## 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)

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

| Resilient Modulus (psi) |
|---|
| 15000.0 |

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

### 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

| | |
|---|---|
| **Liquid Limit** | 11.0 |
| **Plasticity Index** | 1.0 |
| **Is layer compacted?** | 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) | |
|---|---|
| **Is User Defined?** | False |
| **af** | 5.8206 |
| **bf** | 0.4621 |
| **cf** | 3.8497 |
| **hr** | 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 |

## 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)

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

| Resilient Modulus (psi) |
|---|
| 6482.0 |

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

### 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

| | |
|---|---|
| **Liquid Limit** | 44.0 |
| **Plasticity Index** | 27.0 |
| **Is layer compacted?** | 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) | |
|---|---|
| **Is User Defined?** | False |
| **af** | 133.7378 |
| **bf** | 0.5319 |
| **cf** | 0.0500 |
| **hr** | 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 |

## 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: 130.3674 | |
| Bf2: 1 | |
| Bf3: 1.217799 | |

### 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:*

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

$\varepsilon_p = plastic\ strain\left(^{in}/_{in}\right)$
$\varepsilon_r = resilient\ strain\left(^{in}/_{in}\right)$
$T = layer\ temperature(^\circ F)$
$N = number\ of\ load\ repetitions$

| | | |
|---|---|---|
| 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($ft/500ft$)
$k$ = 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
$\sigma_N$ = 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 |

| Subgrade Rutting | | | |
|---|---|---|---|
| $\delta_a(N) = \beta_{s_1} k_1 \varepsilon_v h \left(\frac{\varepsilon_0}{\varepsilon_r}\right) \left\| e^{-\left(\frac{\rho}{N}\right)^{\beta}} \right\|$ | | $\delta_a = permanent\ deformation\ for\ the\ layer$<br>$N = number\ of\ repetitions$<br>$\varepsilon_v = average\ veritcal\ strain(in/in)$<br>$\varepsilon_0, \beta, \rho = material\ properties$<br>$\varepsilon_r = resilient\ strain(in/in)$ | |
| **Granular** | | **Fine** | |
| k1: 2.03 | Bs1: 0.22 | k1: 1.35 | Bs1: 0.37 |
| Standard Deviation (BASERUT)<br>0.0104 * Pow(BASERUT,0.67) + 0.001 | | Standard Deviation (BASERUT)<br>0.0663 * Pow(SUBRUT,0.5) + 0.001 | |

| AC Cracking | | | | | | |
|---|---|---|---|---|---|---|
| **AC Top Down Cracking** | | | | **AC Bottom Up Cracking** | | |
| $FC_{top} = \left(\frac{C_4}{1 + e^{(C_1 - C_2 * log_{10}(Damage))}}\right) * 10.56$ | | | | $FC = \left(\frac{6000}{1 + e^{\left(C_1 * C_1' + C_2 * C_2' log_{10}(D * 100)\right)}}\right) * \left(\frac{1}{60}\right)$<br>$C_2' = -2.40874 - 39.748 * (1 + h_{ac})^{-2.856}$<br>$C_1' = -2 * C_2'$ | | |
| 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<br>C2 - Fatigue Crack | | C3 - Transverse Crack<br>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 Ramp B

## 22420 US 550_HMA on Claystone_RAMP B_FINAL

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

## Design Inputs

| | | | | | |
|---|---|---|---|---|---|
| Design Life: | 20 years | Base construction: | May, 2020 | Climate Data Sources (Lat/Lon) | 37.143, -107.76 |
| Design Type: | FLEXIBLE | Pavement construction: | May, 2020 | | |
| | | 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 | 6.0 |
| Subgrade | A-1-b | 8.0 |
| Subgrade | A-6 | Semi-infinite |

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

### Traffic

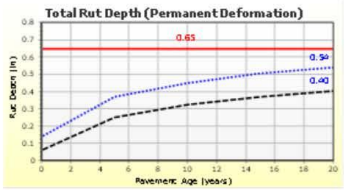
| Age (year) | Heavy Trucks (cumulative) |
|---|---|
| 2020 (initial) | 300 |
| 2030 (10 years) | 695,692 |
| 2040 (20 years) | 1,483,400 |

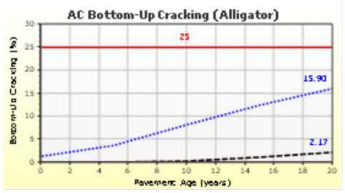
## Design Outputs

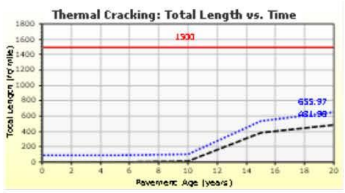
### Distress Prediction Summary

| Distress Type | Distress @ Specified Reliability | | Reliability (%) | | Criterion Satisfied? |
|---|---|---|---|---|---|
| | Target | Predicted | Target | Achieved | |
| Terminal IRI (in/mile) | 200.00 | 164.82 | 90.00 | 99.01 | Pass |
| Permanent deformation - total pavement (in) | 0.65 | 0.54 | 90.00 | 98.96 | Pass |
| AC bottom-up fatigue cracking (% lane area) | 25.00 | 15.90 | 90.00 | 98.35 | Pass |
| AC thermal cracking (ft/mile) | 1500.00 | 655.97 | 90.00 | 100.00 | Pass |
| AC top-down fatigue cracking (ft/mile) | 2500.00 | 751.20 | 90.00 | 100.00 | Pass |
| Permanent deformation - AC only (in) | 0.50 | 0.41 | 90.00 | 98.53 | Pass |

## Distress Charts

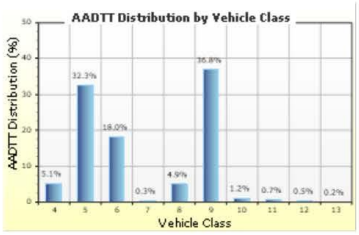



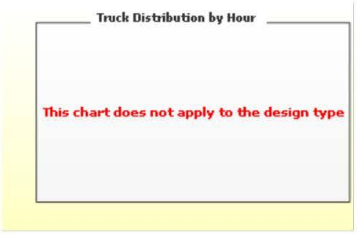




# Traffic Inputs

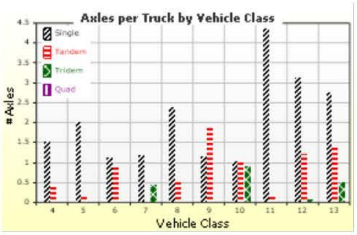
## Graphical Representation of Traffic Inputs

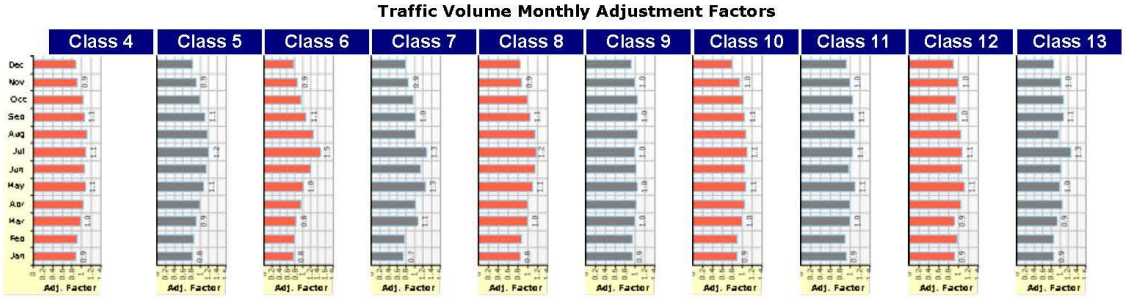
| | | | |
|---|---|---|---|
| Initial two-way AADTT: | 300 | Percent of trucks in design direction (%): | 60.0 |
| Number of lanes in design direction: | 1 | Percent of trucks in design lane (%): | 100.0 |
| | | Operational speed (mph) | 25.0 |







## 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 | |
|---|---|
| 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 |

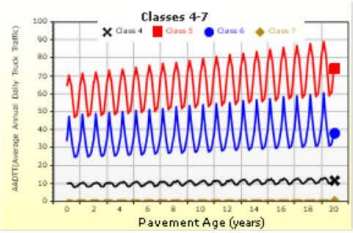
Wheelbase does not apply

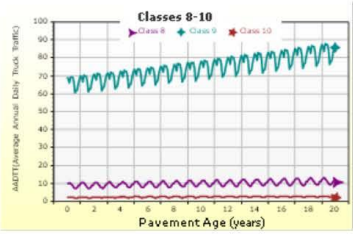
### Number of Axles per Truck

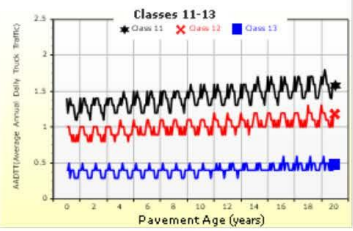
| Vehicle Class | Single Axle | Tandem Axle | Tridem Axle | Quad Axle |
|---|---|---|---|---|
| Class 4 | 1.53 | 0.45 | 0 | 0 |
| Class 5 | 2.02 | 0.16 | 0.02 | 0 |
| Class 6 | 1.12 | 0.93 | 0 | 0 |
| Class 7 | 1.19 | 0.07 | 0.45 | 0.02 |
| Class 8 | 2.41 | 0.56 | 0.02 | 0 |
| Class 9 | 1.16 | 1.88 | 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 |

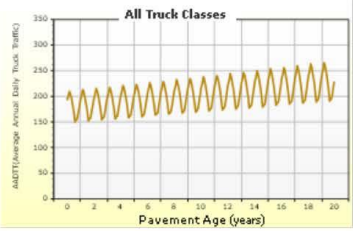
## AADTT (Average Annual Daily Truck Traffic) Growth

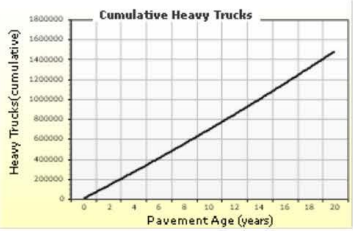
* Traffic cap is not enforced



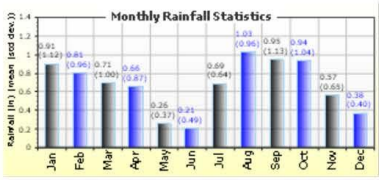



# Climate Inputs

## Climate Data Sources:

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

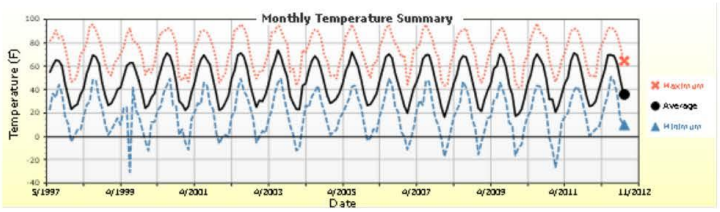


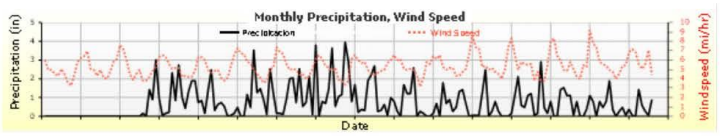

## Annual Statistics:

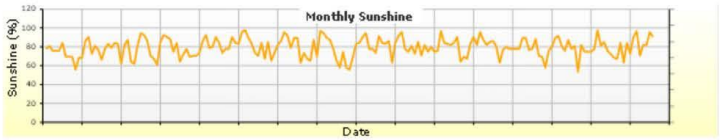
| | |
|---|---|
| Mean annual air temperature (°F) | 47.04 |
| Mean annual precipitation (in) | 8.09 |
| Freezing index (°F - days) | 623.93 |
| Average annual number of freeze/thaw cycles: | 163.30 |

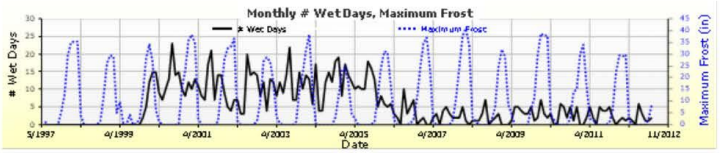
Water table depth (ft) 10.00

## Monthly Climate Summary:

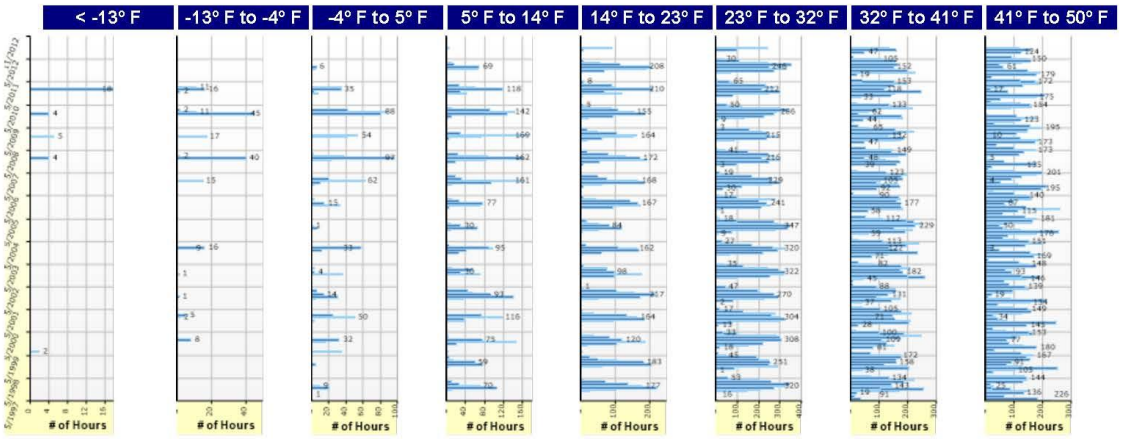


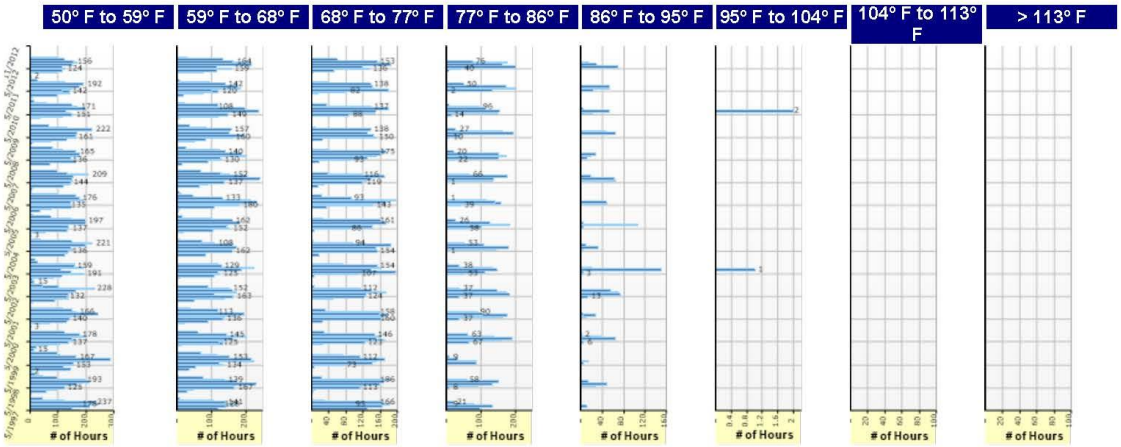



## Hourly Air Temperature Distribution by Month:



# 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 |

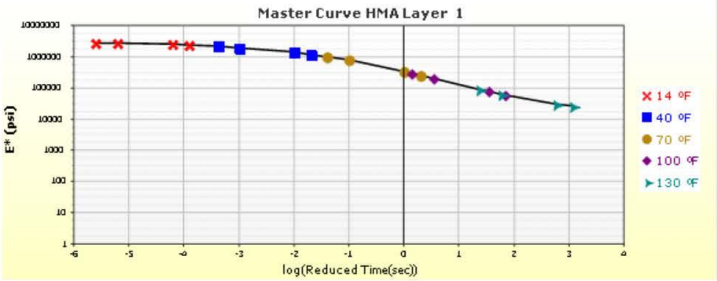
| Layer Name | Layer Type | Interface Friction |
|---|---|---|
| Layer 1 Flexible : R3 Level 1 SX (75) PG 58-28 United | Flexible (1) | 1.00 |
| Layer 2 Non-stabilized Base : ABC Class 6 | Non-stabilized Base (4) | 1.00 |
| Layer 3 Subgrade : A-1-b | Subgrade (5) | 1.00 |
| Layer 4 Subgrade : A-6 | Subgrade (5) | - |

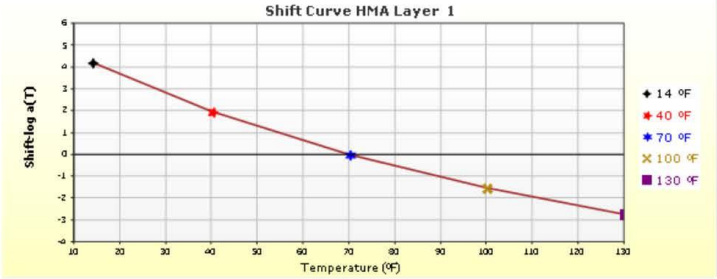
## Thermal Cracking (Input Level: 1)

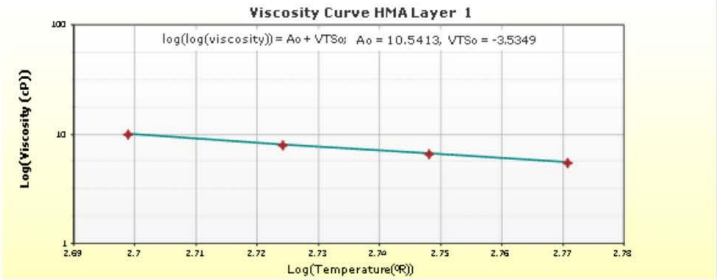
| | |
|---|---|
| **Indirect tensile strength at 14 °F (psi)** | 555.90 |
| **Thermal Contraction** | |
| Is thermal contraction calculated? | True |
| Mix coefficient of thermal contraction (in/in/°F) | - |
| Aggregate coefficient of thermal contraction (in/in/°F) | 5.0e-006 |
| Voids in Mineral Aggregate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

| | Creep Compliance (1/psi) | | |
|---|---|---|---|
| **Loading time (sec)** | **-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 |

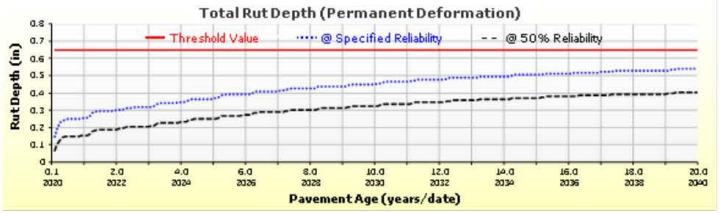
## HMA Layer 1: Layer 1 Flexible : R3 Level 1 SX(75) PG 58-28 United

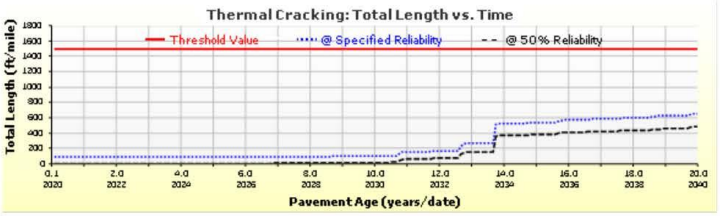


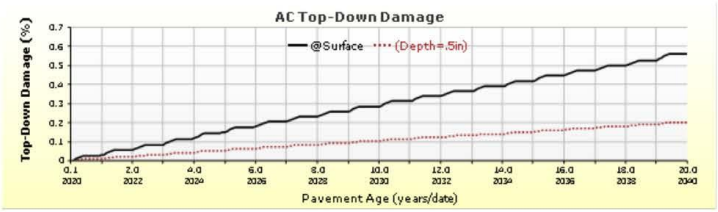



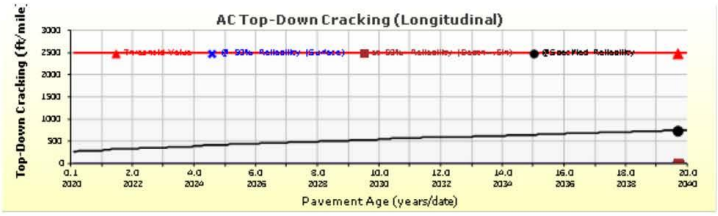
## Analysis Output Charts

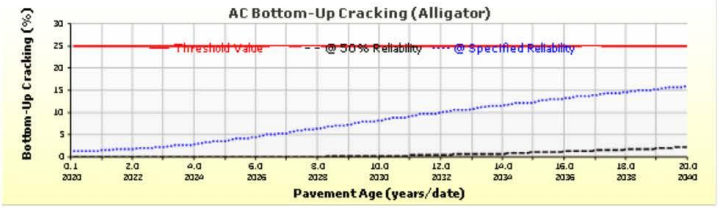



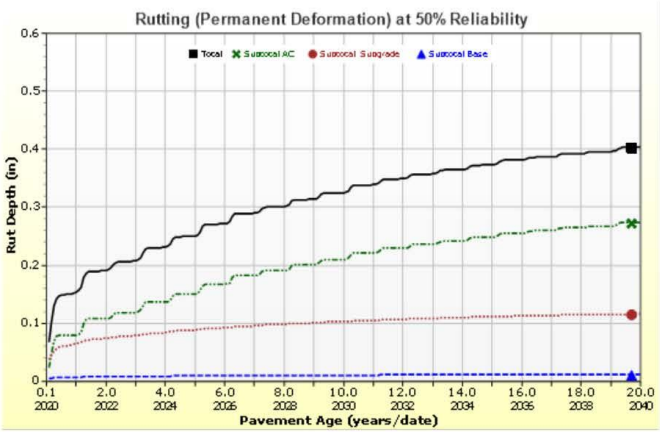



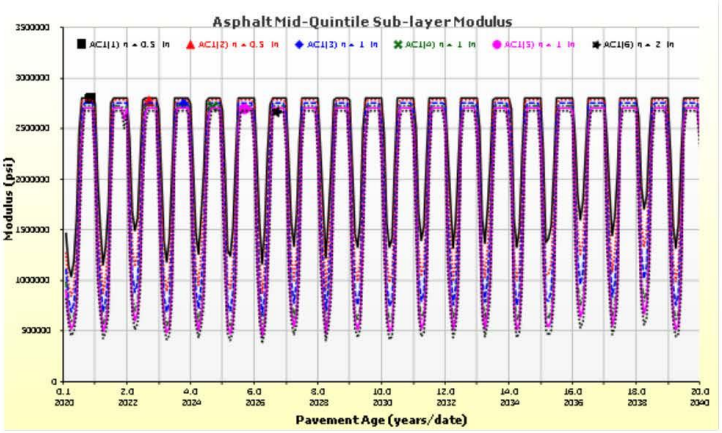

AC Top-Down Damage
@Surface
(Depth=.5in)
Top-Down Damage (%)
Pavement Age (years/date)

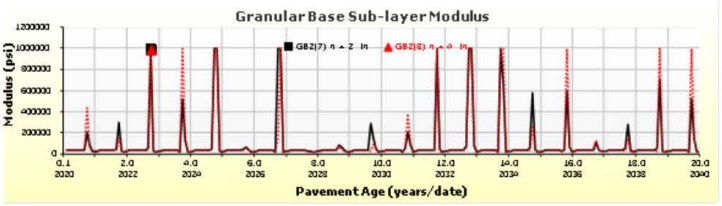

AC Bottom-Up Damage
Bottom-Up Damage (%)
Pavement Age (years/date)

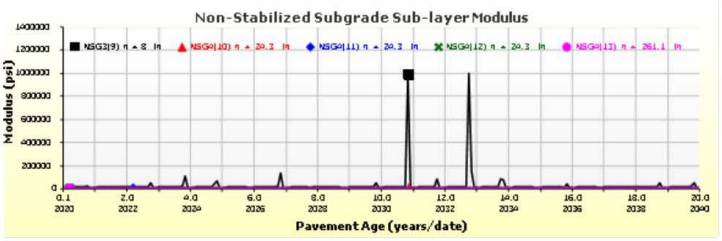

AC Top-Down Cracking (Longitudinal)
Top-Down Cracking (ft/mile)
Pavement Age (years/date)


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 AC
Subtotal Subgrade
Subtotal Base
Rut Depth (in)
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
2020
2.0
2022
4.0
2024
6.0
2026
8.0
2028
10.0
2030
12.0
2032
14.0
2034
16.0
2036
18.0
2038
20.0
2040
Pavement Age (years/date)


Asphalt Mid-Quintile Sub-layer Modulus
Modulus (psi)
Pavement Age (years/date)


Granular Base Sub-layer Modulus
Modulus (psi)
Pavement Age (years/date)


Non-Stabilized Subgrade Sub-layer Modulus
Modulus (psi)
Pavement Age (years/date)

# 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 |

### 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 |

### Asphalt Binder

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

### 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 |

### 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 |

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

| 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) |
|---|
| 25000.0 |

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

### 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

| | |
|---|---|
| **Liquid Limit** | 6.0 |
| **Plasticity Index** | 1.0 |
| **Is layer compacted?** | 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) | |
|---|---|
| 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 3 Subgrade : A-1-b

| 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) |
|---|
| 15000.0 |

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

### 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

| | |
|---|---|
| **Liquid Limit** | 11.0 |
| **Plasticity Index** | 1.0 |
| **Is layer compacted?** | 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) | |
|---|---|
| **Is User Defined?** | False |
| **af** | 5.8206 |
| **bf** | 0.4621 |
| **cf** | 3.8497 |
| **hr** | 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 |

## 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) |
|---|
| 8152.0 |

| | |
|---|---|
| **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?** | True |

| | Is User Defined? | Value |
|---|---|---|
| Maximum dry unit weight (pcf) | False | 108.6 |
| Saturated hydraulic conductivity (ft/hr) | False | 1.856e-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: 130.3674 | |
| Bf2: 1 | |
| Bf3: 1.217799 | |

### AC Rutting

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

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

$$C_1 = -0.1039 * H_{ac}^2 + 2.4868 * H_{ac} - 17.342$$

$$C_2 = 0.0172 * H_{ac}^2 - 1.7331 * H_{ac} + 27.428$$

*Where:*

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

$\varepsilon_p = plastic\ strain\left({}^{in}/_{in}\right)$
$\varepsilon_r = resilient\ strain\left({}^{in}/_{in}\right)$
$T = layer\ temperature(^{\circ}F)$
$N = number\ of\ load\ repetitions$

| | | |
|---|---|---|
| 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

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

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

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

$C_f = observed\ amount\ of\ thermal\ cracking(ft/500ft)$
$k = refression\ coefficient\ determined\ through\ field\ calibration$
$N(\,) = standard\ normal\ distribution\ evaluated\ at(\,)$
$\sigma = standard\ deviation\ of\ the\log\ of\ the\ depth\ of\ cracks\ in\ the\ pavments$
$C = crack\ depth(in)$
$h_{ac} = thickness\ of\ asphalt\ layer(in)$
$\Delta C = Change\ in\ the\ crack\ depth\ due\ to\ a\ cooling\ cycle$
$\Delta K = Change\ in\ the\ stress\ intensity\ factor\ due\ to\ a\ cooling\ cycle$
$A, n = Fracture\ parameters\ for\ the\ asphalt\ mixture$
$E = mixture\ stiffness$
$\sigma_N = Undamaged\ mixture\ tensile\ strength$
$\beta_t = Calibration\ parameter$

| | |
|---|---|
| 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 |

| Subgrade Rutting | | | |
|---|---|---|---|
| $\delta_a(N) = \beta_{s_1} k_1 \varepsilon_v h \left(\frac{\varepsilon_0}{\varepsilon_r}\right) \left\| e^{-\left(\frac{\rho}{N}\right)^{\beta}} \right\|$ | | $\delta_a = permanent\ deformation\ for\ the\ layer$<br>$N = number\ of\ repetitions$<br>$\varepsilon_v = average\ veritcal\ strain(in/in)$<br>$\varepsilon_0, \beta, \rho = material\ properties$<br>$\varepsilon_r = resilient\ strain(in/in)$ | |
| **Granular** | | **Fine** | |
| k1: 2.03 | Bs1: 0.22 | k1: 1.35 | Bs1: 0.37 |
| Standard Deviation (BASERUT)<br>0.0104 * Pow(BASERUT,0.67) + 0.001 | | Standard Deviation (BASERUT)<br>0.0663 * Pow(SUBRUT,0.5) + 0.001 | |

| AC Cracking | | | | | | |
|---|---|---|---|---|---|---|
| **AC Top Down Cracking** | | | | **AC Bottom Up Cracking** | | |
| $FC_{top} = \left(\frac{C_4}{1 + e^{(C_1 - C_2 * log_{10}(Damage))}}\right) * 10.56$ | | | | $FC = \left(\frac{6000}{1 + e^{\left(C_1 * C_1' + C_2 * C_2' log_{10}(D * 100)\right)}}\right) * \left(\frac{1}{60}\right)$<br>$C_2' = -2.40874 - 39.748 * (1 + h_{ac})^{-2.856}$<br>$C_1' = -2 * C_2'$ | | |
| 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<br>C2 - Fatigue Crack | | C3 - Transverse Crack<br>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 – PCCP on Clay

## 22420 US 550_PCCP on Clay_FINAL_24

File Name: C:\Users\kempb\Documents\Projects\22420_550 160 Connection\Pavement Design\FINAL\22420 US 550_PCCP on Clay_FINAL_24.dgpx

## Design Inputs

Design Life: 30 years
Design Type: JPCP

Existing construction: -
Pavement construction: May, 2020
Traffic opening: May, 2020

Climate Data Sources (Lat/Lon): 37.143, -107.76

### Design Structure

| Layer type | Material Type | Thickness (in) |
|---|---|---|
| PCC | R5 Level 1 Lawson | 8.5 |
| NonStabilized | ABC Class 6 | 4.0 |
| Subgrade | A-1-b | 24.0 |
| Subgrade | A-7-6 | Semi-infinite |

| Joint Design: | |
|---|---|
| Joint spacing (ft) | 15.0 |
| Dowel diameter (in) | 1.25 |
| Slab width (ft) | 13.0 (w) |

### Traffic

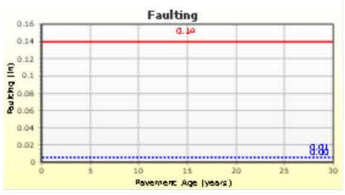
| Age (year) | Heavy Trucks (cumulative) |
|---|---|
| 2020 (initial) | 589 |
| 2035 (15 years) | 1,586,350 |
| 2050 (30 years) | 3,497,640 |

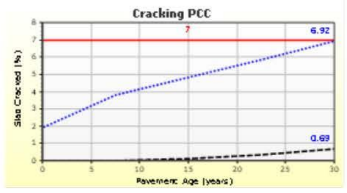
## Design Outputs

### Distress Prediction Summary

| Distress Type | Distress @ Specified Reliability | | Reliability (%) | | Criterion Satisfied? |
|---|---|---|---|---|---|
| | Target | Predicted | Target | Achieved | |
| Terminal IRI (in/mile) | 200.00 | 149.72 | 90.00 | 99.76 | Pass |
| Mean joint faulting (in) | 0.14 | 0.01 | 90.00 | 100.00 | Pass |
| JPCP transverse cracking (percent slabs) | 7.00 | 6.92 | 90.00 | 90.29 | Pass |

### Distress Charts

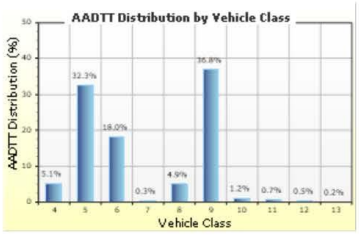



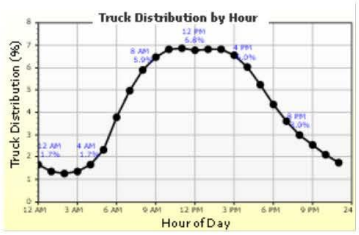




# Traffic Inputs

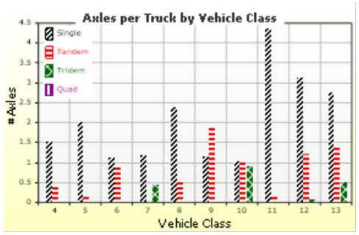
## Graphical Representation of Traffic Inputs

| | | | |
|---|---|---|---|
| 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 |

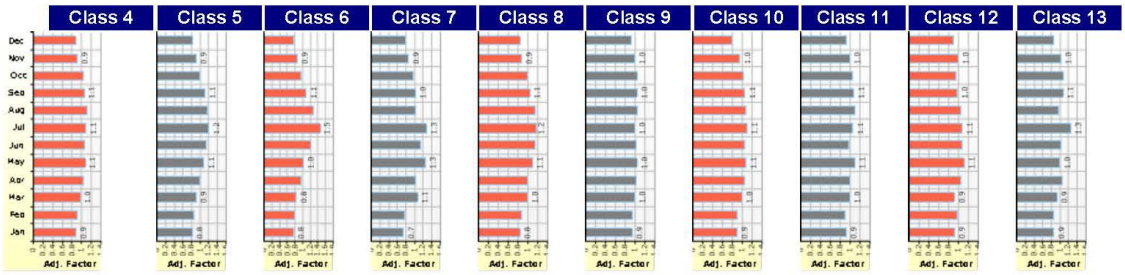







**Traffic Volume Monthly Adjustment Factors**



## 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

| Hour | Distribution (%) | Hour | Distribution (%) |
|---|---|---|---|
| 12 AM | 1.65% | 12 PM | 6.75% |
| 1 AM | 1.37% | 1 PM | 6.81% |
| 2 AM | 1.28% | 2 PM | 6.83% |
| 3 AM | 1.36% | 3 PM | 6.56% |
| 4 AM | 1.66% | 4 PM | 6.02% |
| 5 AM | 2.32% | 5 PM | 5.23% |
| 6 AM | 3.8% | 6 PM | 4.35% |
| 7 AM | 4.95% | 7 PM | 3.59% |
| 8 AM | 5.9% | 8 PM | 2.98% |
| 9 AM | 6.48% | 9 PM | 2.56% |
| 10 AM | 6.83% | 10 PM | 2.12% |
| 11 AM | 6.85% | 11 PM | 1.75% |
| | | 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 |

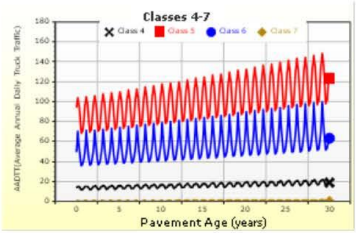
| Wheelbase | | | | |
|---|---|---|---|---|
| Value Type | Axle Type | Short | Medium | Long |
| Average spacing of axles (ft) | | 12.0 | 15.0 | 18.0 |
| Percent of Trucks (%) | | 17.0 | 22.0 | 61.0 |

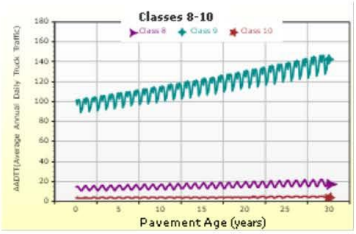
### Number of Axles per Truck

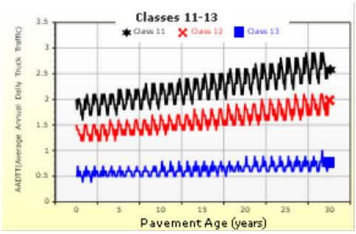
| Vehicle Class | Single Axle | Tandem Axle | Tridem Axle | Quad Axle |
|---|---|---|---|---|
| Class 4 | 1.53 | 0.45 | 0 | 0 |
| Class 5 | 2.02 | 0.16 | 0.02 | 0 |
| Class 6 | 1.12 | 0.93 | 0 | 0 |
| Class 7 | 1.19 | 0.07 | 0.45 | 0.02 |
| Class 8 | 2.41 | 0.56 | 0.02 | 0 |
| Class 9 | 1.16 | 1.88 | 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 |

## AADTT (Average Annual Daily Truck Traffic) Growth

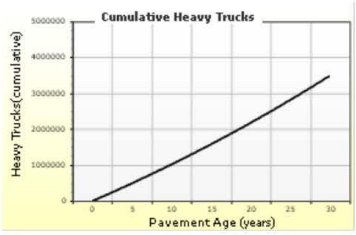
* Traffic cap is not enforced



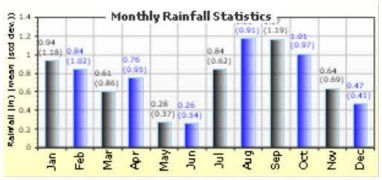




## Climate Inputs

### Climate Data Sources:

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

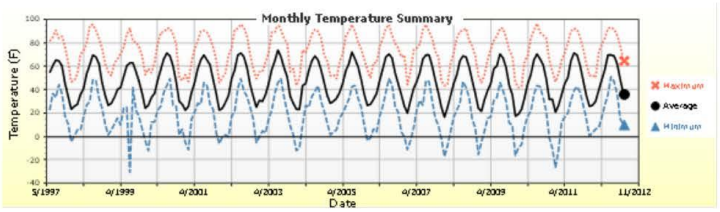


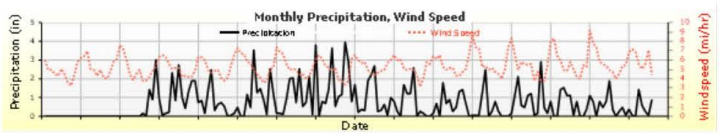

### Annual Statistics:

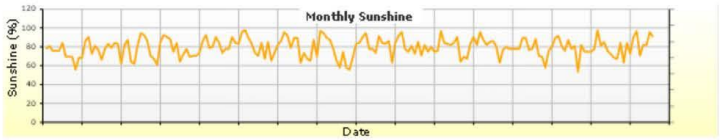
| | |
|---|---|
| Mean annual air temperature (°F) | 47.07 |
| Mean annual precipitation (in) | 8.96 |
| Freezing index (°F - days) | 650.37 |
| Average annual number of freeze/thaw cycles: | 163.30 |

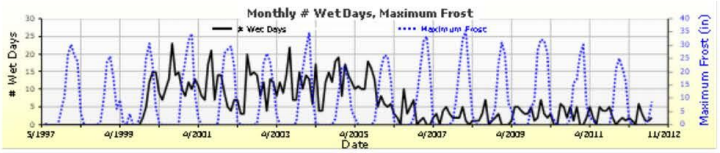
| | |
|---|---|
| Water table depth (ft) | 10.00 |

### Monthly Climate Summary:



## Hourly Air Temperature Distribution by Month: