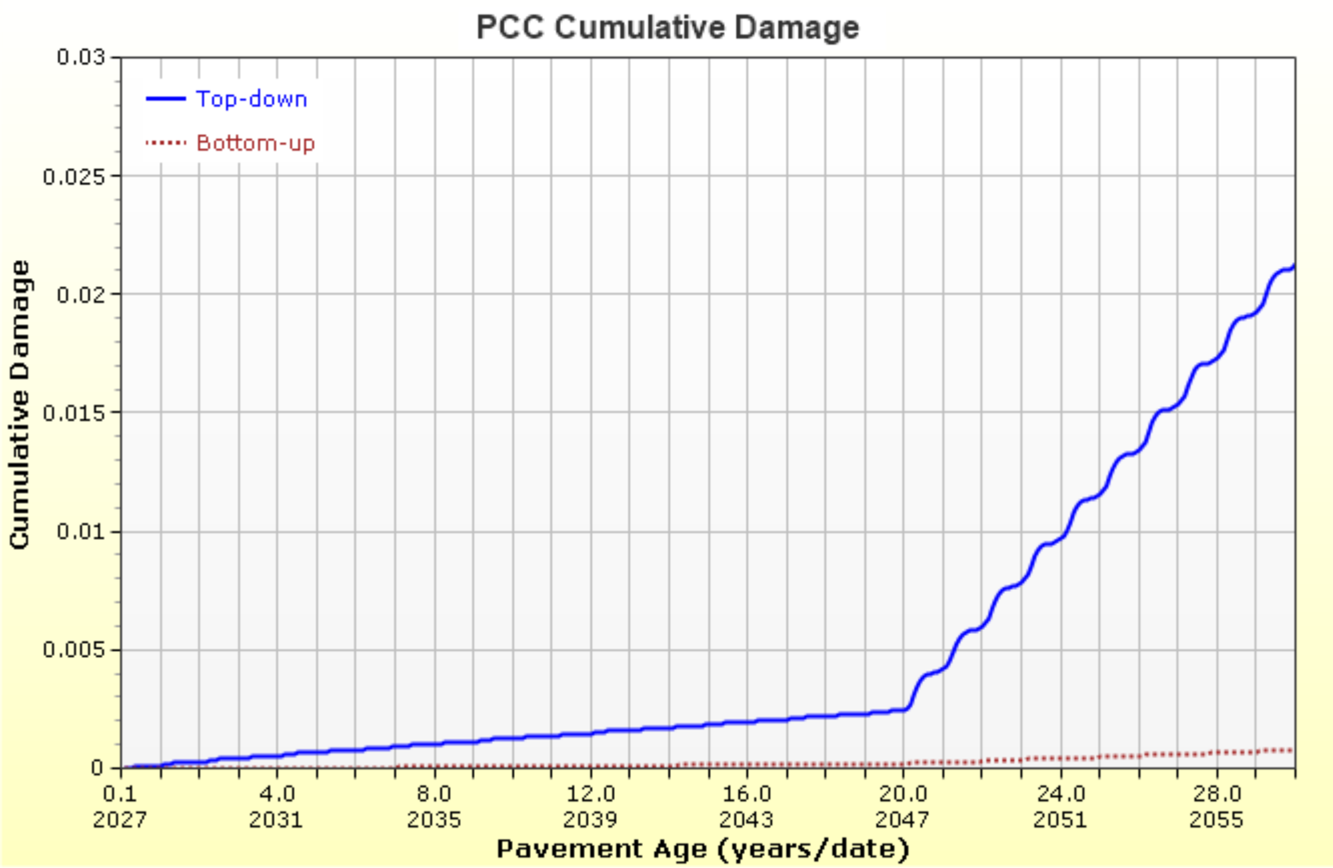
Analysis Output Charts



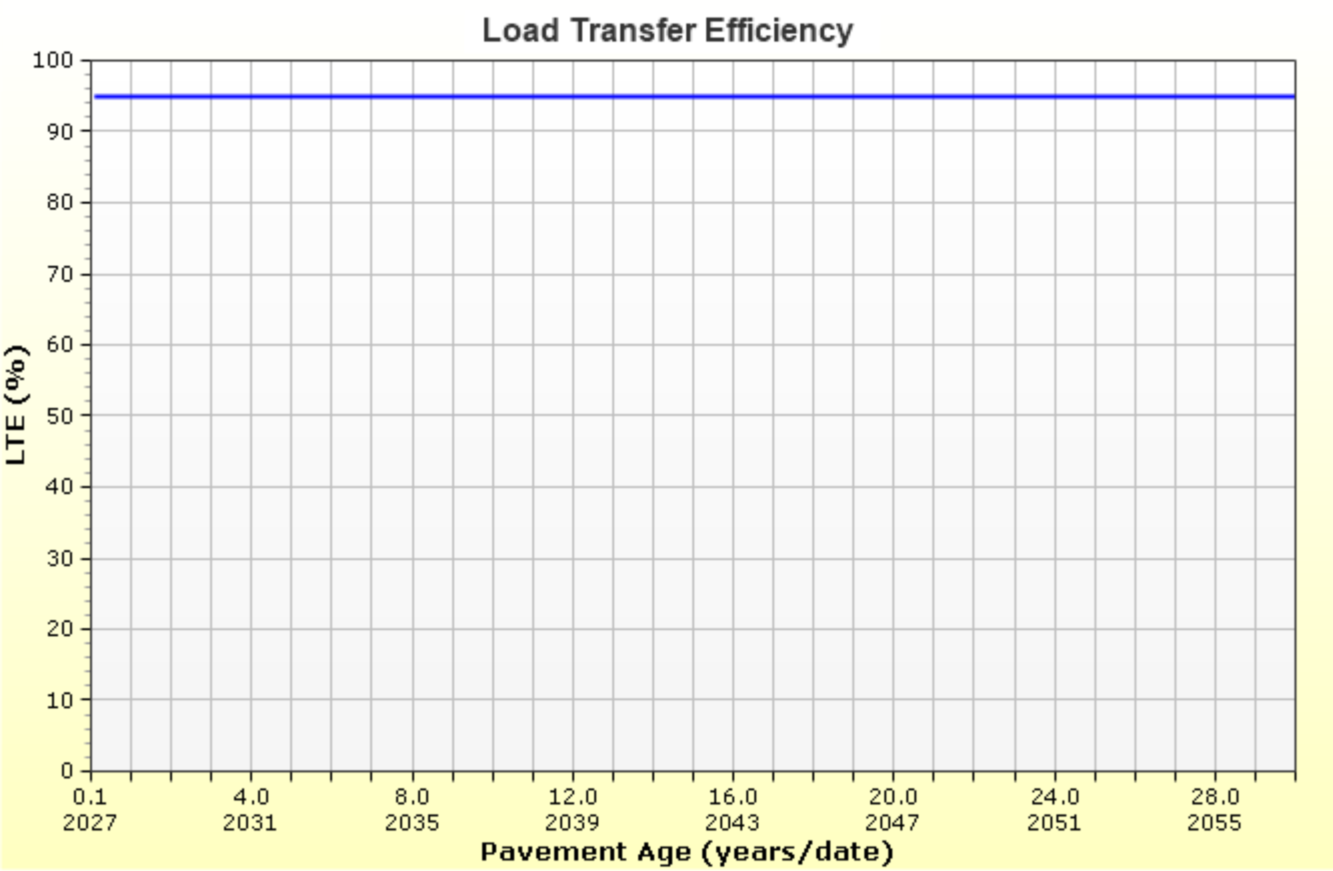
PCC Modulus (Epcc)
PCC - E (Mpsi)
4.45
4.4
4.35
4.3
4.25
4.2
4.15
PCC Flexural Strength (MR)
PCC - MR (psi)
750
740
730
720
710
700
690
680
670
0.1 2027
4.0 2031
8.0 2035
12.0 2039
16.0 2043
20.0 2047
24.0 2051
28.0 2055
Pavement Age (years/date)



Base Modulus (Ebase)
Base - E (kpsi)
800
700
600
500
400
300
200
100
0
Dynamic k-Value
Dynamic k (psi/in.)
228.5
228
227.5
227
226.5
226
225.5
0.1 2027
4.0 2031
8.0 2035
12.0 2039
16.0 2043
20.0 2047
24.0 2051
28.0 2055
Pavement Age (years/date)



PCC Cumulative Damage
Top-down
Bottom-up
Cumulative Damage
0.03
0.025
0.02
0.015
0.01
0.005
0
0.1 2027
4.0 2031
8.0 2035
12.0 2039
16.0 2043
20.0 2047
24.0 2051
28.0 2055
Pavement Age (years/date)



Load Transfer Efficiency
LTE (%)
100
90
80
70
60
50
40
30
20
10
0
0.1 2027
4.0 2031
8.0 2035
12.0 2039
16.0 2043
20.0 2047
24.0 2051
28.0 2055
Pavement Age (years/date)

Layer Information

Layer 1 PCC : JPCP Default

PCC	
Thickness (in)	12.0
Unit weight (pcf)	150.0
Poisson's ratio	0.2

Thermal	
PCC coefficient of thermal expansion (in/in/ºF x 10^-6)	4.9
PCC thermal conductivity (BTU/hr-ft-ºF)	1.25
PCC heat capacity (BTU/lb-ºF)	0.28

Mix		
Cement type		Type I (1)
Cementitious material content (lb/yd^3)		600
Water to cement ratio		0.42
Aggregate type		Dolomite (2)
PCC zero-stress temperature (ºF)	Calculated Internally?	True
	User Value	-
	Calculated Value	101.6
Ultimate shrinkage (microstrain)	Calculated Internally?	True
	User Value	-
	Calculated Value	657.2
Reversible shrinkage (%)		50
Time to develop 50% of ultimate shrinkage (days)		35
Curing method		Curing Compound

PCC strength and modulus (Input Level: 3)

28-Day PCC compressive strength (psi)	4000.0
28-Day PCC elastic modulus (psi)	3600000.0

Identifiers

Field	Value
Display name/identifier	JPCP Default
Description of object	
Author	
Date Created	5/25/2021 10:12:41 AM
Approver	
Date approved	5/25/2021 10:12:41 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Layer 2 Chemically Stabilized : Cement Treated Base

Chemically Stabilized	
Layer thickness (in)	4
Poisson's ratio	0.2
Unit weight (pcf)	150

Strength	
Elastic/resilient modulus (psi)	700000

Thermal	
Heat capacity (BTU/lb-ºF)	0.2
Thermal conductivity (BTU/hr-ft-ºF)	1

Identifiers

Field	Value
Display name/identifier	Cement Treated Base
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Layer 3 Non-stabilized Base : Crushed stone

Unbound	
Layer thickness (in)	8.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
25000.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Crushed stone
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	6.0
Plasticity Index	1.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	127.2
Saturated hydraulic conductivity (ft/hr)	False	5.054e-02
Specific gravity of solids	False	2.7
Water Content (%)	False	7.4

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	7.2555
bf	1.3328
cf	0.8242
hr	117.4000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	8.7
#100	
#80	12.9
#60	
#50	
#40	20.0
#30	
#20	
#16	
#10	33.8
#8	
#4	44.7
3/8-in.	57.2
1/2-in.	63.1
3/4-in.	72.7
1-in.	78.8
1 1/2-in.	85.8
2-in.	91.6
2 1/2-in.	
3-in.	
3 1/2-in.	97.6

Layer 4 Subgrade : Stabilized Subgrade

Unbound	
Layer thickness (in)	8.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Annual representative values
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
15000.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Stabilized Subgrade
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	36.0
Plasticity Index	17.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	True	115.2
Saturated hydraulic conductivity (ft/hr)	False	1.02e-05
Specific gravity of solids	False	2.7
Water Content (%)	True	20

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	116.4986
bf	0.6287
cf	0.1631
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	76.1
#100	
#80	
#60	
#50	
#40	81.0
#30	
#20	
#16	
#10	85.0
#8	
#4	91.0
3/8-in.	100.0
1/2-in.	100.0
3/4-in.	100.0
1-in.	100.0
1 1/2-in.	100.0
2-in.	100.0
2 1/2-in.	
3-in.	
3 1/2-in.	100.0

Layer 5 Subgrade : A-6

Unbound	
Layer thickness (in)	Semi-infinite
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 2)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
5600.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	A-6
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	36.0
Plasticity Index	17.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	True	115.2
Saturated hydraulic conductivity (ft/hr)	False	1.02e-05
Specific gravity of solids	False	2.7
Water Content (%)	True	20

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	116.4986
bf	0.6287
cf	0.1631
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	76.1
#100	
#80	
#60	
#50	
#40	81.0
#30	
#20	
#16	
#10	85.0
#8	
#4	91.0
3/8-in.	100.0
1/2-in.	100.0
3/4-in.	100.0
1-in.	100.0
1 1/2-in.	100.0
2-in.	100.0
2 1/2-in.	
3-in.	100.0
3 1/2-in.	

Calibration Coefficients

PCC Faulting

$$C_{12} = C_1 + (C_2 * FR^{0.25})$$
$$C_{34} = C_3 + (C_4 * FR^{0.25})$$
$$FaultMax_0 = C_{12} * \delta_{curling} * \left[\log(1 + C_5 * 5.0^{EROD}) * \log\left(P_{200} * \frac{WetDays}{p_s}\right)\right]^{C_6}$$
$$FaultMax_i = FaultMax_0 + C_7 * \sum_{j=1}^{m} DE_j * \log(1 + C_5 * 5.0^{EROD})^{C_6}$$
$$\Delta Fault_i = C_{34} * (FaultMax_{i-1} - Fault_{i-1})^2 * DE_i$$
$$C_8 = DowelDeterioration$$

C1: 0.595	C2: 1.636	C3: 0.00217	C4: 0.00444
C5: 250	C6: 0.47	C7: 7.3	C8: 400
pccReliabilityFaultStandardDeviation			
0.07162 * Pow(FAULT,0.368) + 0.00806			

IRI-jpcp

C1 - Cracking	C1: 0.8203	C2: 0.4417
C2 - Spalling	C3: 1.4929	C4: 25.24
C3 - Faulting	**Reliability Standard Deviation**	
C4 - Site Factor	5.4	

PCC Cracking

$$\log(N) = C1 \cdot \left(\frac{MR}{\sigma}\right)^{C2}$$
$$CRK = \frac{100}{1 + C4\, FD^{C5}}$$

Fatigue Coefficients		Cracking Coefficients	
C1: 2	C2: 1.22	C4: 0.52	C5: -2.17
pccReliabilityCrackStandardDeviation			
3.5522 * Pow(CRACK,0.3415) + 0.75			

22119 New Ramps AC 10

File Name: C:\Users\kkb\OneDrive\Documents\My ME Design\Projects\2022\22119\22119 New Ramps AC 10.dgpx

Design Inputs

Design Life:	30 years	Base construction:	May, 2025	Climate Data Sources (Lat/Lon)	35, -97.5
Design Type:	FLEXIBLE	Pavement construction:	May, 2026		
		Traffic opening:	May, 2027		

Design Structure

Layer type	Material Type	Thickness (in)
Flexible	Default asphalt concrete	5.0
Flexible	Default asphalt concrete	5.0
Subgrade	Stabilized Subgrade	8.0
Subgrade	A-6	Semi-infinite

Volumetric at Construction:	
Effective binder content (%)	11.0
Air voids (%)	6.5

Traffic

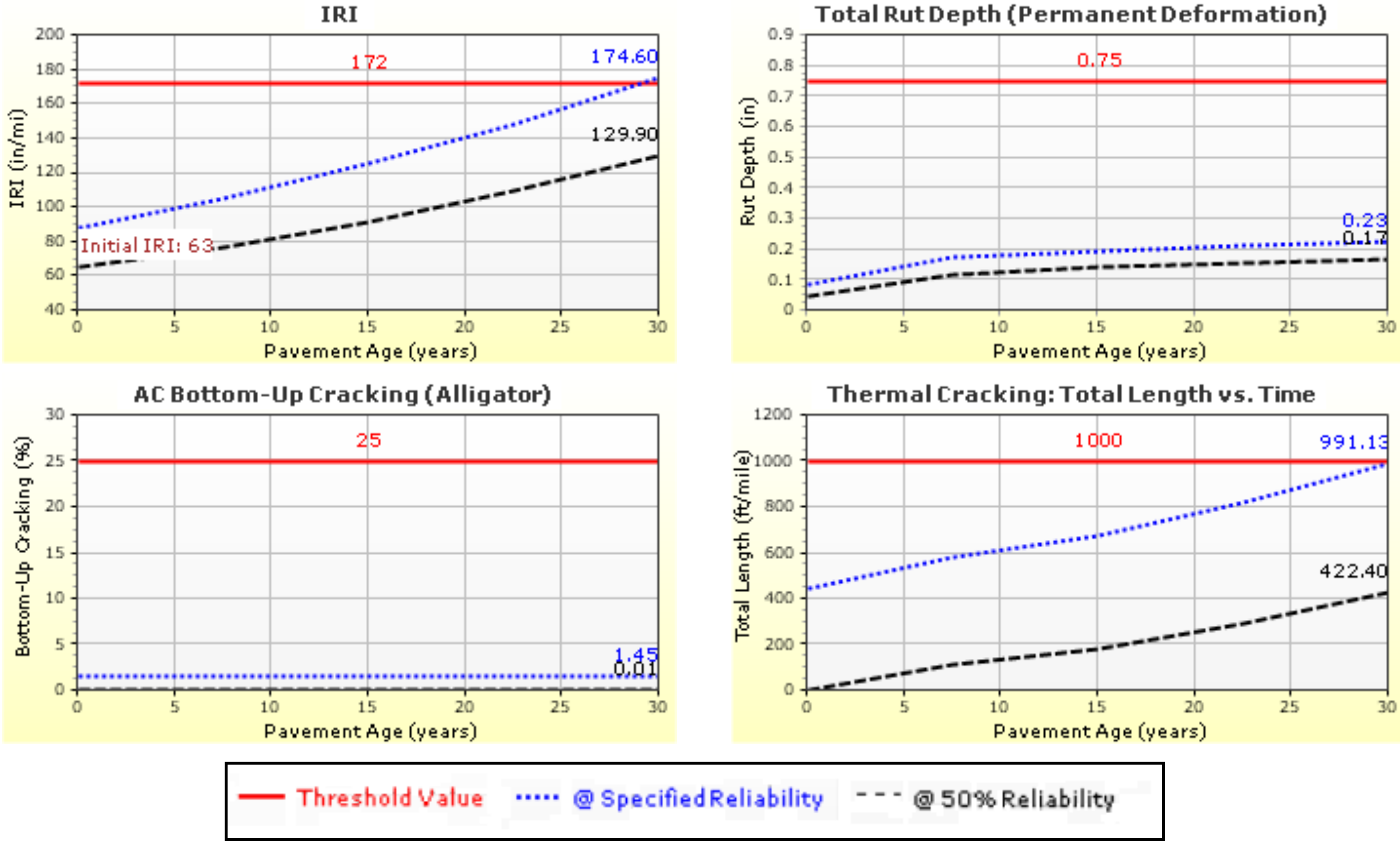
Age (year)	Heavy Trucks (cumulative)
2027 (initial)	304
2042 (15 years)	1,920,190
2057 (30 years)	4,504,520

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	172.00	174.64	90.00	88.61	Fail
Permanent deformation - total pavement (in)	0.75	0.23	90.00	100.00	Pass
AC bottom-up fatigue cracking (% lane area)	25.00	1.45	90.00	100.00	Pass
AC thermal cracking (ft/mile)	1000.00	991.13	90.00	90.35	Pass
AC top-down fatigue cracking (% lane area)	25.00	14.98	90.00	99.81	Pass
Permanent deformation - AC only (in)	0.25	0.08	90.00	100.00	Pass

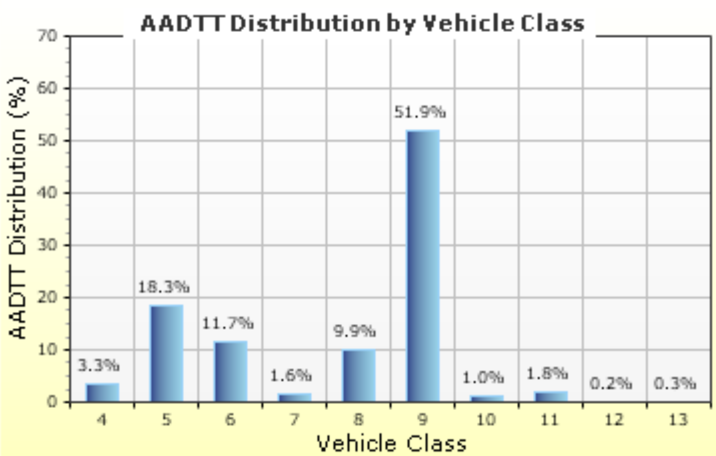
Distress Charts

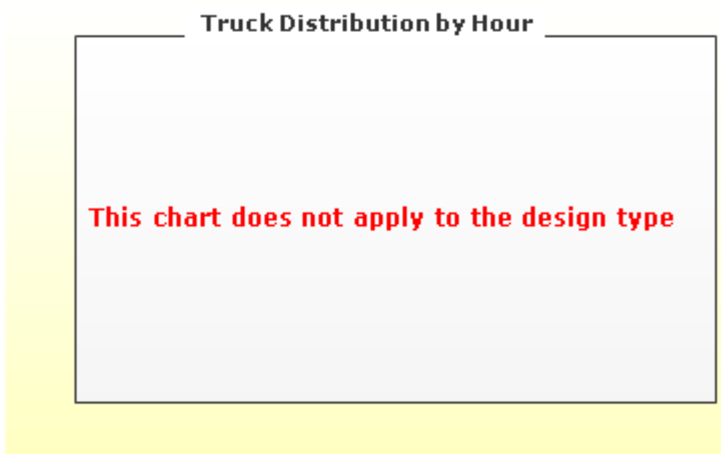


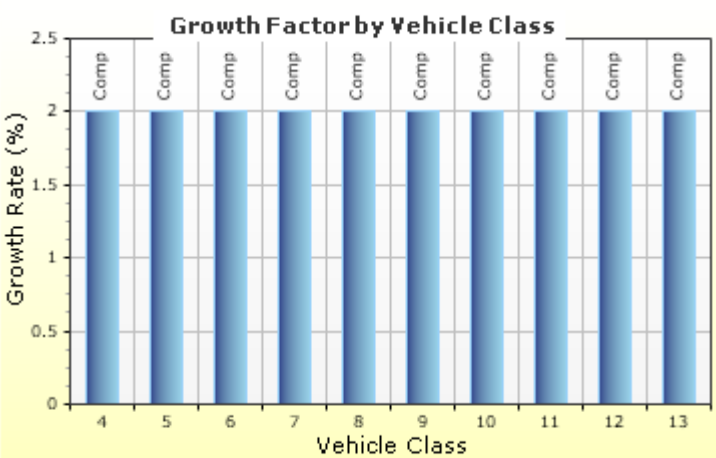
Traffic Inputs

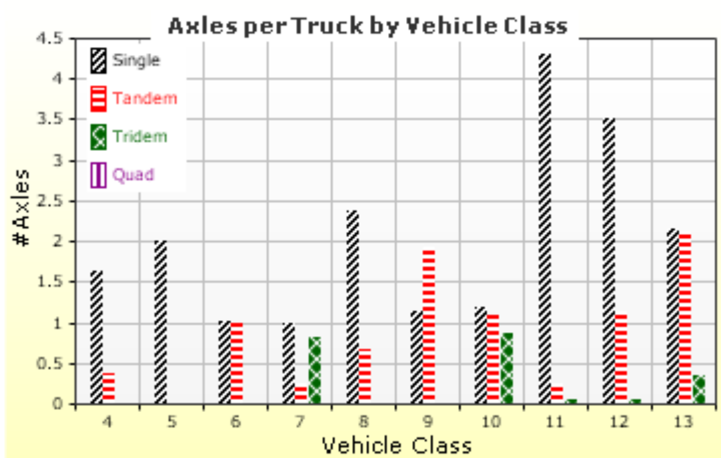
Graphical Representation of Traffic Inputs

Initial two-way AADTT:	304	Percent of trucks in design direction (%):	100.0
Number of lanes in design direction:	1	Percent of trucks in design lane (%):	100.0
		Operational speed (mph)	45.0

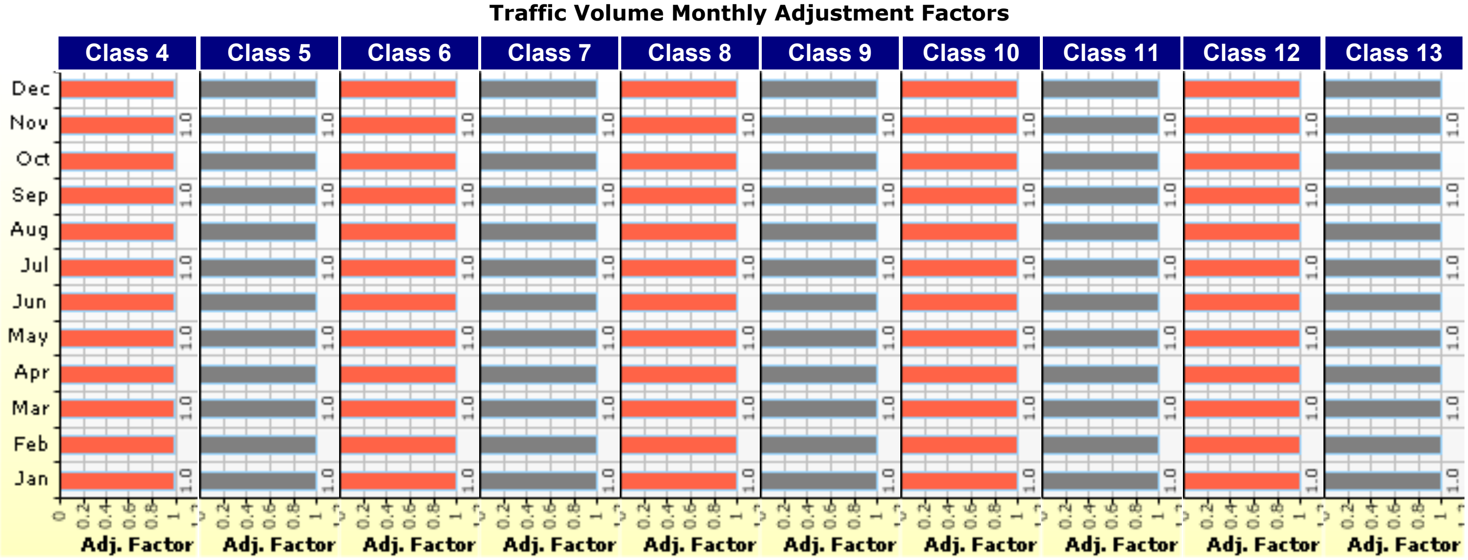








Traffic Volume Monthly Adjustment Factors



Tabular Representation of Traffic Inputs

Volume Monthly Adjustment Factors

Level 3: Default MAF

Month	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
January	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
February	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
March	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
April	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
May	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
June	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
July	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
August	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
September	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
October	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
November	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
December	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Distributions by Vehicle Class

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor	
		Rate (%)	Function
Class 4	3.3%	2%	Compound
Class 5	18.3%	2%	Compound
Class 6	11.7%	2%	Compound
Class 7	1.6%	2%	Compound
Class 8	9.9%	2%	Compound
Class 9	51.9%	2%	Compound
Class 10	1%	2%	Compound
Class 11	1.8%	2%	Compound
Class 12	0.2%	2%	Compound
Class 13	0.3%	2%	Compound

Truck Distribution by Hour does not apply

Axle Configuration

Traffic Wander	
Mean wheel location (in)	18.0
Traffic wander standard deviation (in)	10.0
Design lane width (ft)	12.0

Axle Configuration	
Average axle width (ft)	8.5
Dual tire spacing (in)	12.0
Tire pressure (psi)	120.0

Average Axle Spacing	
Tandem axle spacing (in)	51.6
Tridem axle spacing (in)	49.2
Quad axle spacing (in)	49.2

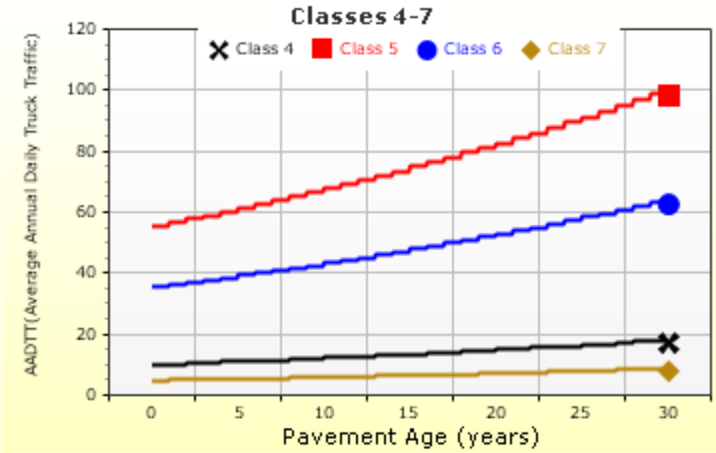
Wheelbase does not apply

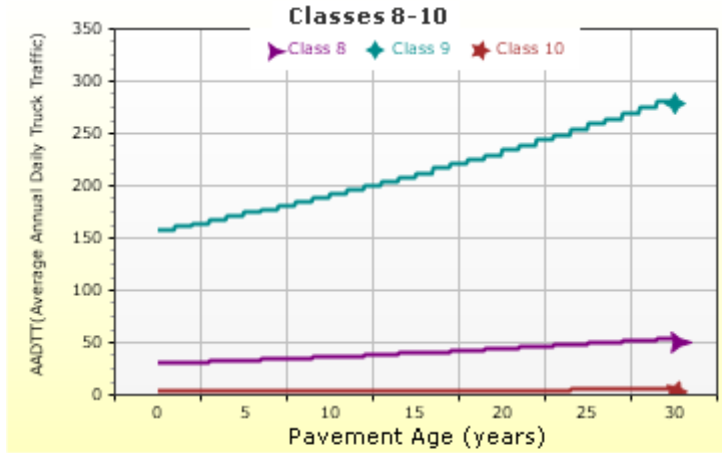
Number of Axles per Truck

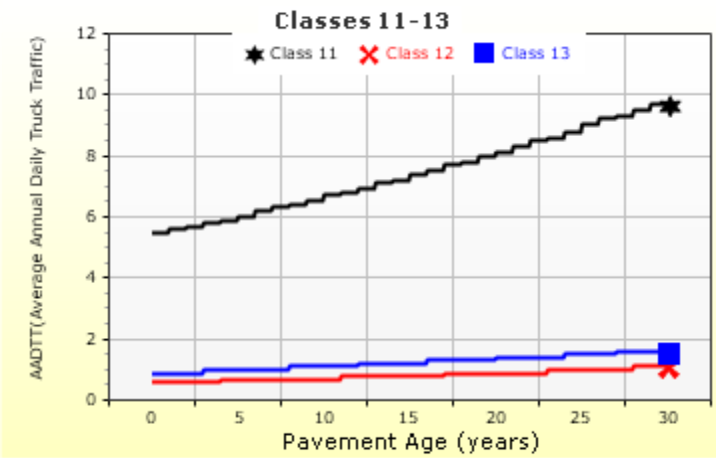
Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.62	0.39	0	0
Class 5	2	0	0	0
Class 6	1.02	0.99	0	0
Class 7	1	0.26	0.83	0
Class 8	2.38	0.67	0	0
Class 9	1.13	1.93	0	0
Class 10	1.19	1.09	0.89	0
Class 11	4.29	0.26	0.06	0
Class 12	3.52	1.14	0.06	0
Class 13	2.15	2.13	0.35	0

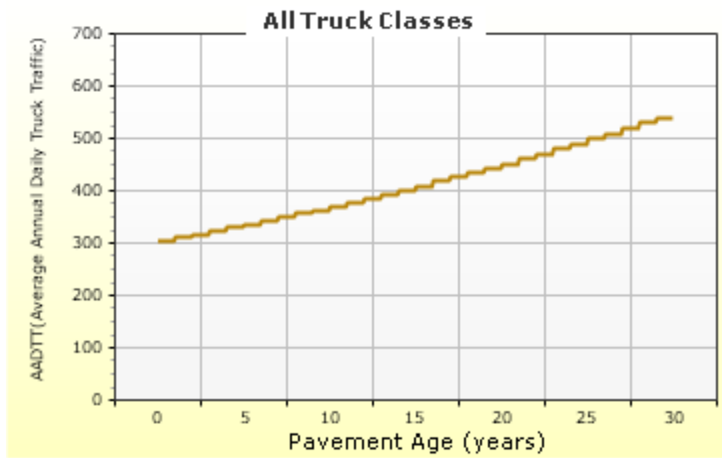
AADTT (Average Annual Daily Truck Traffic) Growth

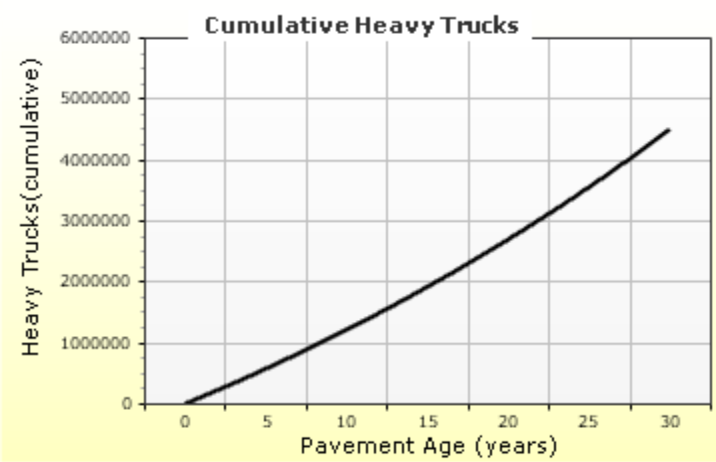
*** Traffic cap is not enforced**











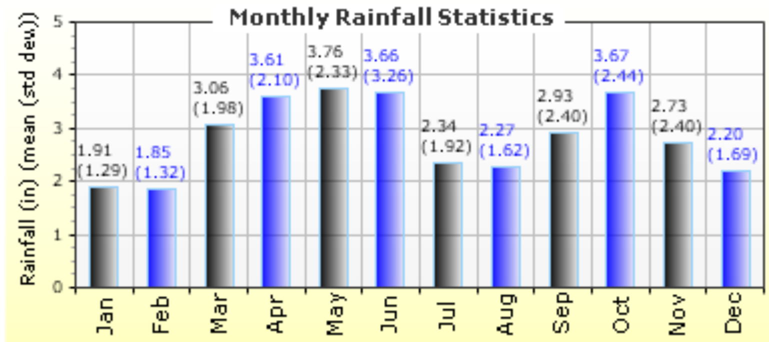
Climate Inputs

Climate Data Sources:

Climate Station Cities:	Location (lat lon elevation(ft))
US, OK	35.00000 -97.50000 1109

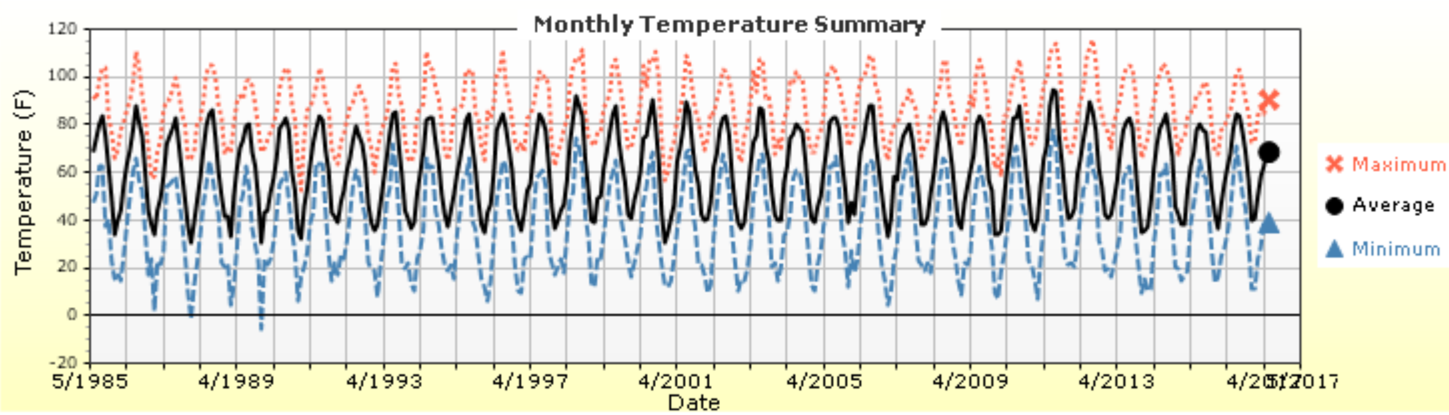
Annual Statistics:

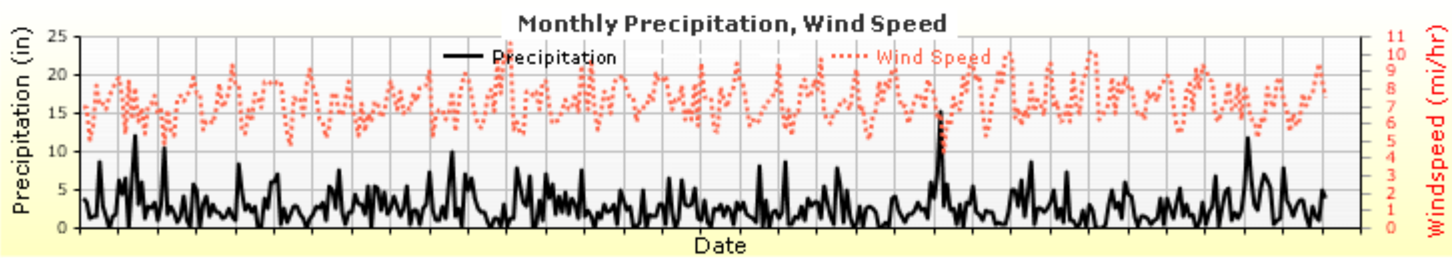
Mean annual air temperature (ºF)	61.10
Mean annual precipitation (in)	34.02
Freezing index (ºF - days)	102.06
Average annual number of freeze/thaw cycles:	61.02

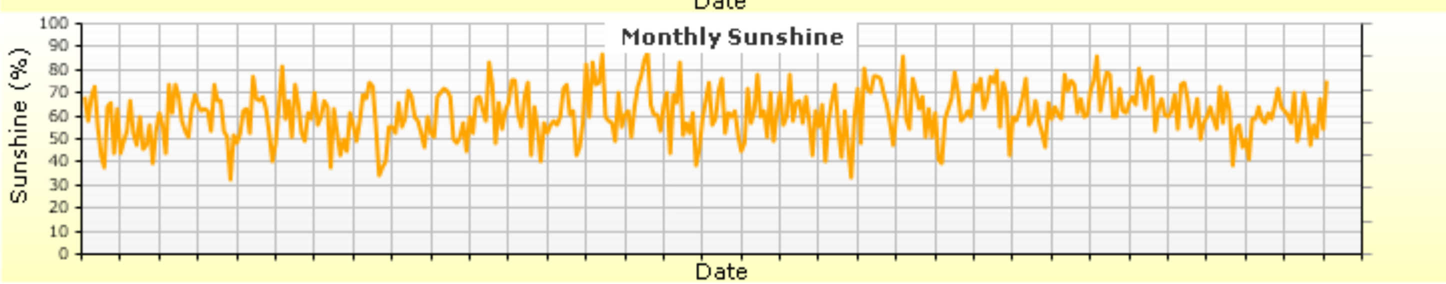


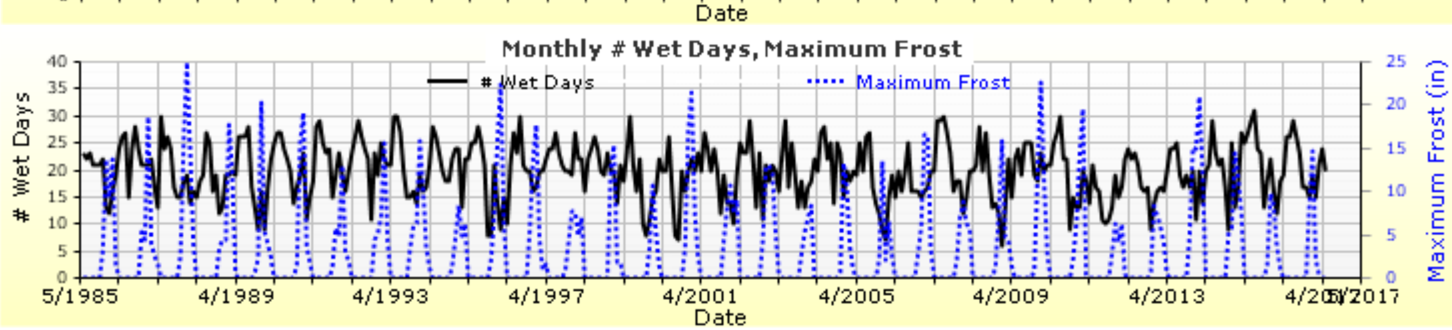
Water table depth (ft) 51.00

Monthly Climate Summary:

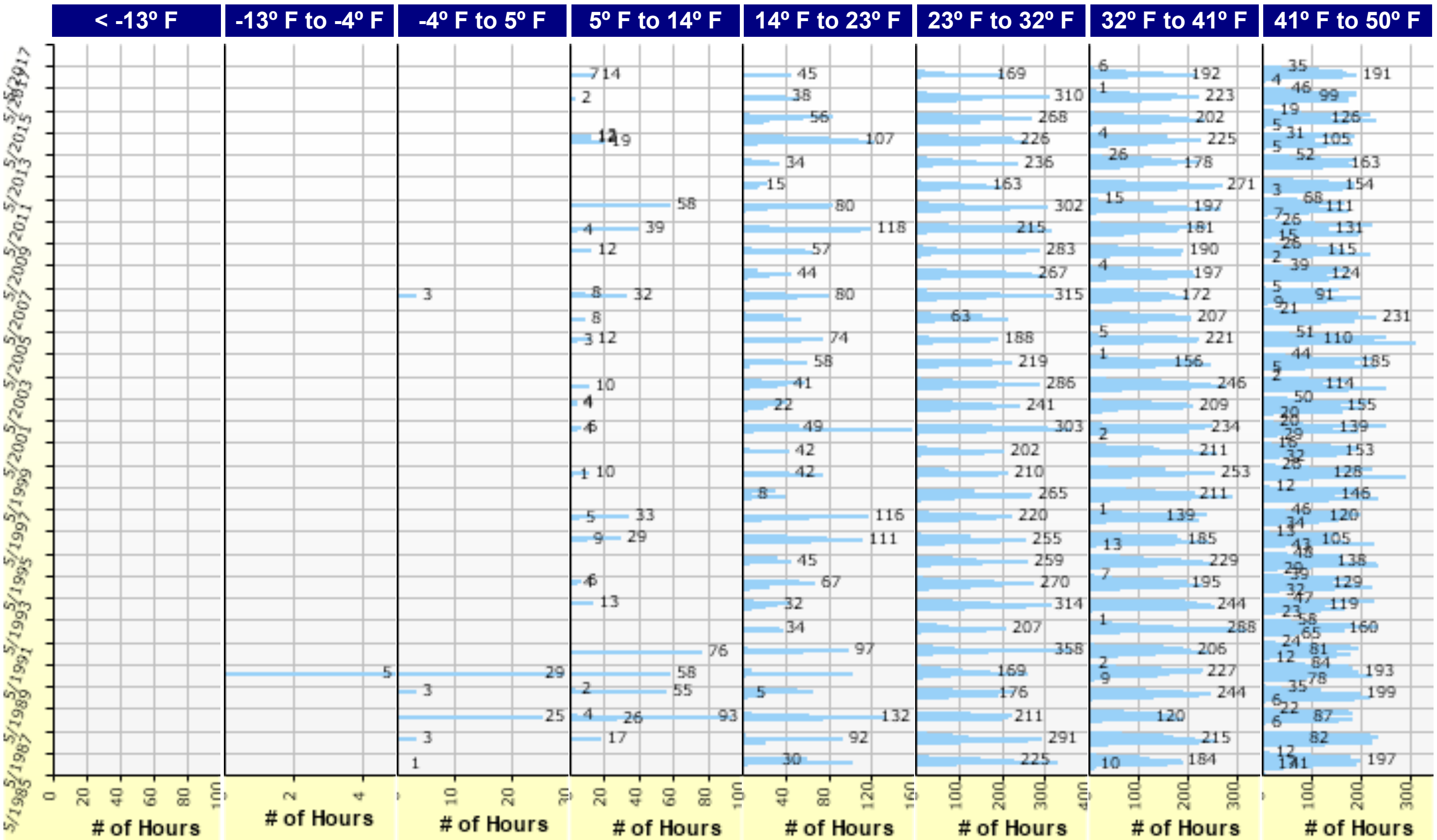


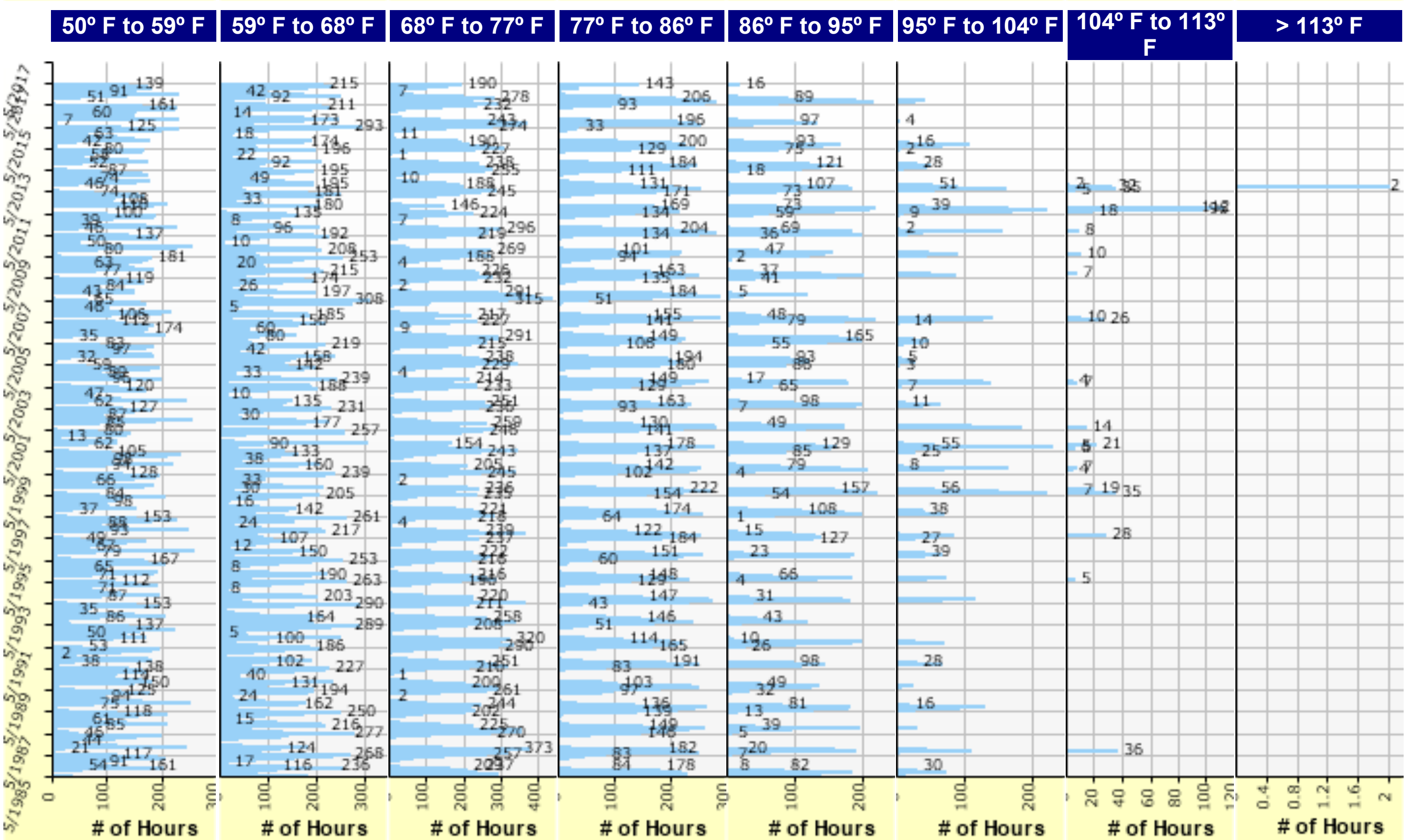






Hourly Air Temperature Distribution by Month:





Design Properties

HMA Design Properties

Use Multilayer Rutting Model	False
Using G* based model (not nationally calibrated)	False
Is NCHRP 1-37A HMA Rutting Model Coefficients	True
Endurance Limit	-
Use Reflective Cracking	True

Structure - ICM Properties	
AC surface shortwave absorptivity	0.85

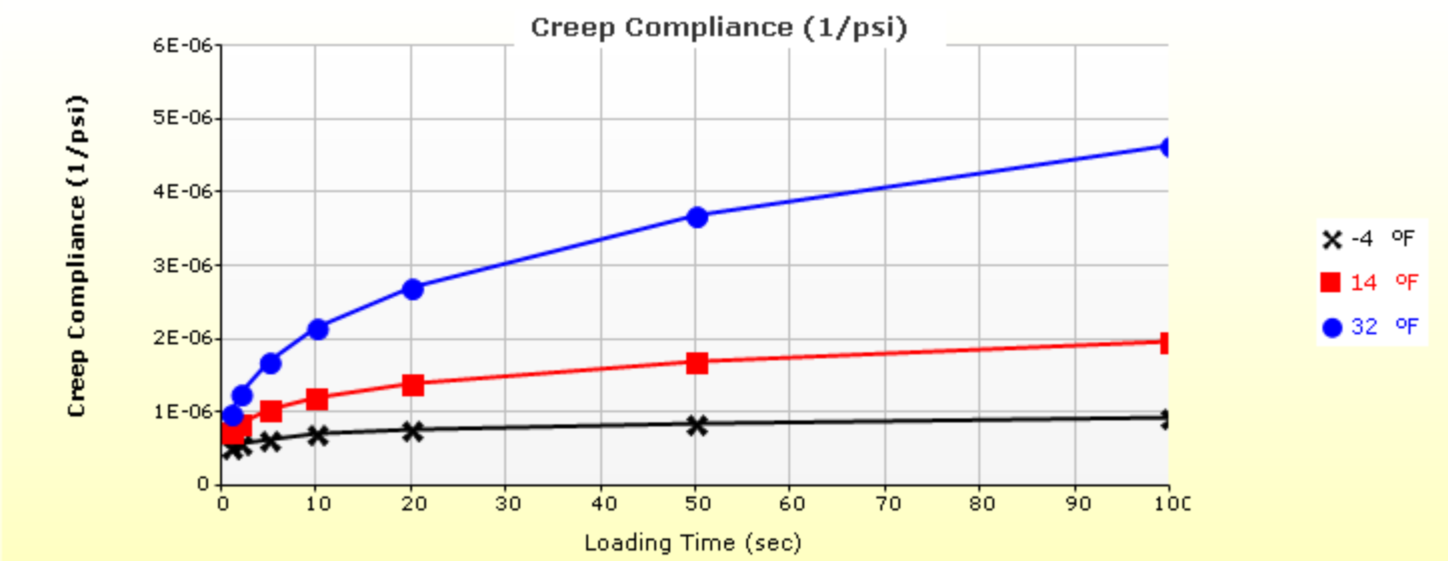
Layer Name	Layer Type	Interface Friction
Layer 1 Flexible : Default asphalt concrete	Flexible (1)	1.00
Layer 2 Flexible : Default asphalt concrete	Flexible (1)	1.00
Layer 3 Subgrade : Stabilized Subgrade	Subgrade (5)	1.00
Layer 4 Subgrade : A-6	Subgrade (5)	-

Thermal Cracking

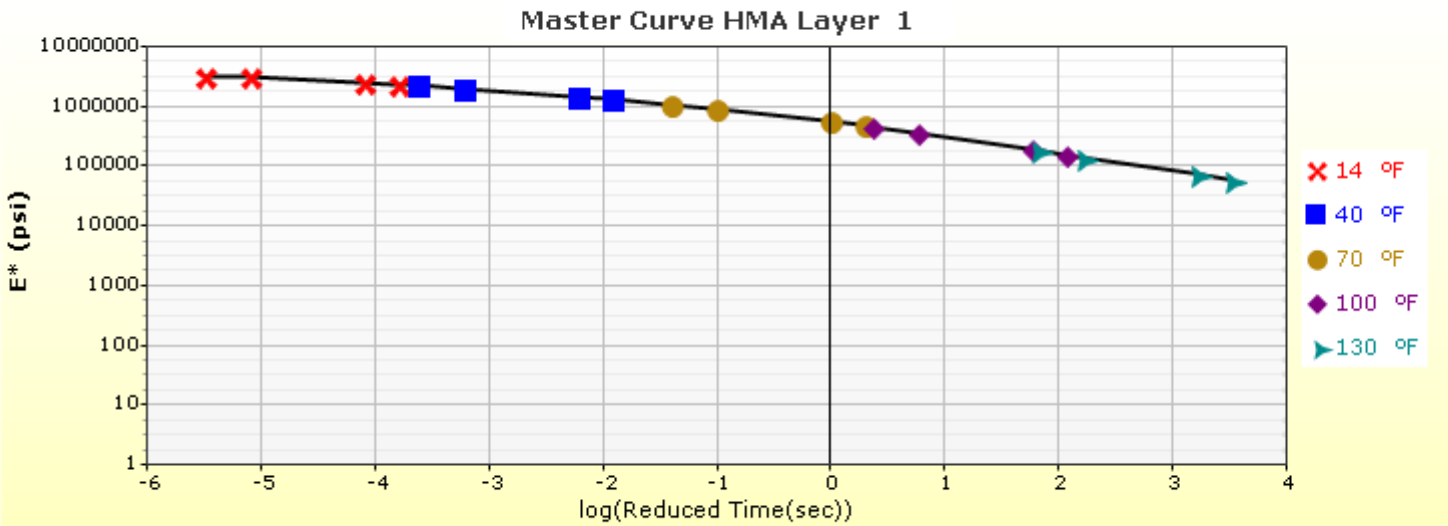
Thermal Contraction	
Is thermal contraction calculated?	True
Mix coefficient of thermal contraction (in/in/ºF)	-
Aggregate coefficient of thermal contraction (in/in/ºF)	5.0e-006
Voids in Mineral Aggregate (%)	17.5

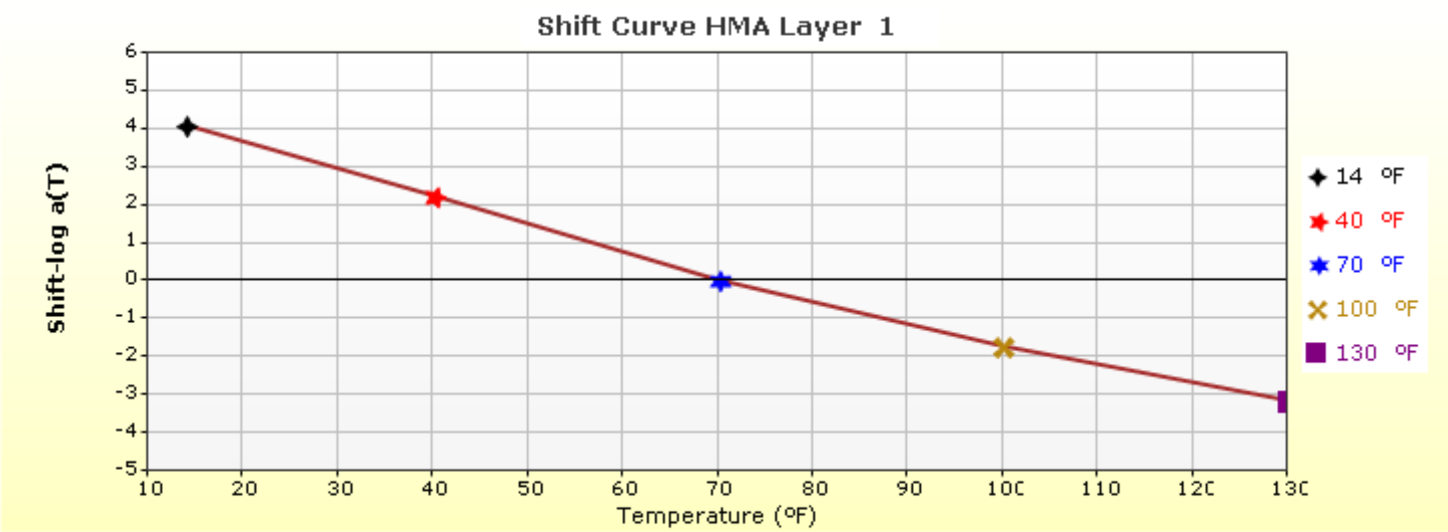
Indirect Tensile Strength (Input Level: 3)	
Test Temperature (ºF)	Indirect Tensilte Strength (psi)
14.0	466.68

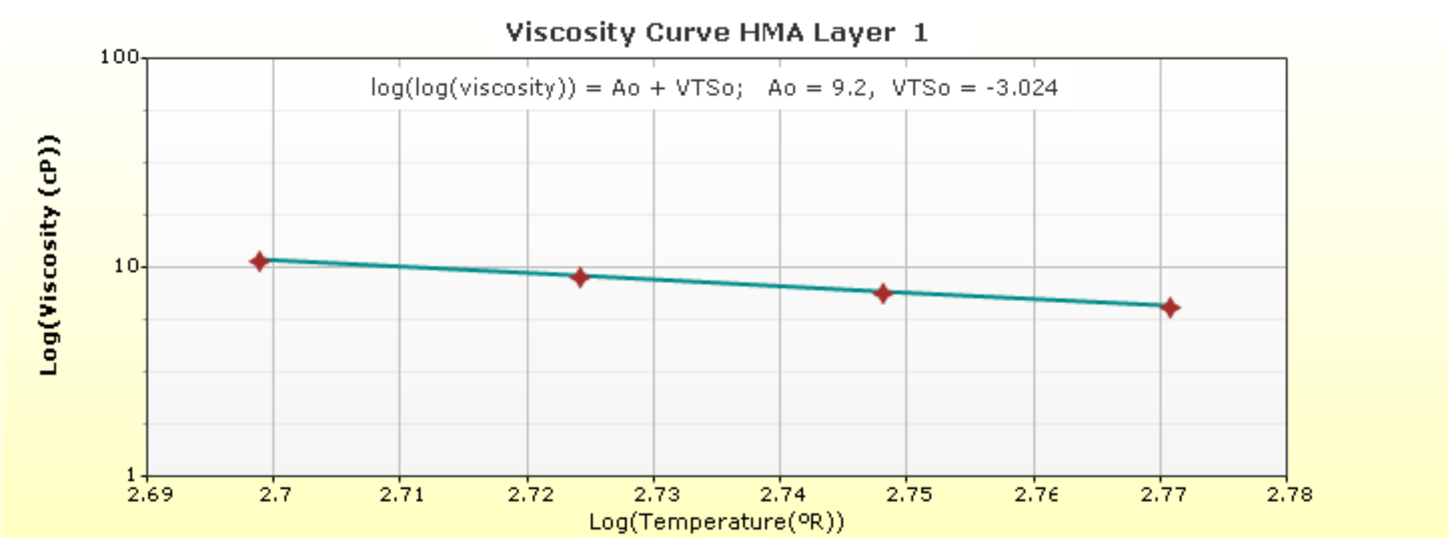
Creep Compliance (1/psi) (Input Level: 3)			
Loading time (sec)	-4 ºF	14 ºF	32 ºF
1	5.34e-007	7.47e-007	1.00e-006
2	5.82e-007	8.66e-007	1.26e-006
5	6.53e-007	1.05e-006	1.71e-006
10	7.12e-007	1.22e-006	2.16e-006
20	7.76e-007	1.41e-006	2.72e-006
50	8.70e-007	1.71e-006	3.70e-006
100	9.49e-007	1.98e-006	4.66e-006



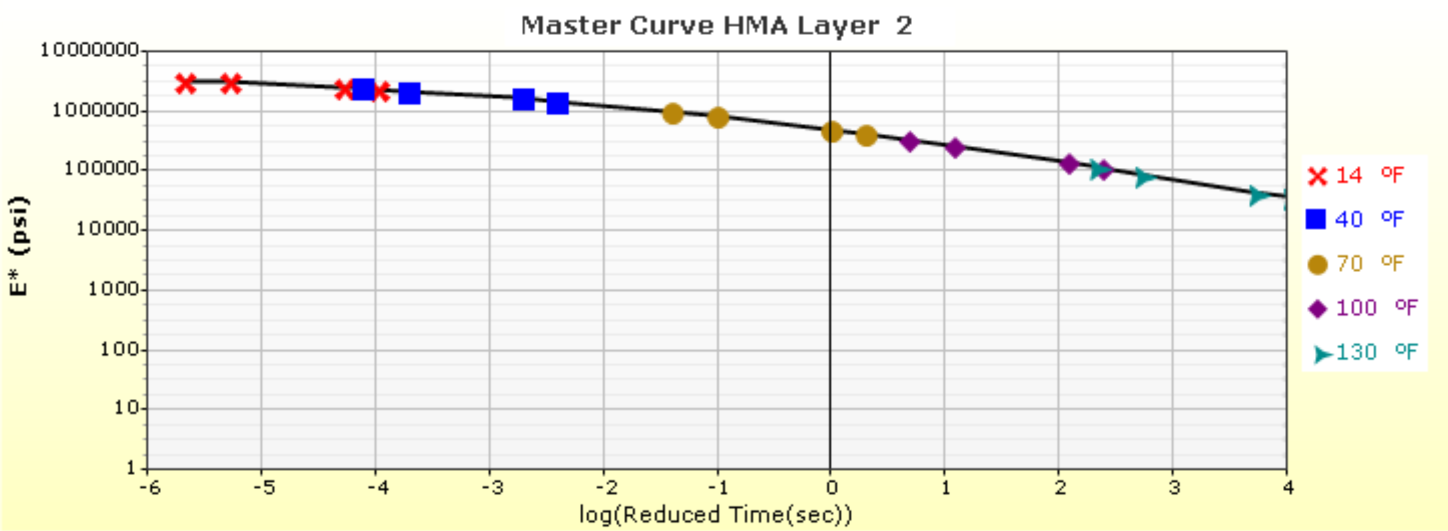
HMA Layer 1: Layer 1 Flexible : Default asphalt concrete

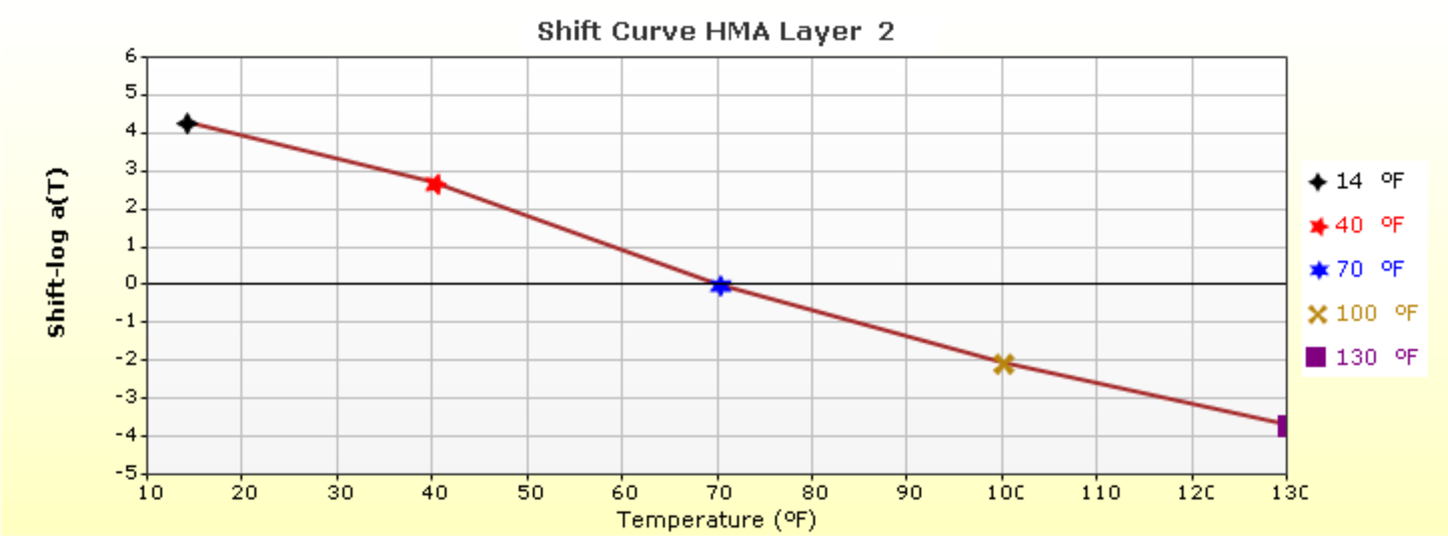


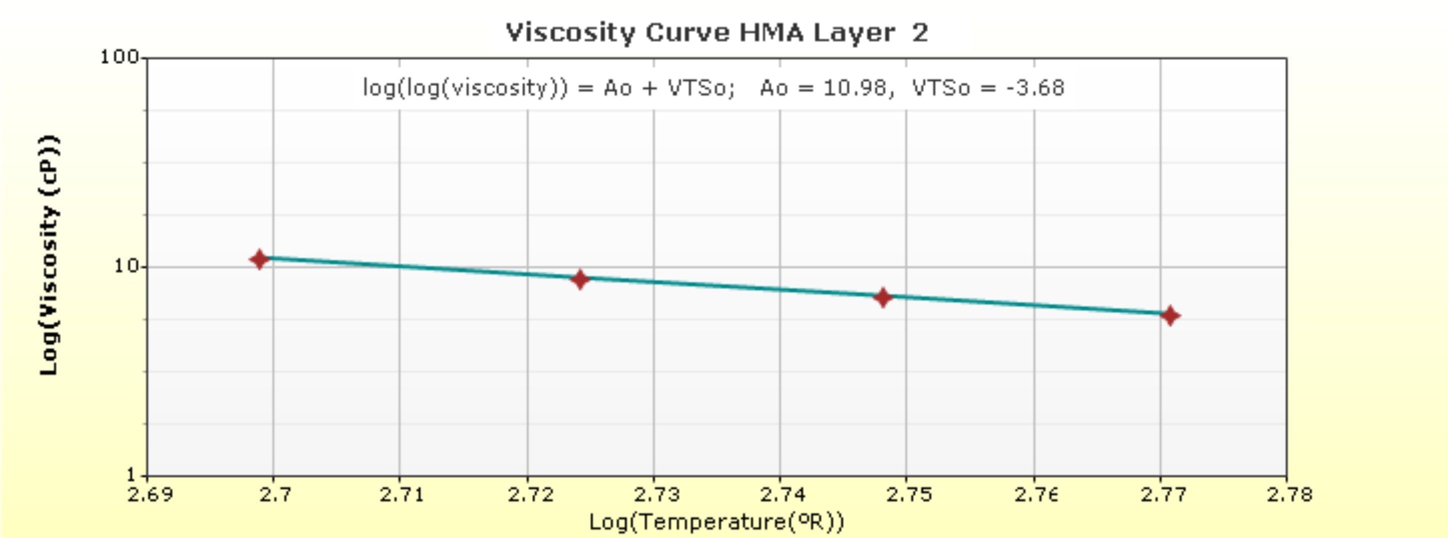




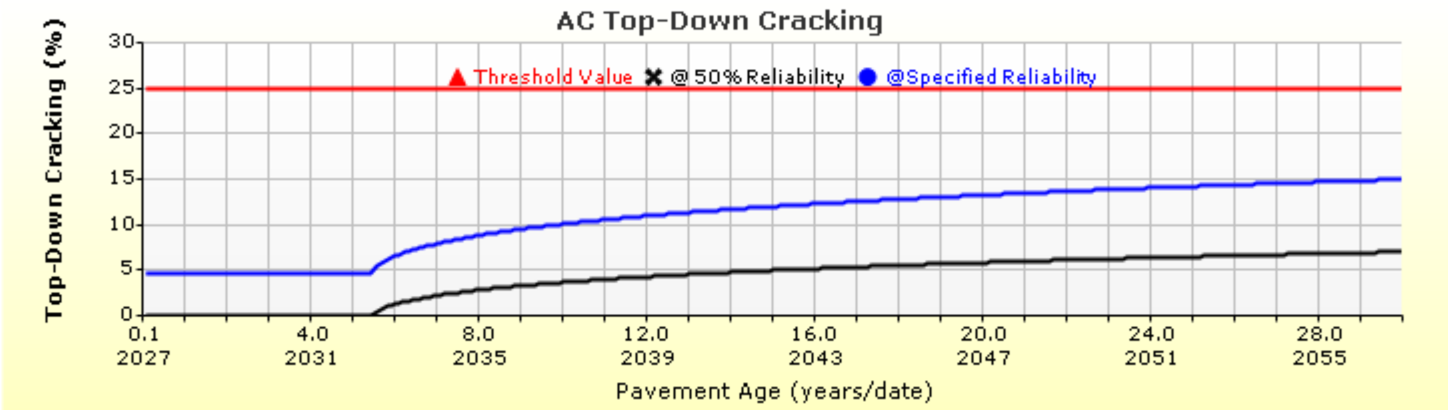
HMA Layer 2: Layer 2 Flexible : Default asphalt concrete



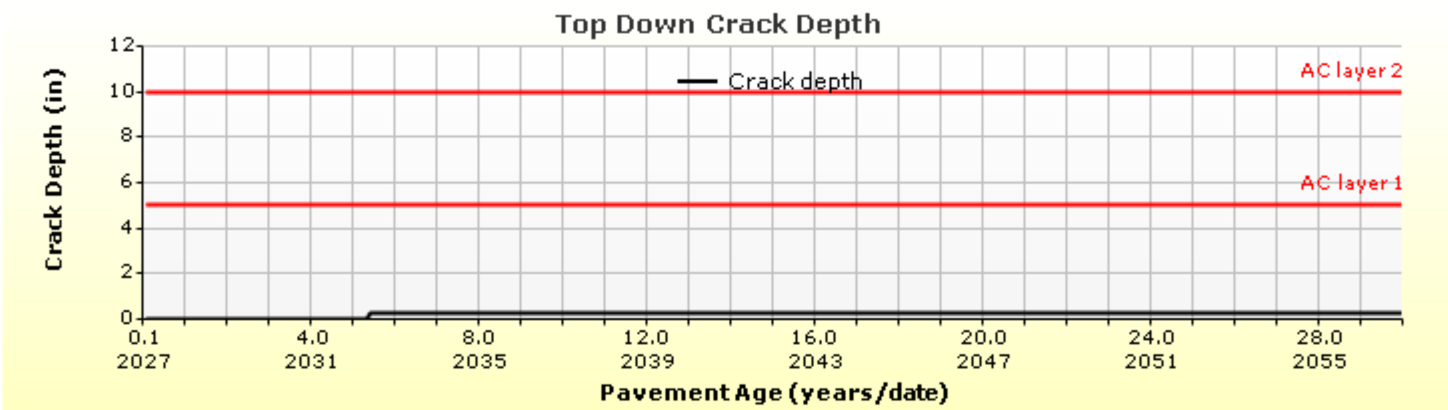




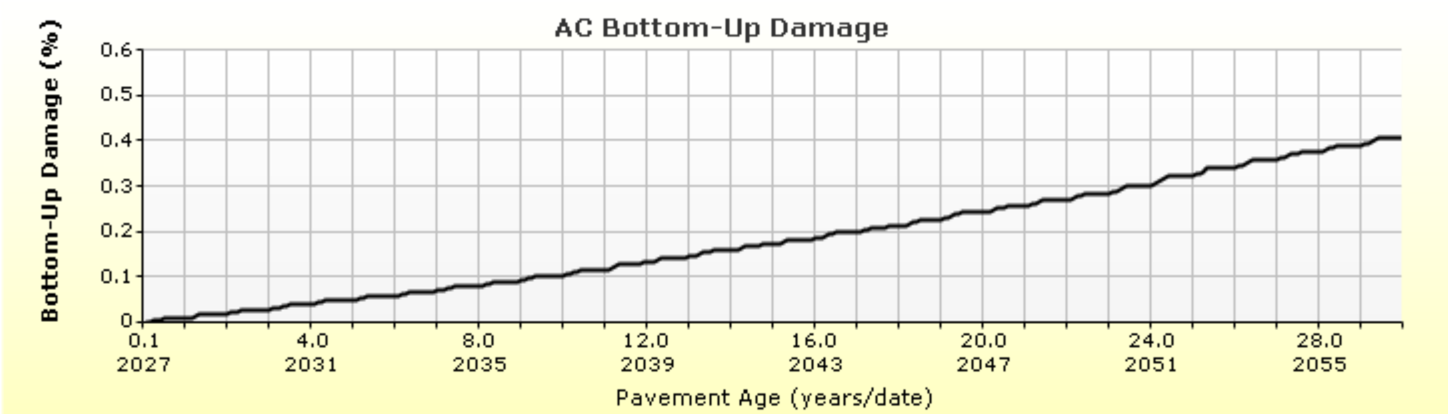
Analysis Output Charts



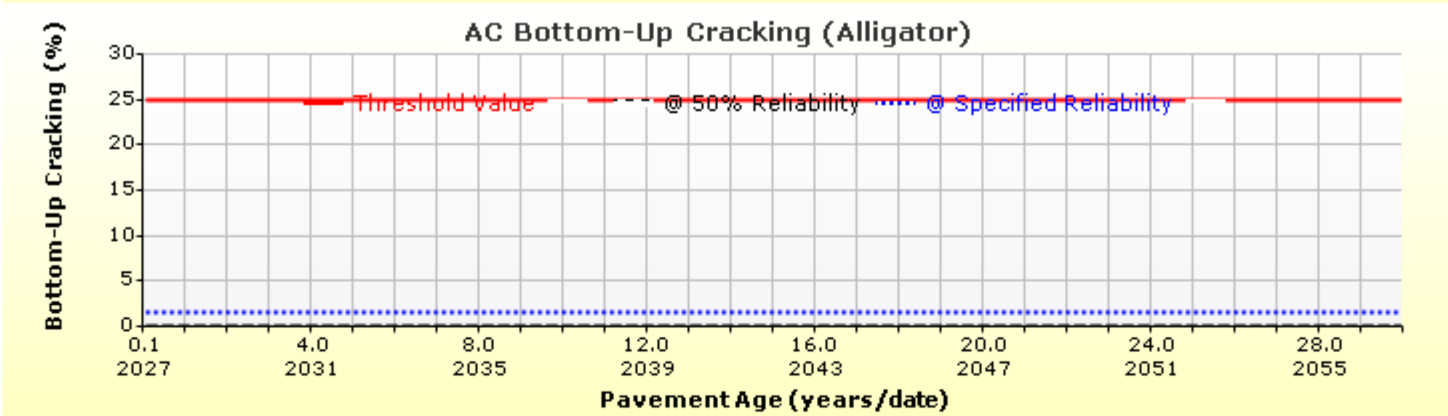
AC Top-Down Cracking
Threshold Value
@ 50% Reliability
@Specified Reliability
Top-Down Cracking (%)
Pavement Age (years/date)



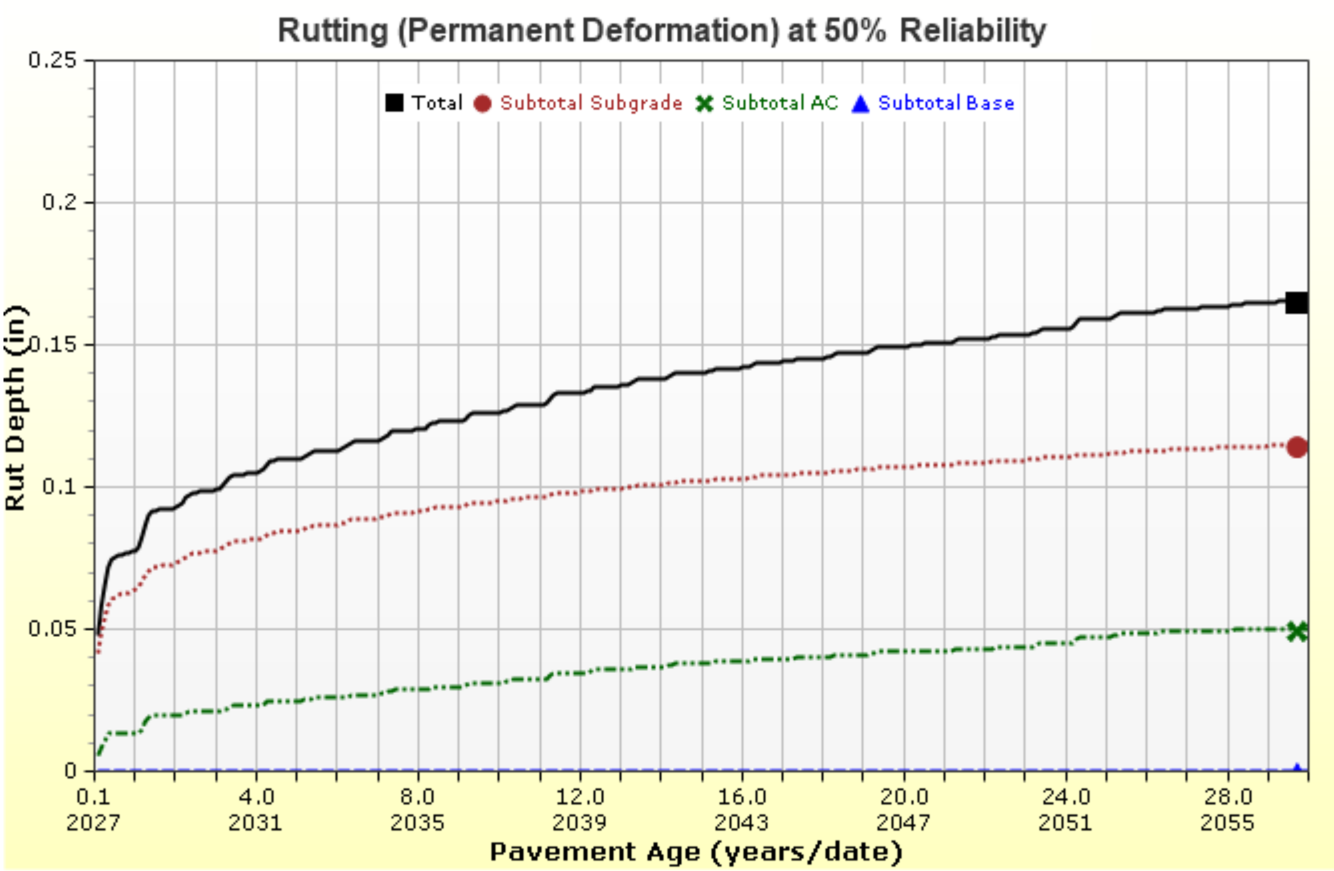
Top Down Crack Depth
Crack depth
AC layer 2
AC layer 1
Crack Depth (in)
Pavement Age (years/date)

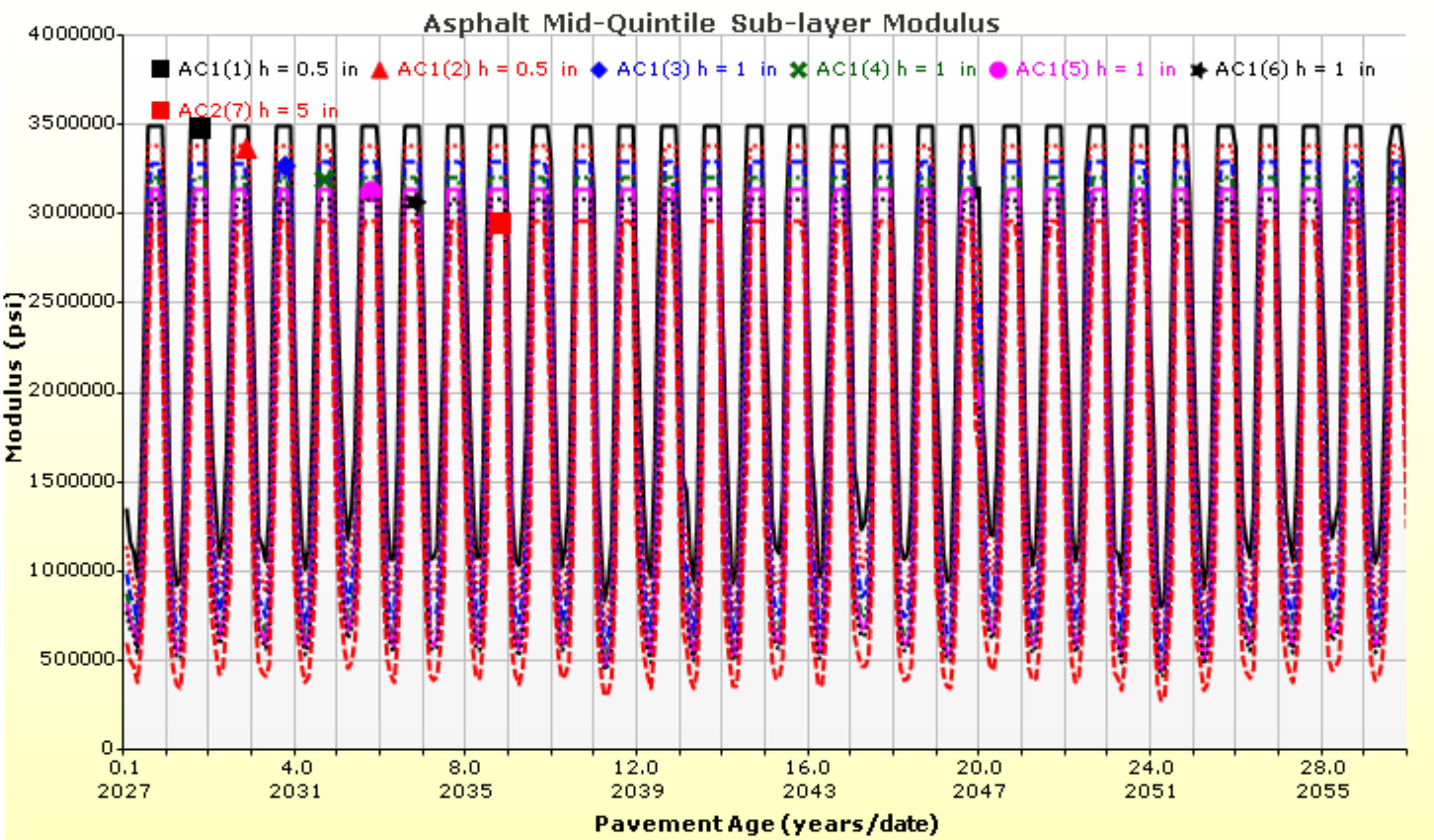


AC Bottom-Up Damage
Bottom-Up Damage (%)
Pavement Age (years/date)

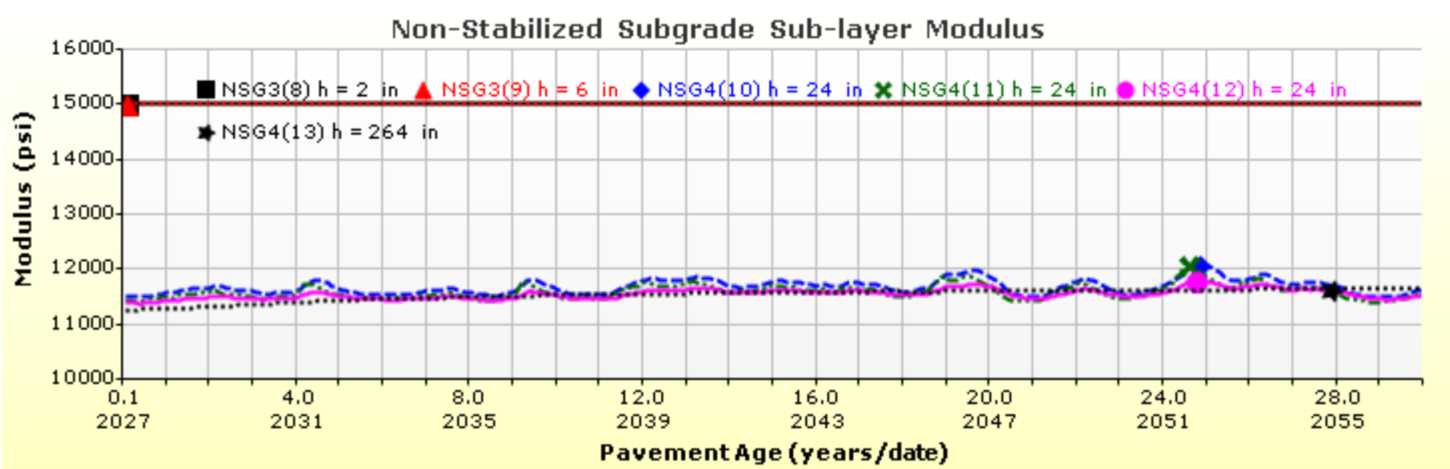


AC Bottom-Up Cracking (Alligator)
Threshold Value
@ 50% Reliability
@ Specified Reliability
Bottom-Up Cracking (%)
Pavement Age (years/date)


Rutting (Permanent Deformation) at 50% Reliability
Total
Subtotal Subgrade
Subtotal AC
Subtotal Base
Rut Depth (in)
0.25
0.2
0.15
0.1
0.05
0
0.1 2027
4.0 2031
8.0 2035
12.0 2039
16.0 2043
20.0 2047
24.0 2051
28.0 2055
Pavement Age (years/date)



Asphalt Mid-Quintile Sub-layer Modulus
AC1(1) h = 0.5 in
AC1(2) h = 0.5 in
AC1(3) h = 1 in
AC1(4) h = 1 in
AC1(5) h = 1 in
AC1(6) h = 1 in
AC2(7) h = 5 in
Modulus (psi)
4000000
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
0.1 2027
4.0 2031
8.0 2035
12.0 2039
16.0 2043
20.0 2047
24.0 2051
28.0 2055
Pavement Age (years/date)



Non-Stabilized Subgrade Sub-layer Modulus
NSG3(8) h = 2 in
NSG3(9) h = 6 in
NSG4(10) h = 24 in
NSG4(11) h = 24 in
NSG4(12) h = 24 in
NSG4(13) h = 264 in
Modulus (psi)
16000
15000
14000
13000
12000
11000
10000
0.1 2027
4.0 2031
8.0 2035
12.0 2039
16.0 2043
20.0 2047
24.0 2051
28.0 2055
Pavement Age (years/date)

Layer Information

Layer 1 Flexible : Default asphalt concrete

Asphalt		
Thickness (in)	5.0	
Unit weight (pcf)	150.0	
Poisson's ratio	Is Calculated?	False
	Ratio	0.35
	Parameter A	-
	Parameter B	-

Asphalt Dynamic Modulus (Input Level: 3)

Gradation	Percent Passing
3/4-inch sieve	100
3/8-inch sieve	77
No.4 sieve	60
No.200 sieve	6

Asphalt Binder

Parameter	Value
Grade	Superpave Performance Grade
Binder Type	76-28
A	9.2
VTS	-3.024

General Info

Name	Value
Reference temperature (ºF)	70
Effective binder content (%)	11
Air voids (%)	6.5
Thermal conductivity (BTU/hr-ft-ºF)	0.67
Heat capacity (BTU/lb-ºF)	0.23
Asphalt content by weight (%)	6
Aggregate parameter	0.4021

Identifiers

Field	Value
Display name/identifier	Default asphalt concrete
Description of object	
Author	
Date Created	10/30/2010 12:00:00 AM
Approver	
Date approved	10/30/2010 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Layer 2 Flexible : Default asphalt concrete

Asphalt		
Thickness (in)	5.0	
Unit weight (pcf)	150.0	
Poisson's ratio	Is Calculated?	False
	Ratio	0.35
	Parameter A	-
	Parameter B	-

Asphalt Dynamic Modulus (Input Level: 3)

Gradation	Percent Passing
3/4-inch sieve	100
3/8-inch sieve	77
No.4 sieve	60
No.200 sieve	6

Asphalt Binder

Parameter	Value
Grade	Superpave Performance Grade
Binder Type	64-22
A	10.98
VTS	-3.68

General Info

Name	Value
Reference temperature (ºF)	70
Effective binder content (%)	11
Air voids (%)	6.5
Thermal conductivity (BTU/hr-ft-ºF)	0.67
Heat capacity (BTU/lb-ºF)	0.23
Asphalt content by weight (%)	-
Aggregate parameter	-

Identifiers

Field	Value
Display name/identifier	Default asphalt concrete
Description of object	
Author	
Date Created	10/30/2010 12:00:00 AM
Approver	
Date approved	10/30/2010 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Layer 3 Subgrade : Stabilized Subgrade

Unbound	
Layer thickness (in)	8.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Annual representative values
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
15000.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Stabilized Subgrade
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	32.0
Plasticity Index	15.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	True	121.9
Saturated hydraulic conductivity (ft/hr)	False	7.663e-06
Specific gravity of solids	False	2.7
Water Content (%)	True	10

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	75.5741
bf	0.9351
cf	0.4315
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	24.8
#100	
#80	32.4
#60	
#50	
#40	43.5
#30	
#20	
#16	
#10	59.4
#8	
#4	67.2
3/8-in.	78.8
1/2-in.	83.3
3/4-in.	90.4
1-in.	94.5
1 1/2-in.	97.7
2-in.	99.4
2 1/2-in.	
3-in.	
3 1/2-in.	99.9

Layer 4 Subgrade : A-6

Unbound	
Layer thickness (in)	Semi-infinite
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
5600.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	A-6
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	26.0
Plasticity Index	13.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	True	115.3
Saturated hydraulic conductivity (ft/hr)	False	1.709e-05
Specific gravity of solids	False	2.7
Water Content (%)	True	22

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	106.0536
bf	0.6958
cf	0.2316
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	72.4
#100	
#80	
#60	
#50	
#40	93.0
#30	
#20	
#16	
#10	97.0
#8	
#4	99.0
3/8-in.	100.0
1/2-in.	100.0
3/4-in.	100.0
1-in.	100.0
1 1/2-in.	100.0
2-in.	100.0
2 1/2-in.	
3-in.	
3 1/2-in.	100.0

Calibration Coefficients

AC Fatigue	
$N_f = 0.00432 * C * \beta_{f1} k_1 \left(\frac{1}{\varepsilon_1}\right)^{k_2 \beta_{f2}} \left(\frac{1}{E}\right)^{k_3 \beta_{f3}}$	k1: 3.75
	k2: 2.87
$C = 10^M$	k3: 1.46
	Bf1: (5.014 * Pow(hac,-3.416)) * 1 + 0
$M = 4.84\left(\frac{V_b}{V_a + V_b} - 0.69\right)$	Bf2: 1.38
	Bf3: 0.88

AC Rutting

$$\frac{\varepsilon_p}{\varepsilon_r} = k_z \beta_{r1} 10^{k_1} T^{k_2 \beta_{r2}} N^{k_3 \beta_{r3}}$$

$$k_z = (C_1 + C_2 * depth) * 0.328196^{depth}$$

$$C_1 = -0.1039 * H_\alpha^2 + 2.4868 * H_\alpha - 17.342$$

$$C_2 = 0.0172 * H_\alpha^2 - 1.7331 * H_\alpha + 27.428$$

Where:

H_{ac} = total AC thickness(in)

ε_p = plastic strain(in/in)
ε_r = resilient strain(in/in)
T = layer temperature(°F)
N = number of load repetitions

acRuttingStandardDeviation	0.24 * Pow(RUT,0.8026) + 0.001	
AC Layer 1	K1:-2.45 K2:3.01 K3:0.22	Br1:0.4 Br2:0.52 Br3:1.36
AC Layer 2	K1:-2.45 K2:3.01 K3:0.22	Br1:0.4 Br2:0.52 Br3:1.36

Thermal Fracture

$$C_f = \beta_{t1} N \left[\frac{1}{\sigma_d} log\left(\frac{C}{h_{AC}}\right)\right]$$

$$\Delta C = A(\Delta K)^n$$

$$A = k_t \beta_t 10^{[4.389 - 2.52 \log(E_{HMA} \sigma_m n)]}$$

Cf = Observed amount of thermal cracking, ft. / 500ft.
β_{t1} = Regression coefficient determined through global calibration (400)
N[z] = Standard normal distribution evaluated at [z]
σ_d = Standard deviation of the logarithm of crack depth in the pavement (0.769), in.
C = Crack depth, in.
h_{AC} = Thickness of asphalt layer, in.
ΔC = Change in the crack depth due to a cooling cycle
ΔK = Change in the stress intensity factor due to a cooling cycle
A, n = Fracture parameters for the asphalt mixture
E = Asphalt mixture stiffness, MPa
σ_m = Undamaged mixture tensile strength, MPa
k_t = Regression coefficient determined through field calibration
β_t = Calibration parameter

Level 1 K: (0.13 * Pow(MAAT,2) - 11.68 * MAAT + 244.14) * 1 + 0	Level 1 Standard Deviation: 0.14 * THERMAL + 343
Level 2 K: (0.13 * Pow(MAAT,2) - 11.68 * MAAT + 244.14) * 1 + 0	Level 2 Standard Deviation: 0.20 * THERMAL + 343
Level 3 K: (0.13 * Pow(MAAT,2) - 11.68 * MAAT + 244.14) * 1 + 0	Level 3 Standard Deviation: 0.2386 * THERMAL + 343

CSM Fatigue

$$N_f = 10^{\left(\frac{k_1 \beta_{c1} \left(\frac{\sigma_s}{M_r}\right)}{k_2 \beta_{c2}}\right)}$$

N_f = number of repetitions to fatigue cracking
σ_s = Tensile stress(psi)
M_r = modulus of rupture(psi)

k1: 0.972	k2: 0.0825	Bc1: 1	Bc2:1

Unbound Layer Rutting

$$\delta_a(N) = \beta_{s_1} k_1 \varepsilon_v h \left(\frac{\varepsilon_0}{\varepsilon_r}\right) \left| e^{-\left(\frac{\rho}{N}\right)^{\beta}} \right|$$

δ_a = permanent deformation for the layer
N = number of repetitions
ε_v = average veritcal strain(in/in)
$\varepsilon_0, \beta, \rho$ = material properties
ε_r = resilient strain(in/in)

Base Rutting		Subgrade Rutting	
k1: 0.965	Bs1: 1	k1: 0.675	Bs1: 1
Standard Deviation (BASERUT) 0.1477 * Pow(BASERUT,0.6711) + 0.001		Standard Deviation (BASERUT) 0.1235 * Pow(SUBRUT,0.5012) + 0.001	

AC Cracking

AC Top Down Cracking

$$L(t) = L_{Max} e^{-\left(\frac{C_1 \rho}{t - C_3 t_o}\right)^{C_2 \beta}}$$

$$t_0(\text{Days}) = \frac{k_{L1}}{1 + e^{(k_{L2} \times 100 \times a_0 / 2A_0) + (k_{L3} \times HT) + (k_{L4} \times LT) + (k_{L5} \times \log_{10} AADTT)}}$$

c1: 2.5219	c2: 0.8069	c3: 1
kL1: 64271618	kL2: 0.2855	kL3: 0.011
kL4: 0.01488	kL5: 3.266	

acCrackingTopStandardDeviation

0.3657 * TOP + 3.6563

AC Bottom Up Cracking

$$FC = \left(\frac{6000}{1 + e^{(C_1 * C_1' + C_2 * C_2' \log_{10}(D * 100))}}\right) * \left(\frac{1}{60}\right)$$

$$C_2' = -2.40874 - 39.748 * (1 + h_{ac})^{-2.856}$$

$$C_1' = -2 * C_2'$$

c1: 1.31	c2: (0.867 + 0.2583 * hac) * 1 + 0	c3: 6000

acCrackingBottomStandardDeviation

1.13 + 13/(1+exp(7.57-15.5*LOG10(BOTTOM+0.0001)))

CSM Cracking

$$FC_{ctb} = C_1 + \frac{C_2}{1 + e^{C_3 - C_4 * \log_{10}(Damage)}}$$

C1: 0	C2: 75	C3: 2	C4: 2

csmCrackingStandardDeviation

CTB*1

IRI Flexible Pavements

C1 - Rutting
C2 - Fatigue Crack
C3 - Transverse Crack
C4 - Site Factors

C1: 40	C2: 0.4	C3: 0.008	C4: 0.015

22119 New Ramps PCC 9

File Name: C:\Users\kkb\OneDrive\Documents\My ME Design\Projects\2022\22119\22119 New Ramps PCC 9.dgpx

Design Inputs

Design Life: 30 years
Design Type: JPCP

Existing construction: -
Pavement construction: May, 2025
Traffic opening: May, 2027

Climate Data Sources (Lat/Lon): 35.389, -97.6

Design Structure

Layer type	Material Type	Thickness (in)
PCC	JPCP Default	9.0
Cement_Base	Cement Treated Base	4.0
Subgrade	Stabilized Subgrade	8.0
Subgrade	A-6	Semi-infinite

Joint Design:	
Joint spacing (ft)	15.0
Dowel diameter (in)	1.50
Slab width (ft)	12.0

Traffic

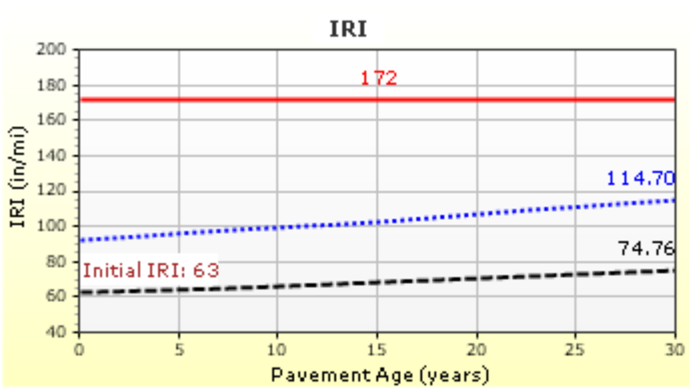
Age (year)	Heavy Trucks (cumulative)
2027 (initial)	304
2042 (15 years)	1,920,190
2057 (30 years)	4,504,520

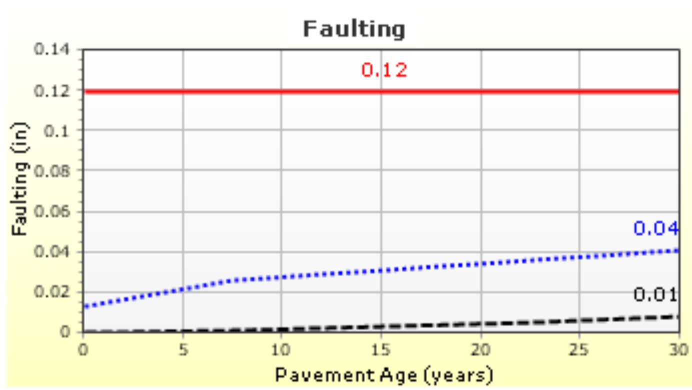
Design Outputs

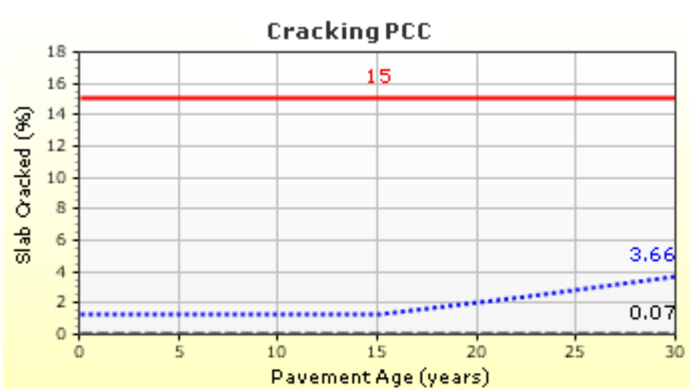
Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	172.00	114.70	95.00	100.00	Pass
Mean joint faulting (in)	0.12	0.04	95.00	100.00	Pass
JPCP transverse cracking (percent slabs)	15.00	3.66	95.00	100.00	Pass

Distress Charts



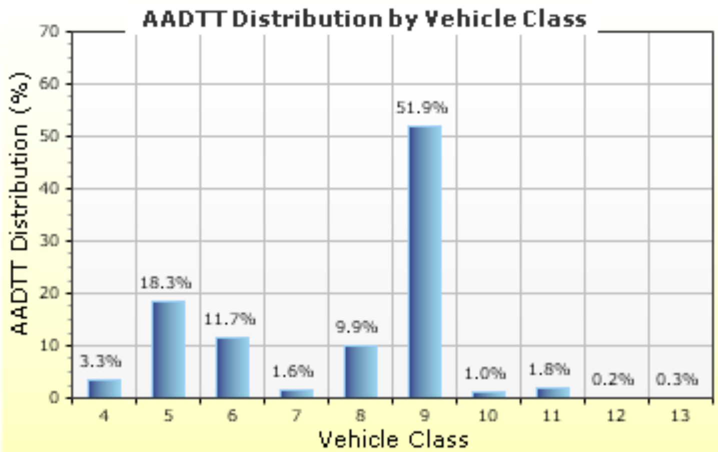


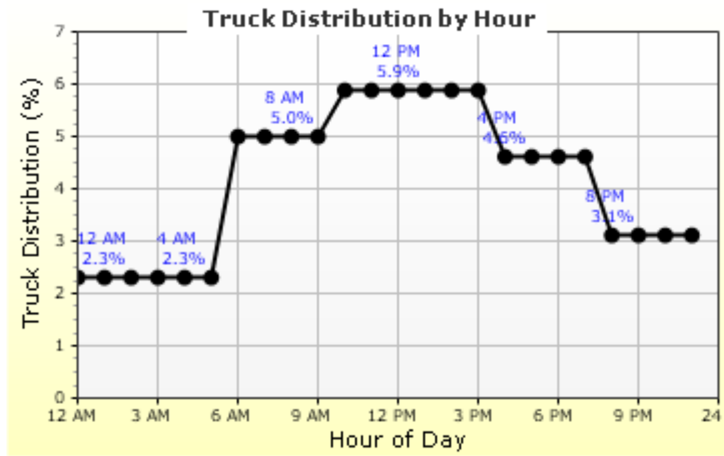


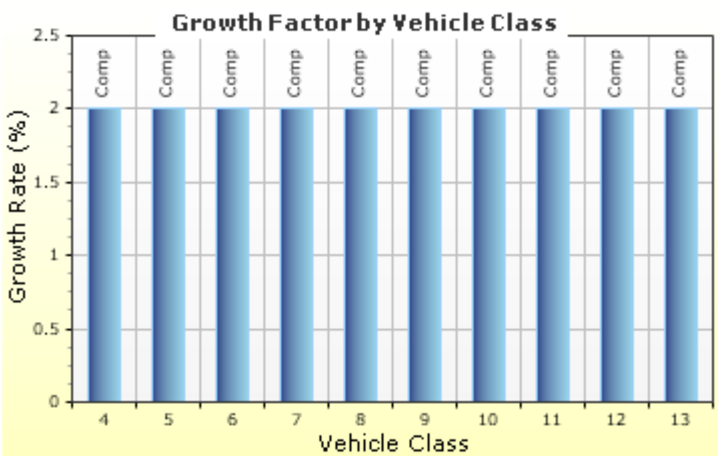
Traffic Inputs

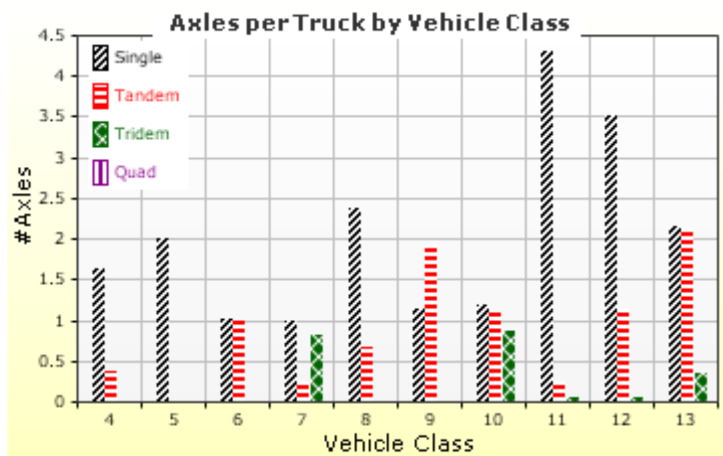
Graphical Representation of Traffic Inputs

Initial two-way AADTT:	304	Percent of trucks in design direction (%):	100.0
Number of lanes in design direction:	1	Percent of trucks in design lane (%):	100.0
		Operational speed (mph)	45.0

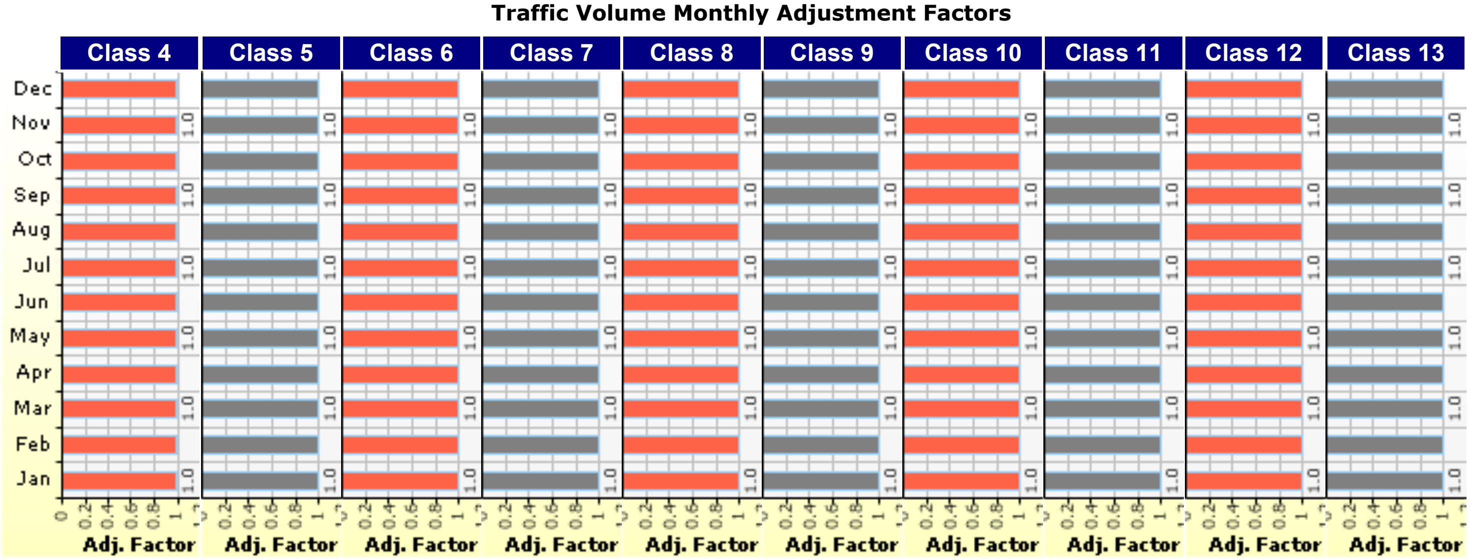








Traffic Volume Monthly Adjustment Factors



Tabular Representation of Traffic Inputs

Volume Monthly Adjustment Factors

Level 3: Default MAF

Month	Vehicle Class 4	5	6	7	8	9	10	11	12	13
January	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
February	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
March	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
April	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
May	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
June	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
July	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
August	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
September	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
October	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
November	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
December	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Distributions by Vehicle Class

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor Rate (%)	Growth Factor Function
Class 4	3.3%	2%	Compound
Class 5	18.3%	2%	Compound
Class 6	11.7%	2%	Compound
Class 7	1.6%	2%	Compound
Class 8	9.9%	2%	Compound
Class 9	51.9%	2%	Compound
Class 10	1%	2%	Compound
Class 11	1.8%	2%	Compound
Class 12	0.2%	2%	Compound
Class 13	0.3%	2%	Compound

Truck Distribution by Hour

Hour	Distribution (%)	Hour	Distribution (%)
12 AM	2.3%	12 PM	5.9%
1 AM	2.3%	1 PM	5.9%
2 AM	2.3%	2 PM	5.9%
3 AM	2.3%	3 PM	5.9%
4 AM	2.3%	4 PM	4.6%
5 AM	2.3%	5 PM	4.6%
6 AM	5%	6 PM	4.6%
7 AM	5%	7 PM	4.6%
8 AM	5%	8 PM	3.1%
9 AM	5%	9 PM	3.1%
10 AM	5.9%	10 PM	3.1%
11 AM	5.9%	11 PM	3.1%
		Total	100%

Axle Configuration

Traffic Wander	
Mean wheel location (in)	18.0
Traffic wander standard deviation (in)	10.0
Design lane width (ft)	12.0

Axle Configuration	
Average axle width (ft)	8.5
Dual tire spacing (in)	12.0
Tire pressure (psi)	120.0

Average Axle Spacing	
Tandem axle spacing (in)	51.6
Tridem axle spacing (in)	49.2
Quad axle spacing (in)	49.2

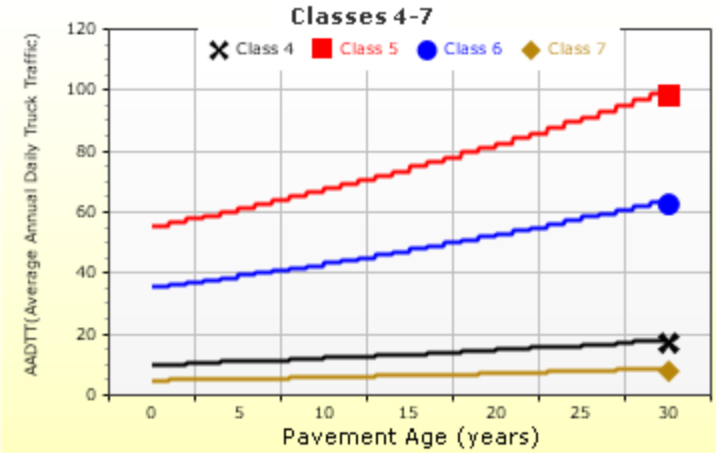
Wheelbase: Value Type / Axle Type	Short	Medium	Long
Average spacing of axles (ft)	12.0	15.0	18.0
Percent of Trucks (%)	17.0	22.0	61.0

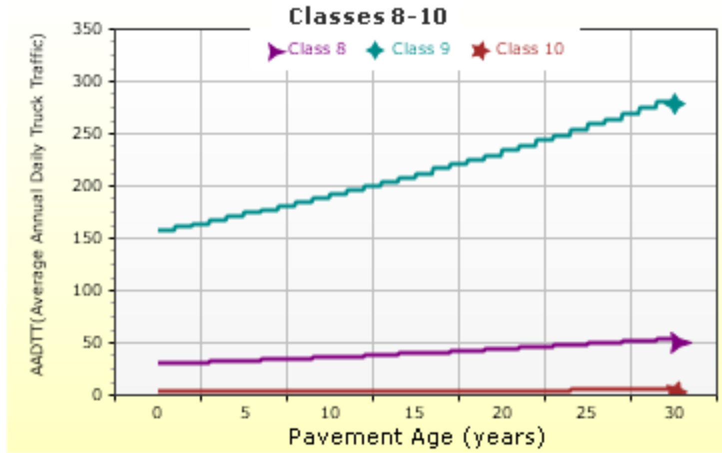
Number of Axles per Truck

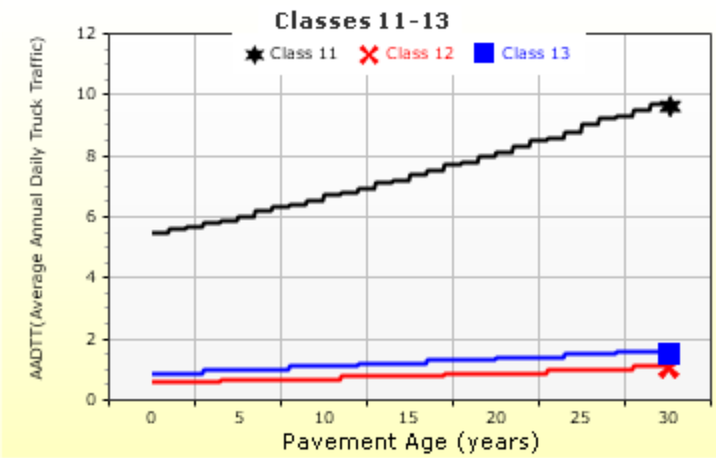
Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.62	0.39	0	0
Class 5	2	0	0	0
Class 6	1.02	0.99	0	0
Class 7	1	0.26	0.83	0
Class 8	2.38	0.67	0	0
Class 9	1.13	1.93	0	0
Class 10	1.19	1.09	0.89	0
Class 11	4.29	0.26	0.06	0
Class 12	3.52	1.14	0.06	0
Class 13	2.15	2.13	0.35	0

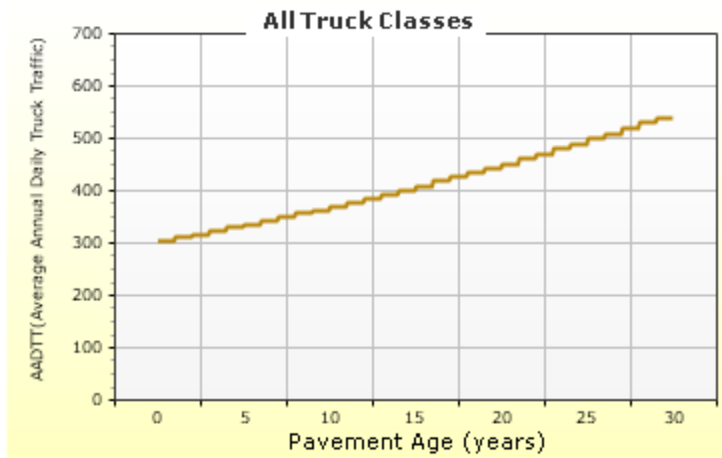
AADTT (Average Annual Daily Truck Traffic) Growth

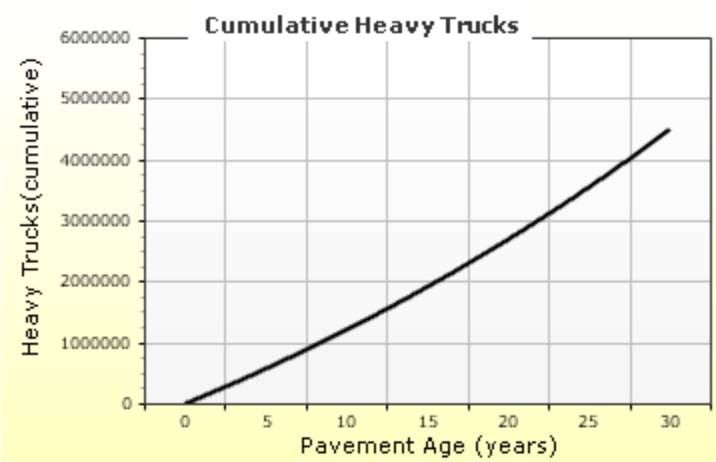
*** Traffic cap is not enforced**







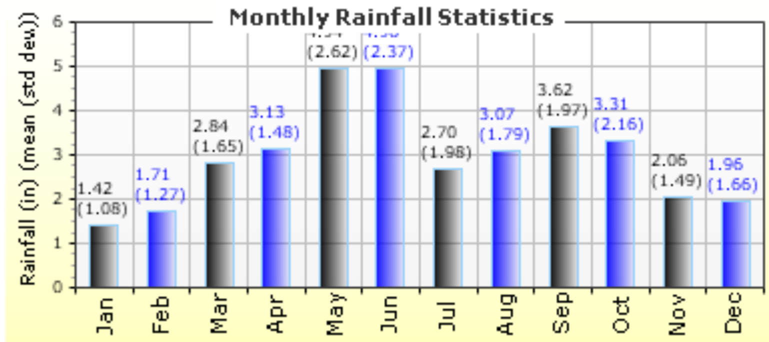




Climate Inputs

Climate Data Sources:

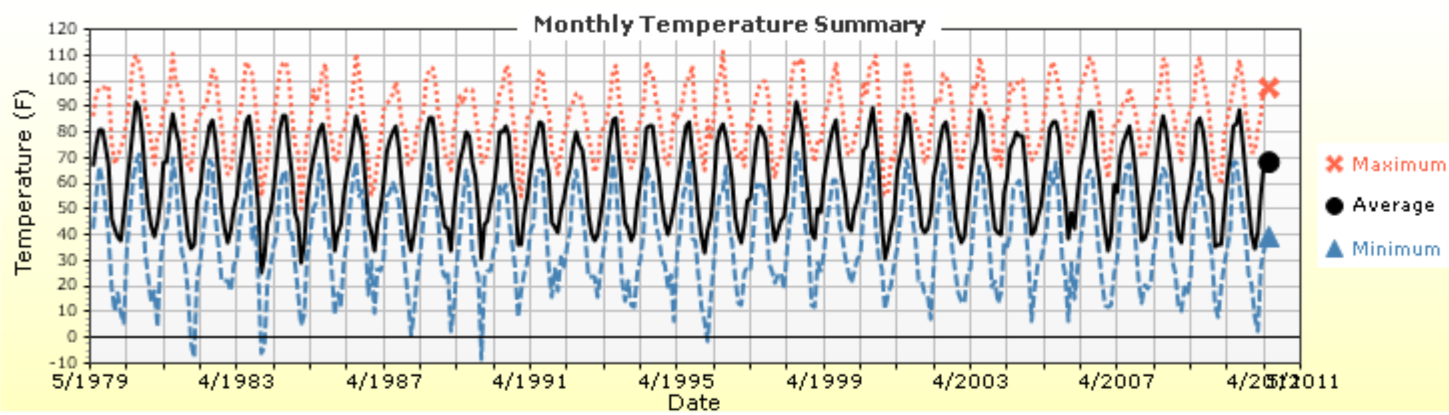
Climate Station Cities:	Location (lat lon elevation(ft))
OKLAHOMA CITY_NARR	35.38900 -97.60000 1274

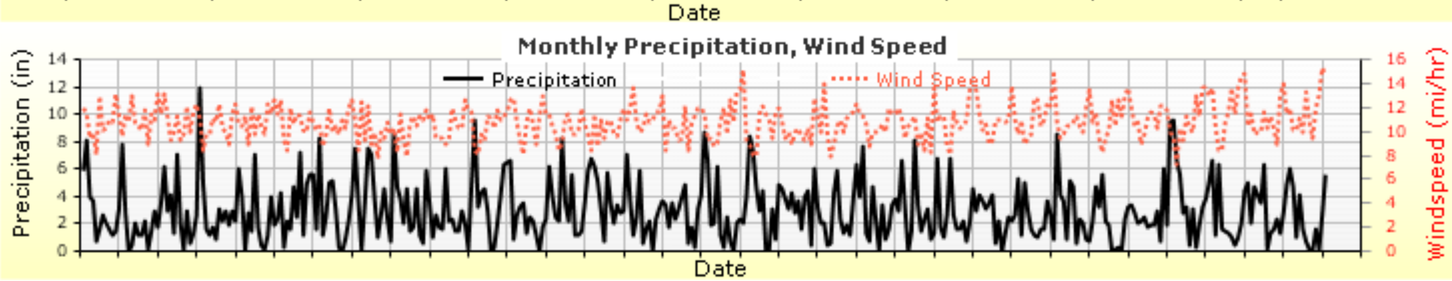


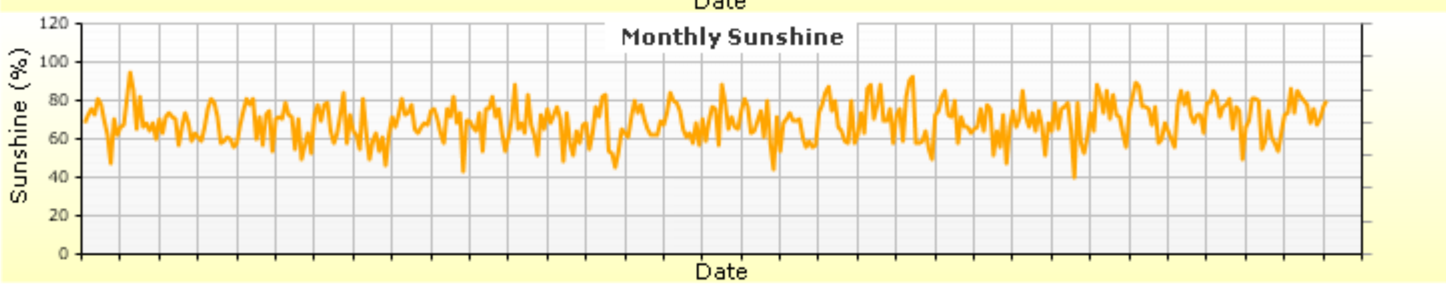
Annual Statistics:

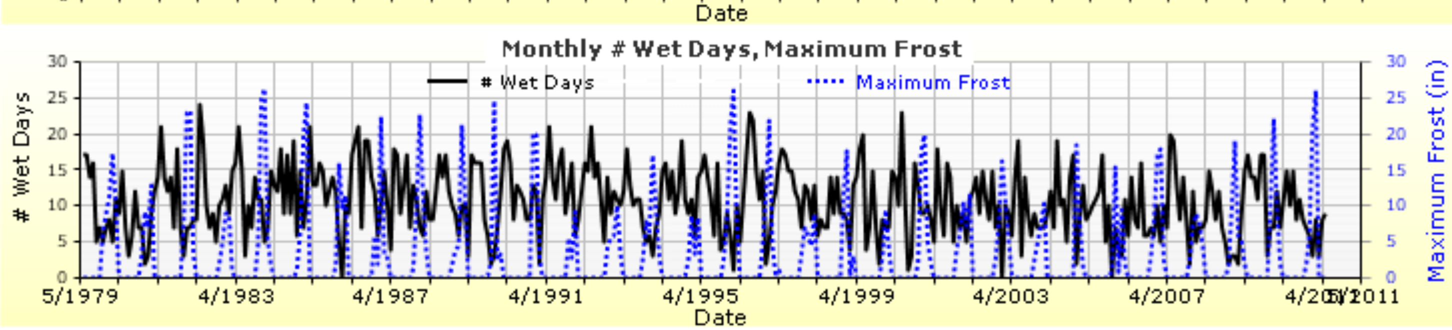
Mean annual air temperature (ºF)	61.19
Mean annual precipitation (in)	35.80
Freezing index (ºF - days)	130.68
Average annual number of freeze/thaw cycles:	41.55
Water table depth (ft)	24.00

Monthly Climate Summary:

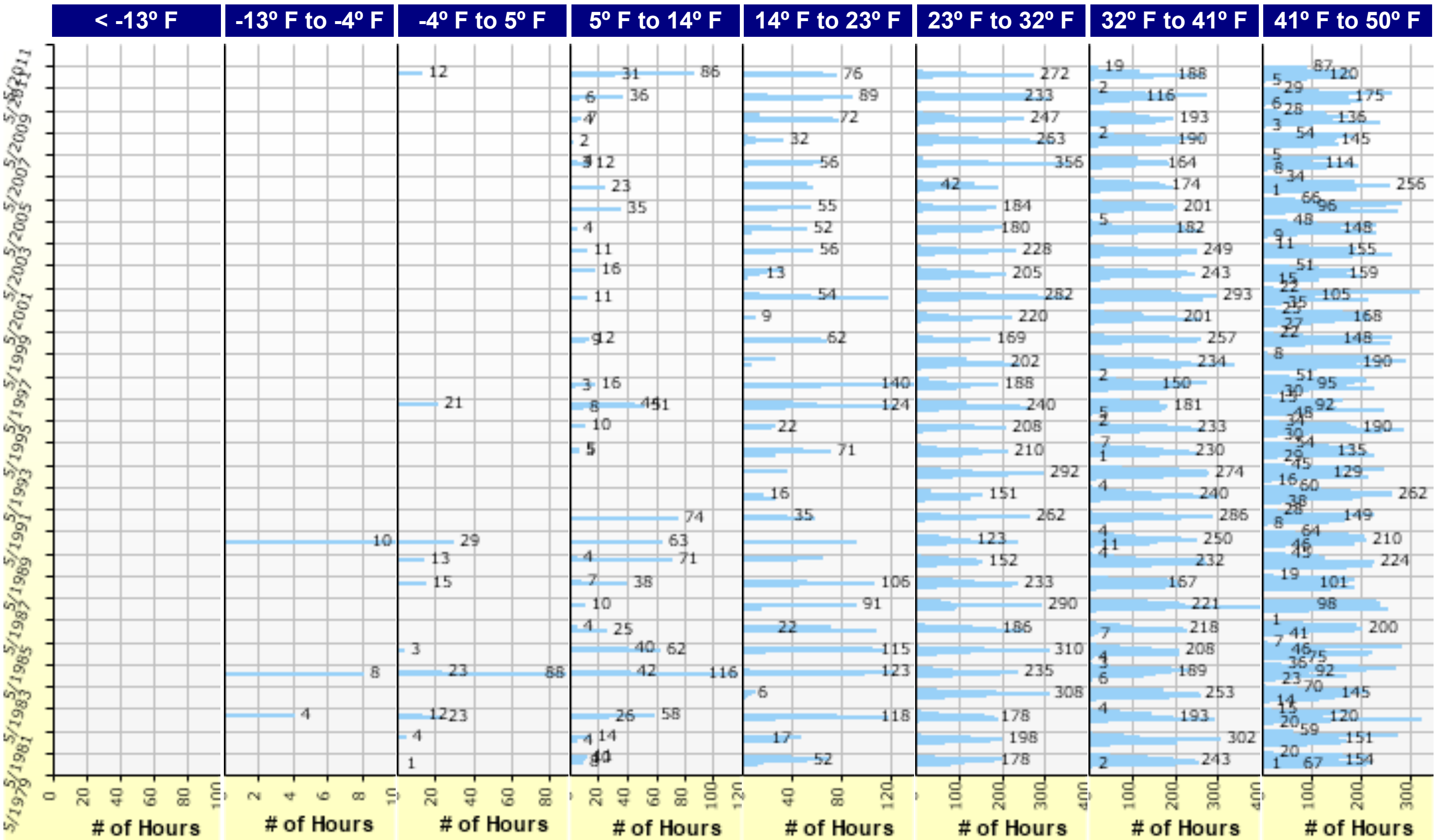


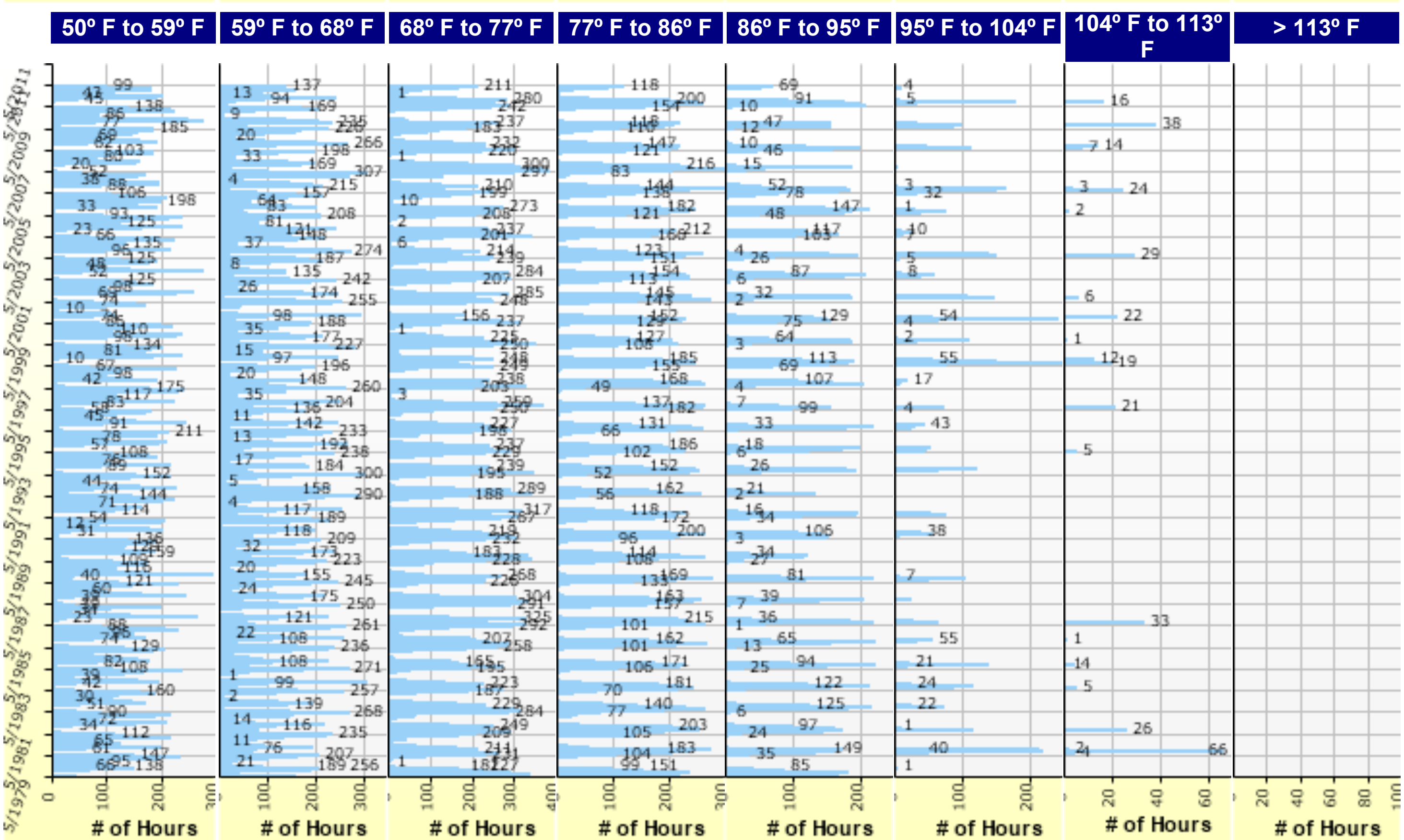






Hourly Air Temperature Distribution by Month:





Design Properties

JPCP Design Properties

Structure - ICM Properties	
PCC surface shortwave absorptivity	0.85

Doweled Joints	
Is joint doweled ?	True
Dowel diameter (in)	1.50
Dowel spacing (in)	12.00

Tied Shoulders	
Tied shoulders	False
Load transfer efficiency (%)	-

PCC joint spacing (ft)	
Is joint spacing random ?	False
Joint spacing (ft)	15.00

Widened Slab	
Is slab widened ?	False
Slab width (ft)	12.00

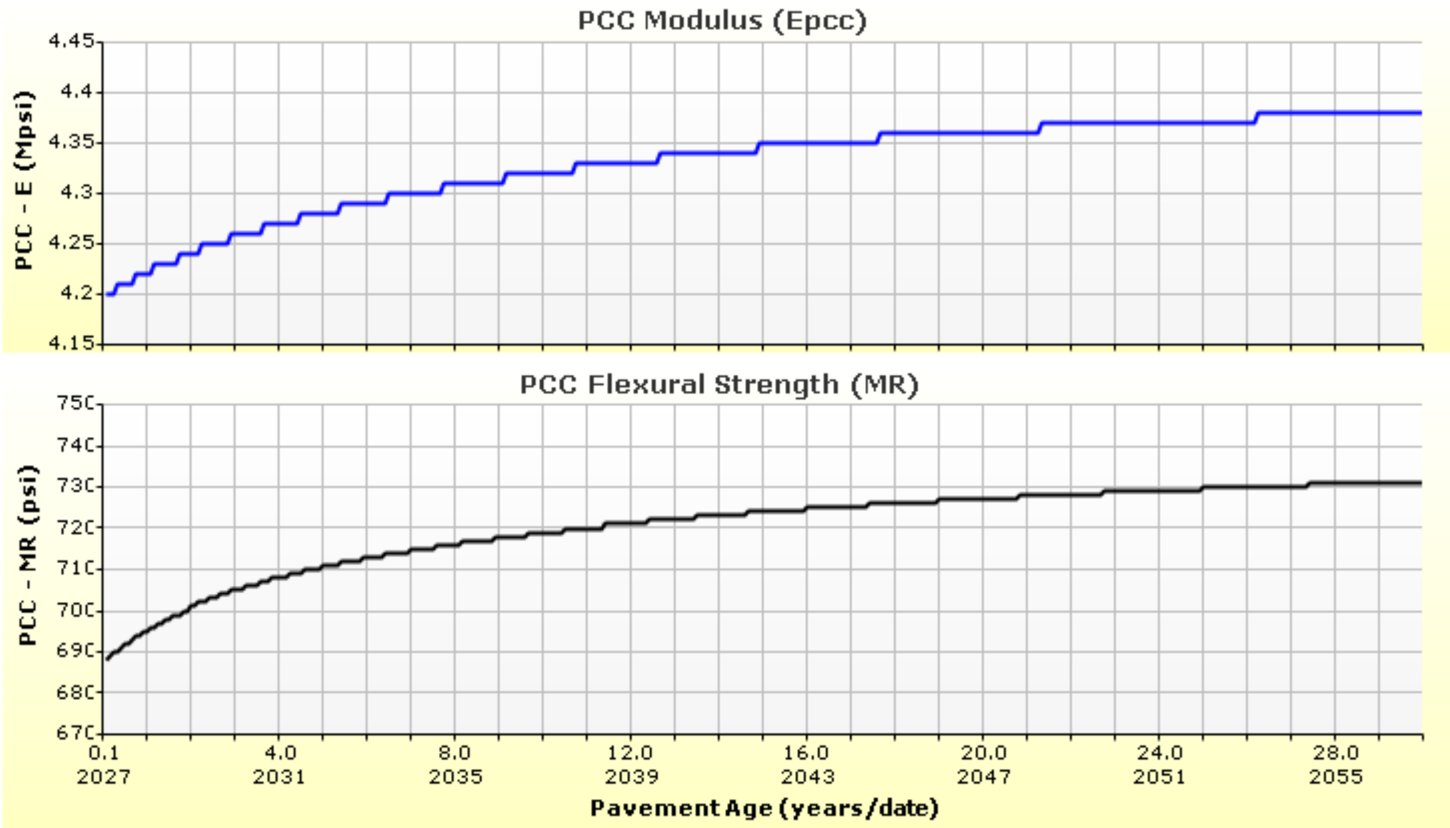
PCC-Base Contact Friction	
PCC-Base full friction contact	True
Months until friction loss	240.00

Sealant type	Preformed

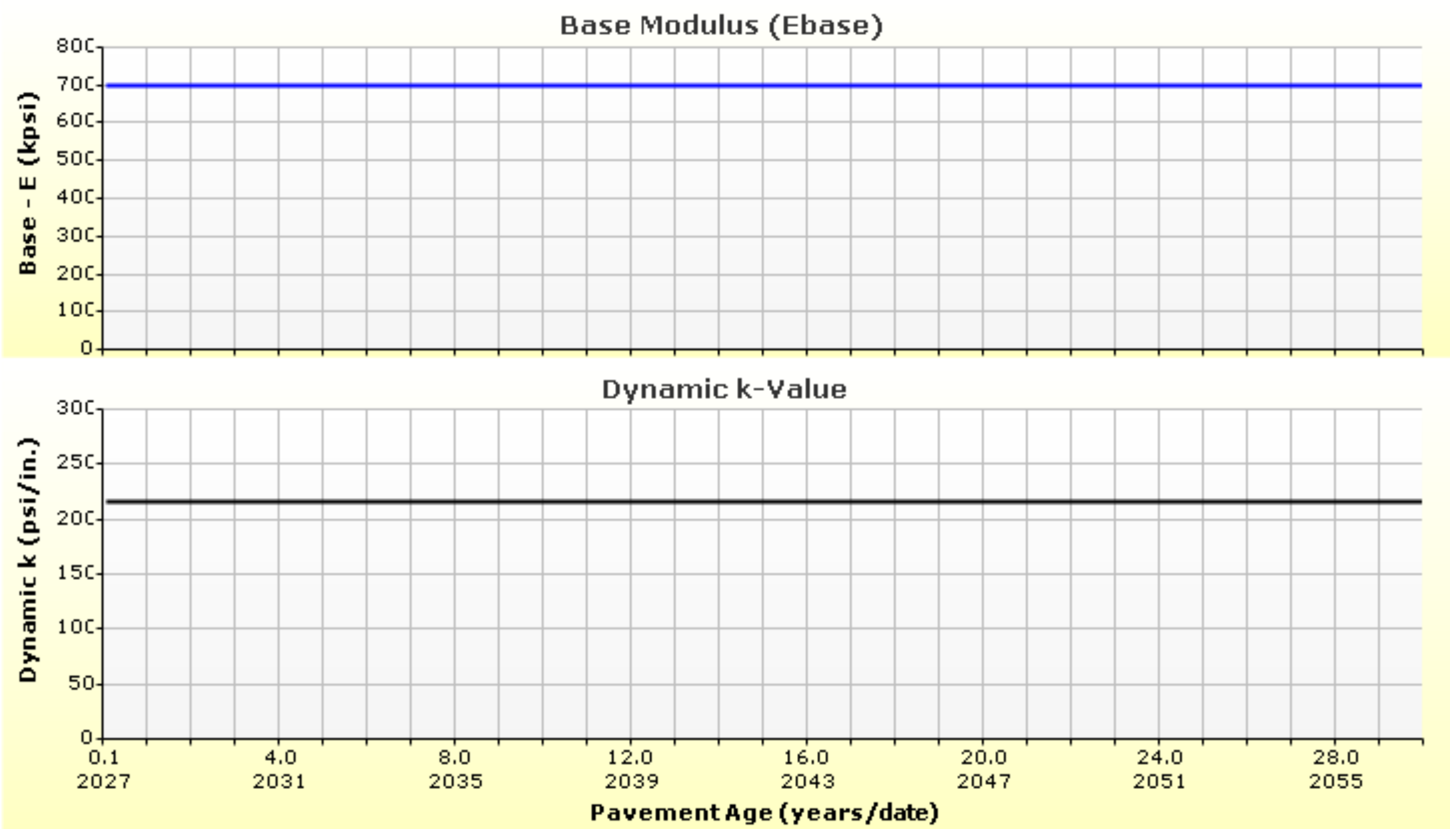
Erodibility index	4

Permanent curl/warp effective temperature difference (ºF)	-10.00

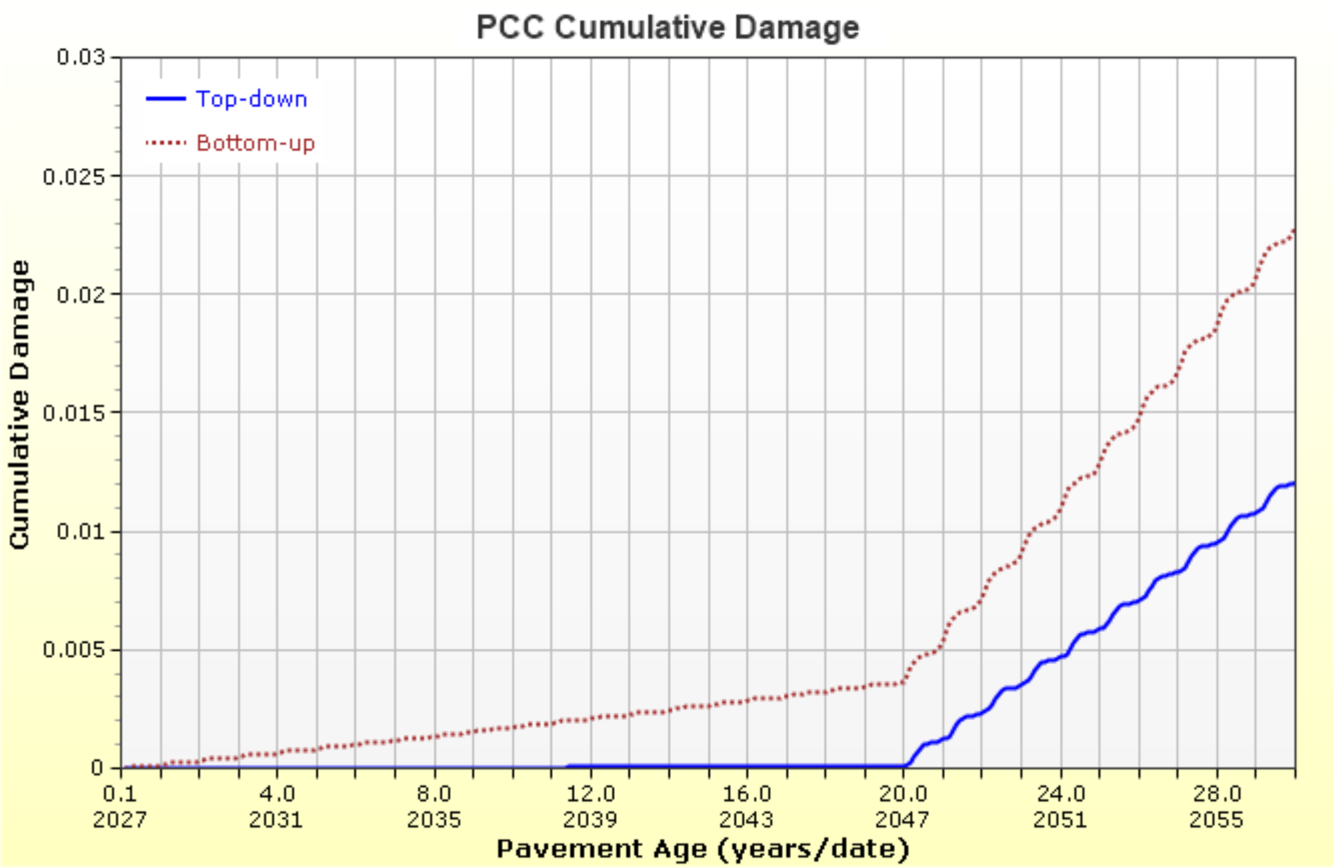
Analysis Output Charts



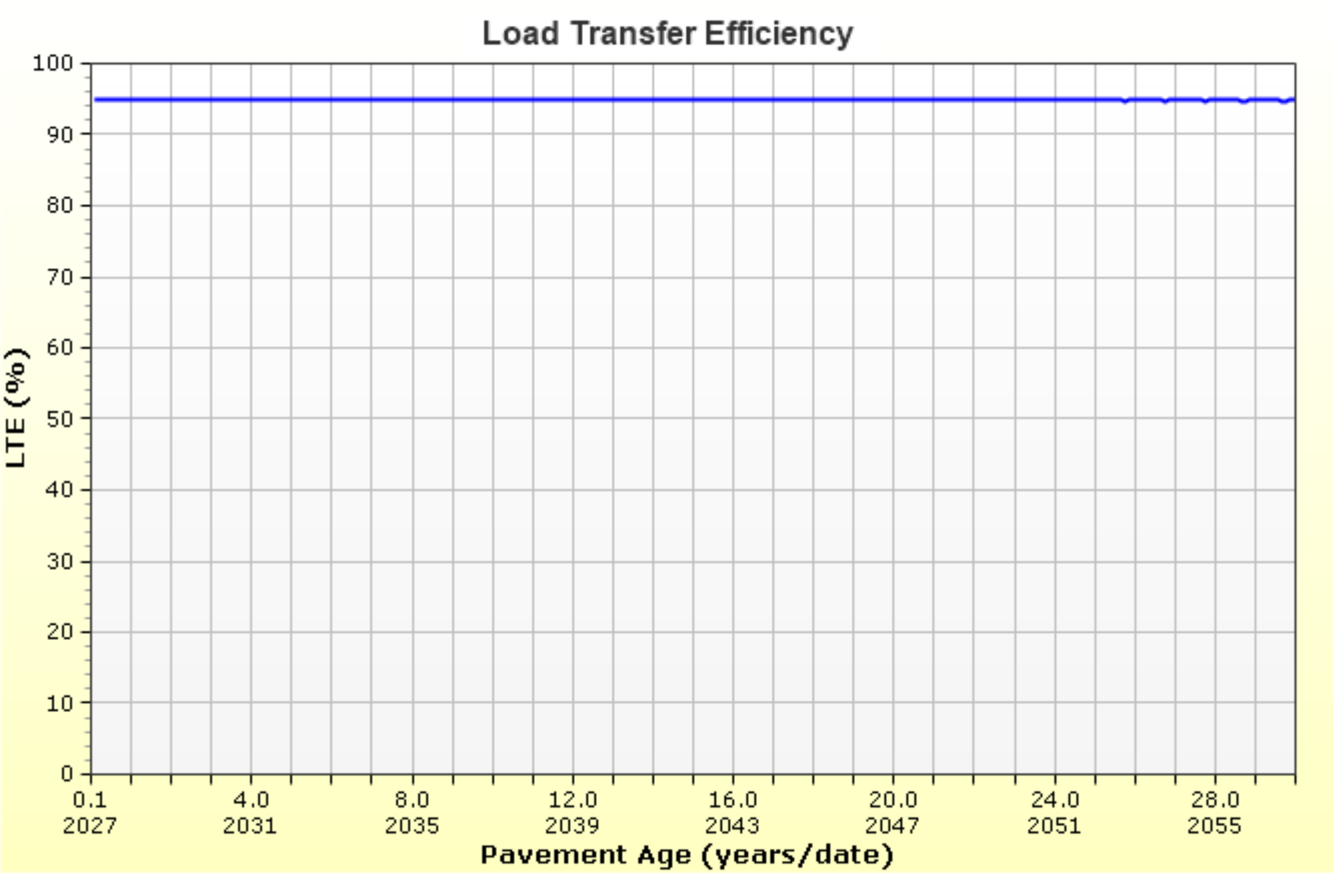
PCC Modulus (Epcc)
PCC - E (Mpsi)
4.45
4.4
4.35
4.3
4.25
4.2
4.15
PCC Flexural Strength (MR)
PCC - MR (psi)
750
740
730
720
710
700
690
680
670
0.1 2027
4.0 2031
8.0 2035
12.0 2039
16.0 2043
20.0 2047
24.0 2051
28.0 2055
Pavement Age (years/date)



Base Modulus (Ebase)
Base - E (kpsi)
800
700
600
500
400
300
200
100
0
Dynamic k-Value
Dynamic k (psi/in.)
300
250
200
150
100
50
0
0.1 2027
4.0 2031
8.0 2035
12.0 2039
16.0 2043
20.0 2047
24.0 2051
28.0 2055
Pavement Age (years/date)



PCC Cumulative Damage
Top-down
Bottom-up
Cumulative Damage
0.03
0.025
0.02
0.015
0.01
0.005
0
0.1 2027
4.0 2031
8.0 2035
12.0 2039
16.0 2043
20.0 2047
24.0 2051
28.0 2055
Pavement Age (years/date)



Load Transfer Efficiency
LTE (%)
100
90
80
70
60
50
40
30
20
10
0
0.1 2027
4.0 2031
8.0 2035
12.0 2039
16.0 2043
20.0 2047
24.0 2051
28.0 2055
Pavement Age (years/date)

Layer Information

Layer 1 PCC : JPCP Default

PCC	
Thickness (in)	9.0
Unit weight (pcf)	150.0
Poisson's ratio	0.2

Thermal	
PCC coefficient of thermal expansion (in/in/ºF x 10^-6)	4.9
PCC thermal conductivity (BTU/hr-ft-ºF)	1.25
PCC heat capacity (BTU/lb-ºF)	0.28

Mix		
Cement type		Type I (1)
Cementitious material content (lb/yd^3)		600
Water to cement ratio		0.42
Aggregate type		Dolomite (2)
PCC zero-stress temperature (ºF)	Calculated Internally?	True
	User Value	-
	Calculated Value	101.6
Ultimate shrinkage (microstrain)	Calculated Internally?	True
	User Value	-
	Calculated Value	657.2
Reversible shrinkage (%)		50
Time to develop 50% of ultimate shrinkage (days)		35
Curing method		Curing Compound

PCC strength and modulus (Input Level: 3)

28-Day PCC compressive strength (psi)	4000.0
28-Day PCC elastic modulus (psi)	3600000.0

Identifiers

Field	Value
Display name/identifier	JPCP Default
Description of object	
Author	
Date Created	5/25/2021 10:12:41 AM
Approver	
Date approved	5/25/2021 10:12:41 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Layer 2 Chemically Stabilized : Cement Treated Base

Chemically Stabilized	
Layer thickness (in)	4
Poisson's ratio	0.2
Unit weight (pcf)	150

Strength	
Elastic/resilient modulus (psi)	700000

Thermal	
Heat capacity (BTU/lb-ºF)	0.2
Thermal conductivity (BTU/hr-ft-ºF)	1

Identifiers

Field	Value
Display name/identifier	Cement Treated Base
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Layer 3 Subgrade : Stabilized Subgrade

Unbound	
Layer thickness (in)	8.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Annual representative values
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
15000.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Stabilized Subgrade
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	36.0
Plasticity Index	17.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	True	115.2
Saturated hydraulic conductivity (ft/hr)	False	1.02e-05
Specific gravity of solids	False	2.7
Water Content (%)	True	20

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	116.4986
bf	0.6287
cf	0.1631
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	76.1
#100	
#80	
#60	
#50	
#40	81.0
#30	
#20	
#16	
#10	85.0
#8	
#4	91.0
3/8-in.	100.0
1/2-in.	100.0
3/4-in.	100.0
1-in.	100.0
1 1/2-in.	100.0
2-in.	100.0
2 1/2-in.	
3-in.	
3 1/2-in.	100.0

Layer 4 Subgrade : A-6

Unbound	
Layer thickness (in)	Semi-infinite
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 2)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
5600.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	A-6
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	36.0
Plasticity Index	17.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	True	115.2
Saturated hydraulic conductivity (ft/hr)	False	1.02e-05
Specific gravity of solids	False	2.7
Water Content (%)	True	20

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	116.4986
bf	0.6287
cf	0.1631
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	76.1
#100	
#80	
#60	
#50	
#40	81.0
#30	
#20	
#16	
#10	85.0
#8	
#4	91.0
3/8-in.	100.0
1/2-in.	100.0
3/4-in.	100.0
1-in.	100.0
1 1/2-in.	100.0
2-in.	100.0
2 1/2-in.	
3-in.	100.0
3 1/2-in.	

Calibration Coefficients

PCC Faulting

$$C_{12} = C_1 + (C_2 * FR^{0.25})$$
$$C_{34} = C_3 + (C_4 * FR^{0.25})$$
$$FaultMax_0 = C_{12} * \delta_{curling} * \left[\log(1 + C_5 * 5.0^{EROD}) * \log\left(P_{200} * \frac{WetDays}{p_s}\right)\right]^{C_6}$$
$$FaultMax_i = FaultMax_0 + C_7 * \sum_{j=1}^{m} DE_j * \log(1 + C_5 * 5.0^{EROD})^{C_6}$$
$$\Delta Fault_i = C_{34} * (FaultMax_{i-1} - Fault_{i-1})^2 * DE_i$$
$$C_8 = DowelDeterioration$$

C1: 0.595	C2: 1.636	C3: 0.00217	C4: 0.00444
C5: 250	C6: 0.47	C7: 7.3	C8: 400
pccReliabilityFaultStandardDeviation			
0.07162 * Pow(FAULT,0.368) + 0.00806			

IRI-jpcp

C1 - Cracking	C1: 0.8203	C2: 0.4417
C2 - Spalling	C3: 1.4929	C4: 25.24
C3 - Faulting	**Reliability Standard Deviation**	
C4 - Site Factor	5.4	

PCC Cracking

$$\log(N) = C1 \cdot \left(\frac{MR}{\sigma}\right)^{C2}$$

$$CRK = \frac{100}{1 + C4\, FD^{C5}}$$

Fatigue Coefficients		**Cracking Coefficients**	
C1: 2	C2: 1.22	C4: 0.52	C5: -2.17
pccReliabilityCrackStandardDeviation			
3.5522 * Pow(CRACK,0.3415) + 0.75			