STATE OF COLORADO

DEPARTMENT OF TRANSPORTATION
Region 6 – Materials Engineering Unit
4670 Holly Street, Unit C
Denver, CO 80216
(303) 398-6703

STA 1281-011
PCN 16501
120th Connection

DATE: January 2, 2009

TO: **Bruce Naylor / Mark Talvitie / Irena Motas**

FROM: James Chang

SUBJECT: **Pavement Design Report**

The following pavement design report, prepared by Region 6 – Materials for the 120th Connection Project, summarizes the pavement design and life cycle cost analyses performed from April 2008 to June 2008.

Subsurface Investigation and Mitigation of Existing Soil Conditions

RockSol Consulting Group, Inc. performed the pavement / subsurface investigations. The cores of the 20 holes drilled indicate that the soil ranges from A-2-4, considered a good base material, to A-6 and A-7-6, generally considered poor base materials because of their high plasticity. Several soils were nonplastic (NP); however, the maximum plasticity index (PI) was 51 with percent swell ranging from 0 to maximum value of 9.07 %. R-values varied from 2 to a maximum of 70. Sulfate levels were negligible with levels from 0 % to 0.1 %.

From the soil investigation, it appears that existing soils will pose a problem at the ends of the projects where there is cut or shallow fill. Soils at the west end cut location are claystone with high % swell of up to 9.07 % and high PI's of up to 51. This would represent a medium to high probable swell damage risk. With the high PI, a depth of treatment of up to 5 feet below the normal subgrade elevation is required per the CDOT Pavement Design Manual. Soils in the east cut area are also a concern. In this area, the ground water level was found to be approximately 14 feet. It is estimated that the cut in this area will be around 20 feet. The investigation shows that the soils in this area could shrink dramatically upon drying and have swell potentials as high as 3.85 %.

In order to address the swell potential problem at these locations and in locations with shallow fill. The use of a 6-inch ABC Class 6 layer underneath the pavement is recommended to provide a stable, easily gradeable base. The soil underneath should then be treated to a depth of 4 feet. Consultation with Staff Materials revealed that the use of lime treatment directly under the pavement may not be advisable even though the sulfate levels are less than the 0.2 % limit for lime treatment. While the low sulfate levels at the bore holes indicate that the risk of chemical swelling is minimal, the sulfate levels might be higher at locations between boreholes, and additional sulfate might be transported to the pavement structure via water flow.

Thus, it is recommended that the existing soil be removed and replaced with A-2-4 or better material for a depth of 4 feet underneath the ABC Class 6. The 6" of ABC Class 6 over 4 feet of A-2-4 or better material should be continued through the fill sections.

The minimum relative compaction of the A-2-4 or better material should be 95 % +/- 2 % of optimum using AASHTO T-180. Unless otherwise specified, all other compaction for the Project should be per section 203 of the 2005 CDOT Standard Specifications for Road and Bridge Construction. Depth of moisture-density control for this Project should be full depth for all embankments and 6 inches for bases of cuts and fills.

To minimize potential swell damage and to preserve the new pavement structure, in cut sections, a side drain system should also be incorporated to keep water at least 2 feet below the bottom of the A-2-4 or better material. Irrigation is not recommended in problem areas because of the potential for damage due to water intrusion. Thus, xeriscape should be considered.

All embankment material should have a minimum resistance value (R-value) of 10 or greater when tested by the Hveem Stabilometer and meet all stability requirements per Colorado Procedure – Laboratory 3102. The embankment material should have a plasticity index less than 30, should be nonswelling when tested at 200 psf, and should have water-soluble sulfate levels less than 2%. All embankment should be constructed in 8-inch lifts and have a maximum dry density not less than 90 pounds per cubic foot.

In embankment areas supporting the roadway shoulders and pavement structure, the A-2-4 material shall be underlain by 6 feet of nonswelling material with a plasticity index less than or equal to 30 and an R-value of 10 or greater. If the distance between the bottom of the A-2-4 and the bottom of the embankment is less than 6 feet, the R-value 10 or greater material shall be placed from the bottom of the A-2-4 to the base of the embankment. Material with an R-value less than 10 material may be utilized beneath the R-value 10 material; however, the material shall have a % swell less than or equal to 3 percent when tested at 200 psf. All proposed treatment shall extend to the side slopes in areas with unprotected slopes. In areas with curb and gutter, the proposed treatment shall, at a minimum, extend for a distance of 6 inches behind the back of the curb.

Unless otherwise specified, rock shall be excavated to a minimum depth of 0.5 foot and a maximum depth of 1 foot below subgrade, within the limits of the roadbed Approved embankment material shall be used to bring the rock-excavated areas to subgrade elevations.

Pavement Design

As shown in Table 1, the traffic projections and 18-kip ESALs (both flexible and rigid), courtesy Jacobs Carter Burgess, were provided for Phase 1 (SH 121 to Wadsworth Blvd.), Phase 2 (Wadsworth Blvd. to US 287), and Phase 2 (US 287 East), assuming either 3.2 % or 4.2 % trucks. The projections were modified several times to better predict future traffic and loadings. The last modification utilized a growth rate of 1.5 % beyond 2030 and incorporated URS 2035 projections. This final version, assuming 4.2 % trucks, was utilized in the flexible and rigid designs.

Twenty-year flexible designs for all three segments were conducted using DARWin Version 3.01.005 by AASHTOWare. The resulting thicknesses were rounded up to the nearest ¼ inch. The 1998 AASHTO supplement was used to calculate the pavement depth required for the thirty-year rigid pavement designs. Climate data from Northglenn Station (ID = CO5984) was inputted to verify that all of the rigid designs passed faulting and corner break checks. One quarter inch was subsequently added to each PCCP design thickness to accommodate diamond grinding at year 22, and then rounded up to the nearest ½ inch.

120th Connection ESAL Calculations - 4.2% Trucks								
			Phase 1		Phase 2-1		Phase 2-2	
			SH-121 to Wads. Blvd.		Wads. Blvd. to US-287		US-287 East	
		Year	ADT	Total VPD	ADT	Total VPD	ADT	Total VPD
Phase 1 Opens		2010	**8,000**					
		2011	**8,000**					
Phase 2 Opens		2012	**30,000**		**25,000**		**30,000**	
		2013	31,167		26,222		31,444	
		2014	32,333		27,444		32,889	
		2015	33,500		28,667		34,333	
		2016	34,667		29,889		35,778	
Phase 1 10 year		2017	35,833		31,111		37,222	
		2018	37,000		32,333		38,667	
		2019	38,167		33,556		40,111	
Phase 1 - 10 year		2020	39,333	288,667	34,778		41,556	
		2021	40,500		36,000		43,000	
Phase 2 - 10 year		2022	41,667		37,222	305,000	44,444	365,000
		2023	42,833		38,444		45,889	
		2024	44,000		39,667		47,333	
		2025	45,167		40,889		48,778	
		2026	46,333		42,111		50,222	
		2027	47,500		43,333		51,667	
		2028	48,667		44,556		53,111	
		2029	49,833		45,778		54,556	
Phase 1 - 20 year		2030	**51,000**	734,500	**47,000**		**56,000**	
		2031	52,400		48,800		57,000	
Phase 2 - 20 year		2032	53,800		**50,600**	732,800	**58,000**	874,000
		2033	55,200		52,400		59,000	
		2034	56,600		54,200		60,000	
		2035	**58,000**		**56,000**		**61,000**	
		2036	58,870		56,840		61,915	
		2037	59,753		57,693		62,844	
		2038	60,649		58,558		63,786	
		2039	61,559		59,436		64,743	
Phase 1 - 30 year		2040	62,482	1,302,331	60,328		65,714	
		2041	63,420		61,233		66,700	
Phase 2 - 30 year		2042	64,371		62,151	1,300,088	67,701	1,497,703
Flexible Pavement -20yr								
Cars	0.003	*95.8%*	703,651	231,149	702,022	230,614	837,292	275,050
SU Trucks	0.249	3.0%	22,035	600,795	21,984	599,405	26,220	714,901
Comb. Trucks	1.087	1.2%	8,814	1,049,100	8,794	1,046,671	10,488	1,248,350
Lane Configuration		0.30	**734,500**	**1,881,044**	**732,800**	**1,876,691**	**874,000**	**2,238,302**
Rigid Pavement - 30yr								
Cars	0.003	*95.8%*	1,247,634	409,848	1,245,484	409,141	1,434,799	471,332
SU Trucks	0.285	3.0%	39,070	1,219,275	39,003	1,217,175	44,931	1,402,187
Comb. Trucks	1.692	1.2%	15,628	2,895,458	15,601	2,890,469	17,972	3,329,824
Lane Configuration		0.30	**1,302,331**	**4,524,581**	**1,300,088**	**4,516,785**	**1,497,703**	**5,203,342**
Comparison to 3.2%:								
Flexible Pavement -20yr				**1,683,192**		**1,679,296**		**2,002,872**
Difference %				111.8%		111.8%		111.8%
Rigid Pavement - 30yr				**4,122,434**		**4,115,331**		**4,740,867**
Difference %				109.8%		109.8%		109.8%
Revisions:	18-Apr	Changed projected growth % beyond 2030 to 1.5%						
	29-Apr	Incorporated 2035 volumes from URS Exhibit						

Table 1. Projected AADT and 18-kip ESALs for the 120th Connection (Courtesy Jacobs Carter Burgess)

Both designs utilized R-values of 10 and 20 which corresponded to mean effective k-values of 71 and 88 psi / inch respectively. The resulting pavement thicknesses are presented in Tables 2 and 3.

Pavement Type = Flexible		Phase 1 SH-121 to Wads Blvd.	Phase 2 Wads. Blvd to US 287	Phase 2 US-287 East
R-Value	% Trucks	inches	inches	inches
10	4.2	9.75 (9.75)	9.75 (9.75)	10.02 (10.25)
20	4.2	8.59 (8.75)	8.59 (8.75)	8.86 (9.0)

Table 2. Design flexible pavement thicknesses. Values shown in ( ) have been rounded up to the nearest ¼".

Pavement Type = Rigid		Phase 1 SH-121 to Wads Blvd.	Phase 2 Wads. Blvd to US 287	Phase 2 US-287 East
k-value	% Trucks	inches	inches	inches
71	4.2	8.94 (9.5)	8.94 (9.5)	9.13 (9.5)
88	4.2	8.86 (9.5)	8.86 (9.5)	9.05 (9.5)

Table 3. Design rigid pavement thicknesses. Values shown in ( ) include an extra ¼" and have been rounded up to the nearest ½".

For the proposed mainline roadway, the design using an R-value of 20 (k-value of 88) were selected. Thus, the proposed flexible pavement section alternative is 9 inches of hot mix asphalt (HMA) over 6 inches of ABC Class 6. The rigid pavement alternative is 10 inches of Portland cement concrete pavement (PCCP) over 6 inches of ABC Class 6.

Separate designs were not conducted for the intersections within the project limits. Pavements at the intersections seeing significant cross traffic usually require the inclusion of cumulative 18-kip ESALs in each direction; however, the conservativeness built into the traffic forecast and the projected 18-kip ESALs accounts for any cross traffic loading. However, it should be noted that the intersection of SH 121 and SH 128 was constructed with 11 inches of PCCP (with load transfer devices) over 6 inches of aggregate base course class 6. To maintain consistency, the proposed pavement in this area should match existing pavement section. The 11" PCCP over 6 inches of ABC Class 6 section should be extended to at least station 35+00 (which corresponds to the beginning of the taper for the left turn lane) on the proposed alignment.

The final designs, of the forty-eight flexible / rigid pavement design runs conducted, are included in the appendix.

Deterministic Life Cycle Cost Analysis

A deterministic life cycle cost analysis (LCCA) was conducted for both pavement section alternatives assuming a combined, one phase project. Per the 2009 Pavement Design Manual, the LCCA utilized a 40-year analysis period (with a base year of 2009) and a discount rate of 3.33 %. For analysis purposes, a 1.25 mile long project with 3 twelve-foot lanes in each direction was used.

The following costs were obtained from the 2009 Pavement Design Manual normalized cost equations for Region 6 and used in the analysis:

- SMA (Fibers) (Asphalt) — $ 75 / ton
- HMA (Grading S) (100) (PG 64-22) — $ 65 / ton
- PCCP (10") — $ 4 / SY-in

The performance period between initial construction and the first rehabilitation for flexible pavement was set at 11 years. The first and second rehabilitation periods were scheduled at 10 years; however, the third rehabilitation period was set at 9 years. Since the analysis period was set at 40 years and the sum of all the treatments for flexible pavement was 41 years, a salvage year was incorporated into the LCCA. The salvage year was calculated as 1/10th the cost of the third rehabilitation since only 9 out of the 10 year performance period for the mill and fill overlay was utilized. User costs were also determined for initial construction and each subsequent rehabilitation using the CDOT WorkZone-RUC software. 120th was assumed to be an urban arterial. Since the analysis was per direction, the ADT used in the calculation of user cost was taken as ½ of the ADT for the year the activity occurred. Preliminary engineering, construction engineering, and traffic control percentages of 2 %, 17 %, and 15 % were utilized.

The results of the final deterministic LCCA, the initial construction cost, the rehabilitation cost, the salvage value, and the total cost are shown in Table 4. The costs are for one direction only and may only be used for comparison purposes since only pavement items were incorporated.

	Flexible	Rigid
Initial Construction Cost	$2,428,440	$2,808,091
Rehabilitation Cost	$1,583,271	$369,090
Salvage Value	-$26,007	$0
Total Cost	$3,985,704	$3,177,181

Table 4. Results of the Deterministic LCCA.

The deterministic LCCA indicates that the difference between flexible pavement and rigid pavement is 25.45 % with rigid pavement being less. The results of the deterministic LCCA can be found in the appendix.

Probabilistic Lifecycle Cost Analysis

A probabilistic LCCA was conducted for the pavement section alternatives assuming a combined, one phase project. Per the soon-to-be-issued 2009 Pavement Design Manual, the LCCA utilized a 40-year analysis period and a discount rate of 3.33 %. For analysis purposes, a 1.25 mile long project with 3 twelve-foot lanes in each direction was used.

The minimum, most likely, and maximum costs of the items utilized in the life cycles cost analysis were obtained from item costs for projects of similar size (as found in the cost data book or bid tabulations from recently advertised projects), the average value curves in the 2009 Pavement Design Manual, and the Engineering Estimates and Market Analysis HMA and Market Analysis April 2008 newsletter.

Statistics Probability Function	LCCAOutput: Alternative 1: Agency Cost (Thousands)	LCCAOutput: Alternative 1: User Cost (Thousands)	Total HMA (Thousands)	LCCAOutput: Alternative 2: Agency Cost (Thousands)	LCCAOutput: Alternative 2: User Cost (Thousands)	Total PCCP (Thousands)
Minimum	$2,938.84	$226.50	$3,165.34	$1,667.60	$0.00	$1,667.60
Maximum	$5,311.37	$2,648.80	$7,960.17	$6,159.23	$4,426.66	$10,585.89
Mean	$3,689.49	$917.78	$4,607.27	$2,986.45	$708.70	$3,695.14
Median	$3,628.03	$839.85	$4,467.88	$2,904.31	$440.02	$3,344.33
Standard Deviation	$466.35	$500.25	$966.59	$823.80	$854.01	$1,677.82
Percentile (5%)	$3,051.71	$274.10	$3,325.81	$1,911.16	$0.00	$1,911.16
Percentile (10%)	$3,100.57	$305.62	$3,406.19	$1,999.52	$0.00	$1,999.52
Percentile (75%)	$4,001.55	$1,242.24	$5,243.79	$3,463.42	$1,101.38	$4,564.80
Percentile (95%)	$4,516.09	$1,812.90	$6,328.99	$4,522.80	$2,519.78	$7,042.58

Table 5. Results of the probabilistic LCCA.

A comparison of the total cost for both alternatives at the 75 % percentile reveals that the sum of the agency cost and user cost over a 40-year analysis period for PCCP is 14.87 % less than that for HMA. All of the costs utilized in the LCCA and the probabilistic LCCA output are included in the appendix.

Initial Recommendations

Both the deterministic LCCA and the probabilistic LCCA show that the rigid pavement section option, over a 40-year analysis period, is less costly than the flexible pavement section option. The deterministic analysis indicates that the rigid pavement alternative is 25.45 % less, after factoring in the initial cost, the rehabilitation cost, and the salvage value while the probabilistic LCCA indicates that the rigid pavement section is 14.87 % less than the flexible pavement alternative. Thus, R-6 Materials recommends using the rigid pavement alternative.

Below, please find Region 6 Materials' recommendations. Pavement design parameters are shown in Table 6.

- The proposed pavement should utilize 10 inches of PCCP over 6 inches of ABC Class 6 over 4 feet of A-2-4 or better material. Transverse joints must utilize load transfer devices while all shoulders should be tied.

- From the intersection of SH 121 and SH to station 35+00 (the beginning of the left turn taper), 11 inches of PCCP over 6 inches of ABC Class 6 over 4 feet of A-2-4 or better material should be used to maintain consistency with the existing intersection pavement.

- In cut areas, properly-sized side drains which keep water levels at least 2 feet from the bottom of theA-2-4 or better material to maintain the integrity of the pavement structure.

- To provide for adequate sulfate resistance in all concrete supplied, Severity of Potential Exposure shall be Class 2 for this project.

- The deck of the proposed structure should incorporate 3 inches of Stone Matrix Asphalt (Fibers) (Asphalt) – SMA (Fibers) (Asphalt) with a nominal maximum aggregate size of ½ inch.

- Patching may be required on this project. If patching is required, it should be to the depth of the existing pavement as directed by the Engineer. The thickness of underlying lifts should be greater than or equal to the lift directly above. The top lift should utilize HMA (Grading SX) (100) (PG 76-28) while lower lifts may utilize HMA (Grading S) (100) (PG 64-22).

Please feel free to contact me via e-mail at James.Chang@dot.state.dot.co.us if there are any questions / comments about any of the information contained herein.

James Chang, P.E.
Region 6 Materials

120TH CONNECTION	
DESIGN PARAMETER	**RIGID PAVEMENT**
Design life (years):	**30**
18k ESAL:	**5,203,342**
% Trucks:	**4.2**
Initial Serviceability:	**4.5**
Terminal Serviceability:	**2.5**
% Reliability:	**95**
R-Value Design:	**--**
Soil Resilient Modulus (psi):	**--**
Structural Coefficient:	**--**
PCC Modulus of Rupture (psi):	**650**
PCC Modulus of Elasticity (psi):	**3,400,000**
PCC Load Transfer Coefficient:	**2.8**
Required Structural Number (in):	**--**
Effective Modulus of Subgrade Reaction (psi/in)	**88**
Overlay structure number (in):	**--**
Drainage Coefficient:	**1.0**
Pavement thickness (in):	**10” PCCP ***
Base Thickness (in):	**6” ABC CL 6**

*Requires 6” ABC CL 6, 4’ of A-2-4 or better material.
All transverse joints require load transfer devices.

Table 6. Rigid Pavement Alternative

Xc: File

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120th Connection

Contents

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1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Flexible Structural Design Module

PCN 16501
120th Connection Phase 1 SH121 to Wadsworth Blvd
Using URS 2035 ESALs with 4.2 % Truck Traffic
Assume 6" ABC CL 6 over 4' R-20 A-2-4 or better
Date: 5/5/08
By: JIC

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	1,881,044
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	95 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	4,939 psi
Stage Construction	1
Calculated Design Structural Number	4.50 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	New HMA	0.44	1	8.75	24	3.85
2	ABC CL 6	0.12	1	6	24	0.72
Total	-	-	-	14.75	-	4.57

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1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Flexible Structural Design Module

PCN 16501
120th Connection Phase 2 Wadsworth Blvd to 287
Using URS 2035 ESALs with 4.2 % Truck Traffic
Assume 6" ABC CL 6 over 4' R-20 A-2-4 or better
Date: 4/18/08
By: JIC

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	1,876,691
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	95 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	4,939 psi
Stage Construction	1
Calculated Design Structural Number	4.50 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	New HMA	0.44	1	8.75	24	3.85
2	ABC CL 6	0.12	1	6	24	0.72
Total	-	-	-	14.75	-	4.57

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1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

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Computer Software Product

Flexible Structural Design Module

PCN 16501
120th Connection Phase 2 287 East
Using URS 2035 ESALs with 4.2 % Truck Traffic
Assume 6" ABC CL 6 over 4' R-20 A-2-4 or better
Date: 5/5/08
By: JIC

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	2,238,302
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	95 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	4,939 psi
Stage Construction	1

Calculated Design Structural Number 4.62 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	New HMA	0.44	1	9	24	3.96
2	ABC CL 6	0.12	1	6	24	0.72
Total	-	-	-	15.00	-	4.68

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Rigid Pavement Design - Based on AASHTO Supplemental Guide

Reference: *LTPP DATA ANALYSIS - Phase I: Validation of Guidelines for k-Value Selection and Concrete Pavement Performance Prediction*

I. General

Agency:	CDOT
Street Address:	4670 Holly St, Unit C
City:	Denver
State:	CO, 80216-6408
Project Number:	16501
ID:	Default
Description:	Rigid Design using R = 20 Phase 1 121 to Wads Blvd URS ESAL 4.2
Location:	120th Connection

II. Design

Serviceability

Initial Serviceability, P1:	4.5	
Terminal Serviceability, P2:	2.5	

PCC Properties

28-day Mean Modulus of Rupture, $(S'_c)'$:	650	psi
Elastic Modulus of Slab, E_c:	3,400,000	psi
Poisson's Ratio for Concrete, m:	0.15	

Base Properties

Elastic Modulus of Base, E_b:	15,000	psi
Design Thickness of Base, H_b:	6.0	in
Slab-Base Friction Factor, f:	1.0	

Reliability and Standard Deviation

Reliability Level (R):	95.0	%
Overall Standard Deviation, S_0:	0.34	

Climatic Properties

Mean Annual Wind Speed, WIND:	9.0	mph
Mean Annual Air Temperature, TEMP:	51.0	^oF
Mean Annual Precipitation, PRECIP:	13.4	in

Subgrade k-Value

88 psi/in

Design ESALs

4.5 million

Pavement Type, Joint Spacing (L)

- (●) JPCP
- ( ) JRCP
- ( ) CRCP

Joint Spacing: 15.0 ft

JPCP

Effective Joint Spacing: 180 in

Edge Support

- ( ) Conventional 12-ft wide traffic lane
- (●) Conventional 12-ft wide traffic lane + tied PCC
- ( ) 2-ft widened slab w/conventional 12-ft traffic lane

Edge Support Factor: 0.94

Sensitivity Analysis

Slab Thickness used for Sensitivity Analysis: 8.86 in

- ( ) Modulus of Rupture
- ( ) Elastic Modulus (Slab)
- ( ) Elastic Modulus (Base)
- (●) Base Thickness
- ( ) k-Value
- ( ) Joint Spacing
- ( ) Reliability
- ( ) Standard Deviation

Calculated Slab Thickness for Above Inputs: 8.86 in

Faulting

DOWELED PAVEMENT			**NONDOWELED PAVEMENT**		
Dowel Diameter:	1.25	in			
K_d:	1,500,000	psi/in			
E_s:	29,000,000	psi			

Base/Slab Frictional Restraint

- ○ Stabilized Base
- ◉ Aggregate Base or LCB w/ bond breaker

ALPHA:	0.000006	/°F			
TRANGE:	105.0	°F	Days90:	30	days
e:	0.00015	strain			
D:	9.50	in	D:	8.86	in
P:	9,000	lbf			
T:	0.45				

Base Type (doweled)

- ○ Stabilized Base
- ◉ Unstabilized Base

Base Type (nondoweled)

- ○ Stabilized Base
- ◉ Unstabilized Base

FI:	503	°F-days	FI:	600	°F-days
CESAL:	4.52	million	CESAL:	4.52	million
Age:	22.0	years	Age:	20.0	years
C_d:	1.00		C_d:	1.00	

Faulting (doweled)

0.05 in

Faulting Check - **PASS**

Faulting (nondoweled)

in

Faulting Check -

Recommended critical mean joint faulting levels for design (Table 28)

Joint Spacing	Critical Mean Joint Faulting
< 25 ft	0.06 in
> 25 ft	0.13 in

Note: Joint load position stress checks need to be performed only for nondoweled pavements

Only two numbers need to be entered in this sheet:

Temperature gradient

Tensile stress at top of slab

Step 1:

Total Negative Temperature Differential

Slab Thickness: 8.86 in

Total Negative Temperature Differential: -5.1 °F

Construction Curling and Moisture Gradient Temperature Differential

Enter temperature gradient: 2.0 °F/in (enter positive value from below)

For temperature gradient use:

Wet Climate:	0 to 2 °F/in	(Annual Precipitation >= 30 in or Thornthwaite Moisture Index > 0)
Dry Climate:	1 to 3 °F/in	(Annual Precipitation < 30 in or Thornthwaite Moisture Index < 0)

Total Effective Negative Temp. Differential: -22.8 °F

Step 2:

Use one or more of the following charts to estimate the tensile stress at top of slab.
Note that the charts show the variation of tensile stress with negative temperature differential for slab thicknesses ranging from 7 to 13 in. These are plotted for a base course thickness of 6 in. The six charts represent three k-values (100, 250 and 500 psi/in) and two values for the elastic modulus of the base (25,000 psi and 1,000,000 psi). Use judgment to extrapolate the value of the tensile stress at the top of the slab from these charts.

Enter Tensile Stress at Top of Slab: 196 psi (use charts below)

Step 3:

Compare the above tensile stress with the maximum tensile stress at the bottom of the slab for which the slab is designed. For the given inputs and the above thickness, this value is

252	psi

The slab is designed for a tensile stress of 252 psi.
If the tensile stress at the top of the slab (obtained from the charts below and entered above) is less than the design stress, the design is acceptable. If the check fails, new inputs have to be provided.

Corner Break Check:	**PASS**

Rigid Pavement Design - Based on AASHTO Supplemental Guide

Reference: *LTPP DATA ANALYSIS - Phase I: Validation of Guidelines for k-Value Selection and Concrete Pavement Performance Prediction*

I. General

Agency: CDOT
Street Address: 4670 Holly St, Unit C
City: Denver
State: CO, 80216-6408

Project Number: 16501

ID: Default

Description: Rigid Design using R = 20 Phase 2 Wads Blvd to 287 URS ESAL 4.2

Location: 120th Connection

II. Design

Serviceability

Initial Serviceability, P1: 4.5
Terminal Serviceability, P2: 2.5

PCC Properties

28-day Mean Modulus of Rupture, $(S'_c)'$: 650 psi
Elastic Modulus of Slab, E_c: 3,400,000 psi
Poisson's Ratio for Concrete, m: 0.15

Base Properties

Elastic Modulus of Base, E_b: 15,000 psi
Design Thickness of Base, H_b: 6.0 in
Slab-Base Friction Factor, f: 1.0

Reliability and Standard Deviation

Reliability Level (R): 95.0 %
Overall Standard Deviation, S_0: 0.34

Climatic Properties

Mean Annual Wind Speed, WIND: 9.0 mph
Mean Annual Air Temperature, TEMP: 51.0 ^oF
Mean Annual Precipitation, PRECIP: 13.4 in

Subgrade k-Value

88 psi/in

Design ESALs

4.5 million

Pavement Type, Joint Spacing (L)

(●) JPCP
( ) JRCP
( ) CRCP

Joint Spacing: 15.0 ft

JPCP

Effective Joint Spacing: 180 in

Edge Support

( ) Conventional 12-ft wide traffic lane
(●) Conventional 12-ft wide traffic lane + tied PCC
( ) 2-ft widened slab w/conventional 12-ft traffic lane

Edge Support Factor: 0.94

Sensitivity Analysis

Slab Thickness used for Sensitivity Analysis: 8.86 in

(●) Modulus of Rupture
( ) Elastic Modulus (Slab)
( ) Elastic Modulus (Base)
( ) Base Thickness
( ) k-Value
( ) Joint Spacing
( ) Reliability
( ) Standard Deviation

Calculated Slab Thickness for Above Inputs: 8.86 in

Faulting

DOWELED PAVEMENT

Dowel Diameter:	1.25	in
K_d:	1,500,000	psi/in
E_s:	29,000,000	psi

Base/Slab Frictional Restraint

- ○ Stabilized Base
- ● Aggregate Base or LCB w/ bond breaker

ALPHA:	0.000006	/°F
TRANGE:	105.0	°F
e:	0.00015	strain
D:	9.50	in
P:	9,000	lbf
T:	0.45	

Base Type

- ○ Stabilized Base
- ● Unstabilized Base

FI:	503	°F-days
CESAL:	4.52	million
Age:	22.0	years
C_d:	1.00	

Faulting (doweled)

0.05 in

Faulting Check - **PASS**

NONDOWELED PAVEMENT

Days90:	30	days
D:	8.86	in

Base Type

- ○ Stabilized Base
- ● Unstabilized Base

FI:	600	°F-days
CESAL:	4.52	million
Age:	20.0	years
C_d:	1.00	

Faulting (nondoweled)

in

Faulting Check -

Recommended critical mean joint faulting levels for design (Table 28)

Joint Spacing	Critical Mean Joint Faulting	
< 25 ft	0.06	in
> 25 ft	0.13	in

Note: Joint load position stress checks need to be performed only for nondoweled pavements

Only two numbers need to be entered in this sheet:

Temperature gradient

Tensile stress at top of slab

Step 1:

Total Negative Temperature Differential

Slab Thickness: 8.86 in

Total Negative Temperature Differential: -5.1 °F

Construction Curling and Moisture Gradient Temperature Differential

Enter temperature gradient: 2.0 °F/in (enter positive value from below)

For temperature gradient use:

Wet Climate:	0 to 2 °F/in	(Annual Precipitation >= 30 in or Thornthwaite Moisture Index > 0)
Dry Climate:	1 to 3 °F/in	(Annual Precipitation < 30 in or Thornthwaite Moisture Index < 0)

Total Effective Negative Temp. Differential: -22.8 °F

Step 2:

Use one or more of the following charts to estimate the tensile stress at top of slab.
Note that the charts show the variation of tensile stress with negative temperature differential for slab thicknesses ranging from 7 to 13 in. These are plotted for a base course thickness of 6 in. The six charts represent three k-values (100, 250 and 500 psi/in) and two values for the elastic modulus of the base (25,000 psi and 1,000,000 psi). Use judgment to extrapolate the value of the tensile stress at the top of the slab from these charts.

Enter Tensile Stress at Top of Slab: 196 psi (use charts below)

Step 3:

Compare the above tensile stress with the maximum tensile stress at the bottom of the slab for which the slab is designed. For the given inputs and the above thickness, this value is

252 psi

The slab is designed for a tensile stress of 252 psi.
If the tensile stress at the top of the slab (obtained from the charts below and entered above) is less than the design stress, the design is acceptable. If the check fails, new inputs have to be provided.

Corner Break Check: **PASS**

Rigid Pavement Design - Based on AASHTO Supplemental Guide

Reference: *LTPP DATA ANALYSIS - Phase I: Validation of Guidelines for k-Value Selection and Concrete Pavement Performance Prediction*

I. General

Agency: CDOT
Street Address: 4670 Holly St, Unit C
City: Denver
State: CO, 80216-6408

Project Number: 16501

ID: Default

Description: Rigid Design using R = 20 Phase 2 287 East URS ESALS 4.2

Location: 120th Connection

II. Design

Serviceability

Initial Serviceability, P1: 4.5
Terminal Serviceability, P2: 2.5

PCC Properties

28-day Mean Modulus of Rupture, $(S'_c)'$: 650 psi
Elastic Modulus of Slab, E_c: 3,400,000 psi
Poisson's Ratio for Concrete, m: 0.15

Base Properties

Elastic Modulus of Base, E_b: 15,000 psi
Design Thickness of Base, H_b: 6.0 in
Slab-Base Friction Factor, f: 1.0

Reliability and Standard Deviation

Reliability Level (R): 95.0 %
Overall Standard Deviation, S_0: 0.34

Climatic Properties

Mean Annual Wind Speed, WIND: 9.0 mph
Mean Annual Air Temperature, TEMP: 51.0 ^{o}F
Mean Annual Precipitation, PRECIP: 13.4 in

Subgrade k-Value

88 psi/in

Design ESALs

5.2 million

Pavement Type, Joint Spacing (L)

- (●) JPCP
- ( ) JRCP
- ( ) CRCP

Joint Spacing: 15.0 ft

JPCP

Effective Joint Spacing: 180 in

Edge Support

- ( ) Conventional 12-ft wide traffic lane
- (●) Conventional 12-ft wide traffic lane + tied PCC
- ( ) 2-ft widened slab w/conventional 12-ft traffic lane

Edge Support Factor: 0.94

Sensitivity Analysis

Slab Thickness used for Sensitivity Analysis: 9.05 in

- (●) Modulus of Rupture
- ( ) Elastic Modulus (Slab)
- ( ) Elastic Modulus (Base)
- ( ) Base Thickness
- ( ) k-Value
- ( ) Joint Spacing
- ( ) Reliability
- ( ) Standard Deviation

Calculated Slab Thickness for Above Inputs: 9.05 in

Faulting

DOWELED PAVEMENT

Dowel Diameter:	1.25	in
K_d:	1,500,000	psi/in
E_s:	29,000,000	psi

Base/Slab Frictional Restraint

- ○ Stabilized Base
- ◉ Aggregate Base or LCB w/ bond breaker

ALPHA:	0.000006	/°F
TRANGE:	105.0	°F
e:	0.00015	strain
D:	9.50	in
P:	9,000	lbf
T:	0.45	

Base Type

- ○ Stabilized Base
- ◉ Unstabilized Base

FI:	503	°F-days
CESAL:	4.52	million
Age:	22.0	years
C_d:	1.00	

Faulting (doweled)

0.05 **in**

Faulting Check - **PASS**

NONDOWELED PAVEMENT

Days90:	30	days
D:	8.86	in

Base Type

- ○ Stabilized Base
- ◉ Unstabilized Base

FI:	600	°F-days
CESAL:	4.52	million
Age:	20.0	years
C_d:	1.00	

Faulting (nondoweled)

in

Faulting Check -

Recommended critical mean joint faulting levels for design (Table 28)

Joint Spacing	Critical Mean Joint Faulting	
< 25 ft	0.06	in
> 25 ft	0.13	in

Note: Joint load position stress checks need to be performed only for nondoweled pavements

Only two numbers need to be entered in this sheet:

Temperature gradient

Tensile stress at top of slab

Step 1:

Total Negative Temperature Differential

Slab Thickness: 8.86 in

Total Negative Temperature Differential: -5.1 °F

Construction Curling and Moisture Gradient Temperature Differential

Enter temperature gradient: 2.0 °F/in (enter positive value from below)

For temperature gradient use:

Wet Climate:	0 to 2 °F/in	(Annual Precipitation >= 30 in or Thornthwaite Moisture Index > 0)
Dry Climate:	1 to 3 °F/in	(Annual Precipitation < 30 in or Thornthwaite Moisture Index < 0)

Total Effective Negative Temp. Differential: -22.8 °F

Step 2:

Use one or more of the following charts to estimate the tensile stress at top of slab.
Note that the charts show the variation of tensile stress with negative temperature differential for slab thicknesses ranging from 7 to 13 in. These are plotted for a base course thickness of 6 in. The six charts represent three k-values (100, 250 and 500 psi/in) and two values for the elastic modulus of the base (25,000 psi and 1,000,000 psi). Use judgment to extrapolate the value of the tensile stress at the top of the slab from these charts.

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252 psi

The slab is designed for a tensile stress of 252 psi.
If the tensile stress at the top of the slab (obtained from the charts below and entered above) is less than the design stress, the design is acceptable. If the check fails, new inputs have to be provided.

Corner Break Check: **PASS**

120th Connection ESAL Calculations - 4.2% Trucks

			Phase 1		Phase 2-1		Phase 2-2	
			SH-121 to Wads. Blvd.		Wads. Blvd. to US-287		US-287 East	
		Year	ADT	Total VPD	ADT	Total VPD	ADT	Total VPD
Phase 1 Opens		2010	**8,000**					
		2011	**8,000**					
Phase 2 Opens		2012	**30,000**		**25,000**		**30,000**	
		2013	31,167		26,222		31,444	
		2014	32,333		27,444		32,889	
		2015	33,500		28,667		34,333	
		2016	34,667		29,889		35,778	
Phase 1 10 year		2017	35,833		31,111		37,222	
		2018	37,000		32,333		38,667	
		2019	38,167		33,556		40,111	
Phase 1 - 10 year		2020	39,333	288,667	34,778		41,556	
		2021	40,500		36,000		43,000	
Phase 2 - 10 year		2022	41,667		37,222	305,000	44,444	365,000
		2023	42,833		38,444		45,889	
		2024	44,000		39,667		47,333	
		2025	45,167		40,889		48,778	
		2026	46,333		42,111		50,222	
		2027	47,500		43,333		51,667	
		2028	48,667		44,556		53,111	
		2029	49,833		45,778		54,556	
Phase 1 - 20 year		2030	**51,000**	734,500	**47,000**		**56,000**	
		2031	52,400		48,800		57,000	
Phase 2 - 20 year		2032	53,800		**50,600**	732,800	**58,000**	874,000
		2033	55,200		52,400		59,000	
		2034	56,600		54,200		60,000	
		2035	**58,000**		**56,000**		**61,000**	
		2036	58,870		56,840		61,915	
		2037	59,753		57,693		62,844	
		2038	60,649		58,558		63,786	
		2039	61,559		59,436		64,743	
Phase 1 - 30 year		2040	62,482	1,302,331	60,328		65,714	
		2041	63,420		61,233		66,700	
Phase 2 - 30 year		2042	64,371		62,151	1,300,088	67,701	1,497,703
Flexible Pavement -20yr								
Cars	0.003	*95.8%*	703,651	231,149	702,022	230,614	837,292	275,050
SU Trucks	0.249	3.0%	22,035	600,795	21,984	599,405	26,220	714,901
Comb. Trucks	1.087	1.2%	8,814	1,049,100	8,794	1,046,671	10,488	1,248,350
Lane Configuration		0.30	**734,500**	**1,881,044**	**732,800**	**1,876,691**	**874,000**	**2,238,302**
Rigid Pavement - 30yr								
Cars	0.003	*95.8%*	1,247,634	409,848	1,245,484	409,141	1,434,799	471,332
SU Trucks	0.285	3.0%	39,070	1,219,275	39,003	1,217,175	44,931	1,402,187
Comb. Trucks	1.692	1.2%	15,628	2,895,458	15,601	2,890,469	17,972	3,329,824
Lane Configuration		0.30	**1,302,331**	**4,524,581**	**1,300,088**	**4,516,785**	**1,497,703**	**5,203,342**
Comparison to 3.2%:								
Flexible Pavement -20yr				**1,683,192**		**1,679,296**		**2,002,872**
Difference %				111.8%		111.8%		111.8%
Rigid Pavement - 30yr				**4,122,434**		**4,115,331**		**4,740,867**
Difference %				109.8%		109.8%		109.8%
Revisions:	18-Apr	Changed projected growth % beyond 2030 to 1.5%						
	29-Apr	Incorporated 2035 volumes from URS Exhibit						

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☺

120th Connection

Contents

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1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Life Cycle Cost Module

PCN 16501
120th Connection Des Build
LCCA analysis
HMA - 20 year design life

1) Price of Planing and SMA same
2) calc user cost using AADT for rehab year
Quantities based on 1 direction
3) The Analysis Period is 40 years with a 1 years of Salvage Value
4) SMA is polymer modified, per 2009 PDM use 11 years instead of 10 years for 1st rehab only!
Last rehab is for 9 years so have 1 year of salvage.
5) Using 9" HMA R20 and URS 2035 Projections
6) Adjusted Costs
7) Adjusted User Costs

Date: 06/6/08

Life Cycle Cost Data

Summary

Analysis Period	40 years
Project Length	1.25 mi
Discount Rate	3.33 %
Number of Lanes in One Direction	3
Type of Roadway	Divided

Total Costs -- Using NPV on a basis of total costs for both directions

Initial Construction Cost	$2,428,440
Rehabilitation Cost	$1,583,271
Salvage Value	$-26,007
Total Cost	$3,985,704

Initial Construction

Full Depth HMA Construction

Construction Year	2009
Performance Period	11 years

Cost Information -- Using NPV on a basis of total costs for both directions

Information Type	Source	Costs at Year of Construction (One Direction)	Net Costs
Construction	DARWin Calculated	$1,163,171.08	$2,326,342.16
Maintenance	DARWin Calculated	$51,049.02	$102,098.03
Total	-	$1,214,220.10	$2,428,440.19

Rehabilitation #1

At year 11, mill and 2"/50mm HMA overlay

Rehabilitation Year	2020
Performance Period	10 years

Cost Information -- Using NPV on a basis of total costs for both directions

Information Type	Source	Costs at Year of Rehabilitation (One Direction)	Net Costs
Construction	DARWin Calculated	$444,668.14	$620,262.16
Maintenance	DARWin Calculated	$47,130.38	$65,741.59
Total	-	$491,798.52	$686,003.75

Rehabilitation #2

At year 21, mill and 2"/50mm HMA overlay

Rehabilitation Year	2030
Performance Period	10 years

Cost Information -- Using NPV on a basis of total costs for both directions

Information Type	Source	Costs at Year of Rehabilitation (One Direction)	Net Costs
Construction	DARWin Calculated	$466,984.33	$469,436.97
Maintenance	DARWin Calculated	$47,130.38	$47,377.91
Total	-	$514,114.71	$516,814.88

Rehabilitation #3

At year 31, mill and 2" /50mm HMA overlay

Rehabilitation Year	2040
Performance Period	9 years

Cost Information -- Using NPV on a basis of total costs for both directions

Information Type	Source	Costs at Year of Rehabilitation (One Direction)	Net Costs
Construction	DARWin Calculated	$482,076.42	$349,242.09
Maintenance	DARWin Calculated	$43,081.25	$31,210.38
Total	-	$525,157.67	$380,452.46

Salvage Year	2049

Cost Information -- Using NPV on a basis of total costs for both directions

Phase	Description	Source	Salvage Value	Net Value
Initial Construction	No Salvage Value	User Entered	$0.00	$0.00
Rehabilitation #1	No Salvage Value	User Entered	$0.00	$0.00
Rehabilitation #2	-	DARWin Calculated	$0.00	$0.00
Rehabilitation #3	1 Year Salvage Value since ...	User Entered	$48,207.63	$26,006.90

Initial Construction Maintenance Costs

Year Maintenance Costs Begin	2009
Annual Maintenance Costs	$1,450.00 per lane mi
Annual Increase in Maintenance Costs	0 %
Calculated Non Discounted Maintenance Costs (One Direction)	$51,049.02

Rehabilitation #1 Maintenance Costs

Year Maintenance Costs Begin	2020
Annual Maintenance Costs	$1,450.00 per lane mi
Annual Increase in Maintenance Costs	0 %
Calculated Non Discounted Maintenance Costs (One Direction)	$47,130.38

Rehabilitation #2 Maintenance Costs

Year Maintenance Costs Begin	2030
Annual Maintenance Costs	$1,450.00 per lane mi
Annual Increase in Maintenance Costs	0 %
Calculated Non Discounted Maintenance Costs (One Direction)	$47,130.38

Rehabilitation #3 Maintenance Costs

Year Maintenance Costs Begin	2040
Annual Maintenance Costs	$1,450.00 per lane mi
Annual Increase in Maintenance Costs	0 %
Calculated Non Discounted Maintenance Costs (One Direction)	$43,081.25

Initial Construction Pay Items

Name	Lane	Layer	Unit	Unit Cost	Quantity	Total Cost
15% Traffic Control	N.A.	NA	15%	$1.00	132,068	$132,068.48
17 % Construction Engineering	N.A.	NA	17 % CE Rate	$1.00	150,646	$150,646.11
HMA (Gr. S)(100)(PG 64-22)	T.L.	2	ton	$65.00	10,187	$662,161.50
SMA (Fibers) (Asphalt)	T.L.	1	ton	$75.00	2,911	$218,295.00

Non Discounted Costs (One Direction)

Traffic Lane	$880,456.50
Inner Shoulder	$0.00
Outer Shoulder	$0.00
Miscellaneous	$282,714.58

Total Non Discounted Cost (One Direction)	$1,163,171.08

Rehabilitation #1 Pay Items

Name	Lane	Layer	Unit	Unit Cost	Quantity	Total Cost
15% Traffic Control	N.A.	NA	15%	$1.00	42,644	$42,644.25
2% Preliminary Engineering	N.A.	NA	2% Design Eng...	$1.00	5,686	$5,685.90
17 % Construction Engineering	N.A.	NA	17 % CE Rate	$1.00	48,643	$48,642.87
Removal Asphalt Mat (Planing)	T.L.	2	sq yd	$2.50	26,400	$66,000.00
SMA (Fibers) (Asphalt)	T.L.	2	ton	$75.00	2,911	$218,295.00
Net User Cost	N.A.	NA	lump sum	$63,400.12	1	$63,400.12

Non Discounted Costs (One Direction)

Traffic Lane	$284,295.00
Inner Shoulder	$0.00
Outer Shoulder	$0.00
Miscellaneous	$160,373.14

Total Non Discounted Cost (One Direction)	$444,668.14

Rehabilitation #2 Pay Items

Name	Lane	Layer	Unit	Unit Cost	Quantity	Total Cost
15% Traffic Control	N.A.	NA	15%	$1.00	42,644	$42,644.25
Net User Cost	N.A.	NA	lump sum	$85,716.31	1	$85,716.31
Removal Asphalt Mat (Planing)	T.L.	2	sq yd	$2.50	26,400	$66,000.00
SMA (Fibers) (Asphalt)	T.L.	2	ton	$75.00	2,911	$218,295.00
2% Preliminary Engineering	N.A.	NA	2% Design Eng...	$1.00	5,686	$5,685.90
17 % Construction Engineering	N.A.	NA	17 % CE Rate	$1.00	48,643	$48,642.87

Non Discounted Costs (One Direction)

Traffic Lane	$284,295.00
Inner Shoulder	$0.00
Outer Shoulder	$0.00
Miscellaneous	$182,689.33

Total Non Discounted Cost (One Direction)	$466,984.33

Rehabilitation #3 Pay Items

Name	Lane	Layer	Unit	Unit Cost	Quantity	Total Cost
15% Traffic Control	N.A.	NA	15%	$1.00	42,644	$42,644.25
Net User Cost	N.A.	NA	lump sum	$100,808.40	1	$100,808.40
Removal Asphalt Mat (Planing)	T.L.	2	sq yd	$2.50	26,400	$66,000.00
SMA (Fibers) (Asphalt)	T.L.	2	ton	$75.00	2,911	$218,295.00
2% Preliminary Engineering	N.A.	NA	2% Design Eng...	$1.00	5,686	$5,685.90
17 % Construction Engineering	N.A.	NA	17 % CE Rate	$1.00	48,643	$48,642.87

Non Discounted Costs (One Direction)

Traffic Lane	$284,295.00

Inner Shoulder	$0.00
Outer Shoulder	$0.00
Miscellaneous	$197,781.42
Total Non Discounted Cost (One Direction)	$482,076.42

Initial Construction -- Traffic Lane Dimensions

Layer	Material Description	Width (ft)	Thickness (in)
1	SMA (Fibers) (Asphalt)	36	2
2	HMA (Gr. S)(100)(PG 64-22)	36	7

Initial Construction -- Inner Shoulder Dimensions

Layer	Material Description	Width (ft)	Inner Thickness (in)	Outer Thickness (in)

Initial Construction -- Outer Shoulder Dimensions

Layer	Material Description	Width (ft)	Inner Thickness (in)	Outer Thickness (in)

Rehabilitation #1 -- Traffic Lane Dimensions

Layer	Material Description	Width (ft)	Thickness (in)
1	Removal of Asphalt Mat (Planing)	36	2
2	SMA	36	2

Milling Thickness 0 in

Rehabilitation #1 -- Inner Shoulder Dimensions

Layer	Material Description	Width (ft)	Inner Thickness (in)	Outer Thickness (in)

Milling Thickness 0 in

Rehabilitation #1 -- Outer Shoulder Dimensions

Layer	Material Description	Width (ft)	Inner Thickness (in)	Outer Thickness (in)

Milling Thickness 0 in

Rehabilitation #2 -- Traffic Lane Dimensions

Layer	Material Description	Width (ft)	Thickness (in)
1	Removal of Asphalt Mat (Planing)	36	2
2	SMA (Fibers) (Asphalt)	36	2

Milling Thickness 0 in

Rehabilitation #2 -- Inner Shoulder Dimensions

Layer	Material Description	Width (ft)	Inner Thickness (in)	Outer Thickness (in)

Milling Thickness 0 in

Rehabilitation #2 -- Outer Shoulder Dimensions

Layer	Material Description	Width (ft)	Inner Thickness (in)	Outer Thickness (in)

Milling Thickness 0 in

Rehabilitation #3 -- Traffic Lane Dimensions

Layer	Material Description	Width (ft)	Thickness (in)
1	Removal of Asphalt Mat (Planing)	36	2
2	SMA (Fibers) (Asphalt)	36	2

Milling Thickness 2 in

Rehabilitation #3 -- Inner Shoulder Dimensions

Layer	Material Description	Width (ft)	Inner Thickness (in)	Outer Thickness (in)
1	Removal of Asphalt Mat (Planing)	8	2	2
2	HMA (Grading SX) (100) (PG 76-28)	8	2	2

Milling Thickness 0 in

Rehabilitation #3 -- Outer Shoulder Dimensions

Layer	Material Description	Width (ft)	Inner Thickness (in)	Outer Thickness (in)
1	Removal of Asphalt Mat (Planing)	10	2	2
2	HMA (Grading SX) (100) (PG 76-28)	10	2	2

Milling Thickness 0 in

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Life Cycle Cost Module

PCN 16501
120th Connection Des Build
LCCA analysis
PCCP analysis - 30 year design life

1) user cost using AADT for rehab year
Quantities based on 1 direction
2) 10" PCCP from URS 2035 Traffic Projections
3) Adjusted User Cost

Date: 6/6/08

Life Cycle Cost Data

Summary

Analysis Period	40 years
Project Length	1.25 mi
Discount Rate	3.33 %
Number of Lanes in One Direction	3
Type of Roadway	Divided

Total Costs -- Using NPV on a basis of total costs for both directions

Initial Construction Cost	$2,808,091
Rehabilitation Cost	$369,090
Salvage Value	-
Total Cost	$3,177,181

Initial Construction

JPCP with Aggregate Base

Construction Year	2009
Performance Period	22 years

Cost Information -- Using NPV on a basis of total costs for both directions

Information Type	Source	Costs at Year of Construction (One Direction)	Net Costs
Construction	DARWin Calculated	$1,395,081.60	$2,790,163.20
Maintenance	DARWin Calculated	$8,964.09	$17,928.17
Total	-	$1,404,045.69	$2,808,091.37

Rehabilitation #1

50% Grinding, Joint Resealing and 1/2% Slab Replacement

Rehabilitation Year	2031
Performance Period	18 years

Cost Information -- Using NPV on a basis of total costs for both directions

Information Type	Source	Costs at Year of Rehabilitation (One Direction)	Net Costs
Construction	DARWin Calculated	$371,612.77	$361,525.70
Maintenance	DARWin Calculated	$7,775.43	$7,564.37
Total	-	$379,388.20	$369,090.07

Salvage Values

Salvage Year 2049

Cost Information -- Using NPV on a basis of total costs for both directions

Phase	Description	Source	Salvage Value	Net Value
Initial Construction	No Salvage Value	User Entered	$0.00	$0.00
Rehabilitation #1	No Salvage Value	User Entered	$0.00	$0.00

Initial Construction Maintenance Costs

Year Maintenance Costs Begin	2009
Annual Maintenance Costs	$150.00 per lane mi
Annual Increase in Maintenance Costs	0 %
Calculated Non Discounted Maintenance Costs (One Direction)	$8,964.09

Rehabilitation #1 Maintenance Costs

Year Maintenance Costs Begin	2031
Annual Maintenance Costs	$150.00 per lane mi
Annual Increase in Maintenance Costs	0 %
Calculated Non Discounted Maintenance Costs (One Direction)	$7,775.43

Initial Construction Pay Items

Name	Lane	Layer	Unit	Unit Cost	Quantity	Total Cost
15% Traffic Control	N.A.	NA	15%	$1.00	158,400	$158,400.00
17 % Construction Engineering	N.A.	NA	17 % CE Rate	$1.00	180,682	$180,681.60
PCCP 10"	T.L.	1	sq yd-in	$4.00	264,000	$1,056,000.00

Non Discounted Costs (One Direction)

Traffic Lane	$1,056,000.00
Inner Shoulder	$0.00

Outer Shoulder	$0.00
Miscellaneous	$339,081.60
Total Non Discounted Cost (One Direction)	$1,395,081.60

Rehabilitation #1 Pay Items

Name	Lane	Layer	Unit	Unit Cost	Quantity	Total Cost
15% Traffic Control	N.A.	NA	15%	$1.00	26,096	$26,095.50
Net User Cost	N.A.	NA	lump sum	$128,301.60	1	$128,301.60
50% Concrete Grinding	T.L.	1	sq yd known	$2.50	26,240	$65,600.00
1/2 % Slab Replacement	T.L.	2	each	$7,000.00	8	$56,000.00
Joint Resealing (Transverse)	T.L.	3	linear ft known	$1.75	15,840	$27,720.00
Joint Resealing (Longitudinal)	T.L.	4	linear ft known	$1.75	19,800	$34,650.00
17 % Construction Engineering	N.A.	NA	17 % CE Rate	$1.00	29,766	$29,766.27
2% Preliminary Engineering	N.A.	NA	2% Design Eng...	$1.00	3,479	$3,479.40

Non Discounted Costs (One Direction)

Traffic Lane	$183,970.00
Inner Shoulder	$0.00
Outer Shoulder	$0.00
Miscellaneous	$187,642.77
Total Non Discounted Cost (One Direction)	$371,612.77

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120th Connection

Contents

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RealCost Input Data

1. Economic Variables	
Value of Time for Passenger Cars ($/hour)	$17.00
Value of Time for Single Unit Trucks ($/hour)	$35.00
Value of Time for Combination Trucks ($/hour)	$36.50

2. Analysis Options	
Include User Costs in Analysis	Yes
Include User Cost Remaining Service Life Value	Yes
Use Differential User Costs	Yes
User Cost Computation Method	Specified
Include Agency Cost Remaining Service Life Value	Yes
Traffic Direction	Both
Analysis Period (Years)	40
Beginning of Analysis Period	2009
Discount Rate (%)	3.3 **LCCANORMAL(3.3,0.22)**

3. Project Details and Quantity Calculations	
State Route	SH 128
Project Name	120th Connection Project STA 1281-011
Region	6
County	Broomfield / Jefferson
Analyzed By	J Chang
Mileposts	
Begin	0.00
End	1.25
Length of Project (miles)	1.25
Comments	

4. Traffic Data	
AADT Construction Year (total for both directions)	10,000
Cars as Percentage of AADT (%)	95.8
Single Unit Trucks as Percentage of AADT (%)	3.0
Combination Trucks as Percentage of AADT (%)	1.2
Annual Growth Rate of Traffic (%)	1.3 **LCCATRIANG(0.34,1.34,2.34)**
Speed Limit Under Normal Operating Conditions (mph)	40
No of Lanes in Each Direction During Normal Conditions	3
Free Flow Capacity (vphpl)	2200
Rural or Urban Hourly Traffic Distribution	Urban
Queue Dissipation Capacity (vphpl)	1000
Maximum AADT (total for both directions)	30,000
Maximum Queue Length (miles)	3.0

Alternative 1

Initial Construction	2" SMA over 7" HMA	
Agency Construction Cost ($1000)	$2,428.44	
User Work Zone Costs ($1000)	$0.00	
Work Zone Duration (days)	0	
No of Lanes Open in Each Direction During Work Zone	2	
Activity Service Life (years)	11.0	
Maintenance Frequency (years)	1	
Agency Maintenance Cost ($1000)	10.9	
Work Zone Length (miles)	1.25	
Work Zone Speed Limit (mph)	35	
Work Zone Capacity (vphpl)	1700	
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)		
Inbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		
Outbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		

Rehabilitation #1	2" mill and fill	
Agency Construction Cost ($1000)	$738.41 **LCCATRIANG(613.2242,761.991,840.0058)**	
User Work Zone Costs ($1000)	$514.60	
Work Zone Duration (days)	22	
No of Lanes Open in Each Direction During Work Zone	2	
Activity Service Life (years)	10.0 **LCCALOGNORMAL(10,3.1)**	
Maintenance Frequency (years)	1	
Agency Maintenance Cost ($1000)	10.9	
Work Zone Length (miles)	1.25	
Work Zone Speed Limit (mph)	35	
Work Zone Capacity (vphpl)	1700	
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)		
Inbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		
Outbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		

Rehabilitation #2	2" mill and fill	
Agency Construction Cost ($1000)	$738.41	
	LCCATRIANG(613.2242,761.991,840.0058)	
User Work Zone Costs ($1000)	$791.00	
Work Zone Duration (days)	22	
No of Lanes Open in Each Direction During Work Zone	2	
Activity Service Life (years)	10.0	
	LCCALOGNORMAL(10,3.1)	
Maintenance Frequency (years)	1	
Agency Maintenance Cost ($1000)	10.9	
Work Zone Length (miles)	1.25	
Work Zone Speed Limit (mph)	35	
Work Zone Capacity (vphpl)	1700	
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)		
Inbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		
Outbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		

Rehabilitation #3	2" mill and fill	
Agency Construction Cost ($1000)	$738.41	
	LCCATRIANG(613.2242,761.991,840.0058)	
User Work Zone Costs ($1000)	$820.80	
Work Zone Duration (days)	22	
No of Lanes Open in Each Direction During Work Zone	2	
Activity Service Life (years)	10.0	
	LCCALOGNORMAL(10,3.1)	
Maintenance Frequency (years)	1	
Agency Maintenance Cost ($1000)	10.9	
Work Zone Length (miles)	1.25	
Work Zone Speed Limit (mph)	35	
Work Zone Capacity (vphpl)	1700	
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)		
Inbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		
Outbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		

Rehabilitation #4	2" mill and fill	
Agency Construction Cost ($1000)	$738.41 **LCCATRIANG(613.2242,761.991,840.0058)**	
User Work Zone Costs ($1000)	$820.80	
Work Zone Duration (days)	22	
No of Lanes Open in Each Direction During Work Zone	2	
Activity Service Life (years)	10.0 **LCCALOGNORMAL(10,3.1)**	
Maintenance Frequency (years)	1	
Agency Maintenance Cost ($1000)	10.9	
Work Zone Length (miles)	1.25	
Work Zone Speed Limit (mph)	35	
Work Zone Capacity (vphpl)	1700	
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)		
Inbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		
Outbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		

Rehabilitation #5	2" mill and fill	
Agency Construction Cost ($1000)	$738.41 **LCCATRIANG(613.2242,761.991,840.0058)**	
User Work Zone Costs ($1000)	$820.80	
Work Zone Duration (days)	22	
No of Lanes Open in Each Direction During Work Zone	2	
Activity Service Life (years)	10.0 **LCCALOGNORMAL(10,3.1)**	
Maintenance Frequency (years)	1	
Agency Maintenance Cost ($1000)	10.9	
Work Zone Length (miles)	1.25	
Work Zone Speed Limit (mph)	35	
Work Zone Capacity (vphpl)	1700	
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)		
Inbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		
Outbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		

Rehabilitation #6	2" mill and fill	
Agency Construction Cost ($1000)	$738.41 **LCCATRIANG(613.2242,761.991,840.0058)**	
User Work Zone Costs ($1000)	$820.80	
Work Zone Duration (days)	22	
No of Lanes Open in Each Direction During Work Zone	2	
Activity Service Life (years)	10.0 **LCCALOGNORMAL(10,3.1)**	
Maintenance Frequency (years)	1	
Agency Maintenance Cost ($1000)	10.9	
Work Zone Length (miles)	1.25	
Work Zone Speed Limit (mph)	35	
Work Zone Capacity (vphpl)	1700	
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)		
Inbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		
Outbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		

Alternative 2

Initial Construction	Placing Pavement	
Agency Construction Cost ($1000)	$2,555.52 **LCCATRIANG(2236.08,2555.52,2874.96)**	
User Work Zone Costs ($1000)	$0.00	
Work Zone Duration (days)	0	
No of Lanes Open in Each Direction During Work Zone	2	
Activity Service Life (years)	22.0 **LCCALOGNORMAL(22,6.6)**	
Maintenance Frequency (years)	1	
Agency Maintenance Cost ($1000)	1.1	
Work Zone Length (miles)	1.25	
Work Zone Speed Limit (mph)	35	
Work Zone Capacity (vphpl)	1700	
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)		
Inbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		
Outbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		

Rehabilitation #1	Year 22 PCCP Rehab (50% grinding, 1/2% slab repl, Joint Resealing Trans, Joint Resealing long)	
Agency Construction Cost ($1000)	$827.58 **LCCATRIANG(668.928,804,1009.824)**	
User Work Zone Costs ($1000)	$1,044.60	
Work Zone Duration (days)	0	
No of Lanes Open in Each Direction During Work Zone	2	
Activity Service Life (years)	18.0 **LCCALOGNORMAL(18,6.6)**	
Maintenance Frequency (years)	1	
Agency Maintenance Cost ($1000)	1.1	
Work Zone Length (miles)	1.25	
Work Zone Speed Limit (mph)	35	
Work Zone Capacity (vphpl)	1700	
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)		
Inbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		
Outbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		

Rehabilitation #2	Year 22 PCCP Rehab (50% grinding, 1/2% slab repl, Joint Resealing Trans, Joint Resealing long)	
Agency Construction Cost ($1000)	$827.58 **LCCATRIANG(668.928,804,1009.824)**	
User Work Zone Costs ($1000)	$1,044.60	
Work Zone Duration (days)	0	
No of Lanes Open in Each Direction During Work Zone	2	
Activity Service Life (years)	18.0 **LCCALOGNORMAL(18,6.6)**	
Maintenance Frequency (years)	1	
Agency Maintenance Cost ($1000)	1.1	
Work Zone Length (miles)	1.25	
Work Zone Speed Limit (mph)	35	
Work Zone Capacity (vphpl)	1700	
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)		
Inbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		
Outbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		

Rehabilitation #3	Year 22 PCCP Rehab (50% grinding, 1/2% slab repl, Joint Resealing Trans, Joint Resealing long)	
Agency Construction Cost ($1000)	$827.58 **LCCATRIANG(668.928,804,1009.824)**	
User Work Zone Costs ($1000)	$1,044.60	
Work Zone Duration (days)	0	
No of Lanes Open in Each Direction During Work Zone	2	
Activity Service Life (years)	18.0 **LCCALOGNORMAL(18,6.6)**	
Maintenance Frequency (years)	1	
Agency Maintenance Cost ($1000)	1.1	
Work Zone Length (miles)	1.25	
Work Zone Speed Limit (mph)	35	
Work Zone Capacity (vphpl)	1700	
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)		
Inbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		
Outbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		

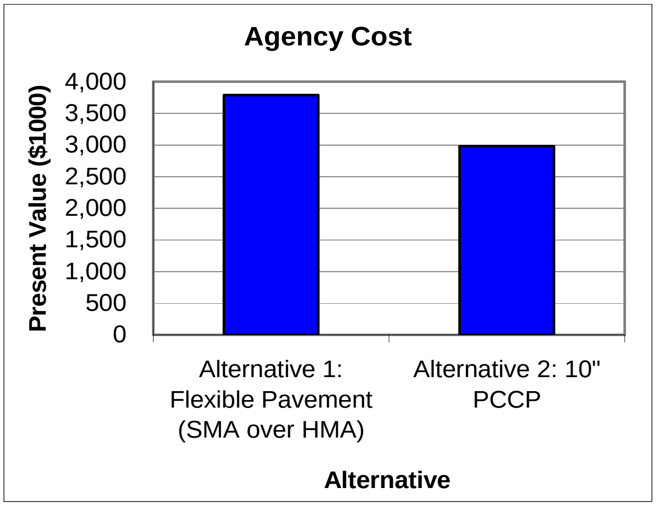
Rehabilitation #4	Year 22 PCCP Rehab (50% grinding, 1/2% slab repl, Joint Resealing Trans, Joint Resealing long)	
Agency Construction Cost ($1000)	$827.58 **LCCATRIANG(668.928,804,1009.824)**	
User Work Zone Costs ($1000)	$1,044.60	
Work Zone Duration (days)	0	
No of Lanes Open in Each Direction During Work Zone	2	
Activity Service Life (years)	18.0 **LCCALOGNORMAL(18,6.6)**	
Maintenance Frequency (years)	1	
Agency Maintenance Cost ($1000)	1.1	
Work Zone Length (miles)	1.25	
Work Zone Speed Limit (mph)	35	
Work Zone Capacity (vphpl)	1700	
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)		
Inbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		
Outbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		

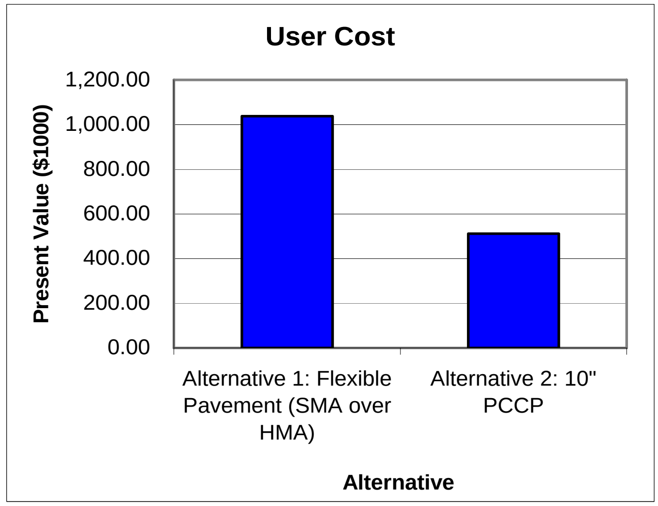
Rehabilitation #5	Year 22 PCCP Rehab (50% grinding, 1/2% slab repl, Joint Resealing Trans, Joint Resealing long)	
Agency Construction Cost ($1000)	$827.58 **LCCATRIANG(668.928,804,1009.824)**	
User Work Zone Costs ($1000)	$1,044.60	
Work Zone Duration (days)	0	
No of Lanes Open in Each Direction During Work Zone	2	
Activity Service Life (years)	18.0 **LCCALOGNORMAL(18,6.6)**	
Maintenance Frequency (years)	1	
Agency Maintenance Cost ($1000)	1.1	
Work Zone Length (miles)	1.25	
Work Zone Speed Limit (mph)	35	
Work Zone Capacity (vphpl)	1700	
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)		
Inbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		
Outbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		

Rehabilitation #6	Year 22 PCCP Rehab (50% grinding, 1/2% slab repl, Joint Resealing Trans, Joint Resealing long)	
Agency Construction Cost ($1000)	$827.58 **LCCATRIANG(668.928,804,1009.824)**	
User Work Zone Costs ($1000)	$1,044.60	
Work Zone Duration (days)	0	
No of Lanes Open in Each Direction During Work Zone	2	
Activity Service Life (years)	18.0 **LCCALOGNORMAL(18,6.6)**	
Maintenance Frequency (years)	1	
Agency Maintenance Cost ($1000)	1.1	
Work Zone Length (miles)	1.25	
Work Zone Speed Limit (mph)	35	
Work Zone Capacity (vphpl)	1700	
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)		
Inbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		
Outbound	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		

Deterministic Results

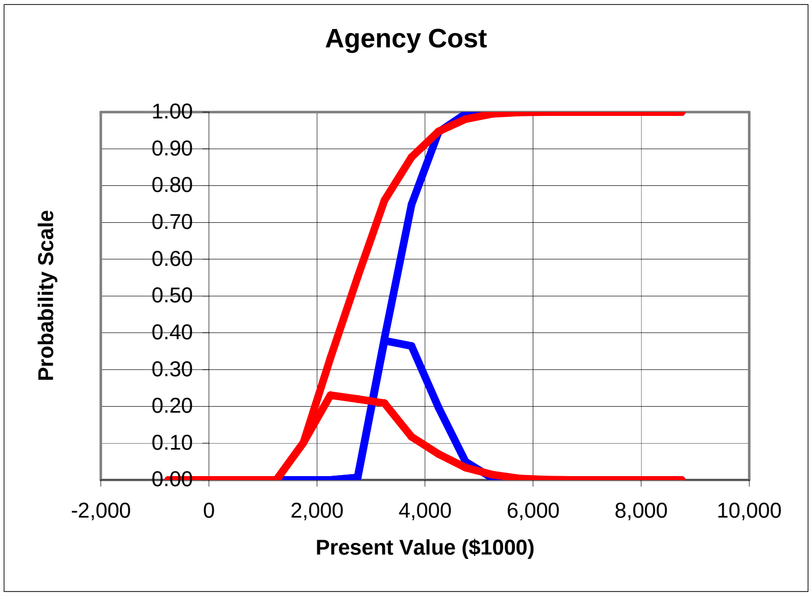
Total Cost	Alternative 1: Flexible Pavement (SMA over HMA)		Alternative 2: 10" PCCP	
	Agency Cost ($1000)	User Cost ($1000)	Agency Cost ($1000)	User Cost ($1000)
Undiscounted Sum	$4,962.22	$2,044.32	$3,424.91	$1,044.60
Present Value	$3,788.31	$1,037.67	$2,984.06	$511.38
EUAC	$171.93	$47.09	$135.43	$23.21

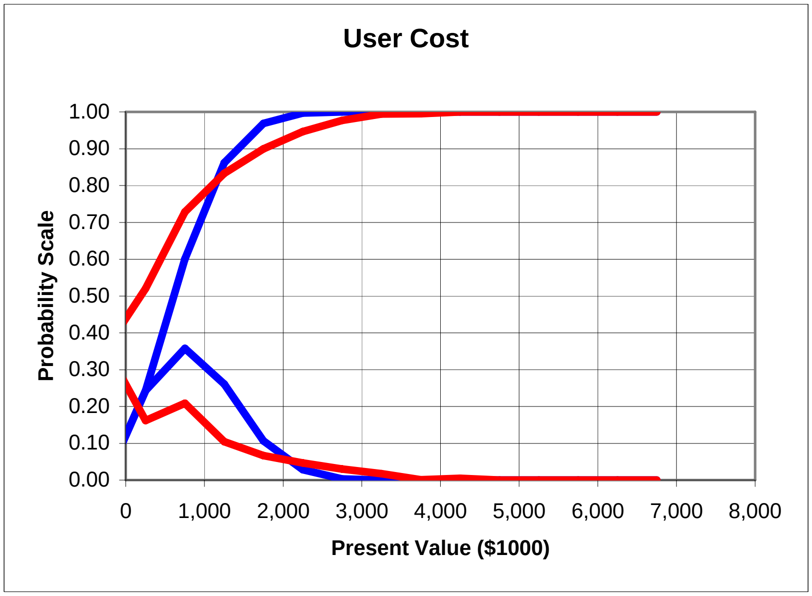




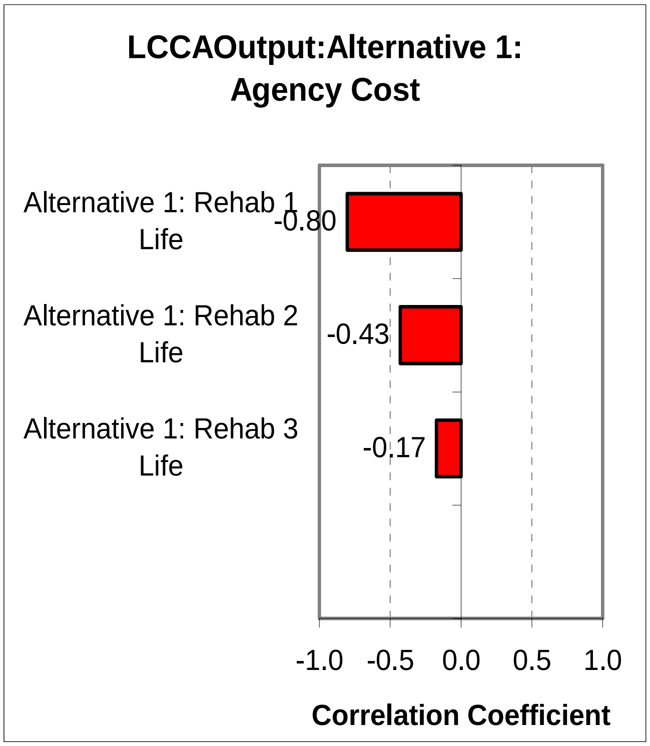
Probabilistic Results

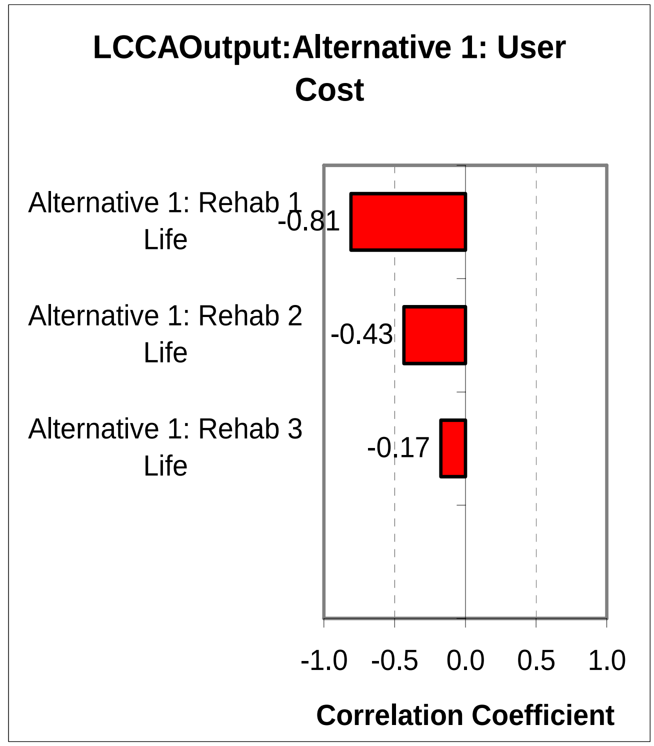
Total Cost (Present Value)	Alternative 1: Flexible Pavement (SMA over HMA)		Alternative 2: 10" PCCP	
	Agency Cost ($1000)	User Cost ($1000)	Agency Cost ($1000)	User Cost ($1000)
Mean	$3,689.49	$917.78	$2,986.45	$708.70
Standard Deviation	$466.35	$500.25	$823.80	$854.02
Minimum	$2,938.84	$226.50	$1,667.60	$0.00
Maximum	$5,311.37	$2,648.80	$6,159.23	$4,426.66

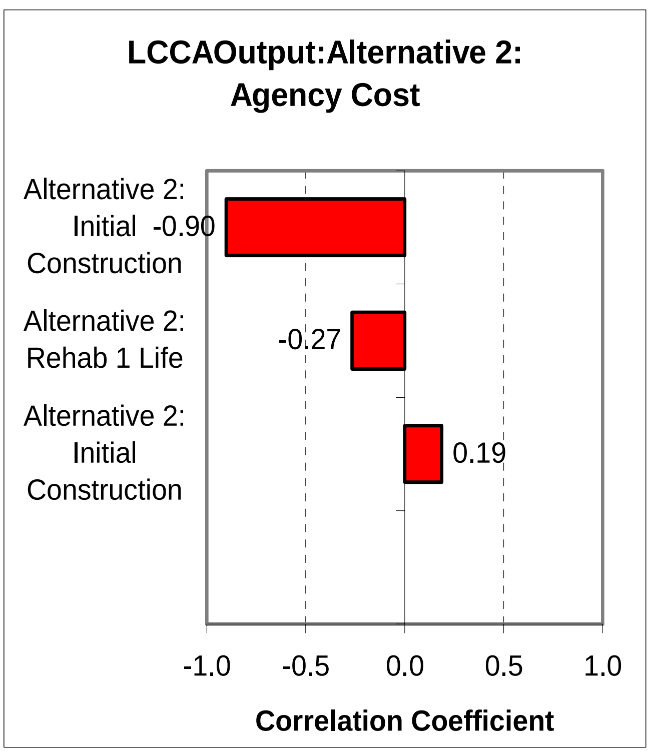


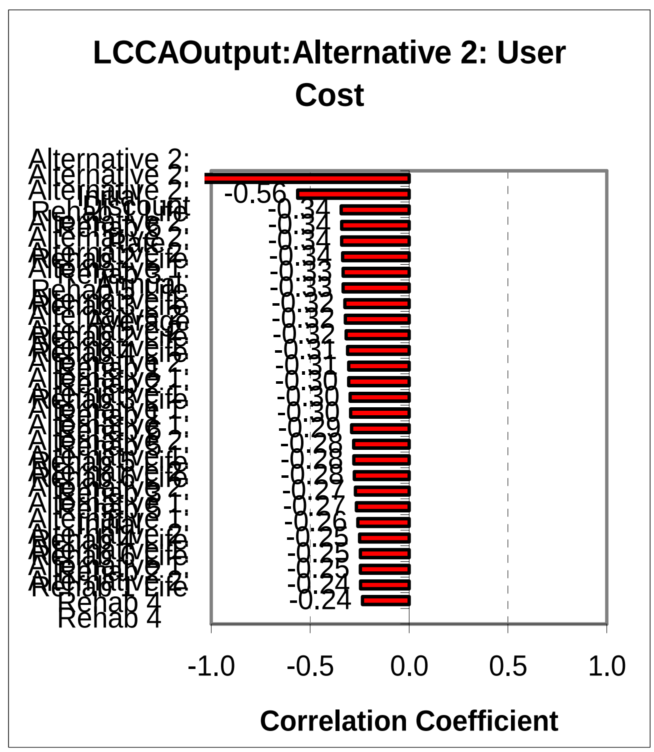


Tornado Graphs









Costs Used

SMA (Fibers) (Asphalt)	5,800 tons	
Min	$60.00	LCCA on 5/22/2008
Most Likely	$67.00	
Max	$83.00	
Min	$65.00	LCCA on 5/29/2008
Most Likely	$75.00	
Max	$85.00	
2009 PDM	$67.00	Average Value Curve for Normalized Modified Asphalt
2008 Cost Data Book		
Est	$66.00	IM 0252-386, 35,994 tons
Avg	$72.44	
Awarded	$59.98	
Est	$63.00	IM 0252-393, 18,602 tons
Avg	$70.95	
Awarded	$64.00	
EEMA 4 2008	$65.00	FY 2008 Third Quarter Averages for Regions 1,2,4, and 6
HMA Grading S 100 PG 64-22	20,374 tons	
Min	$45.00	LCCA on 5/22/2008
Most Likely	$51.00	
Max	$76.00	
Min	$55.00	LCCA on 5/29/2008
Most Likely	$65.00	
Max	$70.00	
2009 PDM	$49.00	Average Value Curve for Normalized Unmodified Asphalt
2008 Cost Data Book		
Est	$55.00	IM 0252-352 Tomah Road to Douglas, 18,530 tons
Avg	$54.73	
Awarded	$50.45	
EEMA 4 2008	$56.00	FY 2008 Third Quarter Averages for Regions 1,2,4, and 6
PCCP 10"	53,000 SY	
Min	$33.50	LCCA on 5/22/2008
Most Likely	$35.00	
Max	$40.00	
Min	$35.00	LCCA on 5/29/2008
Most Likely	$40.00	
Max	$45.00	
2009 PDM	$33.50	Average Value Curve for PCCP, 3.35 / SY-in
FY 2005 Project		
Est	$32.00	IM 2706-034, I-270 between Vasquez and I-70, 82,890 SY
Interstate Highway Construction	$34.15	
Castle Rock Construction	$33.90	
EEMA 4 2008		> 50,000 tons, price between $30 - $45 per SY

Removal of Asphalt Mat (Planing)	53,000 SY	
Min	$1.00	LCCA on 5/22/2008
Most Likely	$2.07	
Max	$3.00	
Min	$1.50	LCCA on 5/29/2008
Most Likely	$2.50	
Max	$3.00	
2008 Cost Data Book		
Est	$1.80	STA 391A-003 Kipling: 6th Ave to Colfax Ave., 42,916 SY
Avg	$1.62	
Awarded	$1.52	
Est	$1.55	NH 0404-046 Colfax Ave: Airport Rd to Tower Rd, 49,497 SY
Avg	$1.41	
Awarded	$1.45	
Slab Replacement	320 SY	
Min	$100.00	LCCA on 5/22/2008
Most Likely	$150.00	$9,900 per slab used for deterministic = $495 / SY
Max	$200.00	
Min	$300.00	LCCA on 5/29/2008
Most Likely	$350.00	$7,000 per slab used for deterministic = $495 / SY
Max	$400.00	
FY 2007 Project		
Est	$260.00	IM 0253-196, I-25 and I-225 PM Project, 1655 SY
New Design	$305.00	
Penhall	$231.00	
FY 2008 Project		
Est	$275.00	IM 0704-207, I-70 PM Project, 1840 SY
Quality Paving	$228.00	
New Design	$302.00	
Sawing and Sealing Joints	35,640 LF	(Combines Longitudinal and Transverse Joints)
Min	$1.25	LCCA on 5/22/2008
Most Likely	$1.50	
Max	$2.00	
Min	$1.50	LCCA on 5/29/2008
Most Likely	$1.75	
Max	$2.25	
FY 2007 Project		
Est	$1.40	IM 0253-196, I-25 and I-225 PM Project, 330,000 LF
New Design	$1.50	
Penhall	$1.46	
FY 2008 Project		
Est	$1.55	IM 0704-207, I-70 PM Project, 116,000 LF
Quality Paving	$1.75	
New Design	$1.78	
Grinding and Texturing Concrete	26,240 SY	
Min	$1.50	LCCA on 5/22/2008
Most Likely	$2.07	
Max	$3.00	

	Min	$2.00	LCCA on 5/29/2008					
	Most Likely	$2.50						
	Max	$3.50						
	FY 2005 Project							
	Est	$4.50	IM 0701-169, R-3 Project, 328,797 SY					
	American Civil Constructors	$3.27						
	Penhall	$3.75						