Marion County 4K AADTT 2W1L on Overlay on HMA on CompAgg

File Name: \\iotisip01pa\dot-darwin$\Projects_DarWinME Inputs\HMA Materials Input Files\Asphalt Material Properties New\Greenfield\HMA Surface\Marion County 4K AADTT 2W1L

Design Inputs

Design Life: 4 years
Design Type: ACC_ACC

Existing construction: May, 2024
Pavement construction: June, 2024
Traffic opening: September, 2024

Climate Data Sources (Lat/Lon): 39.71, -86.272

Design Structure

Layer type	Material Type	Thickness (in)
Flexible (OL)	Greenfield, 4, 76, SURFACE, 9.5 mm	1.5
Flexible (existing)	Existing Asphalt 19.0mm	7.5
NonStabilized	Crushed stone	3.0
NonStabilized	Subgrade Treatment (#53 Aggregate)	6.0
Subgrade	A-6	Semi-infinite

Volumetric at Construction:	
Effective binder content (%)	11.6
Air voids (%)	7.0

Traffic

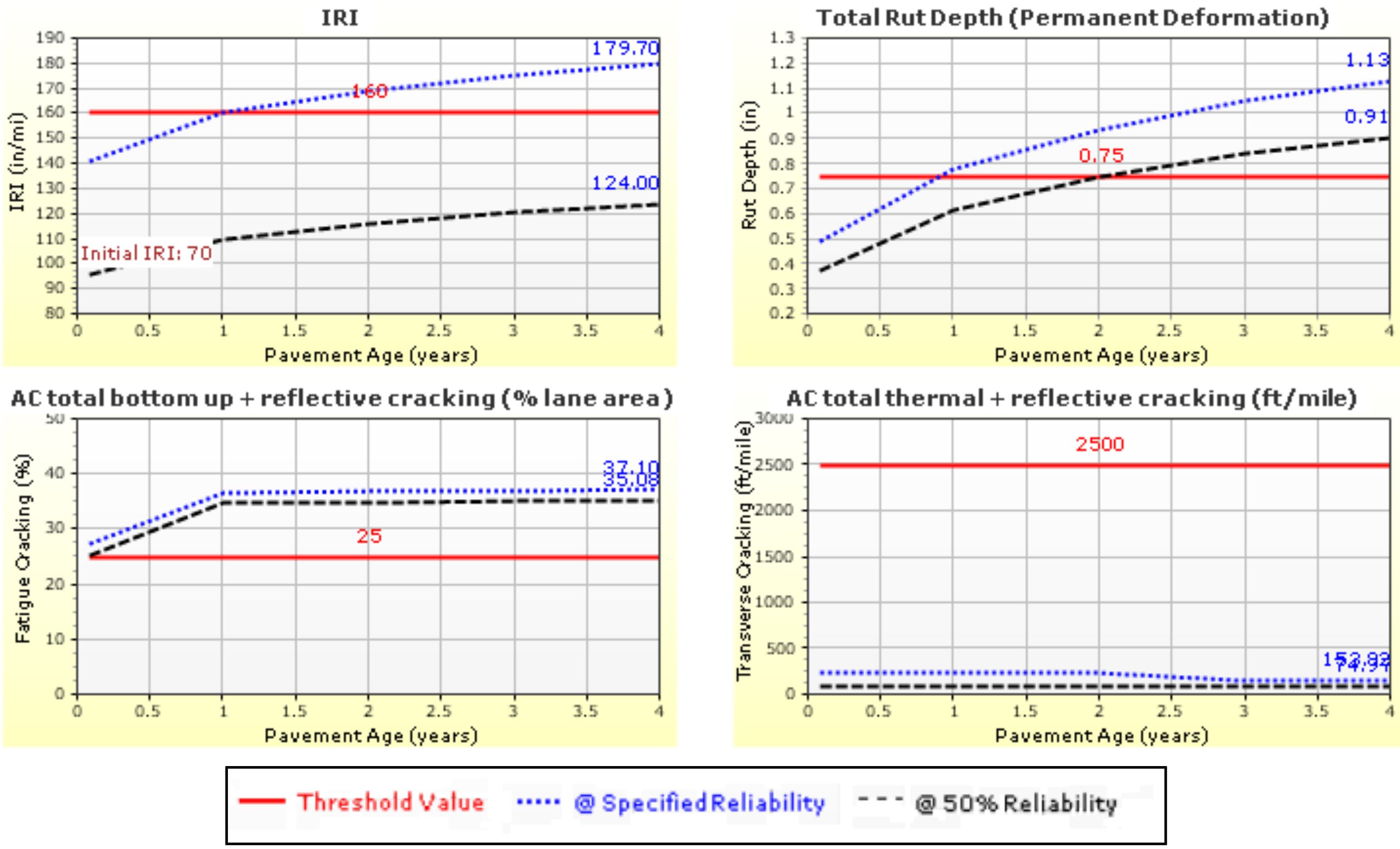
Age (year)	Heavy Trucks (cumulative)
2024 (initial)	4,000
2026 (2 years)	2,936,790
2028 (4 years)	5,932,710

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	179.74	95.00	85.60	Fail
Permanent deformation - total pavement (in)	0.75	1.13	95.00	11.69	Fail
AC total fatigue cracking: bottom up + reflective (% lane area)	25.00	37.10	95.00	0.00	Fail
AC total transverse cracking: thermal + reflective (ft/mile)	2500.00	153.92	95.00	100.00	Pass
Permanent deformation - AC only (in)	0.40	0.47	95.00	81.65	Fail
AC bottom-up fatigue cracking (% lane area)	10.00	0.00	50.00	100.00	Pass
AC thermal cracking (ft/mile)	500.00	0.01	50.00	100.00	Pass
AC top-down fatigue cracking (ft/mile)	2000.00	1143.05	95.00	99.80	Pass

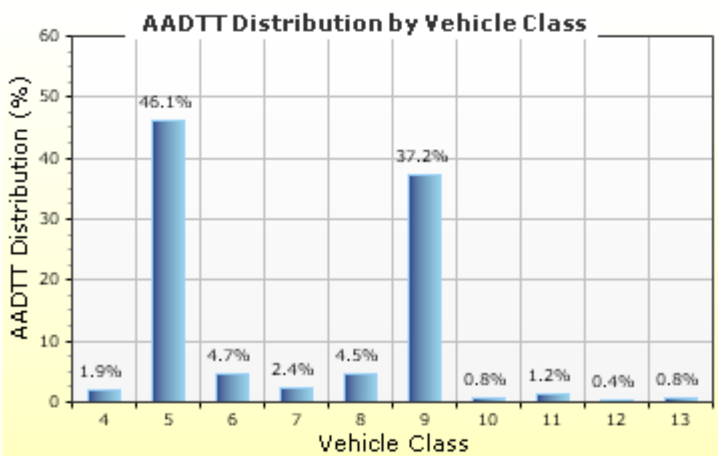
Distress Charts

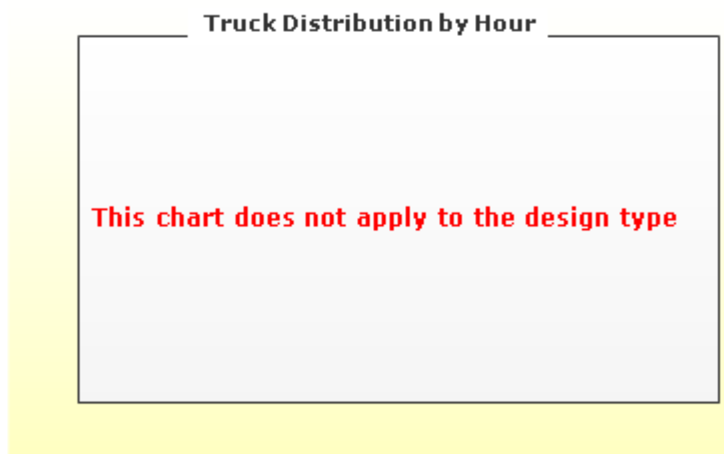


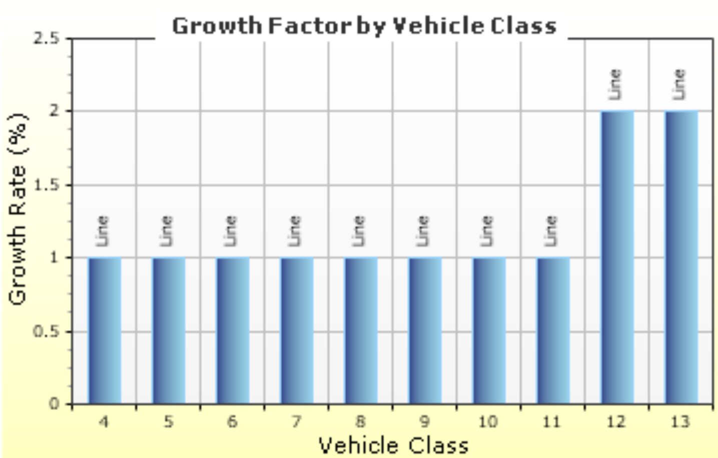
Traffic Inputs

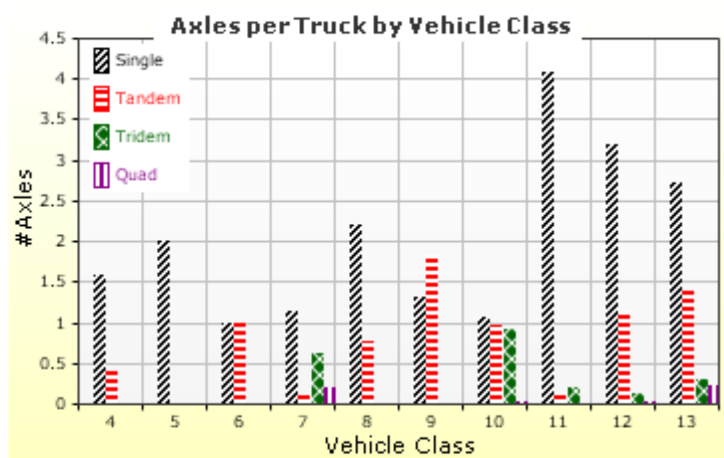
Graphical Representation of Traffic Inputs

Initial two-way AADTT:	4,000	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)	30.0

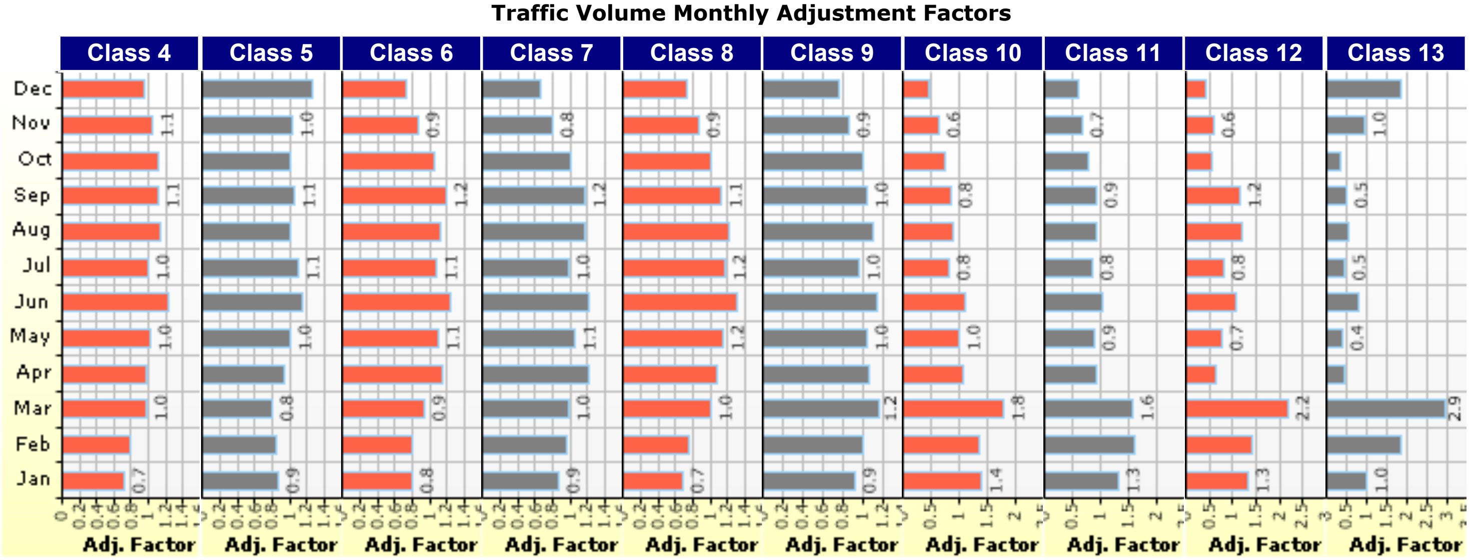








Traffic Volume Monthly Adjustment Factors



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	0.7	0.9	0.8	0.9	0.7	0.9	1.4	1.3	1.3	1.0
February	0.8	0.8	0.8	0.9	0.7	1.0	1.3	1.6	1.4	1.9
March	1.0	0.8	0.9	1.0	1.0	1.2	1.8	1.6	2.2	2.9
April	1.0	0.9	1.1	1.2	1.1	1.1	1.1	0.9	0.6	0.4
May	1.0	1.0	1.1	1.1	1.2	1.0	1.0	0.9	0.7	0.4
June	1.2	1.2	1.2	1.2	1.3	1.1	1.1	1.1	1.1	0.8
July	1.0	1.1	1.1	1.0	1.2	1.0	0.8	0.8	0.8	0.5
August	1.1	1.0	1.1	1.2	1.2	1.1	0.9	0.9	1.2	0.5
September	1.1	1.1	1.2	1.2	1.1	1.0	0.8	0.9	1.2	0.5
October	1.1	1.0	1.1	1.0	1.0	1.0	0.7	0.8	0.5	0.3
November	1.1	1.0	0.9	0.8	0.9	0.9	0.6	0.7	0.6	1.0
December	0.9	1.3	0.7	0.7	0.7	0.8	0.4	0.6	0.4	1.9

Distributions by Vehicle Class

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor	
		Rate (%)	Function
Class 4	1.9%	1%	Linear
Class 5	46.1%	1%	Linear
Class 6	4.7%	1%	Linear
Class 7	2.4%	1%	Linear
Class 8	4.5%	1%	Linear
Class 9	37.2%	1%	Linear
Class 10	0.8%	1%	Linear
Class 11	1.2%	1%	Linear
Class 12	0.4%	2%	Linear
Class 13	0.8%	2%	Linear

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

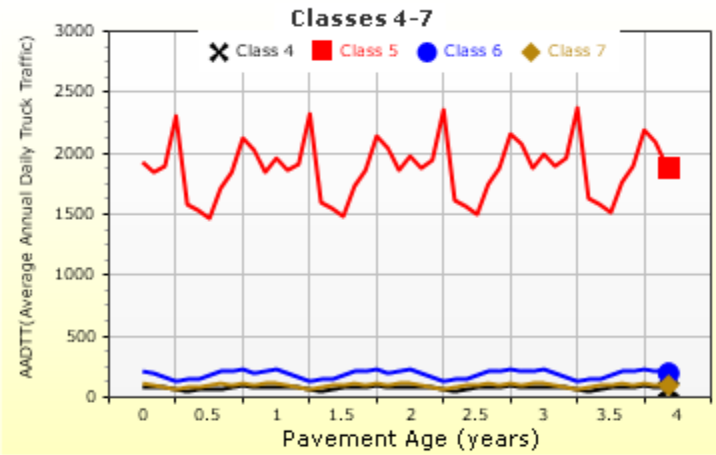
Wheelbase does not apply

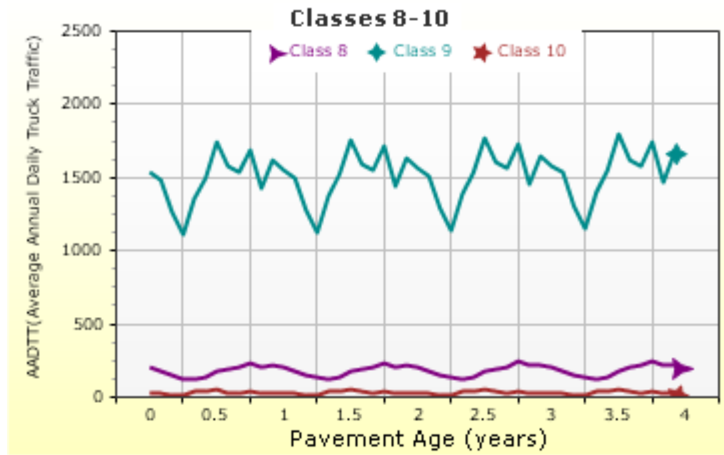
Number of Axles per Truck

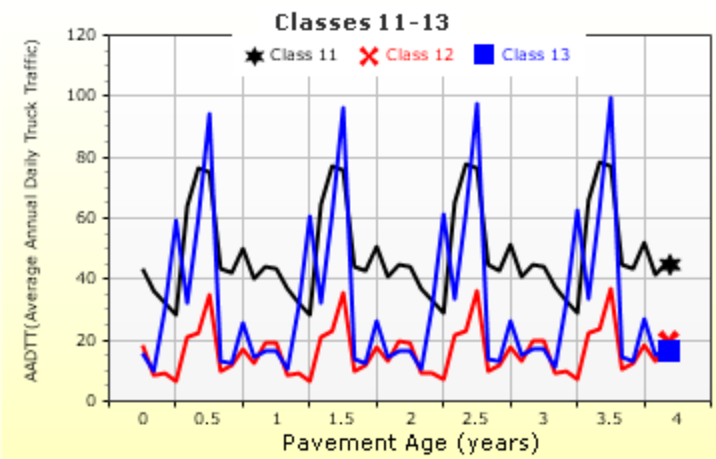
Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.58	0.41	0	0
Class 5	2	0	0	0
Class 6	1	1	0	0
Class 7	1.14	0.14	0.64	0.2
Class 8	2.21	0.78	0	0
Class 9	1.3	1.84	0	0
Class 10	1.07	0.98	0.93	0.03
Class 11	4.09	0.14	0.2	0
Class 12	3.18	1.14	0.13	0.03
Class 13	2.73	1.38	0.31	0.24

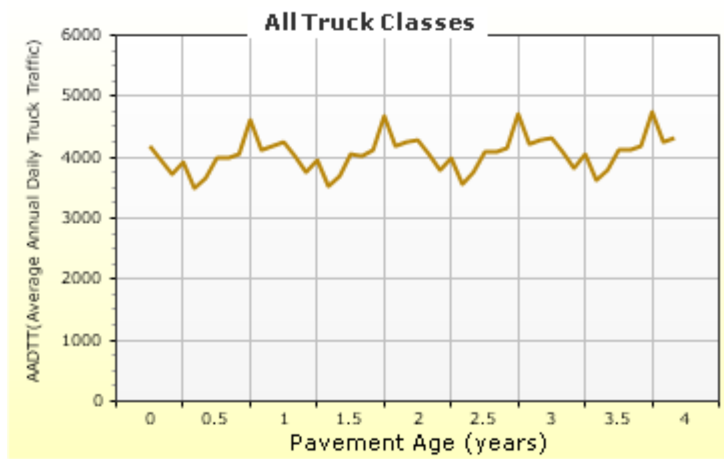
AADTT (Average Annual Daily Truck Traffic) Growth

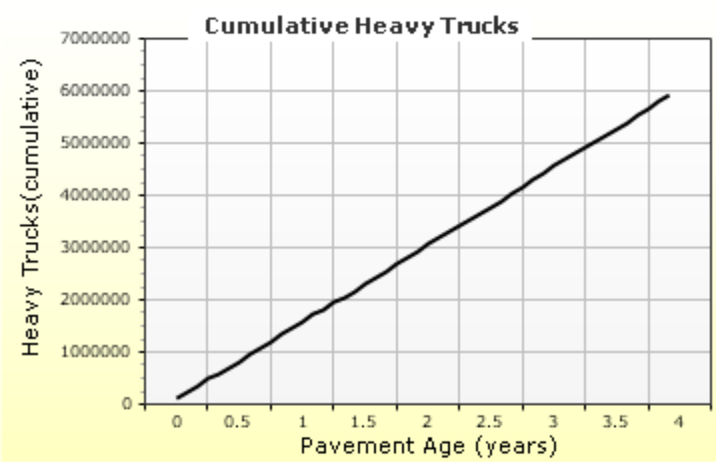
*** Traffic cap is not enforced**







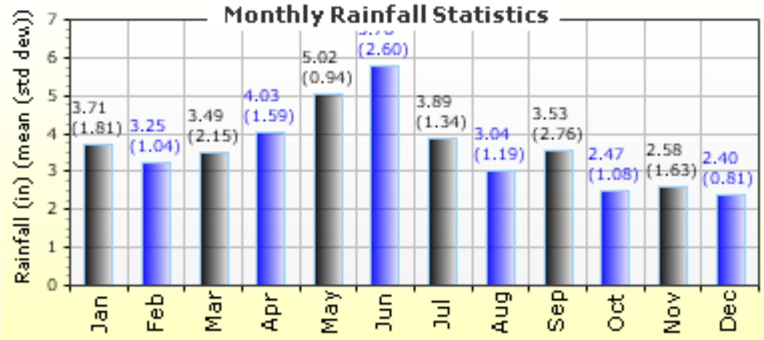




Climate Inputs

Climate Data Sources:

Climate Station Cities:	Location (lat lon elevation(ft))
INDIANAPOLIS, IN	39.71000 -86.27200 790

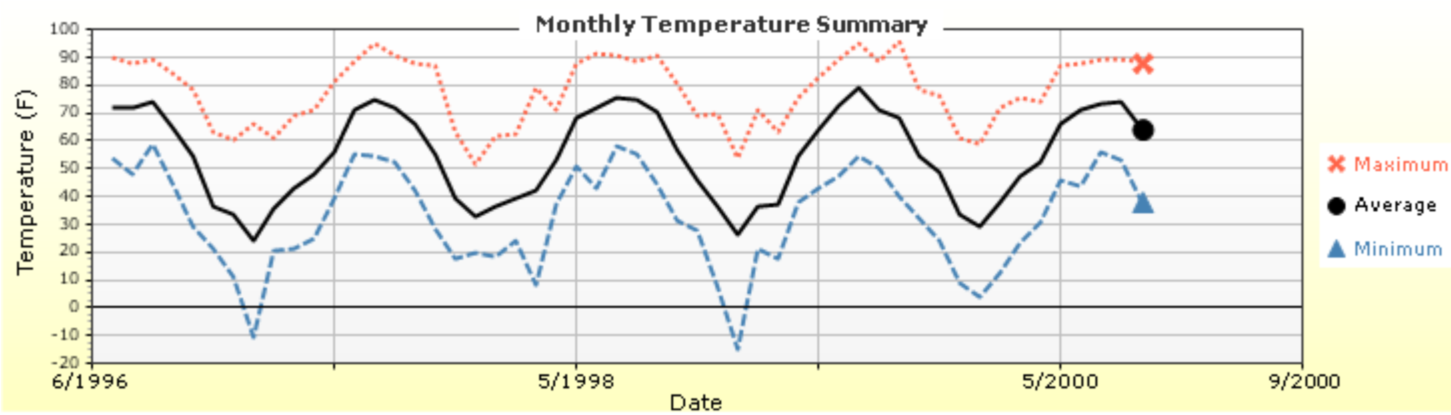


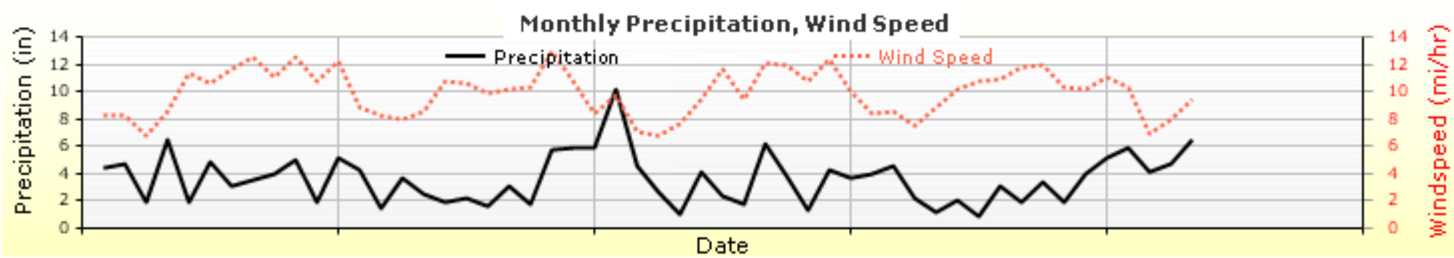
Annual Statistics:

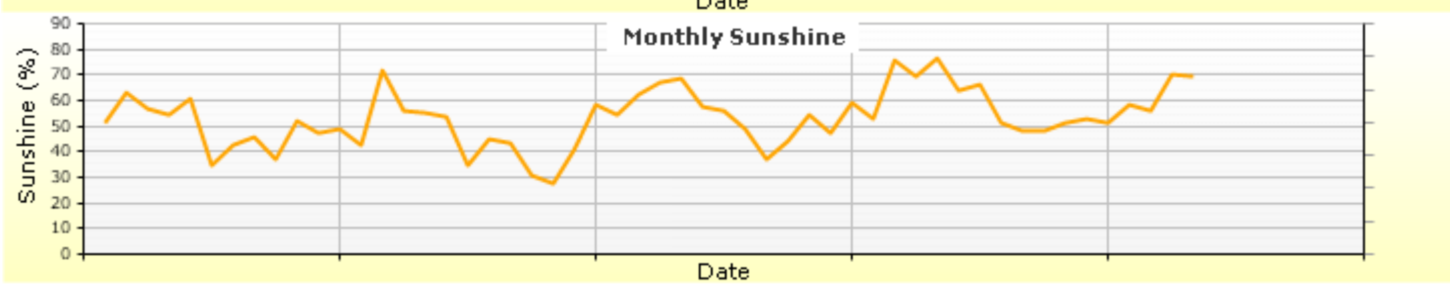
Mean annual air temperature (ºF)	54.73
Mean annual precipitation (in)	43.56
Freezing index (ºF - days)	321.80
Average annual number of freeze/thaw cycles:	57.61

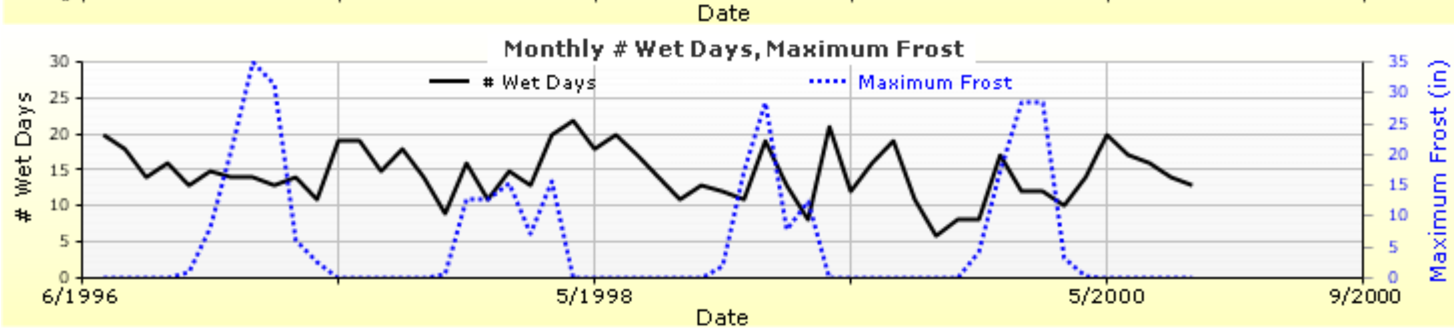
Water table depth (ft) 5.00

Monthly Climate Summary:





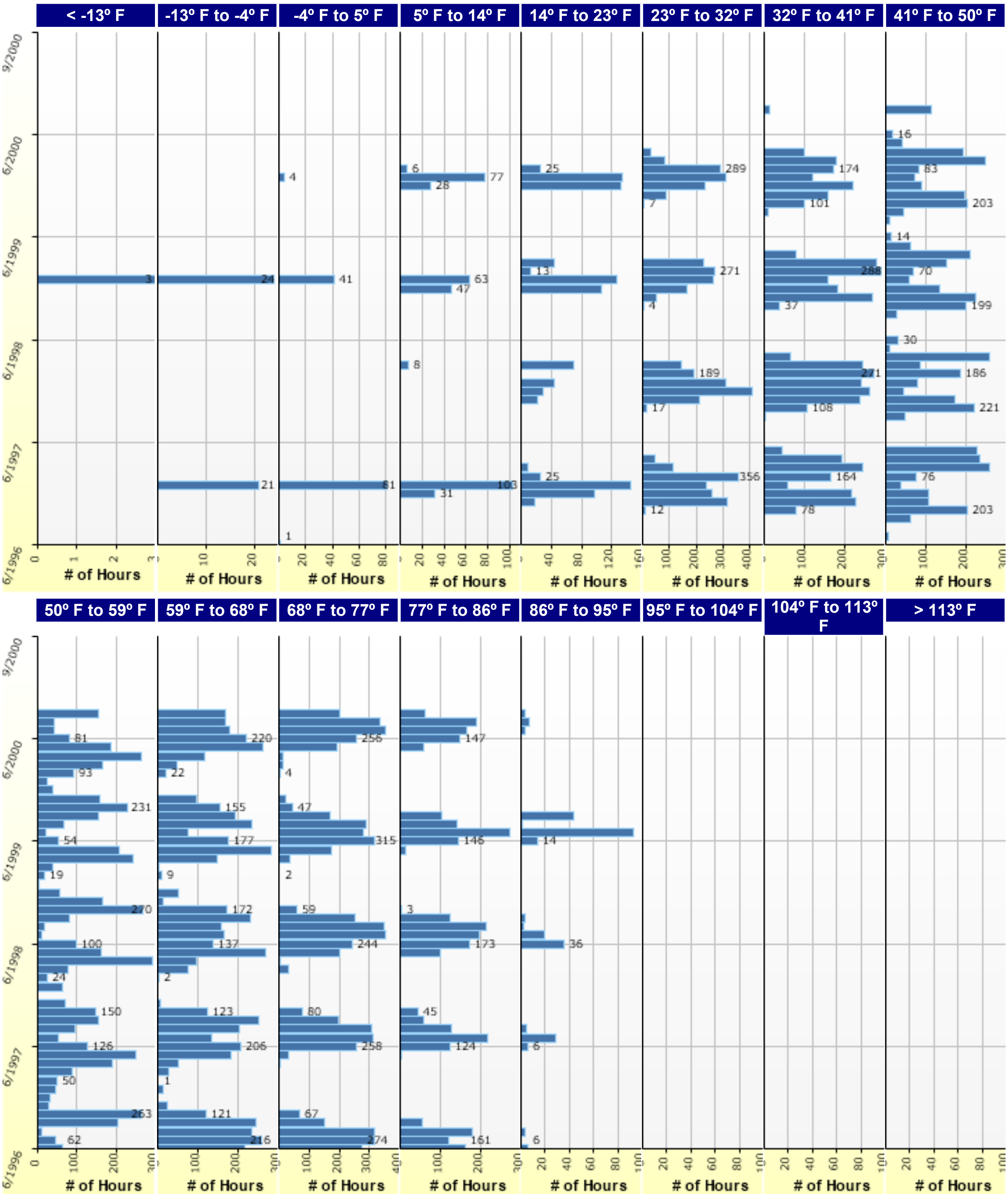




Marion County 4K AADTT 2W1L on Overlay on HMA on CompAgg

File Name: \\iotisip01pa\dot-darwin$\Projects_DarWinME Inputs\HMA Materials Input Files\Asphalt Material Properties New\Greenfield\HMA Surface\Marion County 4K AADTT 2W1L

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 : Greenfield, 4, 76, SURFACE, 9.5 mm	Flexible (1)	1.00
Layer 2 Flexible : Existing Asphalt 19.0mm(existing)	Flexible (1)	1.00
Layer 3 Non-stabilized Base : Crushed stone	Non-stabilized Base (4)	1.00
Layer 4 Non-stabilized Base : Subgrade Treatment (#53 Aggregate)	Non-stabilized Base (4)	1.00
Layer 5 Subgrade : A-6	Subgrade (5)	-

HMA Rehabilitation (Input Level: 3)

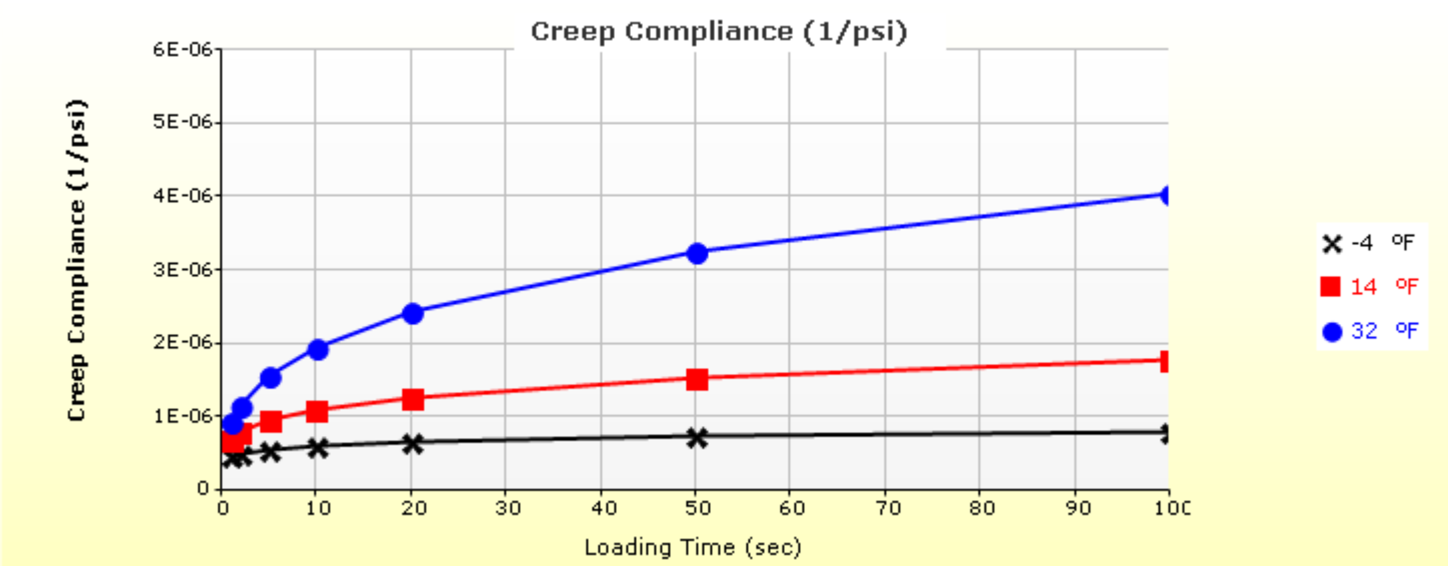
Milled thickness (in)	0.00
Structural rating	Fair
Environmental rating	Good
Total rut depth (in)	0.00

Thermal Cracking (Input Level: 3)

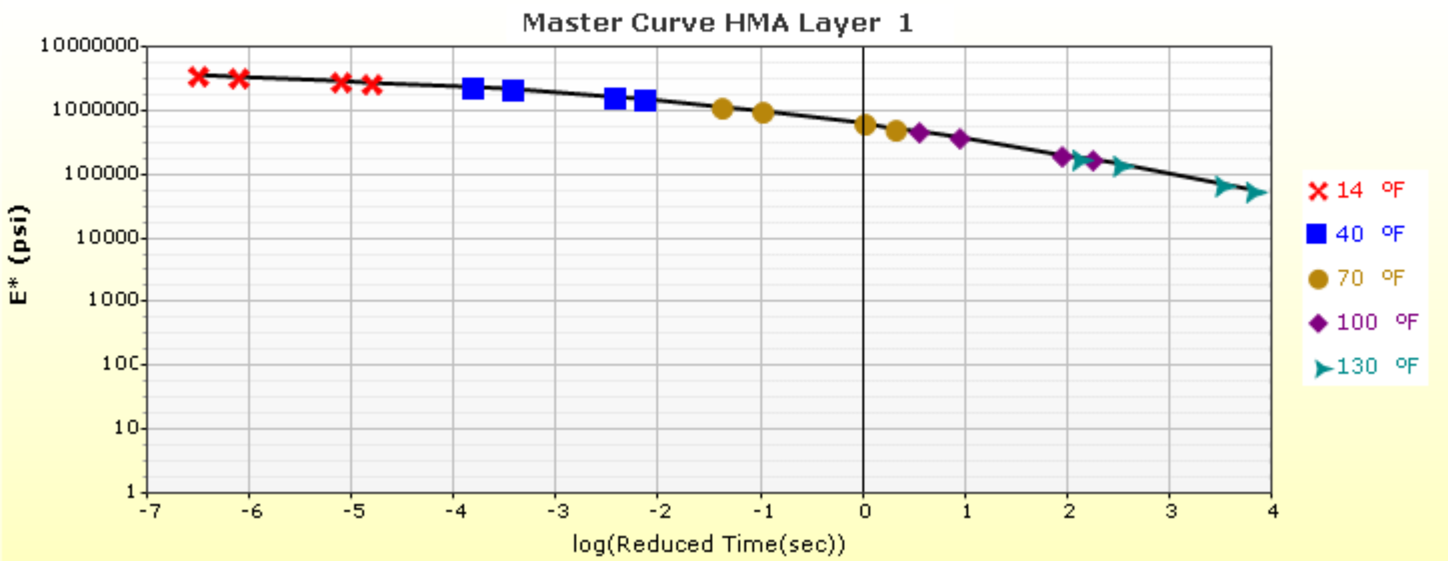
Indirect tensile strength at 14 ºF (psi)	388.87

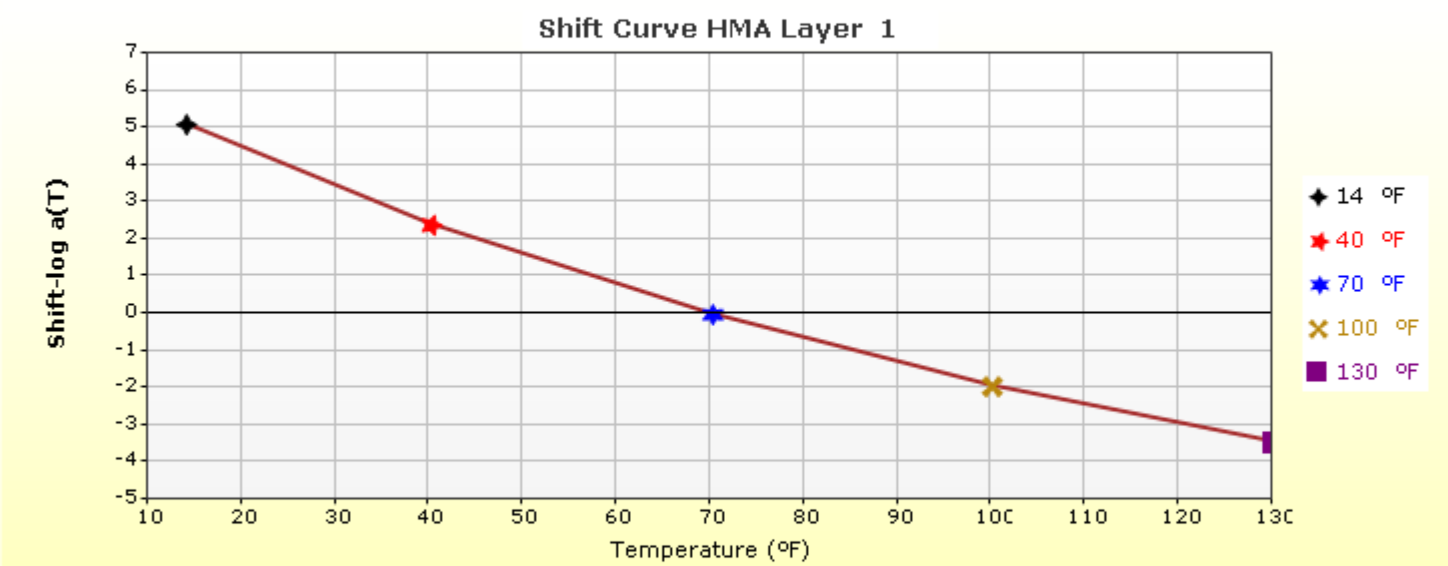
Thermal Contraction	
Is thermal contraction calculated?	True
Mix coefficient of thermal contraction (in/in/ºF)	-
Aggregate coefficient of thermal contraction (in/in/ºF)	6.1e-006
Voids in Mineral Aggregate (%)	18.6

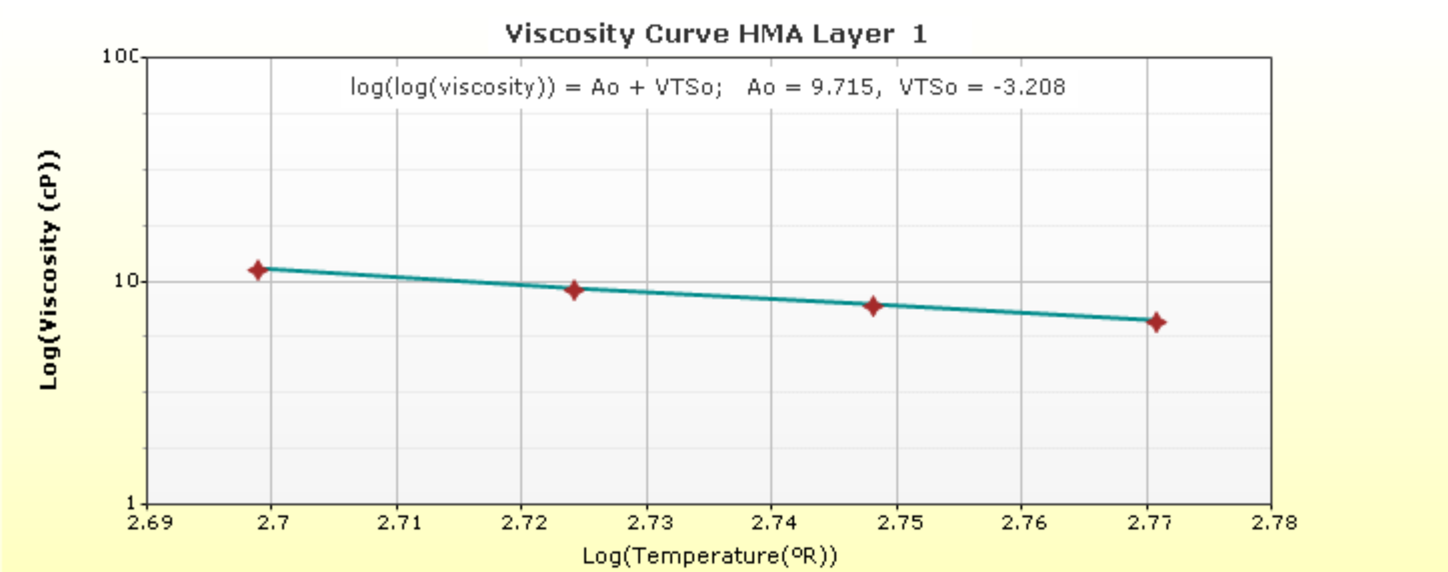
	Creep Compliance (1/psi)		
Loading time (sec)	-4 ºF	14 ºF	32 ºF
1	4.68e-007	6.91e-007	9.34e-007
2	5.09e-007	7.97e-007	1.17e-006
5	5.68e-007	9.62e-007	1.56e-006
10	6.18e-007	1.11e-006	1.95e-006
20	6.71e-007	1.28e-006	2.43e-006
50	7.49e-007	1.55e-006	3.26e-006
100	8.14e-007	1.78e-006	4.06e-006



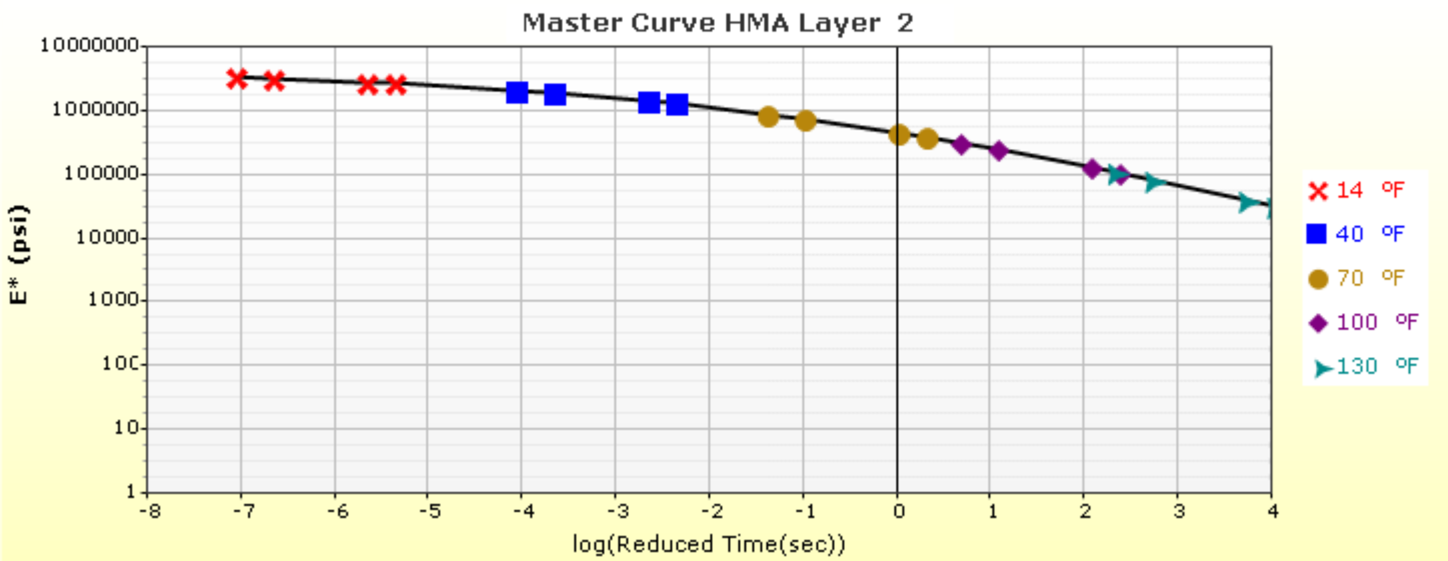
HMA Layer 1: Layer 1 Flexible : Greenfield, 4, 76, SURFACE, 9.5 mm

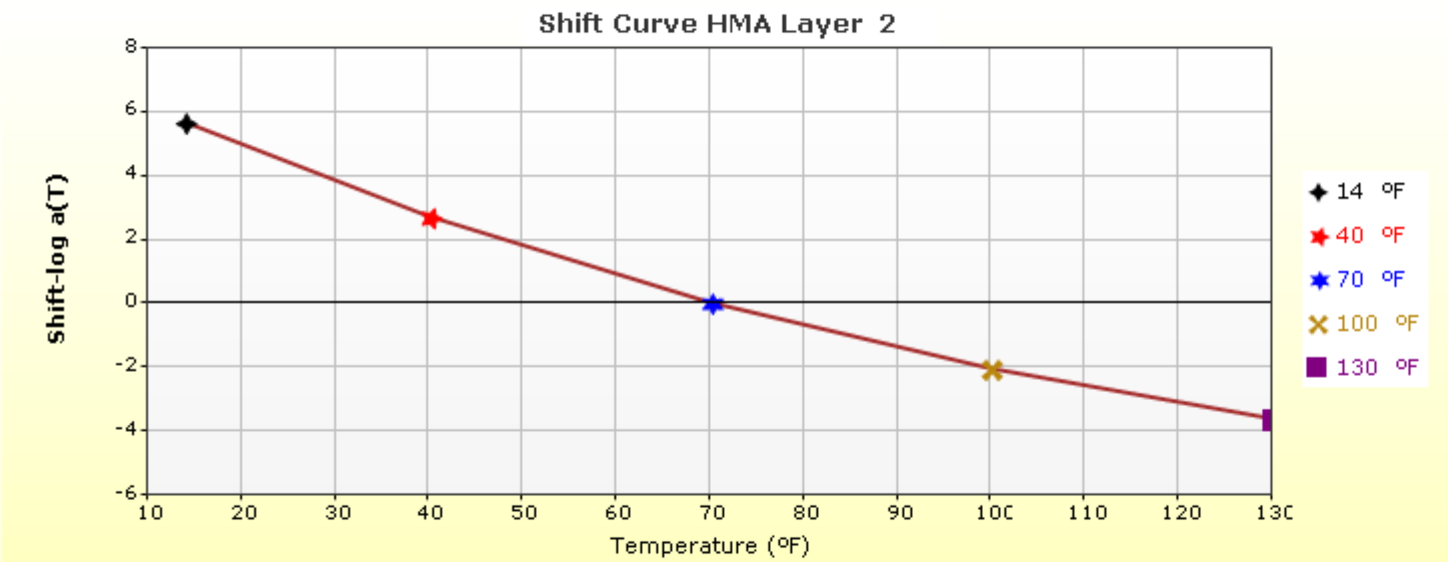


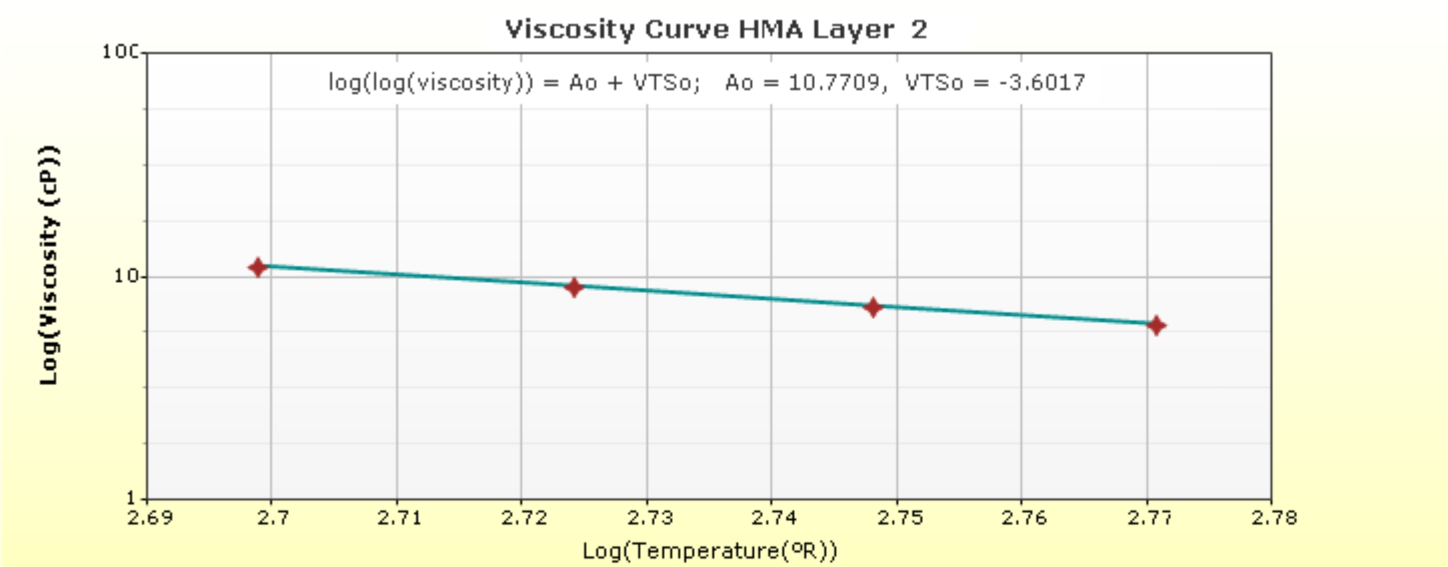




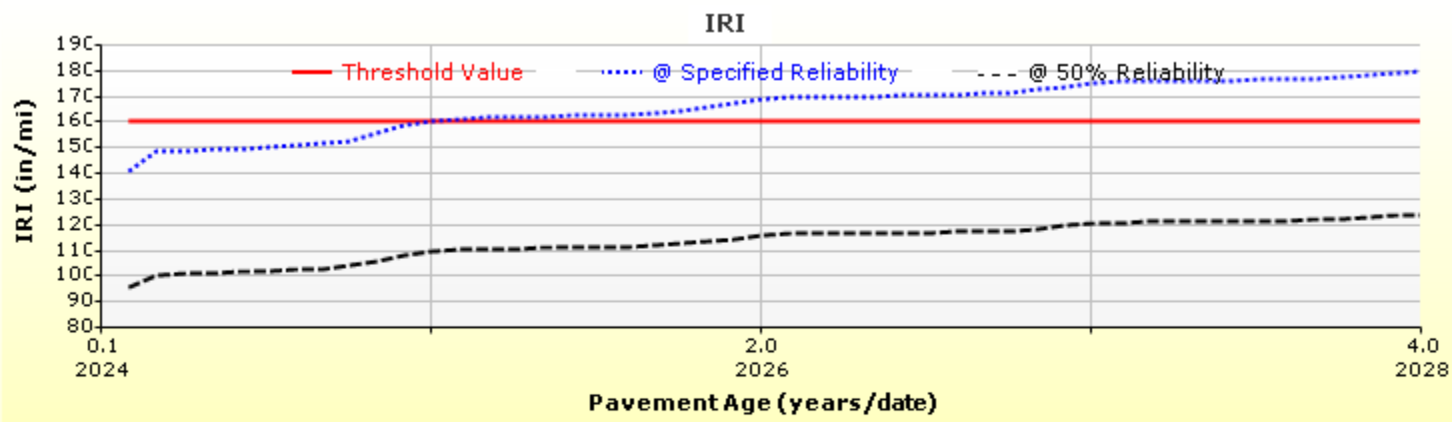
HMA Layer 2: Layer 2 Flexible : Existing Asphalt 19.0mm(existing)

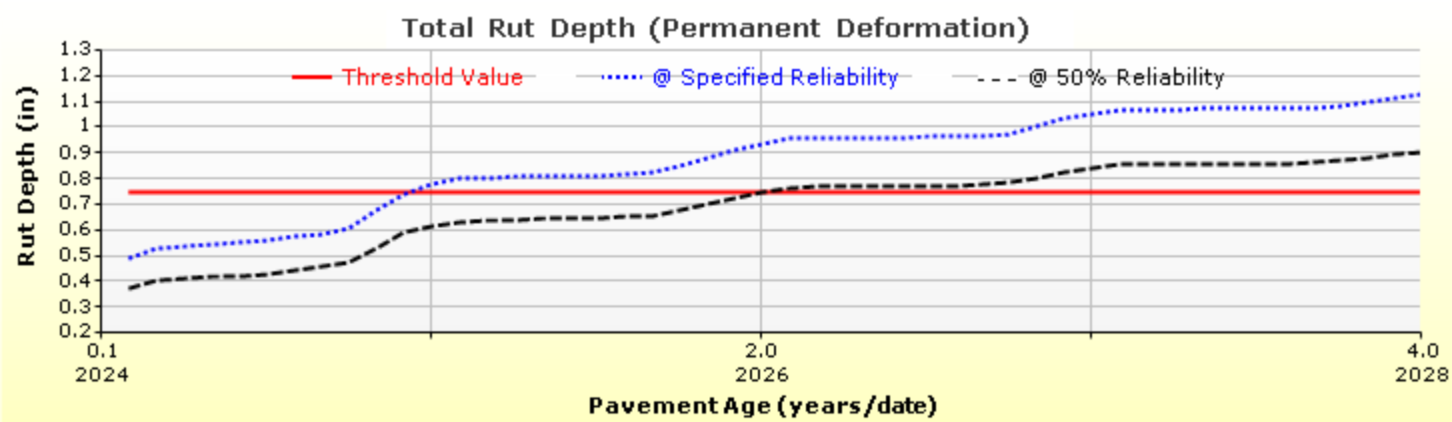


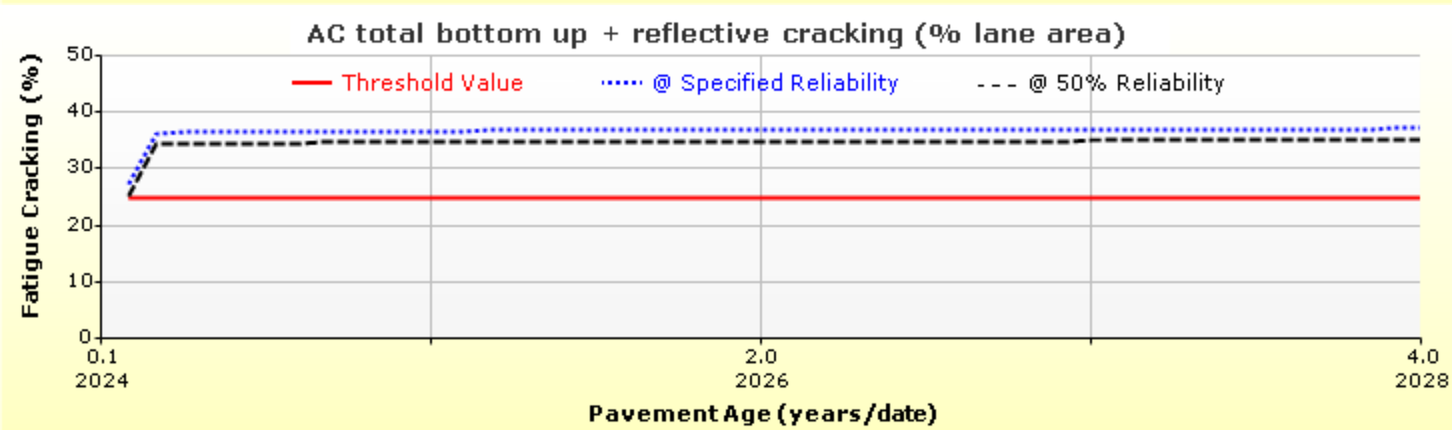


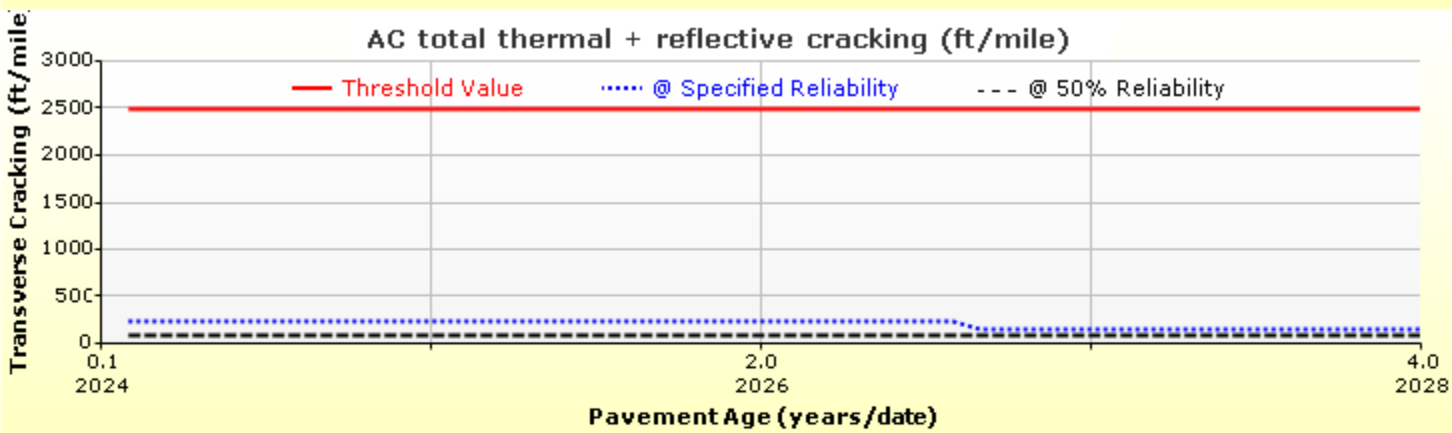


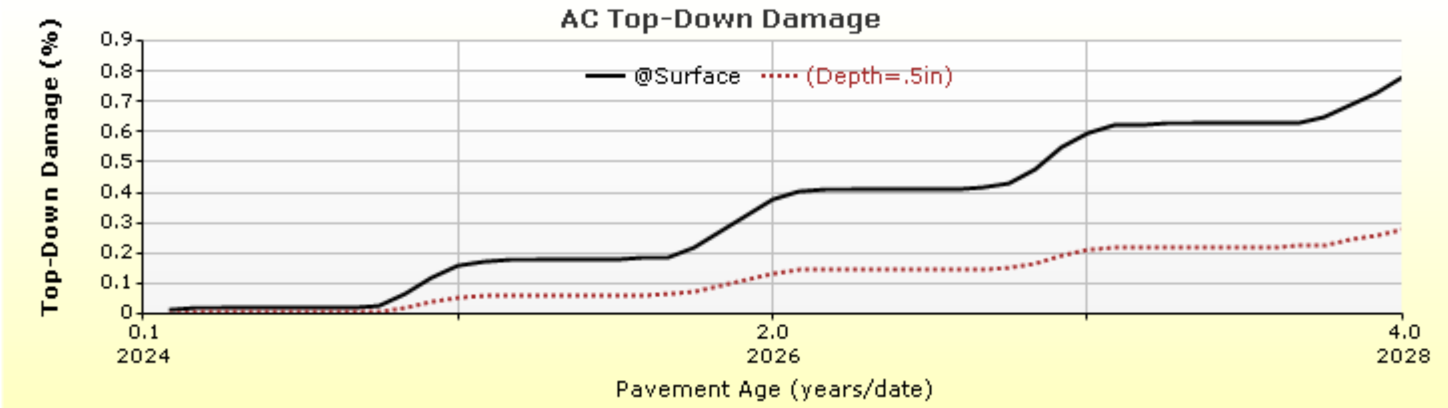
Analysis Output Charts

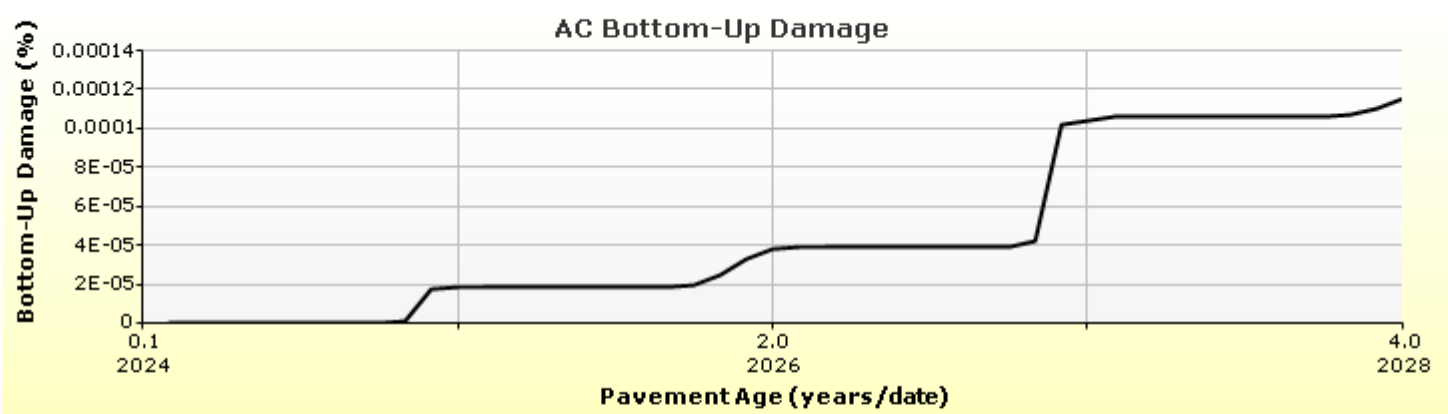


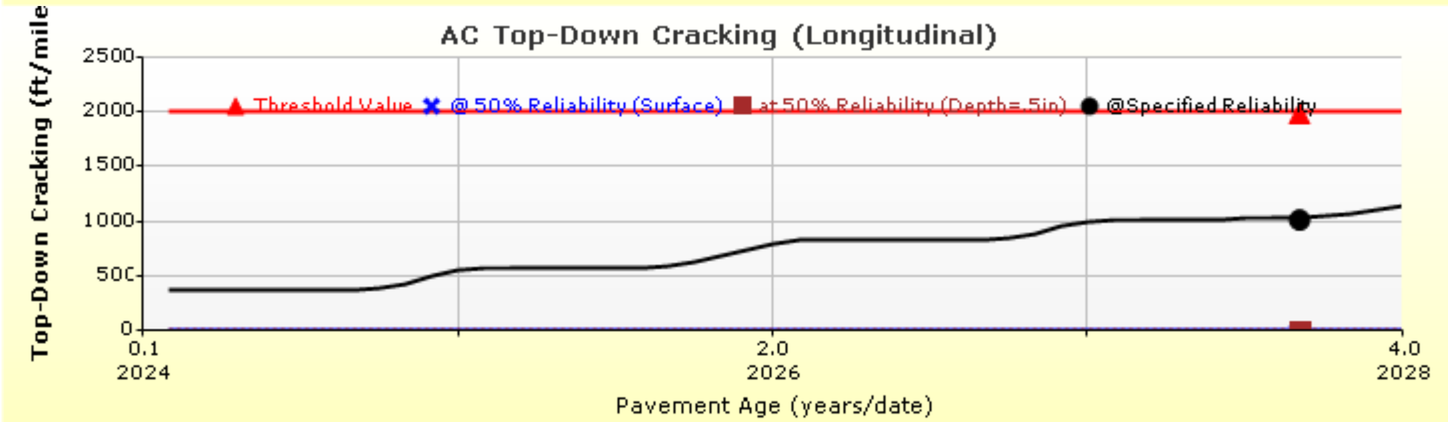


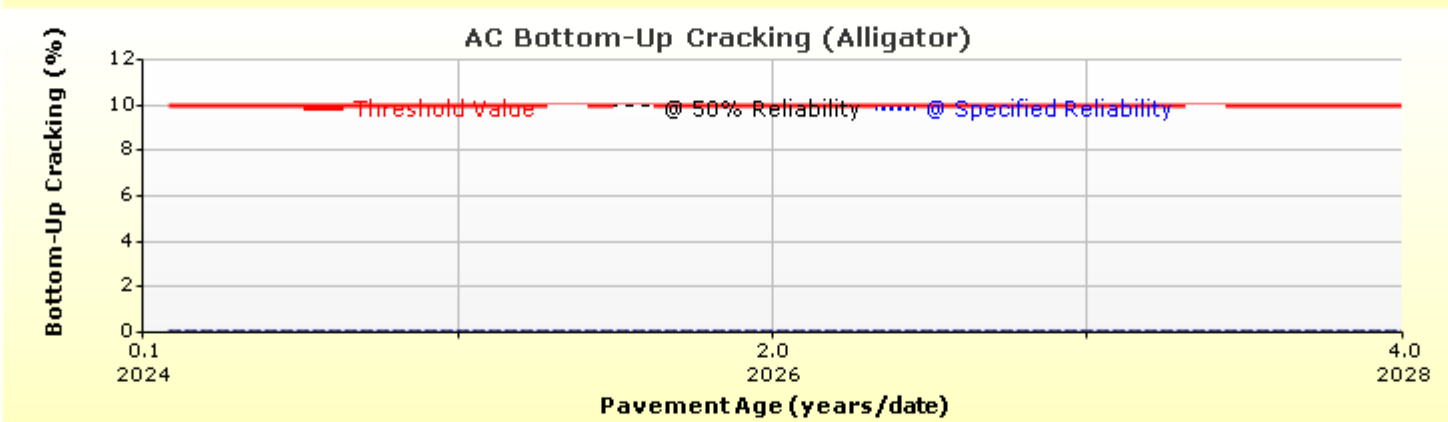


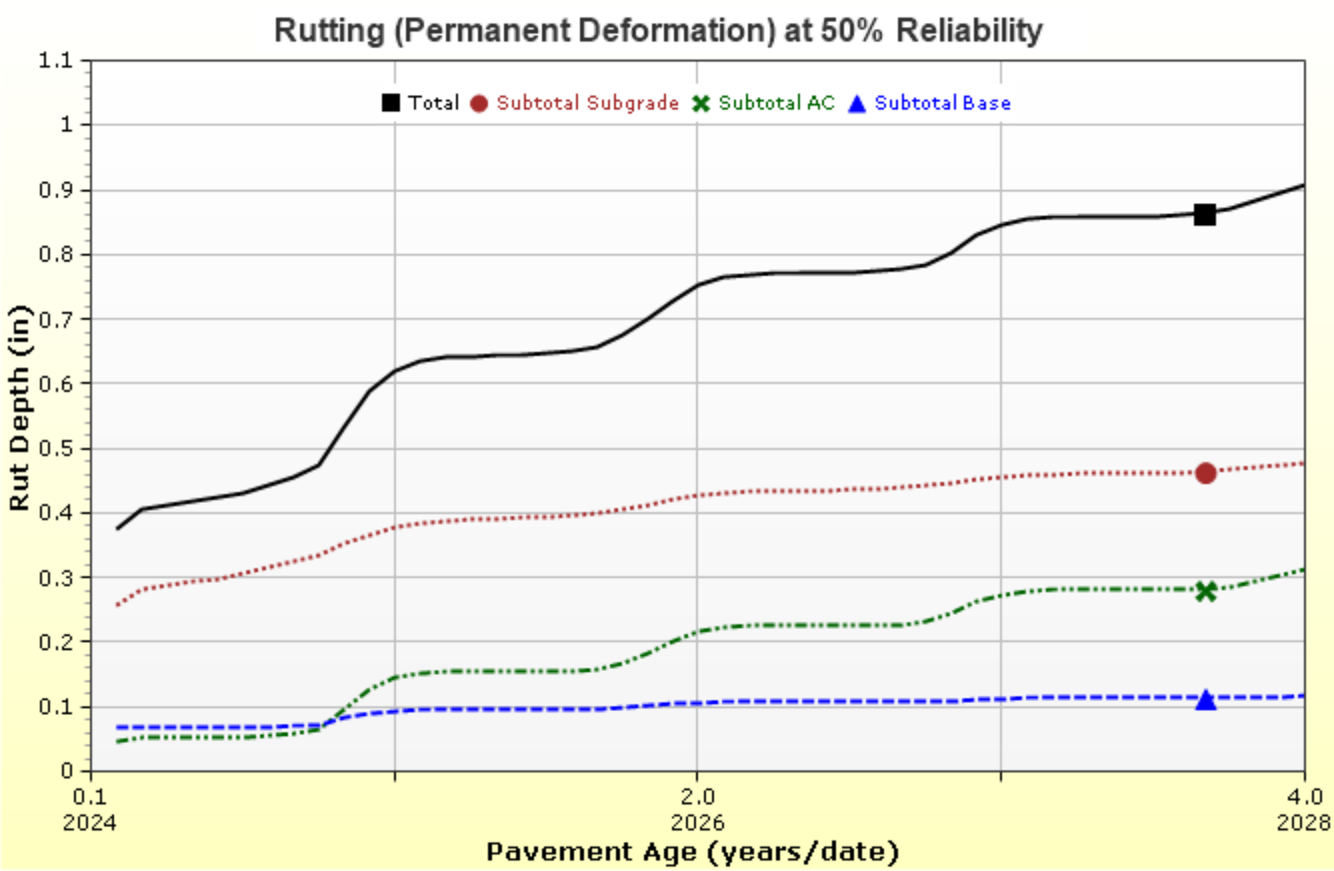


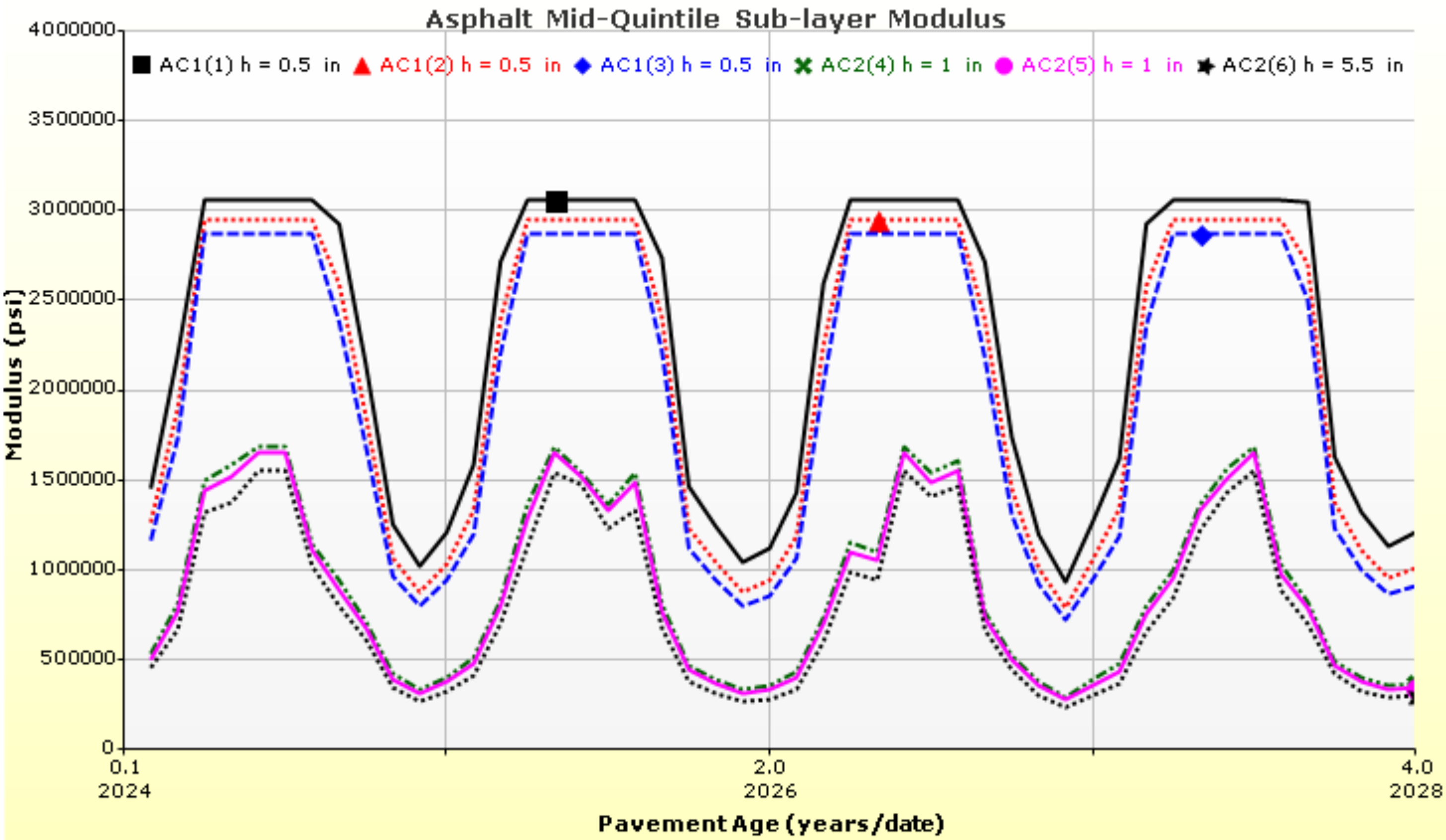

AC Top-Down Damage
@Surface
(Depth=.5in)
Top-Down Damage (%)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
2024
2.0
2026
4.0
2028
Pavement Age (years/date)

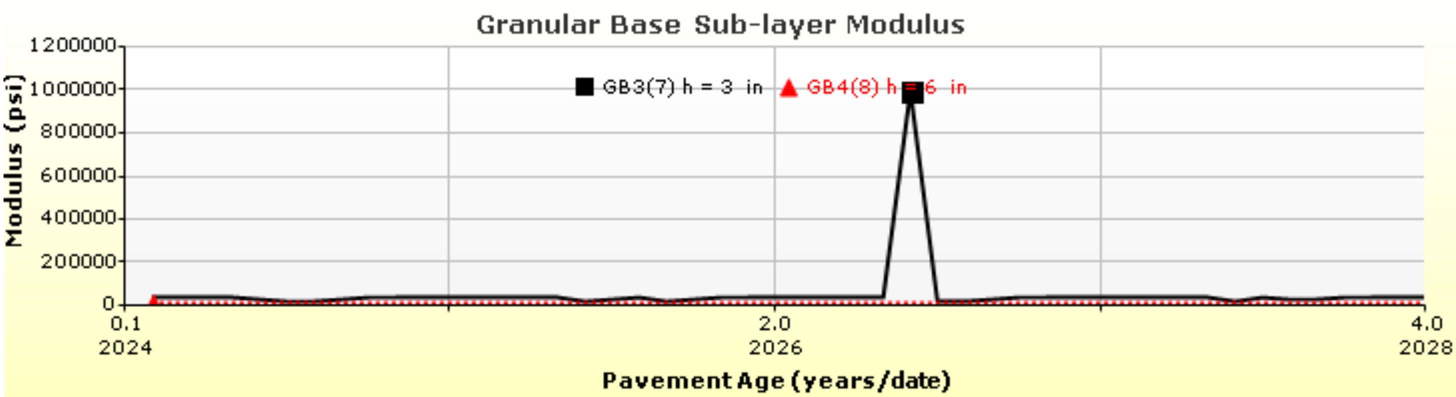

AC Bottom-Up Damage
Bottom-Up Damage (%)
0.00014
0.00012
0.0001
8E-05
6E-05
4E-05
2E-05
0
0.1
2024
2.0
2026
4.0
2028
Pavement Age (years/date)

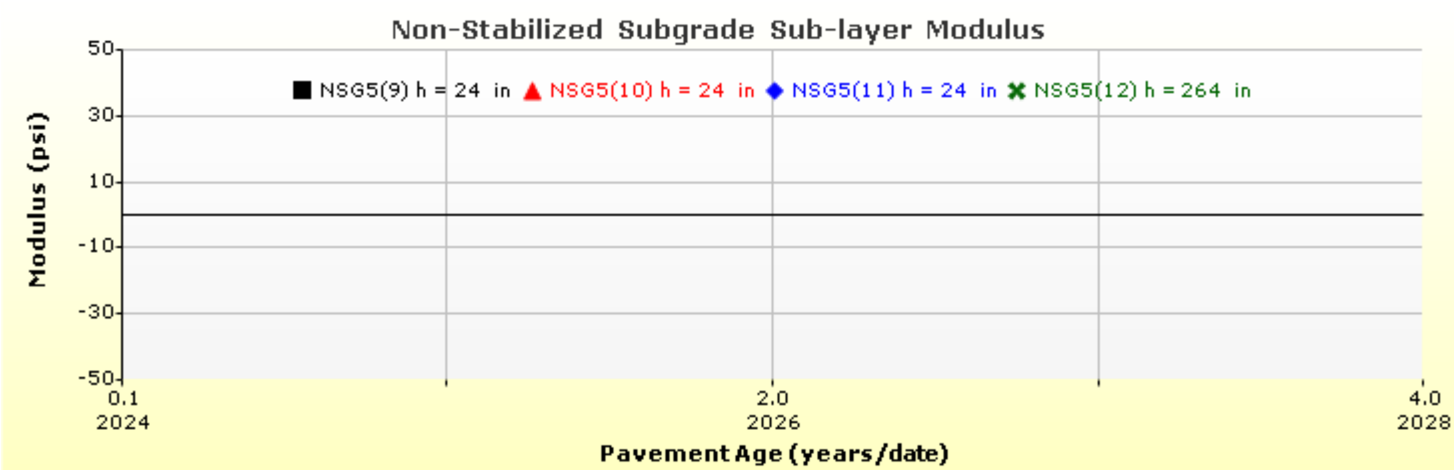

AC Top-Down Cracking (Longitudinal)
Threshold Value
@ 50% Reliability (Surface)
at 50% Reliability (Depth=.5in)
@Specified Reliability
Top-Down Cracking (ft/mile
2500
2000
1500
1000
500
0
0.1
2024
2.0
2026
4.0
2028
Pavement Age (years/date)


AC Bottom-Up Cracking (Alligator)
Threshold Value
@ 50% Reliability
@ Specified Reliability
Bottom-Up Cracking (%)
12
10
8
6
4
2
0
0.1
2024
2.0
2026
4.0
2028
Pavement Age (years/date)


Rutting (Permanent Deformation) at 50% Reliability
Total
Subtotal Subgrade
Subtotal AC
Subtotal Base
Rut Depth (in)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
2024
2.0
2026
4.0
2028
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 = 0.5 in
AC2(4) h = 1 in
AC2(5) h = 1 in
AC2(6) h = 5.5 in
Modulus (psi)
4000000
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
0.1 2024
2.0 2026
4.0 2028
Pavement Age (years/date)


Granular Base Sub-layer Modulus
GB3(7) h = 3 in
GB4(8) h = 6 in
Modulus (psi)
1200000
1000000
800000
600000
400000
200000
0
0.1 2024
2.0 2026
4.0 2028
Pavement Age (years/date)


Non-Stabilized Subgrade Sub-layer Modulus
NSG5(9) h = 24 in
NSG5(10) h = 24 in
NSG5(11) h = 24 in
NSG5(12) h = 264 in
Modulus (psi)
50
30
10
-10
-30
-50
0.1 2024
2.0 2026
4.0 2028
Pavement Age (years/date)

Layer Information

Layer 1 Flexible : Greenfield, 4, 76, SURFACE, 9.5 mm

Asphalt		
Thickness (in)	1.5	
Unit weight (pcf)	142.6	
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	95.82
No.4 sieve	68.8
No.200 sieve	6.21

Asphalt Binder

Parameter	Value
Grade	Superpave Performance Grade
Binder Type	76-22
A	9.715
VTS	-3.208

General Info

Name	Value
Reference temperature (ºF)	70
Effective binder content (%)	11.6
Air voids (%)	7
Thermal conductivity (BTU/hr-ft-ºF)	0.63
Heat capacity (BTU/lb-ºF)	0.31

Identifiers

Field	Value
Display name/identifier	Greenfield, 4, 76, SURFACE, 9.5
Description of object	
Author	
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 2 Flexible : Existing Asphalt 19.0mm(existing)

Asphalt		
Thickness (in)	7.5	
Unit weight (pcf)	143.8	
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	97
3/8-inch sieve	69
No.4 sieve	43
No.200 sieve	2

Asphalt Binder

Parameter	Value
Grade	Viscosity Grade
Binder Type	AC 20
A	10.7709
VTS	-3.6017

General Info

Name	Value
Reference temperature (ºF)	70
Effective binder content (%)	10
Air voids (%)	6
Thermal conductivity (BTU/hr-ft-ºF)	0.67
Heat capacity (BTU/lb-ºF)	0.23

Identifiers

Field	Value
Display name/identifier	Existing Asphalt 19.0mm
Description of object	
Author	
Date Created	10/30/2010 1:00:00 AM
Approver	
Date approved	10/30/2010 1:00:00 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)	3.0
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)
30000.0

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 Non-stabilized Base : Subgrade Treatment (#53 Aggregate)

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

Modulus (Input Level: 2)

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

Resilient Modulus (psi)
5500.0

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

Identifiers

Field	Value
Display name/identifier	Subgrade Treatment (#53
Description of object	by spec
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?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	128.2
Saturated hydraulic conductivity (ft/hr)	False	2.756e-02
Specific gravity of solids	False	2.7
Water Content (%)	False	7.1

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	4.0662
bf	1.6498
cf	0.7309
hr	117.4000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	8.7
#100	
#80	
#60	
#50	
#40	
#30	21.0
#20	
#16	
#10	
#8	37.5
#4	47.5
3/8-in.	
1/2-in.	67.5
3/4-in.	80.0
1-in.	90.0
1 1/2-in.	100.0
2-in.	
2 1/2-in.	
3-in.	
3 1/2-in.	

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:	Annual representative values
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)
3500.0

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	33.0
Plasticity Index	16.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	107.9
Saturated hydraulic conductivity (ft/hr)	False	1.95e-05
Specific gravity of solids	False	2.7
Water Content (%)	False	17.1

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	108.4091
bf	0.6801
cf	0.2161
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	63.2
#100	
#80	73.5
#60	
#50	
#40	82.4
#30	
#20	
#16	
#10	90.2
#8	
#4	93.5
3/8-in.	96.4
1/2-in.	97.4
3/4-in.	98.4
1-in.	99.0
1 1/2-in.	99.5
2-in.	99.8
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: 0.007566
k2: 3.9492
k3: 1.281
Bf1: 1
Bf2: 1
Bf3: 1

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:

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

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

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

$T = layer\ temperature(^\circ F)$

$N = number\ of\ load\ repetitions$

AC Rutting Standard Deviation	0.24 * Pow(RUT,0.8026) + 0.001	
AC Layer	K1:-3.35412 K2:1.5606 K3:0.4791	Br1:1 Br2:1 Br3:1

Thermal Fracture

$$C_f = 400 * N\left(\frac{\log C / h_{ac}}{\sigma}\right)$$

$$\Delta C = (k * \beta t)^{n+1} * A * \Delta K^n$$

$$A = 10^{(4.389 - 2.52 * \log(E * \sigma_m * n))}$$

$C_f = observed\ amount\ of\ thermal\ cracking(ft/500ft)$

$k = refression\ coefficient\ determined\ through\ field\ calibration$

$N() = standard\ normal\ distribution\ evaluated\ at()$

$\sigma = standard\ deviation\ of\ the\ \log\ of\ the\ depth\ of\ cracks\ in\ the\ pavments$

$C = crack\ depth(in)$

$h_{ac} = thickness\ of\ asphalt\ layer(in)$

$\Delta C = Change\ in\ the\ crack\ depth\ due\ to\ a\ cooling\ cycle$

$\Delta K = Change\ in\ the\ stress\ intensity\ factor\ due\ to\ a\ cooling\ cycle$

$A, n = Fracture\ parameters\ for\ the\ asphalt\ mixture$

$E = mixture\ stiffness$

$\sigma_M = Undamaged\ mixture\ tensile\ strength$

$\beta_t = Calibration\ parameter$

Level 1 K: 1.5	
Level 2 K: 0.5	
Level 3 K: 1.5	

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: 1	k2: 1	Bc1: 0.75	Bc2:1.1

Subgrade 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)

Granular		Fine	
k1: 2.03	Bs1: 1	k1: 1.35	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

$$FC_{top} = \left(\frac{C_4}{1 + e^{(C_1 - C_2 * log_{10}(Damage))}}\right) * 10.56$$

c1: 7	c2: 3.5	c3: 0	c4: 1000

AC Cracking Top Standard Deviation

200 + 2300/(1+exp(1.072-2.1654*LOG10 (TOP+0.0001)))

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	c2: 1	c3: 6000

AC Cracking Bottom Standard Deviation

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

CSM Cracking

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

C1: 0	C2: 75	C3: 5	C4: 3

CSM Standard Deviation

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