US 550/160 Connection
Pavement Justification Report

Project Number NH 5501-011

Project ID 22420

Colorado Department of Transportation

Region 5 Engineering – Materials

2018

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Pavement Recommendation

This report is to provide documentation to the Region 5, Durango Residencies for a roadway improvement project. The project completes the connection of US 550 to US 160 at the Grandview Interchange (US 550 MP 12.50– 16.86). The current two-lane configuration of US 550 will be upgraded to a four-lane facility with intermittent auxiliary lanes and sections of frontage road for residential and commercial access. A roundabout will be constructed at the Grandview Interchange to facilitate traffic movements between US 550 and US 160. County Roads 219 and 220 will be reconstructed and realigned to meet this new configuration.

The pavement recommendations were developed following the Colorado Department of Transportation 2019 ME Pavement Design Manual (PDM) and using the AASHTOWare Pavement Mechanistic Empirical Design (M-E Design) software, Version 2.3.1.

Two pavement types; Hot Mix Asphalt (HMA), and Portland Cement Concrete Pavement (PCCP), were considered for US 550 mainline. In addition to the two pavement types, three pavement designs for each type (6 total), were developed based on the discrete subgrade they are to be constructed.

Pavement for CR 219, CR 220, Frontage Roads, and Ramp B shall be HMA. Pavement for the Roundabout shall be PCCP.

Table 1. HMA Recommended Pavement Structure Summary

Segments	Thickness of HMA Surface Course (in.)	Thickness of ABC Class 6 Base (in.)	Thickness of ABC Class 3 Subbase (in.)
US 550 Subgrade Surficial Soils	6	4	24
US 550 Subgrade Alluvial Gravel	6	4	0
US 550 Subgrade Bedrock	6	4	24
CR 219, CR 220, Frontage Rd.	5	4	24
Ramp B	6	6	8

ABC = Aggregate Base Course

Table 2. PCCP Recommended Pavement Structure Summary

Segments	Thickness of PCCP Surface Course (in.)	Thickness of ABC Class 6 (in.)	Thickness of ABC Class 3 Subbase (in.)
US 550 Subgrade Surficial Soils	8.5	4	24
US 550 Subgrade Alluvial Gravel	8.5	4	0
US 550 Subgrade Bedrock	8.5	4	24
Roundabout	9.5	4	24

ABC = Aggregate Base Course

Pavement Design Analysis

Pavement performance is dependent upon several factors, including; traffic loading and climate. Table 3 summarizes the HMA and PCCP pavement design parameters, specific design parameters can be found in Appendix A.

Table 3. Pavement Design Parameters

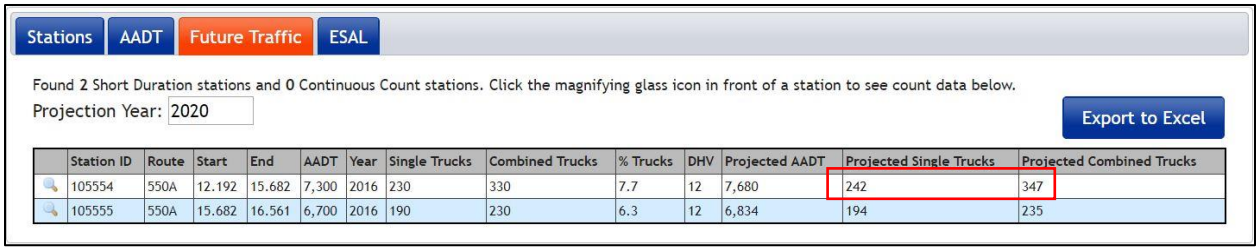
Parameters	Input		
	US 550 Mainline	**CR 219, CR 220, Frontage Rd. and Ramp B**	**Roundabout**
Reliability	90%	90%	90%
Two Way annual average daily truck traffic (AADTT)	589	200/300	1,500
Number of Lanes in Design Direction	2	1	1
Percent of Trucks in Design Direction	50	60	60
Percent of Trucks in Design Lane	90	100	100
Operational speed (mph)	45 mph	25 mph	20 mph
Vehicle Class Distribution (CDOT)	Cluster 3	Cluster 3	Cluster 3
Growth rate %	1.25	1.0/1.25	1.25
Growth function	Compound	Compound	Compound
Climate station	Durango, CO	Durango, CO	Durango, CO
Depth of Water Table	10	10	10
Design life (Rigid)	30-year minimum	NA	30-year minimum
Design life (Flexible)	20-year minimum	20-year minimum	NA
Performance criteria thresholds	*See Table 6 and Table 7*		

A discussion of design parameters and recommended threshold values of performance is provided below.

Traffic Loading

CDOT Online Transportation Information System (OTIS) was used to determine current and future traffic for this project (http://dtdapps.coloradodot.info/otis).

Average Annual Daily Truck Traffic (AADTT) is a design input for M-E Design and is calculated as the sum of projected single unit and projected combination trucks. From OTIS, the AADTT for the design year (2020) is 589 for mainline US 550. The AADTT for the roundabout is 1,500 and was calculated by combining US 550 and US 160 traffic.



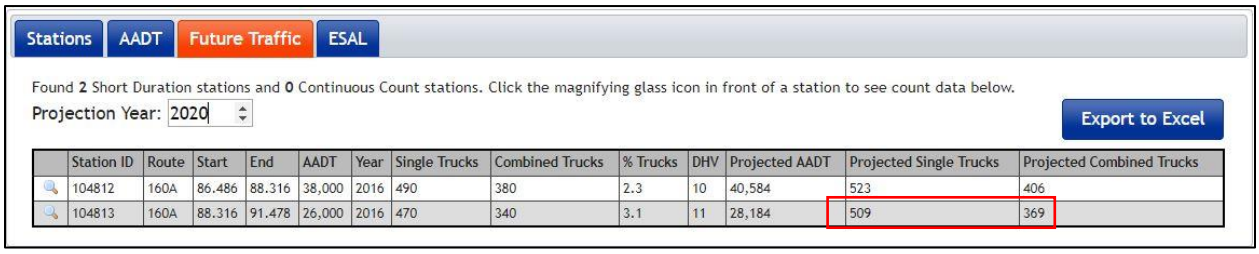
Stations | AADT | Future Traffic | ESAL

Found 2 Short Duration stations and 0 Continuous Count stations. Click the magnifying glass icon in front of a station to see count data below.

Projection Year: 2020 Export to Excel

Station ID	Route	Start	End	AADT	Year	Single Trucks	Combined Trucks	% Trucks	DHV	Projected AADT	Projected Single Trucks	Projected Combined Trucks
105554	550A	12.192	15.682	7,300	2016	230	330	7.7	12	7,680	242	347
105555	550A	15.682	16.561	6,700	2016	190	230	6.3	12	6,834	194	235

Figure 1. US 550 Design Year 2020 AADTT



Stations | AADT | Future Traffic | ESAL

Found 2 Short Duration stations and 0 Continuous Count stations. Click the magnifying glass icon in front of a station to see count data below.

Projection Year: 2020 Export to Excel

Station ID	Route	Start	End	AADT	Year	Single Trucks	Combined Trucks	% Trucks	DHV	Projected AADT	Projected Single Trucks	Projected Combined Trucks
104812	160A	86.486	88.316	38,000	2016	490	380	2.3	10	40,584	523	406
104813	160A	88.316	91.478	26,000	2016	470	340	3.1	11	28,184	509	369

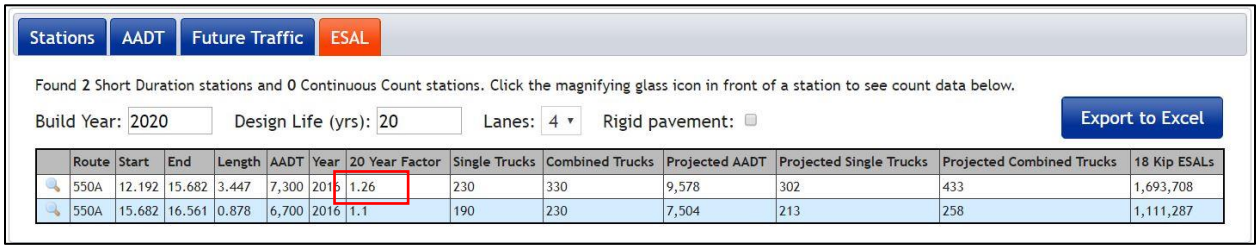
Figure 2. US 160 Design Year 2020 AADTT

A compound growth rate is used to account for traffic increase with time. The growth rate equation can be found in the 2019 PDM, Equation 3-1:

$$T_f = (1 + r)^n$$

Where,
T_f = OTIS 20-Year Growth Factor
r = Growth Rate
n = Number of Years

From OTIS, the 20-Year Growth Factor for this project is 1.26 resulting in a Growth Rate of 1.16. For purposes of conservative design, this value was rounded to 1.25.



Stations | AADT | Future Traffic | ESAL

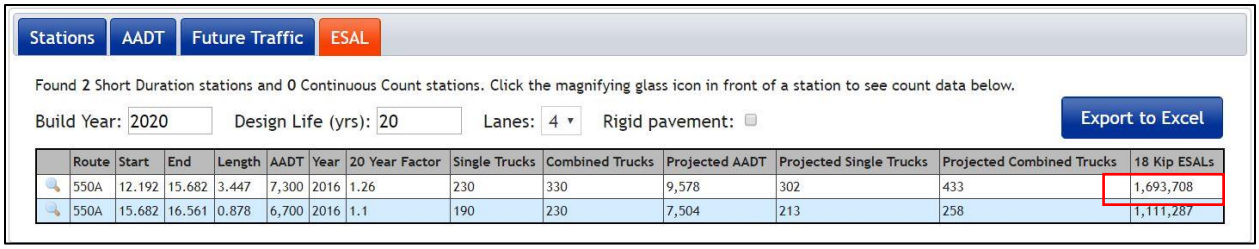
Found 2 Short Duration stations and 0 Continuous Count stations. Click the magnifying glass icon in front of a station to see count data below.

Build Year: 2020 Design Life (yrs): 20 Lanes: 4 Rigid pavement: Export to Excel

Route	Start	End	Length	AADT	Year	20 Year Factor	Single Trucks	Combined Trucks	Projected AADT	Projected Single Trucks	Projected Combined Trucks	18 Kip ESALs
550A	12.192	15.682	3.447	7,300	2016	1.26	230	330	9,578	302	433	1,693,708
550A	15.682	16.561	0.878	6,700	2016	1.1	190	230	7,504	213	258	1,111,287

Figure 3. 20-Year Growth Factor

From OTIS, the 20-year 18k ESALs are 1,693,708 in the design lane, resulting in a 75 gyration mix (PDM table 6.9).



	Route	Start	End	Length	AADT	Year	20 Year Factor	Single Trucks	Combined Trucks	Projected AADT	Projected Single Trucks	Projected Combined Trucks	18 Kip ESALs
	550A	12.192	15.682	3.447	7,300	2016	1.26	230	330	9,578	302	433	1,693,708
	550A	15.682	16.561	0.878	6,700	2016	1.1	190	230	7,504	213	258	1,111,287

Figure 4. 20-Year 18k ESALs

Climate

Durango, CO weather station was selected within the M-E Design program. M-E Design uses weather station data to predict the pavements response to climatic factors such as temperature, precipitation and freeze/thaw cycles.

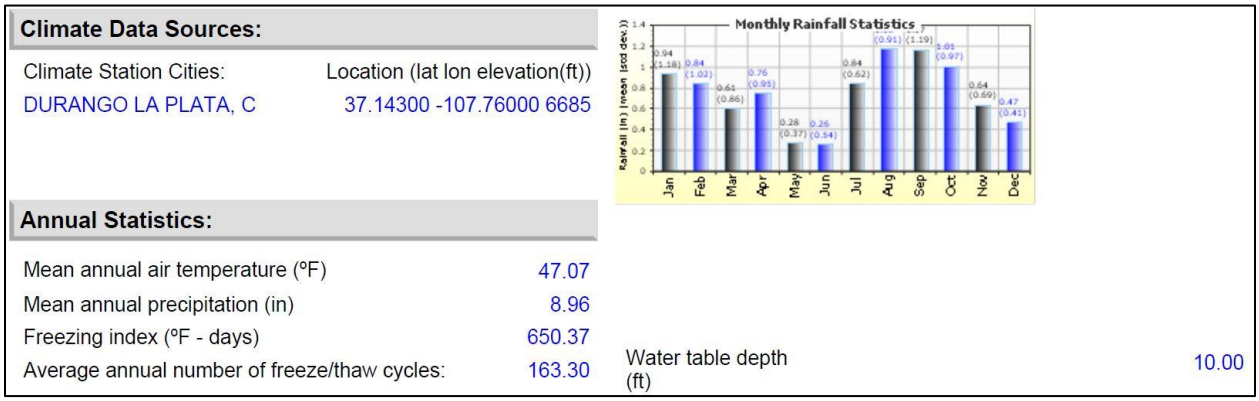


Figure 5. M-E Design Weather Station Selection

Roadbed Characterization

Yeh and Associates preformed a geotechnical investigation to identify surface and subsurface conditions along the proposed alignment. The findings from this investigation can be found in the *Draft Geotechnical Data Report* (GDR) prepared by Yeh and Associates, Inc., dated July 17, 2018.

From the GDR, subsurface conditions along the proposed alignment can be classified into three distinct layers; surficial soil (low plasticity and high plasticity clay); terrace alluvium (gravelly soil); and bedrock (claystone with interbedded shale, sandstone and conglomerate). Because the proposed alignment will be constructed on these distinct subgrades, three discrete pavement designs (for each pavement material), were developed to optimize use of in-situ conditions. For purposes of pavement design, the subgrade was characterized as follows:

Table 4. Subgrade Classification

Layer	AASHTO Classification	R-value	Resilient Modulus (psi)	Plasticity Index	Approximate Location
Surficial Clay	A-7-6	10	6,482	27	South End
Terrace Alluvium	A-1-b	79	15,000 (max)	NP	Middle Portion
Claystone	A-6	23	8,152	12	North End

Pavement sections are layered systems and cannot be modeled as a homogeneous mass, therefore, the design resilient modulus (M_r) of the aggregate base and subbase layers must be adjusted for limiting modulus criteria. This phenomenon is described by the elastic layer theory and is necessary to avoid decompaction and build-up of tensile stresses in the unbound layers. Following the elastic layer theory, the M_r of subbase was determined to be 15,000 psi and the M_r of the base layer was 25,000 psi (PDM figure 5.2 and 5.3).

Following Chapter 4 of the PDM, the design resilient modulus was determined using the R-value correlation equation (Eq. 4-1, PDM):

$$\boldsymbol{M_r = 3438.6 \times R^{0.2753}}$$

Where,
M_r = Resilient Modulus (psi)
R = R-value (AASHTO T 190)

Section 4.9 of the CDOT 2019 M-E Pavement Design Manual, Expansive Subgrade Soils, recommends Depth of Treatment Below Normal Subgrade based on Plasticity Index (PI). Surficial soils and bedrock within the project limits were sampled and analyzed for their physical properties. As reported in the GDR, the PI of the surficial soil and bedrock layers for areas of proposed "cut" was found to range from 8 to 27.

In order to maintain a consistent pavement section throughout the project length, the baseline pavement design requires 3 feet of subgrade treatment. This 3-foot treatment consists of 1-foot of subgrade, excavated; moisture-conditioned; and recompacted in accordance with Section 203 of the 2017 CDOT Standard Specifications, overlain by 2 feet of subbase. To achieve the project goal of maximizing the use of available on-site materials, the subbase course shall consist of granular material derived from the terrace alluvium deposit: Aggregate Base Course (ABC) Class 3 or material with a minimum R-Value of 70.

A filter separator layer is required on top of the reworked subgrade, directly beneath the subbase layer. Edge drains may be required to collect and divert water from the pavement structure.

Table 5. Treatment of Expansive Soils

Plasticity Index	Depth of Treatment Below Normal Subgrade Elevation
10 - 20	2 feet
20 - 30	3 feet
30 - 40	4 feet
40 - 50	5 feet
More than 50	Placed in the bottom of fills of less than 50 feet, or greater than 6 feet in height, or wasted

Table adapted from Table 4.9 of the CDOT 2019 *M-E Pavement Design Manual*

Recommended Threshold Values of Performance Criteria

M-E Design uses limiting threshold values of pavement distress and smoothness to evaluate the adequacy of a design. Table 5 provides the limit and predicted threshold values for new construction of Flexible Pavements and Table 6 shows criteria for new construction of Rigid Pavement (PDM table 2.4 and 2.6).

Table 6. HMA Threshold Values of Performance Criteria

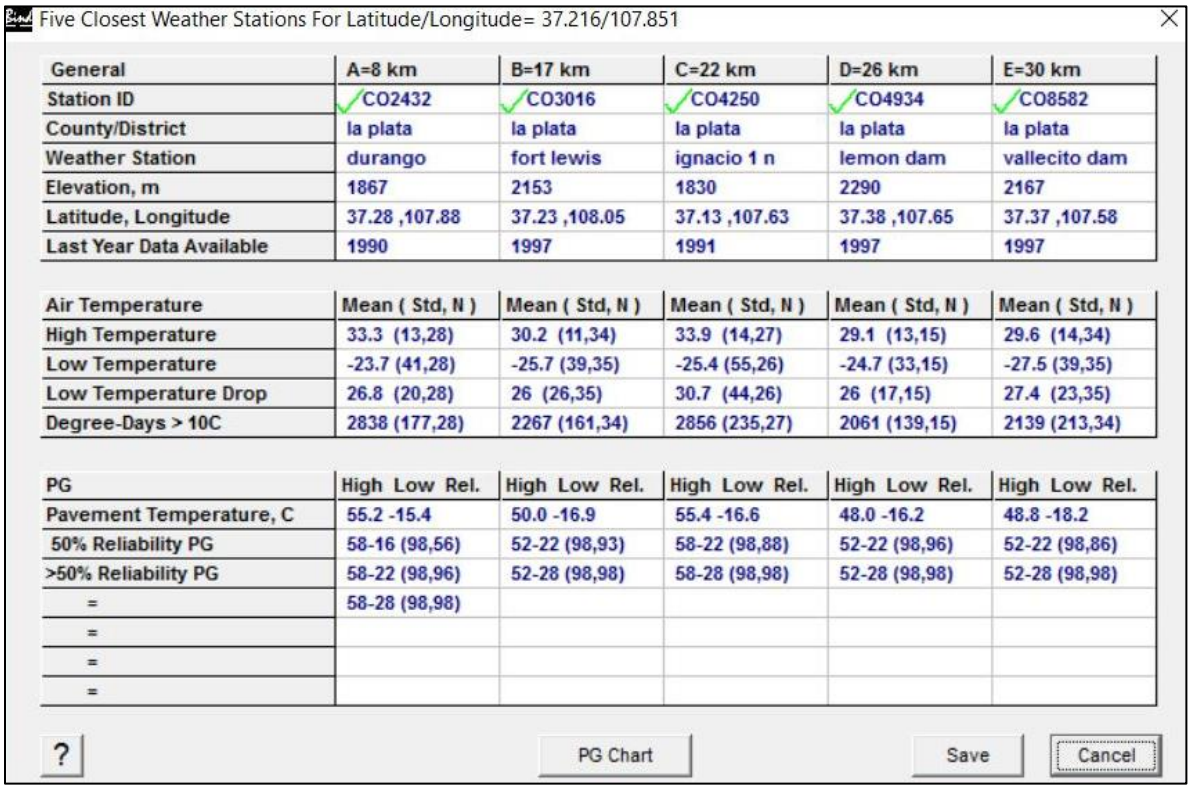
Performance Criteria	Limit	Surficial Clay Predicted	Terrace Alluvium Predicted	Claystone Predicted	Frontage and CR Predicted	Ramp B Predicted
Terminal IRI (inches per mile)	200	166.01	163.06	165.78	168.39	164.82
AC Top-Down Fatigue Cracking (feet per mile)	2,500	1070.44	1903.42	1287.90	1214.32	751.20
AC Bottom-Up Fatigue Cracking (percent lane area)	25	20.67	18.52	19.86	22.89	15.90
AC Thermal Cracking (feet per mile)	1,500	656.15	660.29	657.14	764.24	655.97
Permanent Deformation (total inches)	0.65	0.53	0.49	0.53	0.53	0.54
Permanent Deformation AC Only (total inches)	0.50	0.38	0.37	0.38	0.38	0.41

Table 7. PCCP Threshold Values of Performance Criteria

Performance Criteria	Limit	Surficial Clay Predicted	Terrace Alluvium Predicted	Claystone Predicted	RAB Predicted
Terminal IRI (inches per mile)	200	149.72	149.48	149.61	153.18
Mean Joint Faulting (inches)	0.14	0.01	0.01	0.01	0.03
JPCP Transverse Cracking (percent slabs)	7.00	6.92	6.33	6.67	5.45

Asphalt Binder Recommendations

Using the Long Term Pavement Performance (LTPP) binder selection program (LTPPBind 3.1), the 98% reliability binder for this project area is PG 58-28. From LTPPBind; Figure 6 shows the weather stations in the project vicinity, Figure 7 shows the selected station, Figure 8 shows the PG binder selection.



General	A=8 km	B=17 km	C=22 km	D=26 km	E=30 km
Station ID	CO2432	CO3016	CO4250	CO4934	CO8582
County/District	la plata	la plata	la plata	la plata	la plata
Weather Station	durango	fort lewis	ignacio 1 n	lemon dam	vallecito dam
Elevation, m	1867	2153	1830	2290	2167
Latitude, Longitude	37.28 ,107.88	37.23 ,108.05	37.13 ,107.63	37.38 ,107.65	37.37 ,107.58
Last Year Data Available	1990	1997	1991	1997	1997

Air Temperature	Mean (Std, N)	Mean (Std, N)	Mean (Std, N)	Mean (Std, N)	Mean (Std, N)
High Temperature	33.3 (13,28)	30.2 (11,34)	33.9 (14,27)	29.1 (13,15)	29.6 (14,34)
Low Temperature	-23.7 (41,28)	-25.7 (39,35)	-25.4 (55,26)	-24.7 (33,15)	-27.5 (39,35)
Low Temperature Drop	26.8 (20,28)	26 (26,35)	30.7 (44,26)	26 (17,15)	27.4 (23,35)
Degree-Days > 10C	2838 (177,28)	2267 (161,34)	2856 (235,27)	2061 (139,15)	2139 (213,34)

PG	High Low Rel.	High Low Rel.	High Low Rel.	High Low Rel.	High Low Rel.
Pavement Temperature, C	55.2 -15.4	50.0 -16.9	55.4 -16.6	48.0 -16.2	48.8 -18.2
50% Reliability PG	58-16 (98,56)	52-22 (98,93)	58-22 (98,88)	52-22 (98,96)	52-22 (98,86)
>50% Reliability PG	58-22 (98,96)	52-28 (98,98)	58-28 (98,98)	52-28 (98,98)	52-28 (98,98)
=	58-28 (98,98)				
=					
=					
=					

Figure 6. Five Closest Weather Stations

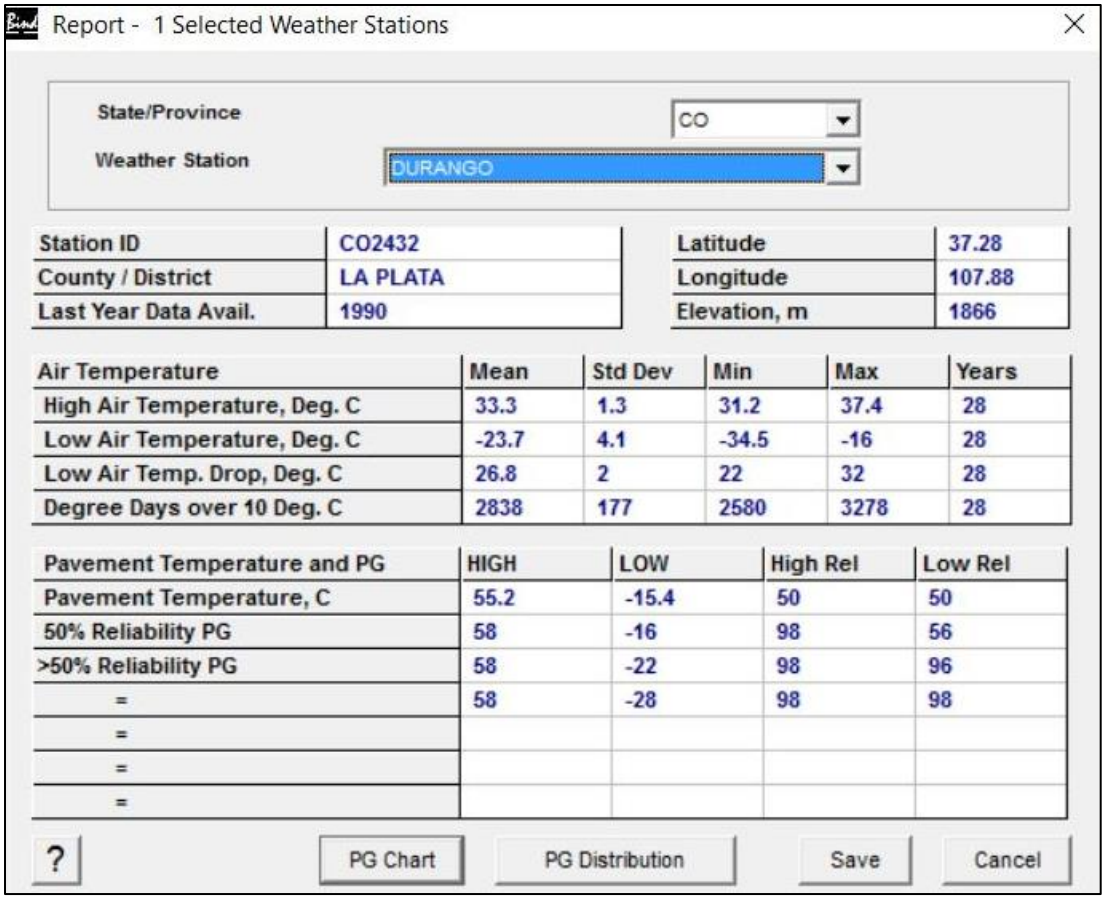


Figure 7. Selected Weather Station

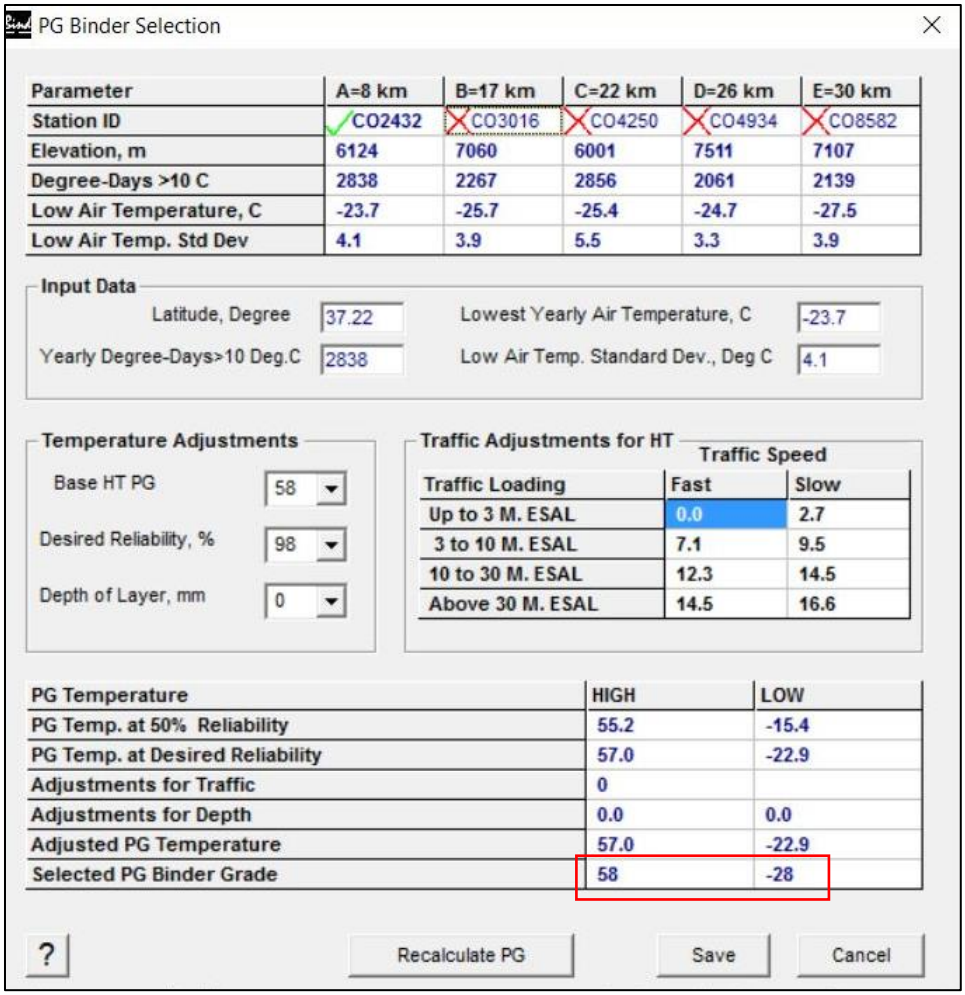


Figure 8. PG Binder Selection

Appendix A – Specific Design Parameters

Table 8. Specific ME-Design Factors

Design Parameter	US 550	Frontage Rd. and CR	Ramp B	Roundabout
Reliability (%)	90	90	90	90
Highway Classification	Principal Arterial	Other	Other	Principal Arterial
Operational Speed (mph)	45	25	25	20
AADTT (2020)	589	200	300	1,500
Lanes (Each Direction)	2	1	1	1
Growth Factor	1.26	NA	NA	1.26
Growth Rate	1.25	1.0	1.25	1.25
Single Unit Truck (%)	32.3	32.3	32.3	32.3
Combination Truck (%)	36.8	36.8	36.8	36.8
Weather Station	Durango, CO	Durango, CO	Durango, CO	Durango, CO
Clay Subgrade R-value	10	10	-	-
Clay Subgrade M_r (psi)	6,482	6,482	-	-
Alluvium Subgrade R-value	79	-	-	-
Alluvium Subgrade M_r (psi)	15,000 (max)	-	-	-
Claystone Subgrade R-value	23	-	23	23
Claystone Subgrade M_r (psi)	8,152	-	8,152	8,152
Subbase M_r (psi)	15,000 (max)	15,000 (max)	15,000 (max)	15,000 (max)
Base M_r (psi)	25,000 (max)	25,000 (max)	25,000 (max)	25,000 (max)
HMA Specific Design Parameters				
Asphalt Binder	PG 58-28	PG 58-28	PG 58-28	-
HMA Grade	(SX)	(SX)	(SX)	-
Design Gyrations	75	75	75	-
Design Life (years)	20	20	20	-
Initial IRI (in/mile)	62	62	62	-
Performance Threshold	see Table 6	see Table 5	see Table 6	-
PCCP Specific Design Parameters				
Joint Spacing (ft.)	15	-	-	15
Slab Width (ft.)	13	-	-	13
28-Day MOR (psi)	650	-	-	650
28-Day Elastic Modulus (psi)	3,930,000	-	-	3,930,000
Design Life (years)	30	-	-	30
Dowel Diameter (inch)	1.25	-	-	1.25
Initial IRI (in/mile)	78	-	-	78
Performance Threshold	see Table 7	-	-	see Table 7

Appendix B – Soil Survey and R-Value

COLORADO DEPARTMENT OF TRANSPORTATION
PRELIMINARY SOIL SURVEY

Note 1: If samples are submitted leave sieve analysis section blank.
Note 3: Sulfate content expressed as percent (dry soil), or ppm in water.
Note 2: Comments should be placed in the description column of the form.
Note 4: R-values referenced are noted 'Survey by Group Class' portion of this report.

Form #157 No.	Form #554 No.	Date:
	N/A	02/02/18
Project No.		
Project location	US 160-550 S Connection	
Project code (SA#)	19378	

STATION AND LOG	TEST NO.	DESCRIPTION	SULFATE CONTENT (SO_4)	R-VAL REF	Per CP 24, Section 4						LIQUID LIMIT	PLASTIC. INDEX	CLASSIFICATION AND GROUP INDEX	MOIST. %
					3/4"	3/8"	#4	#10	#40	#200				
Boring location R1														
4-9'	R1	Light Grey/Brown Clay (Sample) (MURPHYP1821135741)		10		100	99	98	94	81	44	27	A-7-6 (21)	3.7
Boring location R2														
4-9'	R2	Dark Tan Clay (Sample) (MURPHYP1821140335)		*		100	99	99	97	82	38	23	A-6 (18)	4.1
		* Sample untestable, to be resampled												
Boring location R3														
4-9'	R3	Dark Grey/Brown Clay (Sample) (MURPHYP1821140554)		*		100	99	99	96	78	43	27	A-7-6 (20)	3.5
		* Sample untestable, to be resampled												
Boring location R4														
14-19'	R4	Similar to R2												
Boring location R5														
4-9'	R5	Light Red Clay (Sample) (MURPHYP1821140717)		22	98	97	97	96	95	88	34	26	A-6 (21)	4.3
Boring location R6														
9-14'	R6	Similar to R5												
Boring location R7														
5-13'	R7	Light Red Sandy Clay (Sample) (MURPHYP17CB075332)		11				100	97	77	41	23	A-7-6 (17)	6.8
		(Resampled, See ensuing 555)												
Boring location R8														
10-15'	R8a	Tan Sandy/Rocky Clay (Sample)(MURPHYP17CB080726)		*			100	99	99	90	40	24	A-6 (22)	2.4
15-20'	R8b	Tan Sandy Clay (Sample)(MURPHYP17CB081624)		18		100	99	99	97	79	32	16	A-4 (0)	2.9
		(Resampled, See ensuing 555) *Sample Untestable												
Boring location R9														
9-19'	R9	Light Tan Fine Clay (Sample - combine 2)(MURPHYP17CB081948)		22	100	99	99	97	91	57	27	11	A-6 (3)	2.8
		(Resampled, See ensuing 555)												
Boring location R12 5-18'	R12	Rocky Cobbles w/Tan Clay (Sample) (MURPHYP1818104045)		18	78	57	41	37	32	25	39	23	A-2-6 (1)	4.7
Boring location A2 10-25'	A2	Reddish Sandy/Rocky Clay (Sample) (MURPHYP1818104454)		28		100	97	91	72	48	24	6	A-4 (0)	3.2

☐ Materials and Geotechnical
☐ Region Materials Engineer
☐ Resident Engineer

CDOT Form #555 04/09

COLORADO DEPARTMENT OF TRANSPORTATION

PRELIMINARY SOIL SURVEY

Note 1: If samples are submitted leave sieve analysis section blank.
Note 3: Sulfate content expressed as percent (dry soil), or ppm in water.
Note 2: Comments should be placed in the description column of the form.
Note 4: R-values referenced are noted 'Survey by Group Class' portion of this report.

Form #157 No.	Form #554 No.	Date:
	N/A	4/4 & 4/5/18
Project No.		
Project location	US 160-550 S Connection	
Project code (SA#)	22420 (new 19378)	

STATION AND LOG	TEST NO.	DESCRIPTION	SULFATE CONTENT (SO_4)	R-VAL REF	Per CP 24, Section 4						LIQUID LIMIT	PLASTIC. INDEX	CLASSIFICATION AND GROUP INDEX	MOIST. %	
					3/4"	3/8"	#4	#10	#40	#200					
Boring Location R71															
10'-14'	R71	Light reddish sandy clay (sample) WISNERL184B083458		12				99	98	78	47	29	A-7-6 (22)	4.3	
		(RESAMPLE of R7)													
Boring Location R81															
10'-14'	R81a	Tan clay (sample) WISNERL184B084723		9					100	92	36	20	A-6 (18)	2.7	
14'-19'	R81b	Calcium coated(?) tan clay (sample) WISNERL184B084802		*				100	99	88	48	31	A-7-6 (28)	3.5	
		(RESAMPLE of R8) *Sample Untestable													
Boring Location R91															
2'-10'	R91a	Calcium coated(?) light gray clay (sample) WISNERL184B084850		*				100	98	89	47	30	A-7-6 (27)	3.4	
10'-15'	R91b	Light gray clay (sample) WISNERL184B084927		18				97	91	60	30	14	A-6 (6)	2.5	
		(RESAMPLE of R9) *Sample Untestable													
Pit Location Knagg #1															
	K1	Mudstone/claystone (sample 2 sacks) WISNERL184B084956		23				99	74	65	36	12	A-6 (6)	6.2	
Pit Location Knagg #2															
	K2	Weathered claystone (sample 2 sacks) WISNERL184B085032		~~47~~				99	74	64	36	12	A-6 (6)	6.3	
		(Possible Error Given Other Similar Matl. Results)													
Pit Location Knagg #3															
	K3	Pit-run gravel with large cobbles (sample 3 sacks) WISNERL184B0850		79				86	40	15	NV	NP	A-1-b (0)	0.9	
Boring Location WB2															
22'-40'	WB2	Gravel (sample) WISNERL184B150354		~~86~~				77	38	12	NV	NP	A-1-b (0)	0.6	
		(Sample Invalid Due to ODEX Crushing of Matl.)													
Boring Location WC1															
39'-55'	WC1	Weathered mudstone bedrock (sample) WISNERL184B151857		25				99	84	70	34	12	A-6 (7)	5.3	
Boring Location E2															
95'-105'	E2	Weathered shale bedrock (sample) WISNERL184B152404		25				100	88	65	31	11	A-6 (5)	5.6	

☐ Materials and Geotechnical
☐ Region Materials Engineer
☐ Resident Engineer

CDOT Form #555 04/09

Appendix C – Pavement Designs

Pavement M-E Design Report – HMA on Clay

22420 US 550_HMA on Clay_FINAL_24

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

Design Inputs

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

Design Structure

Layer type	Material Type	Thickness (in)
Flexible	R3 Level 1 SX(75) PG 58-28 United	6.0
NonStabilized	ABC Class 6	4.0
Subgrade	A-1-b	24.0
Subgrade	A-7-6	Semi-infinite

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

Traffic

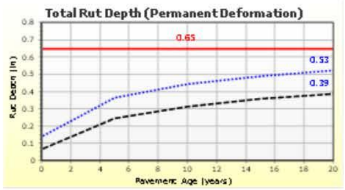
Age (year)	Heavy Trucks (cumulative)
2020 (initial)	589
2030 (10 years)	1,024,410
2040 (20 years)	2,184,310

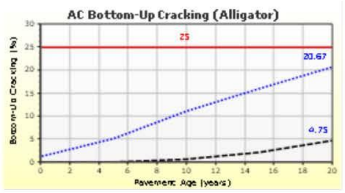
Design Outputs

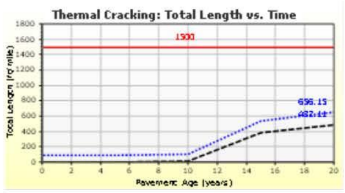
Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	200.00	166.01	90.00	98.88	Pass
Permanent deformation - total pavement (in)	0.65	0.53	90.00	99.34	Pass
AC bottom-up fatigue cracking (% lane area)	25.00	20.67	90.00	94.84	Pass
AC thermal cracking (ft/mile)	1500.00	656.15	90.00	100.00	Pass
AC top-down fatigue cracking (ft/mile)	2500.00	1070.44	90.00	99.87	Pass
Permanent deformation - AC only (in)	0.50	0.38	90.00	99.22	Pass

Distress Charts



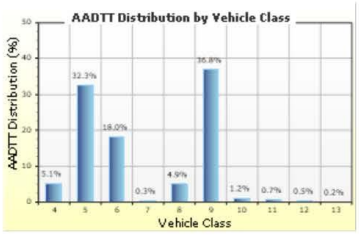


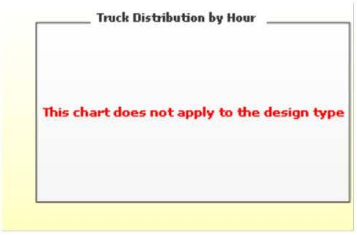


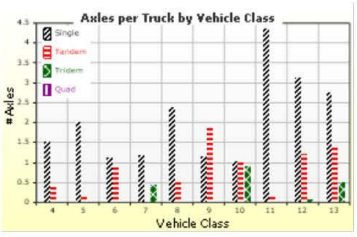
Traffic Inputs

Graphical Representation of Traffic Inputs

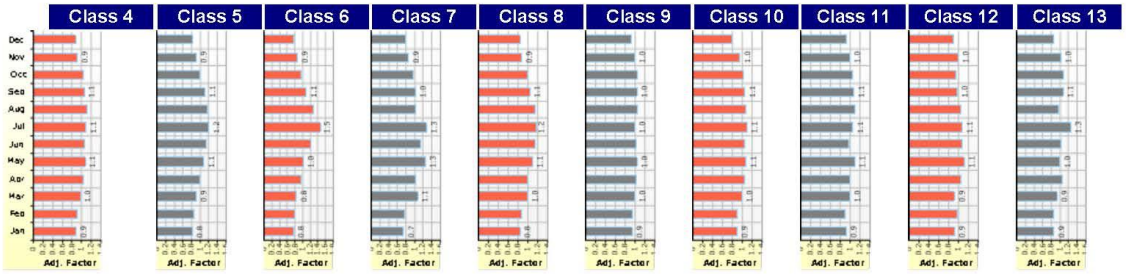
Initial two-way AADTT:	589	Percent of trucks in design direction (%):	50.0
Number of lanes in design direction:	2	Percent of trucks in design lane (%):	90.0
		Operational speed (mph)	45.0







Traffic Volume Monthly Adjustment Factors



Tabular Representation of Traffic Inputs

Volume Monthly Adjustment Factors

Level 3: Default MAF

Month	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
January	0.9	0.8	0.8	0.7	0.8	0.9	0.9	0.9	0.9	0.9
February	0.9	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	0.8
March	1.0	0.9	0.8	1.1	1.0	1.0	1.0	1.0	0.9	0.9
April	1.0	1.0	0.9	1.0	1.0	1.0	1.1	1.0	1.0	1.1
May	1.1	1.1	1.0	1.3	1.1	1.0	1.1	1.1	1.1	1.0
June	1.1	1.1	1.2	1.1	1.1	1.0	1.1	1.0	1.1	1.0
July	1.1	1.2	1.5	1.3	1.2	1.0	1.1	1.1	1.1	1.3
August	1.1	1.2	1.3	1.0	1.1	1.0	1.1	1.1	1.1	1.0
September	1.1	1.1	1.1	1.0	1.1	1.0	1.1	1.1	1.0	1.1
October	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	1.1
November	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0
December	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.9	0.9	0.9

Distributions by Vehicle Class

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

Truck Distribution by Hour does not apply

Axle Configuration

Traffic Wander	
Mean wheel location (in)	18.0
Traffic wander standard deviation (in)	10.0
Design lane width (ft)	12.0

Axle Configuration	
Average axle width (ft)	8.5
Dual tire spacing (in)	12.0
Tire pressure (psi)	120.0

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

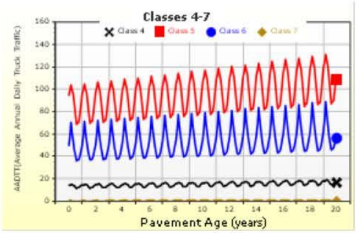
Wheelbase does not apply

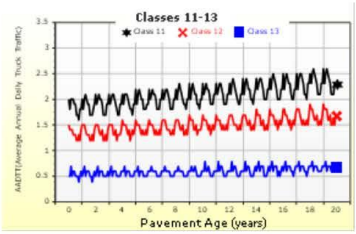
Number of Axles per Truck

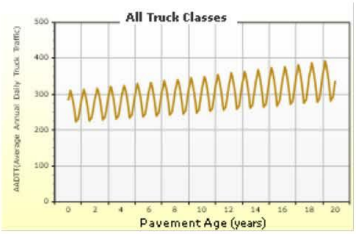
Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.53	0.45	0	0
Class 5	2.02	0.16	0.02	0
Class 6	1.12	0.93	0	0
Class 7	1.19	0.07	0.45	0.02
Class 8	2.41	0.56	0.02	0
Class 9	1.16	1.88	0.01	0
Class 10	1.05	1.01	0.93	0.02
Class 11	4.35	0.13	0	0
Class 12	3.15	1.22	0.09	0
Class 13	2.77	1.4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

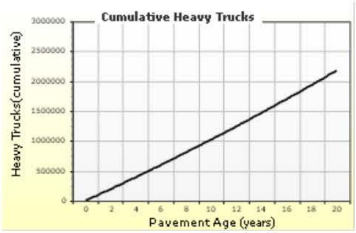
AADTT (Average Annual Daily Truck Traffic) Growth

* Traffic cap is not enforced





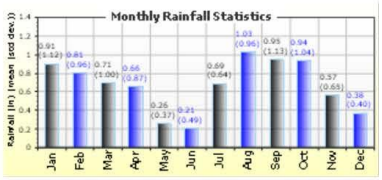




Climate Inputs

Climate Data Sources:

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

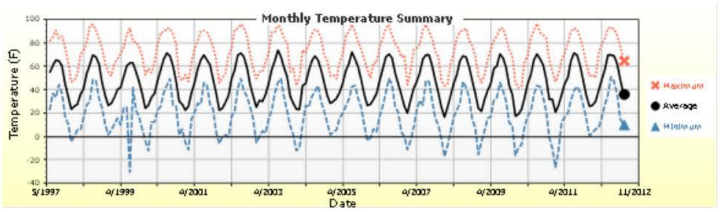


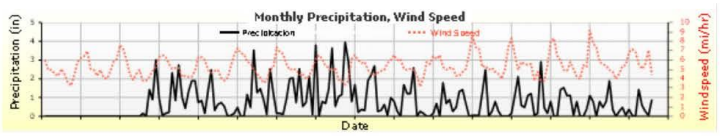
Annual Statistics:

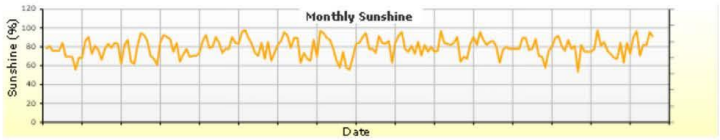
Mean annual air temperature (°F)	47.04
Mean annual precipitation (in)	8.09
Freezing index (°F - days)	623.93
Average annual number of freeze/thaw cycles:	163.30

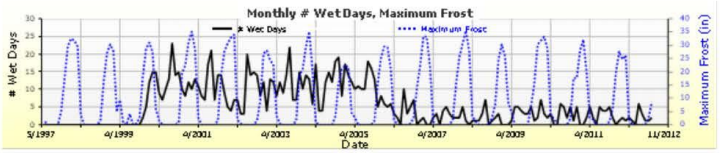
Water table depth (ft)	10.00

Monthly Climate Summary:

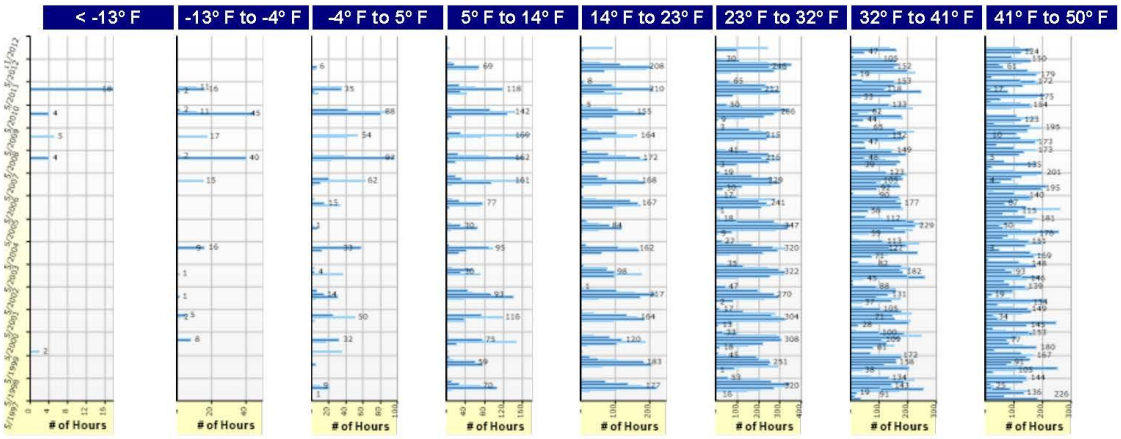


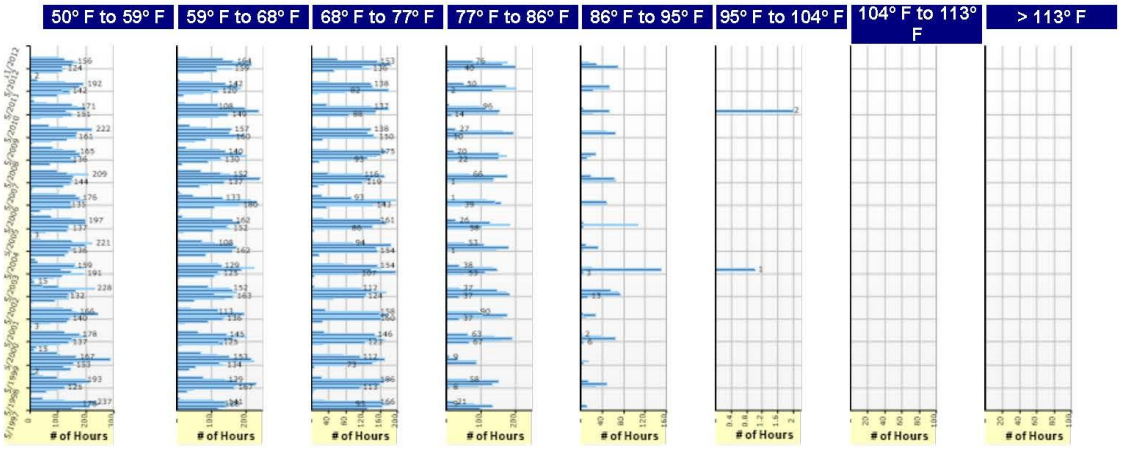






Hourly Air Temperature Distribution by Month:





Design Properties

HMA Design Properties

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

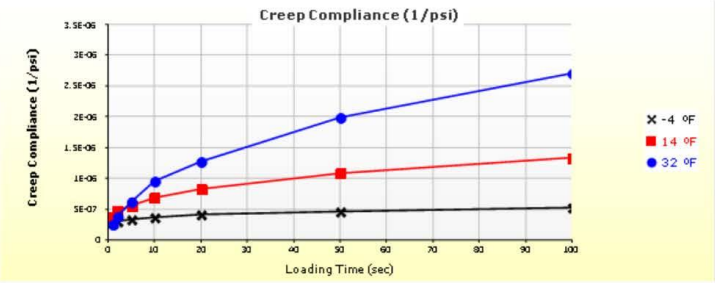
Structure - ICM Properties	
AC surface shortwave absorptivity	0.85

Layer Name	Layer Type	Interface Friction
Layer 1 Flexible : R3 Level 1 SX (75) PG 58-28 United	Flexible (1)	1.00
Layer 2 Non-stabilized Base : ABC Class 6	Non-stabilized Base (4)	1.00
Layer 3 Subgrade : A-1-b	Subgrade (5)	1.00
Layer 4 Subgrade : A-7-6	Subgrade (5)	-

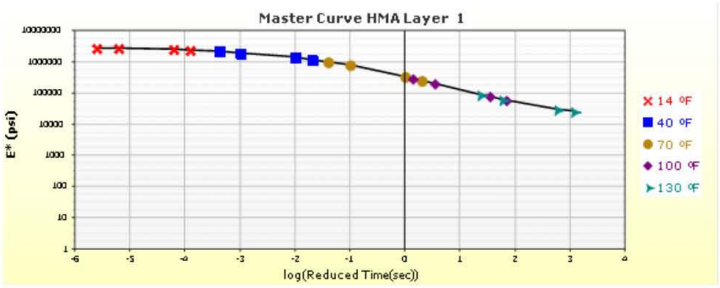
Thermal Cracking (Input Level: 1)

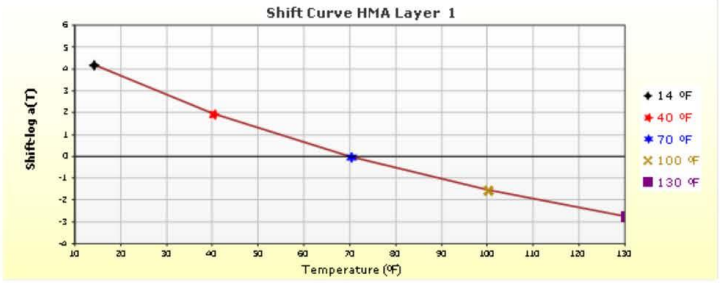
Indirect tensile strength at 14 °F (psi)	555.90
Thermal Contraction	
Is thermal contraction calculated?	True
Mix coefficient of thermal contraction (in/in/°F)	-
Aggregate coefficient of thermal contraction (in/in/°F)	5.0e-006
Voids in Mineral Aggregate (%)	16.2

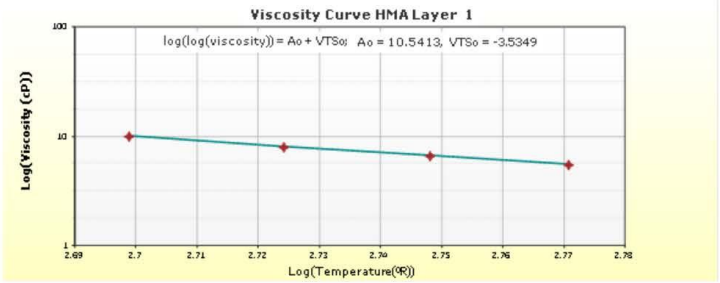
	Creep Compliance (1/psi)		
Loading time (sec)	**-4 °F**	**14 °F**	**32 °F**
1	2.78e-007	3.91e-007	2.65e-007
2	3.11e-007	4.79e-007	3.91e-007
5	3.48e-007	5.57e-007	6.33e-007
10	3.74e-007	6.94e-007	9.55e-007
20	4.22e-007	8.31e-007	1.28e-006
50	4.63e-007	1.08e-006	1.99e-006
100	5.28e-007	1.35e-006	2.72e-006



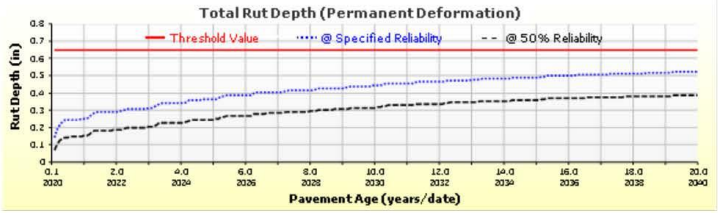
HMA Layer 1: Layer 1 Flexible : R3 Level 1 SX(75) PG 58-28 United

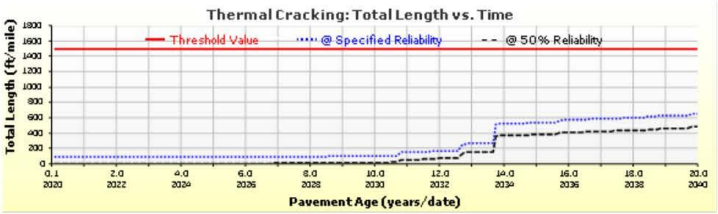


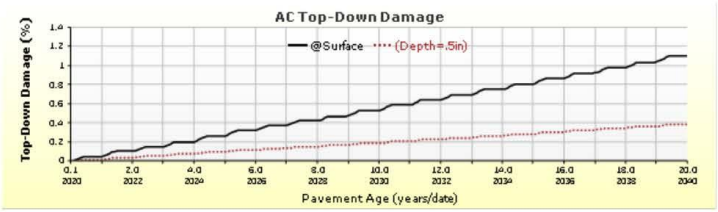




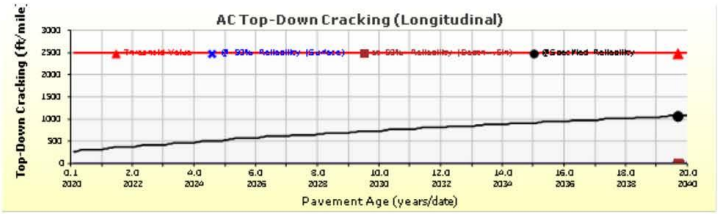
Analysis Output Charts

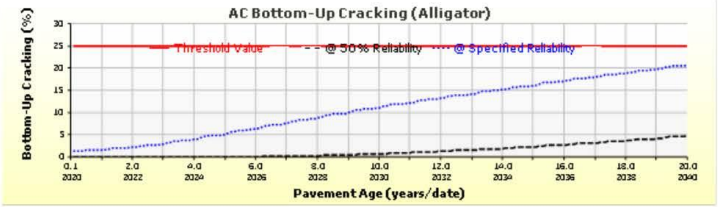


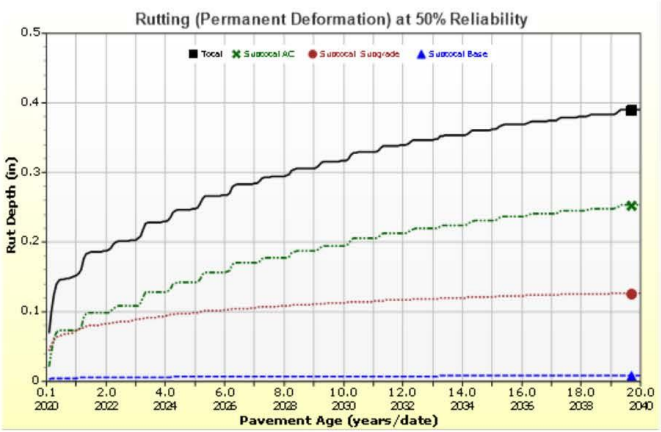


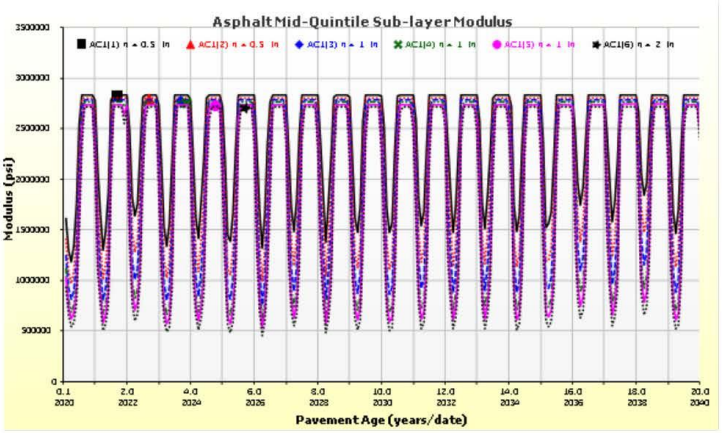

AC Top-Down Damage
@Surface
(Depth=.5in)
Top-Down Damage (%)
Pavement Age (years/date)

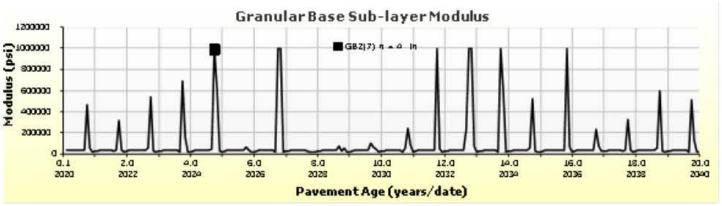

AC Bottom-Up Damage
Bottom-Up Damage (%)
Pavement Age (years/date)

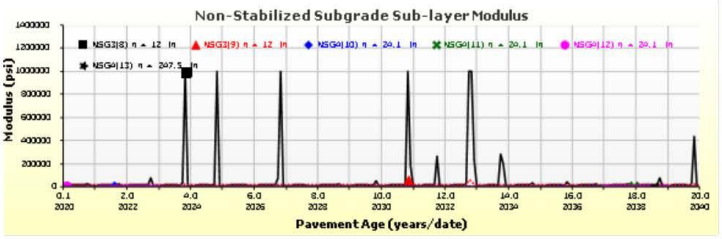

AC Top-Down Cracking (Longitudinal)
Top-Down Cracking (ft/mile)
Pavement Age (years/date)


AC Bottom-Up Cracking (Alligator)
Threshold Value
@ 50% Reliability
@ Specified Reliability
Bottom-Up Cracking (%)
Pavement Age (years/date)


Rutting (Permanent Deformation) at 50% Reliability
Total
Subtotal AC
Subtotal Subgrade
Subtotal Base
Rut Depth (in)
0.5
0.4
0.3
0.2
0.1
0
0.1
2020
2.0
2022
4.0
2024
6.0
2026
8.0
2028
10.0
2030
12.0
2032
14.0
2034
16.0
2036
18.0
2038
20.0
2040
Pavement Age (years/date)


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


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


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

Layer Information

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

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

Asphalt Dynamic Modulus (Input Level: 1)

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

Asphalt Binder

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

General Info

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

Identifiers

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