# WISCONSIN DEPARTMENT OF TRANSPORTATION
# TRANSPORTATION DISTRICTS – SE REGION

## MEMORANDUM TO FILE/PAVEMENT DESIGN TRANSMITTAL

Date: January 20, 2015

**SUBJECT:** **I.D. 2788-01-00**
Waukesha Bypass
(STH 59 to IH 94)
Waukesha Bypass
Waukesha County

### *PAVEMENT DESIGN STATUS:*

Attached is the pavement design report for the above-mentioned project. Both TSS – Engineering Services and the Project Development Group, SE Region, has achieved concurrence.

### *SCOPE OF WORK:*

The purpose of the West Waukesha Bypass is to provide a safe and efficient north-south arterial roadway on the west side of the City of Waukesha to complete the long-planned circumferential route around Waukesha; to accommodate growing traffic volumes along the corridor; and to improve roadway deficiencies that include tight curves, steep hills, narrow lanes, and lack of shoulders. The proposed improvements address two major needs:

- Improve safety by providing a roadway that meets current design standards.
- Accommodate traffic demand generated by existing and planned development within and outside the study corridor.

### *SUMMARY OF PAVEMENT DESIGN RECOMMENDATIONS:*

#### Section #1 - STH 59 to Northview Road:

- Utilize some form of Subgrade Improvement, Reference the Geotechnical Engineering Report
- Remove the existing pavement, median, or curb & gutter as required
- Place 6-inches of Base Aggregate Dense 1 ¼-inch
- Place non-reinforced Portland Cement, Concrete Pavement 8-inch, doweled with normal joints spaced at a standard 15 feet apart

#### Section #2 - Northview Road to IH-94:

- Utilize some form of Subgrade Improvement, Reference the Geotechnical Engineering Report
- Remove the existing pavement, median, or curb & gutter as required
- Place 6-inches of Base Aggregate Dense 1 ¼-inch
- Place non-reinforced Portland Cement, Concrete Pavement 8-inch, doweled with normal joints spaced at a standard 15 feet apart

#### Section #3 - STH 59:

- Utilize some form of Subgrade Improvement, Reference the Geotechnical Engineering Report
- Remove the existing pavement, median, or curb & gutter as required
- Place 11-inches of Base Aggregate Dense 1 ¼-inch

- Place 3 ½-inches of 19.0 mm HMA Pavement Type E-3, with Asphaltic Material PG 58-28 as a lower layer
- Place 2-inches of 12.5 mm HMA Pavement Type E-3, with Asphaltic Material PG 58-28, as an upper layer

**Section #4 - USH 18 & Minor Side Roads at Saylesville Road & CTH "X":**

- Utilize some form of Subgrade Improvement, Reference the Geotechnical Engineering Report
- Remove the existing pavement, median, or curb & gutter as required
- Place 11-inches of Base Aggregate Dense 1 ¼-inch
- Place 3 ½-inches of 19.0 mm HMA Pavement Type E-3, with Asphaltic Material PG 58-28 as a lower layer
- Place 2-inches of 12.5 mm HMA Pavement Type E-3, with Asphaltic Material PG 58-28, as an upper layer

**Minor Side Roads – Excluding Saylesville Road & CTH "X":**

- Remove the existing pavement, median, or curb & gutter as required
- Place 10-inches of Base Aggregate Dense 1 ¼-inch
- Place 3-inches of 19.0 mm HMA Pavement Type E-3, with Asphaltic Material PG 58-28 as a lower layer
- Place 2-inches of 12.5 mm HMA Pavement Type E-3, with Asphaltic Material PG 58-28, as an upper layer

**Shoulders:**

- Follow the FDM 14-5-1, with regards to Base Aggregate Dense material
- Pavement to match adjacent mainline pavement

Pavement Design Engineer — Date 1/20/15

Project Engineer/Manager — Date

Project Supervisor — Date

***Wisconsin Department of Transportation - SE Region***

# PAVEMENT TYPE SELECTION REPORT

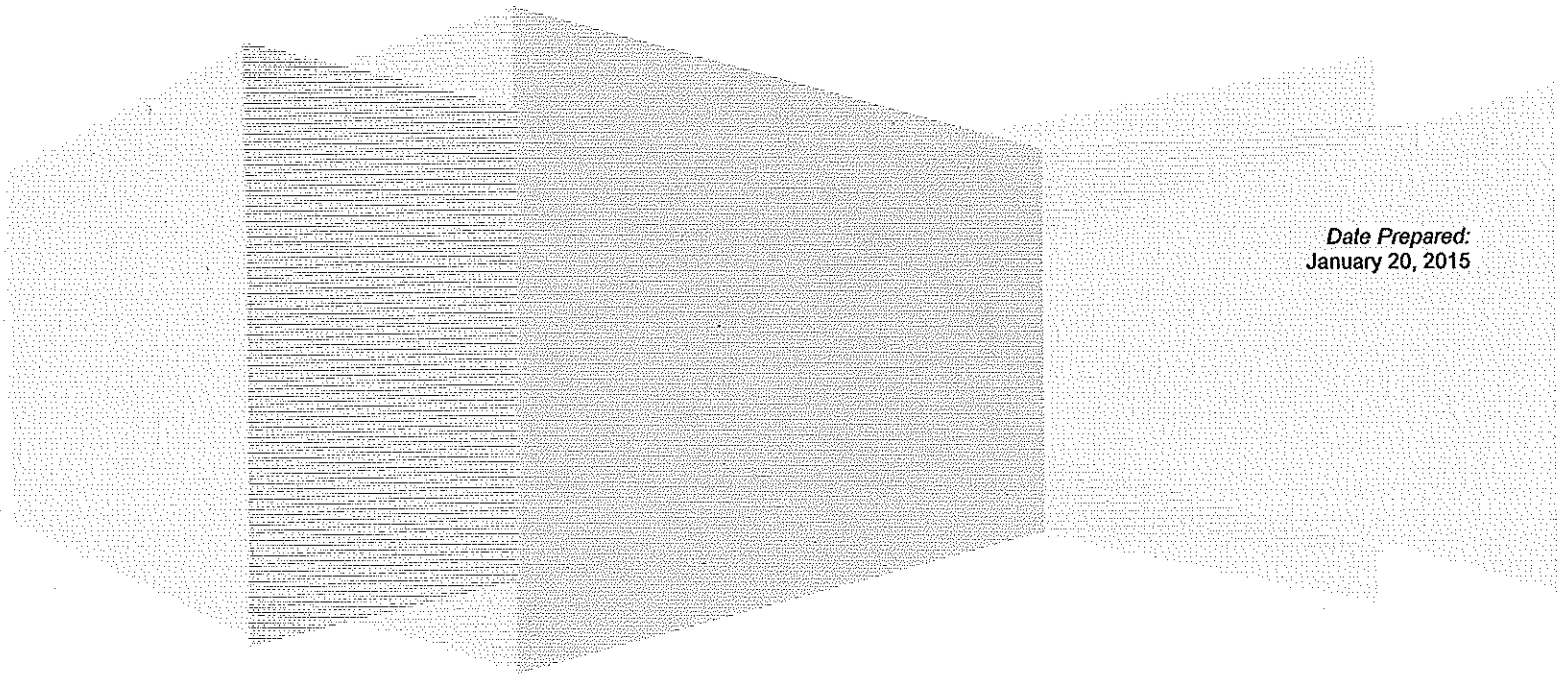
**I.D. 2788-01-00**
Waukesha Bypass
(STH 59 to IH 94)
Waukesha Bypass
Waukesha County

**I.D. 2788-00-01**
Waukesha Bypass
(Summit Ave. to Genesee Rd.)
USH 18
Waukesha County

**I.D. 2788-00-02**
Waukesha Bypass
(Summit Ave. to Northview Rd.)
Waukesha County

**I.D. 2788-02-00**
Waukesha Bypass
(Intersection Summit Ave & Meadowbrook Rd.)
USH 18
Waukesha County

*Prepared By:*
Todd R. Peschke, P.E.
SE Regional Pavement Design Engineer



*Date Prepared:*
January 20, 2015

# PAVEMENT STRUCTURAL DESIGN REPORT

**I.D. 2788-01-00**
Waukesha Bypass
(STH 59 to IH 94)
Waukesha Bypass
Waukesha County

## Executive Summary:

**Project Type:** Reconstruction, Expansion

**Recommended Pavement Structure Description:**

**Section #1 - STH 59 to Northview Road:**

- Utilize some form of Subgrade Improvement, Reference the Geotechnical Engineering Report
- Remove the existing pavement, median, or curb & gutter as required
- Place 6-inches of Base Aggregate Dense 1 ¼-inch
- Place non-reinforced Portland Cement, Concrete Pavement 8-inch, doweled with normal joints spaced at a standard 15 feet apart

**Section #2 - Northview Road to IH-94:**

- Utilize some form of Subgrade Improvement, Reference the Geotechnical Engineering Report
- Remove the existing pavement, median, or curb & gutter as required
- Place 6-inches of Base Aggregate Dense 1 ¼-inch
- Place non-reinforced Portland Cement, Concrete Pavement 8-inch, doweled with normal joints spaced at a standard 15 feet apart

**Section #3 - STH 59:**

- Utilize some form of Subgrade Improvement, Reference the Geotechnical Engineering Report
- Remove the existing pavement, median, or curb & gutter as required
- Place 11-inches of Base Aggregate Dense 1 ¼-inch
- Place 3 ½-inches of 19.0 mm HMA Pavement Type E-3, with Asphaltic Material PG 58-28 as a lower layer
- Place 2-inches of 12.5 mm HMA Pavement Type E-3, with Asphaltic Material PG 58-28, as an upper layer

**Section #4 - USH 18 & Minor Side Roads at Saylesville Road & CTH "X":**

- Utilize some form of Subgrade Improvement, Reference the Geotechnical Engineering Report
- Remove the existing pavement, median, or curb & gutter as required
- Place 11-inches of Base Aggregate Dense 1 ¼-inch
- Place 3 ½-inches of 19.0 mm HMA Pavement Type E-3, with Asphaltic Material PG 58-28 as a lower layer
- Place 2-inches of 12.5 mm HMA Pavement Type E-3, with Asphaltic Material PG 58-28, as an upper layer

**Minor Side Roads – Excluding Saylesville Road & CTH "X":**

- Remove the existing pavement, median, or curb & gutter as required
- Place 10-inches of Base Aggregate Dense 1 ¼-inch

- Place 3-inches of 19.0 mm HMA Pavement Type E-3, with Asphaltic Material PG 58-28 as a lower layer
- Place 2-inches of 12.5 mm HMA Pavement Type E-3, with Asphaltic Material PG 58-28, as an upper layer

**Shoulders:**

- Follow the FDM 14-5-1, with regards to Base Aggregate Dense material
- Pavement to match adjacent mainline pavement

**Pavement Type Selection Basis:** WisPave 4, WisDOT's pavement design program and the AASHTO Pavement ME Design Program

## Project Description:

**Purpose of Project:** The purpose of the West Waukesha Bypass is to provide a safe and efficient north-south arterial roadway on the west side of the City of Waukesha to complete the long-planned circumferential route around Waukesha; to accommodate growing traffic volumes along the corridor; and to improve roadway deficiencies that include tight curves, steep hills, narrow lanes, and lack of shoulders. The proposed improvements address two major needs:

- Improve safety by providing a roadway that meets current design standards.
- Accommodate traffic demand generated by existing and planned development within and outside the study corridor.

**Proposed Improvement:** Reconstruction, Expansion

**Project Length:** 5.16 miles

**Functional Classification:** Major Arterial

**Existing Facility:**

***Stationing:*** *Sta 100+52 to Sta 373+12*

**Section #1**: Waukesha Bypass, STH 59 to Northview Road – Sta 100+52 to Sta 340+50

**Section #2**: Waukesha Bypass, Northview Road to IH-94 – Sta 340+50 to 373+12

**Section #3**: STH 59 – Sta 34+07 to Sta 61+83

**Section #4**: USH 18 – Sta 39+00 to Sta 66+00 and Minor Side Roads at Saylesville Road & CTH "X"

***Year Built and Rehabilitation History:*** Not Available

**Posted Speed Limit:**

**Section #1**: STH 59 to Northview Road – 45 mph

**Section #2**: Northview Road to IH-94 – 25 mph to 35 mph

**Section #3**: STH 59 – 55 mph

**Section #4**: USH 18 – 45 mph

**Existing Typical Section & Pavement Condition:** Not applicable to reconstruction/expansion

| | Section #1 | Section #2 | Section #3 | Section #4 |
|---|---|---|---|---|
| Number of Roadways: | 2 | 2 | 2 | 1 |
| Number of Lanes: | 4 | 4 | 4 | 2 |

| | | | | |
|---|---|---|---|---|
| Lane Width: | 4 @ 12 ft. | 4 @ 12 ft. | 4 @ 12 ft. | 2 @ 12 ft. |
| Crown Slope: | 2% | 2% | 2% | 2% |

**Proposed Typical Section:**

| | Section #1 | Section #2 | Section #3 | Section #4 |
|---|---|---|---|---|
| Number of Roadways: | 2 | 2 | 2 | 1 |
| Number of Lanes: | 4 | 4 | 4 | 2 |
| Lane Width: | 4 @ 12 ft. | 4 @ 12 ft. | 4 @ 12 ft. | 2 @ 12 ft. |
| Crown Slope: | 2% | 2% | 2% | 2% |

## Traffic Data: SEE EXHIBIT #1

| *WisPave Inputs* | Section #1 | Section #2 | Section #3 | Section #4 |
|---|---|---|---|---|
| **Construction Year:** | 2017 | 2017 | 2017 | 2017 |
| **Construction Year ADT:** | 19,400 | 21,200 | 13,000 | 9,900 |
| **Design Year:** | 2037 | 2037 | 2037 | 2037 |
| **Design Year ADT:** | 24,900 | 26,800 | 15,100 | 15,600 |
| **Directional Factor:** | 0.5 | 0.5 | 0.5 | 0.5 |
| **Lane Distribution Factor:** | 0.90 | 0.90 | 0.95 | 1.00 |
| **Percent Trucks:** | 8.3% | | | |
| 2D | 2.2% | | | |
| 3SU | 0.7% | | | |
| 2S-1, 2S-2 | 4.6% | | | |
| 3S-2 | 0.8% | | | |
| Double Bottom | 0.0% | | | |

| *AASHTOWare ME Inputs* | Section #1 | Section #2 | Section #3 | Section #4 |
|---|---|---|---|---|
| **Constr. Yr. Truck Total:** | 1,618 | 1,768 | 1,084 | 826 |
| **Growth Rate %:** | 1.26% | 1.18% | 0.75% | 2.30% |
| **Number of Lanes:** | 4 | 4 | 4 | 2 |
| **HMA Design Year:** | 2035 | 2035 | 2035 | 2035 |
| **HMA Design Year ADT:** | 24,286 | 26,179 | 14,876 | 14,906 |
| **Concrete Design Year:** | 2042 | 2042 | 2042 | 2042 |
| **Concrete Design Year ADT:** | 26,503 | 28,417 | 15,677 | 17,478 |
| **% Trucks in Design Direction:** | 50 | 50 | 50 | 50 |
| **% Trucks in Design Lane:** | 90 | 90 | 90 | 100 |
| **Operational Speed (mph):** | 45 | 35 | 55 | 45 |
| **Percent Trucks:** | 8.34 | | | |

| **Distribution Truck %:** | | | **AADTT Distribution (%)** | | |
|---|---|---|---|---|---|
| 2D | (C4) | 0.48% | 2D | (C4) | 5.8% |
| | (C5) | 1.79% | | (C5) | 21.5% |
| 3SU | (C6) | 0.37% | 3SU | (C6) | 4.4% |
| | (C7) | 0.33% | | (C7) | 4.0% |
| 2S-1, 2S-2 | (C8) | 4.56% | 2S-1, 2S-2 | (C8) | 54.7% |
| 3S-2 | (C9) | 0.51% | 3S-2 | (C9) | 6.1% |
| | (C10) | 0.30% | | (C10) | 3.6% |
| Double Bottom | (C11, C12, C13) | 0.00% | Double Bottom | (C11, C12, C13) | 0.0% |

NOTE: The traffic data for Saylesville Road and CTH "X" is just a little less than the traffic data used for USH 18, Section #4, therefore USH 18 will govern the pavement structure recommended for Saylesville Road and CTH "X". A minimum pavement structure is recommended for all the other Minor Side Roads, 5-inches of HMA on 10-inches of Base Aggregate Dense.

**Design Lane Daily 18 Kip "Equivalent Single Axial Load" (ESAL):**

| Section #1 | | Section #2 | |
|---|---|---|---|
| Rigid Design: | 552 | Rigid Design: | 598 |
| Flexible Design: | 423 | Flexible Design: | 457 |
| **Section #3** | | **Section #4** | |
| Rigid Design: | 370 | Rigid Design: | 353 |
| Flexible Design: | 282 | Flexible Design: | 271 |

**Design Lane Total Life 18 Kip "Equivalent Single Axial Load" (ESAL):**

| Section #1 | | Section #2 | |
|---|---|---|---|
| Rigid Design: | 4,100,000 | Rigid Design: | 4,400,000 |
| Flexible Design: | 3,100,000 | Flexible Design: | 3,400,000 |
| **Section #3** | | **Section #4** | |
| Rigid Design: | 2,700,000 | Rigid Design: | 2,600,000 |
| Flexible Design: | 2,100,000 | Flexible Design: | 2,000,000 |

## Soil & Subgrade Parameters: SEE EXHIBIT #2

| | |
|---|---|
| Design Group Index (DGI): | 12 |
| Frost Index (FI): | F-3 |
| Soil Support Value (SSV): | 4.2 (use 4.7 if subgrade improvement is included) |
| Mod. of Subgrade Reaction (k): | 150 pci (use 375 pci if subgrade improvement is included) |

**Predominant Soil Type:** Reference the Geotechnical Engineering Report

**Potential Construction Problems:** Reference the Geotechnical Engineering Report

**Subgrade Improvement:** Yes

**Geotechnical Investigation Report Author:** Reviewed by Casey Wierzchowski, SE Regional Geotechnical Engineer

**Soil Parameters received on:** January 7, 2015

**AASHTOWare ME Subgrade Inputs:**

| | | |
|---|---|---|
| Depth to Bedrock *(If < 20 feet)*: | | 13 ft. Between Sta 290+00 to Sta 340+00 and 3 ft. at Sta 45+00 |
| AASHTO Soils Classification: | | A-4 |
| Resilient Modulus (Mr): | | 9,450 for HMA Pavements<br>15,000 for Concrete Pavements |
| Maximum Dry Density (pcf): | | 116 |
| Specific Gravity: | | 2.65 |
| Optimum Moisture Content: | | 14% |
| Grain Size Distribution: | *#4:* | 85% |
| | *#10:* | 74% |
| | *#40:* | 65% |
| | *#200:* | 52% |
| Atterberg Limits: | *Liquid Limit:* | 25% |
| | *Plasticity Index:* | 6% |

## Subgrade Improvement Parameters:

### AASHTOWare ME Subgrade Improvement Inputs:

| | | |
|---|---|---|
| Selected Subgrade Improvement Type: | | Breaker Run |
| AASHTO Soils Classification: | | A-1-a |
| Resilient Modulus (Mr): | | 42,000 |
| Specific Gravity: | | 2.6 |
| Optimum Moisture Content: | | 16.6 |
| Grain Size Distribution: | #200: | 1% |
| | #10: | 5% |
| | 1 ½": | 35% |
| | 5": | 100% |
| Atterberg Limits: | *Liquid Limit:* | < 25 |
| | *Plasticity Index:* | < 6 |

## Base Aggregate Dense Parameters:

### AASHTOWare ME Base Aggregate Dense Inputs:

| | | |
|---|---|---|
| Selected Base Aggregate Dense Type: | | Base Aggregate Dense 1 ¼-inch |
| AASHTO Soils Classification: | | A-1-a |
| Resilient Modulus (Mr): | | 40,000 |
| Grain Size Distribution: | *#200:* | 7% |
| | *#40:* | 18.0% |
| | *#10:* | 32.0% |
| | *#4:* | 44.0% |
| | *⅜":* | 61.0% |
| | *¾":* | 82.0% |
| | *1 ½":* | 97.0% |
| Atterberg Limits: | *Liquid Limit:* | < 25 |
| | *Plasticity Index:* | < 6 |

## HMA Parameters:

### AASHTOWare ME Base Aggregate Dense Inputs:

| | | |
|---|---|---|
| Selected HMA Type: | | E-10 for Sections #1 & #2, E-3 for Sections #3 & #4 |
| Unit Weight: | | 145 pcf |
| Effective Binder Content: | | 9.3% |
| Air Voids: | | 6.9% |
| Poisson's Ratio: | | 0.30 |
| Asphalt Binder Type: | | PG64-28 for Sections #1 & #2, PG58-28 for Sections #3 & #4 |
| Grain Size Distribution: | *#200:* | 5% |
| | *#4:* | 60% |
| | *⅜":* | 90% |
| | *¾":* | 95% |

## Concrete Parameters:

### AASHTOWare ME Base Aggregate Dense Inputs:

| | |
|---|---|
| Selected Cement Type: | Type II |
| Cementitious Material Content: | 565 lb/yd$^3$ |
| Water to Cement Ratio: | 0.38 |
| Reversible Shrinkage: | 50% |
| Selected Mix Type: | A-F |
| Selected Aggregate Type: | Dolomite (2) |
| Unit Weight: | 146 pcf |
| Poisson's Ratio: | 0.19 |
| Coefficient of Thermal Expansion: | 5.34 in/in/°F x 10^-6 |
| Thermal Conductivity: | 1.25 BTU/hr-ft-°F |
| Heat Capacity: | 0.28 BTU/lb-°F |
| Modulus of Rupture: | 890 psi (90-day) |
| Elastic Modulus: | 4,854,000 psi (90-day) |

## Alternatives:

**Section #1:** SEE EXHIBITS #3 thru #37

Alternative #1: 8-inches of Concrete Pavement over 6-inches of Base Aggregate Dense
Alternative #2: 7-inches of HMA Pavement over 14-inches of Base Aggregate Dense
Alternative #3: 8 ¾-inches of HMA over 6-inches of Base Aggregate Dense

**Section #2:** SEE EXHIBITS #38 thru #72

Alternative #1: 8-inches of Concrete Pavement over 6-inches of Base Aggregate Dense
Alternative #2: 7-inches of HMA Pavement over 14-inches of Base Aggregate Dense
Alternative #3: 9-inches of HMA over 6-inches of Base Aggregate Dense

**Section #3:** SEE EXHIBITS #73 thru #107

Alternative #1: 8-inches of Concrete Pavement over 6-inches of Base Aggregate Dense
Alternative #2: 5 ½-inches of HMA Pavement over 11-inches of Base Aggregate Dense
Alternative #3: 8 ¼-inches of HMA over 6-inches of Base Aggregate Dense

**Section #4:** SEE EXHIBITS #108 thru #142

Alternative #1: 8-inches of Concrete Pavement over 6-inches of Base Aggregate Dense
Alternative #2: 5 ½-inches of HMA Pavement over 11-inches of Base Aggregate Dense
Alternative #3: 8 ¼-inches of HMA over 6-inches of Base Aggregate Dense

## Life Cycle Cost Analysis:

WisDOT's WisPave design program, version 4, was used for the LCCA computations

**Section #1:** SEE EXHIBITS #143 thru #181

| | 8" Concrete | 7" HMA | 8 ¾" HMA |
|---|---|---|---|
| Initial Costs: | $6,244,905 | $6,493,600 | $6,612,928 |
| Present Worth Costs: | $7,506,031 | $8,684,232 | $8,803,560 |
| Percent Difference: | 0.00% | 15.70% | 17.29% |

**Section #2:** SEE EXHIBITS #182 thru #220

| | 8" Concrete | 7" HMA | 9" HMA |
|---|---|---|---|
| Initial Costs: | $731,892 | $752,962 | $777,867 |
| Present Worth Costs: | $875,162 | $980,790 | $1,005,695 |
| Percent Difference: | 0.00% | 12.07% | 14.92% |

**Section #3:** SEE EXHIBITS #221 thru #259

| | 8" Concrete | 5 ½" HMA | 8 ¼" HMA |
|---|---|---|---|
| Initial Costs: | $687,765 | $540,611 | $638,107 |
| Present Worth Costs: | $820,673 | $761,738 | $859,234 |
| Percent Difference: | 7.74% | 0.00% | 12.80% |

**Section #4:** SEE EXHIBITS #260 thru #298

| | 8" Concrete | 5 ½" HMA | 8 ¼" HMA |
|---|---|---|---|
| Initial Costs: | $478,959 | $392,679 | $459,046 |
| Present Worth Costs: | $559,111 | $538,444 | $604,810 |
| Percent Difference: | 3.84% | 0.00% | 12.33% |

**NOTE:** The recommended pavement structure for each Section is the lowest cost alternative.

## Design Performance Criteria – Target & Reliability Values:

| *For a new Flexible Pavement Structure:* | *Target Limit* | *Reliability (%)* |
|---|---|---|
| Initial IRI (in./mile): | 55 | |
| Terminal IRI (in./mile): | 200 | 95% |
| AC Bottom-up Fatigue cracking (percent): | 10% | 95% |
| AC Thermal Cracking (ft/mile): | 1,500 | 95% |
| Permanent Deformation – Total Pavement (in.): | 0.75 | 95% |
| Permanent Deformation – AC only (in.): | 0.40 | 95% |

| *For a new JPCP Structure:* | *Target Limit* | *Reliability (%)* |
|---|---|---|
| Initial IRI (in./mile): | 55 | |
| Terminal IRI (in./mile): | 200 | 95% |
| JPCP transverse cracking (percent slabs): | 15 | 95% |
| Mean joint faulting (in.) | 0.15 | 95% |

## Recommendations & Considerations:

"The Pavement Type Selection Process" and "Exception Process" is defined in the Facilities Development Manual, Procedure 14-15.

### Section #1 - STH 59 to Northview Road:

- Utilize some form of Subgrade Improvement, Reference the Geotechnical Engineering Report
- Remove the existing pavement, median, or curb & gutter as required
- Place 6-inches of Base Aggregate Dense 1 ¼-inch
- Place non-reinforced Portland Cement, Concrete Pavement 8-inch, doweled with normal joints spaced at a standard 15 feet apart

**Section #2 - Northview Road to IH-94:**

- Utilize some form of Subgrade Improvement, Reference the Geotechnical Engineering Report
- Remove the existing pavement, median, or curb & gutter as required
- Place 6-inches of Base Aggregate Dense 1 ¼-inch
- Place non-reinforced Portland Cement, Concrete Pavement 8-inch, doweled with normal joints spaced at a standard 15 feet apart

**Section #3 - STH 59:**

- Utilize some form of Subgrade Improvement, Reference the Geotechnical Engineering Report
- Remove the existing pavement, median, or curb & gutter as required
- Place 11-inches of Base Aggregate Dense 1 ¼-inch
- Place 3 ½-inches of 19.0 mm HMA Pavement Type E-3, with Asphaltic Material PG 58-28 as a lower layer
- Place 2-inches of 12.5 mm HMA Pavement Type E-3, with Asphaltic Material PG 58-28, as an upper layer

**Section #4 - USH 18 & Minor Side Roads at Saylesville Road & CTH "X":**

- Utilize some form of Subgrade Improvement, Reference the Geotechnical Engineering Report
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**Minor Side Roads – Excluding Saylesville Road & CTH "X":**

- Remove the existing pavement, median, or curb & gutter as required
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**Shoulders:**

- Follow the FDM 14-5-1, with regards to Base Aggregate Dense material
- Pavement to match adjacent mainline pavement

# WisDOT TRAFFIC FORECAST REPORT

PROJECT ID(S): 2788-01-00
ROUTE(S): CTH TT
Region/COUNTY(IES): SE / Waukesha
LOCATION: West Waukesha Bypass
COMPLETED: 24 November, 2014


Developed by: Brent DesRoches
Phone: (262) 548-5611
FAX #: (262) 548-4425
E-Mail: brent.desroches@dot.wi.gov


WISCONSIN DEPARTMENT OF TRANSPORTATION

**Design Values (%)**

| | | | |
|---|---|---|---|
| **Site(s)** | 671771 | | |
| **Routes(s)** | CTH TT | | |
| Volume(s) | 26800 | | |
| Site Growth % | 2.65% | | |
| K250 | 10.0 | | |
| K100 | 10.7 | | |
| K30 | 11.2 | | |
| P | 12.4 | | |
| D(Dsgn. Hr.) | 59/41 | | |
| T(DHV) | 7.1 | | |
| T(PHV) | 6.2 | | |

Site IDs are Colored, **Bolded**, and Underlined

-000- 2013 Count (000) 2017 AADT
*000* 2012 Count [000] 2027 AADT
+000+ 2009 Count 000 2037 AADT
/000/ XXXX AADT

| | | | |
|---|---|---|---|
| **Trucks** | 671771 | | |
| AADTT | 2220 | | |
| 2D | 2.2 | | |
| 3AX | 0.7 | | |
| 2S1+2S2 | 4.6 | | |
| 3-S2 | 0.8 | | |
| DBL-BTM | 0.0 | | |
| Total % | 8.3% | | |

**NOTES ON THE FORECAST:**

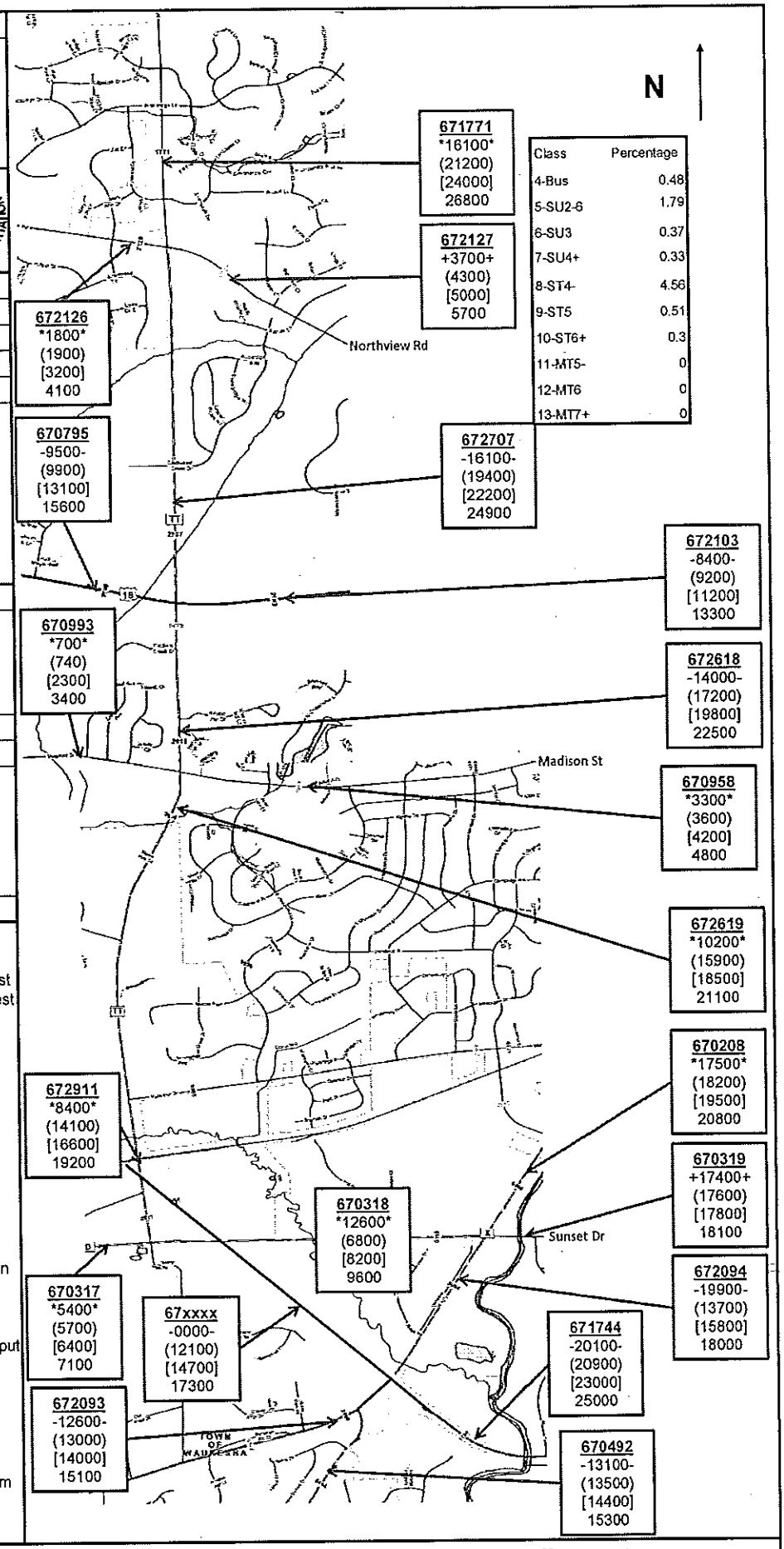
1. This projection assumes the residential development West of CTH TT will be added to the roadway network and the West Waukesha Bypass will be built. This is the build forecast.

2. Truck classification percentages were taken from a 2010 consultant classification tube counts on CTH TT North of Joanne Dr.

3. CTH TT is a Factor Group II (Urban-Other) highway (indicating low to moderate fluctuation in traffic from a seasonal perspective). It is functionally classified as a Urban Principal Arterial (14) for count purposes.

4. The Traffic Analysis Forecasting Information System output and history regression were used as a comparison tool to check against the SEWRPC forecast. Adjustments were made as needed.

5. 2013 volumes represent the 24 hr expanded volumes from turn movement counts.




Traffic Forecasting Section; Bureau of Planning and Economic Development; Division of Transportation Investment Management

EXHIBIT #1

## Peschke, Todd - DOT

**From:** Cain, Douglas - DOT
**Sent:** Wednesday, January 07, 2015 4:29 PM
**To:** Peschke, Todd - DOT
**Cc:** Cain, Douglas - DOT; Wierzchowski, Casey W - DOT
**Subject:** FW: West Waukesha Bypass Pavement Design Request; ID's: 2788-00-00, 2788-00-01, 2788-00-02
**Attachments:** FRCSTRPTV3_PebbleCreekBuild.pdf; Forecast Notes & Methods.docx; Exisiting_TS_30% Plans.pdf; Proposed_TS_30%plans.pdf; Waukesha Bypass Preliminary Pavement Parameters (Text).pdf; 2788-00-01 Pavement Design Request.docx

---

**From:** Kerry.Meyer@CH2M.com [mailto:Kerry.Meyer@CH2M.com]
**Sent:** Wednesday, January 07, 2015 12:50 PM
**To:** Cain, Douglas - DOT
**Cc:** GEvans@waukeshacounty.gov
**Subject:** West Waukesha Bypass Pavement Design Request; ID's: 2788-00-00, 2788-00-01, 2788-00-02

Doug,

I have attached the pavement design request form for the West Waukesha Bypass project.

In addition, the traffic forecast, existing and proposed typical section information that is available, and the preliminary pavement parameters are also included.

Please let me know if you have any questions or need additional information.

Thanks
kerry

***Kerry Meyer, PE***
Project Manager
Transportation Business Group
***CH2M HILL***
*135 S. 84th Street Suite 400*
*Milwaukee, WI 53214*
*Ph: (414) 847-0326*
*Cell: (414) 688-0737*
*Fax: (414) 454-8891*
*Email: kerry.meyer@ch2m.com*

# 27880001 Wauk Bypass Section#1 PCC 1-12-15

File Name: C:\ME Designs\12290401 IH43 10-29-14\27880001 Wauk Bypass Section#1 PCC 1-12-15.dgpx

## Design Inputs

| | | | | | |
|---|---|---|---|---|---|
| Design Life: | 25 years | Existing construction: | - | Climate Data Sources (Lat/Lon) | 42.761, -87.814 |
| Design Type: | Jointed Plain Concrete Pavement (JPCP) | Pavement construction: | September, 2017 | | |
| | | Traffic opening: | October, 2017 | | |

### Design Structure


| Layer type | Material Type | Thickness (in.): |
|---|---|---|
| PCC | JPCP Default | 8.0 |
| NonStabilized | A-1-a | 6.0 |
| NonStabilized | A-1-a | 16.0 |
| Subgrade | A-4 | Semi-infinite |

| Joint Design: | |
|---|---|
| Joint spacing (ft) | 15.0 |
| Dowel diameter (in.) | 1.25 |
| Slab width (ft) | 12.0 |

### Traffic

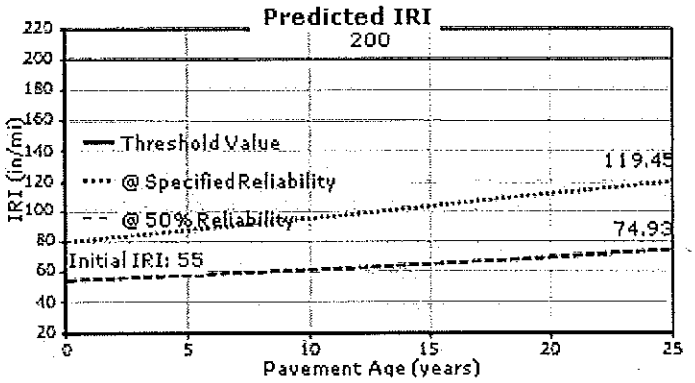
| Age (year) | Heavy Trucks (cumulative) |
|---|---|
| 2017 (initial) | 1,618 |
| 2029 (12 years) | 3,542,360 |
| 2042 (25 years) | 7,653,710 |

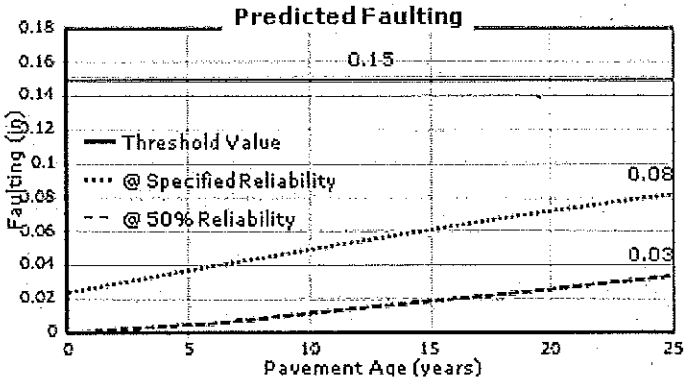
## Design Outputs

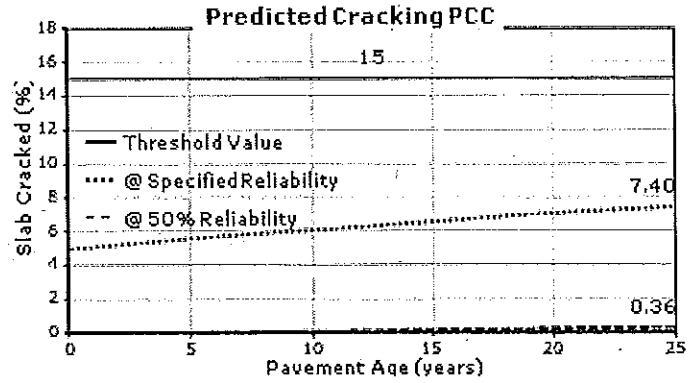
### Distress Prediction Summary

| Distress Type | Distress @ Specified Reliability | | Reliability (%) | | Criterion Satisfied? |
|---|---|---|---|---|---|
| | Target | Predicted | Target | Achieved | |
| Terminal IRI (in./mile) | 200.00 | 119.45 | 95.00 | 100.00 | Pass |
| Mean joint faulting (in.) | 0.15 | 0.08 | 95.00 | 100.00 | Pass |
| JPCP transverse cracking (percent slabs) | 15.00 | 7.40 | 95.00 | 99.97 | Pass |

### Distress Charts



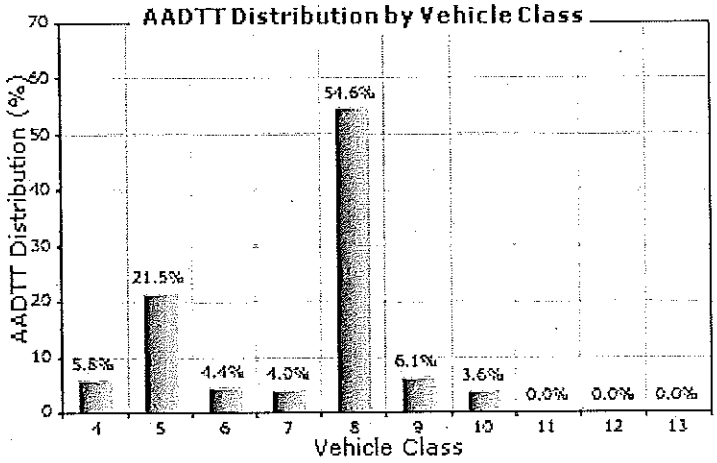



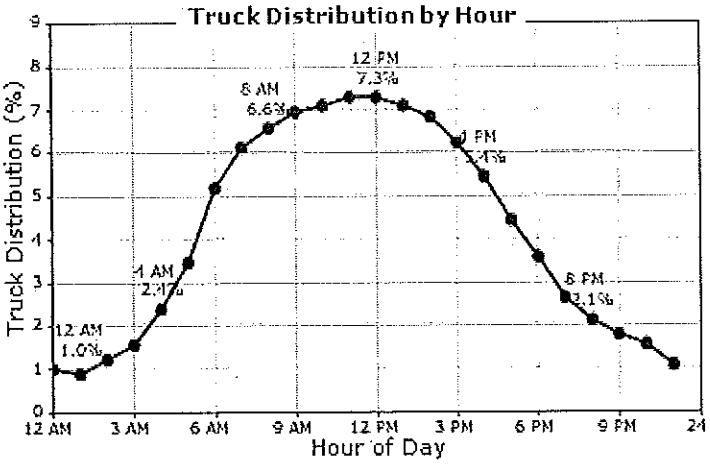



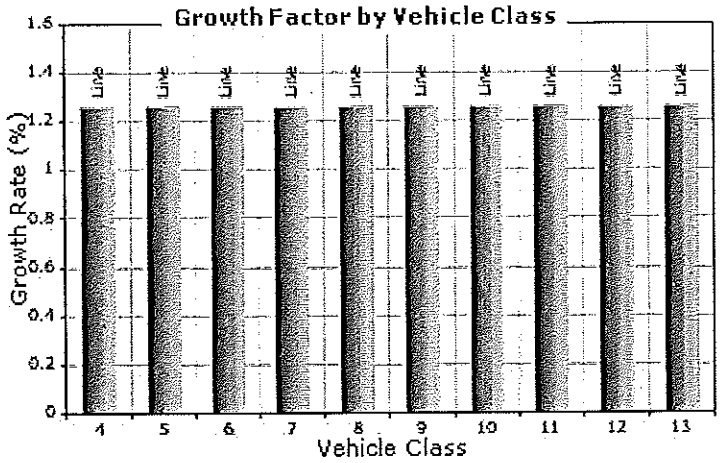
## Traffic Inputs

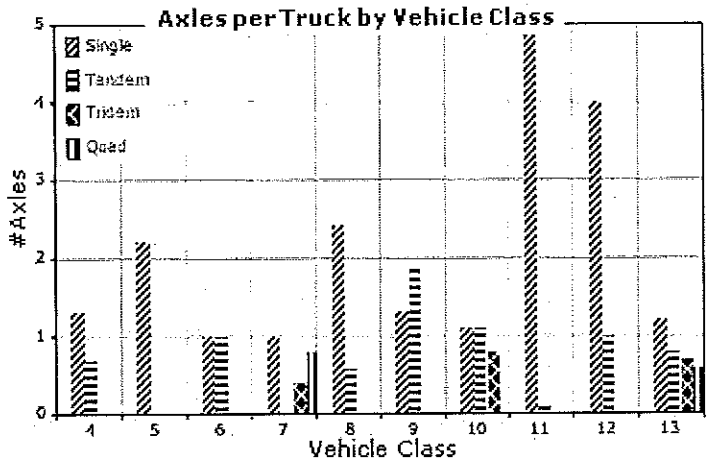
### Graphical Representation of Traffic Inputs

| | | | |
|---|---|---|---|
| Initial two-way AADTT: | 1,618 | Percent of trucks in design direction (%): | 50.0 |
| Number of lanes in design direction: | 4 | Percent of trucks in design lane (%): | 90.0 |
| | | Operational speed (mph) | 45.0 |



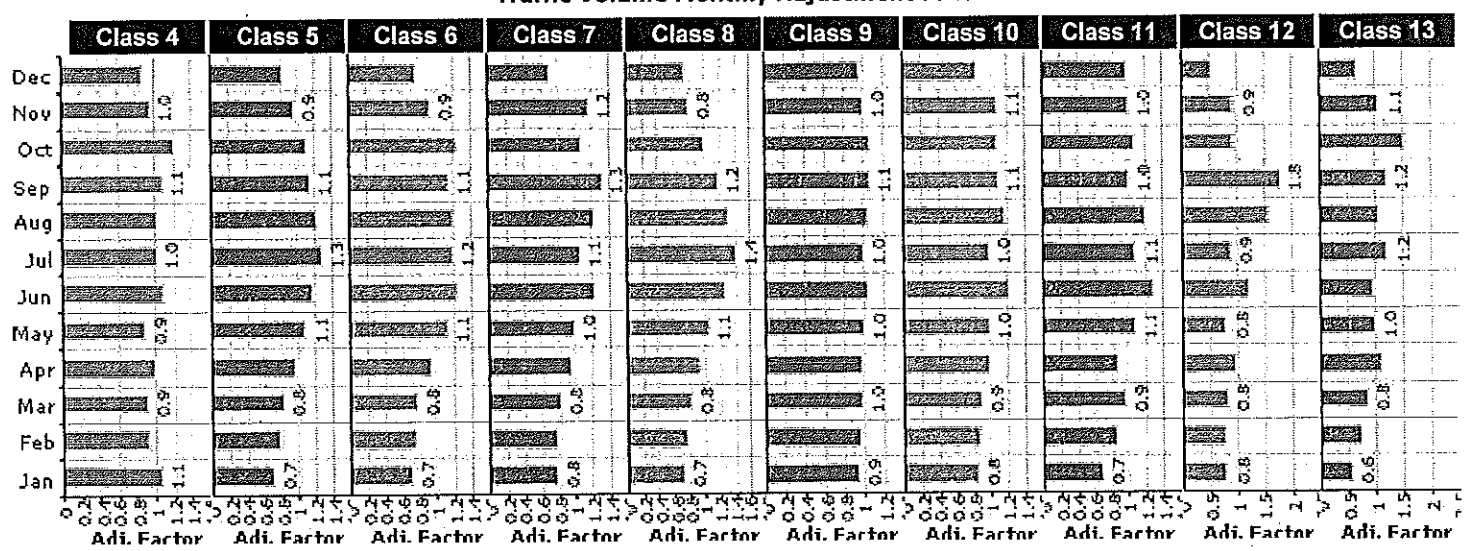




**EXHIBIT #4**

## 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 | 1.1 | 0.7 | 0.7 | 0.8 | 0.7 | 0.9 | 0.8 | 0.7 | 0.8 | 0.6 |
| February | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 1.0 | 0.9 | 0.8 | 0.8 | 0.7 |
| March | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 1.0 | 0.9 | 0.9 | 0.8 | 0.8 |
| April | 1.0 | 1.0 | 0.9 | 0.9 | 0.9 | 1.0 | 1.0 | 0.9 | 1.0 | 1.1 |
| May | 0.9 | 1.1 | 1.1 | 1.0 | 1.1 | 1.0 | 1.0 | 1.1 | 0.8 | 1.0 |
| June | 1.1 | 1.2 | 1.2 | 1.2 | 1.3 | 1.1 | 1.2 | 1.3 | 1.2 | 1.0 |
| July | 1.0 | 1.3 | 1.2 | 1.1 | 1.4 | 1.0 | 1.0 | 1.1 | 0.9 | 1.2 |
| August | 1.0 | 1.2 | 1.2 | 1.2 | 1.3 | 1.1 | 1.2 | 1.2 | 1.6 | 1.1 |
| September | 1.1 | 1.1 | 1.1 | 1.3 | 1.2 | 1.1 | 1.1 | 1.0 | 1.8 | 1.2 |
| October | 1.2 | 1.1 | 1.2 | 1.1 | 1.0 | 1.1 | 1.1 | 1.1 | 0.9 | 1.5 |
| November | 1.0 | 0.9 | 0.9 | 1.2 | 0.8 | 1.0 | 1.1 | 1.0 | 0.9 | 1.1 |
| December | 0.9 | 0.8 | 0.8 | 0.7 | 0.7 | 1.0 | 0.8 | 1.0 | 0.5 | 0.7 |

### Distributions by Vehicle Class

| Vehicle Class | AADTT Distribution (%) (Level 3) | Growth Factor | |
|---|---|---|---|
| | | Rate (%) | Function |
| Class 4 | 5.8% | 1.26% | Linear |
| Class 5 | 21.5% | 1.26% | Linear |
| Class 6 | 4.4% | 1.26% | Linear |
| Class 7 | 4% | 1.26% | Linear |
| Class 8 | 54.6% | 1.26% | Linear |
| Class 9 | 6.1% | 1.26% | Linear |
| Class 10 | 3.6% | 1.26% | Linear |
| Class 11 | 0% | 1.26% | Linear |
| Class 12 | 0% | 1.26% | Linear |
| Class 13 | 0% | 1.26% | Linear |

### Truck Distribution by Hour

| Hour | Distribution (%) | Hour | Distribution (%) |
|---|---|---|---|
| 12 AM | 1.02% | 12 PM | 7.3% |
| 1 AM | 0.93% | 1 PM | 7.09% |
| 2 AM | 1.25% | 2 PM | 6.82% |
| 3 AM | 1.58% | 3 PM | 6.23% |
| 4 AM | 2.39% | 4 PM | 5.44% |
| 5 AM | 3.46% | 5 PM | 4.44% |
| 6 AM | 5.19% | 6 PM | 3.58% |
| 7 AM | 6.12% | 7 PM | 2.67% |
| 8 AM | 6.59% | 8 PM | 2.14% |
| 9 AM | 6.93% | 9 PM | 1.79% |
| 10 AM | 7.09% | 10 PM | 1.56% |
| 11 AM | 7.3% | 11 PM | 1.09% |
| | | Total | 100% |

### Axle Configuration

| Traffic Wander | |
|---|---|
| Mean wheel location (in.) | 15 |
| 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 | | | | |
|---|---|---|---|---|
| Value Type | Axle Type | Short | Medium | Long |
| Average spacing of axles (ft) | | 12 | 15 | 18 |
| Percent of Trucks (%) | | 17 | 22 | 61 |

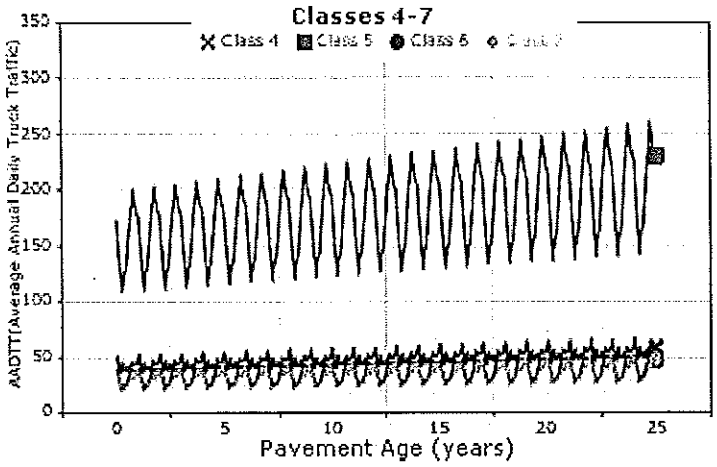
### Number of Axles per Truck

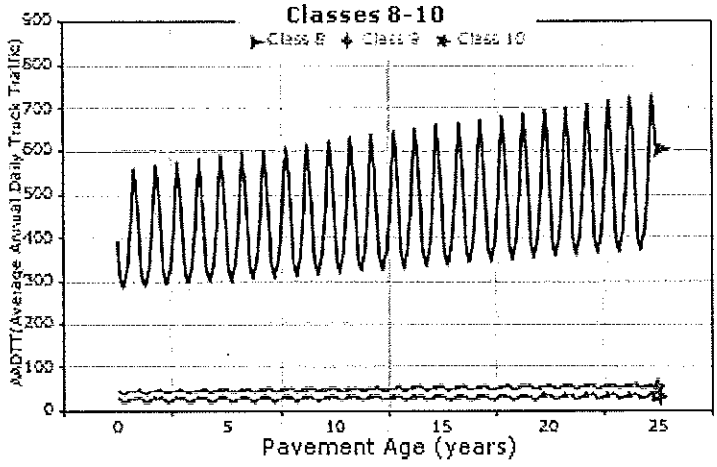
| Vehicle Class | Single Axle | Tandem Axle | Tridem Axle | Quad Axle |
|---|---|---|---|---|
| Class 4 | 1.3 | 0.7 | 0 | 0 |
| Class 5 | 2.2 | 0 | 0 | 0 |
| Class 6 | 1 | 1 | 0 | 0 |
| Class 7 | 1 | 0 | 0.4 | 0.8 |
| Class 8 | 2.4 | 0.6 | 0 | 0 |
| Class 9 | 1.3 | 1.9 | 0 | 0 |
| Class 10 | 1.1 | 1.1 | 0.8 | 0 |
| Class 11 | 4.9 | 0.1 | 0 | 0 |
| Class 12 | 4 | 1 | 0 | 0 |
| Class 13 | 1.2 | 0.8 | 0.7 | 0.6 |

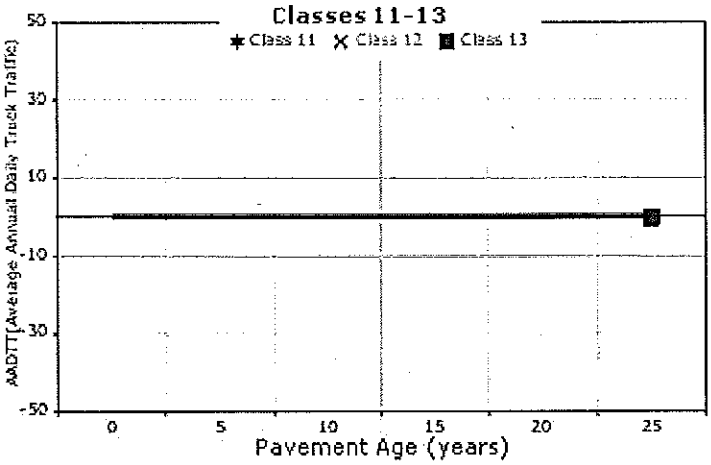
**EXHIBIT #5**

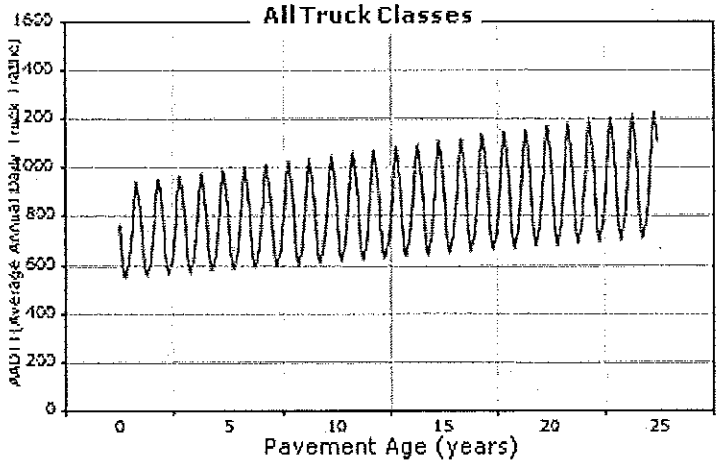
# AADTT (Average Annual Daily Truck Traffic) Growth

* Traffic cap is not enforced



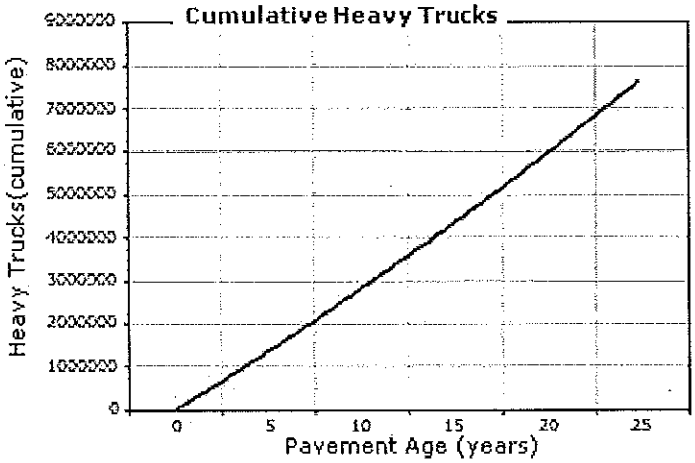
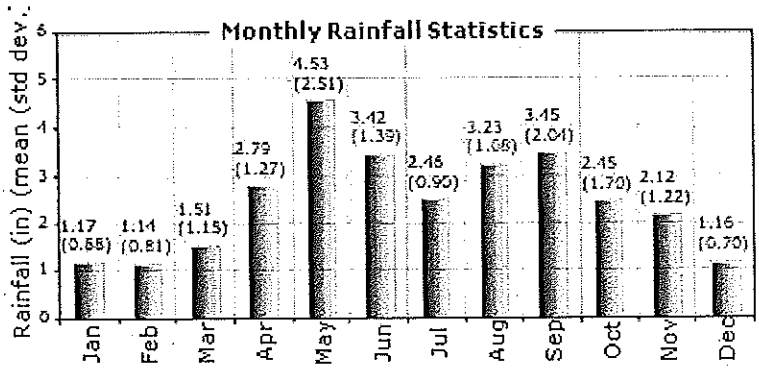




**EXHIBIT #6**

# Climate Inputs

## Climate Data Sources:

| Climate Station Cities: | Location (lat lon elevation(ft)) |
|---|---|
| RACINE, WI | 42.76100 -87.81400 665 |

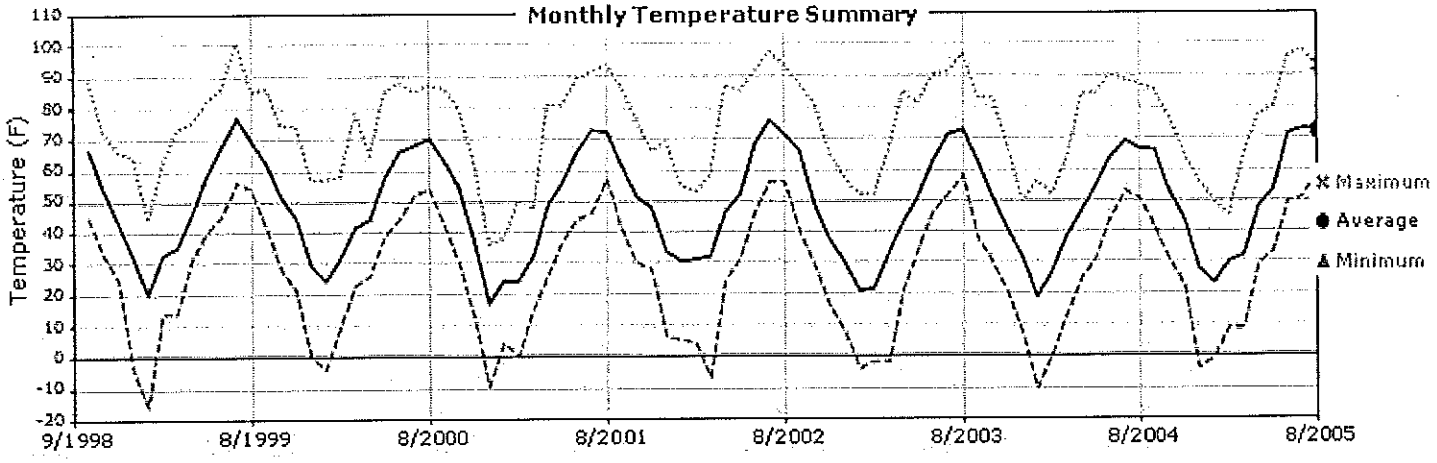


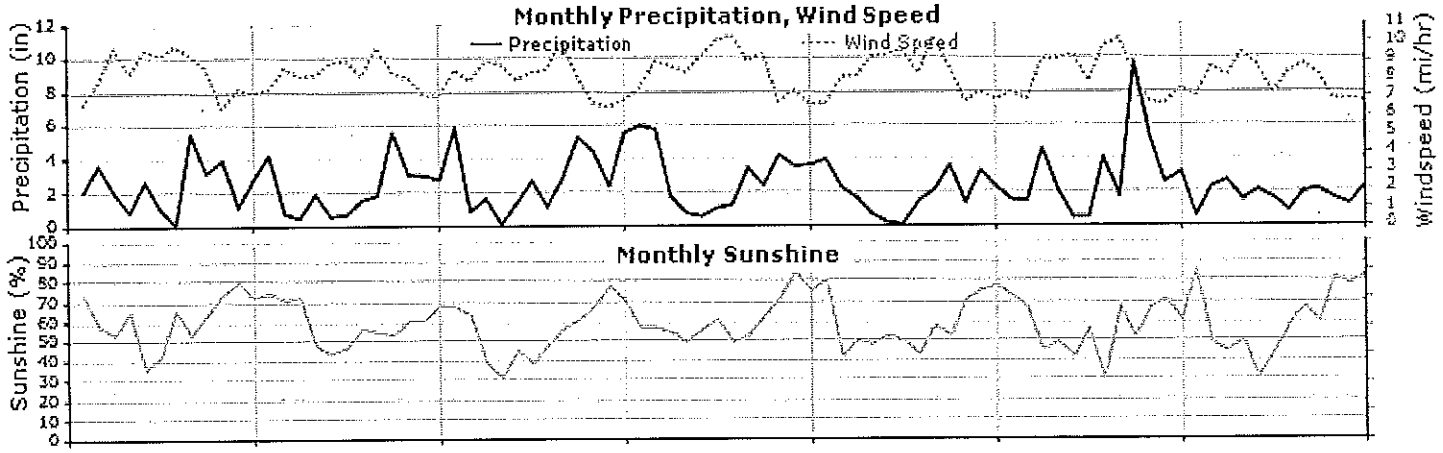

## Annual Statistics:

| | |
|---|---|
| Mean annual air temperature (°F) | 48.60 |
| Mean annual precipitation (in.) | 29.44 |
| Freezing index (°F - days) | 786.30 |
| Average annual number of freeze/thaw cycles: | 55.83 |

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

## Monthly Climate Summary:







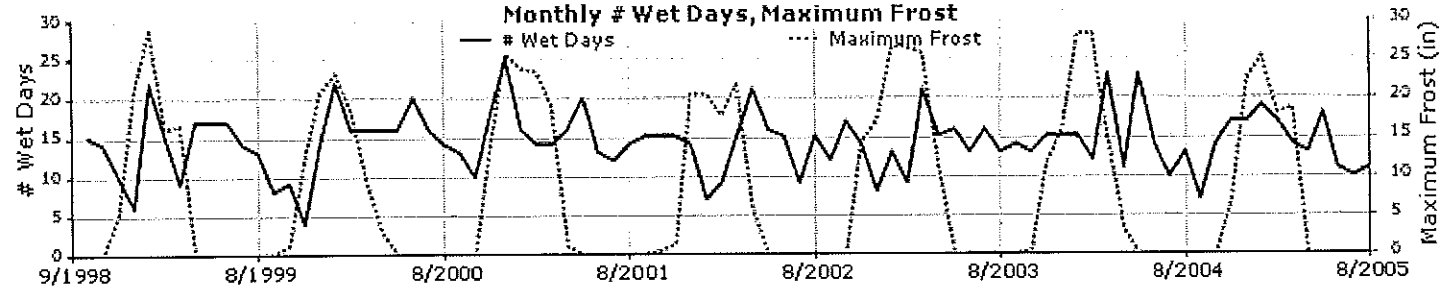
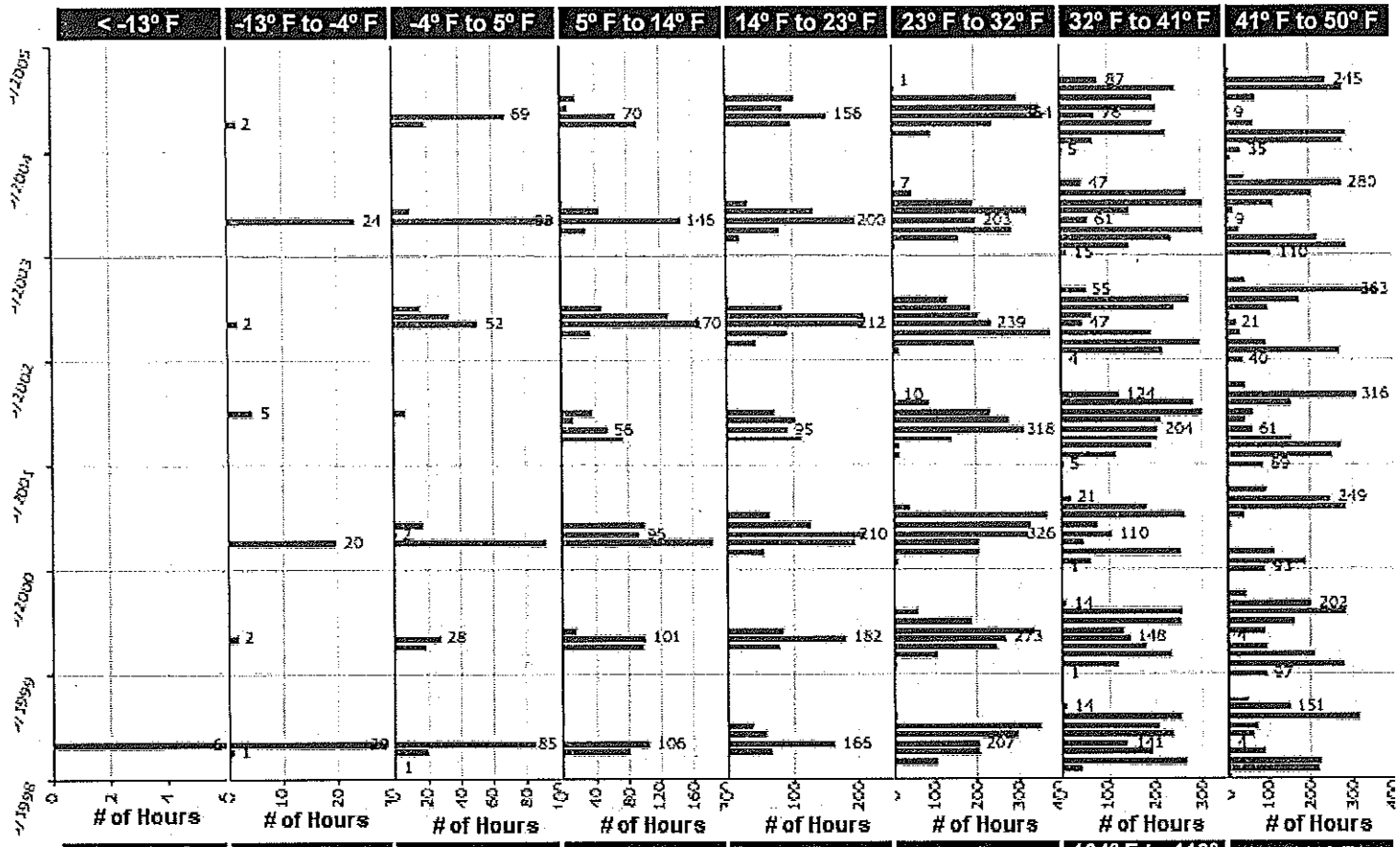



**EXHIBIT #7**

## Hourly Air Temperature Distribution by Month:



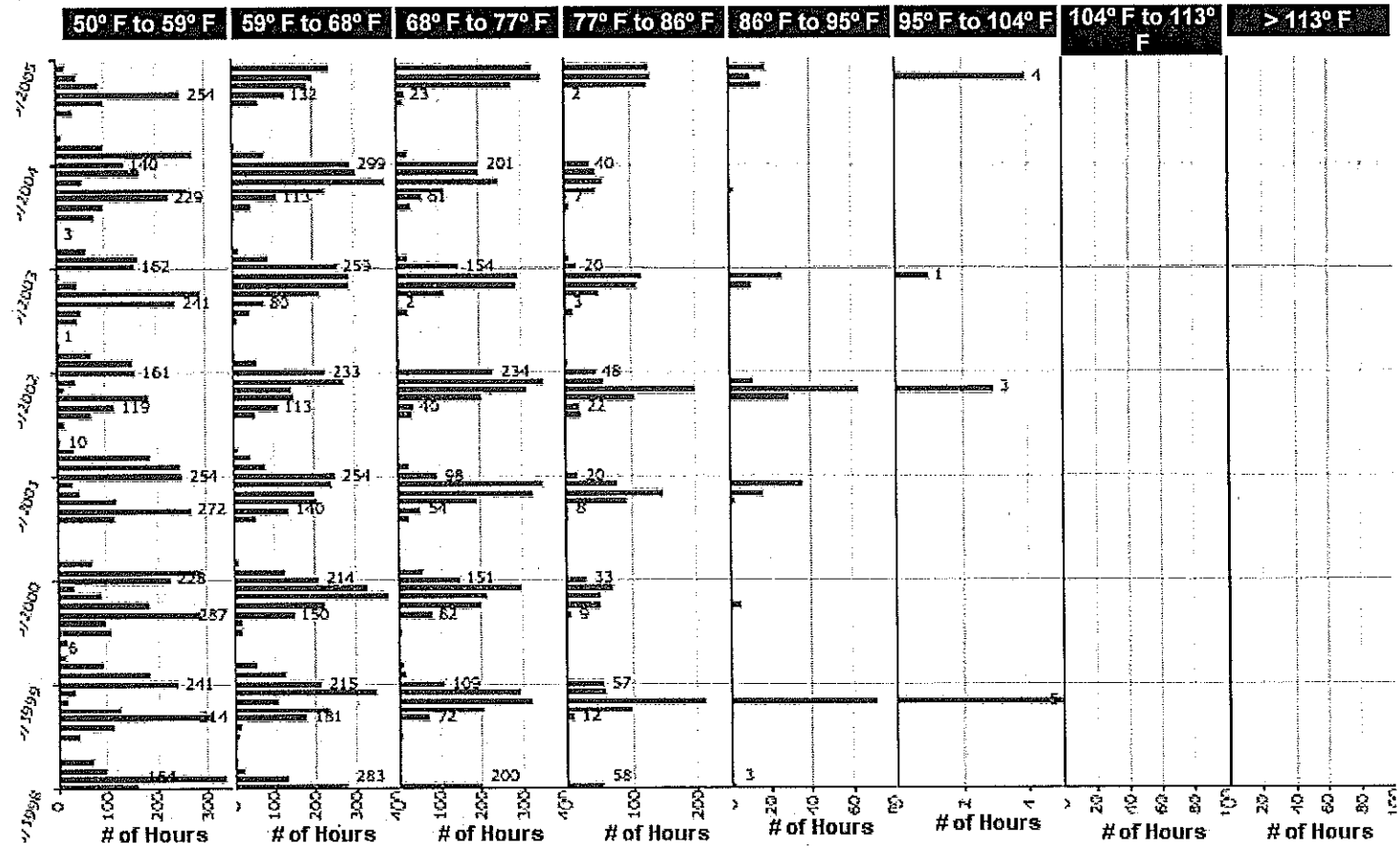




**EXHIBIT #8**

# Design Properties

## JPCP Design Properties

| Structure - ICM Properties | |
|---|---|
| PCC surface shortwave absorptivity | 0.85 |

| Doweled Joints | |
|---|---|
| Is joint doweled ? | True |
| Dowel diameter (in.) | 1.25 |
| Dowel spacing (in.) | 12.00 |

| Tied Shoulders | |
|---|---|
| Tied shoulders | True |
| Load transfer efficiency (%) | 50.00 |

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

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

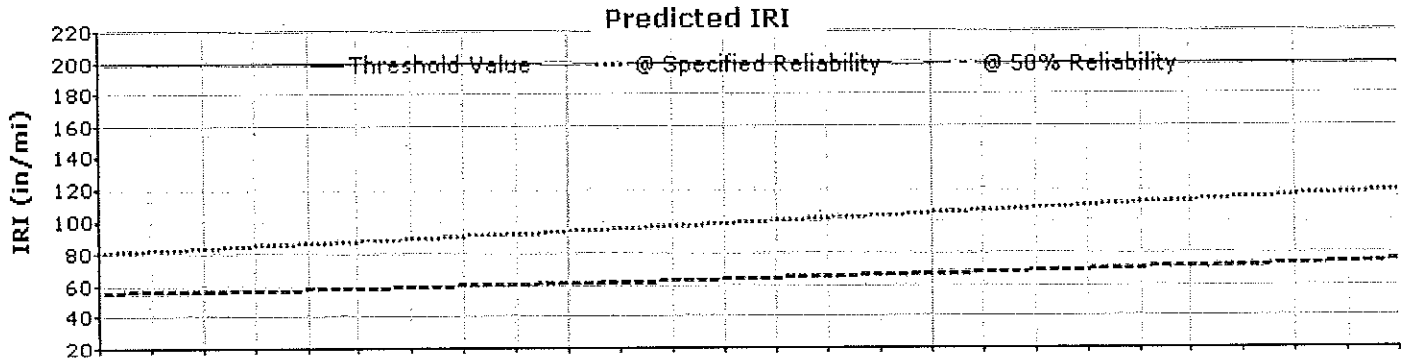
| PCC-Base Contact Friction | |
|---|---|
| PCC-Base full friction contact | True |
| Months until friction loss | 240.00 |

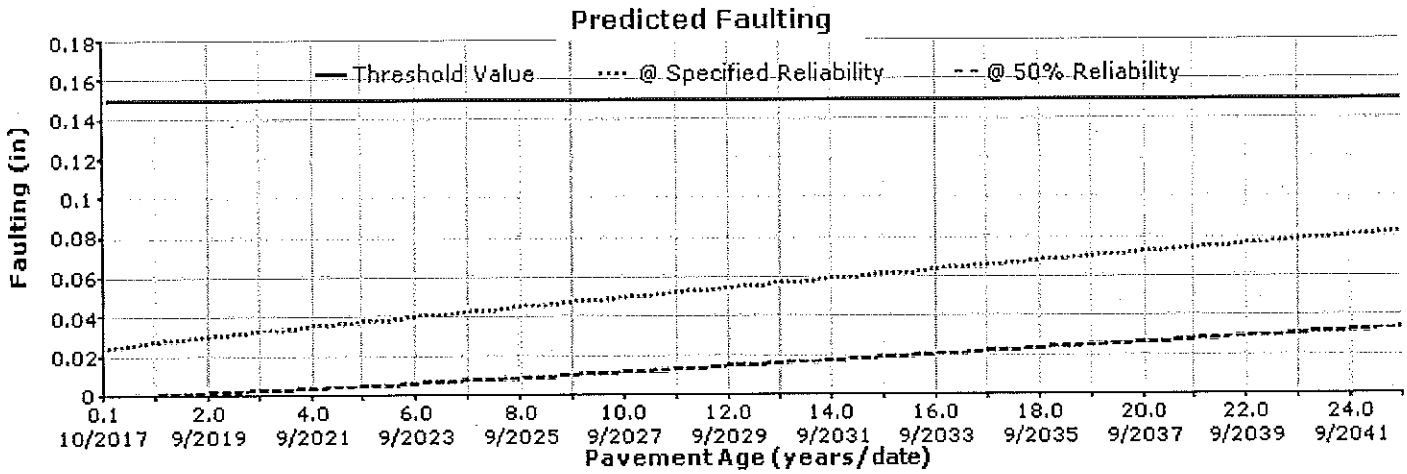
| Sealant type | Preformed |
|---|---|

| Erodibility index | 3 |
|---|---|

| Permanent curl/warp effective temperature difference (°F) | -10.00 |
|---|---|

## Analysis Output Charts



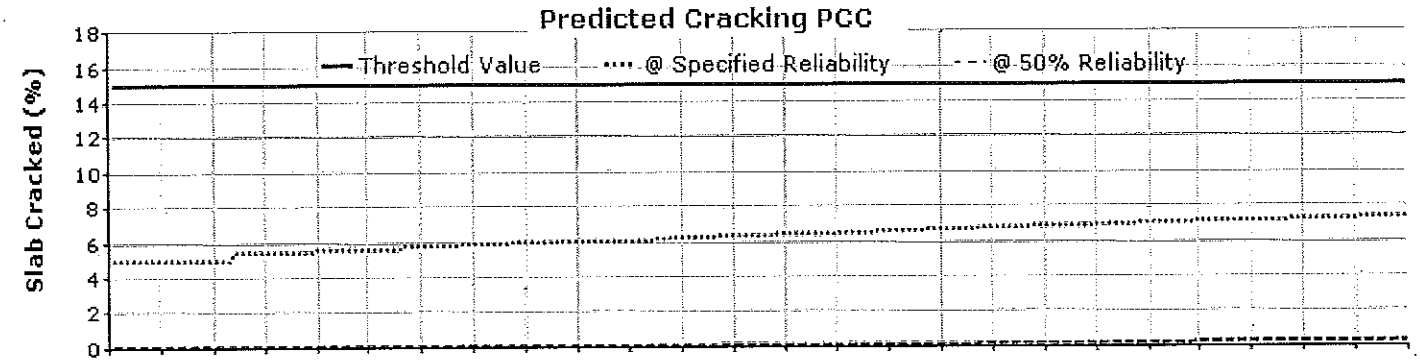
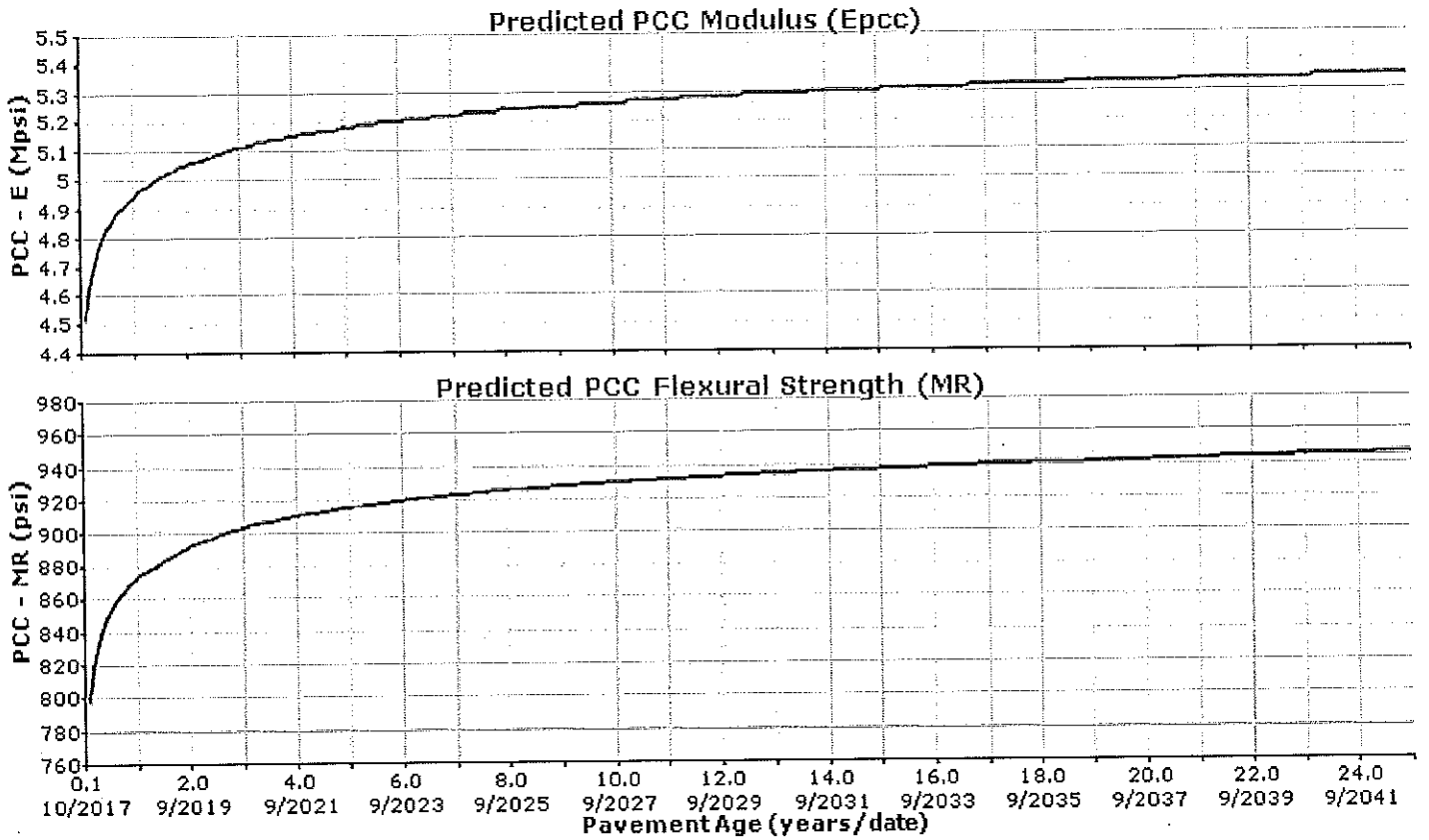




**EXHIBIT #10**


Predicted PCC Modulus (Epcc)
PCC - E (Mpsi)
5.5
5.4
5.3
5.2
5.1
5
4.9
4.8
4.7
4.6
4.5
4.4
Predicted PCC Flexural Strength (MR)
PCC - MR (psi)
980
960
940
920
900
880
860
840
820
800
780
760
0.1 10/2017
2.0 9/2019
4.0 9/2021
6.0 9/2023
8.0 9/2025
10.0 9/2027
12.0 9/2029
14.0 9/2031
16.0 9/2033
18.0 9/2035
20.0 9/2037
22.0 9/2039
24.0 9/2041
Pavement Age (years/date)

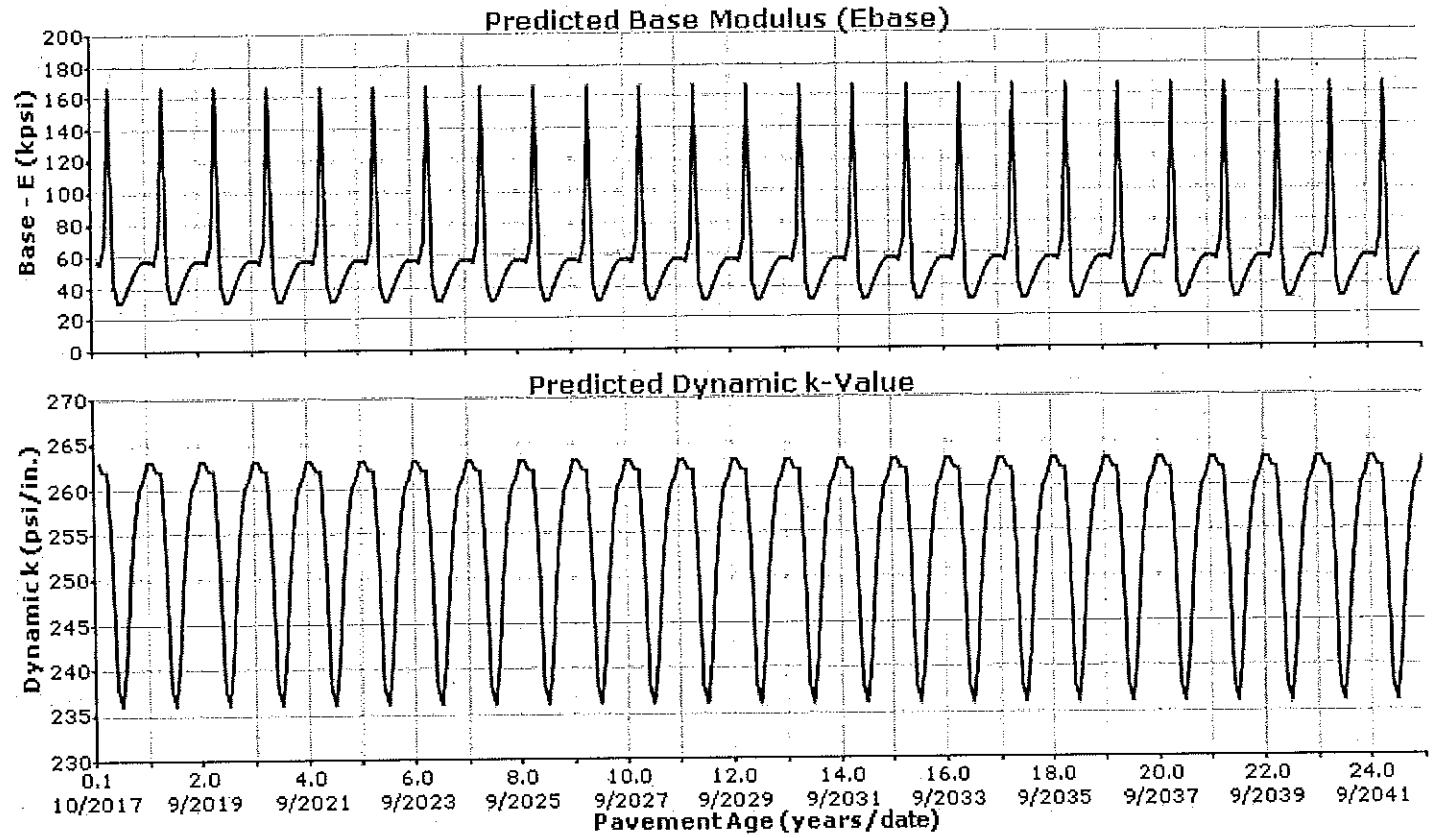
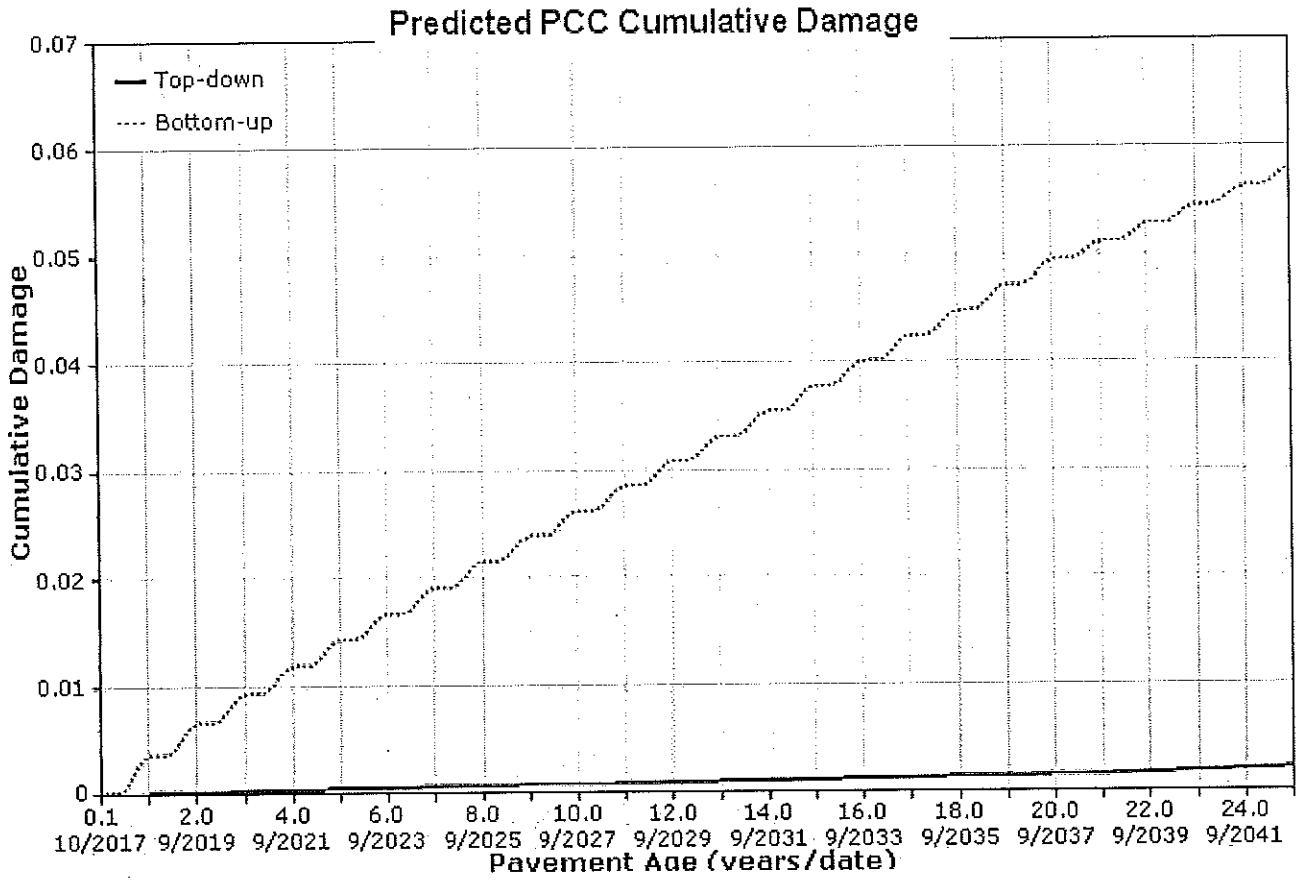

Predicted Base Modulus (Ebase)
Base - E (kpsi)
200
180
160
140
120
100
80
60
40
20
0
Predicted Dynamic k-Value
Dynamic k (psi/in.)
270
265
260
255
250
245
240
235
230
0.1 10/2017
2.0 9/2019
4.0 9/2021
6.0 9/2023
8.0 9/2025
10.0 9/2027
12.0 9/2029
14.0 9/2031
16.0 9/2033
18.0 9/2035
20.0 9/2037
22.0 9/2039
24.0 9/2041
Pavement Age (years/date)

**EXHIBIT #11**


Predicted PCC Cumulative Damage
Top-down
Bottom-up
Cumulative Damage
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.1 10/2017
2.0 9/2019
4.0 9/2021
6.0 9/2023
8.0 9/2025
10.0 9/2027
12.0 9/2029
14.0 9/2031
16.0 9/2033
18.0 9/2035
20.0 9/2037
22.0 9/2039
24.0 9/2041
Pavement Age (years/date)

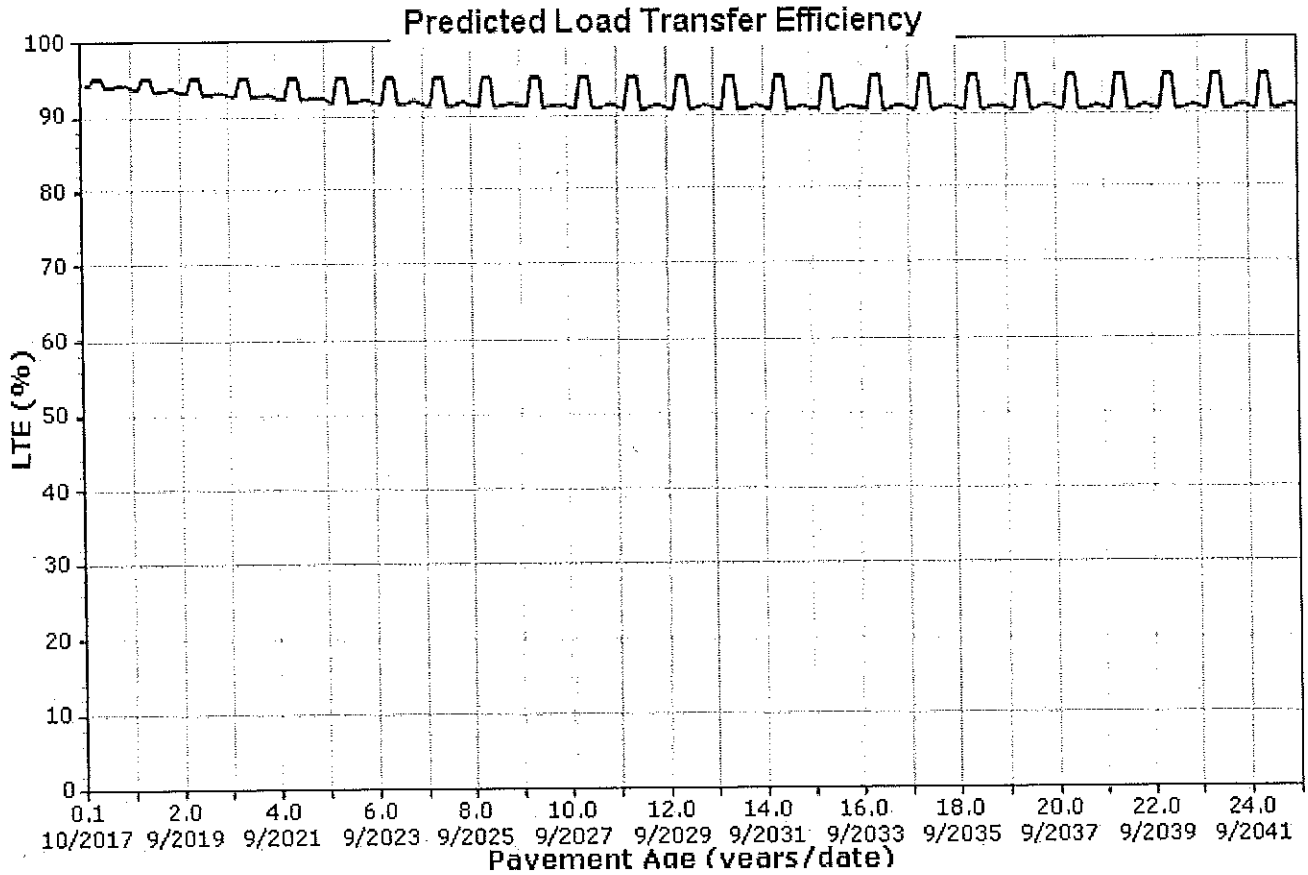

Predicted Load Transfer Efficiency
LTE (%)
100
90
80
70
60
50
40
30
20
10
0
0.1 10/2017
2.0 9/2019
4.0 9/2021
6.0 9/2023
8.0 9/2025
10.0 9/2027
12.0 9/2029
14.0 9/2031
16.0 9/2033
18.0 9/2035
20.0 9/2037
22.0 9/2039
24.0 9/2041
Pavement Age (years/date)

**EXHIBIT #12**

# Layer Information

## Layer 1 PCC : JPCP Default

| PCC | |
|---|---|
| Thickness (in.) | 8.0 |
| Unit weight (pcf) | 148.0 |
| Poisson's ratio | 0.2 |

| Thermal | |
|---|---|
| PCC coefficient of thermal expansion (in./in./°F x 10^-6) | 5.37 |
| PCC thermal conductivity (BTU/hr-ft-°F) | 1.25 |
| PCC heat capacity (BTU/lb-°F) | 0.28 |

| Mix | | |
|---|---|---|
| Cement type | | Type II (2) |
| Cementitious material content (lb/yd^3) | | 780 |
| Water to cement ratio | | 0.37 |
| Aggregate type | | Dolomite (2) |
| PCC zero-stress temperature (°F) | Calculated Internally? | True |
| | User Value | - |
| | Calculated Value | 102.5 |
| Ultimate shrinkage (microstrain) | Calculated Internally? | True |
| | User Value | - |
| | Calculated Value | 600.7 |
| Reversible shrinkage (%) | | 50 |
| Time to develop 50% of ultimate shrinkage (days) | | 35 |
| Curing method | | Curing Compound |

### PCC strength and modulus (Input Level: 3)

| | |
|---|---|
| **28-Day PCC modulus of rupture (psi)** | 780.0 |
| **28-Day PCC elastic modulus (psi)** | 4413000.0 |

### Identifiers

| Field | Value |
|---|---|
| Display name/identifier | JPCP Default |
| Description of object | |
| Author | |
| Date Created | 1/12/2015 12:00:00 AM |
| Approver | |
| Date approved | 1/12/2015 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.) | 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) |
|---|
| 40000.0 |

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

### Identifiers

| Field | Value |
|---|---|
| Display name/identifier | A-1-a |
| Description of object | Default material |
| Author | AASHTO |
| Date Created | 1/12/2015 12:00:00 AM |
| Approver | |
| Date approved | 12/9/2014 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

| | |
|---|---|
| **Liquid Limit** | 25.0 |
| **Plasticity Index** | 6.0 |
| **Is layer compacted?** | True |

| | Is User Defined? | Value |
|---|---|---|
| Maximum dry unit weight (pcf) | False | 128.1 |
| Saturated hydraulic conductivity (ft/hr) | False | 2.616e-02 |
| Specific gravity of solids | False | 2.7 |
| Optimum gravimetric water content (%) | False | 7.2 |

| User-defined Soil Water Characteristic Curve (SWCC) | |
|---|---|
| Is User Defined? | False |
| **af** | 4.7511 |
| **bf** | 1.7494 |
| **cf** | 0.7630 |
| **hr** | 184.0000 |

| Sieve Size | % Passing |
|---|---|
| 0.001mm | |
| 0.002mm | |
| 0.020mm | |
| #200 | 7.0 |
| #100 | |
| #80 | |
| #60 | |
| #50 | |
| #40 | 18.0 |
| #30 | |
| #20 | |
| #16 | |
| #10 | 32.0 |
| #8 | |
| #4 | 44.0 |
| 3/8-in. | 61.0 |
| 1/2-in. | |
| 3/4-in. | 82.0 |
| 1-in. | |
| 1 1/2-in. | 97.0 |
| 2-in. | |
| 2 1/2-in. | |
| 3-in. | |
| 3 1/2-in. | |

**EXHIBIT #14**

## Layer 3 Non-stabilized Base : A-1-a

| Unbound | |
|---|---|
| Layer thickness (in.) | 16.0 |
| 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) |
|---|
| 42000.0 |

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

### Identifiers

| Field | Value |
|---|---|
| Display name/identifier | A-1-a |
| Description of object | Default material |
| Author | AASHTO |
| Date Created | 1/12/2015 12:00:00 AM |
| Approver | |
| Date approved | 12/9/2014 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

| | |
|---|---|
| **Liquid Limit** | 25.0 |
| **Plasticity Index** | 6.0 |
| **Is layer compacted?** | True |

| | Is User Defined? | Value |
|---|---|---|
| Maximum dry unit weight (pcf) | False | 109.6 |
| Saturated hydraulic conductivity (ft/hr) | False | 8.267e+02 |
| Specific gravity of solids | True | 2.6 |
| Optimum gravimetric water content (%) | True | 16.6 |

| User-defined Soil Water Characteristic Curve (SWCC) | |
|---|---|
| Is User Defined? | False |
| af | 9.2765 |
| bf | 3.7128 |
| cf | 2.9466 |
| hr | 160.0000 |

| Sieve Size | % Passing |
|---|---|
| 0.001mm | |
| 0.002mm | |
| 0.020mm | |
| #200 | 5.0 |
| #100 | |
| #80 | |
| #60 | |
| #50 | |
| #40 | |
| #30 | |
| #20 | |
| #16 | |
| #10 | 10.0 |
| #8 | |
| #4 | |
| 3/8-in. | |
| 1/2-in. | 30.0 |
| 3/4-in. | |
| 1-in. | |
| 1 1/2-in. | 60.0 |
| 2-in. | |
| 2 1/2-in. | |
| 3-in. | |
| 3 1/2-in. | 90.0 |

## Layer 4 Subgrade : A-4

| 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) |
|---|
| 15000.0 |

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

### Identifiers

| Field | Value |
|---|---|
| Display name/identifier | A-4 |
| Description of object | Default material |
| Author | AASHTO |
| Date Created | 1/12/2015 3:54:50 PM |
| Approver | |
| Date approved | 12/9/2014 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

| | |
|---|---|
| **Liquid Limit** | 25.0 |
| **Plasticity Index** | 6.0 |
| **Is layer compacted?** | False |

| | Is User Defined? | Value |
|---|---|---|
| Maximum dry unit weight (pcf) | False | 114 |
| Saturated hydraulic conductivity (ft/hr) | False | 1.205e-05 |
| Specific gravity of solids | True | 2.65 |
| Optimum gravimetric water content (%) | True | 14 |

| User-defined Soil Water Characteristic Curve (SWCC) | |
|---|---|
| **Is User Defined?** | False |
| **af** | 69.7987 |
| **bf** | 0.9890 |
| **cf** | 0.4694 |
| **hr** | 500.0000 |

| Sieve Size | % Passing |
|---|---|
| 0.001mm | |
| 0.002mm | |
| 0.020mm | |
| #200 | 52.0 |
| #100 | |
| #80 | |
| #60 | |
| #50 | |
| #40 | 65.0 |
| #30 | |
| #20 | |
| #16 | |
| #10 | 74.0 |
| #8 | |
| #4 | 85.0 |
| 3/8-in. | |
| 1/2-in. | |
| 3/4-in. | |
| 1-in. | |
| 1 1/2-in. | |
| 2-in. | |
| 2 1/2-in. | |
| 3-in. | |
| 3 1/2-in. | |

## Calibration Coefficients

### PCC Faulting

$$C_{12} = C_1 + (C_2 * FR^{0.25})$$

$$C_{34} = C_3 + (C_4 * FR^{0.25})$$

$$FaultMax_0 = C_{12} * \delta_{curling} * \left[\log(1 + C_5 * 5.0^{EROD}) * \log\left(P_{200} * \frac{WetDays}{p_S}\right)\right]^{C_6}$$

$$FaultMax_i = FaultMax_0 + C_7 * \sum_{j=1}^{m} DE_j * \log(1 + C_5 * 5.0^{EROD})^{C_6}$$

$$\Delta Fault_i = C_{34} * (FaultMax_{i-1} - Fault_{i-1})^2 * DE_i$$

$$C_8 = DowelDeterioration$$

| | | | |
|---|---|---|---|
| C1: 1.0184 | C2: 0.91656 | C3: 0.0021848 | C4: 0.000883739 |
| C5: 250 | C6: 0.4 | C7: 1.83312 | C8: 400 |

**PCC Reliability Faulting Standard Deviation**

Pow(0.0097*FAULT,0.5178)+0.014

### RI-jpcp

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

### PCC Cracking

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

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

| Fatigue Coefficients | | Cracking Coefficients | |
|---|---|---|---|
| C1: 2 | C2: 1.22 | C4: 1 | C5: -1.98 |

**PCC Reliability Cracking Standard Deviation**

Pow(5.3116*CRACK,0.3903) + 2.99

**EXHIBIT #17**

# 27880001 Wauk Bypass Section#1 HMA 1-13-15

File Name: C:\ME Designs\12290401 IH43 10-29-14\27880001 Wauk Bypass Section#1 HMA 1-13-15.dgpx

## Design Inputs

Design Life: 18 years
Design Type: Flexible Pavement

Base construction: September, 2017
Pavement construction: October, 2017
Traffic opening: November, 2017

Climate Data Sources (Lat/Lon): 42.761, -87.814

### Design Structure


| Layer type | Material Type | Thickness (in.): |
|---|---|---|
| Flexible | Default asphalt concrete | 7.0 |
| NonStabilized | A-1-a | 14.0 |
| NonStabilized | A-1-a | 16.0 |
| Subgrade | A-4 | Semi-infinite |

Volumetric at Construction:

| | |
|---|---|
| Effective binder content (%) | 9.2 |
| Air voids (%) | 7.0 |

### Traffic

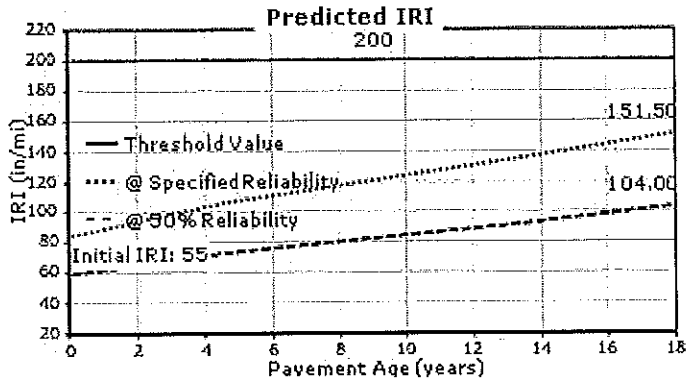
| Age (year) | Heavy Trucks (cumulative) |
|---|---|
| 2017 (initial) | 1,768 |
| 2026 (9 years) | 2,513,690 |
| 2035 (18 years) | 5,297,940 |

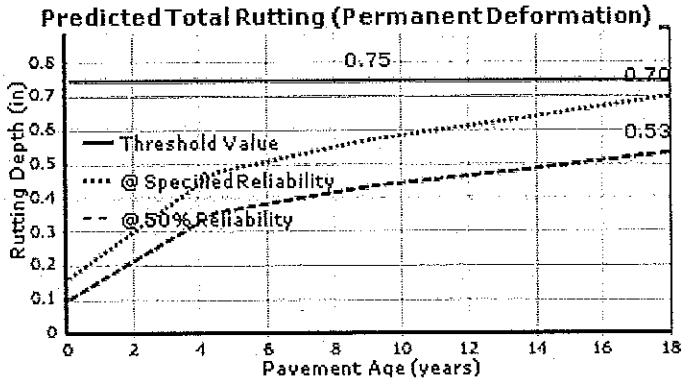
## Design Outputs

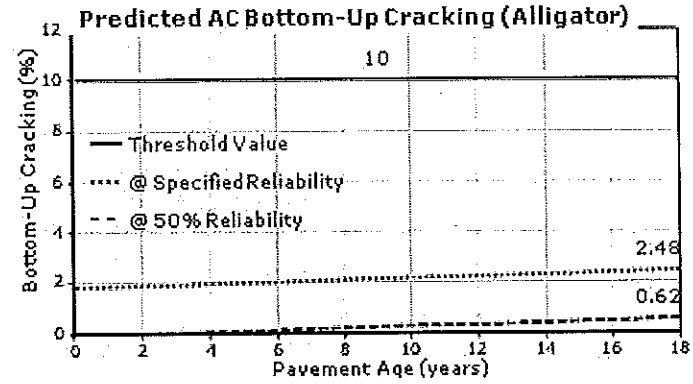
### Distress Prediction Summary

| Distress Type | Distress @ Specified Reliability | | Reliability (%) | | Criterion Satisfied? |
|---|---|---|---|---|---|
| | Target | Predicted | Target | Achieved | |
| Terminal IRI (in./mile) | 200.00 | 151.48 | 95.00 | 99.96 | Pass |
| Permanent deformation - total pavement (in.) | 0.75 | 0.70 | 95.00 | 98.37 | Pass |
| AC bottom-up fatigue cracking (percent) | 10.00 | 2.48 | 95.00 | 100.00 | Pass |
| AC thermal cracking (ft/mile) | 1500.00 | 35.48 | 95.00 | 100.00 | Pass |
| AC top-down fatigue cracking (ft/mile) | 5000.00 | 1917.42 | 95.00 | 100.00 | Pass |
| Permanent deformation - AC only (in.) | 0.40 | 0.37 | 95.00 | 97.94 | Pass |

### Distress Charts



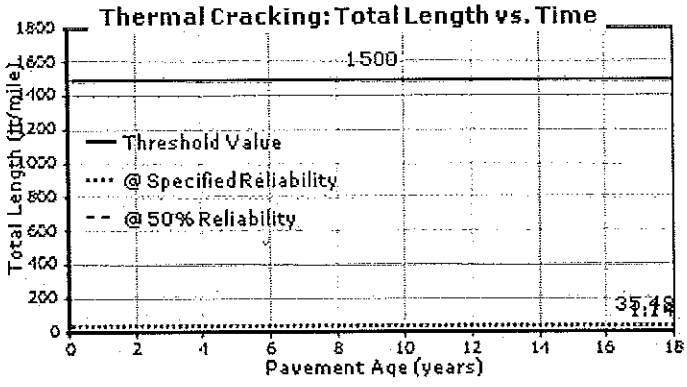
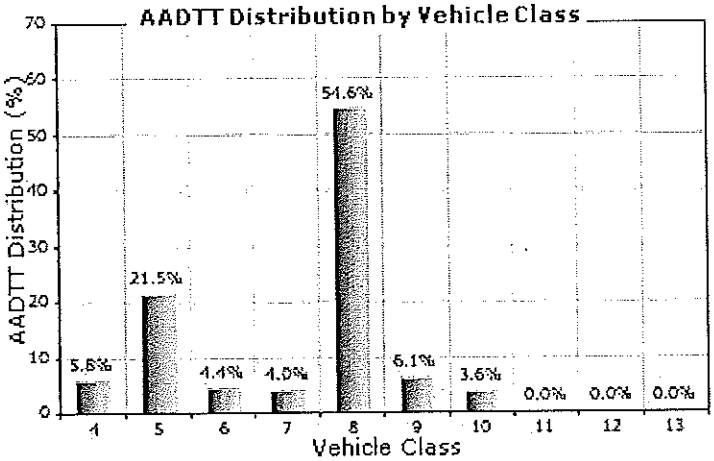



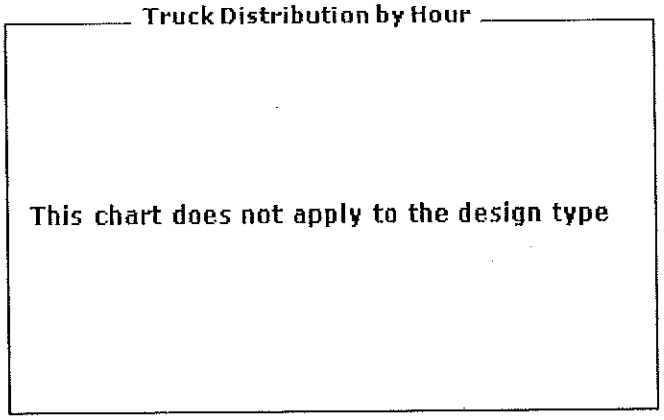

**EXHIBIT #18**

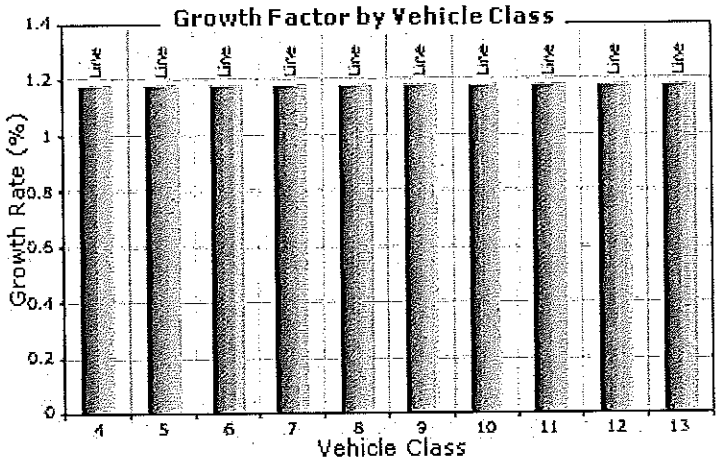
## Traffic Inputs

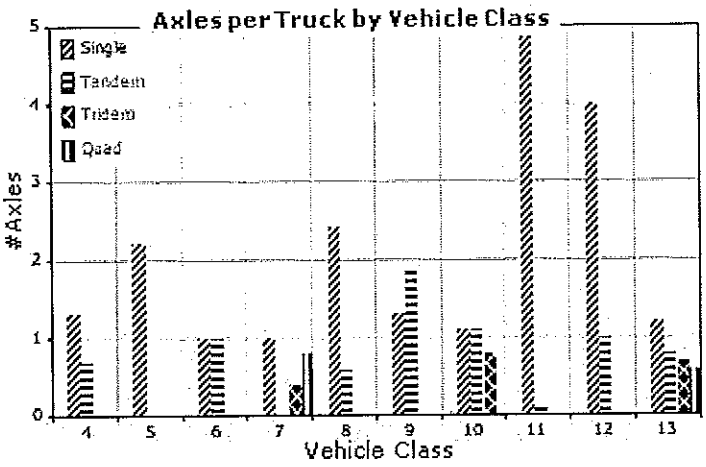
### Graphical Representation of Traffic Inputs

| | | | |
|---|---|---|---|
| Initial two-way AADTT: | 1,768 | Percent of trucks in design direction (%): | 50.0 |
| Number of lanes in design direction: | 4 | Percent of trucks in design lane (%): | 90.0 |
| | | Operational speed (mph) | 45.0 |

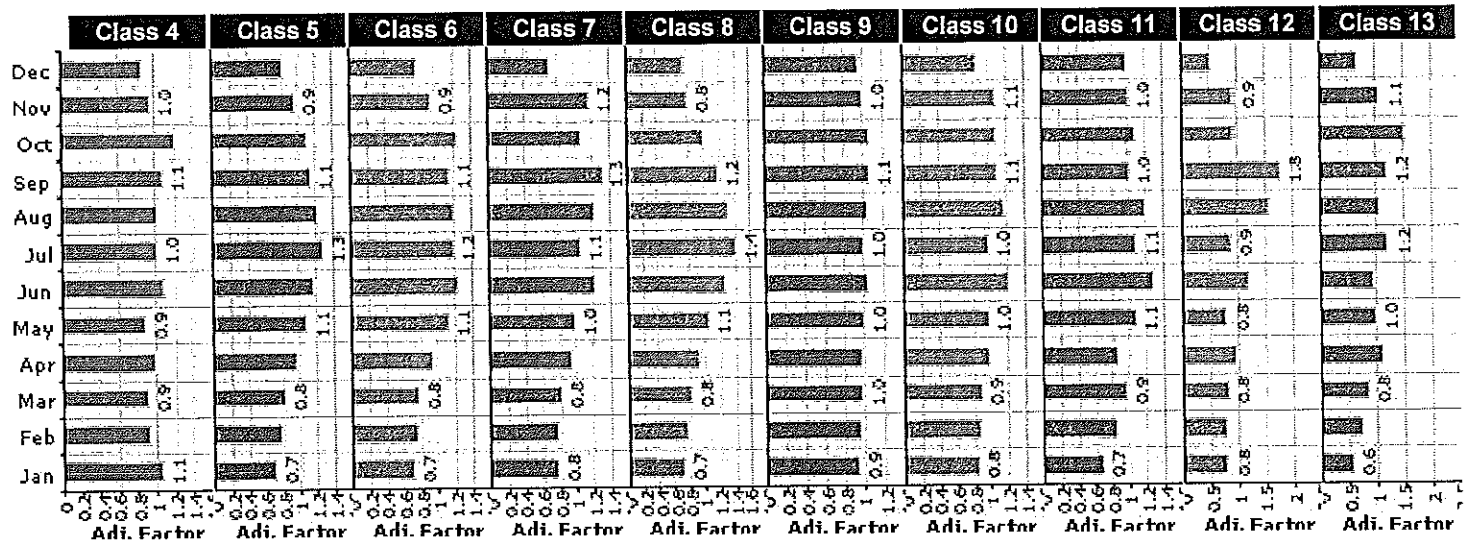



### Traffic Volume Monthly Adjustment Factors



## 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 | 1.1 | 0.7 | 0.7 | 0.8 | 0.7 | 0.9 | 0.8 | 0.7 | 0.8 | 0.6 |
| February | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 1.0 | 0.9 | 0.8 | 0.8 | 0.7 |
| March | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 1.0 | 0.9 | 0.9 | 0.8 | 0.8 |
| April | 1.0 | 1.0 | 0.9 | 0.9 | 0.9 | 1.0 | 1.0 | 0.9 | 1.0 | 1.1 |
| May | 0.9 | 1.1 | 1.1 | 1.0 | 1.1 | 1.0 | 1.0 | 1.1 | 0.8 | 1.0 |
| June | 1.1 | 1.2 | 1.2 | 1.2 | 1.3 | 1.1 | 1.2 | 1.3 | 1.2 | 1.0 |
| July | 1.0 | 1.3 | 1.2 | 1.1 | 1.4 | 1.0 | 1.0 | 1.1 | 0.9 | 1.2 |
| August | 1.0 | 1.2 | 1.2 | 1.2 | 1.3 | 1.1 | 1.2 | 1.2 | 1.6 | 1.1 |
| September | 1.1 | 1.1 | 1.1 | 1.3 | 1.2 | 1.1 | 1.1 | 1.0 | 1.8 | 1.2 |
| October | 1.2 | 1.1 | 1.2 | 1.1 | 1.0 | 1.1 | 1.1 | 1.1 | 0.9 | 1.5 |
| November | 1.0 | 0.9 | 0.9 | 1.2 | 0.8 | 1.0 | 1.1 | 1.0 | 0.9 | 1.1 |
| December | 0.9 | 0.8 | 0.8 | 0.7 | 0.7 | 1.0 | 0.8 | 1.0 | 0.5 | 0.7 |

### Distributions by Vehicle Class

| Vehicle Class | AADTT Distribution (%) (Level 3) | Growth Factor | |
|---|---|---|---|
| | | Rate (%) | Function |
| Class 4 | 5.8% | 1.179% | Linear |
| Class 5 | 21.5% | 1.179% | Linear |
| Class 6 | 4.4% | 1.179% | Linear |
| Class 7 | 4% | 1.179% | Linear |
| Class 8 | 54.6% | 1.179% | Linear |
| Class 9 | 6.1% | 1.179% | Linear |
| Class 10 | 3.6% | 1.179% | Linear |
| Class 11 | 0% | 1.179% | Linear |
| Class 12 | 0% | 1.179% | Linear |
| Class 13 | 0% | 1.179% | Linear |

### Truck Distribution by Hour

| Hour | Distribution (%) | Hour | Distribution (%) |
|---|---|---|---|
| 12 AM | 1.02% | 12 PM | 7.3% |
| 1 AM | 0.93% | 1 PM | 7.09% |
| 2 AM | 1.25% | 2 PM | 6.82% |
| 3 AM | 1.58% | 3 PM | 6.23% |
| 4 AM | 2.39% | 4 PM | 5.44% |
| 5 AM | 3.46% | 5 PM | 4.44% |
| 6 AM | 5.19% | 6 PM | 3.58% |
| 7 AM | 6.12% | 7 PM | 2.67% |
| 8 AM | 6.59% | 8 PM | 2.14% |
| 9 AM | 6.93% | 9 PM | 1.79% |
| 10 AM | 7.09% | 10 PM | 1.56% |
| 11 AM | 7.3% | 11 PM | 1.09% |
| | | Total | 100% |

### Axle Configuration

| Traffic Wander | |
|---|---|
| Mean wheel location (in.) | 15 |
| 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

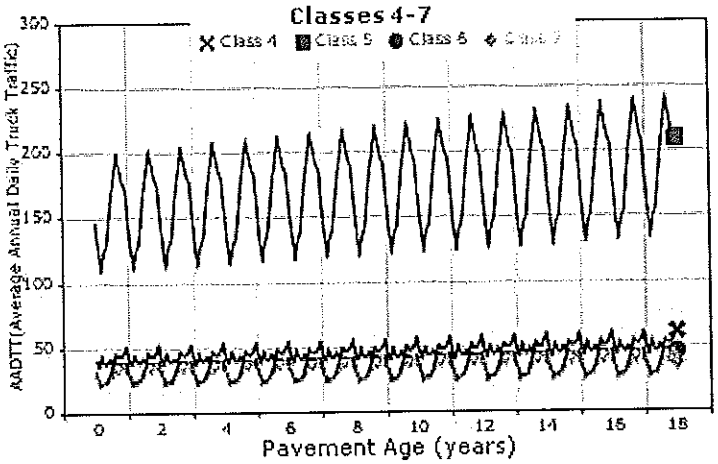
### Number of Axles per Truck

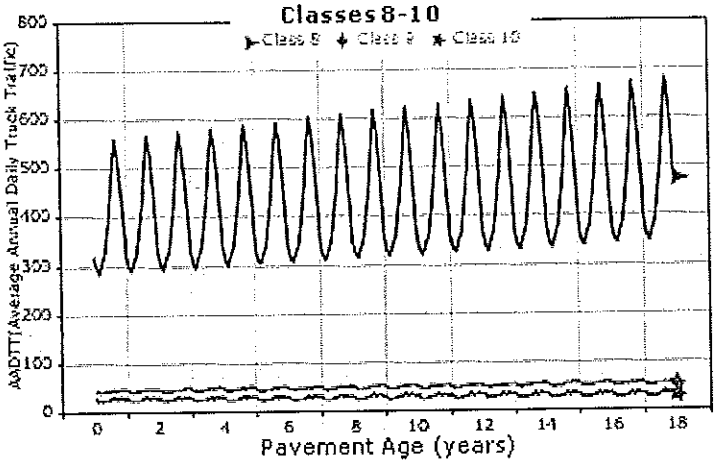
| Vehicle Class | Single Axle | Tandem Axle | Tridem Axle | Quad Axle |
|---|---|---|---|---|
| Class 4 | 1.3 | 0.7 | 0 | 0 |
| Class 5 | 2.2 | 0 | 0 | 0 |
| Class 6 | 1 | 1 | 0 | 0 |
| Class 7 | 1 | 0 | 0.4 | 0.8 |
| Class 8 | 2.4 | 0.6 | 0 | 0 |
| Class 9 | 1.3 | 1.9 | 0 | 0 |
| Class 10 | 1.1 | 1.1 | 0.8 | 0 |
| Class 11 | 4.9 | 0.1 | 0 | 0 |
| Class 12 | 4 | 1 | 0 | 0 |
| Class 13 | 1.2 | 0.8 | 0.7 | 0.6 |

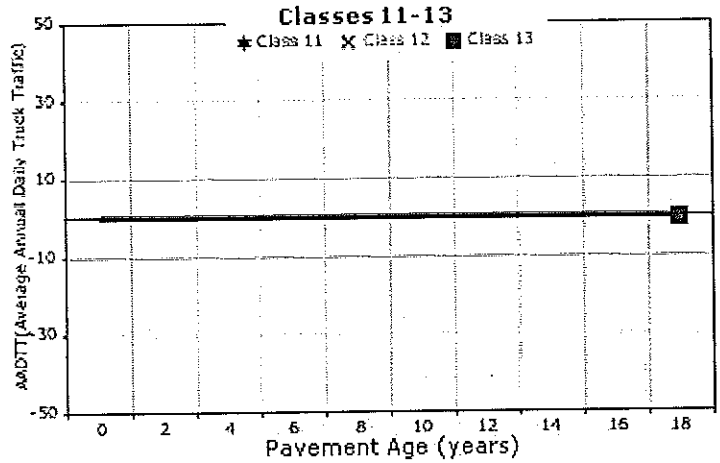
**EXHIBIT #20**

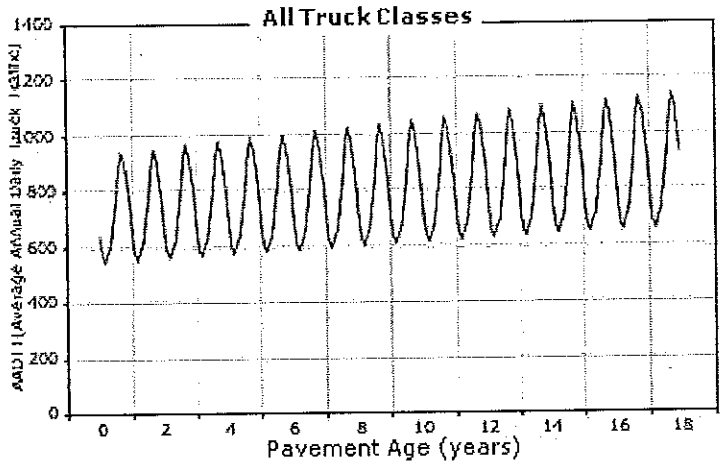
## AADTT (Average Annual Daily Truck Traffic) Growth

* Traffic cap is not enforced



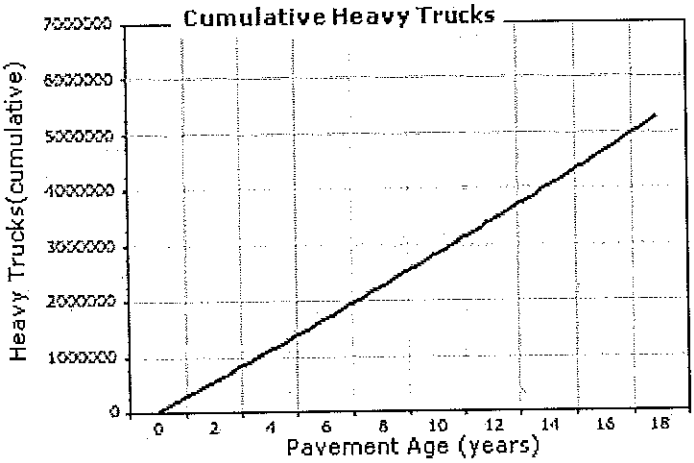
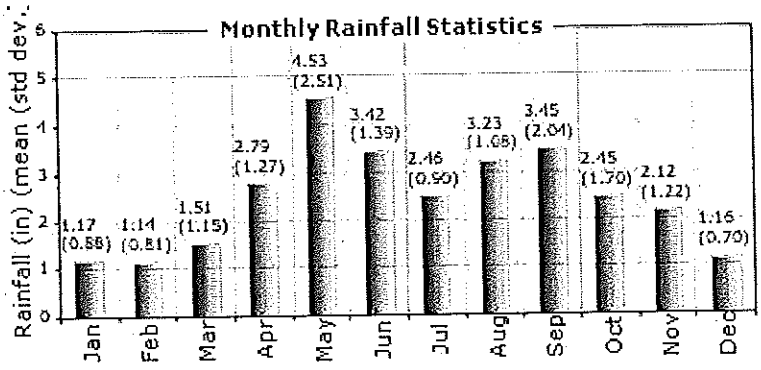




**EXHIBIT #21**

## Climate Inputs

### Climate Data Sources:

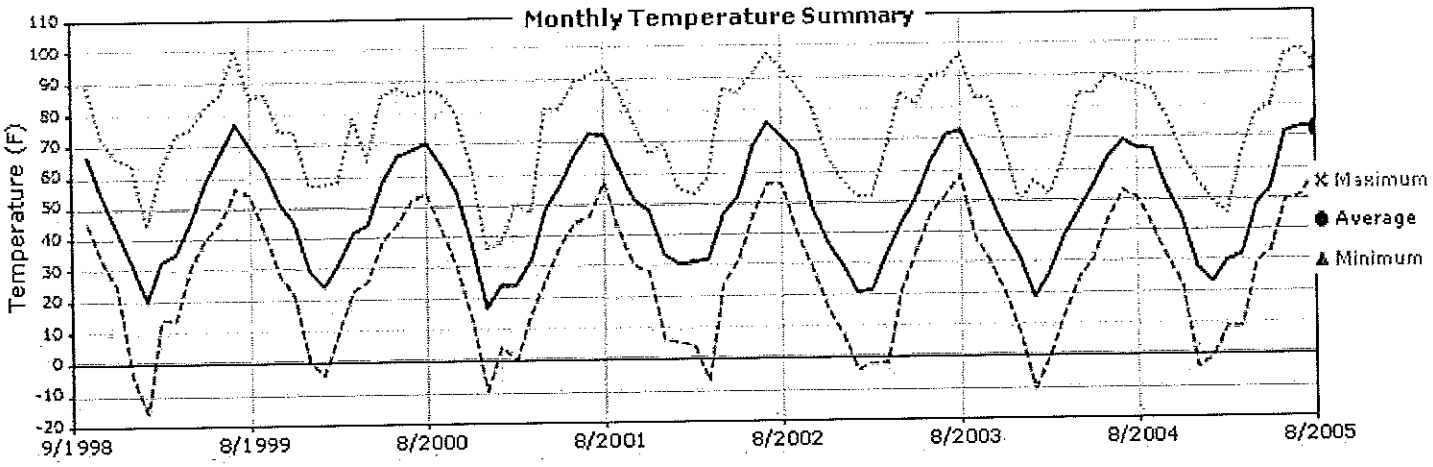
| Climate Station Cities: | Location (lat lon elevation(ft)) |
|---|---|
| RACINE, WI | 42.76100 -87.81400 665 |

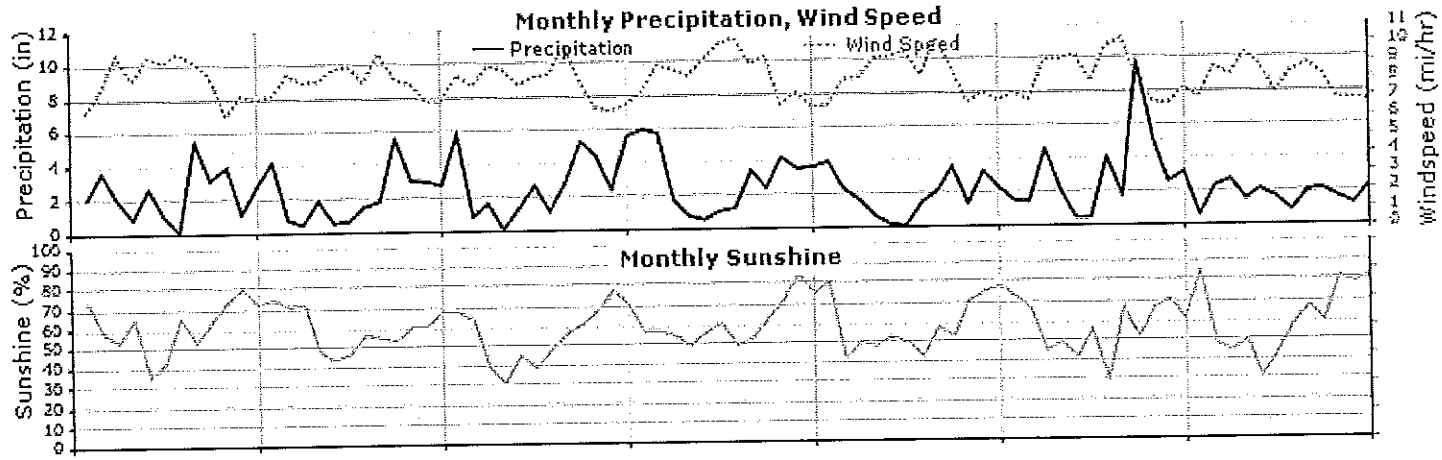



### Annual Statistics:

| | |
|---|---|
| Mean annual air temperature (°F) | 48.60 |
| Mean annual precipitation (in.) | 29.44 |
| Freezing index (°F - days) | 786.30 |
| Average annual number of freeze/thaw cycles: | 55.85 |
| Water table depth (ft) | 10.00 |

### Monthly Climate Summary:







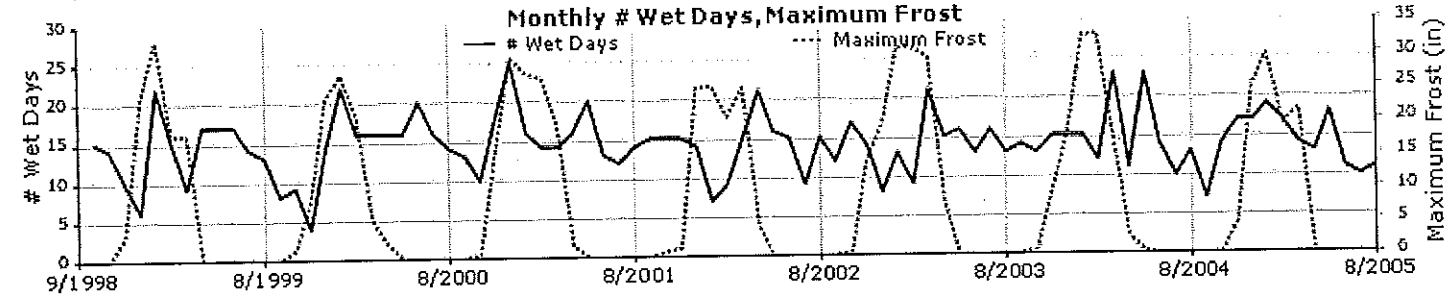



**EXHIBIT #22**

## Hourly Air Temperature Distribution by Month:

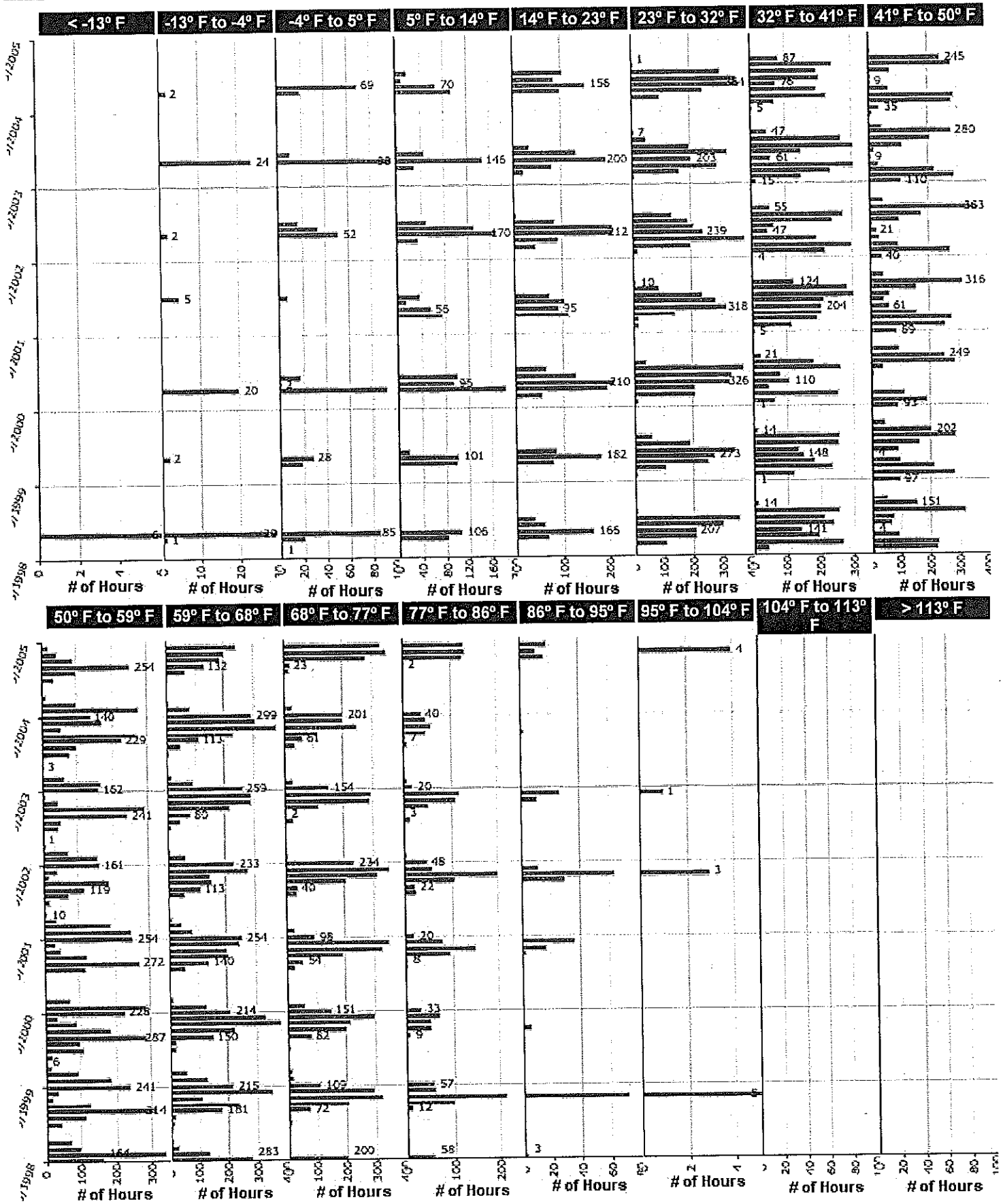



**EXHIBIT #23**

# Design Properties

## HMA Design Properties

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

| Structure - ICM Properties | |
|---|---|
| AC surface shortwave absorptivity | 0.85 |

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

EXHIBIT #24

## Thermal Cracking (Input Level: 3)

| | |
|---|---|
| Indirect tensile strength at 14 °F (psi) | 554.33 |

| 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 | 2.45e-007 | 4.16e-007 | 5.94e-007 |
| 2 | 2.71e-007 | 4.91e-007 | 7.74e-007 |
| 5 | 3.11e-007 | 6.09e-007 | 1.10e-006 |
| 10 | 3.44e-007 | 7.18e-007 | 1.43e-006 |
| 20 | 3.81e-007 | 8.45e-007 | 1.87e-006 |
| 50 | 4.37e-007 | 1.05e-006 | 2.65e-006 |
| 100 | 4.84e-007 | 1.24e-006 | 3.46e-006 |

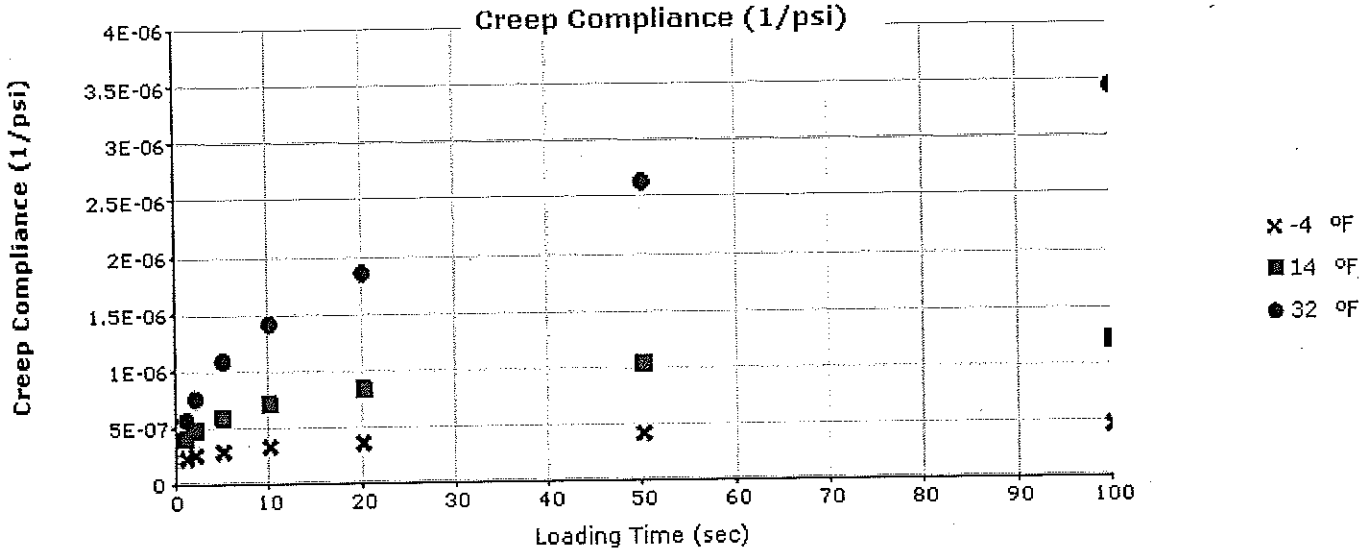
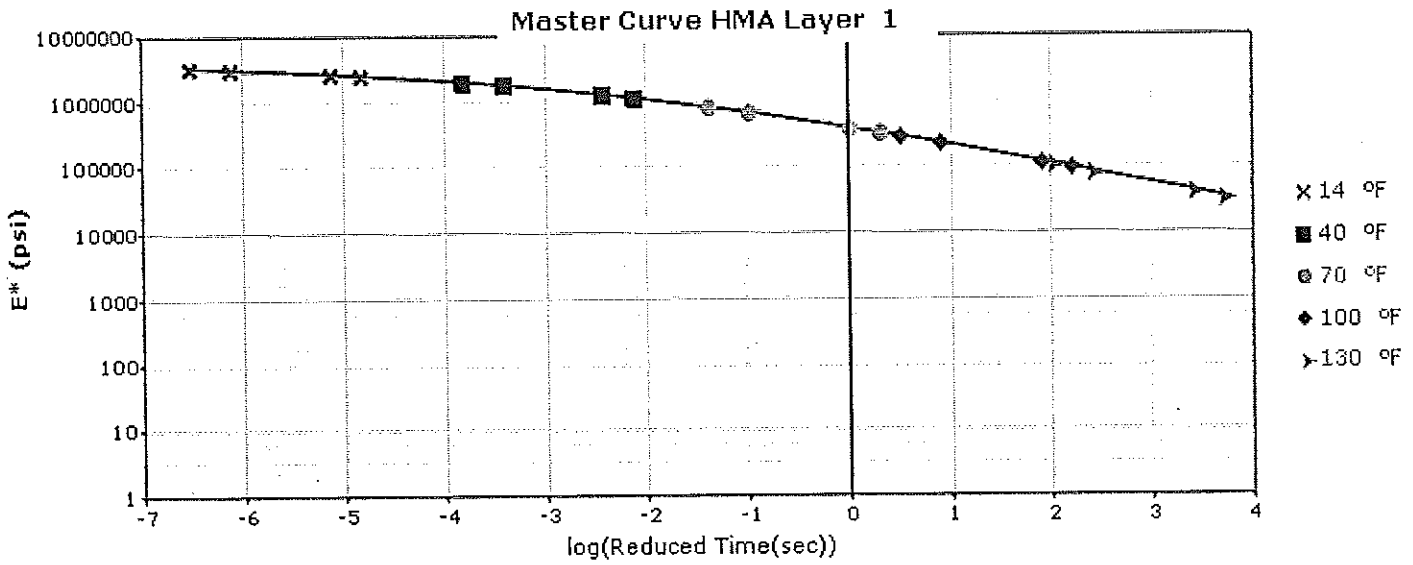
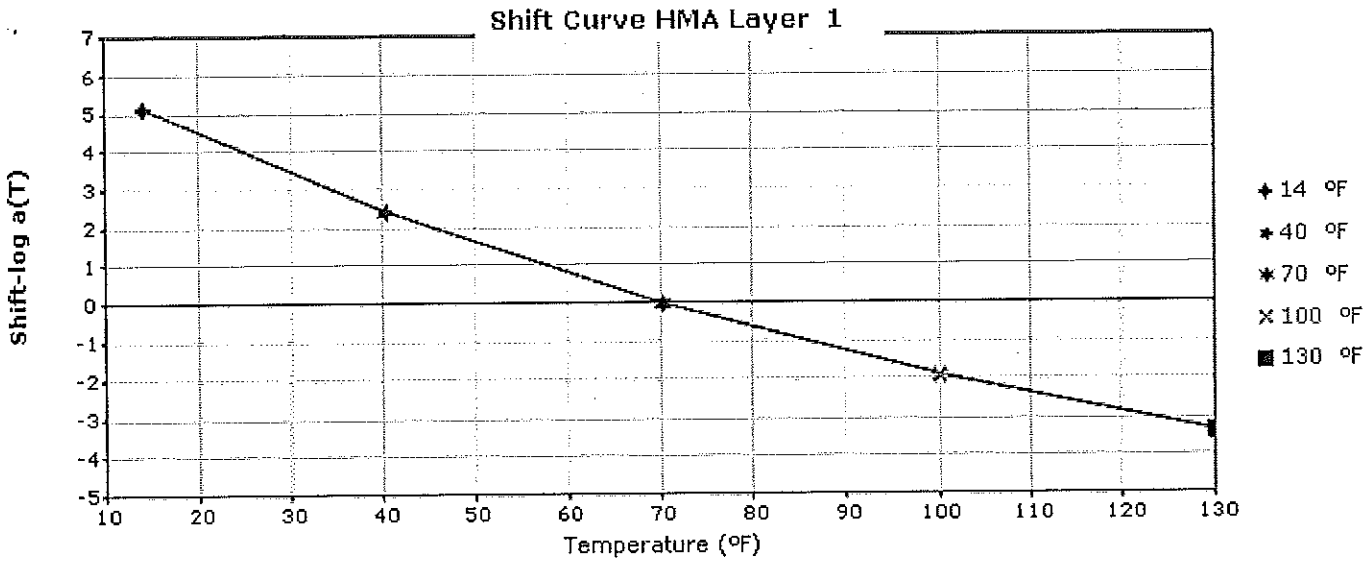



**EXHIBIT #25**

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



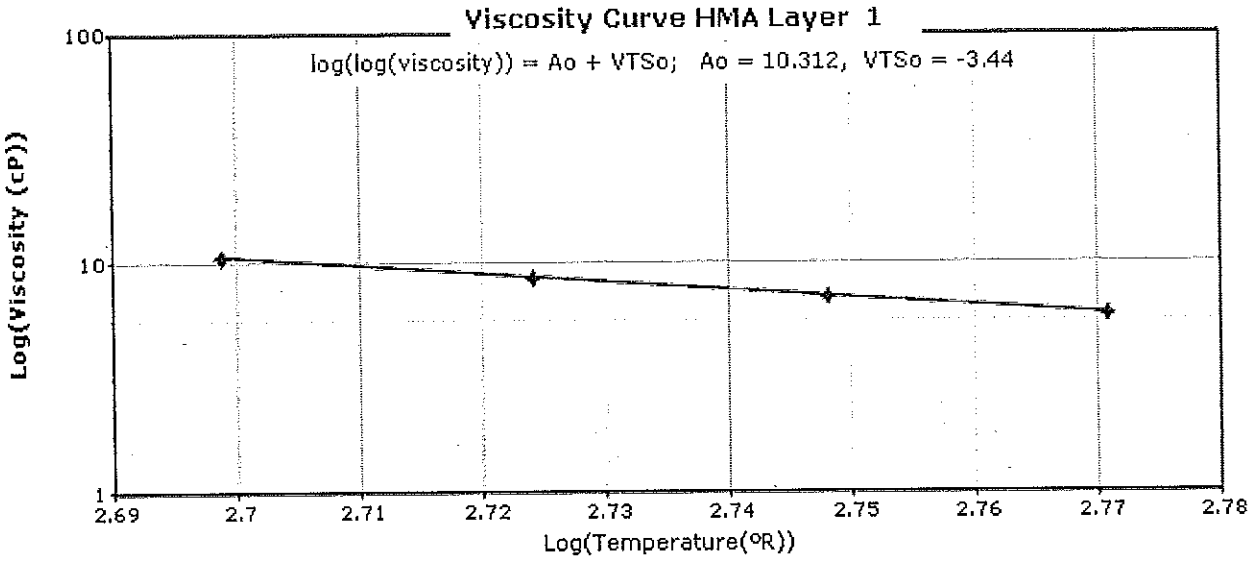
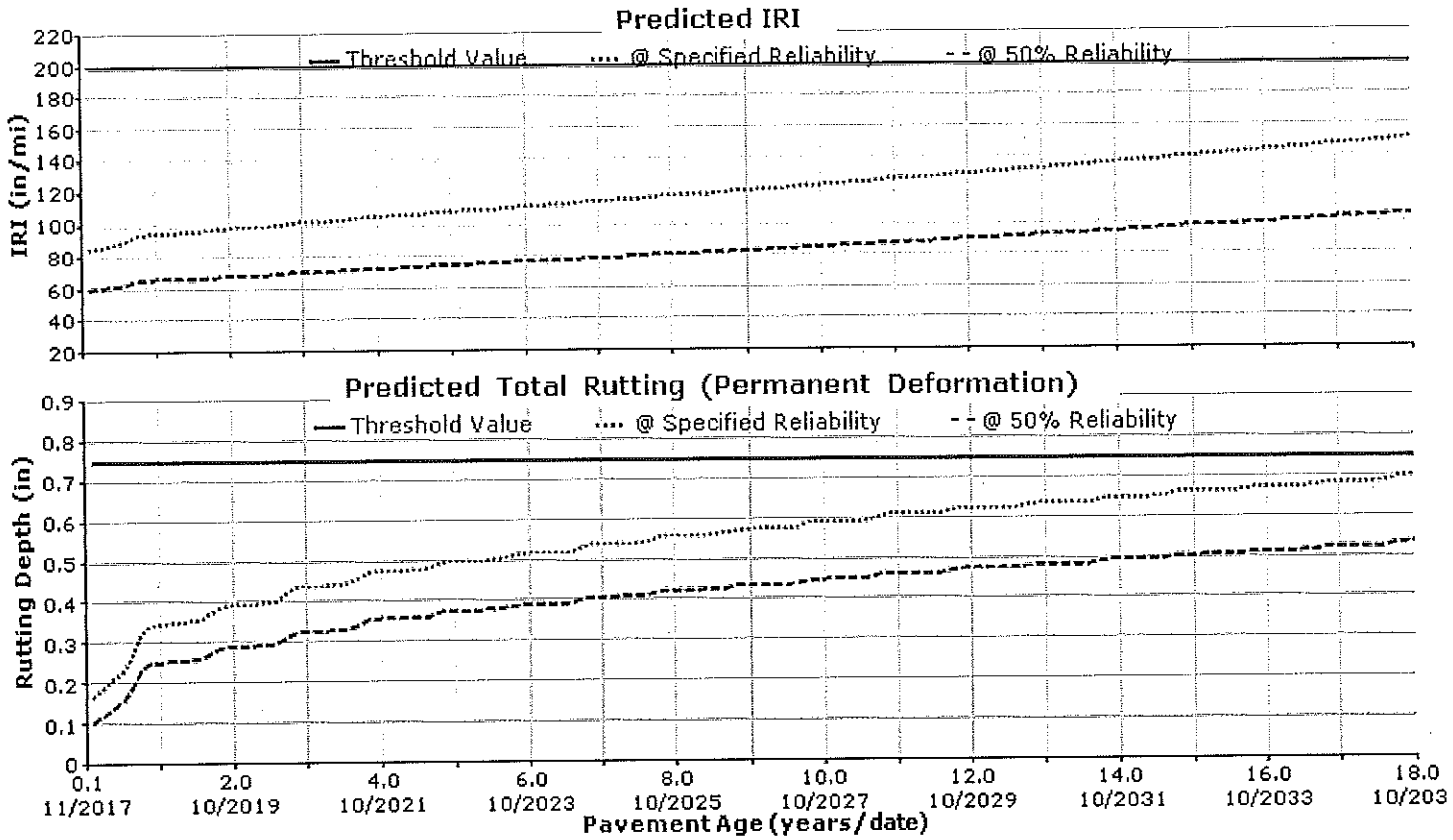



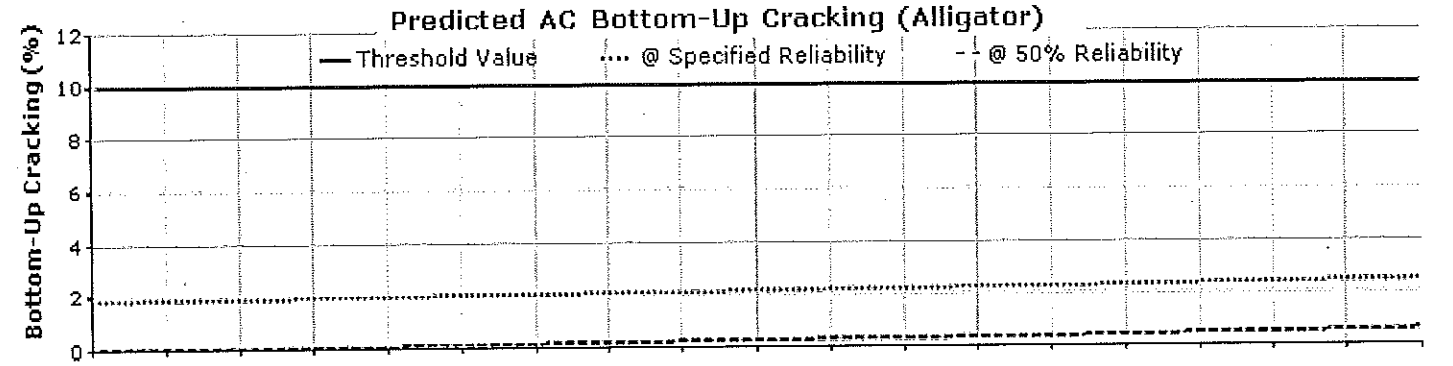

**EXHIBIT #26**

## Analysis Output Charts









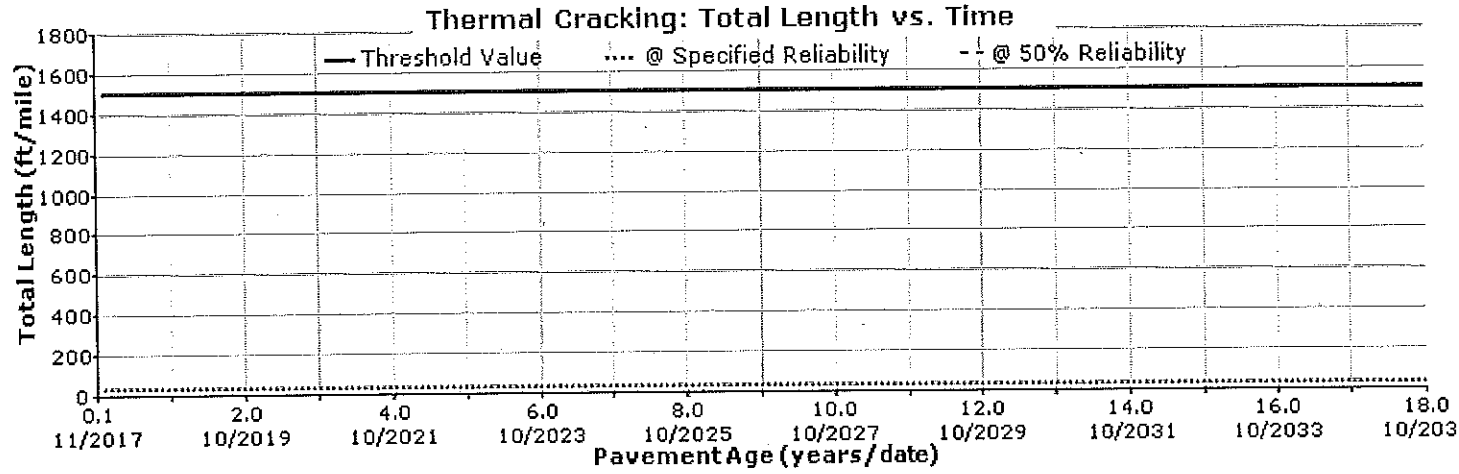
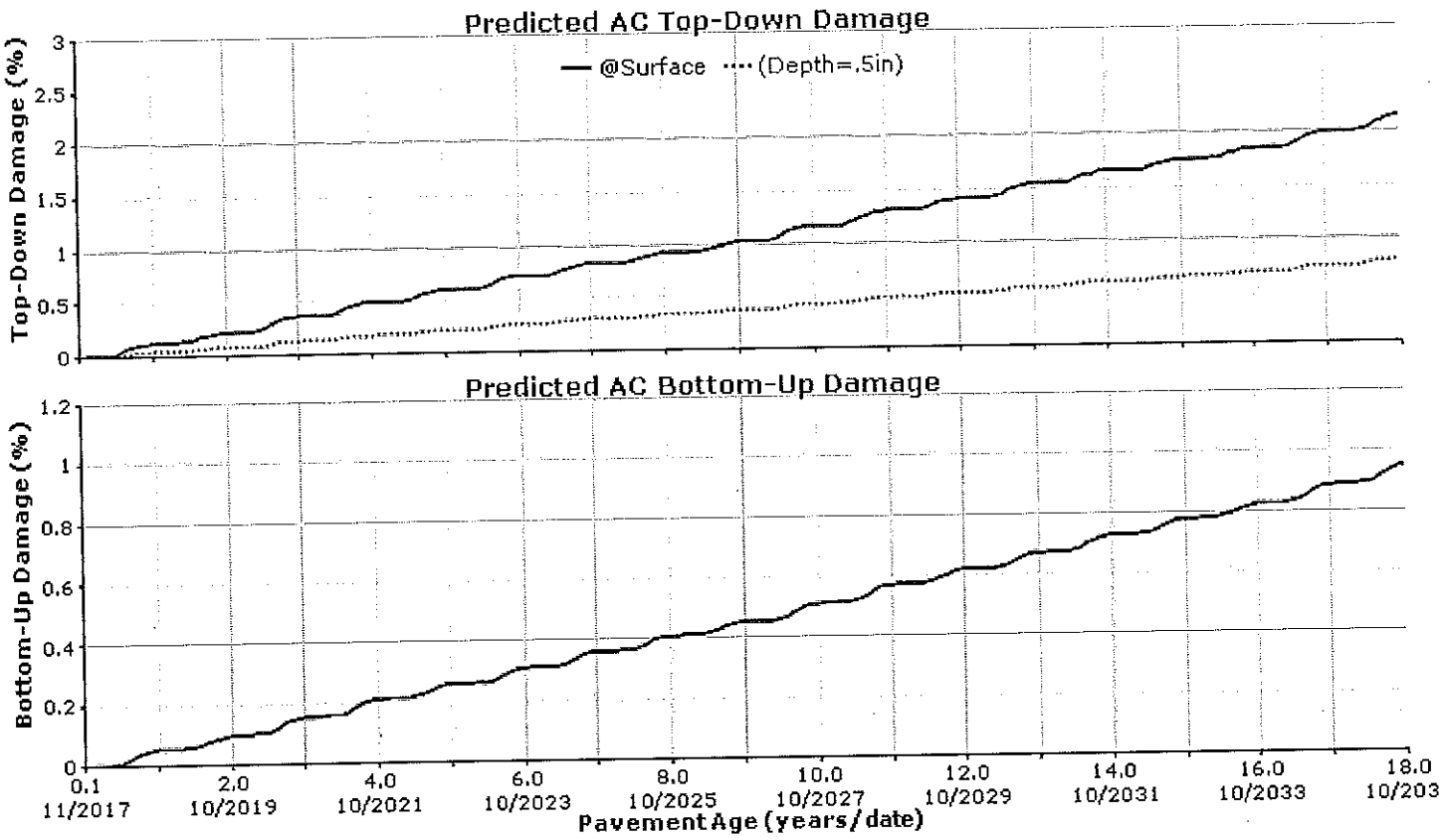




**EXHIBIT #27**


Predicted AC Top-Down Damage
@Surface
(Depth=.5in)
Top-Down Damage (%)
0
0.5
1
1.5
2
2.5
3
Predicted AC Bottom-Up Damage
Bottom-Up Damage (%)
0
0.2
0.4
0.6
0.8
1
1.2
0.1
11/2017
2.0
10/2019
4.0
10/2021
6.0
10/2023
8.0
10/2025
10.0
10/2027
12.0
10/2029
14.0
10/2031
16.0
10/2033
18.0
10/203
Pavement Age (years/date)

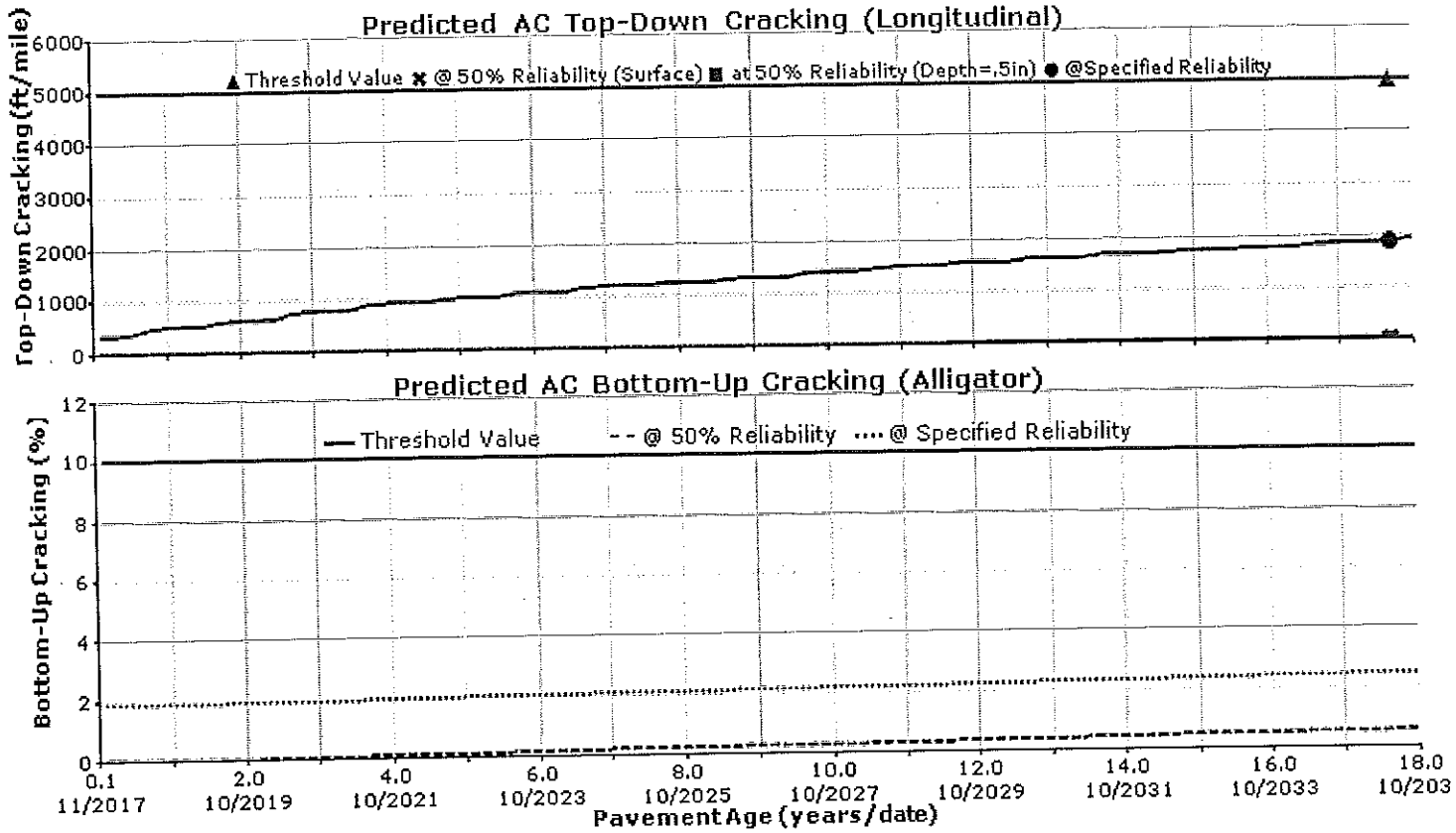

Predicted AC Top-Down Cracking (Longitudinal)
Threshold Value
@ 50% Reliability (Surface)
at 50% Reliability (Depth=.5in)
@Specified Reliability
Top-Down Cracking (ft/mile)
0
1000
2000
3000
4000
5000
6000
Predicted AC Bottom-Up Cracking (Alligator)
Threshold Value
@ 50% Reliability
@ Specified Reliability
Bottom-Up Cracking (%)
0
2
4
6
8
10
12
0.1
11/2017
2.0
10/2019
4.0
10/2021
6.0
10/2023
8.0
10/2025
10.0
10/2027
12.0
10/2029
14.0
10/2031
16.0
10/2033
18.0
10/203
Pavement Age (years/date)

**EXHIBIT #28**

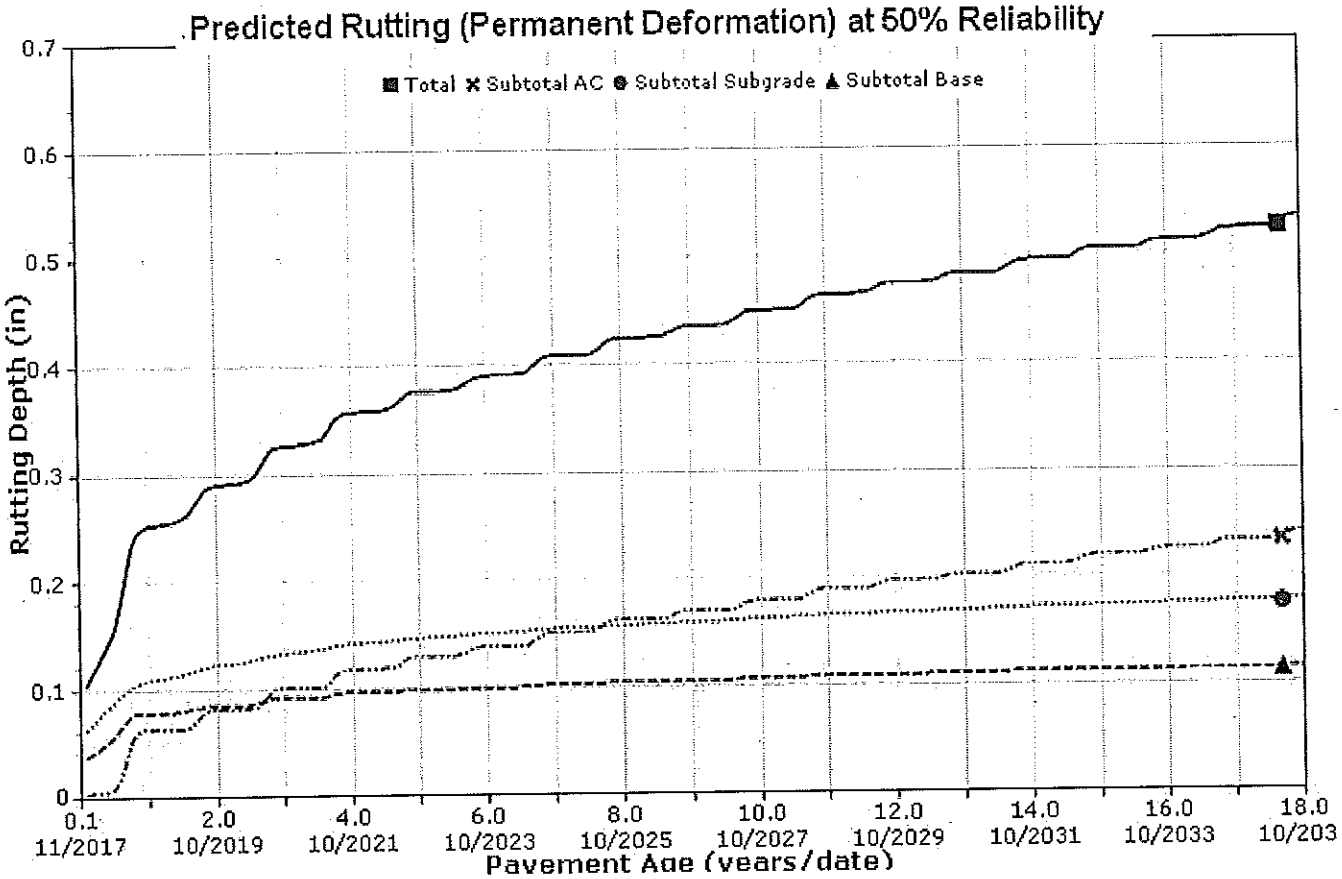
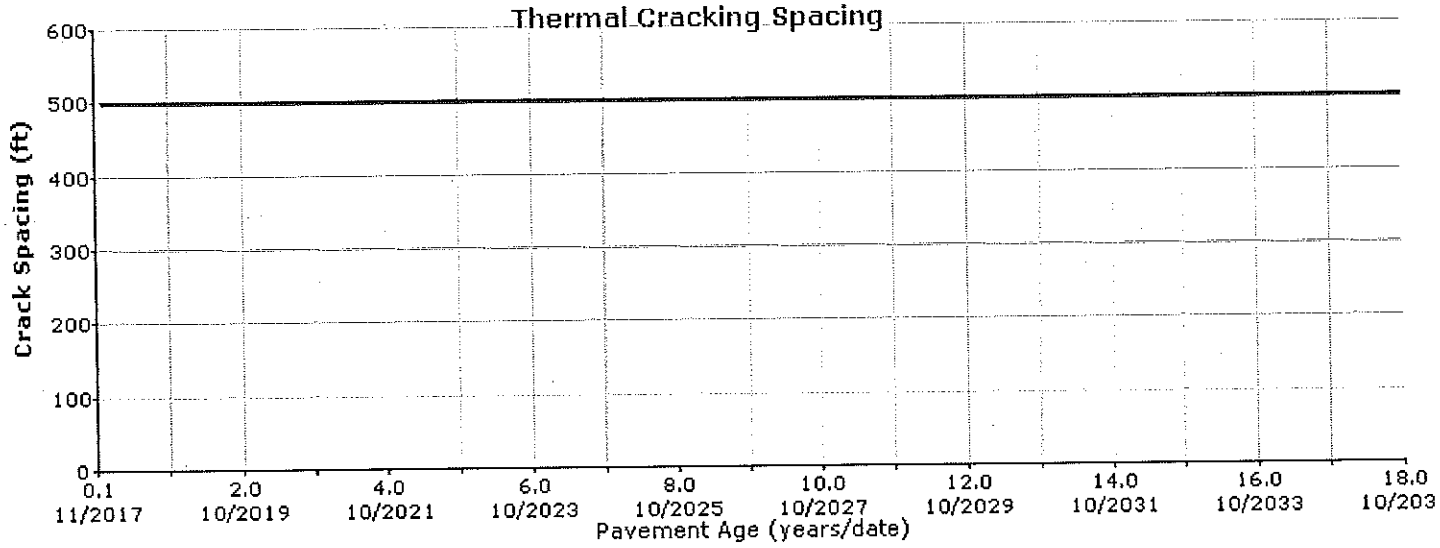

Predicted Rutting (Permanent Deformation) at 50% Reliability
Total
Subtotal AC
Subtotal Subgrade
Subtotal Base
Rutting Depth (in)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
11/2017
2.0
10/2019
4.0
10/2021
6.0
10/2023
8.0
10/2025
10.0
10/2027
12.0
10/2029
14.0
10/2031
16.0
10/2033
18.0
10/203
Pavement Age (years/date)

**EXHIBIT #29**


Thermal Cracking Spacing
Crack Spacing (ft)
600
500
400
300
200
100
0
0.1
11/2017
2.0
10/2019
4.0
10/2021
6.0
10/2023
8.0
10/2025
10.0
10/2027
12.0
10/2029
14.0
10/2031
16.0
10/2033
18.0
10/203
Pavement Age (years/date)

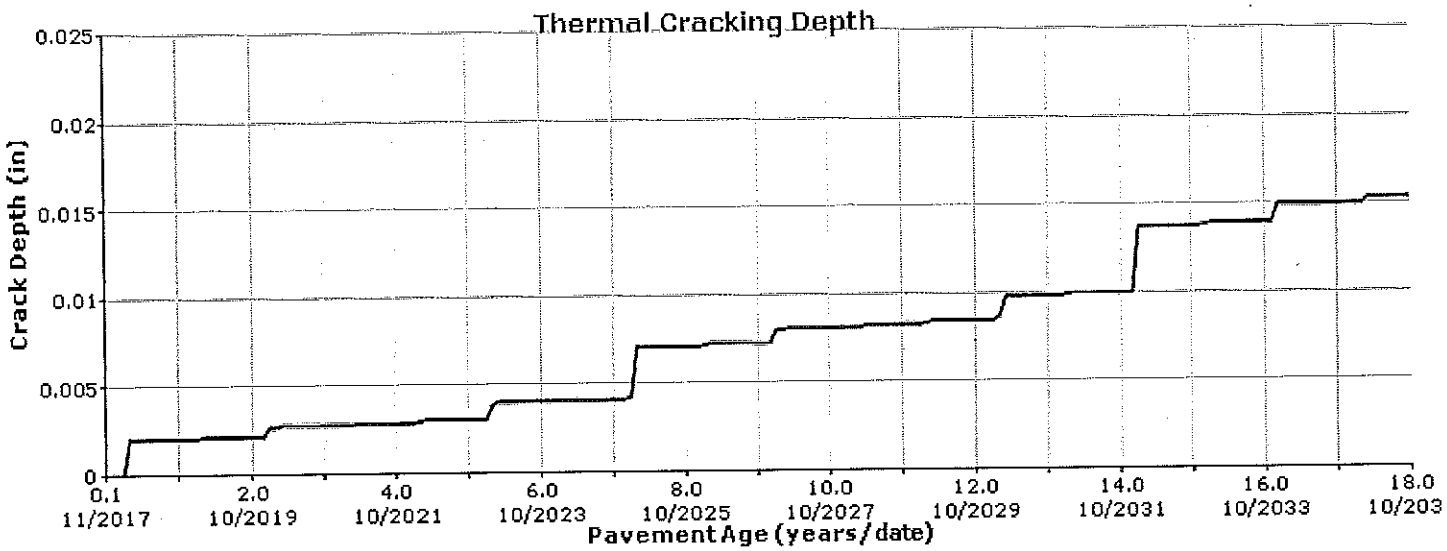
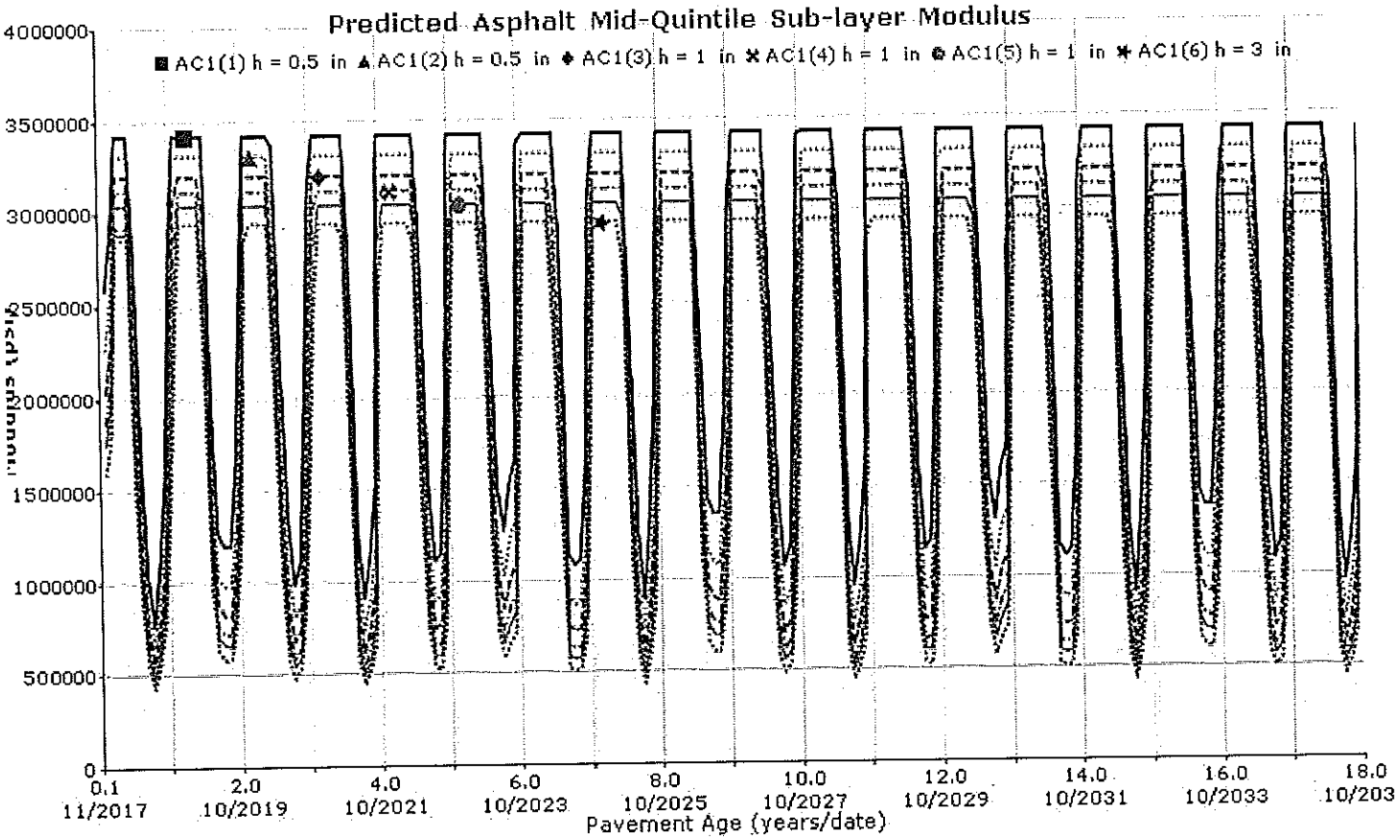
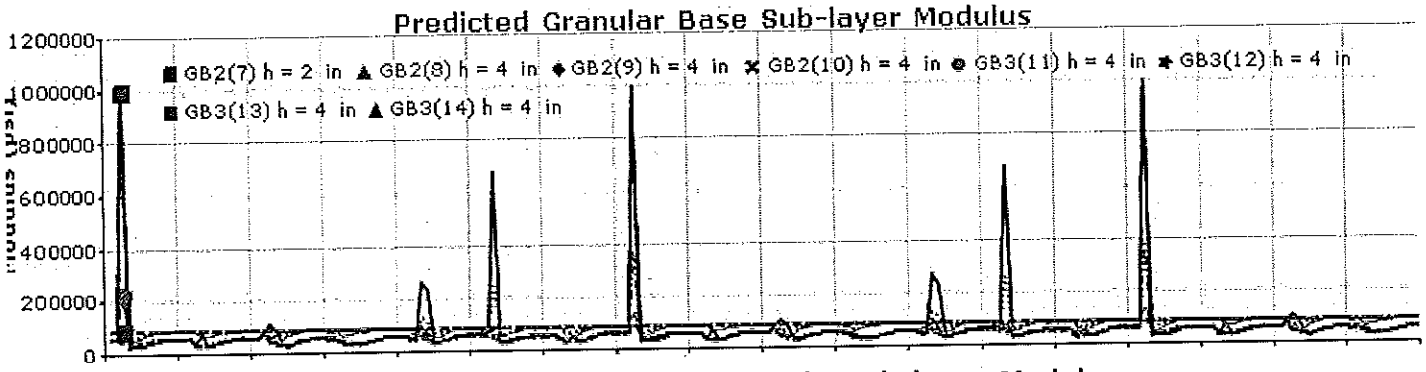

Thermal Cracking Depth
Crack Depth (in)
0.025
0.02
0.015
0.01
0.005
0
0.1
11/2017
2.0
10/2019
4.0
10/2021
6.0
10/2023
8.0
10/2025
10.0
10/2027
12.0
10/2029
14.0
10/2031
16.0
10/2033
18.0
10/203
Pavement Age (years/date)

**EXHIBIT #30**


Predicted Asphalt Mid-Quintile Sub-layer Modulus
AC1(1) h = 0.5 in AC1(2) h = 0.5 in AC1(3) h = 1 in AC1(4) h = 1 in AC1(5) h = 1 in AC1(6) h = 3 in
Modulus (psi)
4000000
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
0.1 11/2017
2.0 10/2019
4.0 10/2021
6.0 10/2023
8.0 10/2025
10.0 10/2027
12.0 10/2029
14.0 10/2031
16.0 10/2033
18.0 10/203
Pavement Age (years/date)


Predicted Granular Base Sub-layer Modulus
GB2(7) h = 2 in GB2(8) h = 4 in GB2(9) h = 4 in GB2(10) h = 4 in GB3(11) h = 4 in GB3(12) h = 4 in
GB3(13) h = 4 in GB3(14) h = 4 in
Modulus (psi)
1200000
1000000
800000
600000
400000
200000
0

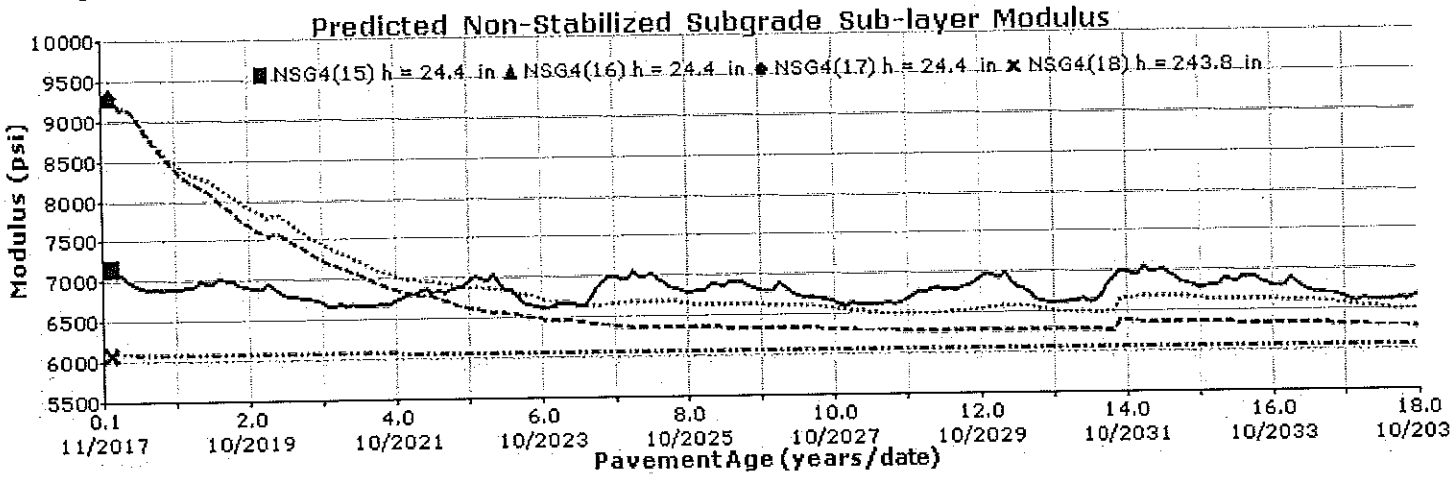

Predicted Non-Stabilized Subgrade Sub-layer Modulus
NSG4(15) h = 24.4 in NSG4(16) h = 24.4 in NSG4(17) h = 24.4 in NSG4(18) h = 243.8 in
Modulus (psi)
10000
9500
9000
8500
8000
7500
7000
6500
6000
5500
0.1 11/2017
2.0 10/2019
4.0 10/2021
6.0 10/2023
8.0 10/2025
10.0 10/2027
12.0 10/2029
14.0 10/2031
16.0 10/2033
18.0 10/203
Pavement Age (years/date)

**EXHIBIT #31**

# Layer Information

## Layer 1 Flexible : Default asphalt concrete

| Asphalt | | |
|---|---|---|
| Thickness (in.) | 7.0 | |
| Unit weight (pcf) | 145.0 | |
| Poisson's ratio | Is Calculated? | False |
| | Ratio | 0.30 |
| | Parameter A | - |
| | Parameter B | - |

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

| Gradation | Percent Passing |
|---|---|
| 3/4-inch sieve | 95 |
| 3/8-inch sieve | 90 |
| No.4 sieve | 60 |
| No.200 sieve | 5 |

### Asphalt Binder

| Parameter | Value |
|---|---|
| Grade | Superpave Performance Grade |
| Binder Type | 64-28 |
| A | 10.312 |
| VTS | -3.44 |

### General Info

| Name | Value |
|---|---|
| Reference temperature (°F) | 70 |
| Effective binder content (%) | 9.2 |
| 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 | 1/13/2015 12:00:00 AM |
| Approver | |
| Date approved | 1/13/2015 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 |

**EXHIBIT #32**

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

| Unbound | |
|---|---|
| Layer thickness (in.) | 14.0 |
| 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) |
|---|
| 40000.0 |

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

### Identifiers

| Field | Value |
|---|---|
| Display name/identifier | A-1-a |
| Description of object | Default material |
| Author | AASHTO |
| Date Created | 12/9/2014 12:00:00 AM |
| Approver | |
| Date approved | 12/9/2014 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

| | |
|---|---|
| **Liquid Limit** | 25.0 |
| **Plasticity Index** | 6.0 |
| **Is layer compacted?** | True |

| | Is User Defined? | Value |
|---|---|---|
| Maximum dry unit weight (pcf) | False | 128.1 |
| Saturated hydraulic conductivity (ft/hr) | False | 2.616e-02 |
| Specific gravity of solids | False | 2.7 |
| Optimum gravimetric water content (%) | False | 7.2 |

| User-defined Soil Water Characteristic Curve (SWCC) | |
|---|---|
| Is User Defined? | False |
| af | 4.7511 |
| bf | 1.7494 |
| cf | 0.7630 |
| hr | 184.0000 |

| Sieve Size | % Passing |
|---|---|
| 0.001mm | |
| 0.002mm | |
| 0.020mm | |
| #200 | 7.0 |
| #100 | |
| #80 | |
| #60 | |
| #50 | |
| #40 | 18.0 |
| #30 | |
| #20 | |
| #16 | |
| #10 | 32.0 |
| #8 | |
| #4 | 44.0 |
| 3/8-in. | 61.0 |
| 1/2-in. | |
| 3/4-in. | 82.0 |
| 1-in. | |
| 1 1/2-in. | 97.0 |
| 2-in. | |
| 2 1/2-in. | |
| 3-in. | |
| 3 1/2-in. | |

**EXHIBIT #33**

## Layer 3 Non-stabilized Base : A-1-a

| Unbound | |
|---|---|
| Layer thickness (in.) | 16.0 |
| 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) |
|---|
| 42000.0 |

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

### Identifiers

| Field | Value |
|---|---|
| Display name/identifier | A-1-a |
| Description of object | Default material |
| Author | AASHTO |
| Date Created | 12/9/2014 12:00:00 AM |
| Approver | |
| Date approved | 12/9/2014 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

| | |
|---|---|
| **Liquid Limit** | 25.0 |
| **Plasticity Index** | 6.0 |
| **Is layer compacted?** | True |

| | Is User Defined? | Value |
|---|---|---|
| Maximum dry unit weight (pcf) | False | 109.6 |
| Saturated hydraulic conductivity (ft/hr) | False | 8.267e+02 |
| Specific gravity of solids | True | 2.6 |
| Optimum gravimetric water content (%) | True | 16.6 |

| User-defined Soil Water Characteristic Curve (SWCC) | |
|---|---|
| Is User Defined? | False |
| af | 9.2765 |
| bf | 3.7128 |
| cf | 2.9466 |
| hr | 160.0000 |

| Sieve Size | % Passing |
|---|---|
| 0.001mm | |
| 0.002mm | |
| 0.020mm | |
| #200 | 5.0 |
| #100 | |
| #80 | |
| #60 | |
| #50 | |
| #40 | |
| #30 | |
| #20 | |
| #16 | |
| #10 | 10.0 |
| #8 | |
| #4 | |
| 3/8-in. | |
| 1/2-in. | 30.0 |
| 3/4-in. | |
| 1-in. | |
| 1 1/2-in. | 60.0 |
| 2-in. | |
| 2 1/2-in. | |
| 3-in. | |
| 3 1/2-in. | 90.0 |

**EXHIBIT #34**

## Layer 4 Subgrade : A-4

| 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) |
|---|
| 9450.0 |

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

### Identifiers

| Field | Value |
|---|---|
| Display name/identifier | A-4 |
| Description of object | Default material |
| Author | AASHTO |
| Date Created | 1/13/2015 12:00:00 AM |
| Approver | |
| Date approved | 1/13/2015 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

| | |
|---|---|
| **Liquid Limit** | 25.0 |
| **Plasticity Index** | 6.0 |
| **Is layer compacted?** | False |

| | Is User Defined? | Value |
|---|---|---|
| Maximum dry unit weight (pcf) | True | 116 |
| Saturated hydraulic conductivity (ft/hr) | False | 9.138e-06 |
| Specific gravity of solids | True | 2.65 |
| Optimum gravimetric water content (%) | True | 14 |

| User-defined Soil Water Characteristic Curve (SWCC) | |
|---|---|
| Is User Defined? | False |
| af | 69.7987 |
| bf | 0.9890 |
| cf | 0.4694 |
| hr | 500.0000 |

| Sieve Size | % Passing |
|---|---|
| 0.001mm | |
| 0.002mm | |
| 0.020mm | |
| #200 | 52.0 |
| #100 | |
| #80 | |
| #60 | |
| #50 | |
| #40 | 65.0 |
| #30 | |
| #20 | |
| #16 | |
| #10 | 74.0 |
| #8 | |
| #4 | 85.0 |
| 3/8-in. | |
| 1/2-in. | |
| 3/4-in. | |
| 1-in. | |
| 1 1/2-in. | |
| 2-in. | |
| 2 1/2-in. | |
| 3-in. | |
| 3 1/2-in. | |

**EXHIBIT #35**

## Calibration Coefficients

### AC Fatigue

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

$$C = 10^M$$

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

| | |
|---|---|
| k1: 0.007566 | |
| k2: 3.9492 | |
| k3: 1.281 | |
| Bf1: 1 | |
| Bf2: 1 | |
| Bf3: 1 | |

### AC Rutting

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

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

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

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

*Where:*

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

$\varepsilon_p = plastic\ strain\left(^{in}/_{in}\right)$

$\varepsilon_r = resilient\ strain\left(^{in}/_{in}\right)$

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

$N = number\ of\ load\ repetitions$

| | | |
|---|---|---|
| K1: -3.35412 | K2: 1.5606 | K3: 0.4791 |
| Br2: 1 | Br3: 1 | Br1: 1 |

**AC Rutting Standard Deviation**

0.24*Pow(RUT,0.8026)+0.001

### 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: 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

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

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

| | | | |
|---|---|---|---|
| k1: 1 | k2: 1 | Bc1: 1 | Bc2:1 |

**EXHIBIT #36**

## 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
$N$ = number of repetitions
$\varepsilon_v$ = average veritcal strain(in/in)
$\varepsilon_0, \beta, \rho$ = material properties
$\varepsilon_r$ = 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

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

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

**AC Cracking Top Standard Deviation**

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

### AC Bottom Up Cracking

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

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

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

| | | |
|---|---|---|
| c1: 1 | c2: 1 | c3: 6000 |

**AC Cracking Bottom Standard Deviation**

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

## CSM Cracking

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

| | | | |
|---|---|---|---|
| C1: 1 | C2: 1 | C3: 0 | C4: 1000 |

**CSM Standard Deviation**

CTB*1

## IRI Flexible Pavements

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

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

**EXHIBIT #37**

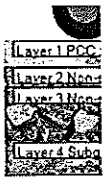
# 27880001 Wauk Bypass Section#2 PCC 1-12-15

File Name: C:\ME Designs\12290401 IH43 10-29-14\27880001 Wauk Bypass Section#2 PCC 1-12-15.dgpx

## Design Inputs

| | | | | | |
|---|---|---|---|---|---|
| Design Life: | 25 years | Existing construction: | - | Climate Data Sources (Lat/Lon) | 42.761, -87.814 |
| Design Type: | Jointed Plain Concrete Pavement (JPCP) | Pavement construction: | September, 2017 | | |
| | | Traffic opening: | October, 2017 | | |

### Design Structure




| Layer type | Material Type | Thickness (in.): |
|---|---|---|
| PCC | JPCP Default | 8.0 |
| NonStabilized | A-1-a | 6.0 |
| NonStabilized | A-1-a | 16.0 |
| Subgrade | A-4 | Semi-infinite |

**Joint Design:**

| | |
|---|---|
| Joint spacing (ft) | 15.0 |
| Dowel diameter (in.) | 1.25 |
| Slab width (ft) | 12.0 |

### Traffic

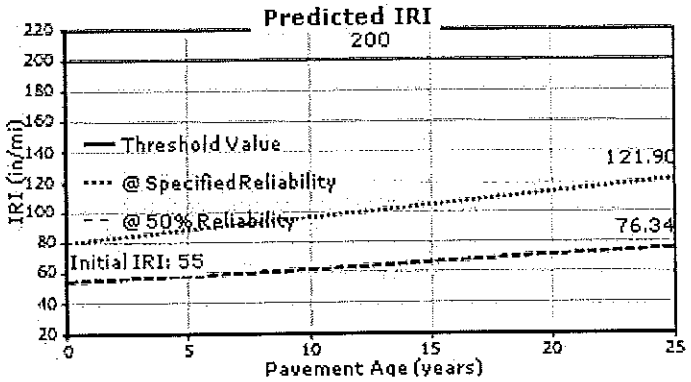
| Age (year) | Heavy Trucks (cumulative) |
|---|---|
| 2017 (initial) | 1,768 |
| 2029 (12 years) | 3,854,030 |
| 2042 (25 years) | 8,292,650 |

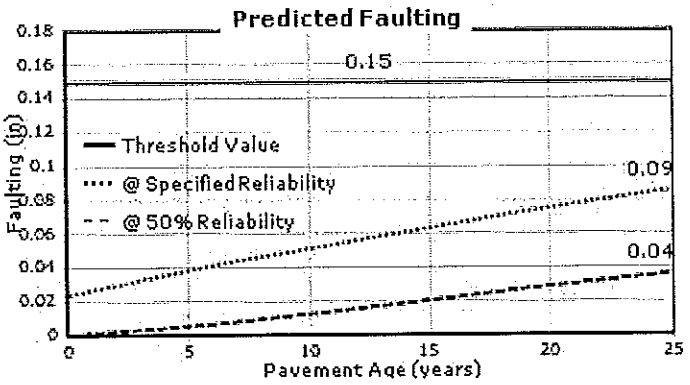
## Design Outputs

### Distress Prediction Summary

| Distress Type | Distress @ Specified Reliability | | Reliability (%) | | Criterion Satisfied? |
|---|---|---|---|---|---|
| | Target | Predicted | Target | Achieved | |
| Terminal IRI (in./mile) | 200.00 | 121.90 | 95.00 | 100.00 | Pass |
| Mean joint faulting (in.) | 0.15 | 0.09 | 95.00 | 99.99 | Pass |
| JPCP transverse cracking (percent slabs) | 15.00 | 7.59 | 95.00 | 99.96 | Pass |

### Distress Charts



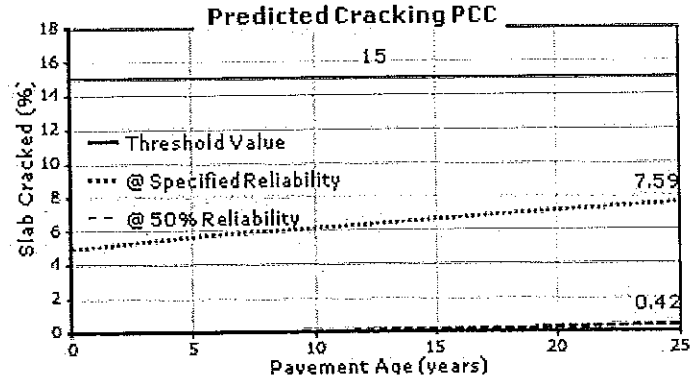
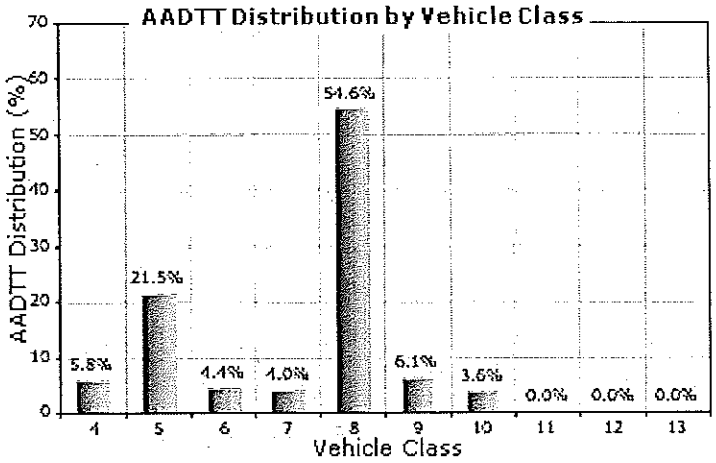



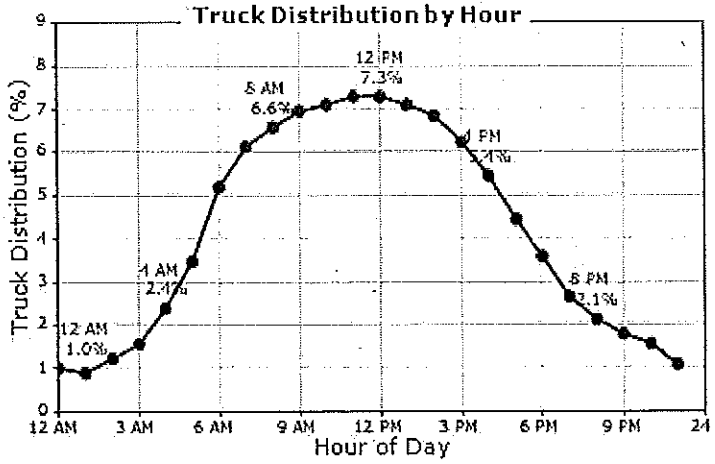

**EXHIBIT #38**

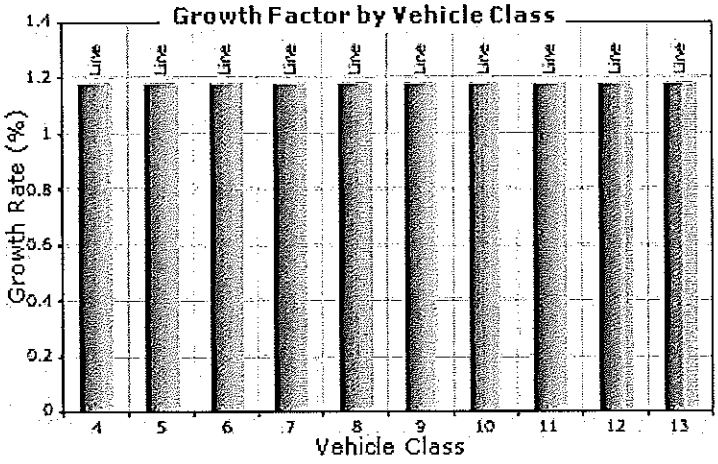
## Traffic Inputs

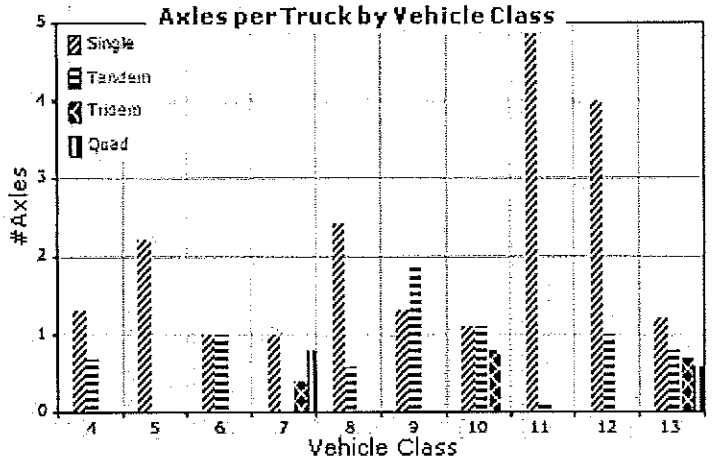
### Graphical Representation of Traffic Inputs

| | | | |
|---|---|---|---|
| Initial two-way AADTT: | 1,768 | Percent of trucks in design direction (%): | 50.0 |
| Number of lanes in design direction: | 4 | Percent of trucks in design lane (%): | 90.0 |
| | | Operational speed (mph) | 35.0 |




### Traffic Volume Monthly Adjustment Factors

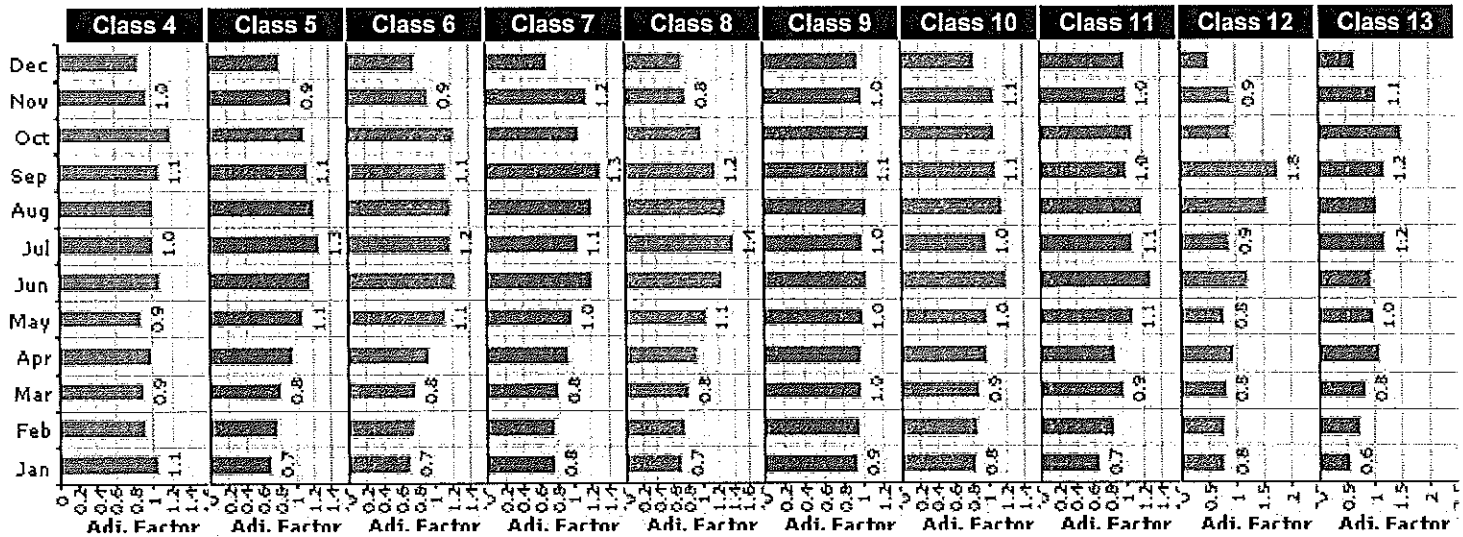



**EXHIBIT #39**

## 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 | 1.1 | 0.7 | 0.7 | 0.8 | 0.7 | 0.9 | 0.8 | 0.7 | 0.8 | 0.6 |
| February | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 1.0 | 0.9 | 0.8 | 0.8 | 0.7 |
| March | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 1.0 | 0.9 | 0.9 | 0.8 | 0.8 |
| April | 1.0 | 1.0 | 0.9 | 0.9 | 0.9 | 1.0 | 1.0 | 0.9 | 1.0 | 1.1 |
| May | 0.9 | 1.1 | 1.1 | 1.0 | 1.1 | 1.0 | 1.0 | 1.1 | 0.8 | 1.0 |
| June | 1.1 | 1.2 | 1.2 | 1.2 | 1.3 | 1.1 | 1.2 | 1.3 | 1.2 | 1.0 |
| July | 1.0 | 1.3 | 1.2 | 1.1 | 1.4 | 1.0 | 1.0 | 1.1 | 0.9 | 1.2 |
| August | 1.0 | 1.2 | 1.2 | 1.2 | 1.3 | 1.1 | 1.2 | 1.2 | 1.6 | 1.1 |
| September | 1.1 | 1.1 | 1.1 | 1.3 | 1.2 | 1.1 | 1.1 | 1.0 | 1.8 | 1.2 |
| October | 1.2 | 1.1 | 1.2 | 1.1 | 1.0 | 1.1 | 1.1 | 1.1 | 0.9 | 1.5 |
| November | 1.0 | 0.9 | 0.9 | 1.2 | 0.8 | 1.0 | 1.1 | 1.0 | 0.9 | 1.1 |
| December | 0.9 | 0.8 | 0.8 | 0.7 | 0.7 | 1.0 | 0.8 | 1.0 | 0.5 | 0.7 |

### Distributions by Vehicle Class

| Vehicle Class | AADTT Distribution (%) (Level 3) | Growth Factor | |
|---|---|---|---|
| | | Rate (%) | Function |
| Class 4 | 5.8% | 1.179% | Linear |
| Class 5 | 21.5% | 1.179% | Linear |
| Class 6 | 4.4% | 1.179% | Linear |
| Class 7 | 4% | 1.179% | Linear |
| Class 8 | 54.6% | 1.179% | Linear |
| Class 9 | 6.1% | 1.179% | Linear |
| Class 10 | 3.6% | 1.179% | Linear |
| Class 11 | 0% | 1.179% | Linear |
| Class 12 | 0% | 1.179% | Linear |
| Class 13 | 0% | 1.179% | Linear |

### Truck Distribution by Hour

| Hour | Distribution (%) | Hour | Distribution (%) |
|---|---|---|---|
| 12 AM | 1.02% | 12 PM | 7.3% |
| 1 AM | 0.93% | 1 PM | 7.09% |
| 2 AM | 1.25% | 2 PM | 6.82% |
| 3 AM | 1.58% | 3 PM | 6.23% |
| 4 AM | 2.39% | 4 PM | 5.44% |
| 5 AM | 3.46% | 5 PM | 4.44% |
| 6 AM | 5.19% | 6 PM | 3.58% |
| 7 AM | 6.12% | 7 PM | 2.67% |
| 8 AM | 6.59% | 8 PM | 2.14% |
| 9 AM | 6.93% | 9 PM | 1.79% |
| 10 AM | 7.09% | 10 PM | 1.56% |
| 11 AM | 7.3% | 11 PM | 1.09% |
| | | Total | 100% |

### Axle Configuration

| Traffic Wander | |
|---|---|
| Mean wheel location (in.) | 15 |
| 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 | | | | |
|---|---|---|---|---|
| Value Type | Axle Type | Short | Medium | Long |
| Average spacing of axles (ft) | | 12 | 15 | 18 |
| Percent of Trucks (%) | | 17 | 22 | 61 |

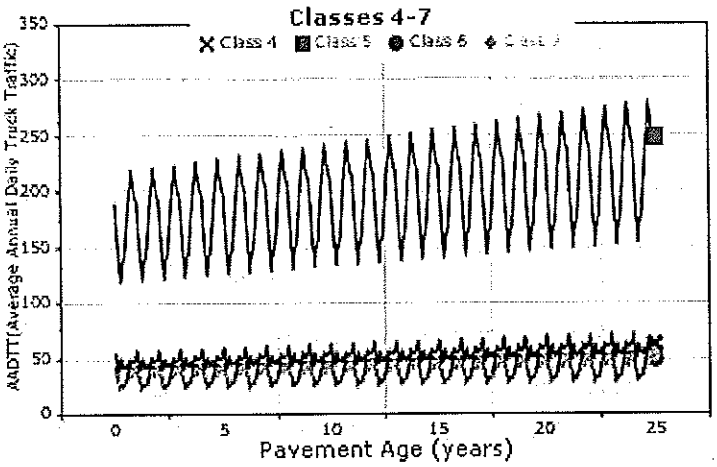
### Number of Axles per Truck

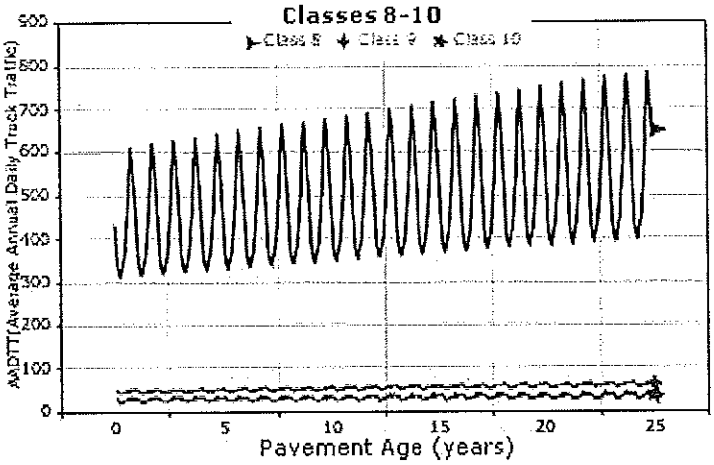
| Vehicle Class | Single Axle | Tandem Axle | Tridem Axle | Quad Axle |
|---|---|---|---|---|
| Class 4 | 1.3 | 0.7 | 0 | 0 |
| Class 5 | 2.2 | 0 | 0 | 0 |
| Class 6 | 1 | 1 | 0 | 0 |
| Class 7 | 1 | 0 | 0.4 | 0.8 |
| Class 8 | 2.4 | 0.6 | 0 | 0 |
| Class 9 | 1.3 | 1.9 | 0 | 0 |
| Class 10 | 1.1 | 1.1 | 0.8 | 0 |
| Class 11 | 4.9 | 0.1 | 0 | 0 |
| Class 12 | 4 | 1 | 0 | 0 |
| Class 13 | 1.2 | 0.8 | 0.7 | 0.6 |

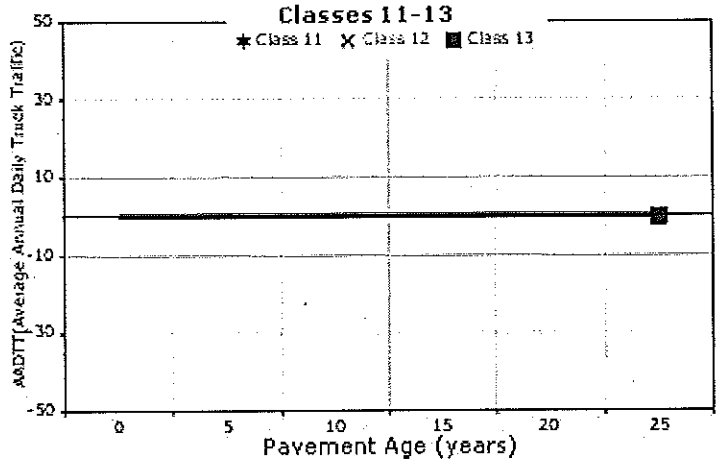
**EXHIBIT #40**

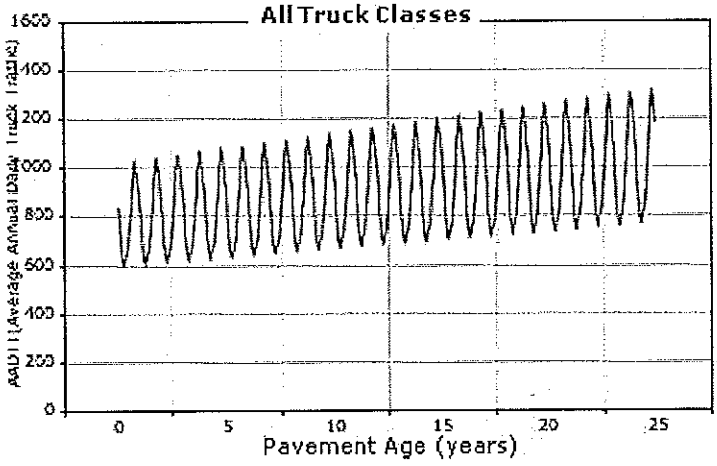
# AADTT (Average Annual Daily Truck Traffic) Growth

* Traffic cap is not enforced



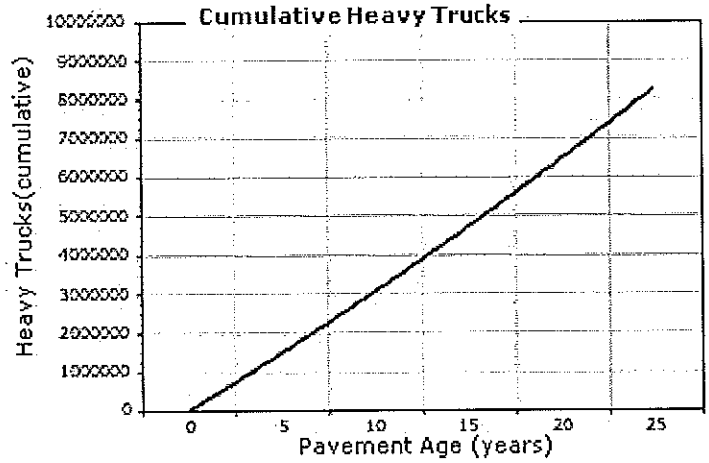
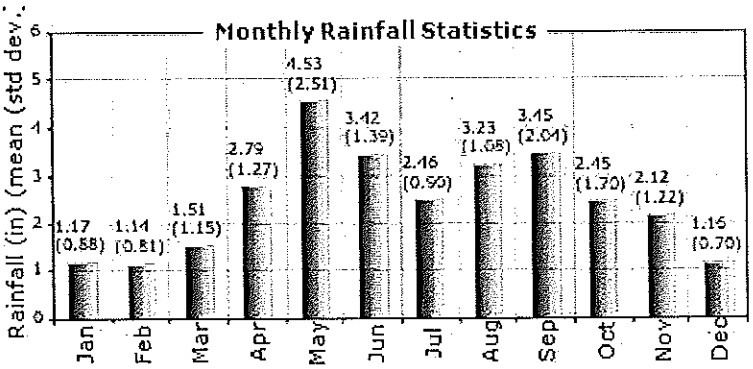




**EXHIBIT #41**

## Climate Inputs

### Climate Data Sources:

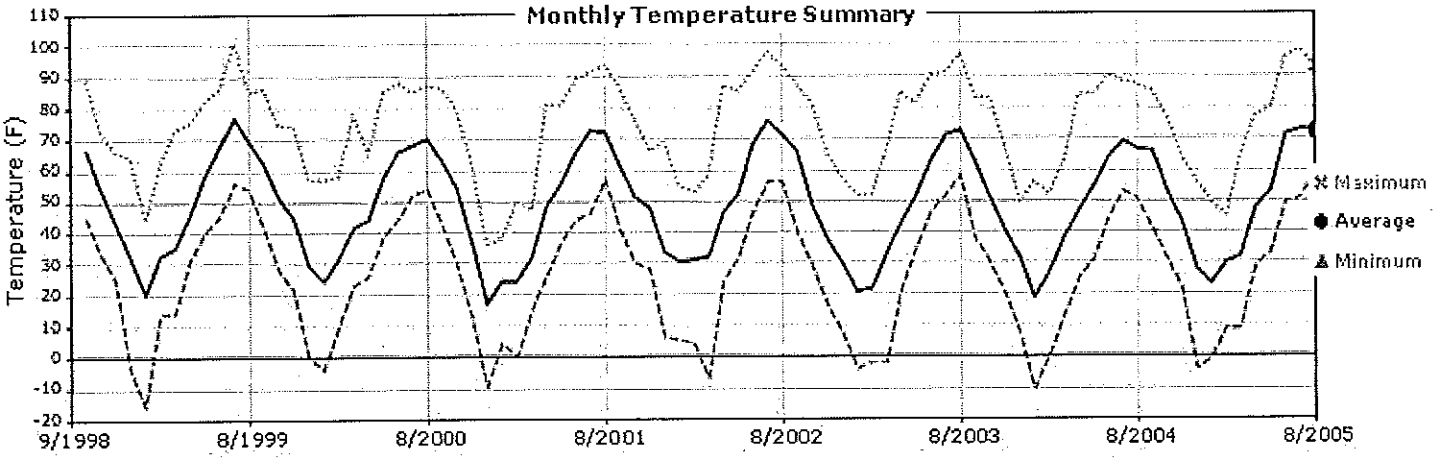
| Climate Station Cities: | Location (lat lon elevation(ft)) |
|---|---|
| RACINE, WI | 42.76100 -87.81400 665 |




### Annual Statistics:

| | |
|---|---|
| Mean annual air temperature (°F) | 48.60 |
| Mean annual precipitation (in.) | 29.44 |
| Freezing index (°F - days) | 786.30 |
| Average annual number of freeze/thaw cycles: | 55.83 |
| Water table depth (ft) | 10.00 |

### Monthly Climate Summary:



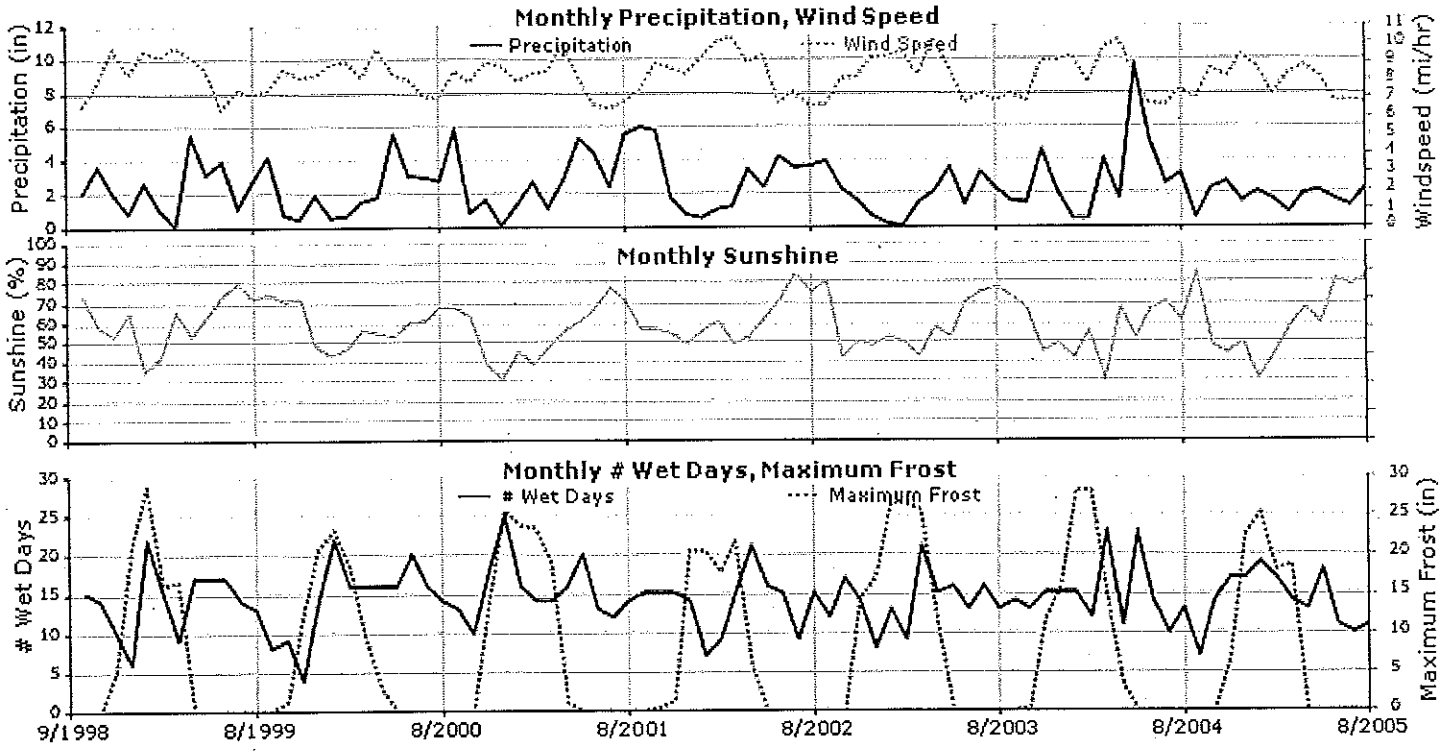
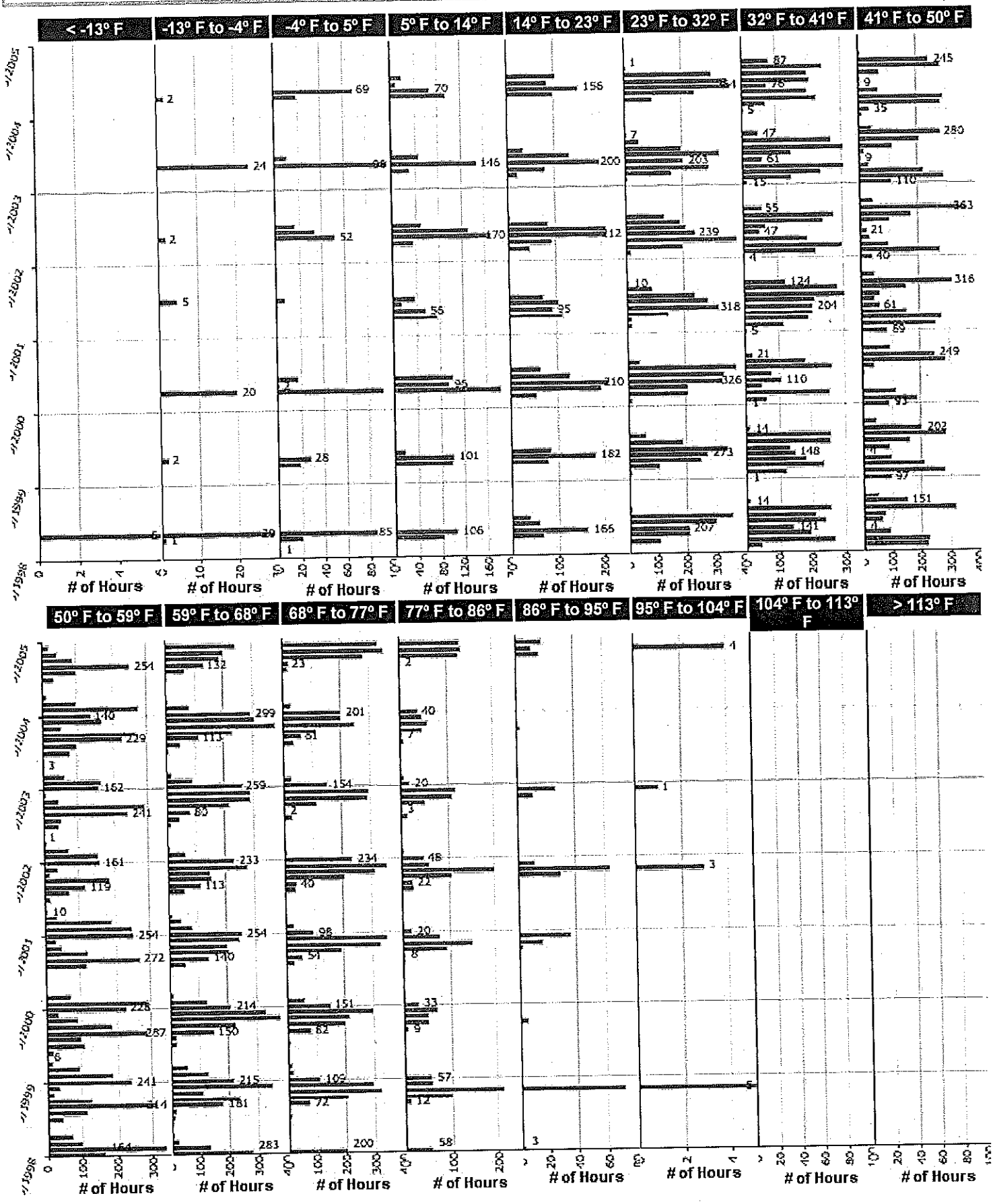




**EXHIBIT #42**

## Hourly Air Temperature Distribution by Month:




## EXHIBIT #43

# Design Properties

## JPCP Design Properties

| Structure - ICM Properties | |
|---|---|
| PCC surface shortwave absorptivity | 0.85 |

| Doweled Joints | |
|---|---|
| Is joint doweled ? | True |
| Dowel diameter (in.) | 1.25 |
| Dowel spacing (in.) | 12.00 |

| Tied Shoulders | |
|---|---|
| Tied shoulders | True |
| Load transfer efficiency (%) | 50.00 |

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

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

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

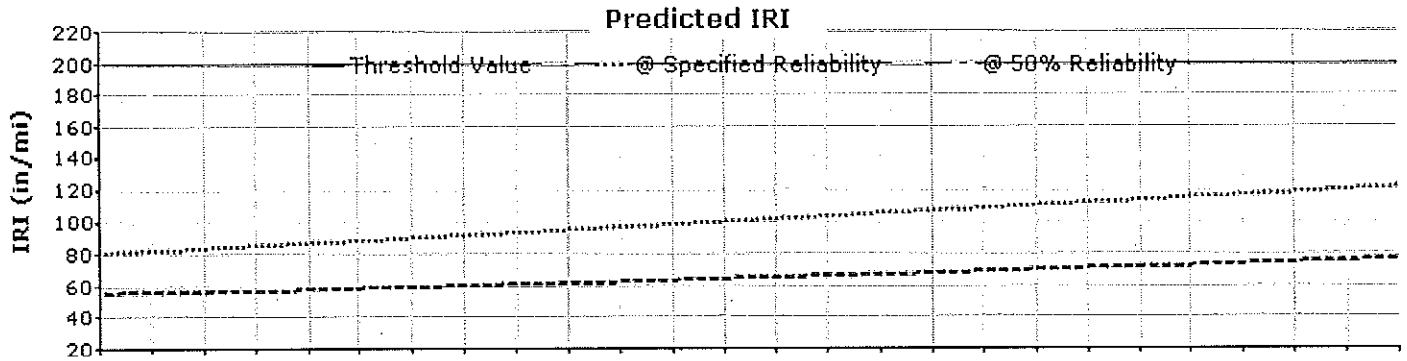
| Sealant type | Preformed |
|---|---|

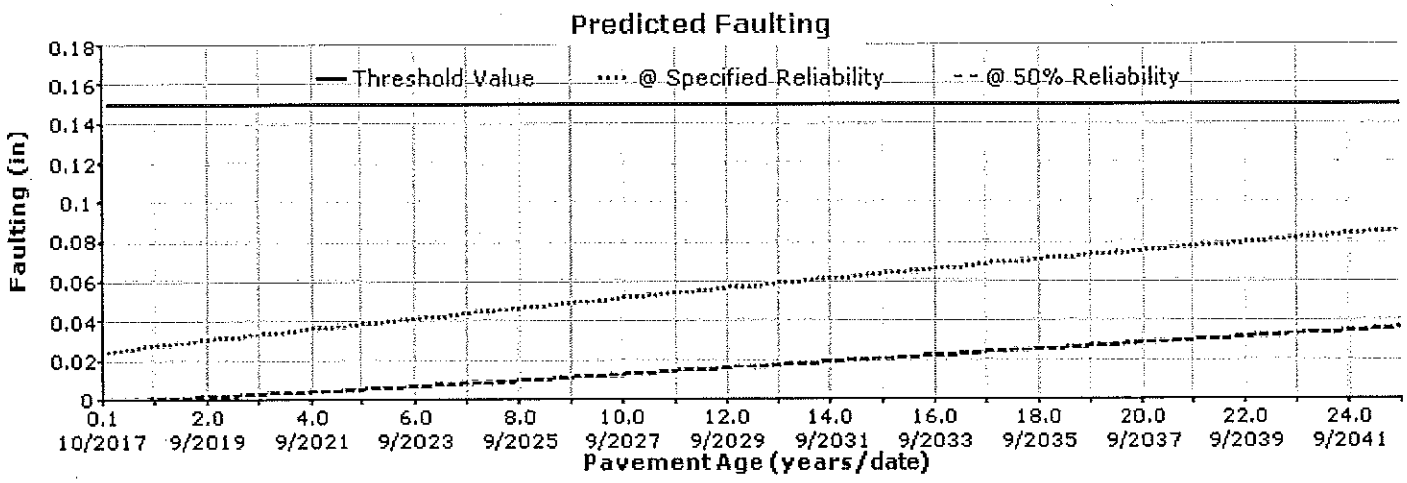
| Erodibility index | 3 |
|---|---|

| Permanent curl/warp effective temperature difference (°F) | -10.00 |
|---|---|

EXHIBIT #44

## Analysis Output Charts



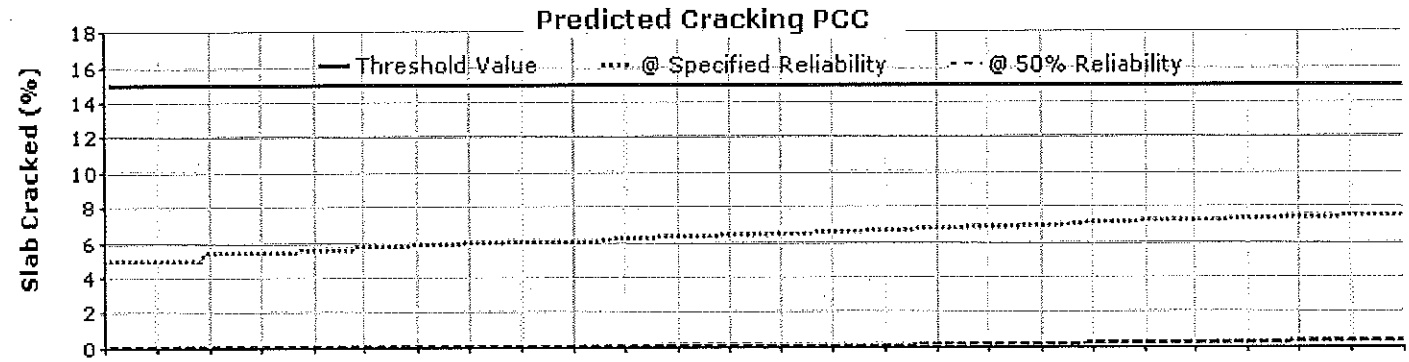
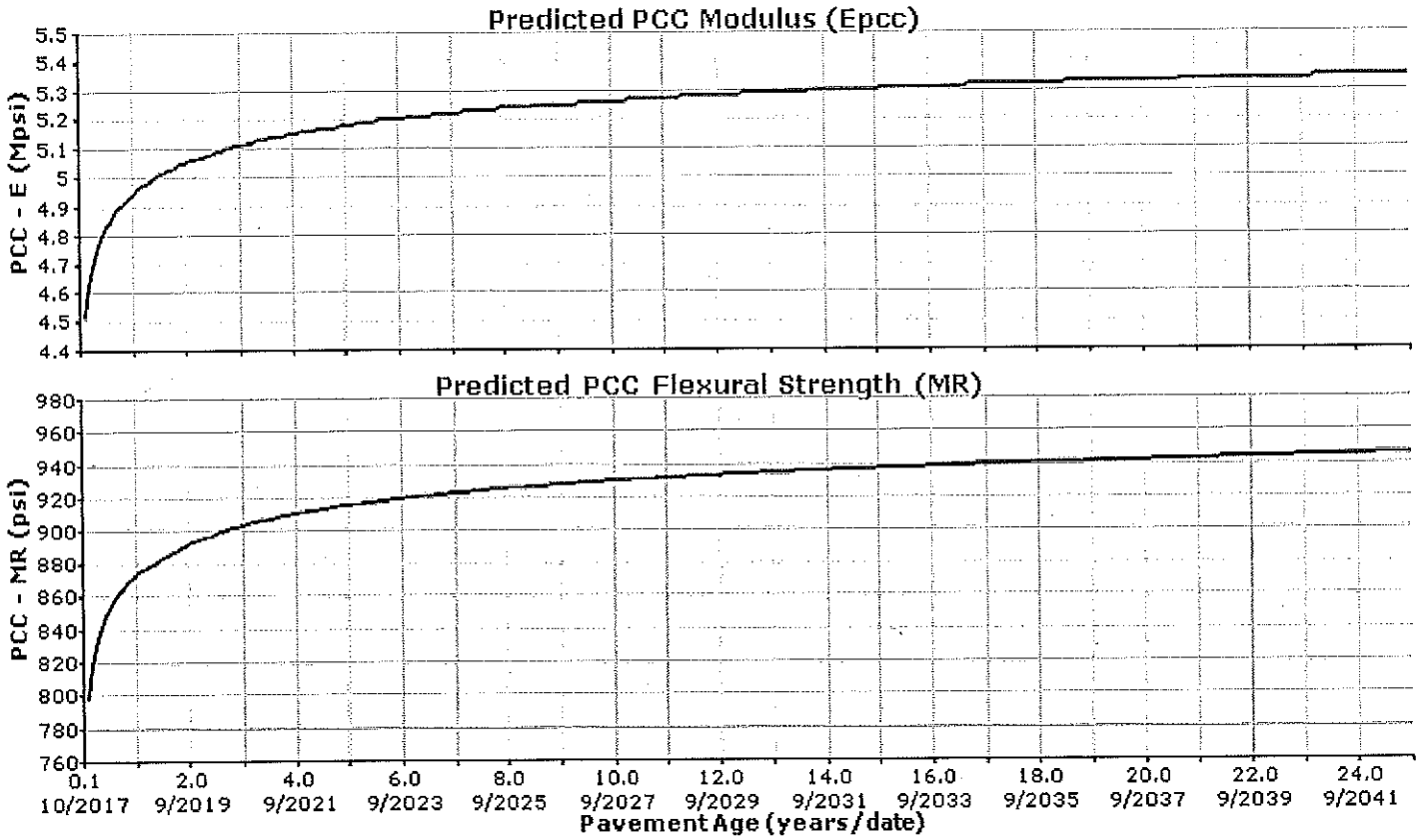




**EXHIBIT #45**


Predicted PCC Modulus (Epcc)
PCC - E (Mpsi)
5.5
5.4
5.3
5.2
5.1
5
4.9
4.8
4.7
4.6
4.5
4.4
Predicted PCC Flexural Strength (MR)
PCC - MR (psi)
980
960
940
920
900
880
860
840
820
800
780
760
0.1 10/2017
2.0 9/2019
4.0 9/2021
6.0 9/2023
8.0 9/2025
10.0 9/2027
12.0 9/2029
14.0 9/2031
16.0 9/2033
18.0 9/2035
20.0 9/2037
22.0 9/2039
24.0 9/2041
Pavement Age (years/date)

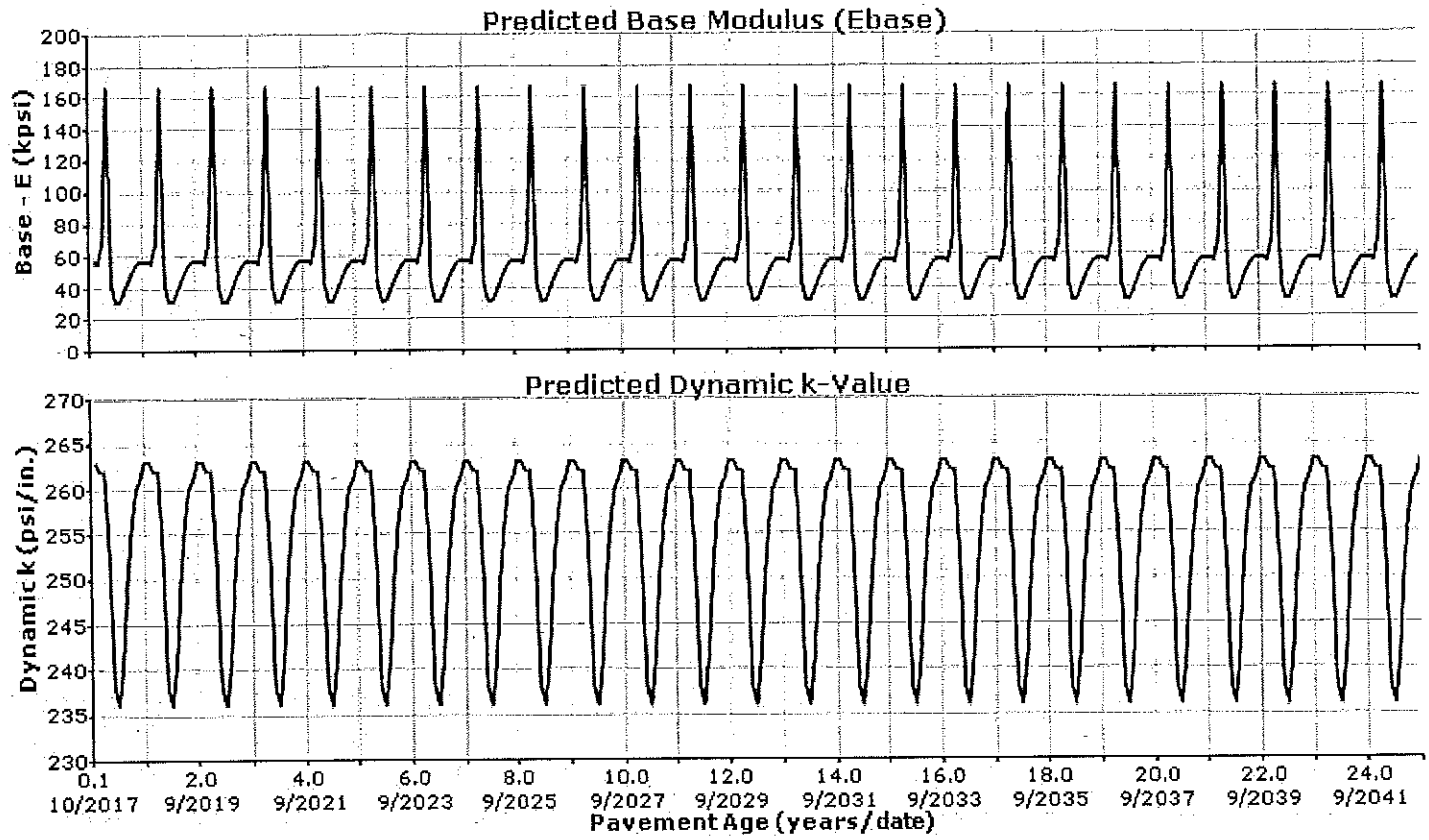
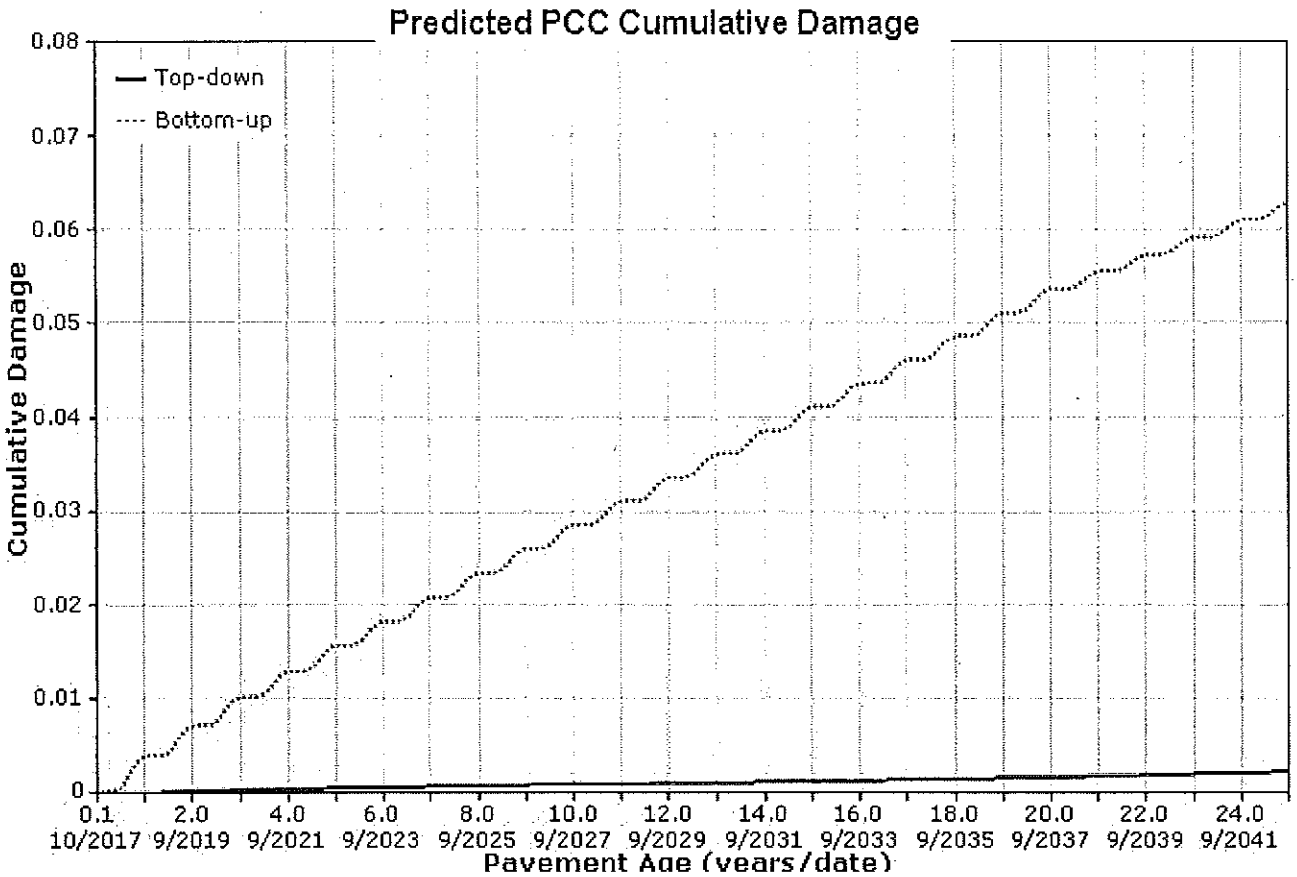

Predicted Base Modulus (Ebase)
Base - E (kpsi)
200
180
160
140
120
100
80
60
40
20
0
Predicted Dynamic k-Value
Dynamic k (psi/in.)
270
265
260
255
250
245
240
235
230
0.1 10/2017
2.0 9/2019
4.0 9/2021
6.0 9/2023
8.0 9/2025
10.0 9/2027
12.0 9/2029
14.0 9/2031
16.0 9/2033
18.0 9/2035
20.0 9/2037
22.0 9/2039
24.0 9/2041
Pavement Age (years/date)

**EXHIBIT #46**


Predicted PCC Cumulative Damage
Top-down
Bottom-up
Cumulative Damage
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.1 10/2017
2.0 9/2019
4.0 9/2021
6.0 9/2023
8.0 9/2025
10.0 9/2027
12.0 9/2029
14.0 9/2031
16.0 9/2033
18.0 9/2035
20.0 9/2037
22.0 9/2039
24.0 9/2041
Pavement Age (years/date)

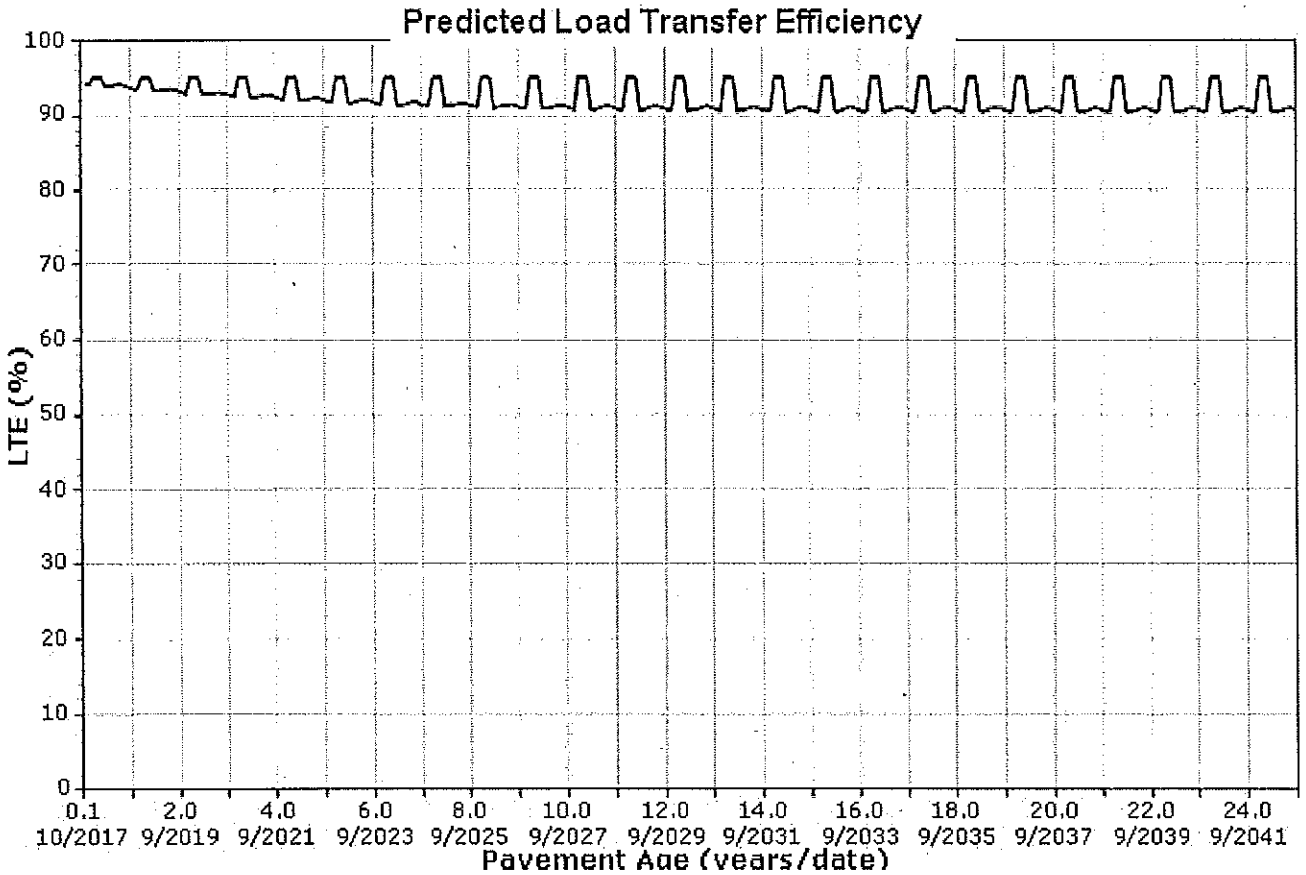

Predicted Load Transfer Efficiency
LTE (%)
100
90
80
70
60
50
40
30
20
10
0
0.1 10/2017
2.0 9/2019
4.0 9/2021
6.0 9/2023
8.0 9/2025
10.0 9/2027
12.0 9/2029
14.0 9/2031
16.0 9/2033
18.0 9/2035
20.0 9/2037
22.0 9/2039
24.0 9/2041
Pavement Age (years/date)

**EXHIBIT #47**

## Layer Information

### Layer 1 PCC : JPCP Default

| PCC | |
|---|---|
| Thickness (in.) | 8.0 |
| Unit weight (pcf) | 148.0 |
| Poisson's ratio | 0.2 |

| Thermal | |
|---|---|
| PCC coefficient of thermal expansion (in./in./°F x 10^-6) | 5.37 |
| PCC thermal conductivity (BTU/hr-ft-°F) | 1.25 |
| PCC heat capacity (BTU/lb-°F) | 0.28 |

| Mix | | |
|---|---|---|
| Cement type | | Type II (2) |
| Cementitious material content (lb/yd^3) | | 780 |
| Water to cement ratio | | 0.37 |
| Aggregate type | | Dolomite (2) |
| PCC zero-stress temperature (°F) | Calculated Internally? | True |
| | User Value | - |
| | Calculated Value | 102.5 |
| Ultimate shrinkage (microstrain) | Calculated Internally? | True |
| | User Value | - |
| | Calculated Value | 600.7 |
| Reversible shrinkage (%) | | 50 |
| Time to develop 50% of ultimate shrinkage (days) | | 35 |
| Curing method | | Curing Compound |

### PCC strength and modulus (Input Level: 3)

| | |
|---|---|
| **28-Day PCC modulus of rupture (psi)** | 780.0 |
| **28-Day PCC elastic modulus (psi)** | 4413000.0 |

### Identifiers

| Field | Value |
|---|---|
| Display name/identifier | JPCP Default |
| Description of object | |
| Author | |
| Date Created | 1/12/2015 12:00:00 AM |
| Approver | |
| Date approved | 1/12/2015 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.) | 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) |
|---|
| 40000.0 |

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

### Identifiers

| Field | Value |
|---|---|
| Display name/identifier | A-1-a |
| Description of object | Default material |
| Author | AASHTO |
| Date Created | 1/12/2015 12:00:00 AM |
| Approver | |
| Date approved | 12/9/2014 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

| | |
|---|---|
| **Liquid Limit** | 25.0 |
| **Plasticity Index** | 6.0 |
| **Is layer compacted?** | True |

| | Is User Defined? | Value |
|---|---|---|
| Maximum dry unit weight (pcf) | False | 128.1 |
| Saturated hydraulic conductivity (ft/hr) | False | 2.616e-02 |
| Specific gravity of solids | False | 2.7 |
| Optimum gravimetric water content (%) | False | 7.2 |

| User-defined Soil Water Characteristic Curve (SWCC) | |
|---|---|
| **Is User Defined?** | False |
| **af** | 4.7511 |
| **bf** | 1.7494 |
| **cf** | 0.7630 |
| **hr** | 184.0000 |

| Sieve Size | % Passing |
|---|---|
| 0.001mm | |
| 0.002mm | |
| 0.020mm | |
| #200 | 7.0 |
| #100 | |
| #80 | |
| #60 | |
| #50 | |
| #40 | 18.0 |
| #30 | |
| #20 | |
| #16 | |
| #10 | 32.0 |
| #8 | |
| #4 | 44.0 |
| 3/8-in. | 61.0 |
| 1/2-in. | |
| 3/4-in. | 82.0 |
| 1-in. | |
| 1 1/2-in. | 97.0 |
| 2-in. | |
| 2 1/2-in. | |
| 3-in. | |
| 3 1/2-in. | |

**EXHIBIT #49**

## Layer 3 Non-stabilized Base : A-1-a

| Unbound | |
|---|---|
| Layer thickness (in.) | 16.0 |
| 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) |
|---|
| 42000.0 |

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

### Identifiers

| Field | Value |
|---|---|
| Display name/identifier | A-1-a |
| Description of object | Default material |
| Author | AASHTO |
| Date Created | 1/12/2015 12:00:00 AM |
| Approver | |
| Date approved | 12/9/2014 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

| | |
|---|---|
| **Liquid Limit** | 25.0 |
| **Plasticity Index** | 6.0 |
| **Is layer compacted?** | True |

| | Is User Defined? | Value |
|---|---|---|
| Maximum dry unit weight (pcf) | False | 109.6 |
| Saturated hydraulic conductivity (ft/hr) | False | 8.267e+02 |
| Specific gravity of solids | True | 2.6 |
| Optimum gravimetric water content (%) | True | 16.6 |

| User-defined Soil Water Characteristic Curve (SWCC) | |
|---|---|
| Is User Defined? | False |
| **af** | 9.2765 |
| **bf** | 3.7128 |
| **cf** | 2.9466 |
| **hr** | 160.0000 |

| Sieve Size | % Passing |
|---|---|
| 0.001mm | |
| 0.002mm | |
| 0.020mm | |
| #200 | 5.0 |
| #100 | |
| #80 | |
| #60 | |
| #50 | |
| #40 | |
| #30 | |
| #20 | |
| #16 | |
| #10 | 10.0 |
| #8 | |
| #4 | |
| 3/8-in. | |
| 1/2-in. | 30.0 |
| 3/4-in. | |
| 1-in. | |
| 1 1/2-in. | 60.0 |
| 2-in. | |
| 2 1/2-in. | |
| 3-in. | |
| 3 1/2-in. | 90.0 |

**EXHIBIT #50**

## Layer 4 Subgrade : A-4

| 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) |
|---|
| 15000.0 |

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

### Identifiers

| Field | Value |
|---|---|
| Display name/identifier | A-4 |
| Description of object | Default material |
| Author | AASHTO |
| Date Created | 1/12/2015 3:54:50 PM |
| Approver | |
| Date approved | 12/9/2014 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

| | |
|---|---|
| **Liquid Limit** | 25.0 |
| **Plasticity Index** | 6.0 |
| **Is layer compacted?** | False |

| | Is User Defined? | Value |
|---|---|---|
| Maximum dry unit weight (pcf) | False | 114 |
| Saturated hydraulic conductivity (ft/hr) | False | 1.205e-05 |
| Specific gravity of solids | True | 2.65 |
| Optimum gravimetric water content (%) | True | 14 |

| User-defined Soil Water Characteristic Curve (SWCC) | |
|---|---|
| Is User Defined? | False |
| af | 69.7987 |
| bf | 0.9890 |
| cf | 0.4694 |
| hr | 500.0000 |

| Sieve Size | % Passing |
|---|---|
| 0.001mm | |
| 0.002mm | |
| 0.020mm | |
| #200 | 52.0 |
| #100 | |
| #80 | |
| #60 | |
| #50 | |
| #40 | 65.0 |
| #30 | |
| #20 | |
| #16 | |
| #10 | 74.0 |
| #8 | |
| #4 | 85.0 |
| 3/8-in. | |
| 1/2-in. | |
| 3/4-in. | |
| 1-in. | |
| 1 1/2-in. | |
| 2-in. | |
| 2 1/2-in. | |
| 3-in. | |
| 3 1/2-in. | |

**EXHIBIT #51**

## Calibration Coefficients

### PCC Faulting

$$C_{12} = C_1 + (C_2 * FR^{0.25})$$

$$C_{34} = C_3 + (C_4 * FR^{0.25})$$

$$FaultMax_0 = C_{12} * \delta_{curling} * \left[\log(1 + C_5 * 5.0^{EROD}) * \log\left(P_{200} * \frac{WetDays}{p_S}\right)\right]^{C_6}$$

$$FaultMax_i = FaultMax_0 + C_7 * \sum_{j=1}^{m} DE_j * \log(1 + C_5 * 5.0^{EROD})^{C_8}$$

$$\Delta Fault_i = C_{34} * (FaultMax_{i-1} - Fault_{i-1})^2 * DE_i$$

$$C_8 = DowelDeterioration$$

| | | | |
|---|---|---|---|
| C1: 1.0184 | C2: 0.91656 | C3: 0.0021848 | C4: 0.000883739 |
| C5: 250 | C6: 0.4 | C7: 1.83312 | C8: 400 |

**PCC Reliability Faulting Standard Deviation**

Pow(0.0097*FAULT,0.5178)+0.014

### IRI-jpcp

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

### PCC Cracking

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

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

| Fatigue Coefficients | | Cracking Coefficients | |
|---|---|---|---|
| C1: 2 | C2: 1.22 | C4: 1 | C5: -1.98 |

**PCC Reliability Cracking Standard Deviation**

Pow(5.3116*CRACK,0.3903) + 2.99

**EXHIBIT #52**

# 27880001 Wauk Bypass Section#2 HMA 1-13-15

File Name: C:\ME Designs\12290401 IH43 10-29-14\27880001 Wauk Bypass Section#2 HMA 1-13-15.dgpx

## Design Inputs

Design Life: 18 years
Design Type: Flexible Pavement

Base construction: September, 2017
Pavement construction: October, 2017
Traffic opening: November, 2017

Climate Data Sources (Lat/Lon): 42.761, -87.814

### Design Structure


| Layer type | Material Type | Thickness (in.): |
|---|---|---|
| Flexible | Default asphalt concrete | 7.0 |
| NonStabilized | A-1-a | 14.0 |
| NonStabilized | A-1-a | 16.0 |
| Subgrade | A-4 | Semi-infinite |

Volumetric at Construction:

| | |
|---|---|
| Effective binder content (%) | 9.2 |
| Air voids (%) | 7.0 |

### Traffic

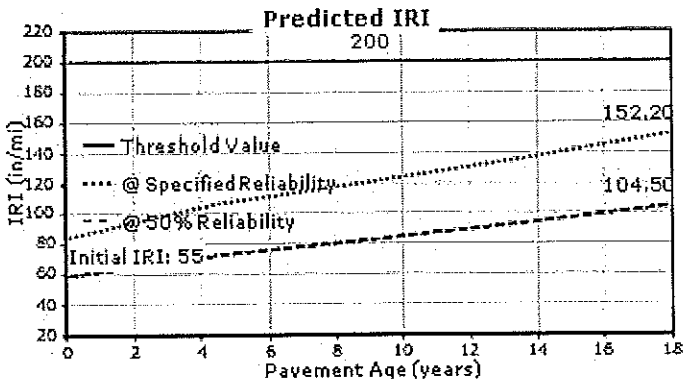
| Age (year) | Heavy Trucks (cumulative) |
|---|---|
| 2017 (initial) | 1,768 |
| 2026 (9 years) | 2,738,680 |
| 2035 (18 years) | 5,754,860 |

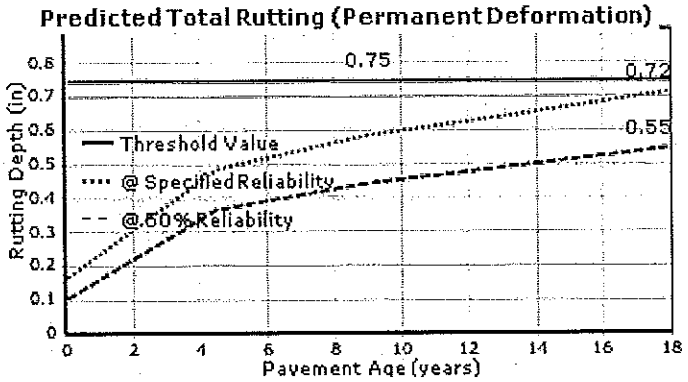
## Design Outputs

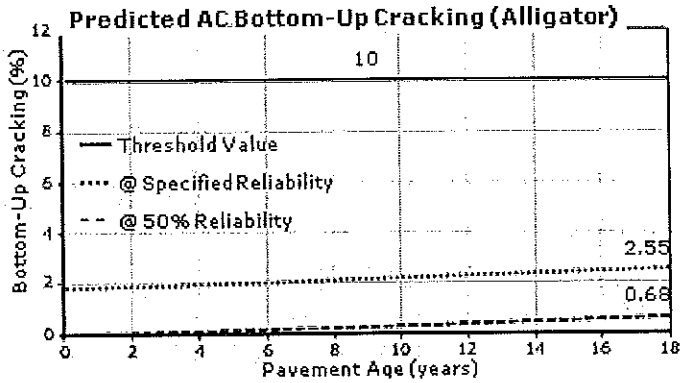
### Distress Prediction Summary

| Distress Type | Distress @ Specified Reliability | | Reliability (%) | | Criterion Satisfied? |
|---|---|---|---|---|---|
| | Target | Predicted | Target | Achieved | |
| Terminal IRI (in./mile) | 200.00 | 152.24 | 95.00 | 99.95 | Pass |
| Permanent deformation - total pavement (in.) | 0.75 | 0.72 | 95.00 | 97.54 | Pass |
| AC bottom-up fatigue cracking (percent) | 10.00 | 2.55 | 95.00 | 100.00 | Pass |
| AC thermal cracking (ft/mile) | 1500.00 | 35.48 | 95.00 | 100.00 | Pass |
| AC top-down fatigue cracking (ft/mile) | 5000.00 | 1991.55 | 95.00 | 100.00 | Pass |
| Permanent deformation - AC only (in.) | 0.40 | 0.38 | 95.00 | 96.82 | Pass |

### Distress Charts



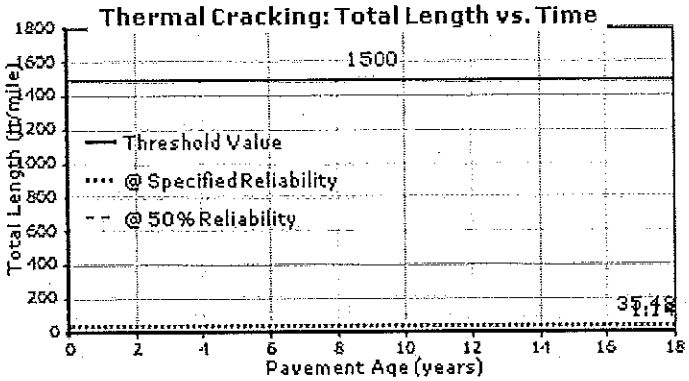
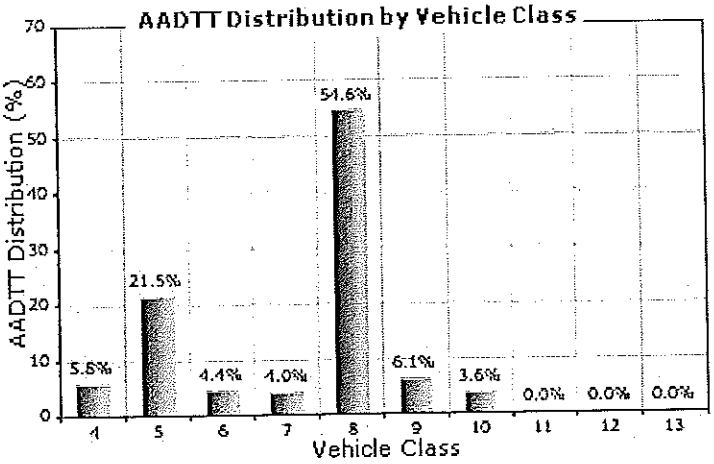



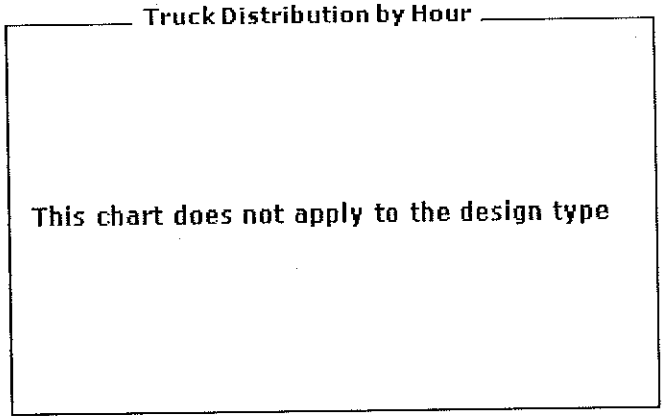

**EXHIBIT #53**

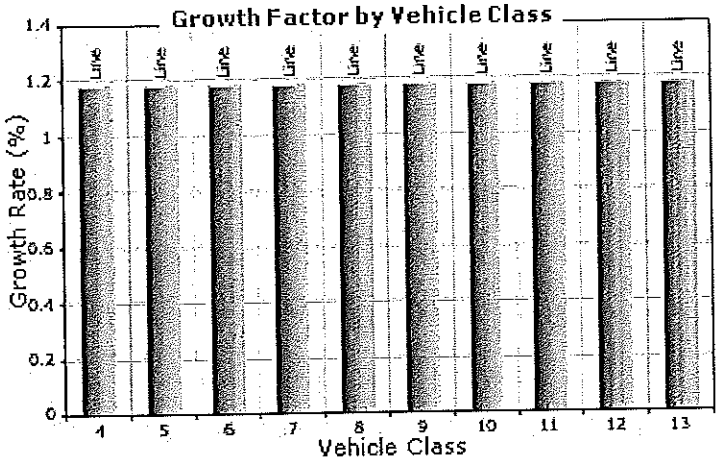
## Traffic Inputs

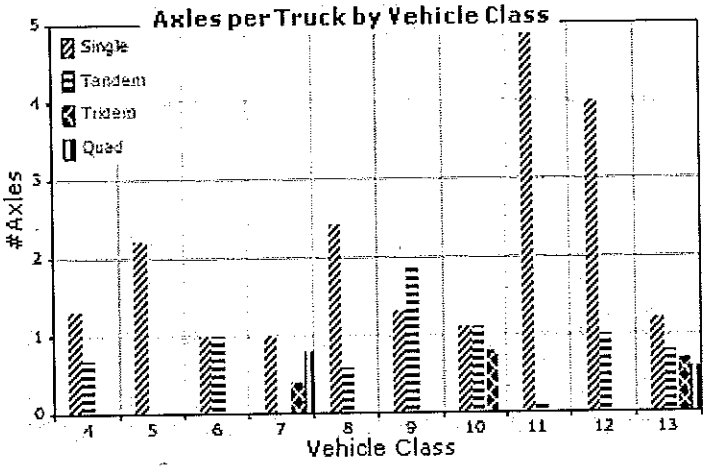
### Graphical Representation of Traffic Inputs

| | | | |
|---|---|---|---|
| Initial two-way AADTT: | 1,768 | Percent of trucks in design direction (%): | 50.0 |
| Number of lanes in design direction: | 4 | Percent of trucks in design lane (%): | 90.0 |
| | | Operational speed (mph) | 45.0 |




Traffic Volume Monthly Adjustment Factors

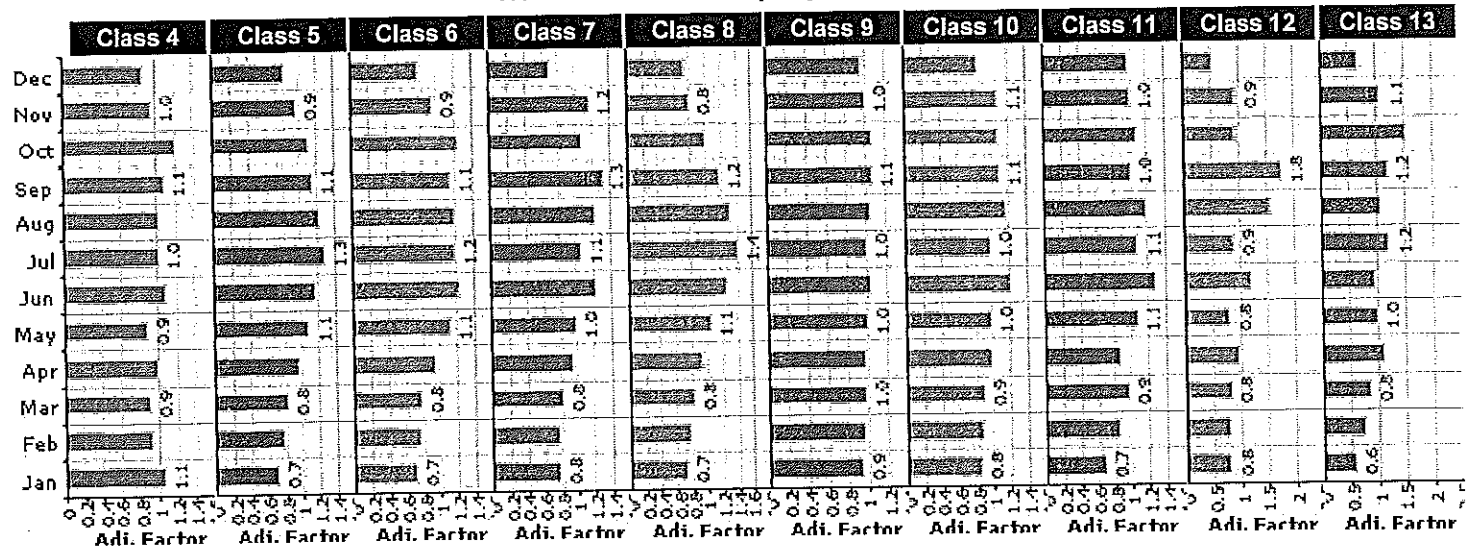



**EXHIBIT #54**

## 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 | 1.1 | 0.7 | 0.7 | 0.8 | 0.7 | 0.9 | 0.8 | 0.7 | 0.8 | 0.6 |
| February | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 1.0 | 0.9 | 0.8 | 0.8 | 0.7 |
| March | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 1.0 | 0.9 | 0.9 | 0.8 | 0.8 |
| April | 1.0 | 1.0 | 0.9 | 0.9 | 0.9 | 1.0 | 1.0 | 0.9 | 1.0 | 1.1 |
| May | 0.9 | 1.1 | 1.1 | 1.0 | 1.1 | 1.0 | 1.0 | 1.1 | 0.8 | 1.0 |
| June | 1.1 | 1.2 | 1.2 | 1.2 | 1.3 | 1.1 | 1.2 | 1.3 | 1.2 | 1.0 |
| July | 1.0 | 1.3 | 1.2 | 1.1 | 1.4 | 1.0 | 1.0 | 1.1 | 0.9 | 1.2 |
| August | 1.0 | 1.2 | 1.2 | 1.2 | 1.3 | 1.1 | 1.2 | 1.2 | 1.6 | 1.1 |
| September | 1.1 | 1.1 | 1.1 | 1.3 | 1.2 | 1.1 | 1.1 | 1.0 | 1.8 | 1.2 |
| October | 1.2 | 1.1 | 1.2 | 1.1 | 1.0 | 1.1 | 1.1 | 1.1 | 0.9 | 1.5 |
| November | 1.0 | 0.9 | 0.9 | 1.2 | 0.8 | 1.0 | 1.1 | 1.0 | 0.9 | 1.1 |
| December | 0.9 | 0.8 | 0.8 | 0.7 | 0.7 | 1.0 | 0.8 | 1.0 | 0.5 | 0.7 |

### Distributions by Vehicle Class

| Vehicle Class | AADTT Distribution (%) (Level 3) | Growth Factor | |
|---|---|---|---|
| | | Rate (%) | Function |
| Class 4 | 5.8% | 1.179% | Linear |
| Class 5 | 21.5% | 1.179% | Linear |
| Class 6 | 4.4% | 1.179% | Linear |
| Class 7 | 4% | 1.179% | Linear |
| Class 8 | 54.6% | 1.179% | Linear |
| Class 9 | 6.1% | 1.179% | Linear |
| Class 10 | 3.6% | 1.179% | Linear |
| Class 11 | 0% | 1.179% | Linear |
| Class 12 | 0% | 1.179% | Linear |
| Class 13 | 0% | 1.179% | Linear |

### Truck Distribution by Hour

| Hour | Distribution (%) | Hour | Distribution (%) |
|---|---|---|---|
| 12 AM | 1.02% | 12 PM | 7.3% |
| 1 AM | 0.93% | 1 PM | 7.09% |
| 2 AM | 1.25% | 2 PM | 6.82% |
| 3 AM | 1.58% | 3 PM | 6.23% |
| 4 AM | 2.39% | 4 PM | 5.44% |
| 5 AM | 3.46% | 5 PM | 4.44% |
| 6 AM | 5.19% | 6 PM | 3.58% |
| 7 AM | 6.12% | 7 PM | 2.67% |
| 8 AM | 6.59% | 8 PM | 2.14% |
| 9 AM | 6.93% | 9 PM | 1.79% |
| 10 AM | 7.09% | 10 PM | 1.56% |
| 11 AM | 7.3% | 11 PM | 1.09% |
| | | Total | 100% |

### Axle Configuration

| Traffic Wander | |
|---|---|
| Mean wheel location (in.) | 15 |
| 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

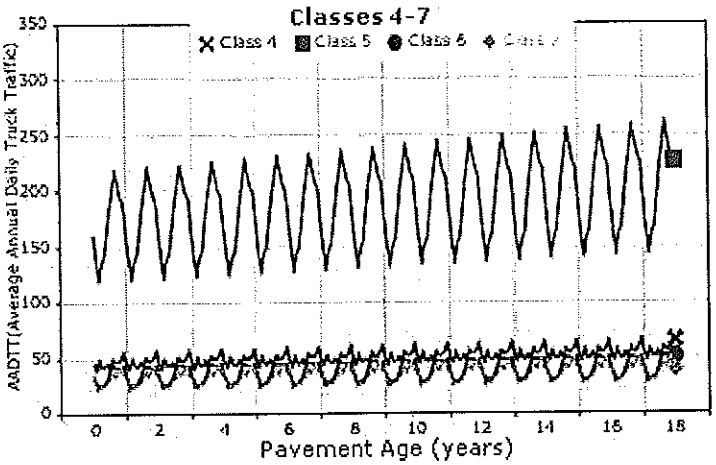
### Number of Axles per Truck

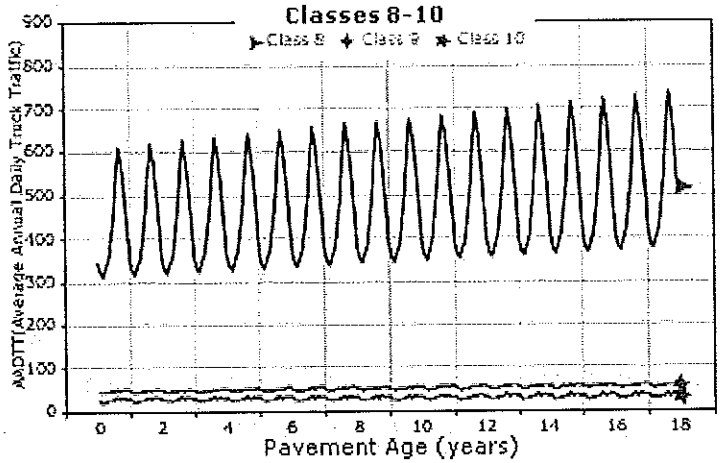
| Vehicle Class | Single Axle | Tandem Axle | Tridem Axle | Quad Axle |
|---|---|---|---|---|
| Class 4 | 1.3 | 0.7 | 0 | 0 |
| Class 5 | 2.2 | 0 | 0 | 0 |
| Class 6 | 1 | 1 | 0 | 0 |
| Class 7 | 1 | 0 | 0.4 | 0.8 |
| Class 8 | 2.4 | 0.6 | 0 | 0 |
| Class 9 | 1.3 | 1.9 | 0 | 0 |
| Class 10 | 1.1 | 1.1 | 0.8 | 0 |
| Class 11 | 4.9 | 0.1 | 0 | 0 |
| Class 12 | 4 | 1 | 0 | 0 |
| Class 13 | 1.2 | 0.8 | 0.7 | 0.6 |

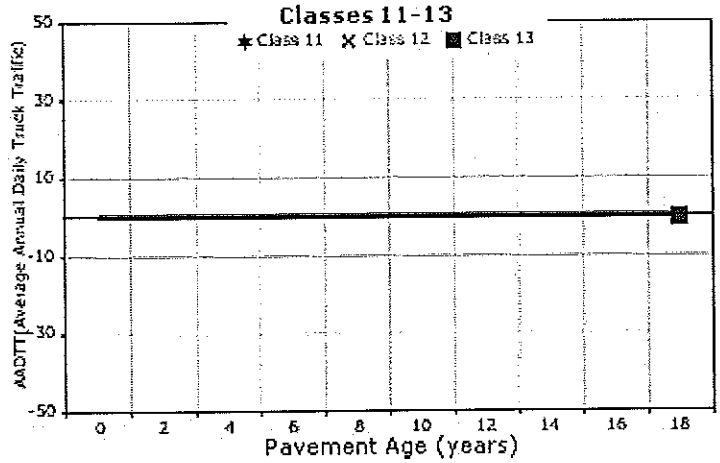
**EXHIBIT #55**

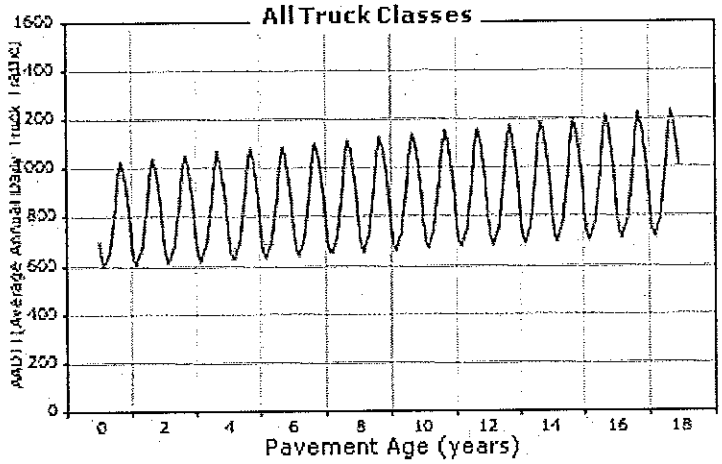
## AADTT (Average Annual Daily Truck Traffic) Growth

* Traffic cap is not enforced



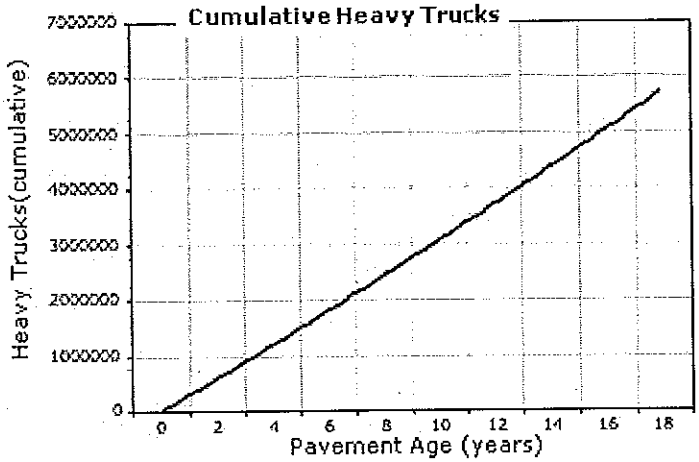
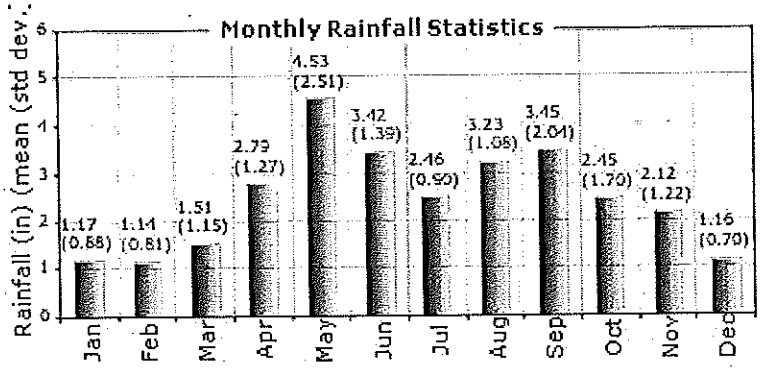




**EXHIBIT #56**

## Climate Inputs

### Climate Data Sources:

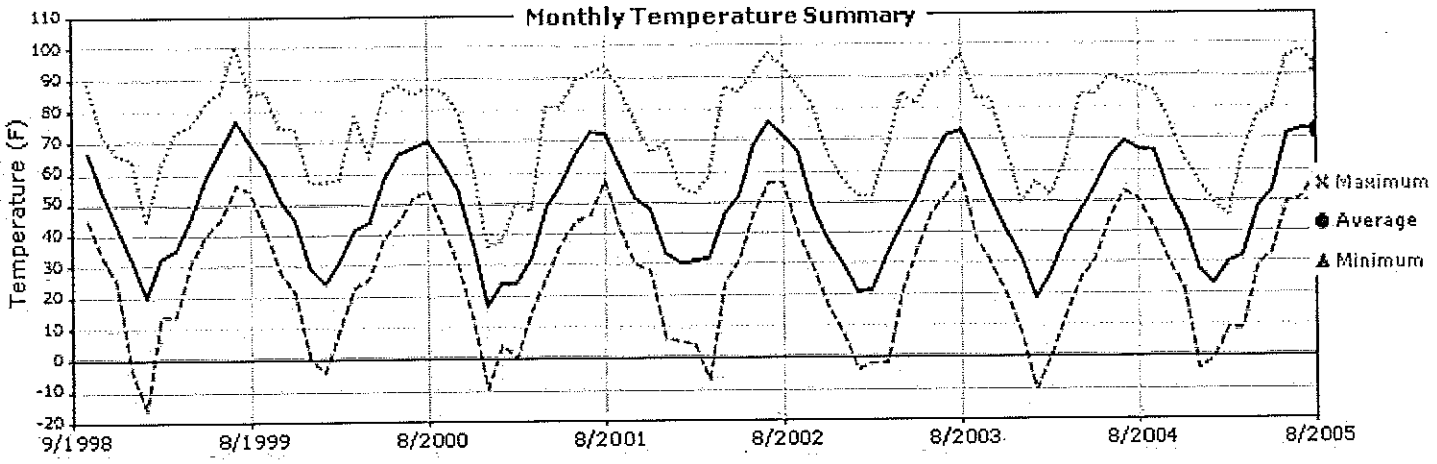
| Climate Station Cities: | Location (lat lon elevation(ft)) |
|---|---|
| RACINE, WI | 42.76100 -87.81400 665 |

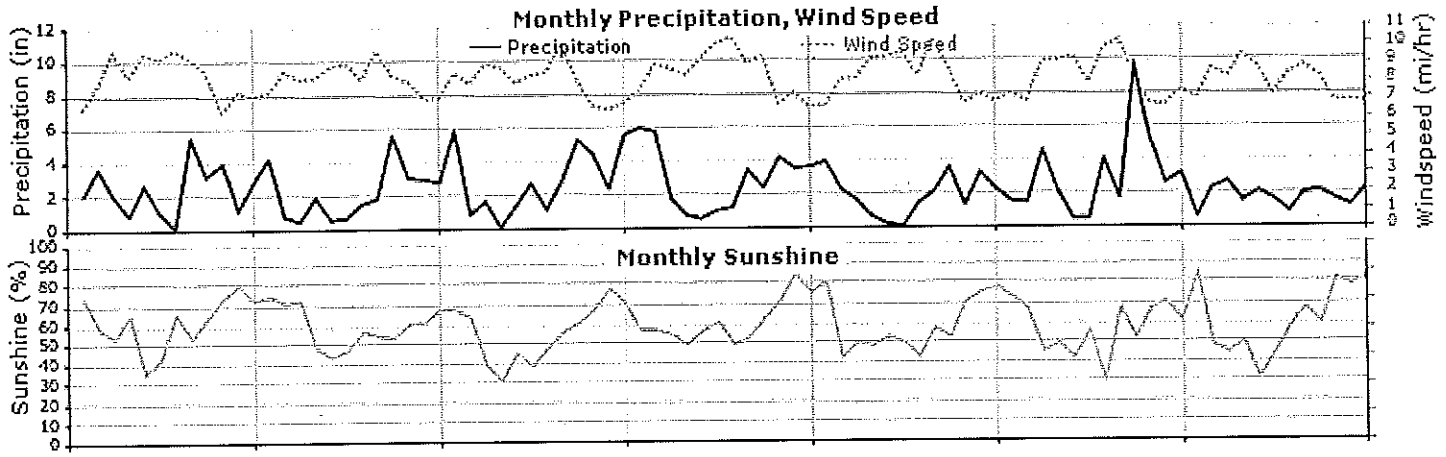



### Annual Statistics:

| | |
|---|---|
| Mean annual air temperature (°F) | 48.60 |
| Mean annual precipitation (in.) | 29.44 |
| Freezing index (°F - days) | 786.30 |
| Average annual number of freeze/thaw cycles: | 55.83 |
| Water table depth (ft) | 10.00 |

### Monthly Climate Summary:







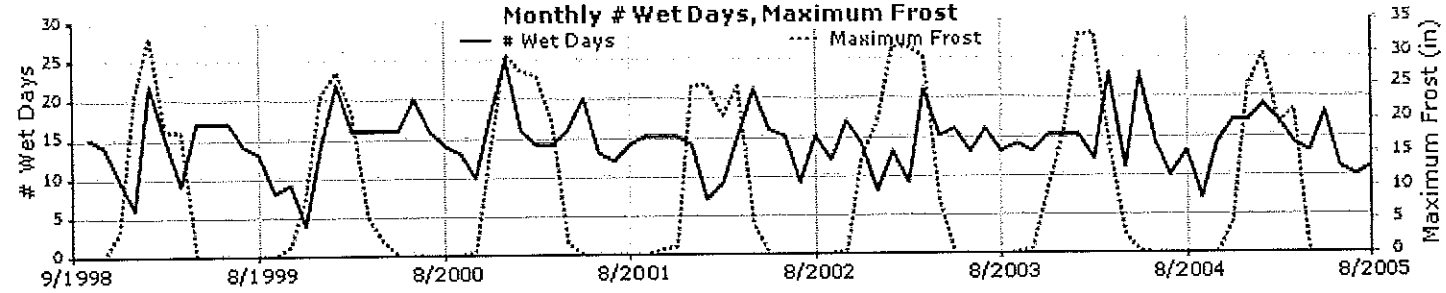
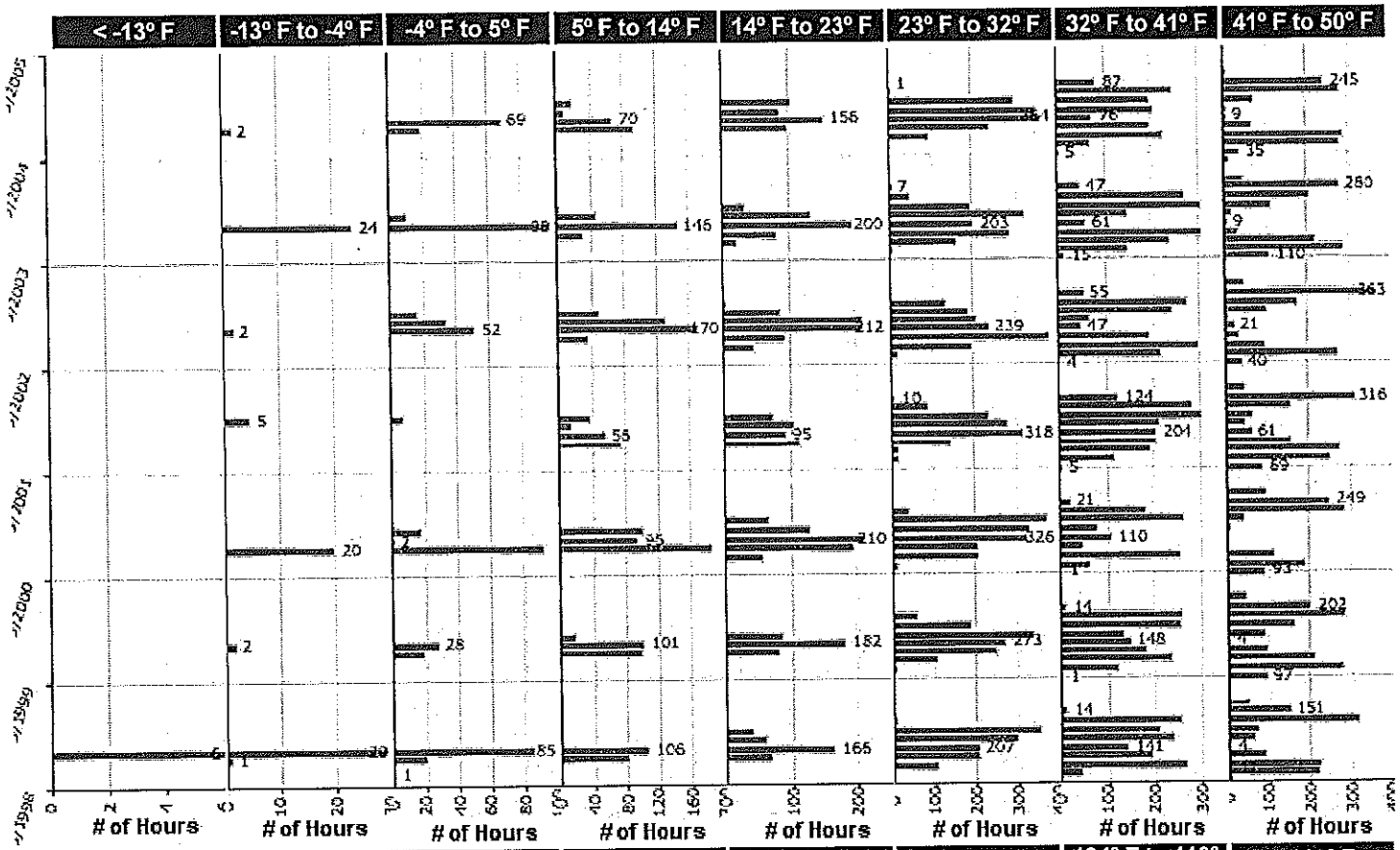



**EXHIBIT #57**

# 27880001 Wauk Bypass Section#2 HMA 1-13-15

File Name: C:\ME Designs\12290401 IH43 10-29-14\27880001 Wauk Bypass Section#2 HMA 1-13-15.dgpx

## Hourly Air Temperature Distribution by Month:



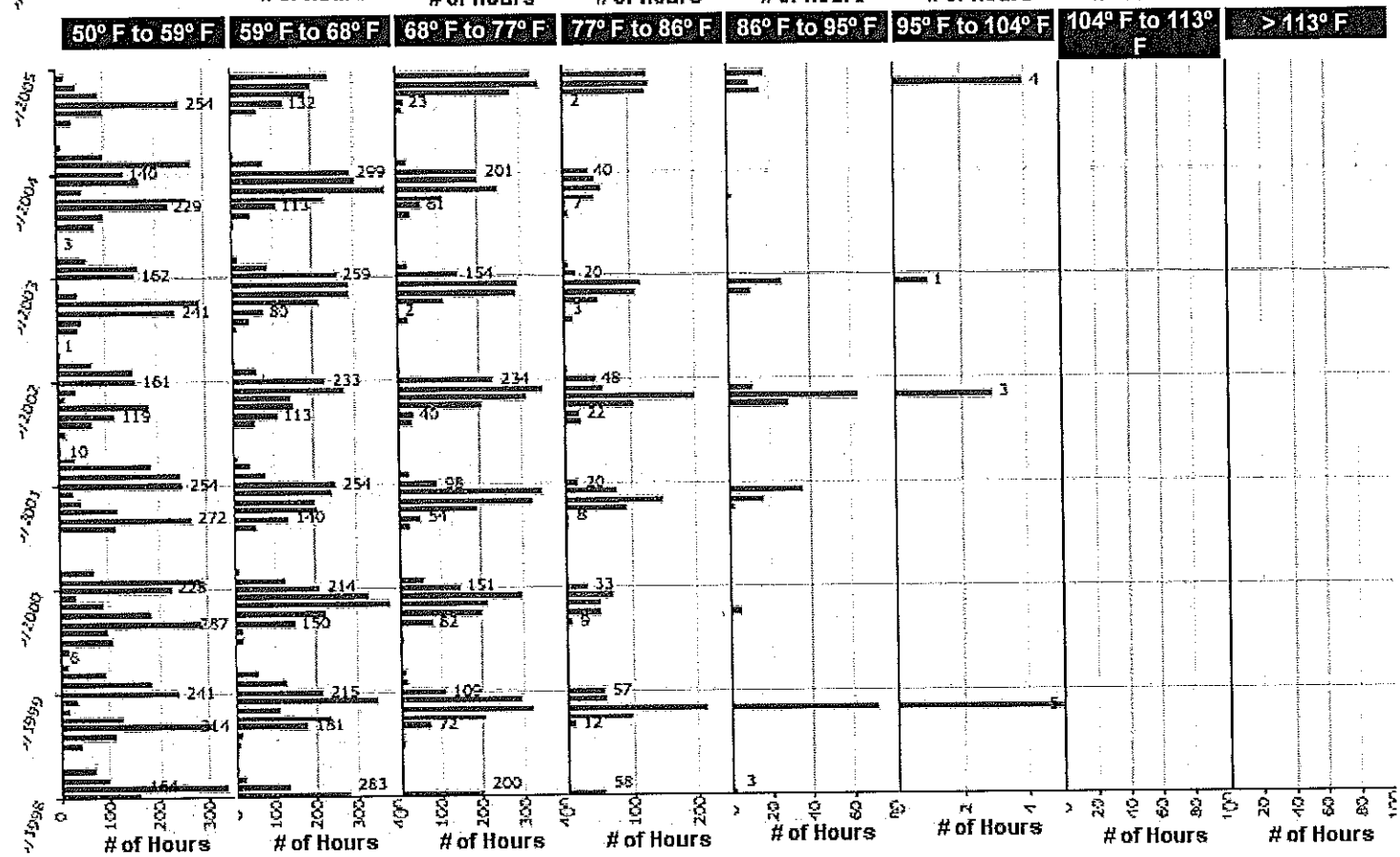




**EXHIBIT #58**

# Design Properties

## HMA Design Properties

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

| Structure - ICM Properties | |
|---|---|
| AC surface shortwave absorptivity | 0.85 |

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

EXHIBIT #59

## Thermal Cracking (Input Level: 3)

| | |
|---|---|
| Indirect tensile strength at 14 °F (psi) | 554.33 |

| 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 | 2.45e-007 | 4.16e-007 | 5.94e-007 |
| 2 | 2.71e-007 | 4.91e-007 | 7.74e-007 |
| 5 | 3.11e-007 | 6.09e-007 | 1.10e-006 |
| 10 | 3.44e-007 | 7.18e-007 | 1.43e-006 |
| 20 | 3.81e-007 | 8.45e-007 | 1.87e-006 |
| 50 | 4.37e-007 | 1.05e-006 | 2.65e-006 |
| 100 | 4.84e-007 | 1.24e-006 | 3.46e-006 |

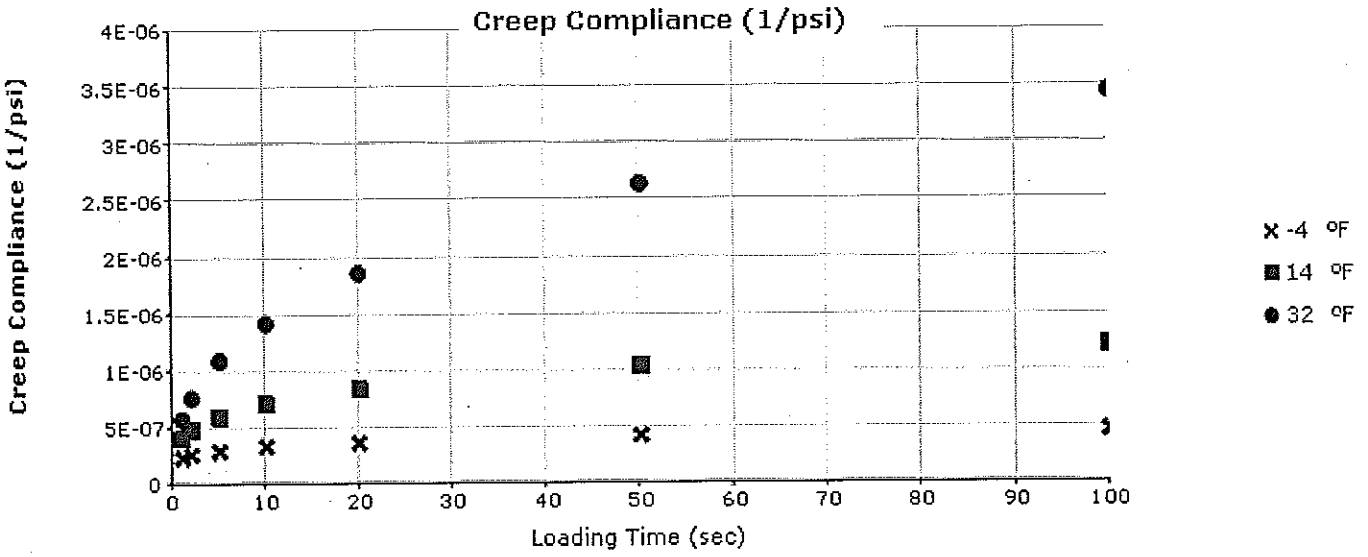
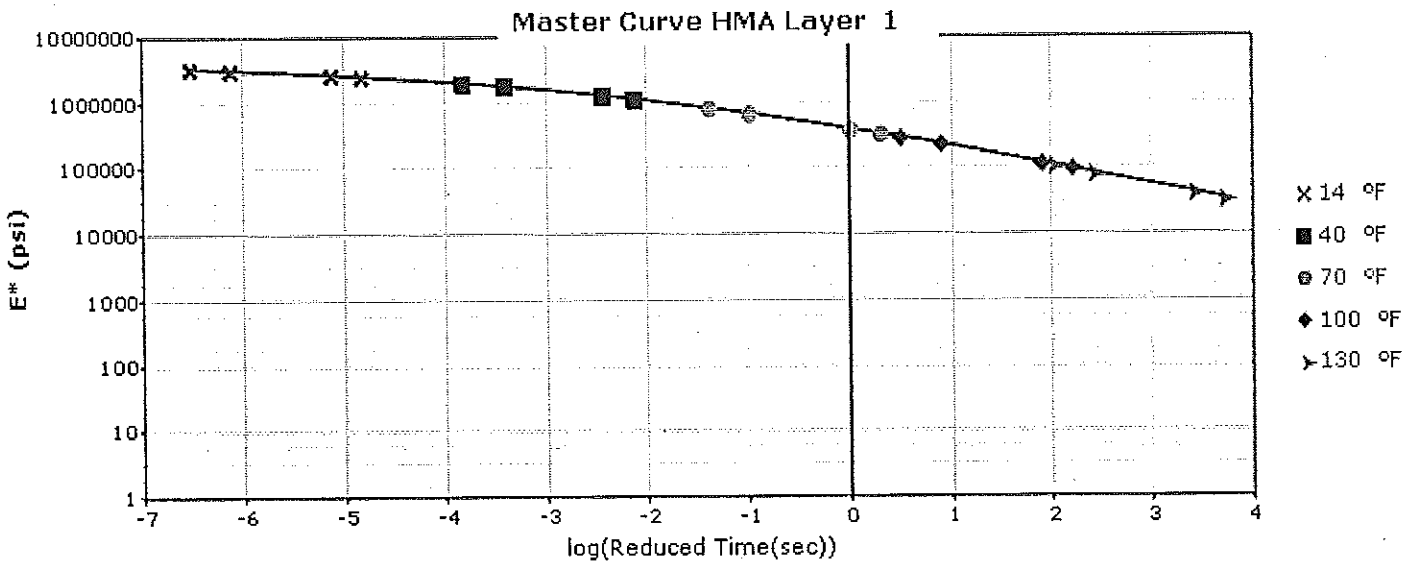
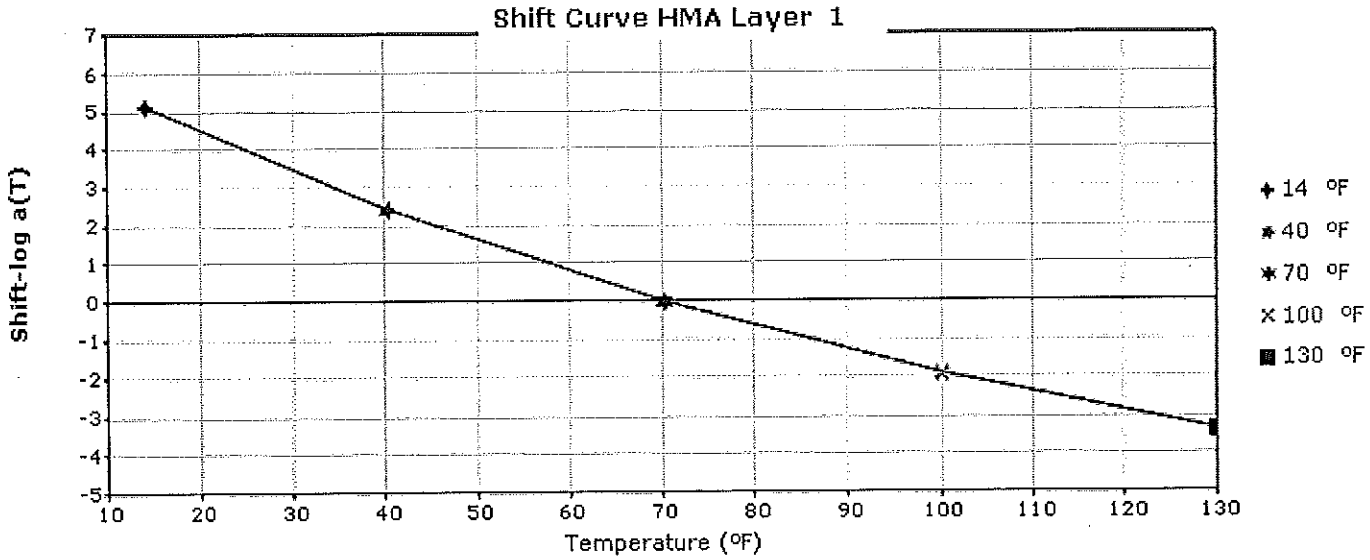



**EXHIBIT #60**

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



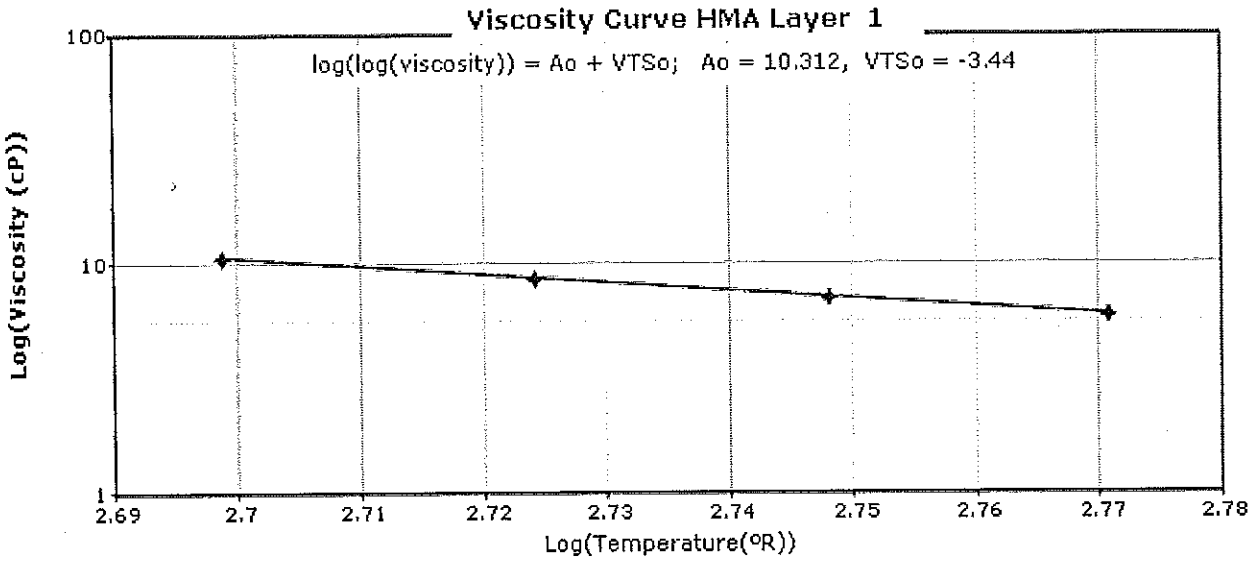
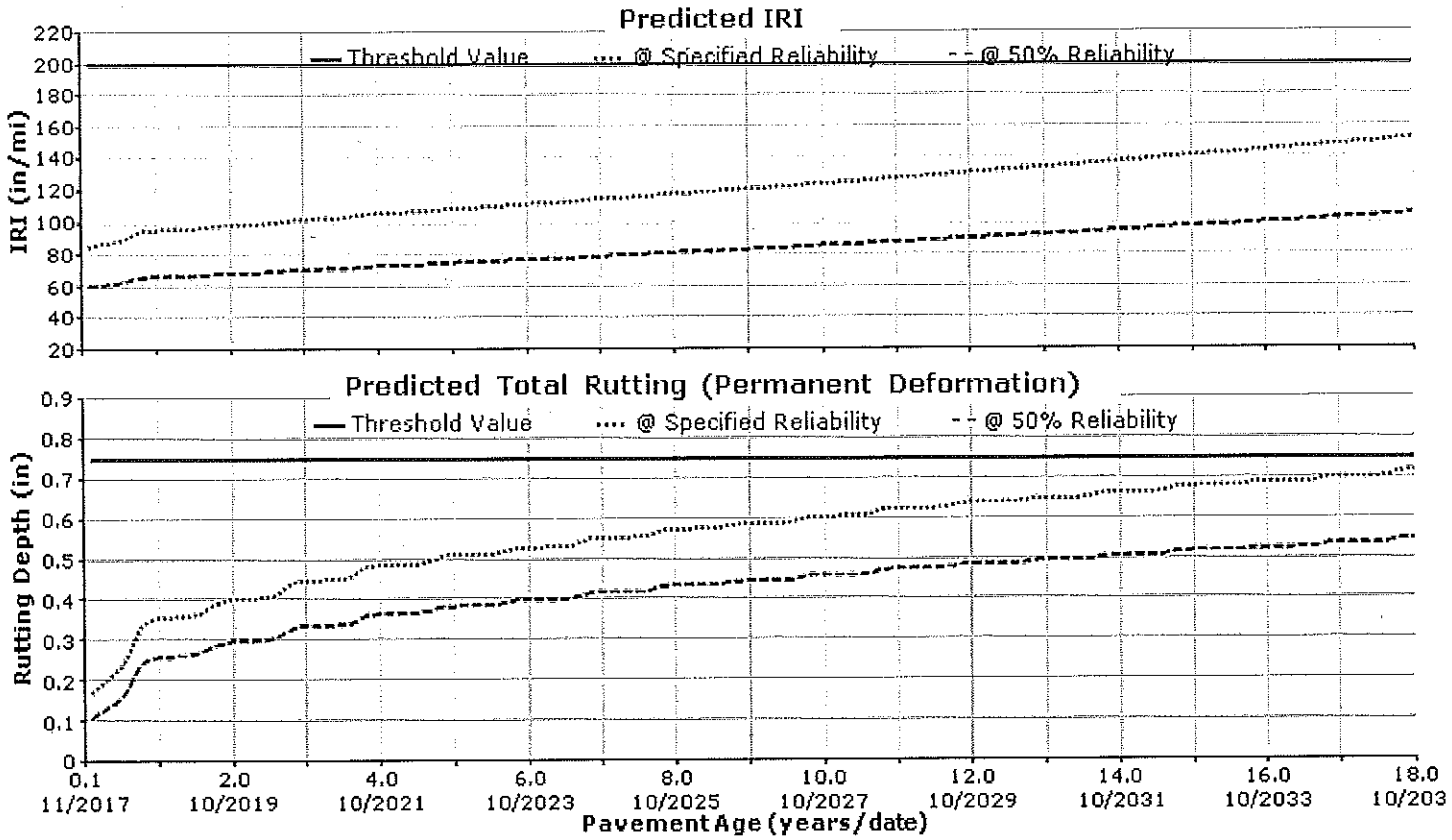



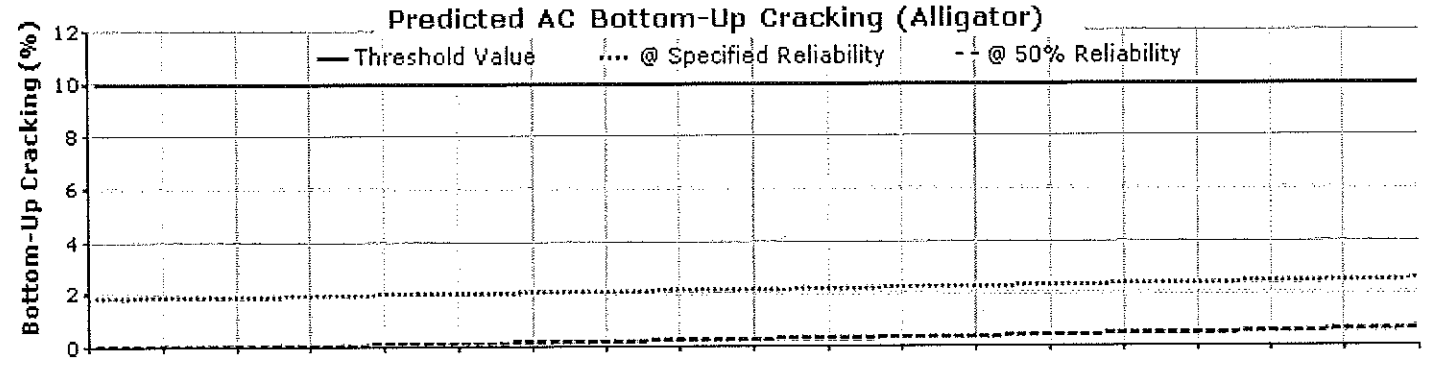

**EXHIBIT #61**

## Analysis Output Charts









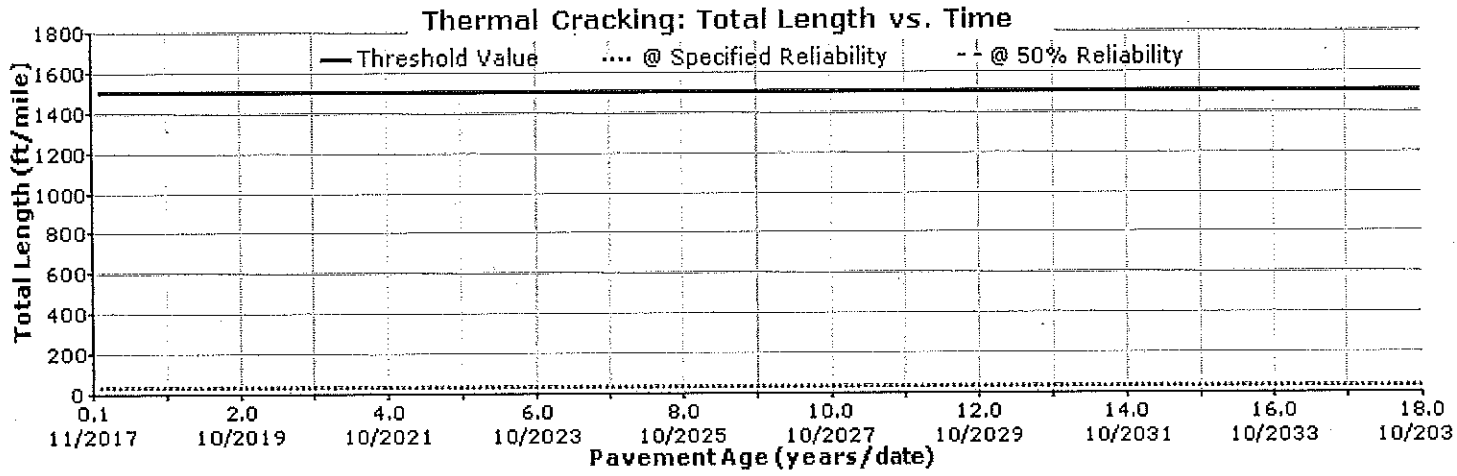




**EXHIBIT #62**