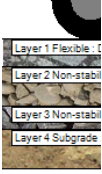


## Design Inputs

Design Life: 20 years      Base construction: May, 2016      Climate Data: 42.554, -92.401  
 Design Type: Flexible Pavement      Pavement construction: June, 2017      Sources (Lat/Lon)  
 Traffic opening: September, 2017

## Design Structure



| Layer type    | Material Type            | Thickness (in.): |
|---------------|--------------------------|------------------|
| Flexible      | Default asphalt concrete | 7.0              |
| NonStabilized | A-1-a                    | 10.0             |
| NonStabilized | Crushed stone            | 6.0              |
| Subgrade      | A-7-6                    | Semi-infinite    |

### Volumetric at Construction:

|                              |      |
|------------------------------|------|
| Effective binder content (%) | 11.6 |
| Air voids (%)                | 7.0  |

## Traffic

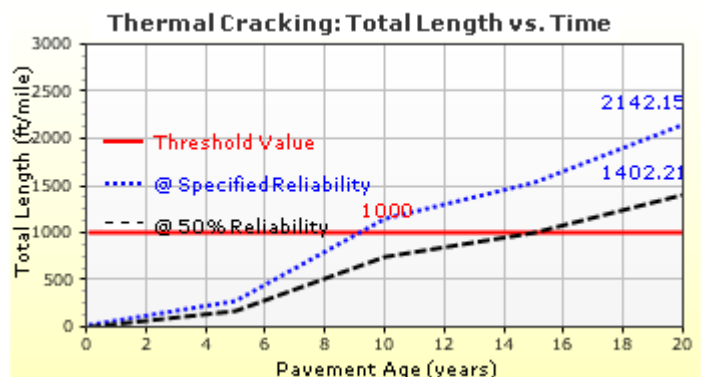
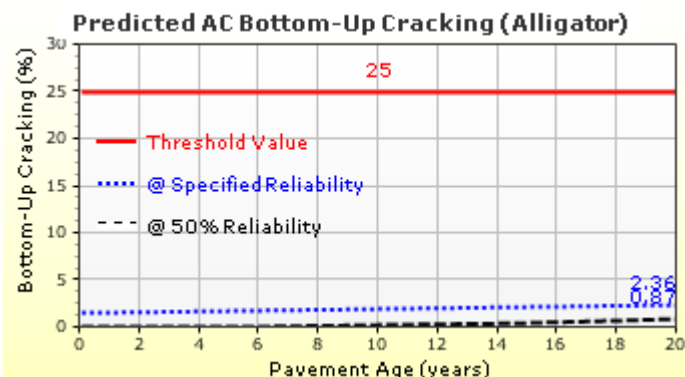
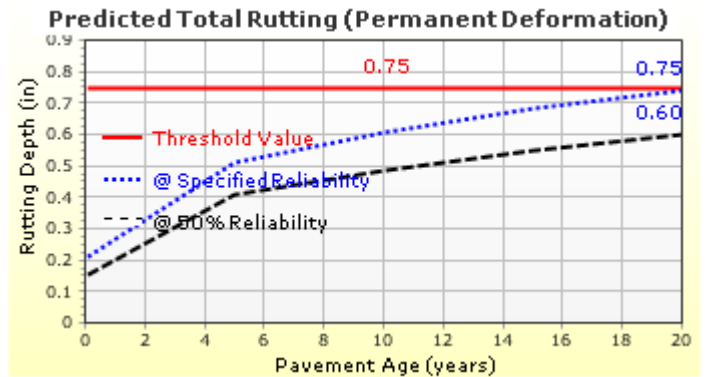
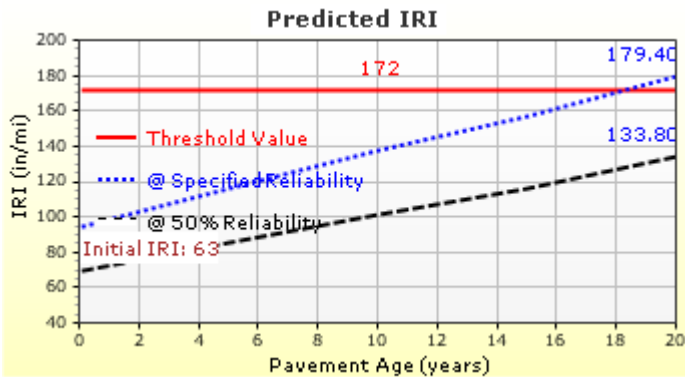
| Age (year)      | Heavy Trucks (cumulative) |
|-----------------|---------------------------|
| 2017 (initial)  | 17,180                    |
| 2027 (10 years) | 3,137,500                 |
| 2037 (20 years) | 6,275,000                 |

## Design Outputs

### Distress Prediction Summary

| Distress Type                                | Distress @ Specified Reliability |           | Reliability (%) |          | Criterion Satisfied? |
|--|----------------------------------|-----------|-----------------|----------|----------------------|
|  | Target                           | Predicted | Target          | Achieved |                      |
| Terminal IRI (in./mile)                      | 172.00                           | 179.43    | 90.00           | 85.83    | Fail                 |
| Permanent deformation - total pavement (in.) | 0.75                             | 0.75      | 90.00           | 90.72    | Pass                 |
| AC bottom-up fatigue cracking (percent)      | 25.00                            | 2.36      | 90.00           | 100.00   | Pass                 |
| AC thermal cracking (ft/mile)                | 1000.00                          | 2142.15   | 90.00           | 24.30    | Fail                 |
| AC top-down fatigue cracking (ft/mile)       | 2000.00                          | 1691.31   | 90.00           | 93.60    | Pass                 |
| Permanent deformation - AC only (in.)        | 0.25                             | 0.41      | 90.00           | 32.28    | Fail                 |

### Distress Charts

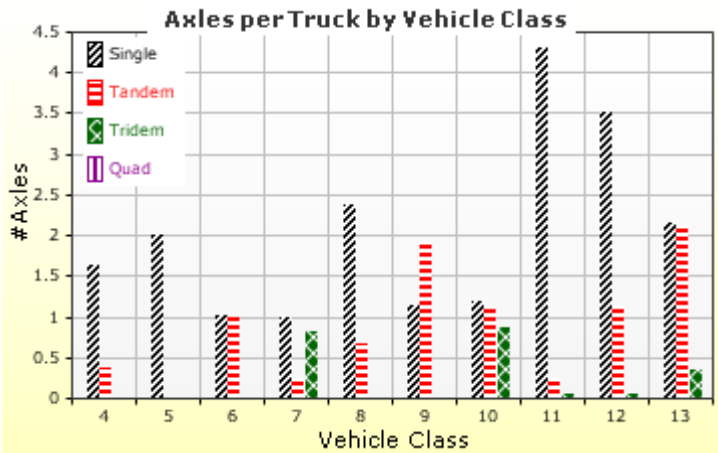
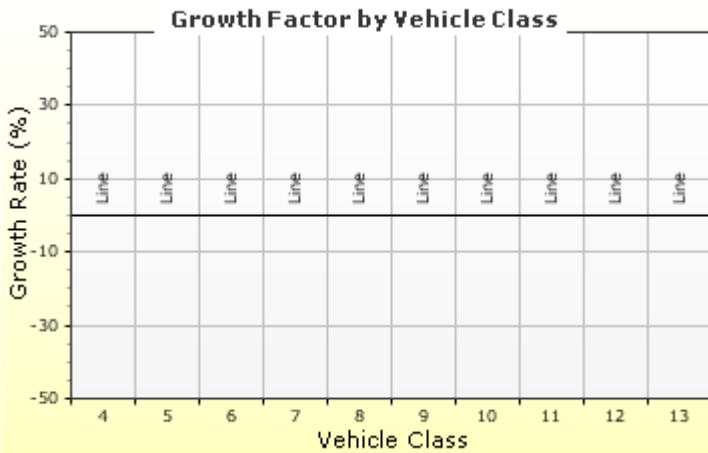
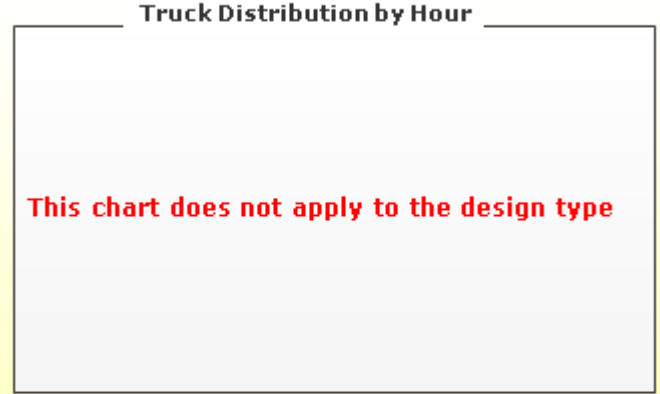
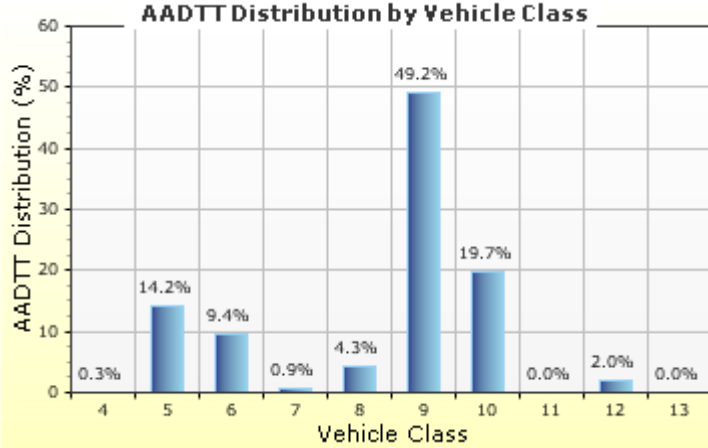


## Traffic Inputs

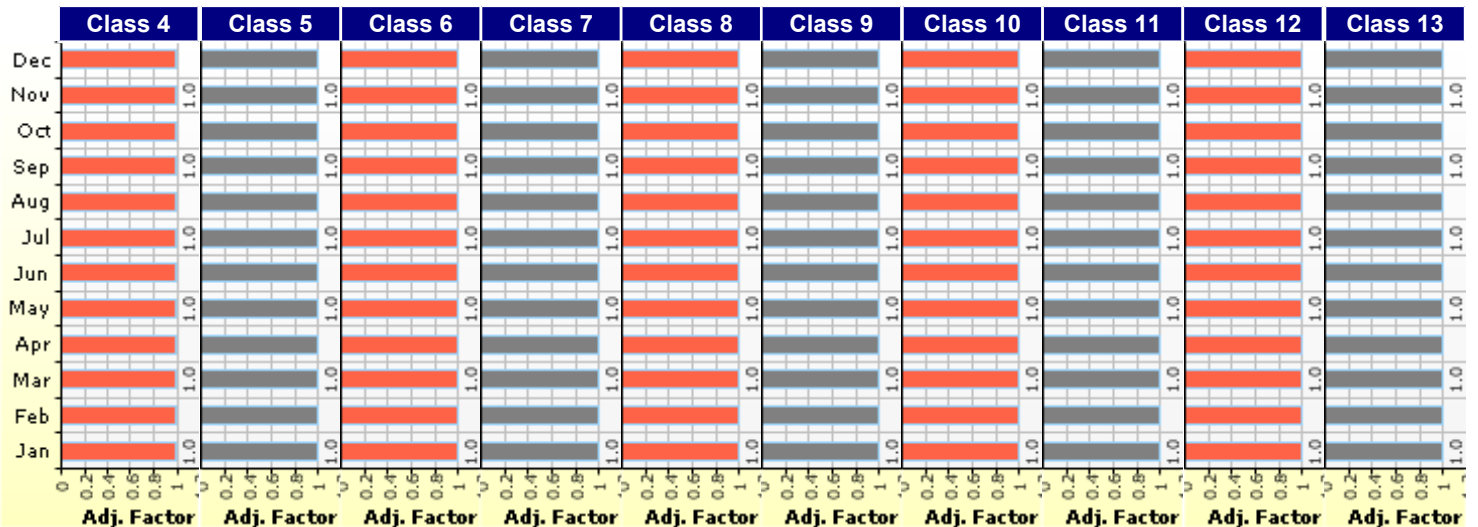
### Graphical Representation of Traffic Inputs

Initial two-way AADTT: **17,180**  
 Number of lanes in design direction: **2**

Percent of trucks in design direction (%): **50.0**  
 Percent of trucks in design lane (%): **10.0**  
 Operational speed (mph): **60.0**



### Traffic Volume Monthly Adjustment Factors





# Case 3 - Large Mine 7 inch overlay

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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   | 1.0           | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| February  | 1.0           | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| March     | 1.0           | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| April     | 1.0           | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| May       | 1.0           | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| June      | 1.0           | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| July      | 1.0           | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| August    | 1.0           | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| September | 1.0           | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| October   | 1.0           | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| November  | 1.0           | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| December  | 1.0           | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |

### Distributions by Vehicle Class

| Vehicle Class | AADTT Distribution (%) (Level 3) | Growth Factor |          |
|---------------|----------------------------------|---------------|----------|
|               |                                  | Rate (%)      | Function |
| Class 4       | 0.3%                             | 0%            | Linear   |
| Class 5       | 14.2%                            | 0%            | Linear   |
| Class 6       | 9.4%                             | 0%            | Linear   |
| Class 7       | 0.9%                             | 0%            | Linear   |
| Class 8       | 4.3%                             | 0%            | Linear   |
| Class 9       | 49.2%                            | 0%            | Linear   |
| Class 10      | 19.7%                            | 0%            | Linear   |
| Class 11      | 0%                               | 0%            | Linear   |
| Class 12      | 2%                               | 0%            | Linear   |
| Class 13      | 0%                               | 0%            | Linear   |

Truck Distribution by Hour does not apply

### Axle Configuration

| Traffic Wander                          |    |
|---|----|
| Mean wheel location (in.)               | 18 |
| Traffic wander standard deviation (in.) | 10 |
| Design lane width (ft)                  | 12 |

| Axle Configuration      |     |
|-------------------------|-----|
| Average axle width (ft) | 8.5 |
| Dual tire spacing (in.) | 12  |
| Tire pressure (psi)     | 120 |

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

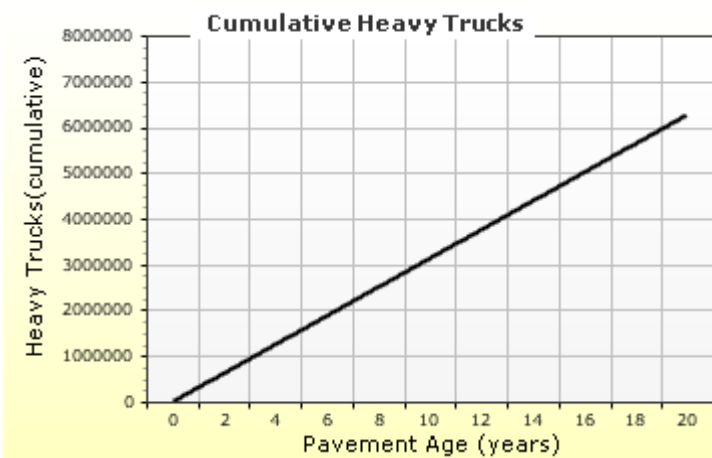
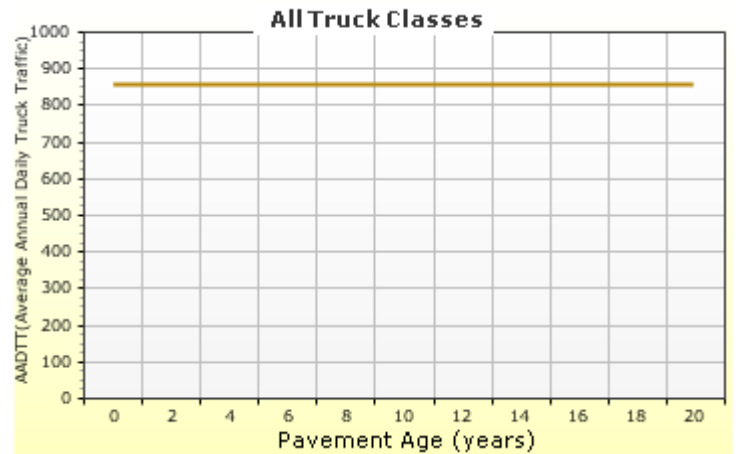
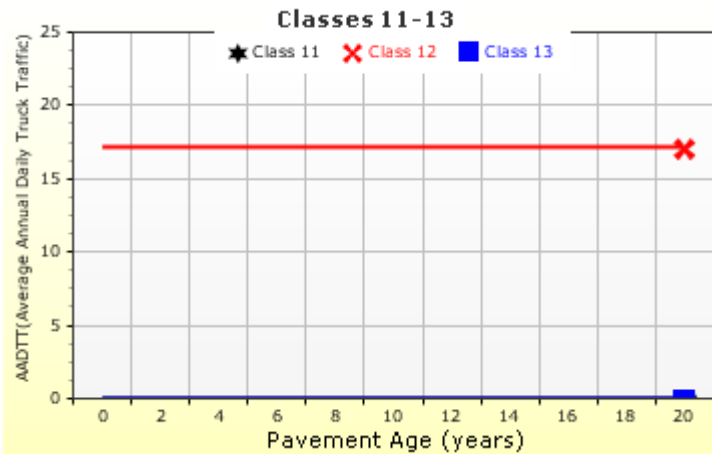
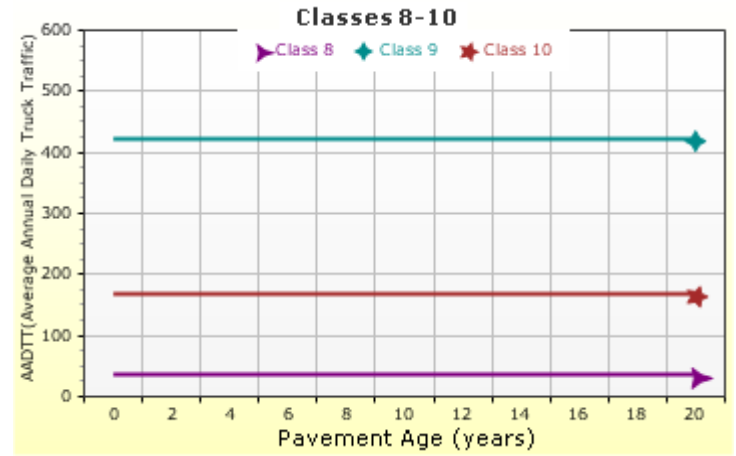
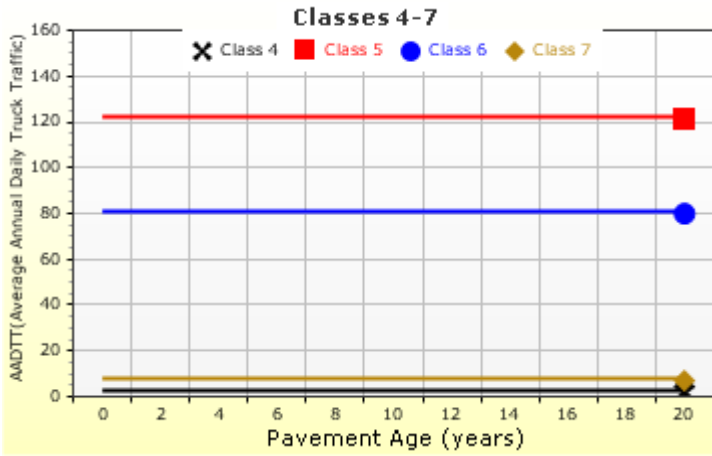
Wheelbase does not apply

### Number of Axles per Truck

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

## AADTT (Average Annual Daily Truck Traffic) Growth

\* Traffic cap is not enforced





# Case 3 - Large Mine 7 inch overlay

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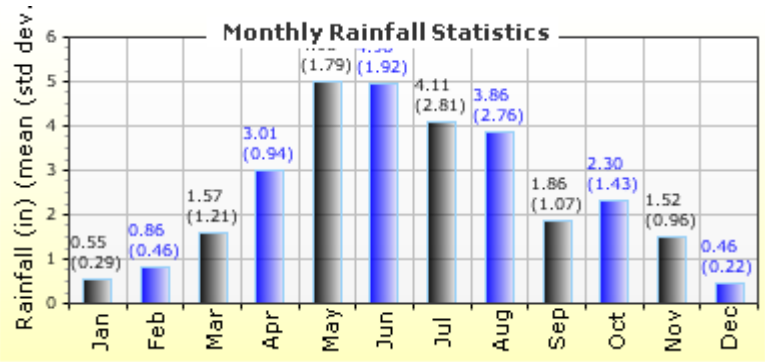
## Climate Inputs

### Climate Data Sources:

Climate Station Cities: **WATERLOO, IA** Location (lat lon elevation(ft)) **42.55400 -92.40100 865**

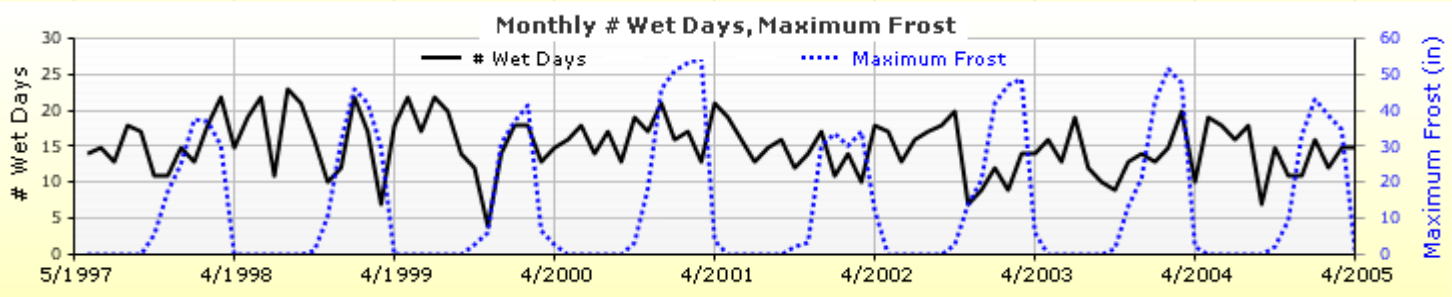
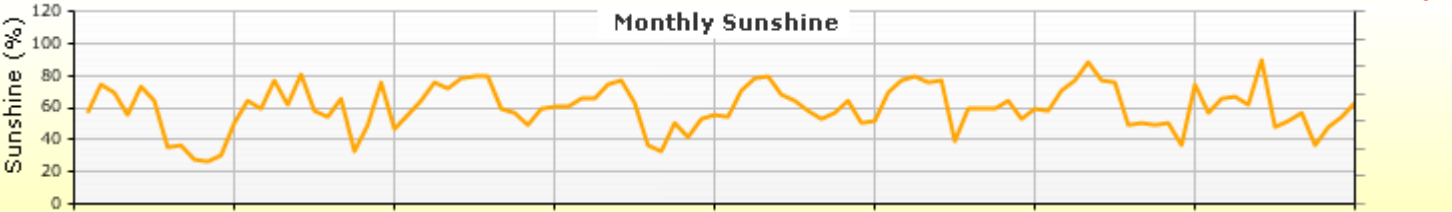
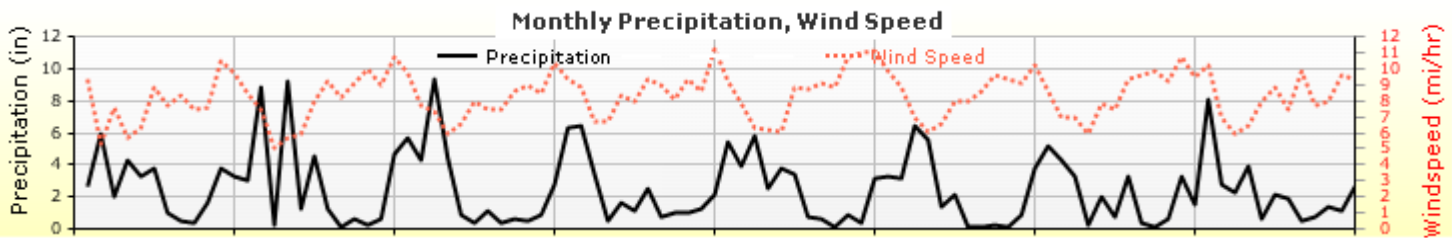
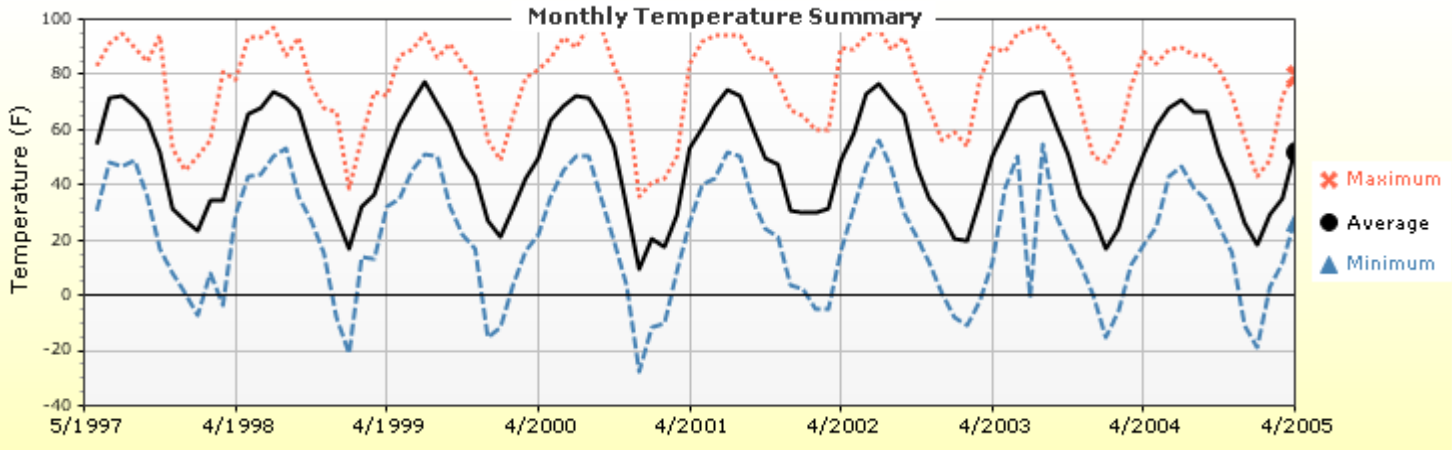
### Annual Statistics:

Mean annual air temperature (°F) **48.98**  
Mean annual precipitation (in.) **30.04**  
Freezing index (°F - days) **1894.842**  
Average annual number of freeze/thaw cycles: **74.47**



Water table depth (ft) **10.00**

### Monthly Climate Summary:



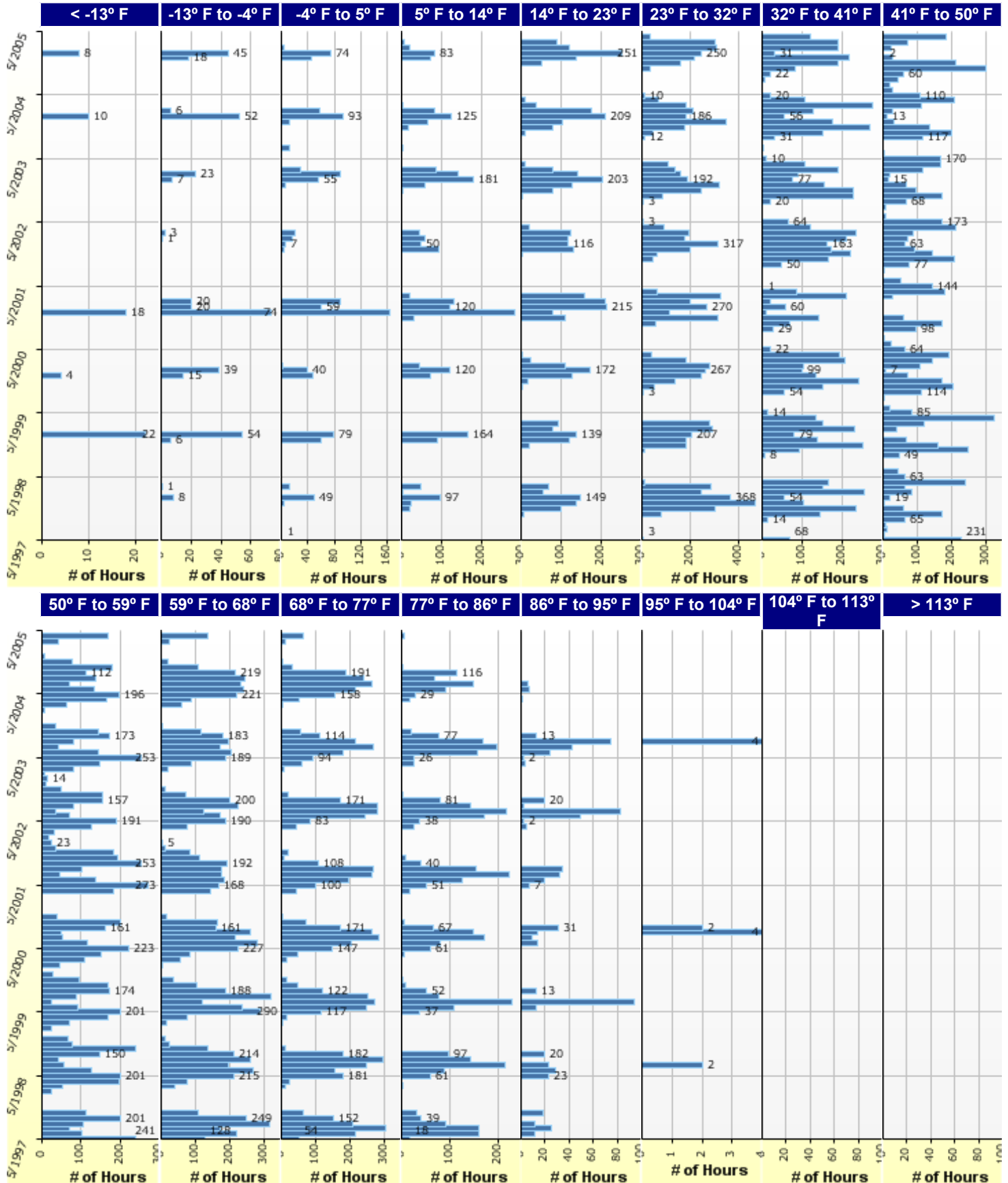


# Case 3 - Large Mine 7 inch overlay

File Name: D:\My ME Design\FINAL REPORT\Case 3 - Large Mine 7 inch overlay.dgpx



## Hourly Air Temperature Distribution by Month:





# Case 3 - Large Mine 7 inch overlay

File Name: D:\My ME Design\FINAL REPORT\Case 3 - Large Mine 7 inch overlay.dgpx



## Design Properties

### HMA Design Properties

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

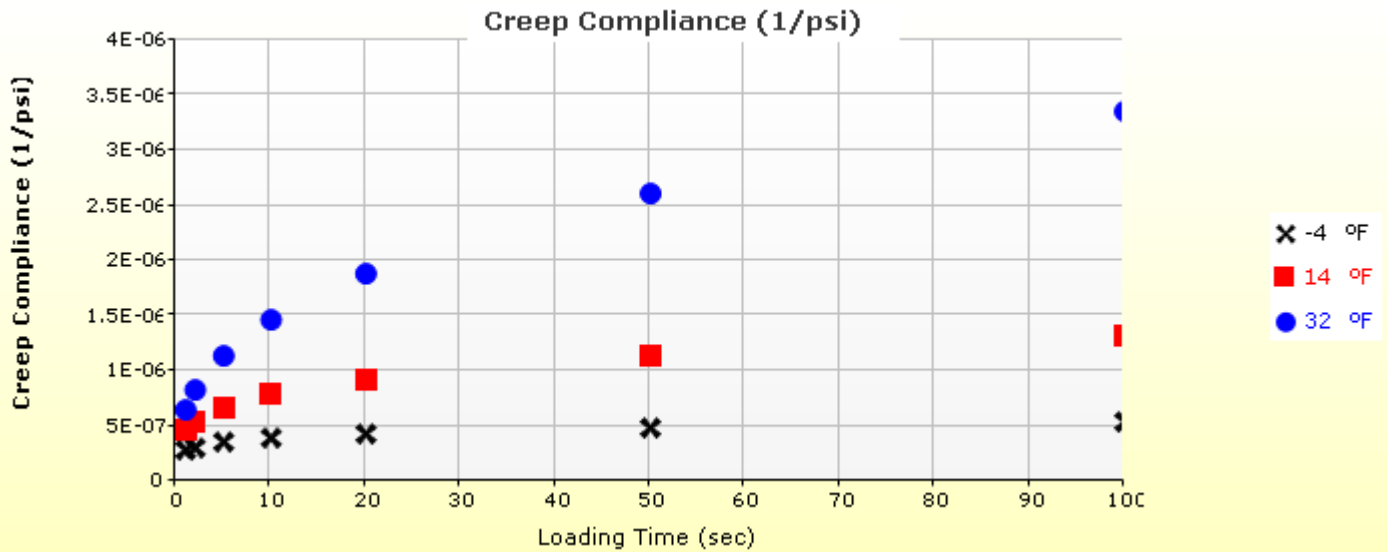
|                                   |      |
|-----------------------------------|------|
| <b>Structure - ICM Properties</b> |      |
| AC surface shortwave absorptivity | 0.85 |

| Layer Name                                  | Layer Type              | Interface Friction |
|---|-------------------------|--------------------|
| Layer 1 Flexible : Default asphalt concrete | Flexible (1)            | 1.00               |
| Layer 2 Non-stabilized Base : A-1-a         | Non-stabilized Base (4) | 1.00               |
| Layer 3 Non-stabilized Base : Crushed stone | Non-stabilized Base (4) | 1.00               |
| Layer 4 Subgrade : A-7-6                    | Subgrade (5)            | -                  |

## Thermal Cracking (Input Level: 3)

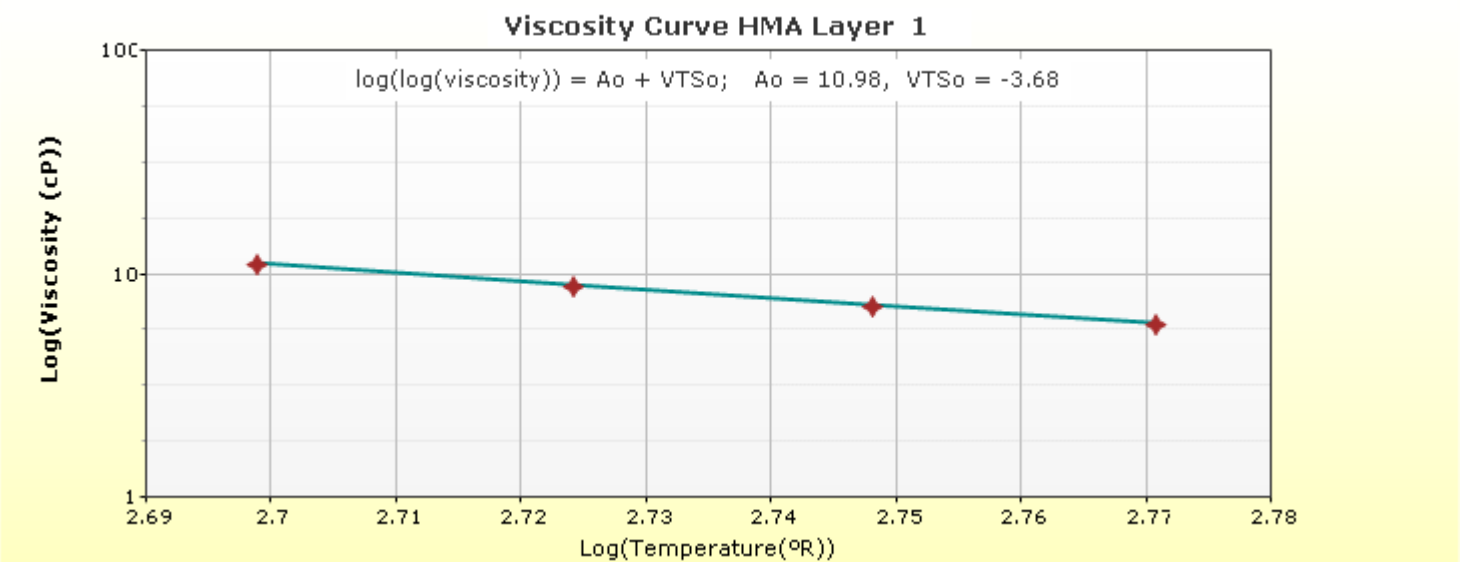
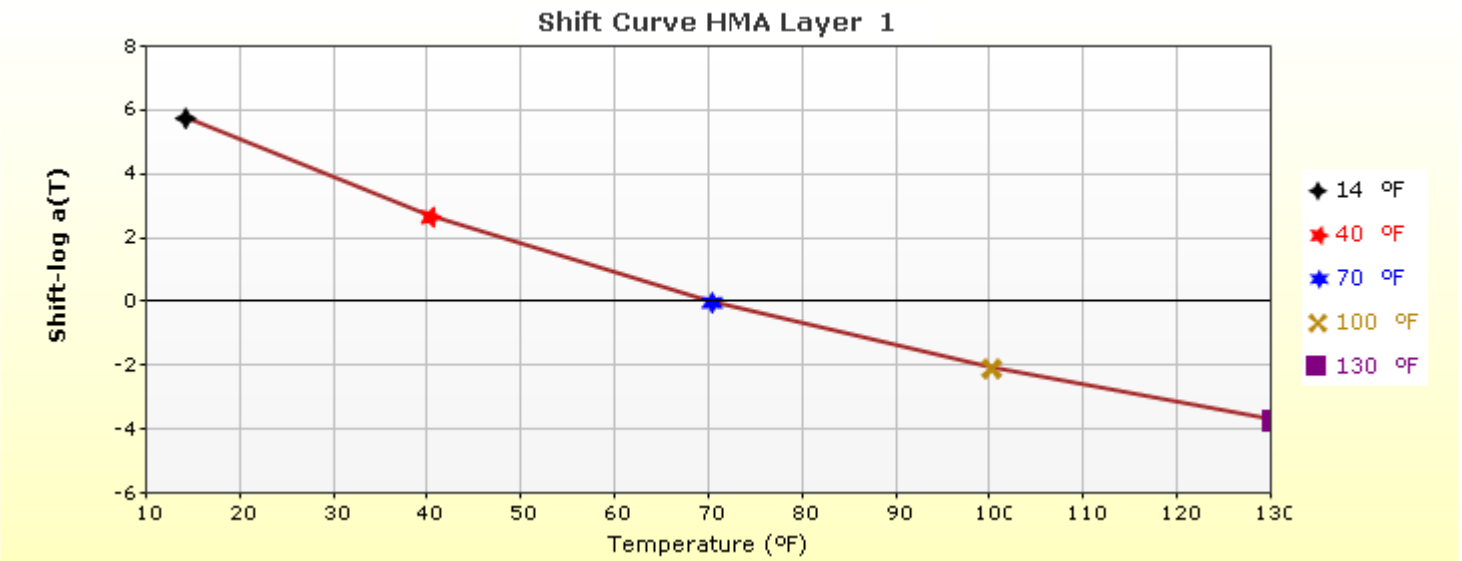
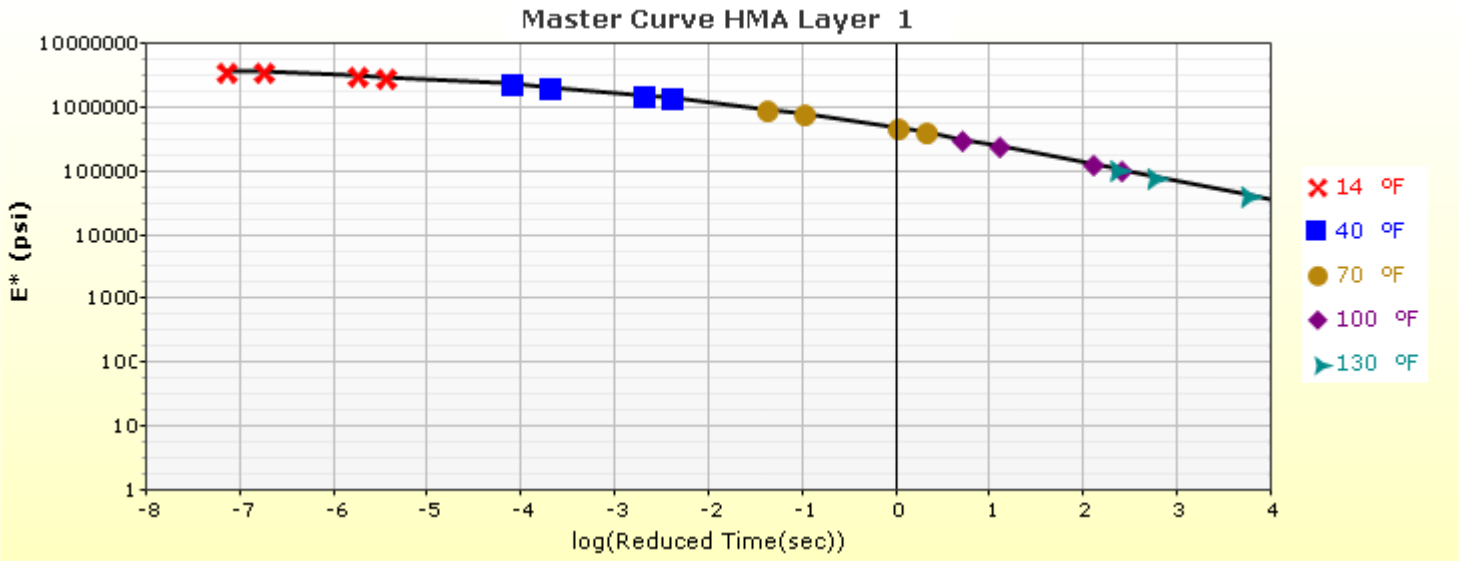
|   |          |
|---|----------|
| Indirect tensile strength at 14 °F (psi)                  | 361.14   |
| <b>Thermal Contraction</b>                                |          |
| Is thermal contraction calculated?                        | True     |
| Mix coefficient of thermal contraction (in./in./°F)       | -        |
| Aggregate coefficient of thermal contraction (in./in./°F) | 5.0e-006 |
| Voids in Mineral Aggregate (%)                            | 18.6     |

| Loading time (sec) | Creep Compliance (1/psi) |           |           |
|--------------------|--------------------------|-----------|-----------|
|                    | -4 °F                    | 14 °F     | 32 °F     |
| 1                  | 2.94e-007                | 4.79e-007 | 6.55e-007 |
| 2                  | 3.23e-007                | 5.59e-007 | 8.38e-007 |
| 5                  | 3.66e-007                | 6.86e-007 | 1.16e-006 |
| 10                 | 4.02e-007                | 8.00e-007 | 1.48e-006 |
| 20                 | 4.41e-007                | 9.34e-007 | 1.90e-006 |
| 50                 | 5.00e-007                | 1.15e-006 | 2.63e-006 |
| 100                | 5.49e-007                | 1.34e-006 | 3.37e-006 |

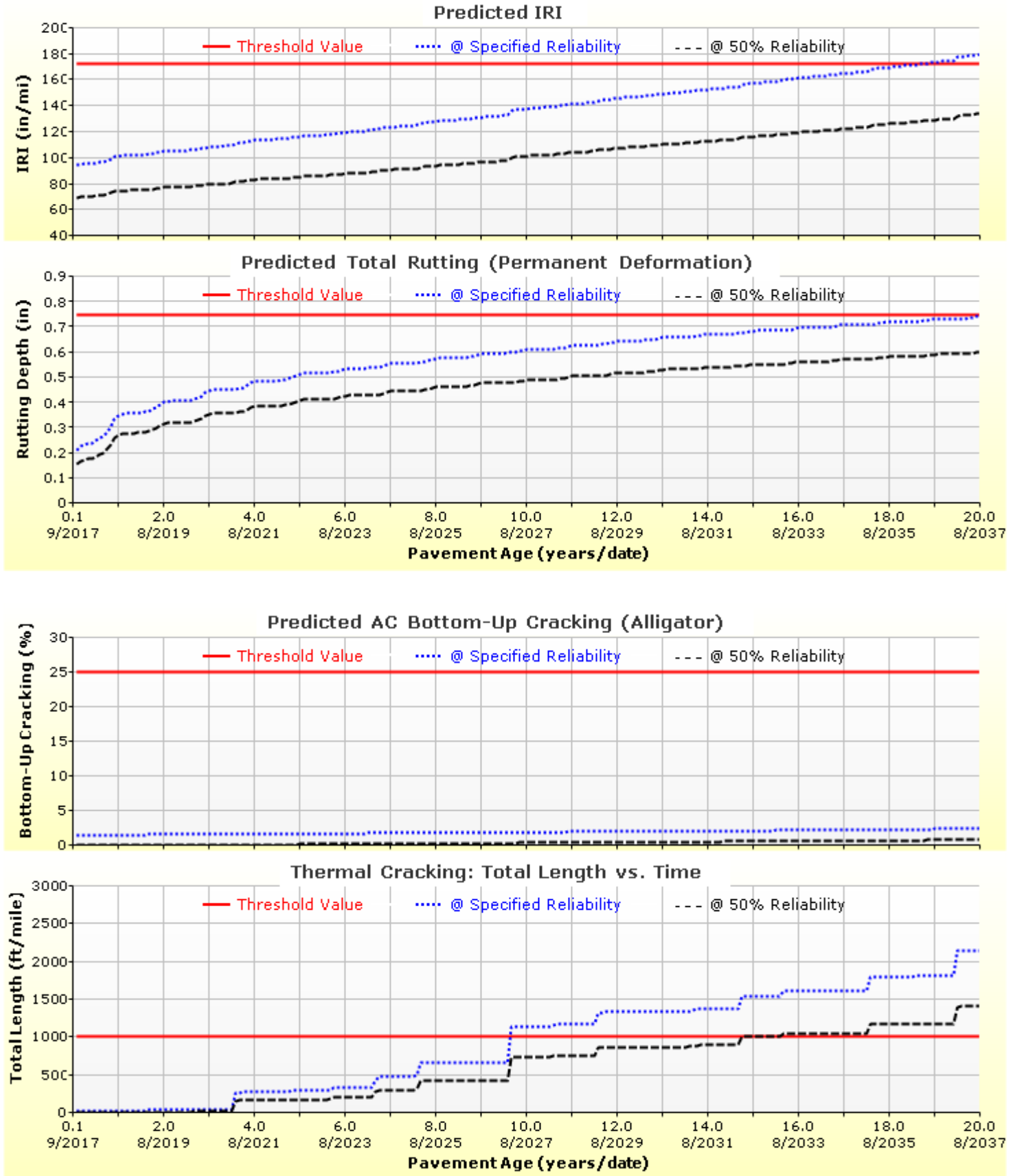


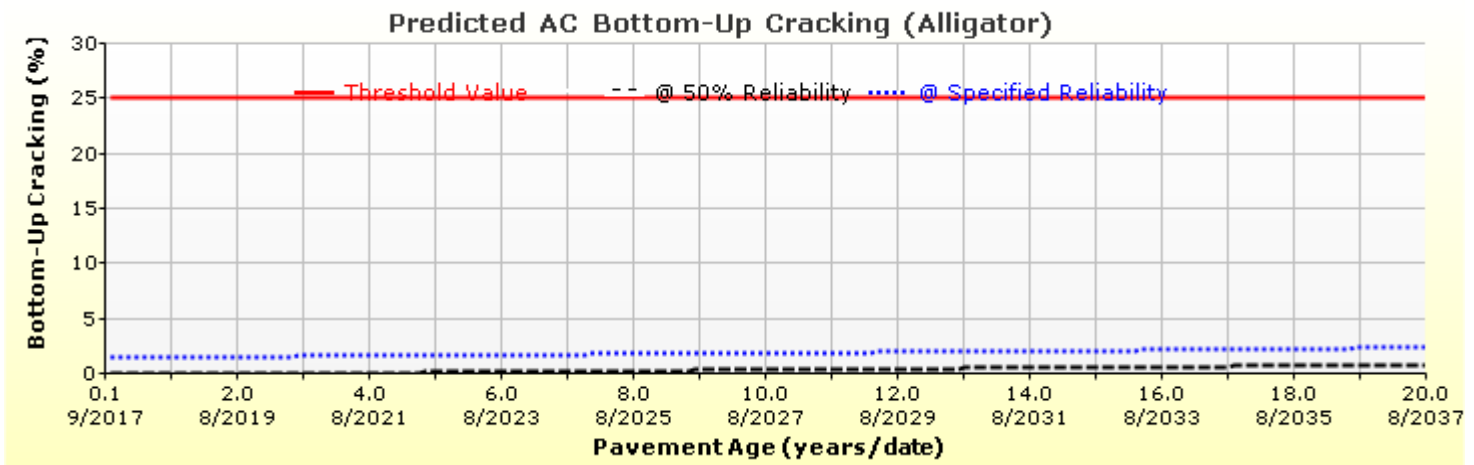
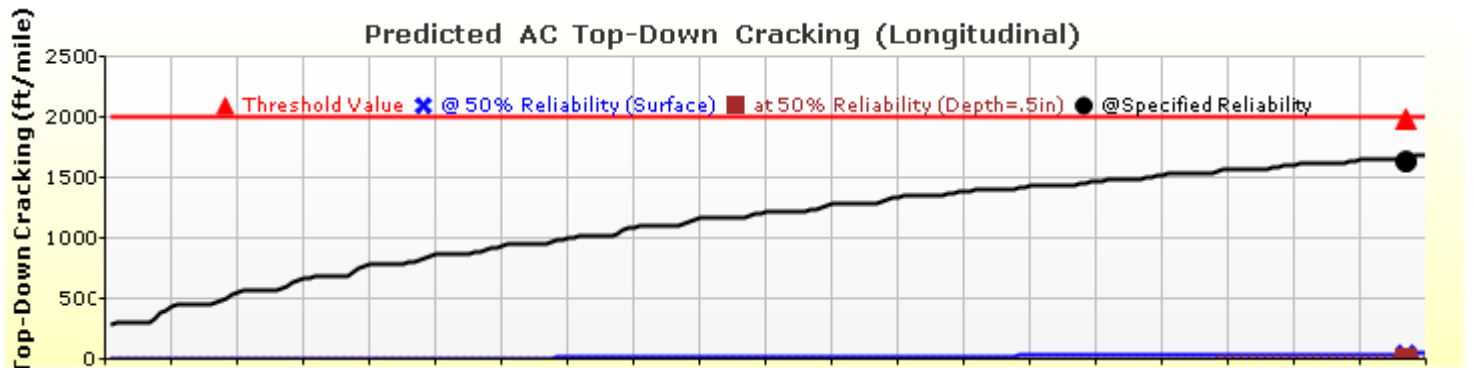
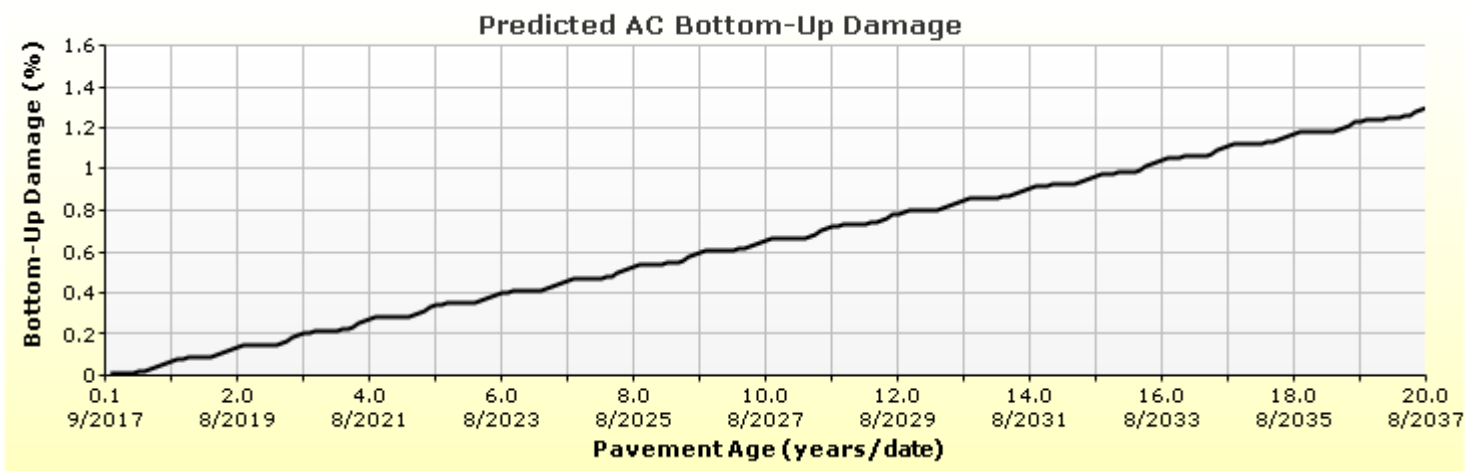
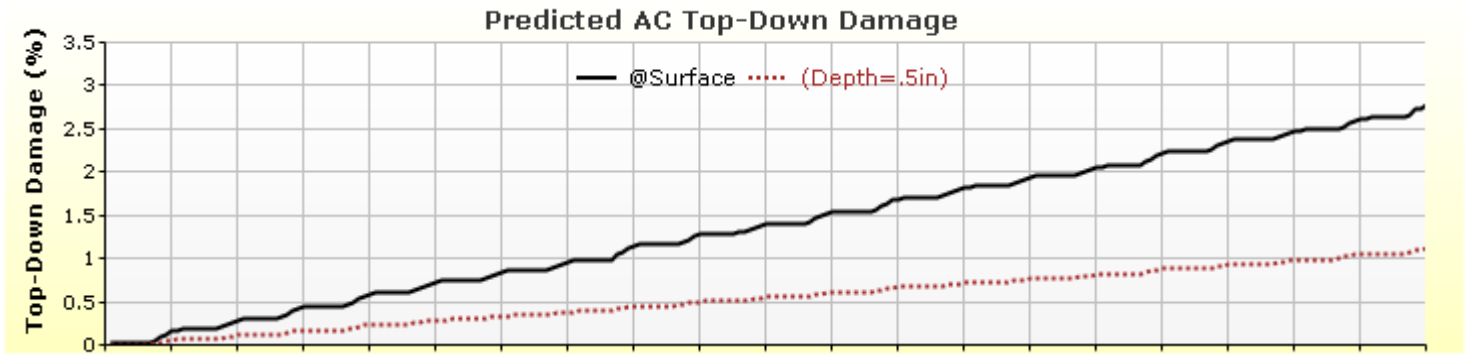


## HMA Layer 1: Layer 1 Flexible : Default asphalt concrete

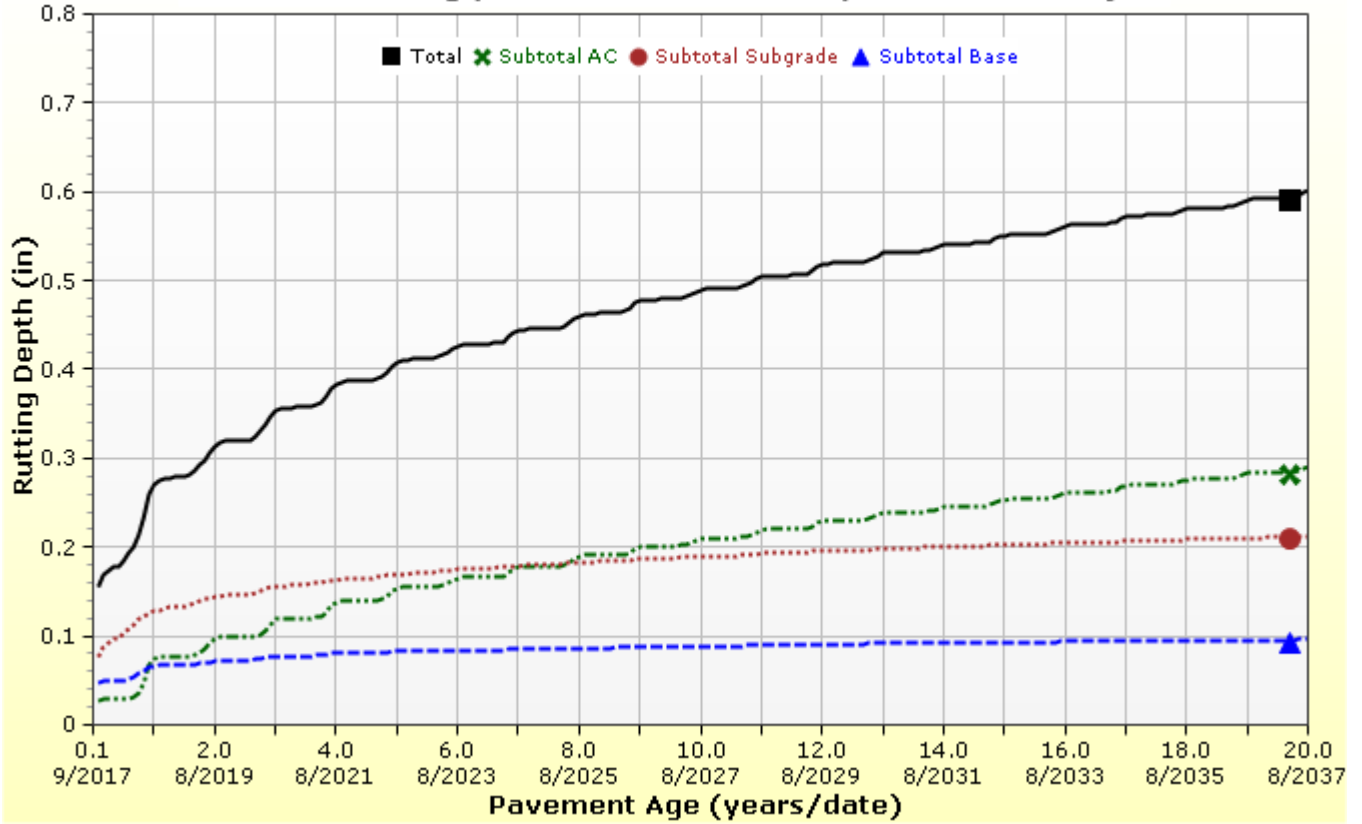


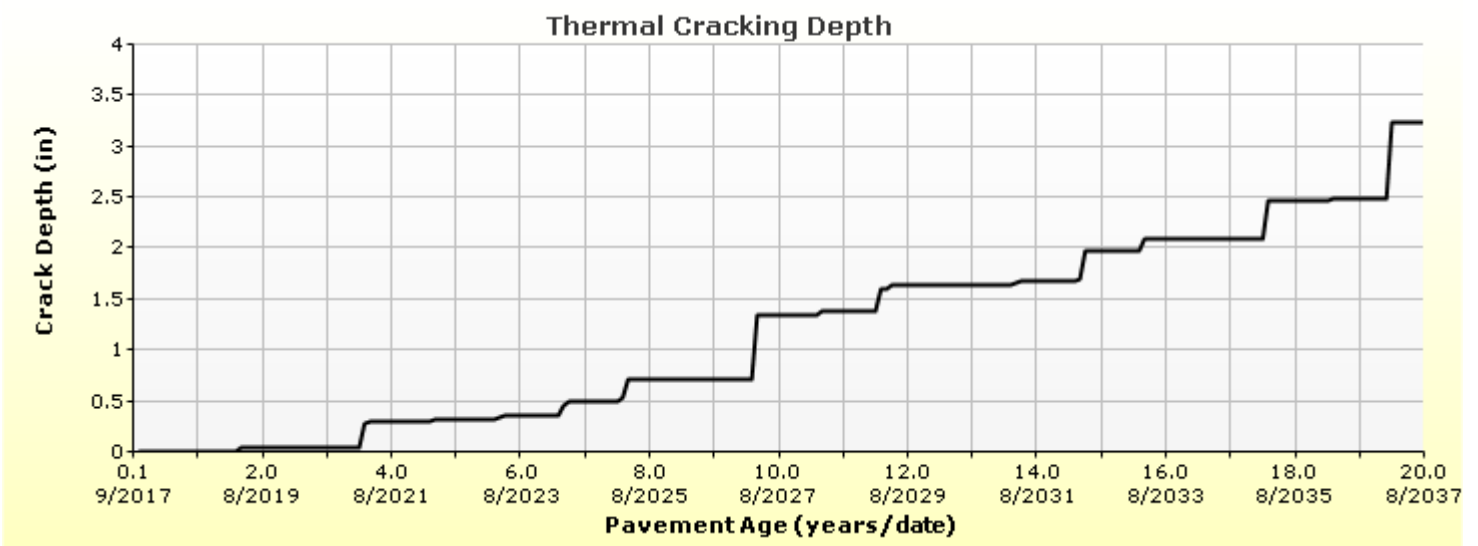
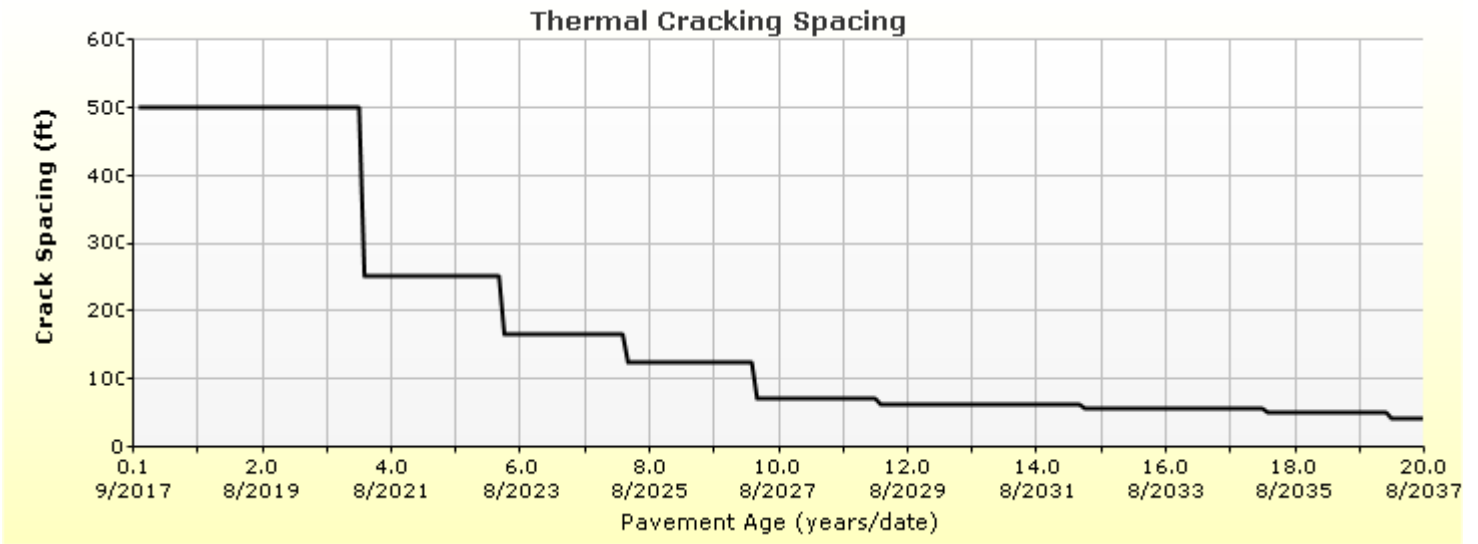
## Analysis Output Charts

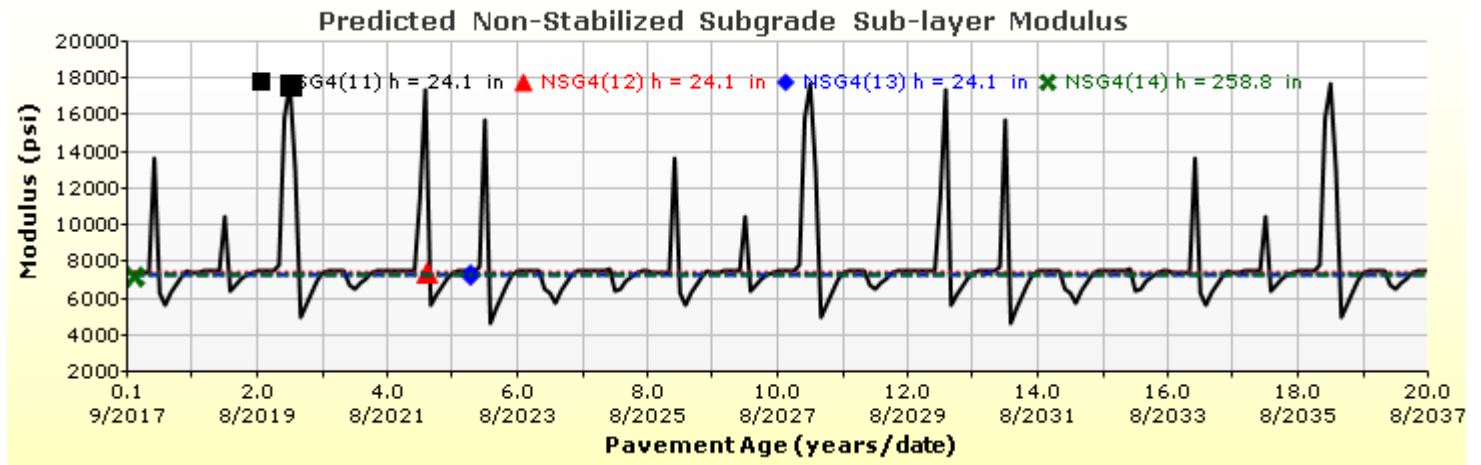
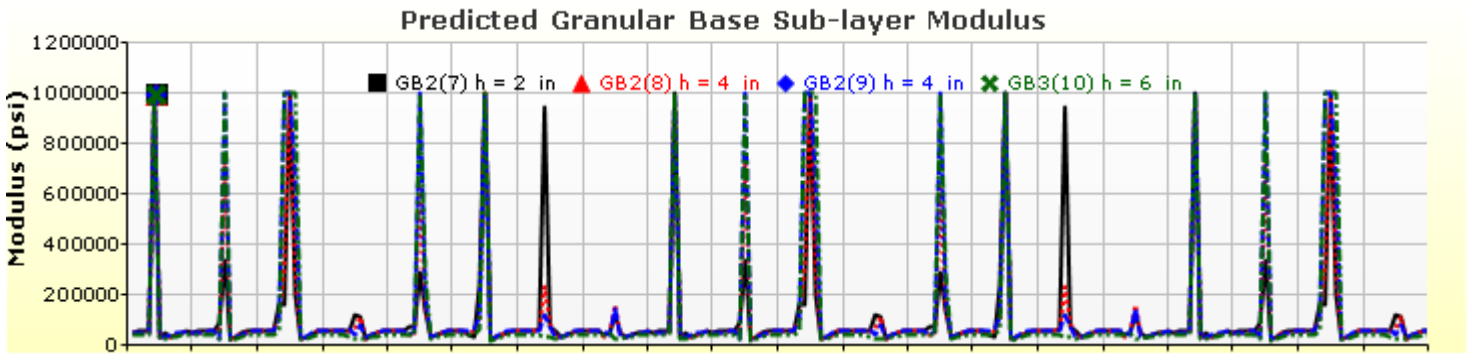
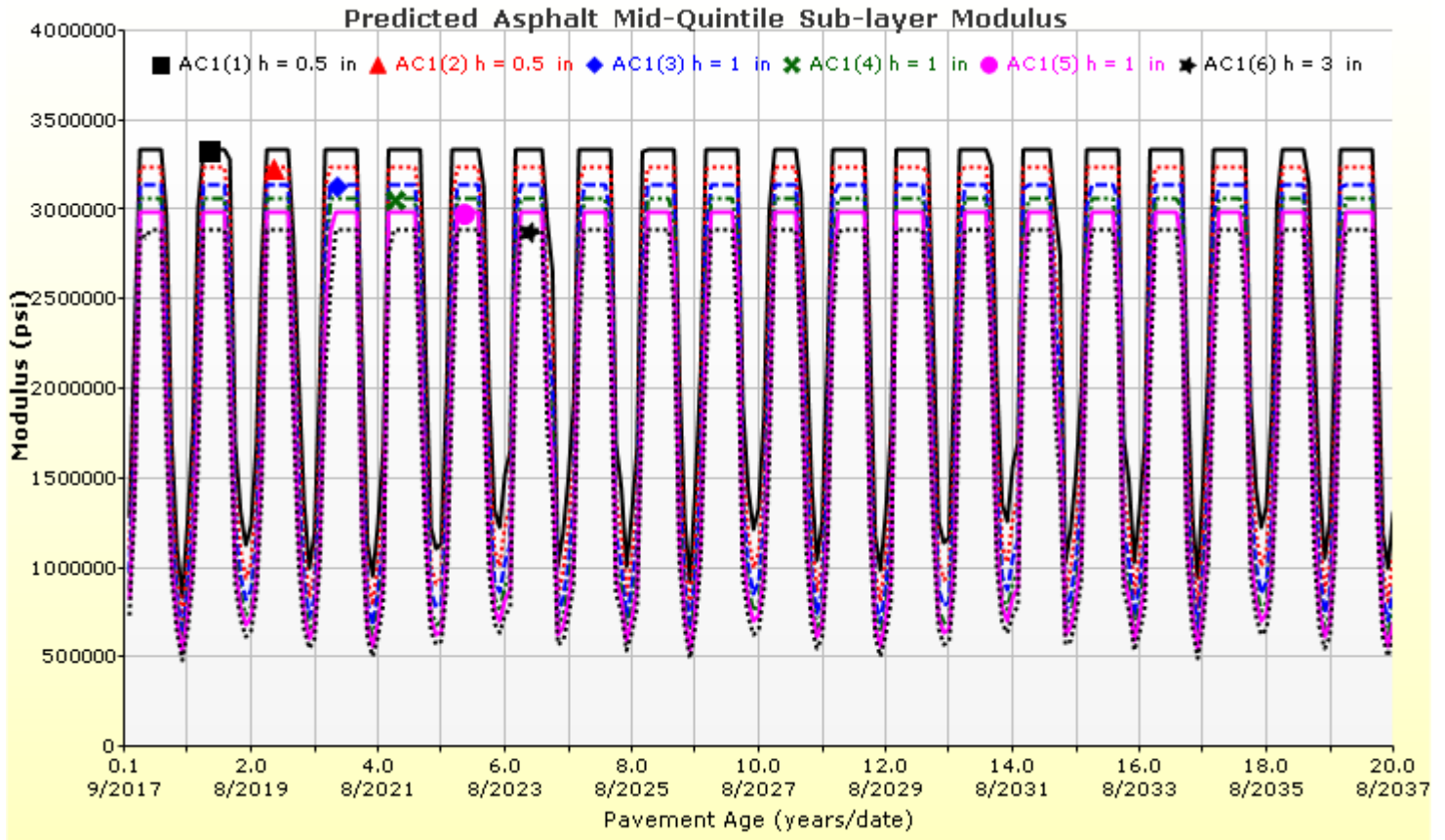




## Predicted Rutting (Permanent Deformation) at 50% Reliability







## Layer Information

### Layer 1 Flexible : Default asphalt concrete

| Asphalt           |                |       |
|-------------------|----------------|-------|
| Thickness (in.)   | 7.0            |       |
| Unit weight (pcf) | 150.0          |       |
| Poisson's ratio   | Is Calculated? | False |
|                   | Ratio          | 0.35  |
|                   | Parameter A    | -     |
|                   | Parameter B    | -     |

### Asphalt Dynamic Modulus (Input Level: 3)

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

### Asphalt Binder

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

### General Info

| Name                                | Value |
|-------------------------------------|-------|
| Reference temperature (°F)          | 70    |
| Effective binder content (%)        | 11.6  |
| Air voids (%)                       | 7     |
| Thermal conductivity (BTU/hr-ft-°F) | 0.67  |
| Heat capacity (BTU/lb-°F)           | 0.23  |

### Identifiers

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

## Layer 2 Non-stabilized Base : A-1-a

### Unbound

|  |      |
|--|------|
| Layer thickness (in.)                      | 10.0 |
| 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)

40000.0

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

### Identifiers

| Field                   | Value                |
|-------------------------|----------------------|
| Display name/identifier | A-1-a                |
| 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 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> | 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       |
| Optimum gravimetric 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      |





# Case 3 - Large Mine 7 inch overlay

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## Layer 3 Non-stabilized Base : Crushed stone

### Unbound

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

### Modulus (Input Level: 3)

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

### Resilient Modulus (psi)

|         |
|---------|
| 30000.0 |
|---------|

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

### 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 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> | 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       |
| Optimum gravimetric 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      |



# Case 3 - Large Mine 7 inch overlay

File Name: D:\My ME Design\FINAL REPORT\Case 3 - Large Mine 7 inch overlay.dgpx



## 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)

13000.0

|   |   |
|---|---|
| <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 2    |                      |
| User defined field 3    |                      |
| Revision Number         | 0                    |

### Sieve

|                            |       |
|----------------------------|-------|
| <b>Liquid Limit</b>        | 51.0  |
| <b>Plasticity Index</b>    | 30.0  |
| <b>Is layer compacted?</b> | False |

|  | Is User Defined? | Value     |
|--|------------------|-----------|
| Maximum dry unit weight (pcf)            | False            | 97.7      |
| Saturated hydraulic conductivity (ft/hr) | False            | 8.946e-06 |
| Specific gravity of solids               | False            | 2.7       |
| Optimum gravimetric water content (%)    | False            | 22.2      |

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

|                         |          |
|-------------------------|----------|
| <b>Is User Defined?</b> | False    |
| <b>af</b>               | 136.4179 |
| <b>bf</b>               | 0.5183   |
| <b>cf</b>               | 0.0324   |
| <b>hr</b>               | 500.0000 |

| Sieve Size | % Passing |
|------------|-----------|
| 0.001mm    |           |
| 0.002mm    |           |
| 0.020mm    |           |
| #200       | 79.1      |
| #100       |           |
| #80        | 84.9      |
| #60        |           |
| #50        |           |
| #40        | 88.8      |
| #30        |           |
| #20        |           |
| #16        |           |
| #10        | 93.0      |
| #8         |           |
| #4         | 94.9      |
| 3/8-in.    | 96.9      |
| 1/2-in.    | 97.5      |
| 3/4-in.    | 98.3      |
| 1-in.      | 98.8      |
| 1 1/2-in.  | 99.3      |
| 2-in.      | 99.6      |
| 2 1/2-in.  |           |
| 3-in.      |           |
| 3 1/2-in.  | 99.9      |

## 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: 1       |
|   | Bf2: 1       |
|   | Bf3: 1       |

### AC Rutting

|   |   |
|---|---|
| $\frac{\epsilon_p}{\epsilon_r} = k_z \beta_{r1} 10^{k_1 T} k_2 \beta_{r2} N^{k_3 \beta_{r3}}$ $k_z = (C_1 + C_2 * depth) * 0.328196^{depth}$ $C_1 = -0.1039 * H_a^2 + 2.4868 * H_a - 17.342$ $C_2 = 0.0172 * H_a^2 - 1.7331 * H_a + 27.428$ <p>Where:<br/> <math>H_{ac}</math> = total AC thickness(in)</p> | $\epsilon_p$ = plastic strain(in/in)<br>$\epsilon_r$ = resilient strain(in/in)<br>$T$ = layer temperature(°F)<br>$N$ = 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)<br>$k$ = regression coefficient determined through field calibration<br>$N()$ = standard normal distribution evaluated at()<br>$\sigma$ = standard deviation of the log of the depth of cracks in the pavements<br>$C$ = crack depth(in)<br>$h_{ac}$ = thickness of asphalt layer(in)<br>$\Delta C$ = Change in the crack depth due to a cooling cycle<br>$\Delta K$ = Change in the stress intensity factor due to a cooling cycle<br>$A, n$ = Fracture parameters for the asphalt mixture<br>$E$ = mixture stiffness<br>$\sigma_m$ = Undamaged mixture tensile strength<br>$\beta_t$ = Calibration parameter |
| Level 1 K: 1.5   | 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: 1.5   | 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<br>$\sigma_s$ = Tensile stress(psi)<br>$M_r$ = modulus of rupture(psi) |        |        |
| k1: 1   | k2: 1  | Bc1: 1 | Bc2: 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 vertical strain(in/in)<br>$\varepsilon_0, \beta, \rho =$ material properties<br>$\varepsilon_r =$ resilient strain(in/in) |        |
| Granular   |        | Fine   |        |
| k1: 2.03   | Bs1: 1 | k1: 1.35   | Bs1: 1 |
| Standard Deviation (BASERUT)<br>0.1477*Pow(BASERUT,0.6711)+0.001   |        | Standard Deviation (BASERUT)<br>0.1235*Pow(SUBRUT,0.5012)+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: 1   | c2: 1   | c3: 6000  |          |
| AC Cracking Top Standard Deviation  |         | AC Cracking Bottom Standard Deviation   |          |
| 200 + 2300/(1+exp(1.072-2.1654*LOG10(TOP+0.0001)))                                      |         | 1.13+13/(1+exp(7.57-15.5*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<br>C2 - Fatigue Crack      C4 - Site Factors |         |           |           |
| C1: 1  | C2: 1 | C3: 0 | C4: 1000 | C1: 40   | C2: 0.4 | C3: 0.008 | C4: 0.015 |
| CSM Standard Deviation                                   |       |       |          |  |         |           |           |
| CTB*1  |       |       |          |  |         |           |           |