



# 22420 US 550\_HMA on Clay\_FINAL\_24

File Name: C:\Users\kempb\Documents\Projects\22420\_550 160 Connection\Pavement Design\FINAL\22420 US 550\_HMA on Clay\_FINAL\_24.dgpx



## Layer 2 Non-stabilized Base : ABC Class 6

Unbound	
Layer thickness (in)	4.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

### Modulus (Input Level: 3)

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

Resilient Modulus (psi)
25000.0

<b>Use Correction factor for NDT modulus?</b>	-
<b>NDT Correction Factor:</b>	-

### Identifiers

Field	Value
Display name/identifier	ABC Class 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

<b>Liquid Limit</b>	6.0
<b>Plasticity Index</b>	1.0
<b>Is layer compacted?</b>	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	127.7
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)

<b>Is User Defined?</b>	False
<b>af</b>	7.2555
<b>bf</b>	1.3328
<b>cf</b>	0.8242
<b>hr</b>	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



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## Layer 3 Subgrade : A-1-b

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

### Modulus (Input Level: 3)

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

Resilient Modulus (psi)
15000.0

<b>Use Correction factor for NDT modulus?</b>	-
<b>NDT Correction Factor:</b>	-

### Identifiers

Field	Value
Display name/identifier	A-1-b
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

<b>Liquid Limit</b>	11.0
<b>Plasticity Index</b>	1.0
<b>Is layer compacted?</b>	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	124.2
Saturated hydraulic conductivity (ft/hr)	False	2.303e-03
Specific gravity of solids	False	2.7
Water Content (%)	False	9.1

### User-defined Soil Water Characteristic Curve (SWCC)

<b>Is User Defined?</b>	False
<b>af</b>	5.8206
<b>bf</b>	0.4621
<b>cf</b>	3.8497
<b>hr</b>	126.8000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	13.4
#100	
#80	20.8
#60	
#50	
#40	37.6
#30	
#20	
#16	
#10	64.0
#8	
#4	74.2
3/8-in.	82.3
1/2-in.	85.8
3/4-in.	90.8
1-in.	93.6
1 1/2-in.	96.7
2-in.	98.4
2 1/2-in.	
3-in.	
3 1/2-in.	99.4



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## Layer 4 Subgrade : A-7-6

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

### Modulus (Input Level: 3)

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

Resilient Modulus (psi)
6482.0

<b>Use Correction factor for NDT modulus?</b>	-
<b>NDT Correction Factor:</b>	-

### Identifiers

Field	Value
Display name/identifier	A-7-6
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	33

### Sieve

<b>Liquid Limit</b>	44.0
<b>Plasticity Index</b>	27.0
<b>Is layer compacted?</b>	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	99.7
Saturated hydraulic conductivity (ft/hr)	False	1.504e-05
Specific gravity of solids	False	2.7
Water Content (%)	False	21.7

### User-defined Soil Water Characteristic Curve (SWCC)

<b>Is User Defined?</b>	False
<b>af</b>	133.7378
<b>bf</b>	0.5319
<b>cf</b>	0.0500
<b>hr</b>	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	81.0
#100	
#80	93.0
#60	
#50	
#40	94.0
#30	
#20	
#16	
#10	98.0
#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



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## Calibration Coefficients

AC Fatigue	
$N_f = 0.00432 * C * \beta_{f1} k_1 \left(\frac{1}{\epsilon_1}\right)^{k_2 \beta_{f2}} \left(\frac{1}{E}\right)^{k_3 \beta_{f3}}$	K1: 0.007566
	K2: 3.9492
	K3: 1.281
$C = 10^M$	BF1: 130.3674
$M = 4.84 \left(\frac{V_b}{V_a + V_b} - 0.69\right)$	BF2: 1
	BF3: 1.217799

AC Rutting	
$\frac{\epsilon_p}{\epsilon_r} = k_z \beta_{r1} 10^{k_1 T^{k_2} \beta_{r2} N^{k_3} B_{r3}}$	$\epsilon_p = \text{plastic strain (in/in)}$ $\epsilon_r = \text{resilient strain (in/in)}$ $T = \text{layer temperature (}^\circ\text{F)}$ $N = \text{number of load repetitions}$
$k_z = (C_1 + C_2 * \text{depth}) * 0.328196^{depth}$	
$C_1 = -0.1039 * H_{\alpha}^2 + 2.4868 * H_{\alpha} - 17.342$	
$C_2 = 0.0172 * H_{\alpha}^2 - 1.7331 * H_{\alpha} + 27.428$	
Where: $H_{\alpha c} = \text{total AC thickness (in)}$	
AC Rutting Standard Deviation	0.1414 * Pow(RUT,0.25) + 0.001
AC Layer	K1:-3.35412 K2:1.5606 K3:0.3791 Br1:6.7 Br2:1 Br3:1

Thermal Fracture		
$C_f = 400 * N \left(\frac{\log C / h_{ac}}{\sigma}\right)$	$C_f = \text{observed amount of thermal cracking (ft/500ft)}$ $k = \text{refression coefficient determined through field calibration}$ $N(\cdot) = \text{standard normal distribution evaluated at } (\cdot)$ $\sigma = \text{standard deviation of the log of the depth of cracks in the pavments}$ $C = \text{crack depth (in)}$ $h_{ac} = \text{thickness of asphalt layer (in)}$ $\Delta C = \text{Change in the crack depth due to a cooling cycle}$ $\Delta K = \text{Change in the stress intensity factor due to a cooling cycle}$ $A, n = \text{Fracture parameters for the asphalt mixture}$ $E = \text{mixture stiffness}$ $\sigma_M = \text{Undamaged mixture tensile strength}$ $\beta_r = \text{Calibration parameter}$	
$\Delta C = (k * \beta t)^{n+1} * A * \Delta K^n$		
$A = 10^{(4.389 - 2.52 * \log(E * \sigma_m * n))}$		
Level 1 K: 6.3		Level 1 Standard Deviation: 0.1468 * THERMAL + 65.027
Level 2 K: 0.5		Level 2 Standard Deviation: 0.2841 * THERMAL + 55.462
Level 3 K: 6.3		Level 3 Standard Deviation: 0.3972 * THERMAL + 20.422

CSM Fatigue			
$N_f = 10^{\left(\frac{k_1 \beta_{c1} \left(\frac{\sigma_s}{M_r}\right)}{k_2 \beta_{c2}}\right)}$		$N_f = \text{number of repetitions to fatigue cracking}$	
		$\sigma_s = \text{Tensile stress (psi)}$	
		$M_r = \text{modulus of rupture (psi)}$	
k1: 1	k2: 1	Bc1: 0.75	Bc2: 1.1



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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 $		$\delta_a$ = permanent deformation for the layer <i>N</i> = number of repetitions $\varepsilon_v$ = average vertical strain(in/in) $\varepsilon_0, \beta, \rho$ = material properties $\varepsilon_r$ = resilient strain(in/in)	
Granular		Fine	
k1: 2.03	Bs1: 0.22	k1: 1.35	Bs1: 0.37
Standard Deviation (BASERUT) 0.0104 * Pow(BASERUT,0.67) + 0.001		Standard Deviation (BASERUT) 0.0663 * Pow(SUBRUT,0.5) + 0.001	

AC Cracking						
AC Top Down Cracking				AC Bottom Up Cracking		
$FC_{top} = \left( \frac{C_4}{1 + e^{(C_1 - C_2 * \log_{10}(Damage))}} \right) * 10.56$				$FC = \left( \frac{6000}{1 + e^{(C_1 * C'_1 + C_2 * C'_2 * \log_{10}(D * 100))}} \right) * \left( \frac{1}{60} \right)$		
$C'_2 = -2.40874 - 39.748 * (1 + h_{ac})^{-2.856}$				$C'_1 = -2 * C'_2$		
c1: 7	c2: 3.5	c3: 0	c4: 1000	c1: 0.021	c2: 2.35	c3: 6000
AC Cracking Top Standard Deviation				AC Cracking Bottom Standard Deviation		
200 + 2300/(1+exp(1.072-2.1654*LOG10(TOP+0.0001)))				1 + 15/(1+exp(-3.1472-4.1349*LOG10(BOTTOM+0.0001)))		

CSM Cracking				IRI Flexible Pavements			
$FC_{ctb} = C_1 + \frac{C_2}{1 + e^{C_3 - C_4(Damage)}}$				C1 - Rutting		C3 - Transverse Crack	
				C2 - Fatigue Crack		C4 - Site Factors	
C1: 0	C2: 75	C3: 5	C4: 3	C1: 50	C2: 0.55	C3: 0.0111	C4: 0.02
CSM Standard Deviation							
CTB*1							

# Pavement M-E Design Report – HMA on Terrace Alluvium



## 22420 US 550\_HMA on Gravel\_FINAL

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### Design Inputs

Design Life: 20 years      Base construction: May, 2020      Climate Data 37.143, -107.76  
 Design Type: FLEXIBLE      Pavement construction: May, 2020      Sources (Lat/Lon)  
 Traffic opening: May, 2020

### Design Structure

Layer type	Material Type	Thickness (in)
Flexible	R3 Level 1 SX(75) PG 58-28 United	6.0
NonStabilized	ABC Class 6	4.0
Subgrade	A-1-b	Semi-infinite

### Volumetric at Construction:

Effective binder content (%)	10.7
Air voids (%)	5.5

### Traffic

Age (year)	Heavy Trucks (cumulative)
2020 (initial)	589
2030 (10 years)	1,024,410
2040 (20 years)	2,184,310

### Design Outputs

#### Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	200.00	163.06	90.00	99.15	Pass
Permanent deformation - total pavement (in)	0.65	0.49	90.00	99.77	Pass
AC bottom-up fatigue cracking (% lane area)	25.00	18.52	90.00	96.66	Pass
AC thermal cracking (ft/mile)	1500.00	660.29	90.00	100.00	Pass
AC top-down fatigue cracking (ft/mile)	2500.00	1903.42	90.00	95.53	Pass
Permanent deformation - AC only (in)	0.50	0.37	90.00	99.43	Pass

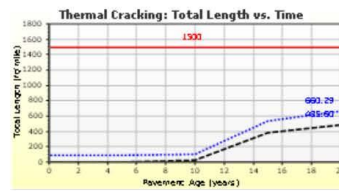
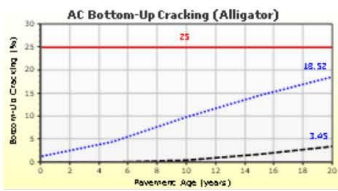
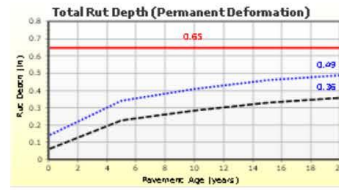


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## Distress Charts





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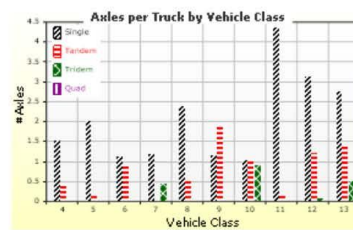
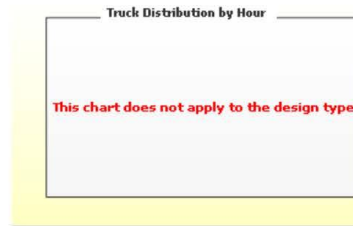
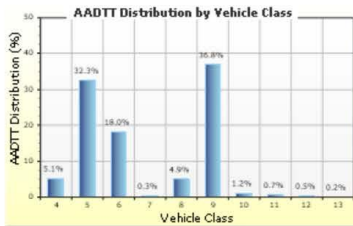
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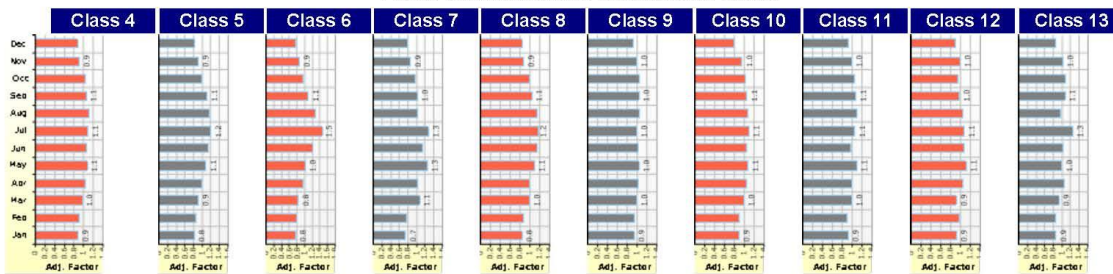
## Traffic Inputs

### Graphical Representation of Traffic Inputs

Initial two-way AADTT:	589	Percent of trucks in design direction (%):	50.0
Number of lanes in design direction:	2	Percent of trucks in design lane (%):	90.0
		Operational speed (mph)	45.0



### Traffic Volume Monthly Adjustment Factors







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## 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	0.9	0.8	0.8	0.7	0.8	0.9	0.9	0.9	0.9	0.9
February	0.9	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	0.8
March	1.0	0.9	0.8	1.1	1.0	1.0	1.0	1.0	0.9	0.9
April	1.0	1.0	0.9	1.0	1.0	1.0	1.1	1.0	1.0	1.1
May	1.1	1.1	1.0	1.3	1.1	1.0	1.1	1.1	1.1	1.0
June	1.1	1.1	1.2	1.1	1.1	1.0	1.1	1.0	1.1	1.0
July	1.1	1.2	1.5	1.3	1.2	1.0	1.1	1.1	1.1	1.3
August	1.1	1.2	1.3	1.0	1.1	1.0	1.1	1.1	1.1	1.0
September	1.1	1.1	1.1	1.0	1.1	1.0	1.1	1.1	1.0	1.1
October	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	1.1
November	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0
December	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.9	0.9	0.9

### Distributions by Vehicle Class

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor	
		Rate (%)	Function
Class 4	5.1%	1.25%	Compound
Class 5	32.3%	1.25%	Compound
Class 6	18%	1.25%	Compound
Class 7	0.3%	1.25%	Compound
Class 8	4.9%	1.25%	Compound
Class 9	36.8%	1.25%	Compound
Class 10	1.2%	1.25%	Compound
Class 11	0.7%	1.25%	Compound
Class 12	0.5%	1.25%	Compound
Class 13	0.2%	1.25%	Compound

### Truck Distribution by Hour does not apply

### Axle Configuration

Traffic Wander		Axle Configuration	
Mean wheel location (in)	18.0	Average axle width (ft)	8.5
Traffic wander standard deviation (in)	10.0	Dual tire spacing (in)	12.0
Design lane width (ft)	12.0	Tire pressure (psi)	120.0

Average Axle Spacing		Wheelbase does not apply	
Tandem axle spacing (in)	51.6		
Tridem axle spacing (in)	49.2		
Quad axle spacing (in)	49.2		

### Number of Axles per Truck

Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.53	0.45	0	0
Class 5	2.02	0.16	0.02	0
Class 6	1.12	0.93	0	0
Class 7	1.19	0.07	0.45	0.02
Class 8	2.41	0.56	0.02	0
Class 9	1.16	1.88	0.01	0
Class 10	1.05	1.01	0.93	0.02
Class 11	4.35	0.13	0	0
Class 12	3.15	1.22	0.09	0
Class 13	2.77	1.4	0.51	0.04



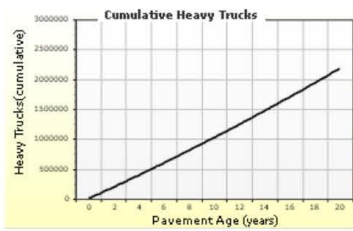
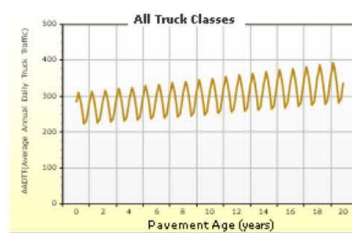
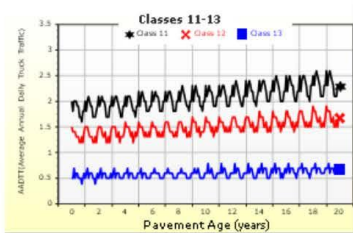
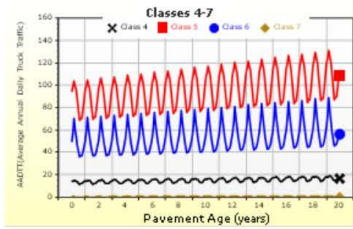
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## AADTT (Average Annual Daily Truck Traffic) Growth

\* Traffic cap is not enforced





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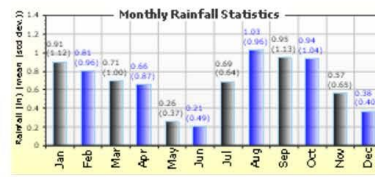
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## Climate Inputs

### Climate Data Sources:

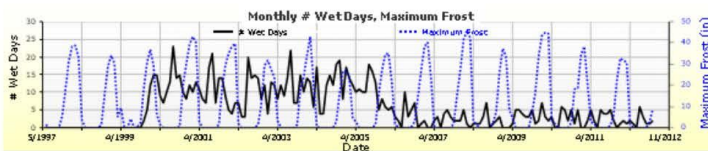
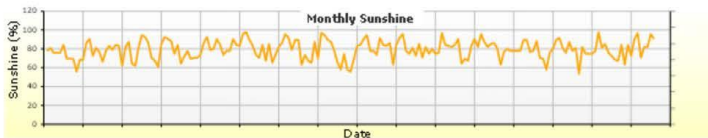
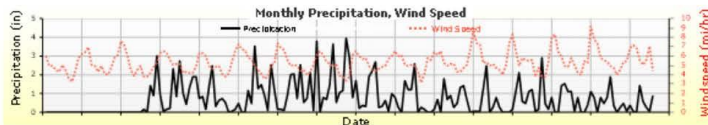
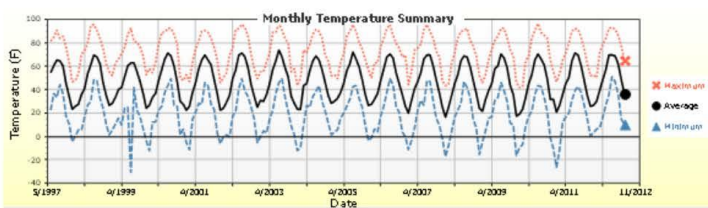
Climate Station Cities:	Location (lat lon elevation(ft))
DURANGO LA PLATA, C	37.14300 -107.76000 6685



### Annual Statistics:

Mean annual air temperature (°F)	47.04		
Mean annual precipitation (in)	8.09		
Freezing index (°F - days)	623.93		
Average annual number of freeze/thaw cycles:	163.30	Water table depth (ft)	10.00

### Monthly Climate Summary:



Report generated on: 10/22/2018 9:54 AM

Version: 2.3.1-hotfix-

Created by: on: 8/26/2015 12:00 AM

Approved by: on: 8/26/2015 12:00 AM

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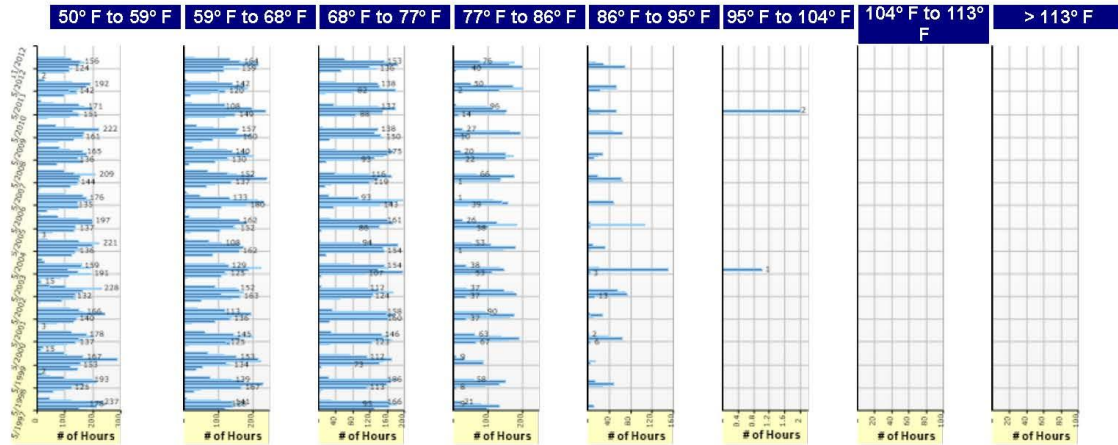
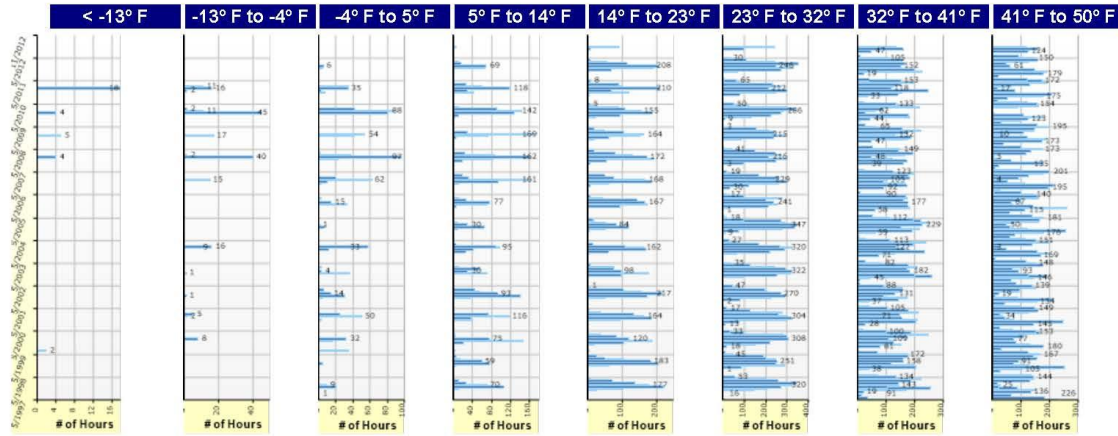


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## Hourly Air Temperature Distribution by Month:





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### Design Properties

#### HMA Design Properties

Use Multilayer Rutting Model	False	Layer Name	Layer Type	Interface Friction
Using G* based model (not nationally calibrated)	False	Layer 1 Flexible : R3 Level 1 SX (75) PG 58-28 United	Flexible (1)	1.00
Is NCHRP 1-37A HMA Rutting Model Coefficients	True	Layer 2 Non-stabilized Base : ABC Class 6	Non-stabilized Base (4)	1.00
Endurance Limit	-	Layer 3 Subgrade : A-1-b	Subgrade (5)	-
Use Reflective Cracking	True			
<b>Structure - ICM Properties</b>				
AC surface shortwave absorptivity	0.85			

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## Thermal Cracking (Input Level: 1)

Indirect tensile strength at 14 °F (psi)	555.90
<b>Thermal Contraction</b>	
Is thermal contraction calculated?	True
Mix coefficient of thermal contraction (in/in/°F)	-
Aggregate coefficient of thermal contraction (in/in/°F)	5.0e-006
Voids in Mineral Aggregate (%)	16.2

Loading time (sec)	Creep Compliance (1/psi)		
	-4 °F	14 °F	32 °F
1	2.78e-007	3.91e-007	2.65e-007
2	3.11e-007	4.79e-007	3.91e-007
5	3.48e-007	5.57e-007	6.33e-007
10	3.74e-007	6.94e-007	9.55e-007
20	4.22e-007	8.31e-007	1.28e-006
50	4.63e-007	1.08e-006	1.99e-006
100	5.28e-007	1.35e-006	2.72e-006



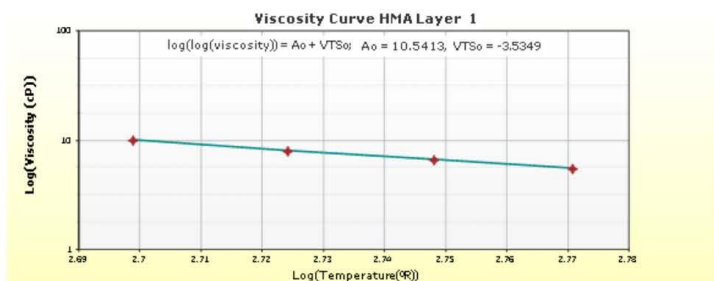
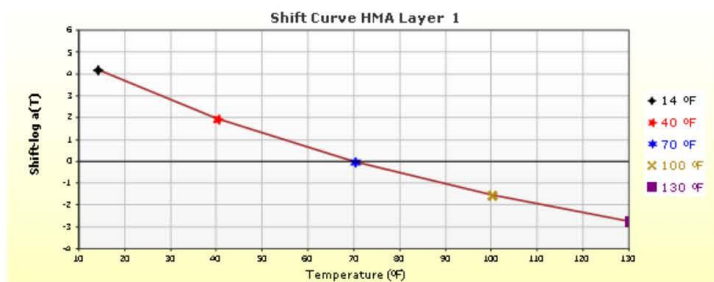
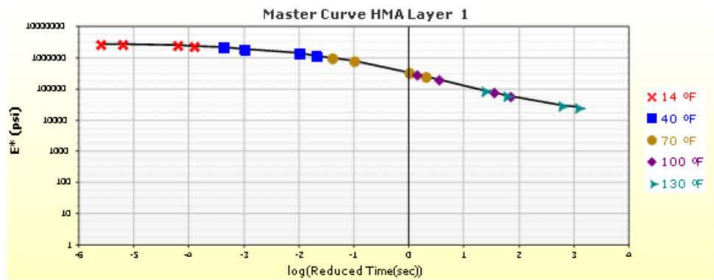


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## HMA Layer 1: Layer 1 Flexible : R3 Level 1 SX(75) PG 58-28 United



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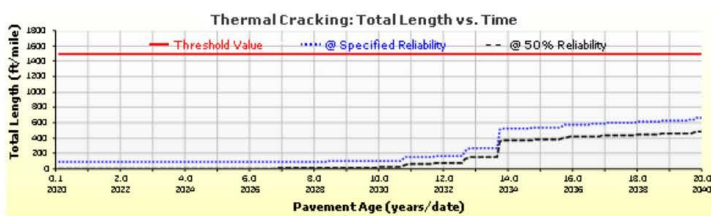
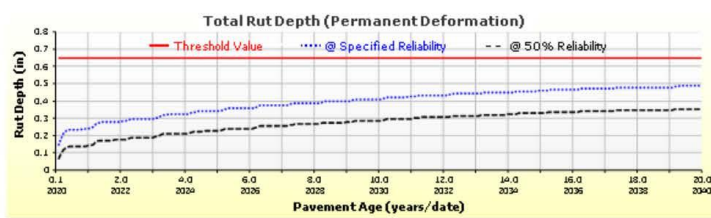


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## Analysis Output Charts



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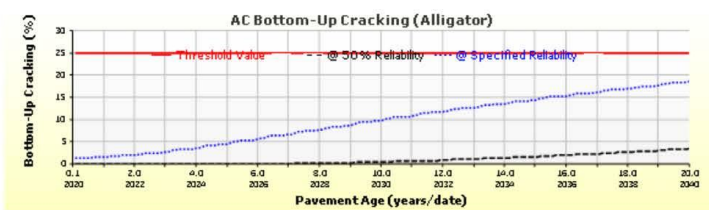
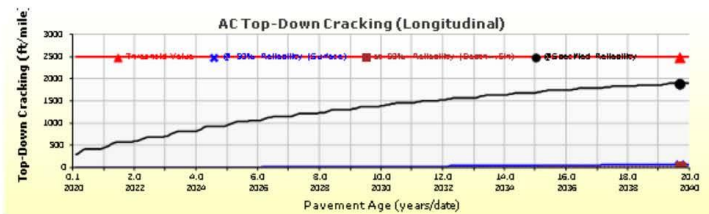
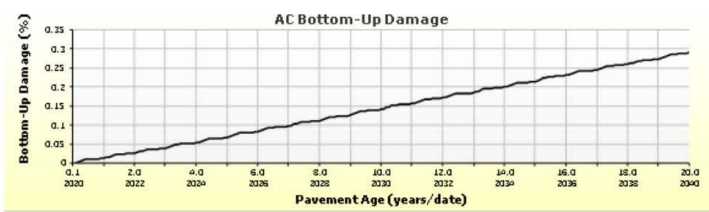
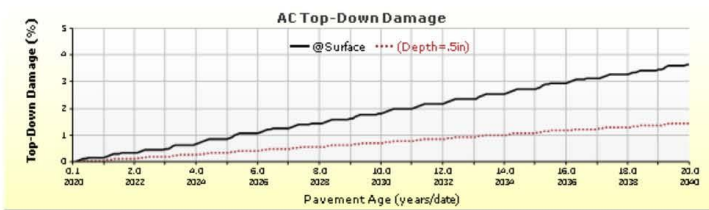
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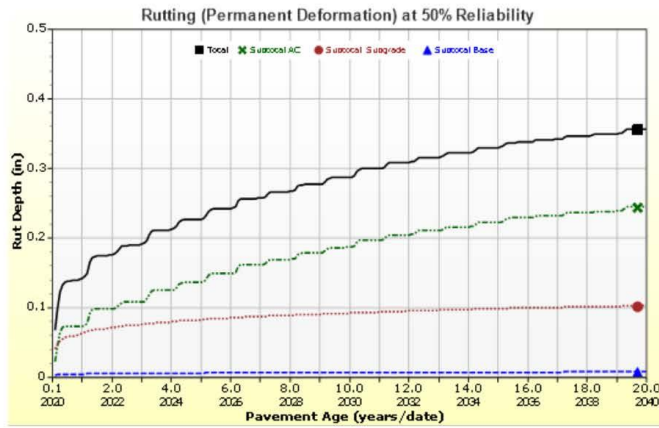
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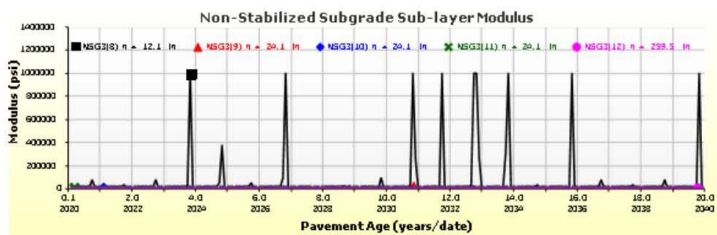
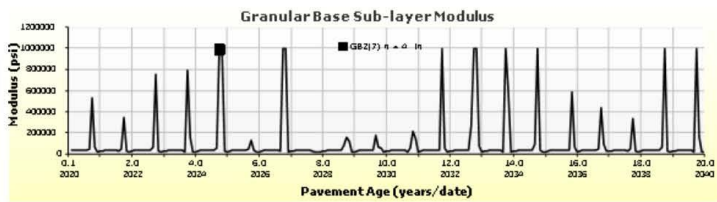
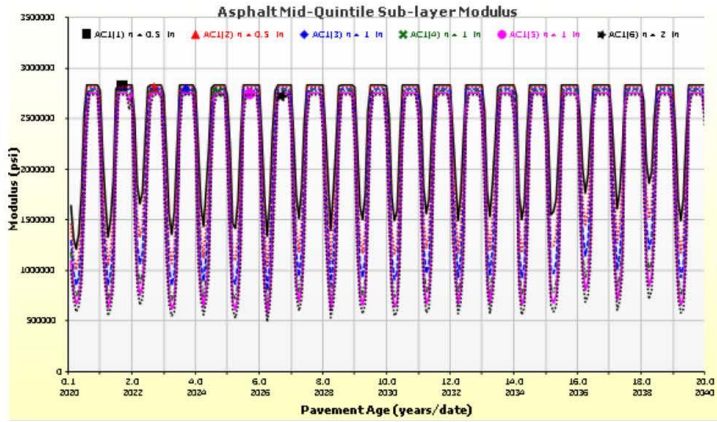
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## Layer Information

### Layer 1 Flexible : R3 Level 1 SX(75) PG 58-28 United

#### Asphalt

Thickness (in)	6.0	
Unit weight (pcf)	145.0	
Poisson's ratio	Is Calculated?	True
	Ratio	-
	Parameter A	-1.63
	Parameter B	3.84E-06

#### General Info

Name	Value
Reference temperature (°F)	70
Effective binder content (%)	10.7
Air voids (%)	5.5
Thermal conductivity (BTU/hr-ft-°F)	0.67
Heat capacity (BTU/lb-°F)	0.23

#### Asphalt Dynamic Modulus (Input Level: 1)

T (°F)	0.5 Hz	1 Hz	10 Hz	25 Hz
14	2067099	2488999	2785899	2873299
40	930800	1472800	2008399	2196999
70	207600	439600	838700	1039200
100	52500	101200	215300	291900
130	24100	35400	60900	78900

#### Identifiers

Field	Value
Display name/identifier	R3 Level 1 SX(75) PG 58-28
Description of object	Mix ID # FS1918
Author	CDOT
Date Created	4/3/2013 12:00:00 AM
Approver	CDOT
Date approved	4/3/2013 12:00:00 AM
State	Colorado
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	SX
User defined field 2	
User defined field 3	
Revision Number	0

#### Asphalt Binder

Temperature (°F)	Binder Gstar (Pa)	Phase angle (deg)
136.4	2227.6	80
147.2	1068.2	82
158	540.1	84



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## Layer 2 Non-stabilized Base : ABC Class 6

Unbound	
Layer thickness (in)	4.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

### Modulus (Input Level: 3)

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

Resilient Modulus (psi)
25000.0

<b>Use Correction factor for NDT modulus?</b>	-
<b>NDT Correction Factor:</b>	-

### Identifiers

Field	Value
Display name/identifier	ABC Class 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

<b>Liquid Limit</b>	6.0
<b>Plasticity Index</b>	1.0
<b>Is layer compacted?</b>	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	127.7
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)

<b>Is User Defined?</b>	False
<b>af</b>	7.2555
<b>bf</b>	1.3328
<b>cf</b>	0.8242
<b>hr</b>	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



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## Layer 3 Subgrade : A-1-b

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

### Modulus (Input Level: 3)

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

Resilient Modulus (psi)
15000.0

<b>Use Correction factor for NDT modulus?</b>	-
<b>NDT Correction Factor:</b>	-

### Identifiers

Field	Value
Display name/identifier	A-1-b
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

<b>Liquid Limit</b>	11.0
<b>Plasticity Index</b>	1.0
<b>Is layer compacted?</b>	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	124.2
Saturated hydraulic conductivity (ft/hr)	False	2.303e-03
Specific gravity of solids	False	2.7
Water Content (%)	False	9.1

### User-defined Soil Water Characteristic Curve (SWCC)

<b>Is User Defined?</b>	False
<b>af</b>	5.8206
<b>bf</b>	0.4621
<b>cf</b>	3.8497
<b>hr</b>	126.8000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	13.4
#100	
#80	20.8
#60	
#50	
#40	37.6
#30	
#20	
#16	
#10	64.0
#8	
#4	74.2
3/8-in.	82.3
1/2-in.	85.8
3/4-in.	90.8
1-in.	93.6
1 1/2-in.	96.7
2-in.	98.4
2 1/2-in.	
3-in.	
3 1/2-in.	99.4



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## Calibration Coefficients

AC Fatigue	
$N_f = 0.00432 * C * \beta_{f1} k_1 \left(\frac{1}{\epsilon_1}\right)^{k_2 \beta_{f2}} \left(\frac{1}{E}\right)^{k_3 \beta_{f3}}$ $C = 10^M$ $M = 4.84 \left(\frac{V_b}{V_a + V_b} - 0.69\right)$	K1: 0.007566
	K2: 3.9492
	K3: 1.281
	Bf1: 130.3674
	Bf2: 1
	Bf3: 1.217799

AC Rutting	
$\frac{\epsilon_p}{\epsilon_r} = k_z \beta_{r1} 10^{k_1 T^{k_2} \beta_{r2} N^{k_3} B_{r3}}$ $k_z = (C_1 + C_2 * depth) * 0.328196^{depth}$ $C_1 = -0.1039 * H_{\alpha}^2 + 2.4868 * H_{\alpha} - 17.342$ $C_2 = 0.0172 * H_{\alpha}^2 - 1.7331 * H_{\alpha} + 27.428$ <p>Where:  <math>H_{\alpha c}</math> = total AC thickness(in)</p>	$\epsilon_p$ = plastic strain(in/in) $\epsilon_r$ = resilient strain(in/in) $T$ = layer temperature( $^{\circ}$ F) $N$ = number of load repetitions
AC Rutting Standard Deviation	0.1414 * Pow(RUT,0.25) + 0.001
AC Layer	K1:-3.35412 K2:1.5606 K3:0.3791 Br1:6.7 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) $k$ = regression coefficient determined through field calibration $N()$ = standard normal distribution evaluated at() $\sigma$ = standard deviation of the log of the depth of cracks in the pavements $C$ = 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: 6.3	Level 1 Standard Deviation: 0.1468 * THERMAL + 65.027
Level 2 K: 0.5	Level 2 Standard Deviation: 0.2841 * THERMAL + 55.462
Level 3 K: 6.3	Level 3 Standard Deviation: 0.3972 * THERMAL + 20.422

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



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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 $		$\delta_a$ = permanent deformation for the layer <i>N</i> = number of repetitions $\varepsilon_v$ = average vertical strain(in/in) $\varepsilon_0, \beta, \rho$ = material properties $\varepsilon_r$ = resilient strain(in/in)	
Granular		Fine	
k1: 2.03	Bs1: 0.22	k1: 1.35	Bs1: 0.37
Standard Deviation (BASERUT) 0.0104 * Pow(BASERUT,0.67) + 0.001		Standard Deviation (BASERUT) 0.0663 * Pow(SUBRUT,0.5) + 0.001	

AC Cracking						
AC Top Down Cracking				AC Bottom Up Cracking		
$FC_{top} = \left( \frac{C_4}{1 + e^{(C_1 - C_2 * \log_{10}(Damage))}} \right) * 10.56$				$FC = \left( \frac{6000}{1 + e^{(C_1 * C'_1 + C_2 * C'_2 * \log_{10}(D * 100))}} \right) * \left( \frac{1}{60} \right)$		
$C'_2 = -2.40874 - 39.748 * (1 + h_{ac})^{-2.856}$				$C'_1 = -2 * C'_2$		
c1: 7	c2: 3.5	c3: 0	c4: 1000	c1: 0.021	c2: 2.35	c3: 6000
AC Cracking Top Standard Deviation				AC Cracking Bottom Standard Deviation		
200 + 2300/(1+exp(1.072-2.1654*LOG10(TOP+0.0001)))				1 + 15/(1+exp(-3.1472-4.1349*LOG10(BOTTOM+0.0001)))		

CSM Cracking				IRI Flexible Pavements			
$FC_{ctb} = C_1 + \frac{C_2}{1 + e^{C_3 - C_4(Damage)}}$				C1 - Rutting		C3 - Transverse Crack	
				C2 - Fatigue Crack		C4 - Site Factors	
C1: 0	C2: 75	C3: 5	C4: 3	C1: 50	C2: 0.55	C3: 0.0111	C4: 0.02
CSM Standard Deviation							
CTB*1							



# Pavement M-E Design Report – HMA on Bedrock



## 22420 US 550\_HMA on Claystone\_FINAL

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### Design Inputs

Design Life: 20 years      Base construction: May, 2020      Climate Data: 37.143, -107.76  
 Design Type: FLEXIBLE      Pavement construction: May, 2020      Sources (Lat/Lon)  
 Traffic opening: May, 2020

### Design Structure

Layer type	Material Type	Thickness (in)
Flexible	R3 Level 1 SX(75) PG 58-28 United	6.0
NonStabilized	ABC Class 6	4.0
Subgrade	A-1-b	24.0
Subgrade	A-6	Semi-infinite

### Traffic

Volumetric at Construction:	
Effective binder content (%)	10.7
Air voids (%)	5.5

Age (year)	Heavy Trucks (cumulative)
2020 (initial)	589
2030 (10 years)	1,024,410
2040 (20 years)	2,184,310

### Design Outputs

#### Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	200.00	165.78	90.00	98.91	Pass
Permanent deformation - total pavement (in)	0.65	0.53	90.00	99.30	Pass
AC bottom-up fatigue cracking (% lane area)	25.00	19.86	90.00	95.57	Pass
AC thermal cracking (ft/mile)	1500.00	657.14	90.00	100.00	Pass
AC top-down fatigue cracking (ft/mile)	2500.00	1287.90	90.00	99.39	Pass
Permanent deformation - AC only (in)	0.50	0.38	90.00	99.25	Pass

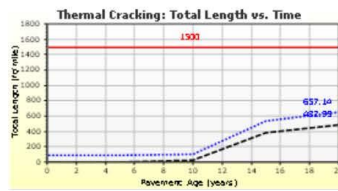
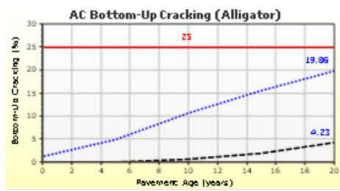
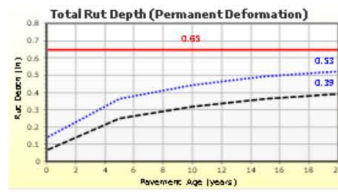


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## Distress Charts





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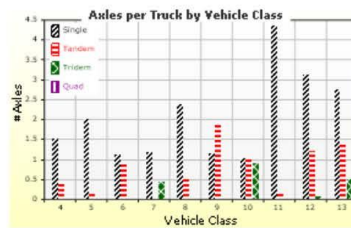
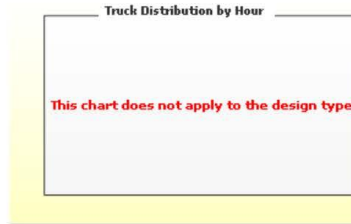
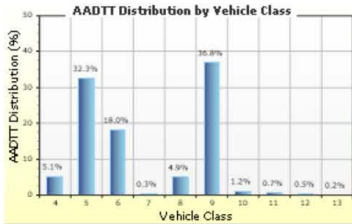
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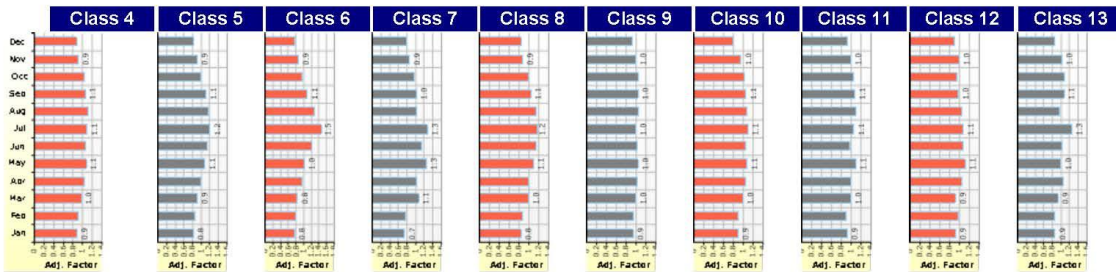
## Traffic Inputs

### Graphical Representation of Traffic Inputs

Initial two-way AADTT:	589	Percent of trucks in design direction (%):	50.0
Number of lanes in design direction:	2	Percent of trucks in design lane (%):	90.0
		Operational speed (mph)	45.0



### Traffic Volume Monthly Adjustment Factors





# 22420 US 550\_HMA on Claystone\_FINAL



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## 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	0.9	0.8	0.8	0.7	0.8	0.9	0.9	0.9	0.9	0.9
February	0.9	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	0.8
March	1.0	0.9	0.8	1.1	1.0	1.0	1.0	1.0	0.9	0.9
April	1.0	1.0	0.9	1.0	1.0	1.0	1.1	1.0	1.0	1.1
May	1.1	1.1	1.0	1.3	1.1	1.0	1.1	1.1	1.1	1.0
June	1.1	1.1	1.2	1.1	1.1	1.0	1.1	1.0	1.1	1.0
July	1.1	1.2	1.5	1.3	1.2	1.0	1.1	1.1	1.1	1.3
August	1.1	1.2	1.3	1.0	1.1	1.0	1.1	1.1	1.1	1.0
September	1.1	1.1	1.1	1.0	1.1	1.0	1.1	1.1	1.0	1.1
October	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	1.1
November	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0
December	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.9	0.9	0.9

### Distributions by Vehicle Class

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor	
		Rate (%)	Function
Class 4	5.1%	1.25%	Compound
Class 5	32.3%	1.25%	Compound
Class 6	18%	1.25%	Compound
Class 7	0.3%	1.25%	Compound
Class 8	4.9%	1.25%	Compound
Class 9	36.8%	1.25%	Compound
Class 10	1.2%	1.25%	Compound
Class 11	0.7%	1.25%	Compound
Class 12	0.5%	1.25%	Compound
Class 13	0.2%	1.25%	Compound

### Truck Distribution by Hour does not apply

### Axle Configuration

Traffic Wander		Axle Configuration	
Mean wheel location (in)	18.0	Average axle width (ft)	8.5
Traffic wander standard deviation (in)	10.0	Dual tire spacing (in)	12.0
Design lane width (ft)	12.0	Tire pressure (psi)	120.0

Average Axle Spacing		Wheelbase does not apply	
Tandem axle spacing (in)	51.6		
Tridem axle spacing (in)	49.2		
Quad axle spacing (in)	49.2		

### Number of Axles per Truck

Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.53	0.45	0	0
Class 5	2.02	0.16	0.02	0
Class 6	1.12	0.93	0	0
Class 7	1.19	0.07	0.45	0.02
Class 8	2.41	0.56	0.02	0
Class 9	1.16	1.88	0.01	0
Class 10	1.05	1.01	0.93	0.02
Class 11	4.35	0.13	0	0
Class 12	3.15	1.22	0.09	0
Class 13	2.77	1.4	0.51	0.04



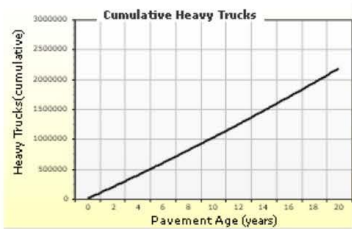
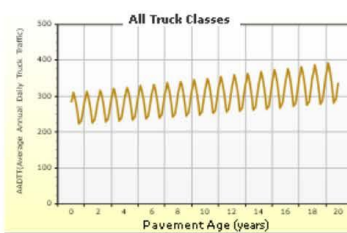
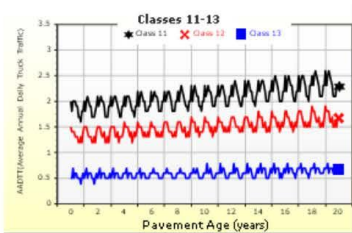
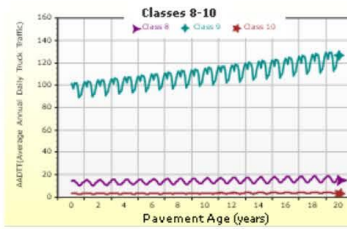
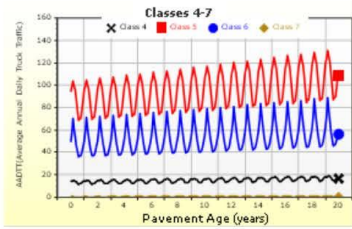
# 22420 US 550\_HMA on Claystone\_FINAL

File Name: C:\Users\kempb\Documents\Projects\22420\_550\_160 Connection\Pavement Design\FINAL\22420 US 550\_HMA on Claystone\_FINAL.dgx



## AADTT (Average Annual Daily Truck Traffic) Growth

\* Traffic cap is not enforced





# 22420 US 550\_HMA on Claystone\_FINAL

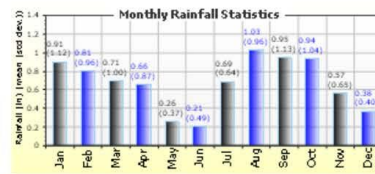


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## Climate Inputs

### Climate Data Sources:

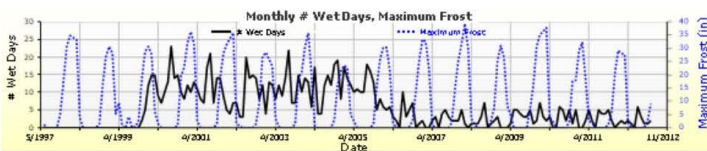
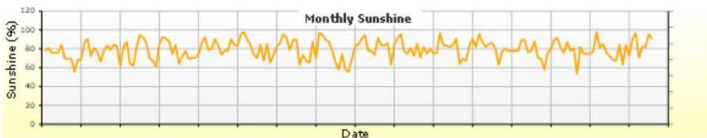
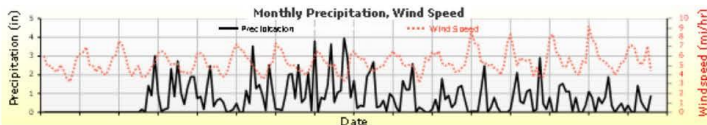
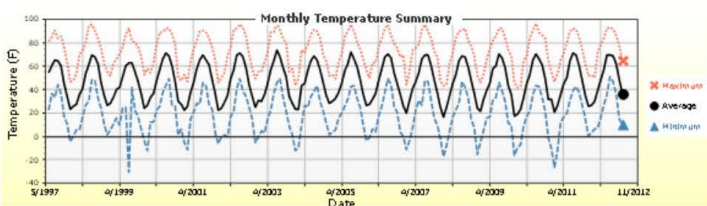
Climate Station Cities:	Location (lat lon elevation(ft))
DURANGO LA PLATA, C	37.14300 -107.76000 6685



### Annual Statistics:

Mean annual air temperature (°F)	47.04		
Mean annual precipitation (in)	8.09		
Freezing index (°F - days)	623.93		
Average annual number of freeze/thaw cycles:	163.30	Water table depth (ft)	10.00

### Monthly Climate Summary:



Report generated on: 10/22/2018 9:50 AM

Version: 2.3.1-hotfix-

Created by: on: 8/26/2015 12:00 AM

Approved by: on: 8/26/2015 12:00 AM

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