Final

Pavement Design Report

I-25 and Crossroads Boulevard Bridge Replacement

Loveland, Colorado
CDOT Region 4
Larimer County

CDOT Project No. IM 0253-242 (20575)

Yeh Project No.: 215-043

March 18, 2016

Prepared for:

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Yeh and Associates, Inc.
Consulting Engineers & Scientists

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Prepared by:	Reviewed by:
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APPENDIX

1. PURPOSE AND SCOPE OF STUDY

This report presents the result of pavement design performed for the proposed I-25 Crossroads Boulevard (Blvd) Bridge Replacement project near Loveland, Colorado. A subsurface exploration and investigation program was conducted (see Final Geotechnical Investigation Report I-25/Crossroads Bridge Replacement Project, dated December 11, 2015) to obtain information on soil and groundwater conditions to determine pavement thicknesses for mainline I-25, associated ramps, and maineline Crossroads Blvd. This report summarizes the pavement related data obtained and presents our pavement design conclusions and recommendations based on the proposed construction and subsurface conditions encountered during preliminary soil investigations.

2. PROPOSED CONSTRUCTION

Based on information provided by AECOM, we understand that the proposed construction will include a new bridge at Crossroads Blvd, reconstruction of mainline I-25 for approximately 7,450 feet, reconstruction of I-25 ramps at Crossroads Blvd, and reconstruction of mainline Crossroads Blvd for approximately 450 feet connecting the existing roundabouts. We realize that the new structure at Crossroads Blvd and I-25 mainline roadway alignment will be constructed at new proposed profile grades to accommodate for a future managed lane build-out.

In order to balance the earthwork, in-situ materials may be handled and reused at different stages of the project based on the planned construction phasing. The contractor shall provide a method to protect soil that has been processed so that it does not become over wetted and unworkable. If soil becomes over wetted, the contractor shall be responsible for returning the soil to an acceptable condition prior to placement of pavement.

As the proposed profile grade may be in cut or fill sections, it is crucial to know the existing pavement structure layers and thicknesses as well as necessary provisions to construct the proposed pavement layers to maximize the use of in-place materials providing an optimized and homogeneous section.

Existing pavement layers within the project limits on I-25 mainline from top to bottom as indicated in the I-25 project history report provided by the Region 4 Pavement Manager are as follows:

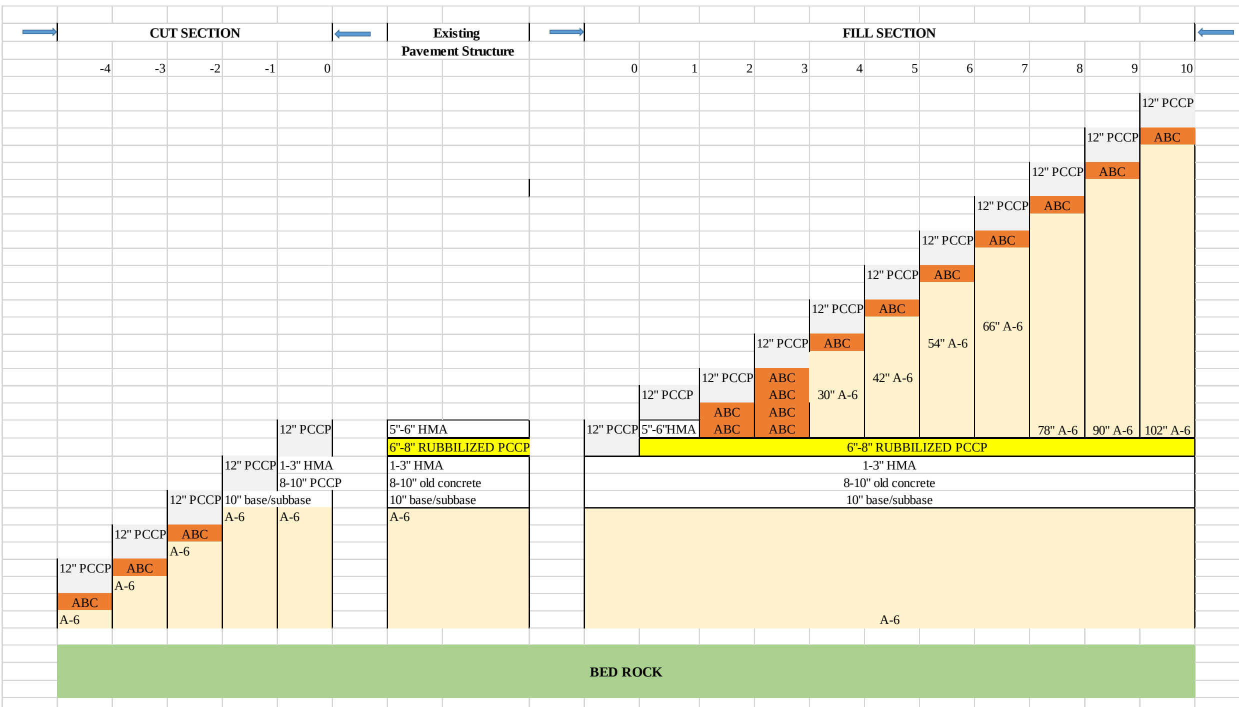
2" of SMA PG 76-28
3" of HMA S (100) PG 76-28
8" of Rubblized PCCP
1"-3" of HMA, potentially degraded to a base
8" of deteriorated PCCP
2" Base Course
8" Sub-base Class 1
Semi-Infinite layer of A-6

The following provisions should be adhered to where PCCP overlay is constructed on top of existing I-25 pavement so the drainage flows away from the pavement structure effectively:

- Fill materials other than Aggregate Base Course (ABC) should not be placed directly over existing rubbilized PCCP unless it is more than 2.5 feet or greater in thickness (see Figure 1).

- New PCCP overlay should be constructed directly over existing HMA when proposed profile is to be raised.
- Existing HMA layer shall be removed when new PCCP overlay is not placed directly on top of the HMA layer.

Figure 1- Depiction of CUT/FILL Sections for New PCCP



3. SUBSURFACE INVESTIGATION

The subsurface investigation program included a total of 37 pavement borings along northbound and southbound I-25, on Crossroads Blvd, and on the existing I-25 ramps at Crossroads Blvd. In general, bulk samples were collected within the top 5 feet in all borings. Lab tests indicate that the surficial soils in the project area along northbound I-25 generally consist of A-6 soils with plasticity indices (PIs) in the low 20's. Soils along southbound I-25 generally consist of A-6 and A-7-6 soils with plasticity indices in the low to high 20's. Higher PIs indicate that the majority of soils at this location are susceptible to swelling. Swell-consolidation tests on samples from borings also supported this assumption. The tests indicated percent swells of -0.5 percent (consolidation) to 1.8 percent (swell) which correspond to a low to medium risk of swell damage.

3.1 Sulfate Concentration

Seven (7) soil samples were tested for soluble sulfate concentration which ranged from 0.008 to 0.069 percent. These concentrations result in a severity of Sulfate Exposure for concrete of class 0 in accordance with Section 601.04 of the CDOT 2011 Standard Specifications for Road and Bridge Construction.

3.2 Chemical Testing

In addition to soluble sulfate, 7 samples were tested for pH, soluble chloride and resistivity. Soluble chloride ranged from 0.0021 to 0.0325 percent, pH ranged from 7 to 10.4 and resistivity ranged from 533 to 1721 ohm.cm. These values should be used in helping to select the appropriate culvert material in conjunction with the CDOT Culvert Pipe Selection guidelines.

3.3 Resilient Modulus, M_r

Hveem "R"-value tests were performed on bulk samples considered to be representative of the subsurface conditions along the alignment that were collected from borings YA-PSB-1, YA-PSB-5, YA-PSB-10, YA-PNB-6, YA-PNB-12, YA-PC-2, YA-PR-1 and YA-PR-4. The measured R-values are presented in Table-1 below. The Mechanistic Empirical (M-E) pavement design software uses a single input value (Resilient Modulus, M_r). The measured R-values were correlated to obtain the design resilient modulus using equation 4-1 from the CDOT Pavement Design Manual ($M_r = 3438.6 * R^{0.2753}$). These values were used to determine a resilient modulus value for use in the M-E Pavement Design program.

Table 1 - MEASURED R-VALUES AND CALCULATED RESILIANT MODULUS

Boring	R-Value	Resilient Modulus M_r	AASHTO Classification
YA-PSB-1	15	7247	A-6 (17)
YA-PSB-5	12	6815	A-7-6 (21)
YA-PSB-10	14	7110	A-7-6 (11)
YA-PNB-6	30	8770	A-6 (3)
YA-PNB-12	16	7376	A-7-6 (8)
YA-PC-2	23	8152	A-6 (3)
YA-PR-1	29	8689	A-6 (4)

4. PAVEMENT DESIGN

The pavement recommendations were developed using the AASHTOWare Mechanistic Empirical Pavement Design program, Version 2.2.

4.1 Traffic

The M-E, pavement design program for determining pavement thickness, uses the truck volumes and compounded annual growth rates and subgrade strength properties to determine the recommended pavement thickness. Version 2.2 of the M-E program used has been calibrated to address Colorado conditions for climate, and PCC and HMA mixes. Truck type distributions called "Cluster" have also been developed for various conditions in Colorado. For example Cluster 1 represents an urban condition with primarily Class 5 (single unit) trucks.

Truck traffic volumes and truck types were obtained from AECOM (see Table 2 Annual Average Daily Traffic Forecasts). This truck information was used to determine the cluster for input to the design program.

Table 2 – ANNUAL AVERAGE DAILY TRAFFIC FORECASTS

Annual Average Daily Traffic Forecasts

NS	I-25	NB			SB			Crossroads	
EW	**Crossroads**	**NB Off**	**NB On**	**I-25**	**SB Off**	**SB On**	**I-25**	**EB**	**WB**
2015	**Count**	4,900	3,800	37,500	4,100	4,300	37,300	7,200	7,400
	Single	170	90	1,690	120	180	1,580	220	470
	Combined	470	140	3,310	110	420	2,760	140	100
2017	**Forecast**	5,100	4,500	39,600	4,500	4,600	39,600	8,500	8,700
	Single	180	90	1,730	130	180	1,730	230	490
	Combined	470	140	3,210	110	430	3,210	150	110
2018	**Forecast**	5,300	4,800	40,600	4,600	4,800	40,600	9,100	9,300
	Single	180	90	1,780	130	180	1,780	240	500
	Combined	470	150	3,300	110	430	3,300	160	110
2035	**Forecast**	7,500	10,400	59,000	7,700	7,500	59,000	19,900	19,800
	Single	190	140	2,580	160	200	2,580	370	670
	Combined	510	220	4,790	140	470	4,790	250	150
2038	**Forecast**	7,900	11,400	62,300	8,200	7,900	62,300	21,800	21,700
	Single	190	140	2,720	170	200	2,720	390	700
	Combined	510	230	5,050	150	470	5,050	260	160
2047	**Forecast**	9,100	14,300	72,000	9,800	9,400	72,000	27,500	27,200
	Single	200	170	3,140	180	210	3,140	460	790
	Combined	530	260	5,840	160	490	5,840	310	180
20-yr Growth Factor		1.5	2.7	1.6	1.9	1.7	1.6	2.8	2.7
HV%									
2015		13%	6%	13%	6%	14%	12%	5%	8%
2017		13%	5%	13%	5%	13%	12%	5%	7%
2018		12%	5%	13%	5%	13%	12%	4%	7%
2035		9%	3%	12%	4%	9%	12%	3%	4%
2038		9%	3%	12%	4%	8%	13%	3%	4%
2047		8%	3%	12%	3%	7%	13%	3%	4%

The above traffic information and 20-year Growth Factors were utilized to determine the annual rate of growth using CDOT Eq. 3.1, $T_f = (1 + r)^{20}$ where T_f is the 20-year Growth Factor.

Table 3 - ANNUAL GROWTH RATE

Segments	Ramp	AADTT (2017)	20-year Growth Factor	Annual Growth Rate (r)	Cluster
I-25 Mainline		9,880	1.6	2.378	2
Crossroads Blvd.		980	2.8	5.283	1
SB On Ramp	Ramp A	610	1.7	2.689	2
NB Off Ramp	Ramp B	650	1.5	2.048	2
SB Off Ramp	Ramp C	240	1.9	3.261	3
NB On Ramp	Ramp D	230	2.7	5.092	2

4.2 Climate

Climate data for the M-E Design software was obtained from Fort Collins weather stations (FORT COLLINS, CO 40.45200 -105.00100 5016). Information such as temperature, precipitation, wind speed, percent sunshine and relative humidity are used to predict the temperature and moisture profiles within the pavement structure.

ANNUAL STATISTICS:
Mean annual air temperature 48.89^0 F
Mean annual precipitation 12.42 (inches)
Freezing index 429.31 days
Average annual number of freeze/thaw cycles: 81.58

4.3 Subgrade Strength

For the pavement design, in order to provide a uniformly strong subgrade, we recommend that in areas with new alignment, the top three feet of material below ABC have a minimum R-value of 20 which is the general characteristic of the in-situ material.

4.4 Recommended Threshold Values of Performance Criteria for Rigid Pavement (JPCP)

PCCP initial design life	30-Years
Terminal IRI (inches per mile)	160
Transverse slab cracking (percent slabs)	7
Mean joint faulting (Inches)	0.12
Reliability (percent)	95

4.5 Recommended Threshold Values of Performance Criteria for Flexible Pavement

HMA initial design life	20-Years
Terminal IRI (inches per mile)	160
Permanent deformation-total pavement (in)	0.55
AC bottom –up fatigue cracking (%lane area)	10
AC thermal cracking (ft/mile)	1500
AC top –down fatigue cracking (ft/mile)	2000
Permanent deformation-AC only (in)	0.40

5. RECOMMENDED PAVEMENT THICKNESSES

Pavement thickness recommendations are presented in Table 4 and Table 5 below. Since, the M-E pavement design is very sensitive to Terminal IRI (in/mile) especially when dealing with relatively high traffic loading, a reliability target of 90 percent was considered for mainline I-25 to reach an optimum thickness design. Consideration of 90 percent reliability for terminal IRI was discussed with the CDOT Region 4 Materials Engineer.

Amongst many iteration of pavement designs on mainline I-25, removing and replacing 3 feet of existing in-situ material with R 40 or better was also considered as a viable option for this project (see Table 4 below).

Table 4 - PAVEMENT THICKNESS RECOMMENDATIONS

Location	Heavy Trucks (Cumulative) (30 years)	Dowel Diameter (in)	Joint Spacing (ft)	IRI Reliability (%)	ABC Class 6 (in)	HMA Thickness (in)	PCCP Thickness (in)	
						S(100) PG 64-22	Design	Recommended*
I-25 Mainline CUT Section, Shallow Bedrock (Moisture Conditioned Subgrade)	69,923,900	1.5	15	90.77	6		11.5	12
I-25 Mainline FILL Section (Moisture Conditioned Subgrade)	69,923,900	1.5	15	90.61	6		12.75	13
I-25 Mainline (R 40 Material)	**69,923,900**	**1.5**	**15**	**91.94**	**6**		**11.75**	**12**
I-25 Mainline JPCP Over AC (Overlay Section)	69,923,900	1.5	15	97.43	6		11.75	12
I-25 Mainline JPCP Over AC (Widened Section)	69,923,900	1.5	15	97.56	12	5	11.75	12
Crossroads Blvd.	48,411,500	1.25	15	96.24	6		8.5	9
Ramp A	10.081,700	1.25	15	96.85	6		7.5	8
Ramp B	9,704,110	1.25	15	97.00	6		7.5	8
Ramp C	4,351,350	1.25	15	98.80	6		7.5	8
Ramp D	5,670,350	1.25	15	98.28	6		7.5	8

** Includes an additional ¼ inch of thickness for future diamond grinding and was rounded up to the nearest ½ inch.*

Table 5 – HMA PAVEMENT THICKNESS RECOMMENDATIONS FOR TRANSITION SECTIONS

Location	Heavy Trucks (cumulative)	TOP LIFT SMA (inch)	Lower Lifts S(100) PG (64-22) (inch)		ABC Class (6) (inch)
			Design	Recommended*	
I-25 Mainline HMA Transition Sections (Moisture Conditioned Subgrade)	40,976,400	2	11.5	11.5	6
RAMPS HMA Transition Sections (Moisture Conditioned Subgrade)					
RAMP A	5,800,950	2	6.75	7	6
RAMP B	5,796,150	2	6.75	7	6
RAMP C	2,419,000	2	5.5	5.5	6
RAMP D	2,804,950	2	5.75	6	6

* *Rounded up to the nearest ½ inch*

6. DETOUR PAVEMENT

This section describes the minimum thickness of new detour pavement required to handle traffic for two years for previously unpaved sections. A reliability factor of safety of 85 percent was used to account for the inherent variations in construction, materials, traffic, climate and other design inputs. The resulting designs are shown in Table 6.

If detour pavement is considered to remain in place as part of the permanent pavement structure, then moisture conditioning of the subgrade and minimum 6 inches of ABC Class will be required prior to the placement of the detour pavement.

Table 6 – MINIMUM DETOUR PAVEMENT THICKNESS RECOMMENDATIONS

HMA Detour		PCCP Detour	
S(100) PG (64-22) (inch)	ABC Class(6) (inch)	PCCP (inch)	ABC Class(6) (inch)
6	**4**	**6**	**4**

7. PAVEMENT SUBGRADE PREPARATION

The swell test results on samples taken from representative soils along the alignment indicated swell potentials ranging from -0.5 percent (consolidation) to 1.8 percent (swell). This range of results typically indicates a low to medium risk for damage due to swelling soils based on Table 4.9 of the CDOT Pavement Design Manual.

Although, there are no indications of swelling conditions in existing pavement, it could be an indication that the in-situ moisture content is high enough that there was minimal swell potential observed. Extra care should be exercised when handling the in-situ material when excavated and used as fill for different construction staging of the project. If the soil is allowed to dry out during construction, the swell potential is greatly increased and concrete pavement becomes more sensitive to swelling soil damage. In this circumstance, stabilization with lime may be considered as an alternative. Removal and replacement of existing soil with 3 feet of R40 or better material may also be considered a viable and cost effective option (see Pavement Thickness Recommendations Table-4).

If lime treatment or removal and replacement of existing soil are not feasible options for this project, then moisture conditioning is recommended in accordance with Table 4.8 of the CDOT Pavement Design Manual, which states that subgrade materials with a PI between 10 and 20 require a minimum treatment depth of 2 feet. Subgrade materials with a PI between 20 and 30 require a minimum treatment depth of 3 feet. We recommend that the soil underneath the proposed ABC Class 6 be moisture conditioned and recompacted to + 2 percent wet of optimum, following section 203 of the 2011 CDOT Standard Specifications for Road and Bridge Construction, to a depth of 3 feet. The prepared subgrade should be proof rolled to determine if any soft spots are present. Any soft spots should be removed and recompacted and proof rolled again. If this does not eliminate the soft spot, the soil should be excavated and replaced, recompacted, and proof rolled until satisfactory. Proof rolling and subgrade compaction tests should be observed and reviewed by a representative of the geotechnical engineer prior to paving.

Granular soils should not be used as backfill for subexcavation or replacement of expansive subgrade soils without a filter separator layer and edge drains to collect and divert the water from the pavement structure. Per CDOT Roadway Design Guide 2005, Typical Section Figures 4-1 through 4-5, the above treatments should extend to the side slope in areas with unprotected slope. In areas with curb and gutter, the treatment should extend for a minimum distance of 12” beyond the back face of the gutter, if possible. These should be shown in the plan set typical sections. A 6-inch aggregate base course should be specified to minimize future pavement distress caused by fines migration and pumping.

8. LIMITATIONS

This study was conducted in accordance with generally accepted geotechnical engineering practices in this area for use by the AECOM for design and construction purposes. The conclusions and recommendations submitted in this report are based upon the data obtained from exploratory borings and field review and the proposed type of construction. Subsurface variations across the site are likely and may not become evident until excavation is performed. If during construction, fill, soil, rock or water conditions appear to be different from those described herein, this office should be advised at once so reevaluation of the recommendations may be made. We recommend on-site observation of excavations and pavement subgrade conditions by a representative of the geotechnical engineer.

9. REFERENCES

Geotechnical Investigation Report, December 11, 2015, Yeh and Associates

2016 Colorado department of Transportation M-E Pavement Design Manual

2011 Colorado department of Transportation Standard Specifications for Road and Bridge Construction

Appendix A

PAVEMENT DESIGN PROGRAM OUTPUTS:

I-25 Mainline CUT Section-New JPCP Dec 2015

I-25 Mainline FILL Section-New JPCP Dec 2015

I-25 Mainline FILL Section R 40-New JPCP Dec 2015

I-25 Mainline Overlay Section-New JPCP Dec 2015

I-25 Mainline Widened Section-New JPCP Dec 2015

I-25 Mainline HMA Transition Section-New AC Dec 2015

Crossroads Blvd-New JPCP Dec 2015

I-25 Ramp A-New JPCP Dec 2015

I-25 Ramp B-New JPCP Dec 2015

I-25 Ramp C-New JPCP Dec 2015

I-25 Ramp D-New JPCP Dec 2015

I-25 Mainline Detour-New AC Dec 2015

I-25 Mainline Detour-New JPCP Dec 2015

I-25 Ramp A HMA Transition New-AC Dec 2015

I-25 Ramp B HMA Transition New-AC Dec 2015

I-25 Ramp C HMA Transition New-AC Dec 2015

I-25 Ramp D HMA Transition New-AC Dec 2015

Jointed Plain Concrete Pavement (JPCP)

Asphalt Concrete (AC)

I-25 Mainline CUT Section-New JPCP Dec 2015

File Name: C:\Users\mghaeli\Desktop\MAY 1 2015\Masoud's Projects\215-043 I 25 @ Crossroads Blvd\Pavement Design\December Designs-New Traffic\I-25 Mainline CUT Section-

Design Inputs

Design Life: 30 years
Design Type: Jointed Plain Concrete Pavement (JPCP)

Existing construction: -
Pavement construction: April, 2017
Traffic opening: August, 2017

Climate Data Sources (Lat/Lon): 40.452, -105.001

Design Structure

Layer type	Material Type	Thickness (in)
PCC	R4 Level 1 Lawson	11.5
NonStabilized	A-1-b	6.0
Subgrade	A-6	36.0
Bedrock	Highly fractured and weathered	Semi-infinite

Joint Design:	
Joint spacing (ft)	15.0
Dowel diameter (in)	1.50
Slab width (ft)	12.0

Traffic

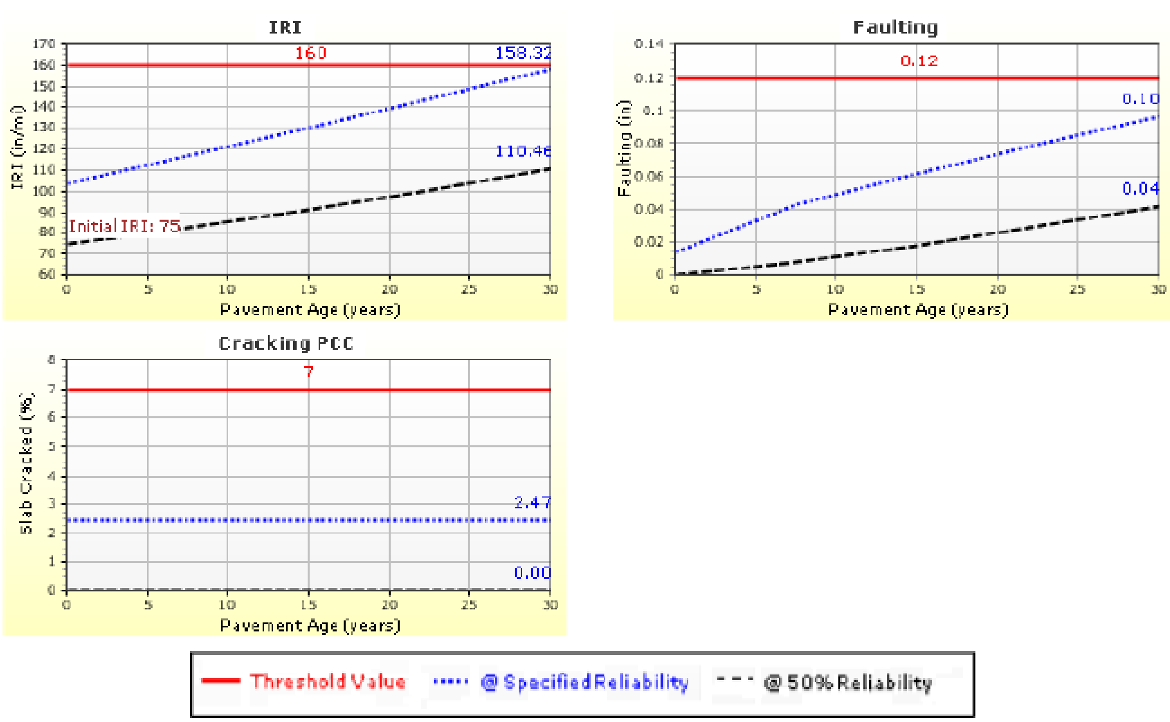
Age (year)	Heavy Trucks (cumulative)
2017 (initial)	9,880
2032 (15 years)	28,862,500
2047 (30 years)	69,923,900

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	158.32	90.00	90.77	Pass
Mean joint faulting (in)	0.12	0.10	95.00	99.07	Pass
JPCP transverse cracking (percent slabs)	7.00	2.47	95.00	100.00	Pass

Distress Charts



I-25 Mainline FILL Section-New JPCP Dec 2015

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Design Inputs

Design Life:	30 years	Existing construction:	-	Climate Data Sources (Lat/Lon)	40.452, -105.001
Design Type:	Jointed Plain Concrete Pavement (JPCP)	Pavement construction:	March, 2017		
		Traffic opening:	September, 2017		

Design Structure

Layer type	Material Type	Thickness (in)
PCC	R4 Level 1 Lawson	12.8
NonStabilized	A-1-b	6.0
Subgrade	A-6	36.0
Subgrade	A-7-6	72.0
Bedrock	Highly fractured and weathered	Semi-infinite

Joint Design:	
Joint spacing (ft)	15.0
Dowel diameter (in)	1.50
Slab width (ft)	12.0

Traffic

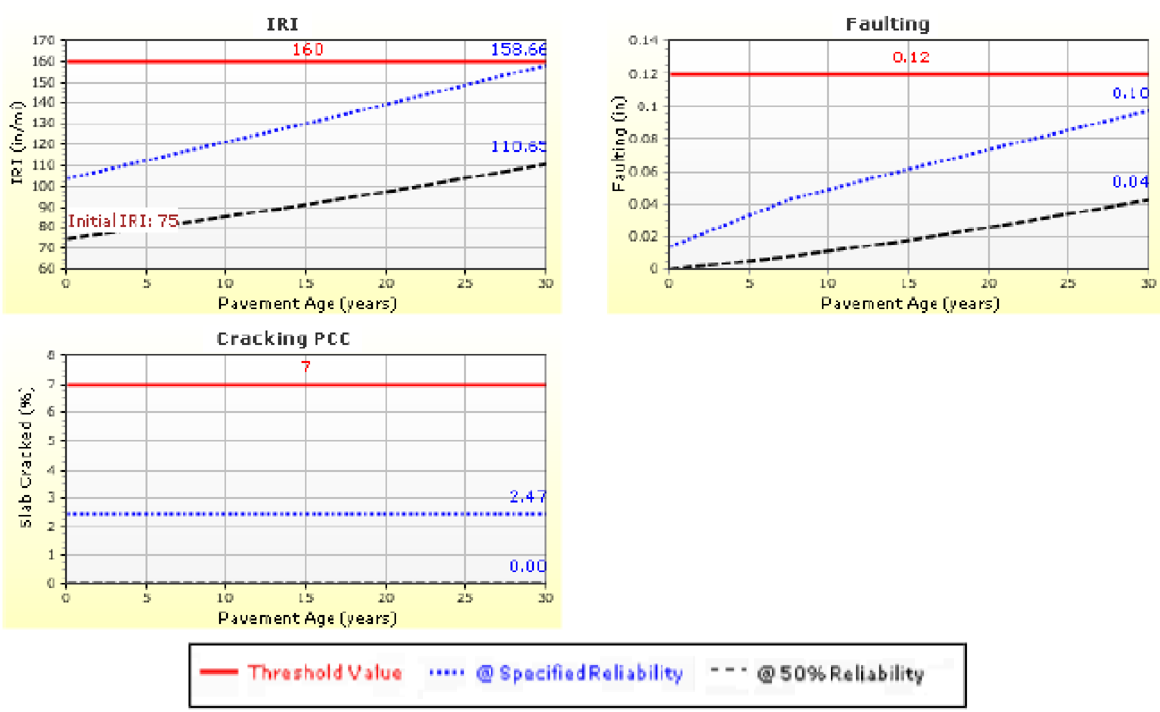
Age (year)	Heavy Trucks (cumulative)
2017 (initial)	9,880
2032 (15 years)	28,862,500
2047 (30 years)	69,923,900

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	158.66	90.00	90.61	Pass
Mean joint faulting (in)	0.12	0.10	95.00	98.91	Pass
JPCP transverse cracking (percent slabs)	7.00	2.47	95.00	100.00	Pass

Distress Charts



I-25 Mainline Fill Section R 40 -New JPCP Dec 2015

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Design Inputs

Design Life:	30 years	Existing construction:	-	Climate Data Sources (Lat/Lon)	40.452, -105.001
Design Type:	Jointed Plain Concrete Pavement (JPCP)	Pavement construction:	June, 2017		
		Traffic opening:	August, 2017		

Design Structure

Layer type	Material Type	Thickness (in)
PCC	R4 Level 1 Lawson	11.8
NonStabilized	A-1-b	6.0
Subgrade	A-2-4	36.0
Subgrade	A-7-6	72.0
Bedrock	Highly fractured and weathered	Semi-infinite

Joint Design:	
Joint spacing (ft)	15.0
Dowel diameter (in)	1.50
Slab width (ft)	12.0

Traffic

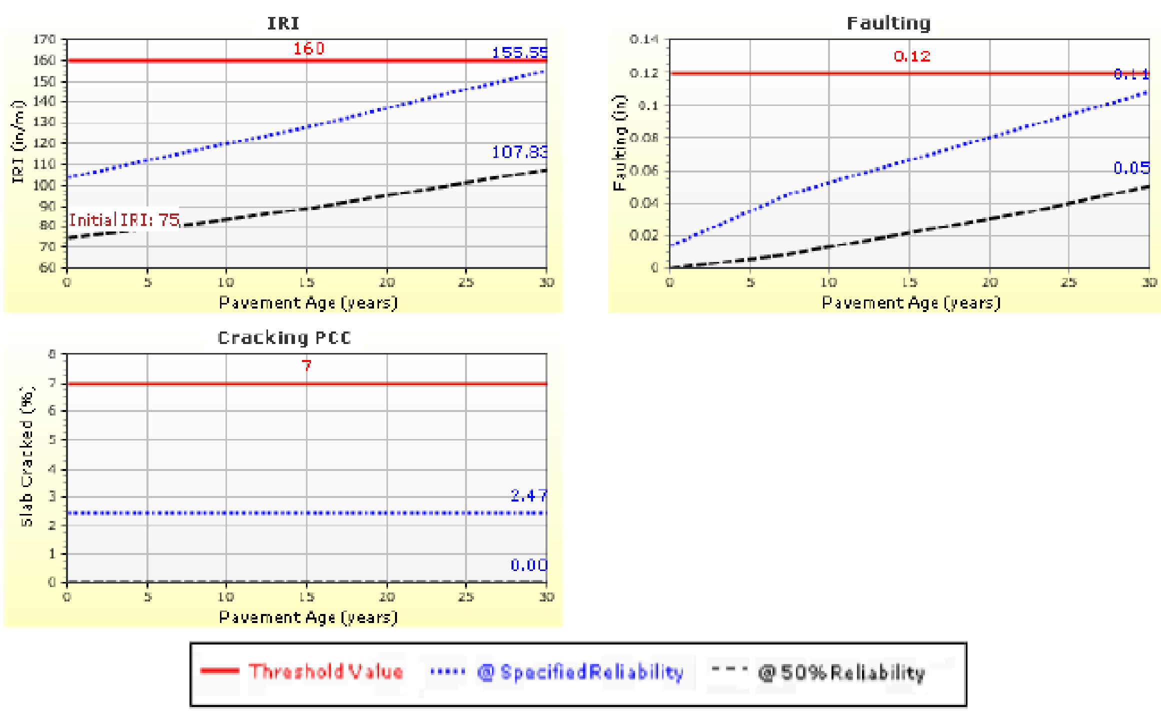
Age (year)	Heavy Trucks (cumulative)
2017 (initial)	9,880
2032 (15 years)	28,862,500
2047 (30 years)	69,923,900

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	155.55	90.00	91.94	Pass
Mean joint faulting (in)	0.12	0.11	95.00	97.53	Pass
JPCP transverse cracking (percent slabs)	7.00	2.47	95.00	100.00	Pass

Distress Charts



I-25 Mainline Overlay Section-New JPCP_over_AC_ Dec 2015

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Design Inputs

Design Life: 30 years
Design Type: JPCP over AC

Existing construction: May, 2010
Pavement construction: July, 2017
Traffic opening: September, 2017

Climate Data Sources (Lat/Lon): 40.452, -105.001

Design Structure

Layer type	Material Type	Thickness (in)
PCC	R4 Level 1 Lawson	11.8
Flexible (existing)	R4 SMA	2.0
Flexible (existing)	R1 Level 1 S(100) PG 64-22	3.0
Stabilized	Sandwich Granular	8.0
NonStabilized	Crushed stone	8.0
NonStabilized	A-1-a	10.0
Subgrade	A-6	36.0
Subgrade	A-7-6	72.0
Bedrock	Highly fractured and weathered	Semi-infinite

Joint Design:	
Joint spacing (ft)	15.0
Dowel diameter (in)	1.50
Slab width (ft)	12.0

Traffic

Age (year)	Heavy Trucks (cumulative)
2017 (initial)	9,880
2032 (15 years)	28,862,500
2047 (30 years)	69,923,900

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	137.67	90.00	97.43	Pass
Mean joint faulting (in)	0.12	0.10	95.00	99.18	Pass
JPCP transverse cracking (percent slabs)	7.00	2.47	95.00	100.00	Pass

I-25 Mainline Widened Section-New JPCP_over_AC_ Dec 2015

File Name: C:\Users\mghaeli\Desktop\MAY 1 2015\Masoud's Projects\215-043 I 25 @ Crossroads Blvd\Pavement Design\Designs with bedrocks within 20'\I-25 Mainline Widened

Design Inputs

Design Life: 30 years
Design Type: JPCP over AC

Existing construction: May, 2017
Pavement construction: July, 2017
Traffic opening: September, 2017

Climate Data Sources (Lat/Lon): 40.452, -105.001

Design Structure

Layer type	Material Type	Thickness (in)
PCC	R4 Level 1 Lawson	11.8
Flexible (existing)	R1 Level 1 S(100) PG 64-22	5.0
NonStabilized	A-1-a	12.0
Subgrade	A-6	36.0
Subgrade	A-7-6	72.0
Bedrock	Highly fractured and weathered	Semi-infinite

Joint Design:	
Joint spacing (ft)	15.0
Dowel diameter (in)	1.50
Slab width (ft)	12.0

Traffic

Age (year)	Heavy Trucks (cumulative)
2017 (initial)	9,880
2032 (15 years)	28,862,500
2047 (30 years)	69,923,900

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	137.05	90.00	97.56	Pass
Mean joint faulting (in)	0.12	0.09	95.00	99.26	Pass
JPCP transverse cracking (percent slabs)	7.00	2.47	95.00	100.00	Pass

I-25 Mainline HMA TransitionNew_AC_Design Dec 15

File Name: C:\Users\mghaeli\Desktop\MAY 1 2015\Masoud's Projects\215-043 I 25 @ Crossroads Blvd\Pavement Design\December Designs-New Traffic\I-25 Mainline HMA

Design Inputs

Design Life: 20 years
Design Type: Flexible Pavement

Base construction: March, 2017
Pavement construction: August, 2017
Traffic opening: September, 2017

Climate Data Sources (Lat/Lon): 40.452, -105.001

Design Structure

Layer type	Material Type	Thickness (in)
Flexible	R4 SMA	2.0
Flexible	R1 Level 1 S(100) PG 64-22	11.5
NonStabilized	Aggregate Base	6.0
Subgrade	A-6	36.0
Subgrade	A-7-6	72.0
Bedrock	Highly fractured and weathered	Semi-infinite

Volumetric at Construction:	
Effective binder content (%)	13.1
Air voids (%)	4.0

Traffic

Age (year)	Heavy Trucks (cumulative)
2017 (initial)	9,880
2027 (10 years)	18,091,700
2037 (20 years)	40,976,400

Design Outputs

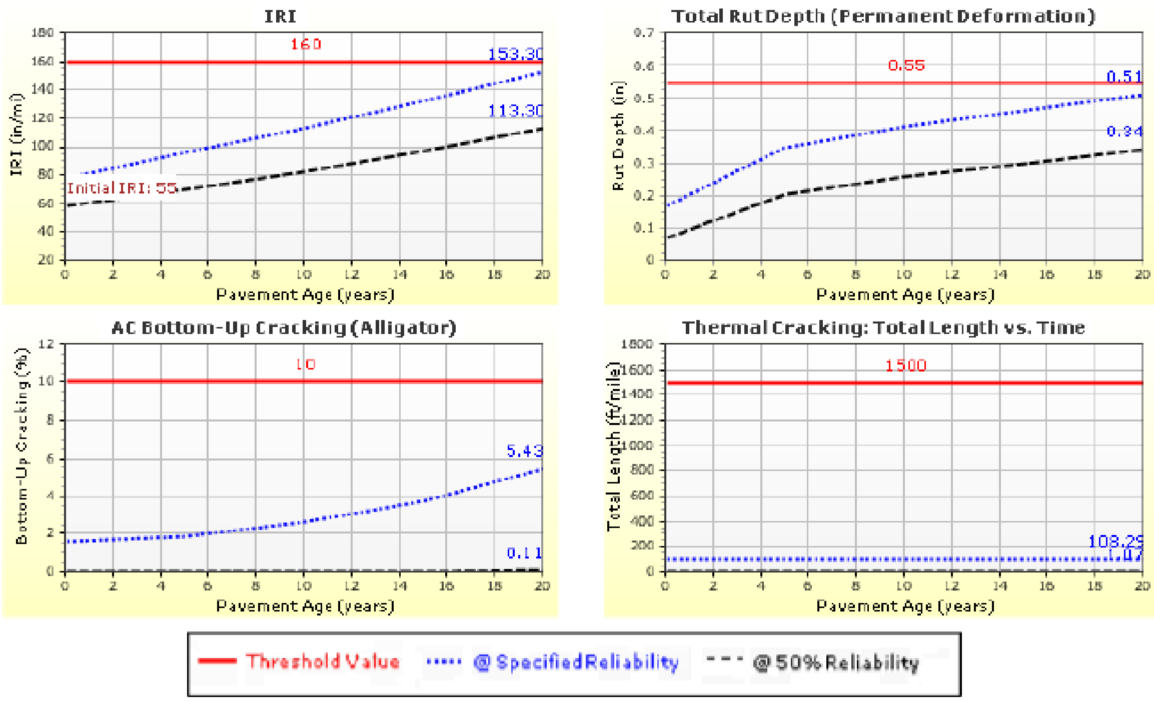
Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	153.28	90.00	93.28	Pass
Permanent deformation - total pavement (in)	0.55	0.51	95.00	97.78	Pass
AC bottom-up fatigue cracking (% lane area)	10.00	5.43	95.00	99.89	Pass
AC thermal cracking (ft/mile)	1500.00	108.29	95.00	100.00	Pass
AC top-down fatigue cracking (ft/mile)	2000.00	330.05	95.00	100.00	Pass
Permanent deformation - AC only (in)	0.40	0.42	95.00	93.19	Fail

I-25 Mainline HMA TransitionNew_AC_Design Dec 15

File Name: C:\Users\mghaeli\Desktop\MAY 1 2015\Masoud's Projects\215-043 I 25 @ Crossroads Blvd\Pavement Design\December Designs-New Traffic\I-25 Mainline HMA

Distress Charts



Crossroads Blvd-New JPCP Dec 2015

File Name: C:\Users\mghaeli\Desktop\MAY 1 2015\Masoud's Projects\215-043 I 25 @ Crossroads Blvd\Pavement Design\December Designs-New Traffic\Crossroads Blvd-New JPCP

Design Inputs

Design Life: 30 years
Design Type: Jointed Plain Concrete Pavement (JPCP)

Existing construction: -
Pavement construction: April, 2017
Traffic opening: August, 2017

Climate Data Sources (Lat/Lon): 40.452, -105.001

Design Structure

Layer type	Material Type	Thickness (in)
PCC	R4 Level 1 Lawson	8.5
NonStabilized	A-1-b	6.0
Subgrade	A-6	36.0
Subgrade	A-7-6	36.0
Bedrock	Highly fractured and weathered	Semi-infinite

Joint Design:	
Joint spacing (ft)	15.0
Dowel diameter (in)	1.50
Slab width (ft)	12.0

Traffic

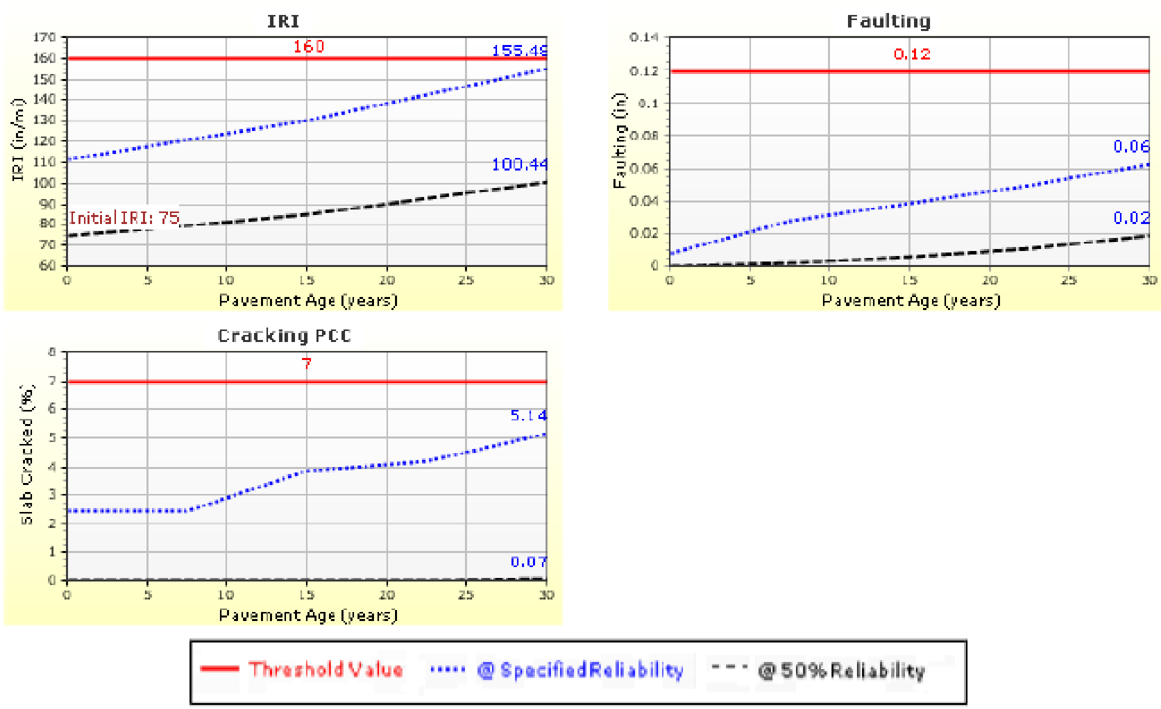
Age (year)	Heavy Trucks (cumulative)
2017 (initial)	4,000
2032 (15 years)	15,297,900
2047 (30 years)	48,411,500

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	155.48	95.00	96.24	Pass
Mean joint faulting (in)	0.12	0.06	95.00	99.99	Pass
JPCP transverse cracking (percent slabs)	7.00	5.14	95.00	98.78	Pass

Distress Charts



Ramp A - New JPCP Dec 2015

File Name: C:\Users\mghaeli\Desktop\MAY 1 2015\Masoud's Projects\215-043 I 25 @ Crossroads Blvd\Pavement Design\December Designs-New Traffic\Ramp A - New JPCP Dec

Design Inputs

Design Life: 30 years
Design Type: Jointed Plain Concrete Pavement (JPCP)

Existing construction: -
Pavement construction: March, 2017
Traffic opening: August, 2017

Climate Data Sources (Lat/Lon): 40.452, -105.001

Design Structure

Layer type	Material Type	Thickness (in)
PCC	R4 Level 1 Lawson	7.5
NonStabilized	A-1-b	6.0
Subgrade	A-6	36.0
Subgrade	A-7-6	72.0
Bedrock	Highly fractured and weathered	Semi-infinite

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

Traffic

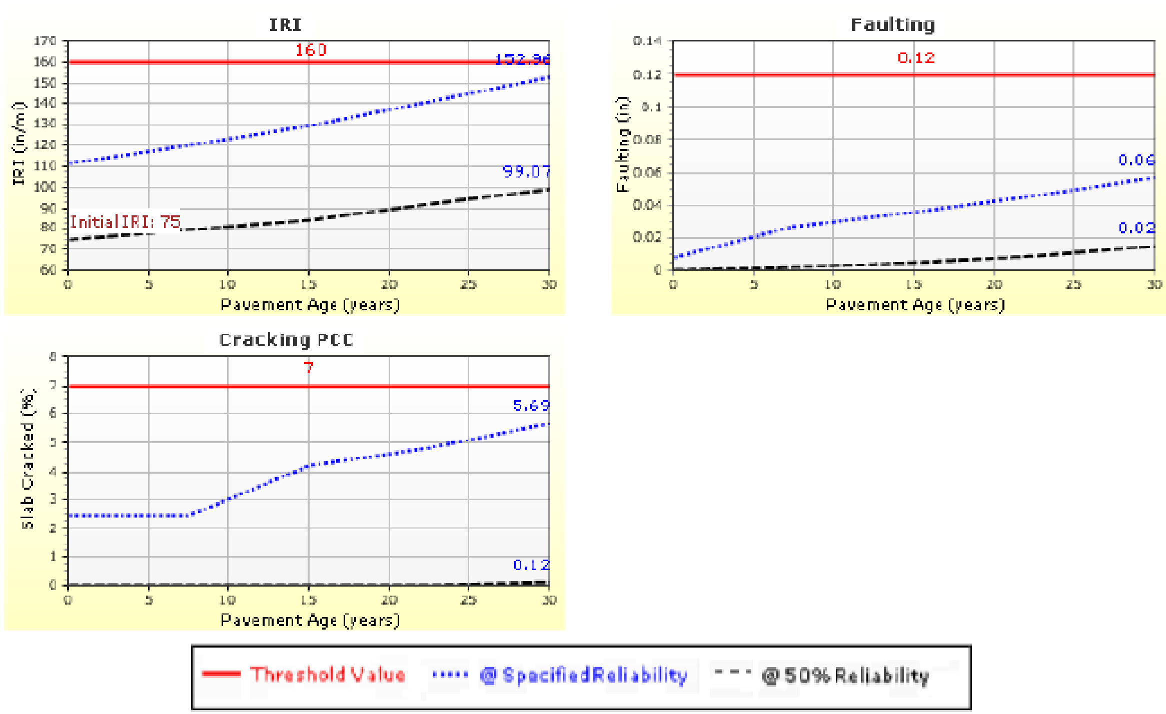
Age (year)	Heavy Trucks (cumulative)
2017 (initial)	610
2032 (15 years)	4,050,690
2047 (30 years)	10,081,700

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	152.96	95.00	96.85	Pass
Mean joint faulting (in)	0.12	0.06	95.00	100.00	Pass
JPCP transverse cracking (percent slabs)	7.00	5.69	95.00	97.89	Pass

Distress Charts



Ramp B - New JPCP Dec 2015

File Name: C:\Users\mghaeli\Desktop\MAY 1 2015\Masoud's Projects\215-043 I 25 @ Crossroads Blvd\Pavement Design\December Designs-New Traffic\Ramp B - New JPCP Dec

Design Inputs

Design Life: 30 years
Design Type: Jointed Plain Concrete Pavement (JPCP)

Existing construction: -
Pavement construction: March, 2017
Traffic opening: August, 2017

Climate Data Sources (Lat/Lon): 40.452, -105.001

Design Structure

Layer type	Material Type	Thickness (in)
PCC	R4 Level 1 Lawson	7.5
NonStabilized	A-1-b	6.0
Subgrade	A-6	36.0
Subgrade	A-7-6	72.0
Bedrock	Highly fractured and weathered	Semi-infinite

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

Traffic

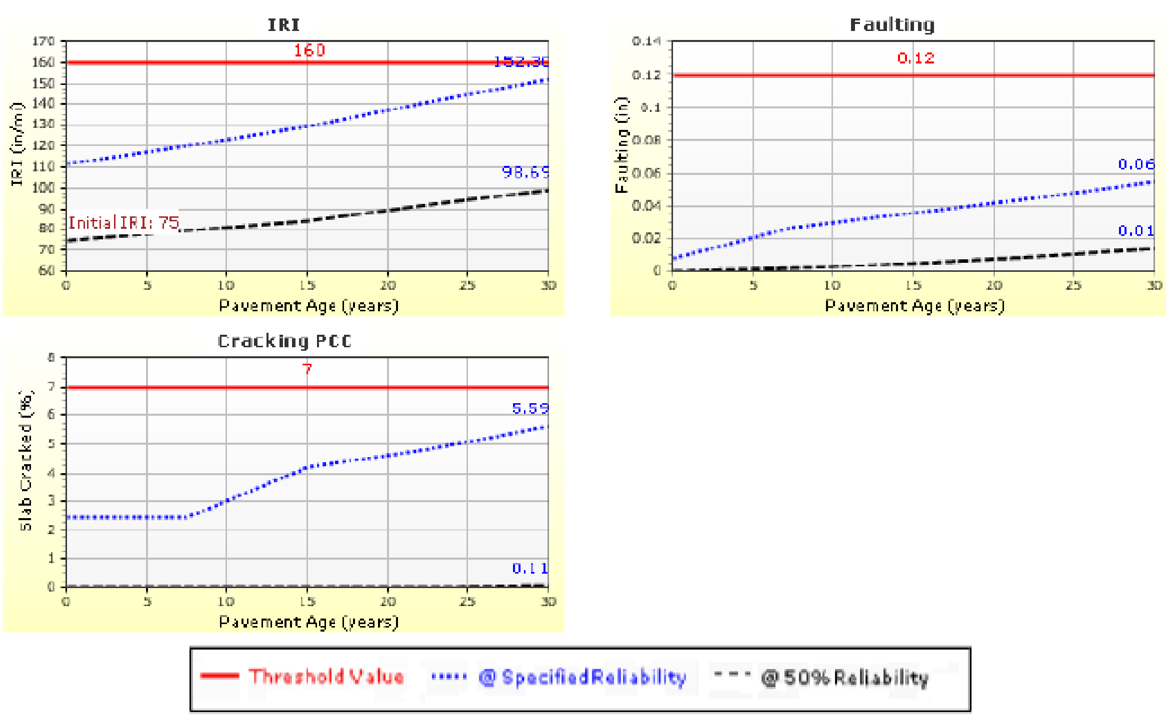
Age (year)	Heavy Trucks (cumulative)
2017 (initial)	650
2032 (15 years)	4,119,940
2047 (30 years)	9,704,110

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	152.30	95.00	97.00	Pass
Mean joint faulting (in)	0.12	0.06	95.00	100.00	Pass
JPCP transverse cracking (percent slabs)	7.00	5.59	95.00	98.06	Pass

Distress Charts



Ramp C - New JPCP Dec 2015

File Name: C:\Users\mghaeli\Desktop\MAY 1 2015\Masoud's Projects\215-043 I 25 @ Crossroads Blvd\Pavement Design\December Designs-New Traffic\Ramp C - New JPCP Dec

Design Inputs

Design Life:	30 years	Existing construction:	-	Climate Data Sources (Lat/Lon)	40.452, -105.001
Design Type:	Jointed Plain Concrete Pavement (JPCP)	Pavement construction:	March, 2017		
		Traffic opening:	August, 2017		

Design Structure

Layer type	Material Type	Thickness (in)
PCC	R4 Level 1 Lawson	7.5
NonStabilized	A-1-b	6.0
Subgrade	A-6	36.0
Subgrade	A-7-6	72.0
Bedrock	Highly fractured and weathered	Semi-infinite

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

Traffic

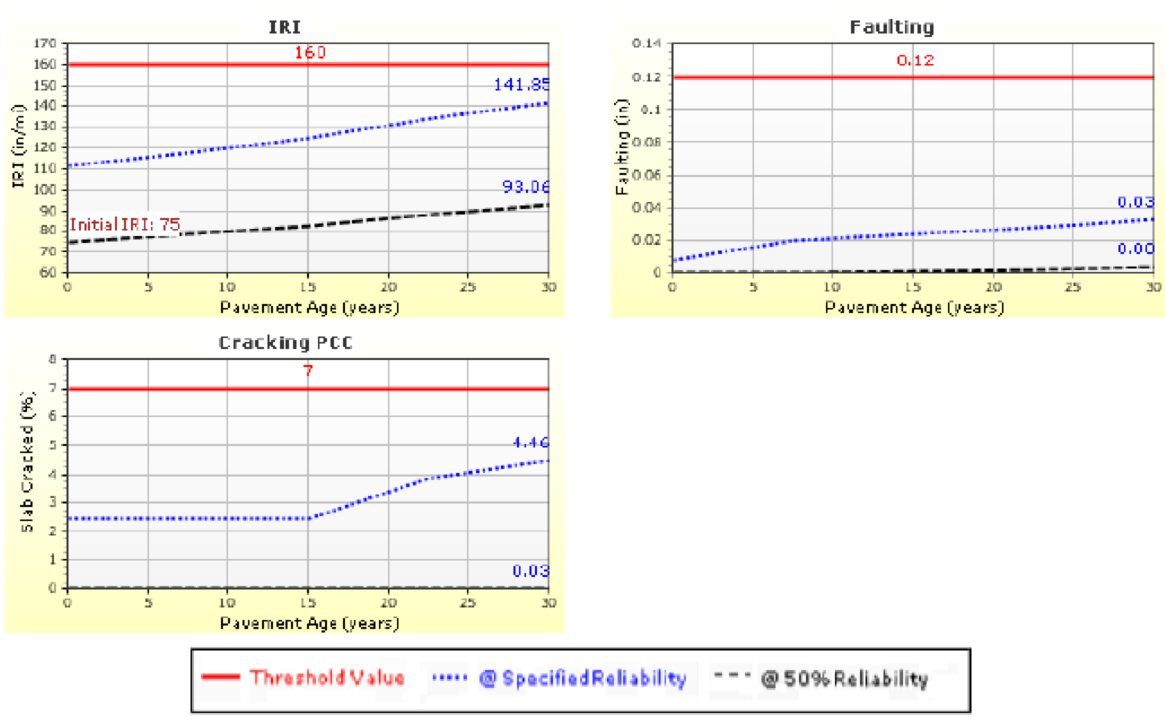
Age (year)	Heavy Trucks (cumulative)
2017 (initial)	240
2032 (15 years)	1,661,930
2047 (30 years)	4,351,350

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	141.85	95.00	98.80	Pass
Mean joint faulting (in)	0.12	0.03	95.00	100.00	Pass
JPCP transverse cracking (percent slabs)	7.00	4.46	95.00	99.52	Pass

Distress Charts



Ramp D - New JPCP Dec 2015

File Name: C:\Users\mghaeli\Desktop\MAY 1 2015\Masoud's Projects\215-043 I 25 @ Crossroads Blvd\Pavement Design\December Designs-New Traffic\Ramp D - New JPCP Dec

Design Inputs

Design Life: 30 years
Design Type: Jointed Plain Concrete Pavement (JPCP)

Existing construction: -
Pavement construction: March, 2017
Traffic opening: August, 2017

Climate Data Sources (Lat/Lon): 40.452, -105.001

Design Structure

Layer type	Material Type	Thickness (in)
PCC	R4 Level 1 Lawson	7.5
NonStabilized	A-1-b	6.0
Subgrade	A-6	36.0
Subgrade	A-7-6	72.0
Bedrock	Highly fractured and weathered	Semi-infinite

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

Traffic

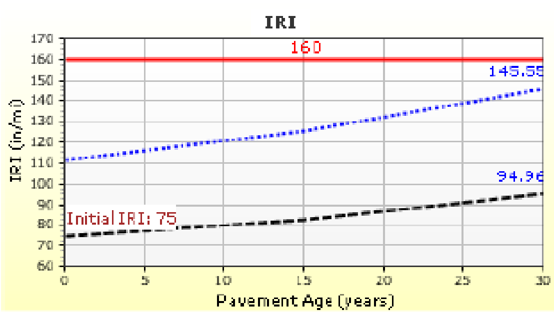
Age (year)	Heavy Trucks (cumulative)
2017 (initial)	230
2032 (15 years)	1,825,360
2047 (30 years)	5,670,350

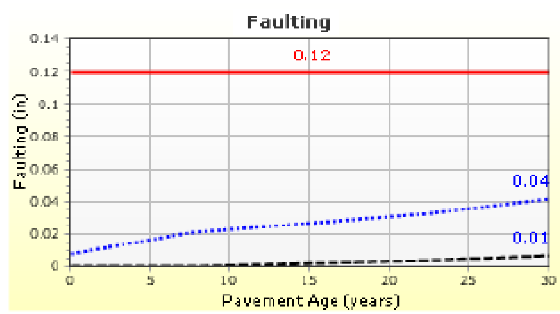
Design Outputs

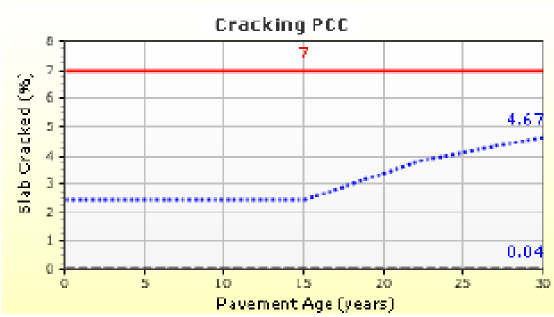
Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	145.55	95.00	98.28	Pass
Mean joint faulting (in)	0.12	0.04	95.00	100.00	Pass
JPCP transverse cracking (percent slabs)	7.00	4.67	95.00	99.33	Pass

Distress Charts







Threshold Value | @ Specified Reliability | @ 50% Reliability

I-25 Mainline Detour New AC Dec 2015

File Name: C:\Users\mghaeli\Desktop\MAY 1 2015\Masoud's Projects\215-043 I 25 @ Crossroads Blvd\Pavement Design\December Designs-New Traffic\I-25 Mainline Detour New

Design Inputs

Design Life: 2 years
Design Type: Flexible Pavement

Base construction: March, 2017
Pavement construction: June, 2017
Traffic opening: September, 2017

Climate Data Sources (Lat/Lon): 40.452, -105.001

Design Structure

Layer type	Material Type	Thickness (in)
Flexible	R1 Level 1 S(100) PG 64-22	6.0
NonStabilized	Aggregate Base	4.0
Subgrade	A-6	36.0
Subgrade	A-7-6	10.0
Bedrock	Highly fractured and weathered	Semi-infinite

Volumetric at Construction:	
Effective binder content (%)	11.5
Air voids (%)	4.9

Traffic

Age (year)	Heavy Trucks (cumulative)
2017 (initial)	9,880
2018 (1 years)	1,623,900
2019 (2 years)	3,286,420

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	86.14	85.00	100.00	Pass
Permanent deformation - total pavement (in)	0.65	0.23	85.00	100.00	Pass
AC bottom-up fatigue cracking (% lane area)	35.00	15.90	85.00	99.59	Pass
AC thermal cracking (ft/mile)	1500.00	81.60	85.00	100.00	Pass
AC top-down fatigue cracking (ft/mile)	3000.00	392.00	85.00	100.00	Pass
Permanent deformation - AC only (in)	0.50	0.12	85.00	100.00	Pass

I-25 Mainline Detour -New JCCP Dec 2015

File Name: C:\Users\mghaeli\Desktop\MAY 1 2015\Masoud's Projects\215-043 I 25 @ Crossroads Blvd\Pavement Design\December Designs-New Traffic\I-25 Mainline Detour -New

Design Inputs

Design Life: 2 years
Design Type: Jointed Plain Concrete Pavement (JPCP)
Existing construction: -
Pavement construction: March, 2017
Traffic opening: August, 2017
Climate Data Sources (Lat/Lon): 40.452, -105.001

Design Structure

Layer type	Material Type	Thickness (in)
PCC	R4 Level 1 Lawson	6.0
NonStabilized	A-1-b	4.0
Subgrade	A-6	36.0
Subgrade	A-7-6	72.0
Bedrock	Highly fractured and weathered	Semi-infinite

Joint Design:	
Joint spacing (ft)	15.0
Dowel diameter (in)	1.50
Slab width (ft)	12.0

Traffic

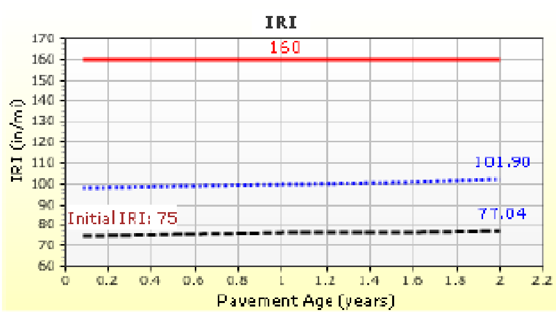
Age (year)	Heavy Trucks (cumulative)
2017 (initial)	9,880
2018 (1 years)	1,623,900
2019 (2 years)	3,286,420

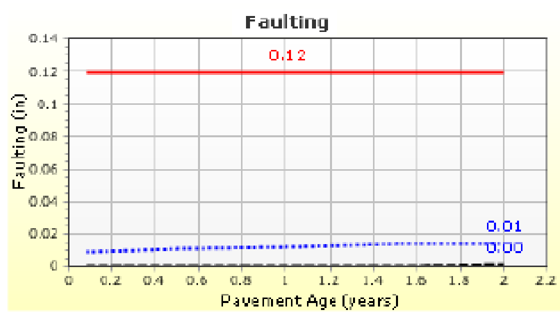
Design Outputs

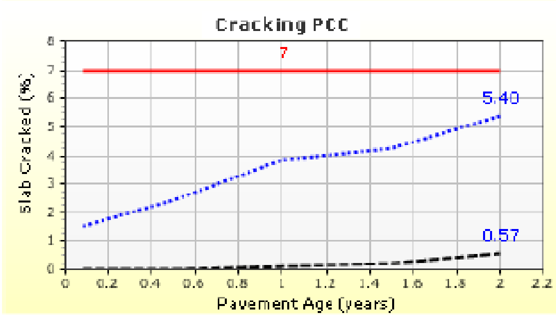
Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	101.90	85.00	99.97	Pass
Mean joint faulting (in)	0.12	0.01	85.00	100.00	Pass
JPCP transverse cracking (percent slabs)	7.00	5.40	85.00	91.64	Pass

Distress Charts







Threshold Value ····· @ Specified Reliability - - - @ 50% Reliability

I-25 Ramp A HMA TransitionNew_AC_Design Dec 2015

File Name: C:\Users\mghaeli\Desktop\MAY 1 2015\Masoud's Projects\215-043 I 25 @ Crossroads Blvd\Pavement Design\December Designs-New Traffic\I-25 Ramp A HMA

Design Inputs

Design Life: 20 years
Design Type: Flexible Pavement

Base construction: March, 2017
Pavement construction: August, 2017
Traffic opening: September, 2017

Climate Data Sources (Lat/Lon): 40.452, -105.001

Design Structure

Layer type	Material Type	Thickness (in)
Flexible	R4 SMA	2.0
Flexible	R1 Level 1 S(100) PG 64-22	6.8
NonStabilized	Aggregate Base	6.0
Subgrade	A-6	36.0
Subgrade	A-7-6	36.0
Bedrock	Highly fractured and weathered	Semi-infinite

Volumetric at Construction:	
Effective binder content (%)	13.1
Air voids (%)	4.0

Traffic

Age (year)	Heavy Trucks (cumulative)
2017 (initial)	610
2027 (10 years)	2,517,900
2037 (20 years)	5,800,950

Design Outputs

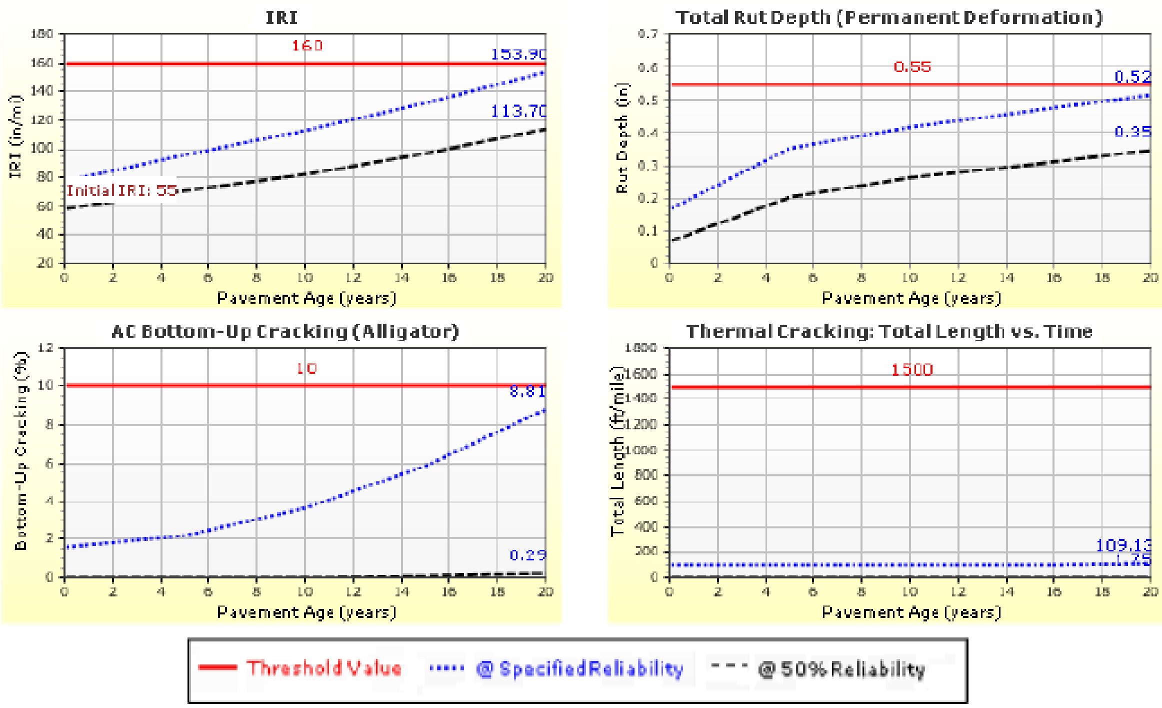
Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	153.89	90.00	93.00	Pass
Permanent deformation - total pavement (in)	0.55	0.52	95.00	97.46	Pass
AC bottom-up fatigue cracking (% lane area)	10.00	8.81	95.00	96.96	Pass
AC thermal cracking (ft/mile)	1500.00	109.13	95.00	100.00	Pass
AC top-down fatigue cracking (ft/mile)	2000.00	334.28	95.00	100.00	Pass
Permanent deformation - AC only (in)	0.40	0.41	95.00	93.56	Fail

I-25 Ramp A HMA TransitionNew_AC_Design Dec 2015

File Name: C:\Users\mghaeli\Desktop\MAY 1 2015\Masoud's Projects\215-043 I 25 @ Crossroads Blvd\Pavement Design\December Designs-New Traffic\I-25 Ramp A HMA

Distress Charts



I-25 Ramp B HMA TransitionNew_AC_Design Dec 2015

File Name: C:\Users\mghaeli\Desktop\MAY 1 2015\Masoud's Projects\215-043 I 25 @ Crossroads Blvd\Pavement Design\December Designs-New Traffic\I-25 Ramp B HMA

Design Inputs

Design Life:	20 years	Base construction:	March, 2017	Climate Data Sources (Lat/Lon)	40.452, -105.001
Design Type:	Flexible Pavement	Pavement construction:	August, 2017		
		Traffic opening:	September, 2017		

Design Structure

Layer type	Material Type	Thickness (in)
Flexible	R4 SMA	2.0
Flexible	R1 Level 1 S(100) PG 64-22	6.8
NonStabilized	Aggregate Base	6.0
Subgrade	A-6	36.0
Subgrade	A-7-6	36.0
Bedrock	Highly fractured and weathered	Semi-infinite

Volumetric at Construction:	
Effective binder content (%)	13.1
Air voids (%)	4.0

Traffic

Age (year)	Heavy Trucks (cumulative)
2017 (initial)	650
2027 (10 years)	2,605,310
2037 (20 years)	5,796,150

Design Outputs

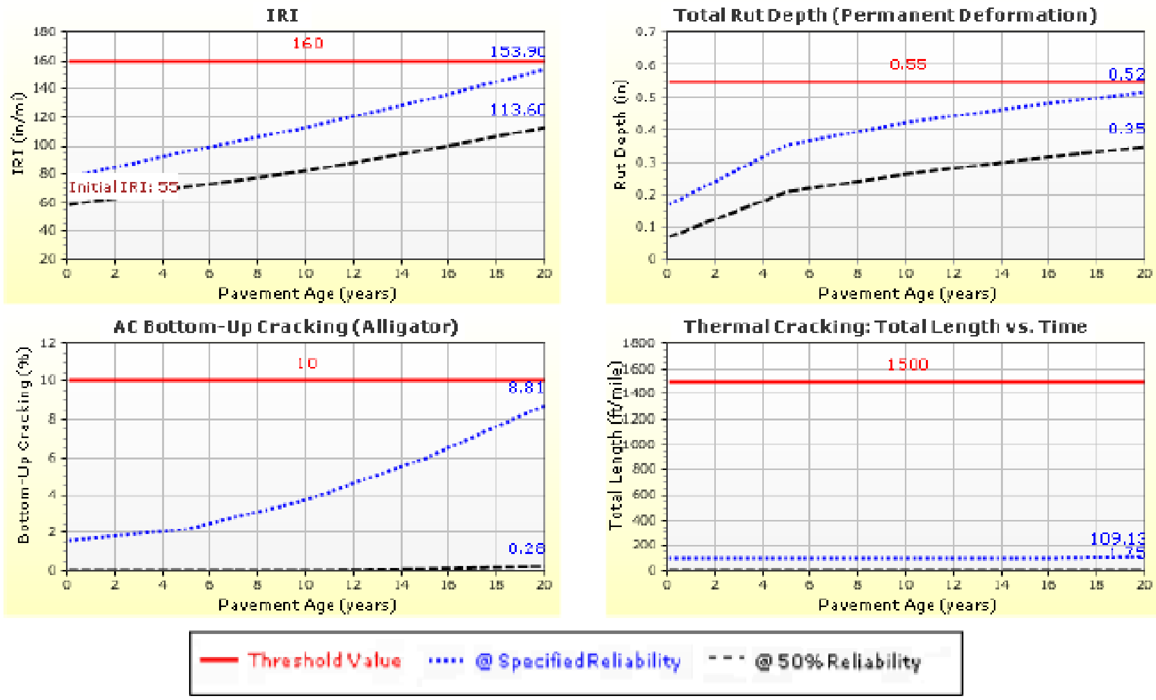
Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	153.86	90.00	93.02	Pass
Permanent deformation - total pavement (in)	0.55	0.52	95.00	97.49	Pass
AC bottom-up fatigue cracking (% lane area)	10.00	8.81	95.00	96.96	Pass
AC thermal cracking (ft/mile)	1500.00	109.13	95.00	100.00	Pass
AC top-down fatigue cracking (ft/mile)	2000.00	334.28	95.00	100.00	Pass
Permanent deformation - AC only (in)	0.40	0.41	95.00	93.64	Fail

I-25 Ramp B HMA TransitionNew_AC_Design Dec 2015

File Name: C:\Users\mghaeli\Desktop\MAY 1 2015\Masoud's Projects\215-043 I 25 @ Crossroads Blvd\Pavement Design\December Designs-New Traffic\I-25 Ramp B HMA

Distress Charts



I-25 Ramp C HMA TransitionNew_AC_Design Dec 2015

File Name: C:\Users\mghaeli\Desktop\MAY 1 2015\Masoud's Projects\215-043 I 25 @ Crossroads Blvd\Pavement Design\December Designs-New Traffic\I-25 Ramp C HMA

Design Inputs

Design Life: 20 years
Design Type: Flexible Pavement

Base construction: March, 2017
Pavement construction: August, 2017
Traffic opening: September, 2017

Climate Data Sources (Lat/Lon): 40.452, -105.001

Design Structure

Layer type	Material Type	Thickness (in)
Flexible	R4 SMA	2.0
Flexible	R1 Level 1 S(100) PG 64-22	5.5
NonStabilized	Aggregate Base	6.0
Subgrade	A-6	36.0
Subgrade	A-7-6	36.0
Bedrock	Highly fractured and weathered	Semi-infinite

Volumetric at Construction:	
Effective binder content (%)	13.1
Air voids (%)	4.0

Traffic

Age (year)	Heavy Trucks (cumulative)
2017 (initial)	240
2027 (10 years)	1,017,090
2037 (20 years)	2,419,000

Design Outputs

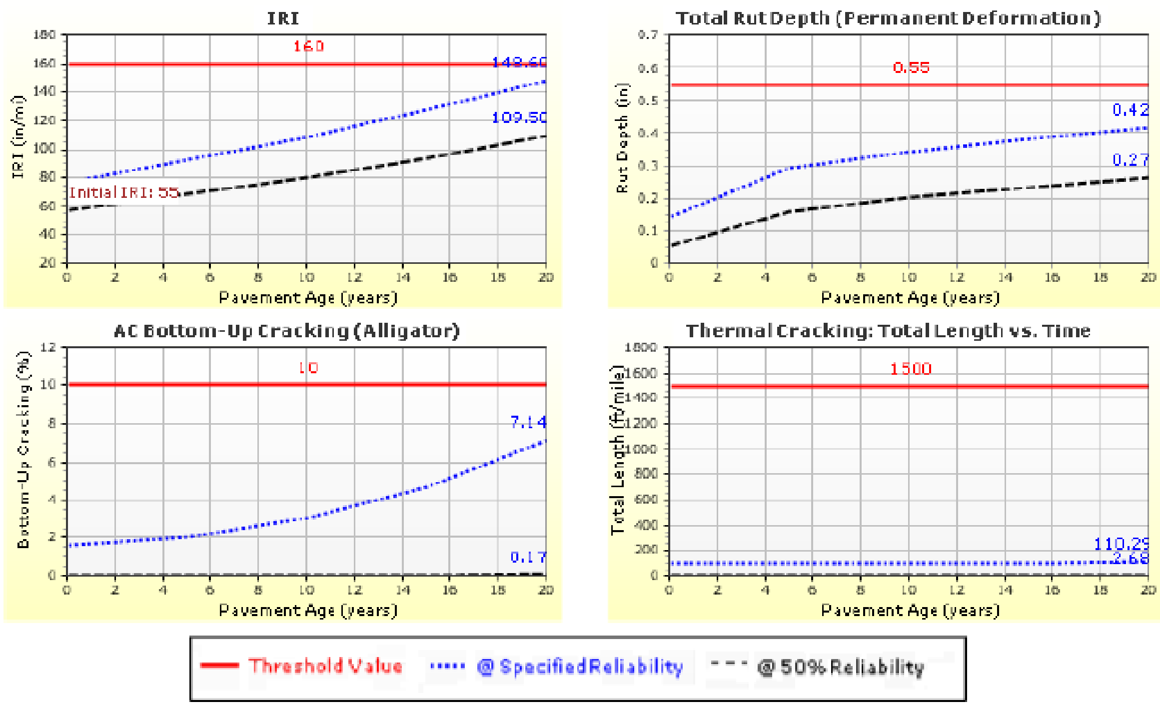
Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	148.58	90.00	95.12	Pass
Permanent deformation - total pavement (in)	0.55	0.42	95.00	99.87	Pass
AC bottom-up fatigue cracking (% lane area)	10.00	7.14	95.00	98.98	Pass
AC thermal cracking (ft/mile)	1500.00	110.29	95.00	100.00	Pass
AC top-down fatigue cracking (ft/mile)	2000.00	341.62	95.00	100.00	Pass
Permanent deformation - AC only (in)	0.40	0.32	95.00	99.48	Pass

I-25 Ramp C HMA TransitionNew_AC_Design Dec 2015

File Name: C:\Users\mghaeli\Desktop\MAY 1 2015\Masoud's Projects\215-043 I 25 @ Crossroads Blvd\Pavement Design\December Designs-New Traffic\I-25 Ramp C HMA

Distress Charts



I-25 Ramp D HMA TransitionNew_AC_Design Dec 2015

File Name: C:\Users\mghaell\Desktop\MAY 1 2015\Masoud's Projects\215-043 I 25 @ Crossroads Blvd\Pavement Design\December Designs-New Traffic\I-25 Ramp D HMA

Design Inputs

Design Life: 20 years
Design Type: Flexible Pavement

Base construction: March, 2017
Pavement construction: August, 2017
Traffic opening: September, 2017

Climate Data Sources (Lat/Lon): 40.452, -105.001

Design Structure

Layer type	Material Type	Thickness (in)
Flexible	R4 SMA	2.0
Flexible	R1 Level 1 S(100) PG 64-22	5.8
NonStabilized	Aggregate Base	6.0
Subgrade	A-6	36.0
Subgrade	A-7-6	36.0
Bedrock	Highly fractured and weathered	Semi-infinite

Volumetric at Construction:	
Effective binder content (%)	13.1
Air voids (%)	4.0

Traffic

Age (year)	Heavy Trucks (cumulative)
2017 (initial)	230
2027 (10 years)	1,061,190
2037 (20 years)	2,804,950

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	160.00	150.56	90.00	94.38	Pass
Permanent deformation - total pavement (in)	0.55	0.46	95.00	99.55	Pass
AC bottom-up fatigue cracking (% lane area)	10.00	8.70	95.00	97.12	Pass
AC thermal cracking (ft/mile)	1500.00	109.48	95.00	100.00	Pass
AC top-down fatigue cracking (ft/mile)	2000.00	341.33	95.00	100.00	Pass
Permanent deformation - AC only (in)	0.40	0.35	95.00	98.60	Pass

I-25 Ramp D HMA TransitionNew_AC_Design Dec 2015

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Distress Charts