DEPARTMENT OF TRANSPORTATION
STATE OF GEORGIA

INTERDEPARTMENT CORRESPONDENCE

FILE CSSTP-0006-00(041), Cherokee County
P.I. No. 0006041
I-575 / Sixes Road Interchange

OFFICE Program Delivery

DATE November 17, 2010

FROM Bobby K. Hilliard, P.E., State Program Delivery Engineer B.H.

TO Ron Wishon, P.E., State Project Review Engineer

SUBJECT **Value Engineering Implementation Revision Request**

This office requests a Value Engineering (VE) Study Implementation Revision on the above noted project. The VE Implementation letter was issued by your office on October 16, 2007.

This office requests to revise the implementation of alternative R-1/2/4 from implement to not implement. This alternative as written in the VE study would retain the existing ramps on the project and widen them with AC pavement as necessary to facilitate the additional lanes and length.

After evaluation of a life-cycle cost analysis, which was conducted by the Office of Materials and Research (OMR), it was determined that the costs of retaining the existing pavement was roughly equal to the replacement of these ramps with full depth concrete up to the gore area given the initial and future maintenance cost involved (see table 2 in LCCA). According to the life-cycle cost analysis, the preferred alternative was determined to be a full depth Portland Cement Concrete Pavement. This pavement design was submitted to the pavement design committee and subsequently approved on August 31, 2010.

Because of this reason it is recommended to revise Alternative R-1/2/4 from implement to not implement.

Concur: Ronald E Wishon — Project Review Engineer — 11/19/10 Date

Concur: James B Beck — Director of Engineering — 11/19/10 Date

Approved: [illegible] — Chief Engineer — 11/22/10 Date

Approved: N/A Project is no longer — FHWA Division Administrator — FOS 11-17-10 LLM Date

Attachments S.H.
BKH:SH:twm

Rigid Pavement Design Analysis

Based on AASHO Interim Guide for Design of Pavement Structures

P.I. No.	0006041	Project No.	CSSTP-0006-00(041)	County	Cherokee
Description	CR 779/Sixes Road at I-575	Location	Sixes Road & Ramps	Type Section	JPCP
Begin Project	Sta. 100+00	End Project	Sta. 127+00	Project Length	0.80miles

Traffic Data

Begin Design Year	2015	Begin one way AADT, VPD	17175
End Design Year	2035	Ending one way AADT, VPD	26550
Total Truck %	9	Mean one way AADT, VPD	21862.5

Design Loading

Mean one way AADT		LDF		Volume, %			ESAL Factor	
21862.5	*	90	*	91	Vehicles	*	0.004	72
21862.5	*	90	*	8	SU	*	0.500	788
21862.5	*	90	*	1	MU	*	2.680	528
				Total Daily ESAL's				1,388
Total Design Period ESALs			=	10,132,400				

Design Data

Terminal Serviceability, (Pt)	2.5	Working Stress	450 psi	Soil Support Value	2.5
Subgrade Modulus, k	130	Subbase Modulus, k_1	225	Subbase Modulus, k_2	280
Trial Depth of PCC Pavement, inches		10.00		Calculated Stress from Equation, psi	444.4
% Understressed	1.3	% Overdesigned	1.3	Balanced Thickness	9.9

Recommended Rigid Pavement Structure

10 inches Plain Portland Cement with 1.5 inch diameter dowel bars
3 inches of 19 mm Superpave Asphaltic Concrete Interlayer
12 inches Graded Aggregate Base

Prepared By	Palliambil Geetha	Date	6/11/2010
Recommended By	Bobby H. Hilliard Office Head / District Engineer	Date	8/27/2010
Approved By	State Pavement Engineer	Date	8/31/2010

DEPARTMENT OF TRANSPORTATION

STATE OF GEORGIA

INTERDEPARTMENTAL CORRESPONDENCE

FILE CSSTP-0006-00(041) Cherokee
PI No. 0006041
Sixes Road at I-575

OFFICE Materials and Research
DATE June 24, 2010

FROM Georgene M. Geary, P. E., State Materials and Research Engineer

TO Bobby Hilliard, P. E., State Program Delivery Engineer
Attention: Tim Matthews

SUBJECT Pavement Type Selection and Pavement Design Recommendation
CR 779/Sixes Road at I-575

The Office of Materials and Research (OMR) has completed the Pavement Type Selection (PTS) and Pavement Design Recommendation for the above referenced project.

Project Descriptions and Locations

This project is the reconstruction of Sixes Road interchange over I-575. A proposed bridge over I-575 will be constructed north of the existing bridge, allowing for two through lanes heading west, and a double left turn lanes onto I-575 southbound. The proposed project will modify the existing diamond interchange with Sixes road. The analysis is performed for Ramps only. The total length of Ramps as per plans is 1.90 miles.

Pavement Design Alternatives Considered

The LCCA analyzed the costs of the project by comparing two alternatives pavement types. Alternative 'A' uses full-depth Hot Mix Asphalt (HMA) pavement, while Alternative 'B' uses full-depth Portland Cement Concrete (PCC) pavement.

Pavement Type Recommendation

The PTS concludes that Alternative B - Full Depth Portland Cement Concrete pavement is the preferred alternative, considering the economics of construction costs, maintenance costs, pavement performance and other factors over the analysis period. The alternates are listed in Table 1 below:

RECEIVED
JUN 29 2010
OFFICE OF PROGRAM DELIVERY

Table 1: Pavement Design Alternatives

Design Alternates	Profile	Surface	Intermediate (Binder)	Base	Subbase
Alternate A, (Full-Depth HMA)	Mainline	12.5 mm Superpave (1.50")	19 mm Superpave (2.00")	25 mm Superpave (8.00")	Graded Aggregate Base (12.00")
Alternate B, (Full-Depth PCC)	Mainline	PCC (10.00")	19 mm Superpave (3.00)	---	Graded Aggregate Base (12.00")

The LCCA is based on the following:

- Staging costs and durations for staging were *not* considered.
- Discount Rate of 3 %.
- The analysis periods were 40 years and 50 years. Recommendations were based on the 40-year analysis.
- The service life prior to first major maintenance activities were as follows:
    - 10 years for Asphaltic Concrete Pavements (AC)
    - 20 years for Portland Cement Concrete Pavements (PCC)
- Deterministic approach to LCCA is based on the guidelines in the following document:
    - Federal Highway Administration Publication No. FHWA-SA-98-079, "Life-Cycle Cost Analysis in Pavement Design."
- Average Plant Production rates were determined from historical project information within the Georgia Department of Transportation. They are:
    - Asphalt Concrete plant production rate of 200 tons per hour.
    - Ready Mix Concrete plant production rate of 6000 square yards per day in addition to the following:
        - A 4000 linear feet of paving for a 12-foot wide lane
        - A 2500 linear feet of paving for a 24-foot wide lane

Tables 2 and 3 summarize the total Agency Costs and User Costs respectively.

Table 2: Agency Costs

Design Alternates	Agency Costs		Total Costs
	Initial Agency Costs (A)	Future Maintenance Costs (B)	(A)+ (B)
Alternate A, Full-Depth HMA	$3,372,433	$878,874	$4,251,307
Alternate B, Full-Depth PCC	$4,011,832	$324,988	$4,336,820

Table 3: User Costs

Design Alternates	User Costs		Total Costs
	Initial User Costs (A)	Future User Costs (B)	(A) + (B)
Alternate A, Full-Depth HMA	$126,967	$78,167	$205,134
Alternate B, Full-Depth PCC	$190,451	$23,952	$214,402

Table 4 summarizes the Total Scores and Ranking from the Decision Matrix. The scores were determined from the LCCA using a 40-year Analysis Period.

Table 4: Total Score

Design Alternates	Rank	Total Score
Alternate B, Full-Depth PCC	1	89.0
Alternate A, Full-Depth HMA	2	79.5

The detailed analysis is attached. If additional information is needed, please contact A. J. Jubran at (404) 363-7582 or Palliambil Geetha at (404) 363-7620.

GMG: JTR: AJJ: PRG

Attachments

1. Report Summary
2. Flexible Pavement Design
3. Rigid Pavement Design
4. Decision Matrix
5. Cost Itemization

Copy: file
Lisa Myers, VE Coordinator, Atlanta

LCCA SUMMARY REPORT

CSSTP-0006-00(041)
0006041
CR 779/Sixes Road at I-575
Cherokee County, Georgia

I. PROJECT AGENCY COSTS

Values in this section represent Agency Costs only. All values are calculated on per mile per both directions basis. Below are the Total Present Value Costs for a 50-year Analysis Period and a 40-year Analysis Period for each alternative. The values represent costs per mile.

Net Present Value / Total Present Value Costs:

Net Present Value (NPV) is the discounted monetary value of Present Value benefits minus Present Value costs ($PV_{benefits} - PV_{costs}$). Because the benefits of keeping the roadway above some pre-established terminal service ability level are the same for all design alternatives, the benefits component of above equation is negated thus the analysis is based solely on the costs.

Below are the Total Present Value Costs for a 40-year Analysis Period for each alternative. A 50-year Analysis Period is also shown for purpose of comparison. The values represent costs per mile.

	50-Year Analysis Period	40-Year Analysis Period
ALTERNATIVE A-HMA Full Depth Mainline	$2,320,477	$2,237,530
ALTERNATIVE B PCC Full Depth Mainline	$2,342,017	$2,282,537

Annualized Costs:

Annualized Costs represents the Net Present Value (NPV) of all discounted cost and benefits of an alternative as if they were to occur uniformly throughout the analysis period.

Below are the Annualized Costs for a 40-year Analysis Period for each alternative. A 50-year Analysis Period is also shown for purpose of comparison. The values represent costs per mile.

	50-Year Analysis Period	40-Year Analysis Period
ALTERNATIVE A-HMA Full Depth Mainline	$90,186	$96,801
ALTERNATIVE B-PCC Full Depth Mainline	$91,024	$98,748

Total Agency Costs Calculations:

Total Agency Costs were based on the quantities of materials, labor and time required for Initial Construction and Maintenance.

Below are the Total Agency Costs per alternative per construction event. The costs are shown in nominal US dollars. The nominal costs are discounted at 3 %.

	ALTERNATIVE A-HMA Full Depth Mainline	ALTERNATIVE B-PCC Full Depth Mainline								
Year 2015	$3,372,433	$4,011,832								
Year 2016										
Year 2017										
Year 2018										
Year 2019										
Year 2020										
Year 2021										
Year 2022										
Year 2023										
Year 2024										
Year 2025	$382,483									
Year 2026										
Year 2027										
Year 2028										
Year 2029										
Year 2030										
Year 2031										
Year 2032										
Year 2033										
Year 2034										
Year 2035	$284,614	$324,988								
Year 2036										
Year 2037										
Year 2038										
Year 2039										
Year 2040										
Year 2041										
Year 2042										
Year 2043										
Year 2044										
Year 2045	$211,777									
Year 2046										
Year 2047										
Year 2048										
Year 2049										
Year 2050										
Year 2051										
Year 2052										
Year 2053										
Year 2054										
Year 2055										
A (Initial)	$3,372,433	$4,011,832								
B (Maint)	$878,874	$324,988					$0	$0	$0	$0

Initial Construction Costs:

The initial construction costs and the maintenance costs were determined by grouping calculated item costs appropriately. The GDOT Item Mean Summary and current market prices from the Office of Engineering Services were the basis for the calculations.

Initial costs were calculated based primarily on pavement designs but other items such as Bituminous Tack Coat and Rumble Strips were also considered. Listed below are the alternatives with their corresponding initial costs. The costs are not discounted because they are based on the most current market prices and are associated with initial construction.

	Cost per mile	Total Cost
ALTERNATIVE A-HMA Full Depth Mainline	$1,774,965	$3,372,433
ALTERNATIVE B-PCC Full Depth Mainline	$2,111,490	$4,011,832

Maintenance Costs:

For Full Depth Reconstruction of JPC pavements, an initial service life of 20 years was used with maintenance assumed to occur in 20 year intervals after its initial service life. For pavements overlaid with JPC, an initial service life of 16 years was used with maintenance assumed to occur in 16 year intervals after its initial service life. For Full Depth Reconstruction of HMA pavements, an initial service life of 10 years was used with maintenance assumed to occur in 10 year intervals after its initial service life. For pavements overlaid with HMA, an initial service life of 8 years was used with maintenance assumed to occur in 8 year intervals after its initial service life.

Listed below are the net present maintenance costs for a 40-year analysis period. A 50-year analysis period is also shown for purpose of comparison. These costs were discounted at the rate of 3 %. The costs are per mile per both directions.

	50-Year Analysis Period	40-Year Analysis Period
ALTERNATIVE A-HMA Full Depth Mainline	$545,512	$462,565
ALTERNATIVE B-PCC Full Depth Mainline	$265,760	$171,046

Salvage Value:

Salvage Value represents the value of an investment alternative at the end of the analysis period. The two fundamental components associated with Salvage Value are Residual Value and Serviceable Life Value.

Residual Value refers to the net value from recycling the pavement. This component is negligible effect on LCCA results when discounted over a 40-year or a 50-year analysis period. Serviceable Life Value refers to the value based on the remaining life in a pavement alternative at the end of the

Below are the Salvage Values for a 40-year analysis period. A 50-year analysis period is also shown for purpose of comparison. The values are costs per mile and are not discounted.

	50-Year Analysis Period	40-Year Analysis Period
ALTERNATIVE A-HMA Full Depth Mainline	$0	$0
ALTERNATIVE B-PCC Full Depth Mainline	$154,458	$0

II. PROJECT USER COSTS

User Costs are the delay costs and vehicle operating costs (VOC) incurred by users of a roadway resulting from construction, maintenance or rehabilitation. They are directly related to the traffic demand, roadway capacity and timing of work periods.

Net Present Value / Total Present Value User Costs:

Below are the Total Present Value User Costs for a 40-year Analysis Period for each alternative. A 50-year Analysis Period is also shown for purpose of comparison. These values represent costs per mile.

	50-Year Analysis Period	40-Year Analysis Period
ALTERNATIVE A-HMA Full Depth Mainline	$175,169	$107,965
ALTERNATIVE B-PCC Full Depth Mainline	$180,047	$112,843

Annualized User Costs:

Below are the Annualized User Costs for a 40-year Analysis Period for each alternative. A 50-year Analysis Period is also shown for purpose of comparison. These values represent costs per mile.

	50-Year Analysis Period	40-Year Analysis Period
ALTERNATIVE A-HMA Full Depth Mainline	$6,808	$4,671
ALTERNATIVE B-PCC Full Depth Mainline	$6,998	$4,882

Total User Costs Calculations:

Total User Costs were based on the Daily User Costswhich were estimated from analysis of the Annual Average Daily Traffic (AADT). Other factors in determining Total User Costs are Production Rates, Quantities and Project Duration.

Total User Costs were calculated by determining the number of work days it would take to perform a particular construction event. The number of days was determined using Production Rates for the particular pavement type of each alternative. The number of days was then multiplied by the Daily User Costs to get the Total User Cost.

Below are the Total User Costs per alternative per construction event. The costs are shown in nominal US dollars. The nominal costs are discounted at 3 %.

	ALTERNATIVE A-HMA Full Depth Mainline	ALTERNATIVE B-PCC Full Depth Mainline								
Year 2015	$126,967	$190,451								
Year 2016										
Year 2017										
Year 2018										
Year 2019										
Year 2020										
Year 2021										
Year 2022										
Year 2023										
Year 2024										
Year 2025	$22,509									
Year 2026										
Year 2027										
Year 2028										
Year 2029										
Year 2030										
Year 2031										
Year 2032										
Year 2033										
Year 2034										
Year 2035	$23,952	$23,952								
Year 2036										
Year 2037										
Year 2038										
Year 2039										
Year 2040										
Year 2041										
Year 2042										
Year 2043										
Year 2044										
Year 2045	$31,706									
Year 2046										
Year 2047										
Year 2048										
Year 2049										
Year 2050										
Year 2051										
Year 2052										
Year 2053										
Year 2054										
Year 2055										
A (Initial)	$126,967	$190,451								
B (Maint)	$78,167	$23,952					$0	$0	$0	$0

User Cost Components:

There are seven (7) conditions that make up the daily user costs for a particular construction event.

I. DELAY COST (Speed reduced due to Speed Limit *inside* Work Zone)
II. DELAY COST (Speed Change due to Conditions/Speed Limit just prior and just after Work Zone)*
III. VEHICLE OPERATING COST (Speed Change due to Conditions/Speed Limit just prior and just after Work Zo
IV. DELAY COST (Stopping due to Queue)
V. VEHICLE OPERATING COST (Stopping due to Queue)
VI. DELAY COST (Idle – Speed reduced due to Queue)
VII. VEHICLE OPERATING COST (Idle – Speed reduced due to Queue)

* *NOTE: User Components II and III occur before and after Work Zone while User Component I occurs inside the physical Work Zone.*

Daily User Costs Calculations:

Daily User Costs were broken down into seven (7) components. Calculations were computed by using Delay Cost Rates and Vehicle Operating Cost Rates.

Below are the Daily User Costs calculations for anticipated construction years. The Daily User Costs shown below are in constant US dollars.

Year 2015 *(initial construction)*	$5,569 per mile
Year 2025 *(rehabilitation)*	$7,961 per mile
Year 2035 *(rehabilitation)*	$11,384 per mile
Year 2045 *(rehabilitation)*	$20,252 per mile

III. CONSTRUCTION

Production Rates:

Production rates were determined from historical information from various projects within the Georgia Department of Transportation. The average of the production rates from statewide projects were calculated and are as follows. For Concrete, the production rate was determined to be approximately 6,000 square yards per day (250 square yards per hour). This figure was based on an average of 4,000 linear feet of pavement for a 12 foot wide pavement being placed in a day. For Asphalt, the production rate was determined to be approximately 200 tons per hour.

Quantities:

Quantities were calculated using the pavement designs for each alternative. The following table illustrates the amount of Asphalt and Concrete for each alternative.

		Asphalt (tons)				Concrete (square yards)			
	Totals	Travel lanes	Inside Shoulders	Outside Shoulders	Overlaid Sections	Travel lanes	Inside Shoulders	Outside Shoulders	Overlaid Sections
ALTERNATIVE A : Full Depth HMA -	Asphalt 33,841	33,841							
	Concrete 0								
ALTERNATIVE B : Full Depth PCC -	Asphalt 8,828	8,828				53,504			
	Concrete 53,504								
		0							
		0							
		0							
		0							
		0							
		0							
		0							
		0							

Project Durations

Initial Construction:

Based upon the calculated quantities and their corresponding production rates, the duration for initial construction was estimated. The following list illustrates the duration of initial construction for each alternative.

ALTERNATIVE A-HMA Full Depth Mainline	12 days
ALTERNATIVE B-PCC Full Depth Mainline	18 days

Rehabilitations:

The duration for rehabilitations was based upon the calculated duration for initial construction which was established from the total construction area and production rates. The duration of rehabilitations was also based on the percentage of full depth replacement which was established from total construction area and the pavement types. Therefore, it was assumed that the duration of rehabilitation would minimally take the percentage of full depth replacement times the total duration of initial construction. In essence, the duration for rehabilitations were calculated by doubling the percentage of full depth replacement, in order to take in account for pavement removal and other activities, and then multiplying that percentage by the calculated duration of initial construction.

Rehabilitation events for Asphalt included Full Depth Asphalt Patching, Milling and Overlaying. The duration for asphalt pavements was assumed to be 10% of the duration for its initial construction (5% Full Depth Asphalt Patching + 5% for Milling and Overlaying).

Rehabilitation events for JPC pavements included Full Depth Slab Replacement, Grinding, and Resealing Joints and Cracks. The duration for JPC pavements was assumed to be 10% of the duration for its initial construction (5% for the Full Depth Slab Replacement + 5% for the Grinding, Resealing and Removal)

Rehabilitation events for CRC pavements included Punchout Repair and Grinding. The duration for CRC pavements was assumed to be 5% of the duration for its initial construction (2.5% for Punchout Repair + 2.5 % for Grinding and Removal).

The following list illustrates the duration of rehabilitations for each alternative.

ALTERNATIVE A-HMA Full Depth Mainline	2 days
ALTERNATIVE B-PCC Full Depth Mainline	2 days

AADT Calculations:

Annual Average Daily Traffic (AADT) calculations for anticipated construction years are as follows:

Year 2015	34,350
Year 2025	42,708
Year 2035	53,100
Year 2045	66,020

Calculations for AADT and Daily User Costs were based on the following assumptions.

- Traffic Growth Rate
  - 2.20% for Passenger Cars
  - 2.20% for Single-Unit and Multi-Unit Trucks
- 24 hour Truck Percentages were broken down into
  - 8.00% of 24 hour Truck Percentage is Single-Unit Trucks
  - 1.00% of 24 hour Truck Percentage is Multi-Unit Trucks
- MicroBENCOST Default Directional Hourly Distribution for Rural roadways used for traffic analysis
- Speed Limit ...55 mph (normal), 40 mph (work zone)
- Queue Dissipation Rate – 1,818 vplph
- Length of work zone is two (2) miles.
- Work Period is 15 hours per day.

IV. PAVEMENT SELECTION

Pavement Selection is a process of analyzing pavement alternatives and of determining the Pavement Alternative which best addresses the requirements of a roadway construction project. Many factors are to be considered in the Pavement Selection process. These factors are called *Decision Factors* While any pavement alternative may be an acceptable solution to the roadway construction project, the Pavement Selection process provides validity to the selection of a particular pavement alternative.

Decision Matrix:

As an aid to the pavement selection process, the *Decision Matrix* was adapted by the Pavement Management Branch. The *Decision Matrix* is based upon the aforementioned Decision Factors.

Each Decision Factor is given a weight based upon its relative importance to the project. This weight is called *Decision Worth*. For every Pavement Alternative, a division is created per Decision Factor called the *Matrix Element*. The Matrix Element can be viewed as a Pavement Alternative per Decision Factor. Each Matrix Element is given a value called the *Element Value*. The Element Value is based on LCCA calculations or the experiences of OMR. From the Element Value, a ratio is calculated called the *Spread Factor*. The *Element Score* is then calculated. The Element Score is the product of the Decision Worth and the Spread Factor. The *Total Score* for an alternative is the sum of its Element Scores.

Below are the Total Scores and Rankings from the Decision Matrix. The scores were determined for the LCCA with 40-year Analysis Period.

	RANK	TOTAL SCORE
ALTERNATIVE B-PCC Full Depth Mainline	1	89.0
ALTERNATIVE A-HMA Full Depth Mainline	2	79.5

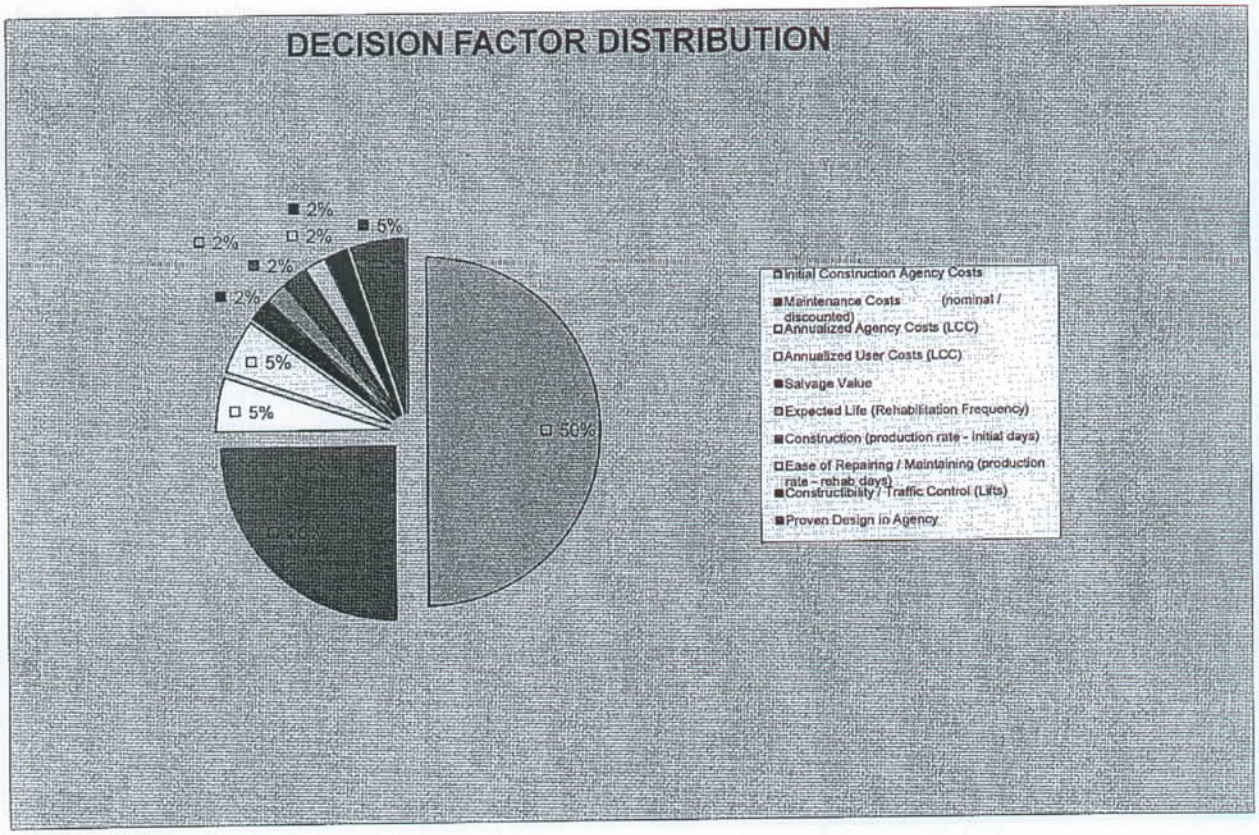
Decision Factors:

Decision Factors play an important role in the Pavement Selection process. They may have varying importance depending on a specific project.

Below are the Decision Factors and their relative importance in this project.

Decision Factors	Relative Importance
· Initial Construction Agency Costs	50%
· Maintenance Costs (nominal / discounted)	25%
· Annualized Agency Costs (LCC)	5%
· Annualized User Costs (LCC)	5%
· Salvage Value	2%
· Expected Life (Rehabilitation Frequency)	2%
· Construction (production rate - initial days)	2%
· Ease of Repairing / Maintaining (production rate - re	2%
· Constructibility / Traffic Control (Lifts)	2%
· Proven Design in Agency	5%

*The Decision Factor, Proven Design in Agency, is not calculated from the general LCCA computations. Rather, it is calculated from the experiences and observations of OMR for the pavement type associated with the particular pavement alternative. Those experiences take into account the past performance of the pavement type, the frequency of use of the pavement type, and the functional class of the roadway to the pavement type.



Element Values:

The values of each Pavement Alternative per Decision Factor are determined based upon calculations from the LCCA. The exception is the value of the Decision Factor for Proven Design in Agency. The value for Proven Design in Agency is more subjective. It is determined by the experiences and observations of OMR with the pavement type associated with the pavement alternative. These values per Pavement Alternative per Decision Factor are called *Element Values*

Below are the *Element Values* used in the Decision Matrix. These *Element Values* represent the 40-year Analysis Period LCCA

	Initial Construction Agency Costs	Maintenance Costs (nominal / discounted)	Annualized Agency Costs (LCC)	Annualized User Costs (LCC)	Salvage Value	Expected Life (Rehabilitation Frequency)	Construction (production rate - initial days)	Ease of Repairing / Maintaining (production rate - rehab days)	Constructibility / Traffic Control (Lifts)	Proven Design in Agency
ALTERNATIVE A-HMA Full Depth Mainline	1,774,965	462,565	96,801	4,671	0	10	12	6	10	1
ALTERNATIVE B-PCC Full Depth Mainline	2,111,490	171,046	98,748	4,882	0	20	18	2	8	1

The Spread Factor:

The *Spread Factor* is a ratio that measures distributional differences in Element Values. The *Spread Factor* ranges from 0.00 to 1.00. The *Spread Factor* is based on the optimum value for each Decision Factor.

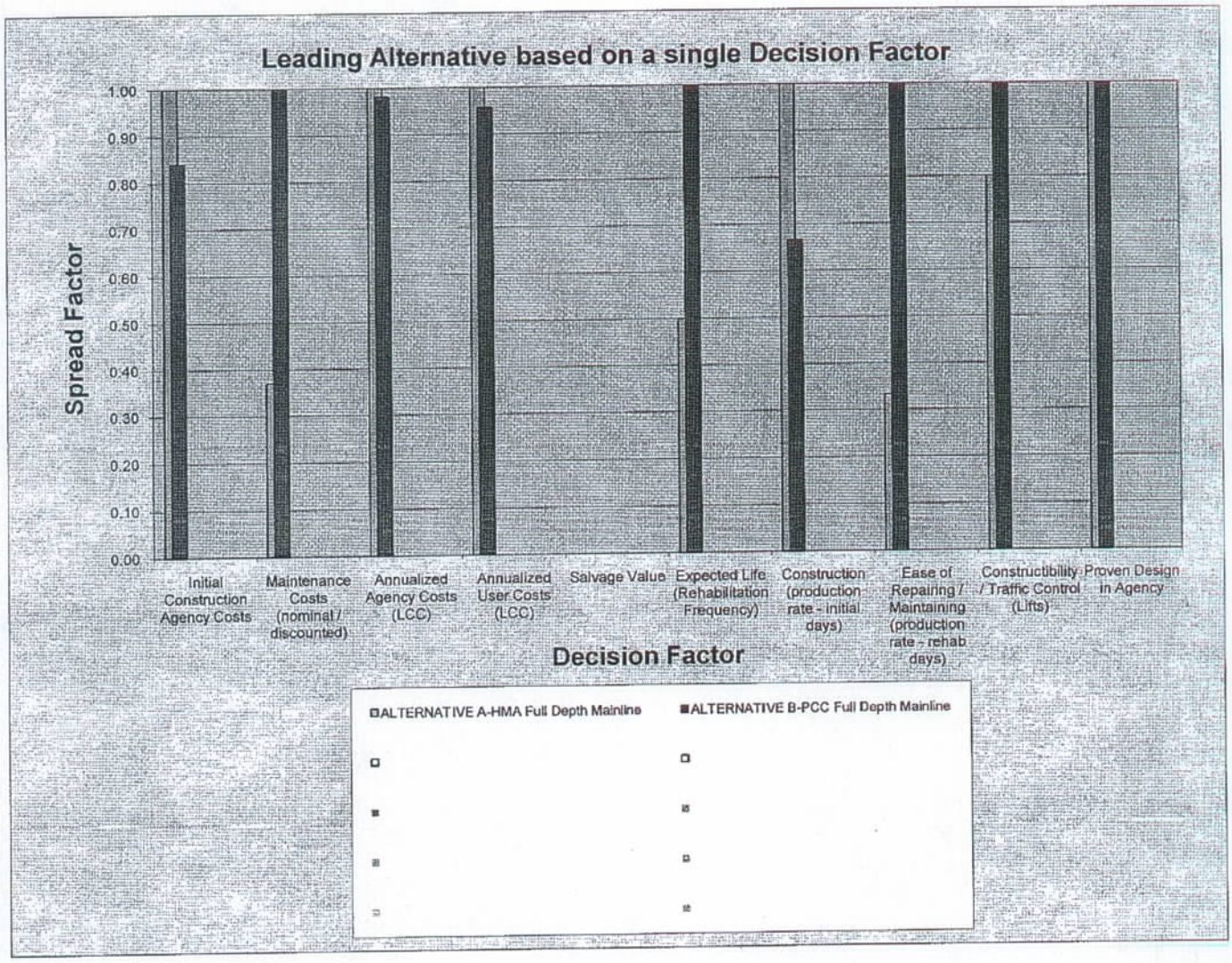
The optimum value can be either the minimum or maximum value depending on the Decision Factor. As an example, for a Decision Factor illustrating cost, the optimum value of the Decision Factor will be the minimum cost value. Furthermore, for a Decision Factor illustrating pavement life, the optimum value of the Decision Factor will be the maximum life value.

The *Spread Factor* for each Element Value is calculated as a ratio. This ratio is based upon the optimum value per Decision Factor. Thus, the pavement alternative with the optimum value will have the *Spread Factor* of 1.00. All other pavement alternatives will have a *Spread Factor* which will be proportioned based on its particular value to the optimum value and will be lower than 1.00.

Below are the Spread Factors used in the Decision Matrix. These Spread Factors are based on calculations from the 40-year Analysis Period LCCA.

	Initial Construction Agency Costs	Maintenance Costs (nominal / discounted)	Annualized Agency Costs (LCC)	Annualized User Costs (LCC)	Salvage Value	Expected Life (Rehabilitation Frequency)	Construction (production rate - initial days)	Ease of Repairing / Maintaining (production rate - rehab days)	Constructibility / Traffic Control (Lifts)	Proven Design in Agency
ALTERNATIVE A-HMA Full Depth Mainline	1.00	0.37	1.00	1.00	0.00	0.50	1.00	0.33	0.80	1.00
ALTERNATIVE B-PCC Full Depth Mainline	0.84	1.00	0.98	0.96	0.00	1.00	0.67	1.00	1.00	1.00

The figure below represents a graphical representation of the advantages / disadvantages that each alternative has over each other per decision factor.



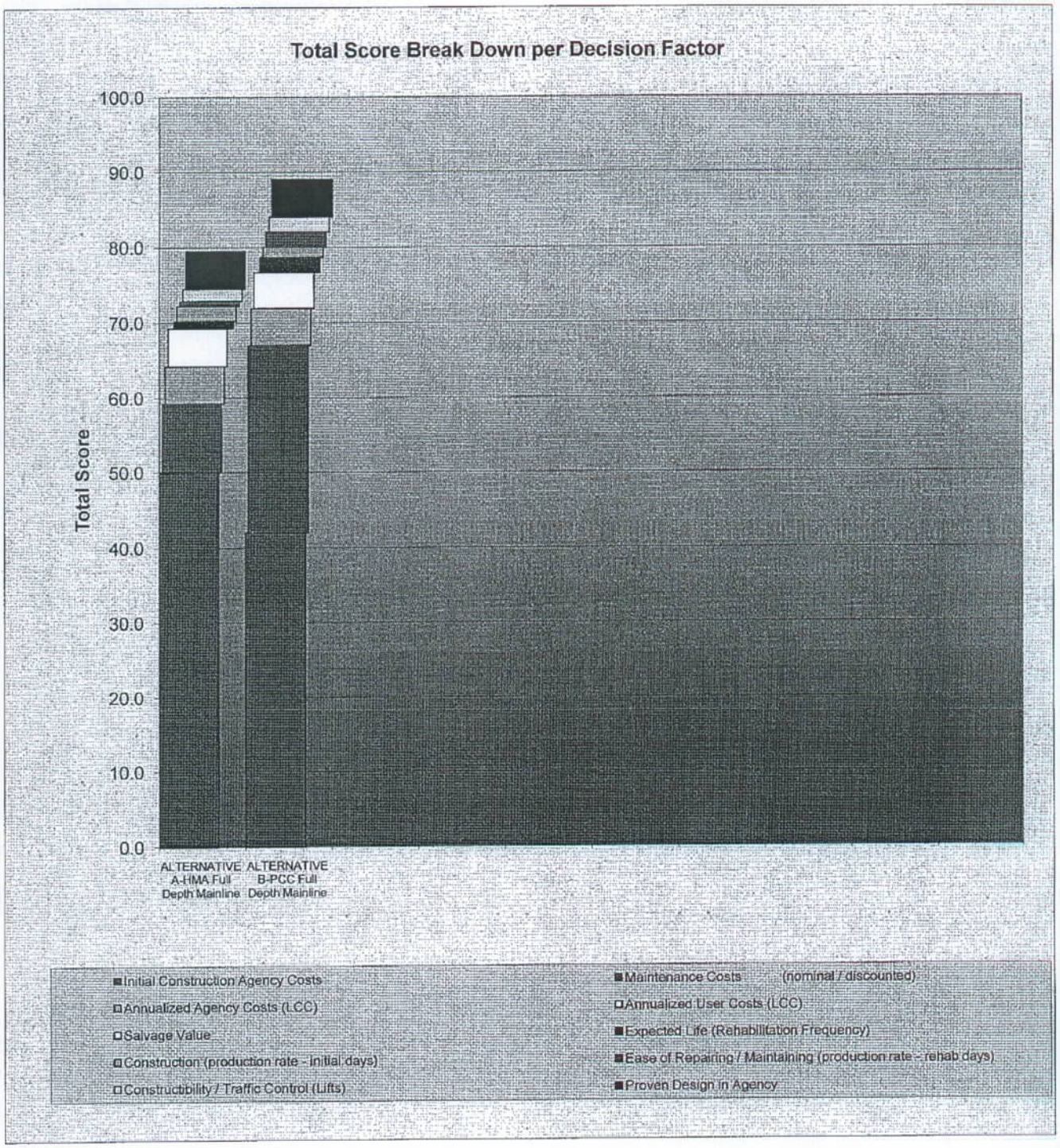
Element Score:

Element Score is the product of Decision Worth and the Spread Factor.

Below are the Element Scores used in the Decision Matrix. These Element Scores are based on calculations from the 40-year Analysis Period LCCA.

	Initial Construction Agency Costs	Maintenance Costs (nominal / discounted)	Annualized Agency Costs (LCC)	Annualized User Costs (LCC)	Salvage Value	Expected Life (Rehabilitation Frequency)	Construction (production rate - initial days)	Cost of Repairing / Maintaining (production rate - rehab days)	Constructibility / Traffic Control (Lifts)	Proven Design in Agency
ALTERNATIVE A-HMA Full Depth Mainline	50.0	9.2	5.0	5.0	0.0	1.0	2.0	0.7	1.6	5.0
ALTERNATIVE B-PCC Full Depth Mainline	42.0	25.0	4.9	4.8	0.0	2.0	1.3	2.0	2.0	5.0

The figure below represents a graphical representation of the total score of each alternative. Furthermore, the figure illustrates the contribution of each decision factor to the total score of each alternative.



V. APPENDICES

APPENDIX A: Pavement Designs - Travel Lanes:

Pavement Designs were created for each alternative analyzed for life cycle costs. Below is each alternative with their corresponding pavement design for the travel lanes.

	FULL DEPTH SECTIONS	OVERLAID SECTIONS
ALTERNATIVE A : Full Depth HMA -- 24 feet - Full Depth width 0 feet - Overlaid width	--- 1.5 inches --- 12.5 mm Superpave 2 inches --- 19 mm Superpave 8 inches --- 25 mm Superpave 12 inches --- Graded Aggregate Base	--- --- --- ---
ALTERNATIVE B : Full Depth PCC -- 24 feet - Full Depth width 0 feet - Overlaid width	10 inches --- PCC 3 inches --- 19 mm Superpave 12 inches --- Graded Aggregate Base --- ---	--- --- --- ---

APPENDIX B: Pavement Designs - Shoulders:

Pavement Designs were created for each alternative analyzed for life cycle costs. Below is each alternative with their corresponding pavement design for the inside and outside shoulders.

	INSIDE SHOULDERS	OUTSIDE SHOULDERS
ALTERNATIVE A : Full Depth HMA --	--- none --- inches --- Graded Aggregate Base --- inches --- <none>	--- none --- inches --- Graded Aggregate Base --- inches --- <none>
ALTERNATIVE B : Full Depth PCC --	--- none --- inches --- Graded Aggregate Base --- ---	--- none --- inches --- Graded Aggregate Base --- ---

DECISION MATRIX

	DECISION FACTOR										Total Score	Rank
	Initial Construction Agency Costs	Maintenance Costs (nominal / discounted)	Annualized Agency Costs (LCC)	Annualized User Costs (LCC)	Salvage Value	Expected Life (Rehabilitation Frequency)	Construction (production rate - initial days)	Ease of Repairing / Maintaining (production rate - rehab days)	Constructibility / Traffic Control (Lifts)	Proven Design In Agency		
Relative Importance	50%	25%	5%	5%	2%	2%	2%	2%	2%	5%		
ALTERNATIVE A-HMA Full Depth Mainline	1.00 50.0	0.37 9.2	1.00 5.0	1.00 5.0	0.00 0.0	0.50 1.0	1.00 2.0	0.33 0.7	0.80 1.6	1.00 5.0	79.5	2
ALTERNATIVE B-PCC Full Depth Mainline	0.84 42.0	1.00 25.0	0.98 4.9	0.96 4.8	0.00 0.0	1.00 2.0	0.67 1.3	1.00 2.0	1.00 2.0	1.00 5.0	89.0	1

FLEXIBLE PAVEMENT DESIGN ANALYSIS

Project: CSSTP-0006-00(041) **County:** Cherokee
P.I. no.: 0006041
Description: CR 779/Sixes Road at I-575

Traffic Data (NOTE: AADTs are one-way)
24-hour Truck Percentage: 9.00%
AADT initial year of design period: 17,175 vpd (2015)
AADT final year of design period: 26,550 vpd (2035)
Mean AADT (one-way): 21,862 vpd

Design Loading

Mean AADT		LDF		Trucks		18-K ESAL		Total Daily Loads
21,862	*	0.90	*	0.090	*	0.51	=	904

Total predicted design period loading = 904 * 20 * 365 = 6,599,200

Design Data
Terminal Serviceability Index: 2.50
Soil Support: 2.50
Regional Factor: 2.00

PROPOSED FLEXIBLE PAVEMENT STRUCTURE

Material	Thickness Inches	Thickness (mm)	Structural Coefficient	Structural Value
12.5 mm Superpave	1.50	(38)	0.44	0.66
19 mm Superpave	2.00	(51)	0.44	0.88
25 mm Superpave	1.00	(25)	0.44	0.44
	7.00	(178)	0.30	2.10
Graded Aggregate Base	12.00	(305)	0.16	1.92

Required SN = 6.08 Proposed SN = 6.00

>>> Proposed pavement is 1.3% Underdesigned <<<

Remarks: Full-depth for Ramps

Prepared by Palliambil June 23, 2010
Pavement Design Engineer Date

Recommended _____
Office Head Date

Approved _____
State Pavement Engineer Date

Rigid Pavement Design Analysis

Based on AASHO Interim Guide for Design of Pavement Structures

P.I. No.	0006041	Project No.	CSSTP-0006-00(041)	County	Cherokee
Description	CR 779/Sixes Road at I-575	Location	Sixes Road & Ramps	Type Section	JPCP
Begin Project	Sta. 100+00	End Project	Sta. 127+00	Project Length	0.80miles

Traffic Data

Begin Design Year	2015
End Design Year	2035
Total Truck %	9

Begin one way AADT, VPD	17175
Ending one way AADT, VPD	26550
Mean one way AADT, VPD	21862.5

Design Loading

Mean one way AADT		LDF		Volume, %			ESAL Factor	
21862.5	*	90	*	91	Vehicles	*	0.004	72
21862.5	*	90	*	8	SU	*	0.500	788
21862.5	*	90	*	1	MU	*	2.680	528
				Total Daily ESAL's				1,388
Total Design Period ESALs			=	10,132,400				

Design Data

Terminal Serviceability, (Pt)	2.5	Working Stress	450 psi	Soil Support Value	2.5
Subgrade Modulus, k	130	Subbase Modulus, k_1	225	Subbase Modulus, k_2	280
Trial Depth of PCC Pavement, inches		10.00	Calculated Stress from Equation, psi		444.4
% Understressed	1.3	% Overdesigned	1.3	Balanced Thickness	9.9

Recommended Rigid Pavement Structure

10 inches Plain Portland Cement with 1.5 inch diameter dowel bars

3 inches of 19 mm Superpave Asphaltic Concrete Interlayer

12 inches Graded Aggregate Base

Prepared By Palliambil Geetha Date 6/11/2010

Recommended By _____ Date _____

Office Head / District Engineer

Approved By _____ Date _____

State Pavement Engineer

ALTERNATIVE A

Mainline Pavement Type HMA
Mainline Pavement Method Full Depth
More Description

ROADWAY PAVEMENT

TRAVEL LANES - New Construction for Widening	Pay Item No	inches	Quantity (per mi per direction)	Quantity (per mi)	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)
12.5 mm Superpave	402-3130	1.50	1,161.60	2,323.20	TN	$66.57	$ 154,655.42	$ 293,845.31
19 mm Superpave	402-3190	2.00	1,548.80	3,097.60	TN	$64.86	$ 200,910.34	$ 381,729.64
25 mm Superpave	402-3121	8.00	6,195.20	12,390.40	TN	$62.90	$ 779,356.16	$ 1,480,776.70
Graded Aggregate Base	310-5120	12.00	14,080.00	28,160.00	SY	$22.28	$ 627,404.80	$ 1,192,069.12
		23.5					$ 1,762,326.72	$ 3,348,420.77

TRAVEL LANES - New Construction for Exceptions	Pay Item No	inches	Quantity (per mi per direction)	Quantity (per mi)	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)

TRAVEL LANES - Overlay Construction	Pay Item No	inches	Quantity (per mi per direction)	Quantity (per mi)	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)

INSIDE SHOULDER - Full Depth none	Pay Item No	inches	Quantity (per mi per direction)	Quantity (per mi)	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)
none	#N/A							
Graded Aggregate Base	#N/A							
<none>	#N/A							

OUTSIDE SHOULDER - Full Depth none	Pay Item No	inches	Quantity (per mi per direction)	Quantity (per mi)	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)
none	#N/A							
Graded Aggregate Base	#N/A							
<none>	#N/A							

OTHER & PREPARATORY WORK

		Include (y/n)	Quantity (per direction)	Quantity	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)
Traffic Control	150-1010							
Staging								
Roadway Bridges								
Raise Bridge								
Roadwork with Raise Bridge								
New Ramp Construction								
Grading	210-0200							
Waterproofing Joints & Cracks	445-0500							
Remove Roadway Slab	609-1000							
Remove Roadway Slab (Exceptions)	609-1000							
Remove Existing Concrete prior to Overlay	609-1000							
Full Depth Slab Replacement prior to Overlay	452-1000							
Mill Asphalt								
Mill Asphalt (Exceptions)								
Joint Reinforcement Fabric								
Bitum Tack Coat (new pavement)	413-1000	y	3,097.60	6,195.20	GL	$2.04	$ 12,638.21	$ 24,012.60
Bitum Tack Coat (exceptions)	413-1000	y						
Bitum Tack Coat (overlay section)	413-1000	y						
Vegetation Removal								
Barrier Wall								
Striping / Signage								
White Markings-Not Included								
Longitudinal Drainage								
Misc: (Guardrail, Soundwalls, EC, etc)								
							$ 12,638.21	$ 24,012.60
INITIAL COSTS (Roadway, Other & Preparatoy Work)							**$ 1,774,964.93**	**$ 3,372,433.36**

ALTERNATIVE A

REHABILITATION YEAR 10

TRAVEL LANES			Quantity (per lane per mi per direction)	Quantity	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)
Mill Asphalt	432-0206	1 1/2	7,040.00	28,160.00	SY	$2.10	$ 59,136.00	$ 112,358.40
							$ 59,136.00	$ 112,358.40
Overlay Design								
12.5 mm Superpave	402-3130	1.50	580.80	2,323.20	TN	$66.57	$ 154,655.42	$ 293,845.31
19 mm Superpave	402-3190				TN	$64.86		
							$ 154,655.42	$ 293,845.31
Full Depth Asphalt Patching					CY	$450.00		
12.5 mm Superpave	402-3130	1.50	29.04	116.16	TN	$66.57	$ 7,732.77	$ 14,692.27
19 mm Superpave	402-3190	2.00	38.72	154.88	TN	$64.86	$ 10,045.52	$ 19,086.48
25 mm Superpave	402-3121	8.00	154.88	619.52	TN	$62.90	$ 38,967.81	$ 74,038.84
	Percentage 5%						$ 56,746.10	$ 107,817.58
INSIDE SHOULDER – none								
Grind Concrete	431-1000	1 1/2			SY	$2.29		
Full Depth Slab Replacement none	452-1000				CY	$450.00		
	Percentage 5%							
OUTSIDE SHOULDER – none								
Grind Concrete	431-1000	1 1/2			SY	$2.29		
Full Depth Slab Replacement none	452-1000				CY	$450.00		
	Percentage 5%							

OTHER REHABILITATION COSTS

	Quantity (per lane per mi per direction)	Quantity	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)
Traffic Control				$300,000.00		
Pavement Markings						
				REHABILITATION #1 COSTS	$ 270,537.52	$ 514,021.29

ALTERNATIVE A

REHABILITATION YEAR 20

TRAVEL LANES			Quantity (per lane per mi per direction)	Quantity	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)
Mill Asphalt	432-0206	1 1/2	7,040.00	28,160.00	SY	$2.10	$ 59,136.00	$ 112,358.40
							$ 59,136.00	$ 112,358.40
Overlay Design								
12.5 mm Superpave	402-3130	1.50	580.80	2,323.20	TN	$66.57	$ 154,655.42	$ 293,845.31
19 mm Superpave	402-3190				TN	$64.86		
							$ 154,655.42	$ 293,845.31
Full Depth Asphalt Patching					CY	$450.00		
12.5 mm Superpave	402-3130	1.50	29.04	116.16	TN	$66.57	$ 7,732.77	$ 14,692.27
19 mm Superpave	402-3190	2.00	38.72	154.88	TN	$64.86	$ 10,045.52	$ 19,086.48
25 mm Superpave	402-3121	8.00	154.88	619.52	TN	$62.90	$ 38,967.81	$ 74,038.84
	Percentage 5%							
							$ 56,746.10	$ 107,817.58
INSIDE SHOULDER – none								
Grind Concrete	431-1000	1 1/2			SY	$2.29		
Full Depth Slab Replacement none	452-1000				CY	$450.00		
	Percentage 5%							
OUTSIDE SHOULDER – none								
Grind Concrete	431-1000	1 1/2			SY	$2.29		
Full Depth Slab Replacement none	452-1000				CY	$450.00		
	Percentage 5%							

OTHER REHABILITATION COSTS

	Quantity (per lane per mi per direction)	Quantity	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)
Traffic Control				$300,000.00		
Pavement Markings						
				REHABILITATION #2 COSTS	$ 270,537.52	$ 514,021.29

ALTERNATIVE A

REHABILITATION YEAR 30

TRAVEL LANES			Quantity (per lane per mi per direction)	Quantity	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)
Mill Asphalt	432-0206	1 1/2	7,040.00	28,160.00	SY	$2.10	$ 59,136.00	$ 112,358.40
							$ 59,136.00	$ 112,358.40
Overlay Design								
12.5 mm Superpave	402-3130	1.50	580.80	2,323.20	TN	$66.57	$ 154,655.42	$ 293,845.31
19 mm Superpave	402-3190				TN	$64.86		
							$ 154,655.42	$ 293,845.31
Full Depth Asphalt Patching					CY	$450.00		
12.5 mm Superpave	402-3130	1.50	29.04	116.16	TN	$66.57	$ 7,732.77	$ 14,692.27
19 mm Superpave	402-3190	2.00	38.72	154.88	TN	$64.86	$ 10,045.52	$ 19,086.48
25 mm Superpave	402-3121	8.00	154.88	619.52	TN	$62.90	$ 38,967.81	$ 74,038.84
	Percentage 5%							
							$ 56,746.10	$ 107,817.58
INSIDE SHOULDER—none								
Grind Concrete	431-1000	1 1/2			SY	$2.29		
Full Depth Slab Replacement none	452-1000				CY	$450.00		
	Percentage 5%							
OUTSIDE SHOULDER—none								
Grind Concrete	431-1000	1 1/2			SY	$2.29		
Full Depth Slab Replacement none	452-1000				CY	$450.00		
	Percentage 5%							

OTHER REHABILITATION COSTS

	Quantity (per lane per mi per direction)	Quantity	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)
Traffic Control				$300,000.00		
Pavement Markings						
				REHABILITATION #3 COSTS	$ 270,537.52	$ 514,021.29

ALTERNATIVE B

Mainline Pavement Type PCC
Mainline Pavement Method Full Depth
More Description

ROADWAY PAVEMENT

TRAVEL LANES - New Construction for Widening	Pay Item No	inches	Quantity (per mi per direction)	Quantity (per mi)	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)
PCC	430-0200	10.00	14,080.00	28,160.00	SY	$42.00	$ 1,182,720.00	$ 2,247,168.00
19 mm Superpave	402-3190	3.00	2,323.20	4,646.40	TN	$64.86	$ 301,365.50	$ 572,594.46
Graded Aggregate Base	310-5120	12.00	14,080.00	28,160.00	SY	$22.28	$ 627,404.80	$ 1,192,069.12
		25					$ 2,111,490.30	$ 4,011,831.58

TRAVEL LANES - New Construction for Exceptions	Pay Item No	inches	Quantity (per mi per direction)	Quantity (per mi)	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)

TRAVEL LANES - Overlay Construction	Pay Item No	inches	Quantity (per mi per direction)	Quantity (per mi)	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)

INSIDE SHOULDER - Full Depth none	Pay Item No	inches	Quantity (per mi per direction)	Quantity (per mi)	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)
none	#N/A							
Graded Aggregate Base	#N/A							

OUTSIDE SHOULDER - Full Depth none	Pay Item No	inches	Quantity (per mi per direction)	Quantity (per mi)	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)
none	#N/A							
Graded Aggregate Base	#N/A							

OTHER & PREPARATORY WORK

		Include (y/n)	Quantity (per direction)	Quantity	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)
Traffic Control	150-1010							
Staging								
Roadway Bridges								
Raise Bridge								
Roadwork with Raise Bridge								
New Ramp Construction								
Grading	210-0200							
Waterproofing Joints & Cracks	445-0500							
Remove Roadway Slab	609-1000							
Remove Roadway Slab (Exceptions)	609-1000							
Remove Existing Concrete prior to Overlay	609-1000							
Full Depth Slab Replacement prior to Overlay	452-1000							
Mill Asphalt								
Mill Asphalt (Exceptions)								
Joint Reinforcement Fabric								
Vegetation Removal								
Barrier Wall								
Striping / Signage								
White Markings-Not Included								
Longitudinal Drainage								
Misc: (Guardrail, Soundwalls, EC, etc)								
						INITIAL COSTS (Roadway, Other & Preparatoy Work)	$ 2,111,490.30	$ 4,011,831.58

ALTERNATIVE B

REHABILITATION YEAR 20

TRAVEL LANES			Quantity (per lane per mi per direction)	Quantity	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)
Grind Concrete	431-1000		7,040.00	28,160.00	SY	$2.29	$ 64,486.40	$ 122,524.16
							$ 64,486.40	$ 122,524.16
Resealing Roadway Joints & Cracks	461-1000		9,504.00	38,016.00	LF	$1.80	$ 68,428.80	$ 130,014.72
							$ 68,428.80	$ 130,014.72
Full Depth Slab Replacement PCC	452-1000	10.00	97.78	391.11	CY	$450.00	$ 176,000.00	$ 334,400.00
	Percentage 5%						$ 176,000.00	$ 334,400.00
INSIDE SHOULDER - none								
Grind Concrete	431-1000				SY	$2.29		
Full Depth Slab Replacement none	452-1000				CY	$450.00		
	Percentage 5%							
OUTSIDE SHOULDER - none								
Grind Concrete	431-1000				SY	$2.29		
Full Depth Slab Replacement none	452-1000				CY	$450.00		
	Percentage 5%							

OTHER REHABILITATION COSTS

	Quantity (per lane per mi per direction)	Quantity	Unit Measure	Unit Cost	ITEM COST (per mi)	ITEM COST (total)
Traffic Control Pavement Markings				$300,000.00		
				REHABILITATION #1 COSTS	$ 308,915.20	$ 586,938.88