Illinois Department of Transportation

To:	Joseph E. Crowe	Attn: District Four
From:	Scott E. Stitt	
Subject:	Pavement Design	
Date:	November 16, 2011	

FAP Route 1380 (US Route 24)
Section 16w-1, RS-3
Fulton County
Through Astoria

We have reviewed the pavement selection for the above captioned section, which was submitted by email dated October 13, 2011. Life cycle costs favor the rigid option over the HMA design.

The approved pavement design is as follows:

US Route 24 through Astoria

8.75 inches of rigid pavement with tied shoulders
6 inches of subbase granular material, type A
Geotextile fabric

If you have any questions, please contact Paul Niedernhofer at (217) 524-1651.

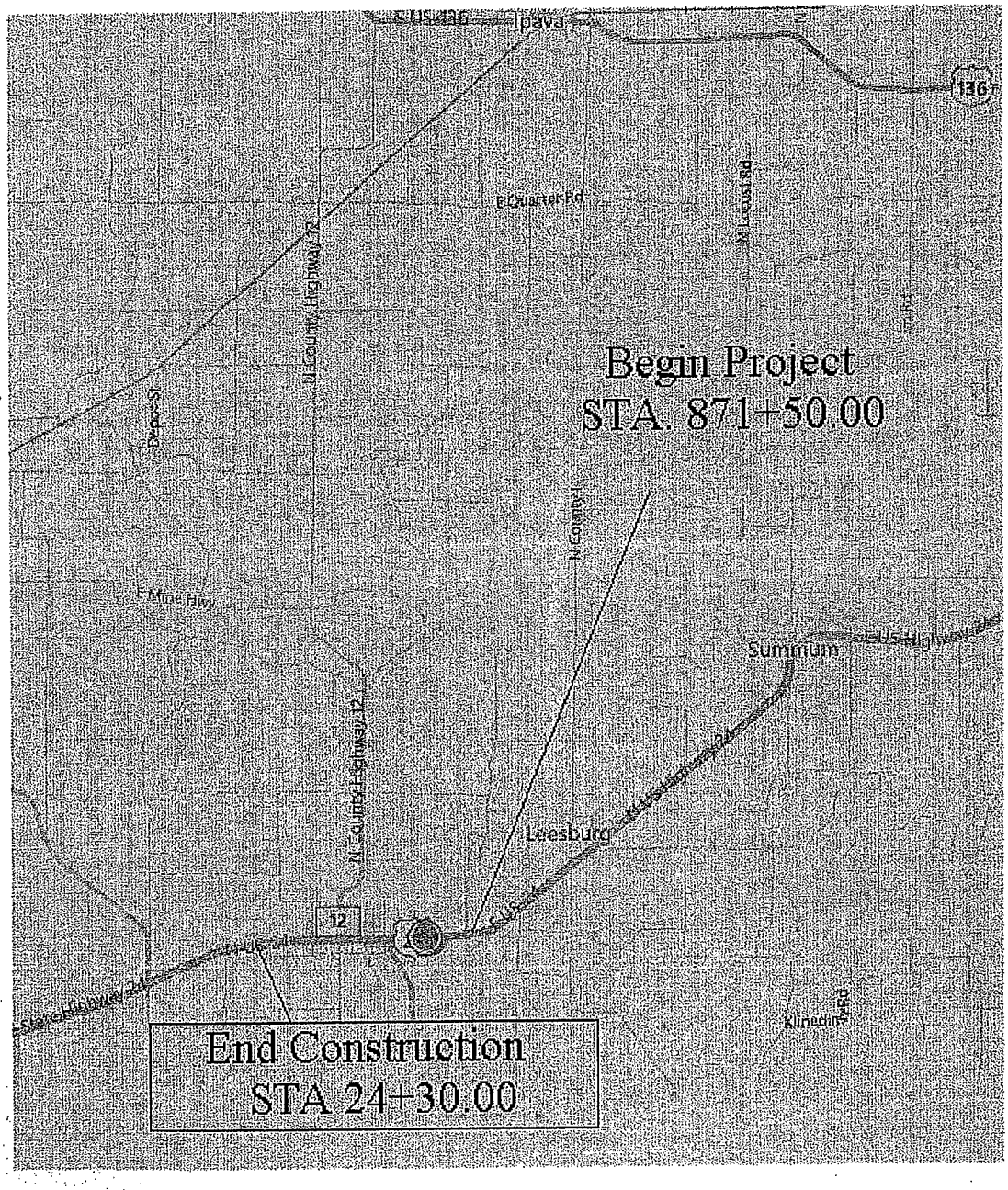
GENERAL LOCATION MAP

FAP 317 (US 24)

Sections: 16W-1, RS-3

Fulton County

Contract No. 88795



RECOMMENDATIONS

The proposed improvement consists of the reconstruction of 21,350 square yards of pavement on US 24 through Astoria. The pavement will be selected based on the percent difference from the Life Cycle Cost Analysis. The results of the Life Cycle Cost Analysis show the present cost per mile per year as $52,632 for the Jointed Plain Concrete Pavement and $60,042 for the Full-Depth HMA Pavement. The percent difference between the two is greater than ten percent. Therefore, the recommendation is for 8 ¾" Jointed PCC pavement tied to type B-6.24 curb and gutter with 6" of subbase granular material, type A on top of geotechnical fabric. It should also be noted that due to the stage construction that will be required, the use of HMA pavement would not be a viable option.

Pavement Design

Route: FAP317 (US Rte. 24)

Section: 16w-1, RS-3

County: Fulton

Catalog No. 0300101-06D

Job No. D-94-085-96

DESIGN DATA:

- Class II Truck Route
- Design Period = 20 years
- Design Year = 2023
- Traffic Growth factor is 1% Annually
- Other Principal Arterial
- 6,405 Feet of New Pavement - 21,350 sy

$(1.01)^{14} = 1.1495$

2023

2009 TRAFFIC	2013 TRAFFIC
ADT = 4,400	ADT = 5,058 ✓
PV= 3,999	PV= 4,597 ✓
SU=251	SU=288 ✓
MU=150	MU=172 ✓

The project involves the construction of new pavement on 6,405 Feet, the Following analyses are required.

- Mechanistic Design:
- Rigid
- Full-Depth HMA

MECHANISTIC DESIGN: (Rigid)

A. Given:

- 6,405 Feet of New Pavement
- Sub- grade Support Rating (SSR) = poor
- Edge Support Tied

From figure54-2.B (DESIGN LANE DISTRIBUTION FACTOR FOR STRUCTURAL DESIGN TRAFFIC) of Chapter 54 of the BDE manual the following information is obtain:

Number of Facility Lanes	Percent of Total Vehicular Class Volume (ADT) in Design Lane					
	Rural			Urban		
	PV	SU	MU	PV	SU	MU
2 or 3*	50%	50%	50%	50%	50%	50%
4	32%	45%	45%	32%	45%	45%
≥ 6	20%	40%	40%	8%	37%	37%

** One-way roads and streets.*

DESIGN LANE DISTRIBUTION FACTORS FOR STRUCTURAL DESIGN TRAFFIC

Figure 54-2.B

B. Solutions:
1. Traffic Factor

Class I	$TF=DP\left[\frac{(0.15 \bullet P \bullet PV)+(143.81 \bullet S \bullet SU)+(696.42 \bullet M \bullet MU)}{1x10^6}\right]$	Equation 54-4.1
Class II	$TF=DP\left[\frac{(0.15 \bullet P \bullet PV)+(135.78 \bullet S \bullet SU)+(567.21 \bullet M \bullet MU)}{1x10^6}\right]$	Equation 54-4.2

MAINELINE	MECHANISTIC DESIGN						
Design Period	20		%PV		%SU		%MU
Growth RATE	1.00%		90.90%		5.70%		3.40%
Data Year/ADT	2009	4,400					
Construction Year	2013		PV ✓		SU ✓		MU ✓
Design Year/ADT	2023	5,058	4,597		288		172

RIGID				FLEXIBLE			
CPV	CSU	CMU		CPV	CSU	CMU	
0.15	143.81	696.42		0.15	132.50	482.53	CLASS I (4 LANES OR MORE) (
0.15	135.78	567.21		0.15	112.06	385.44	CLASS II (2 OR 3 LANES WITH
0.15	129.58	562.47		0.15	109.14	384.35	CLASS III (2 OR 3 LANES WITH
0.15	127.75	555.90		0.15	109.14	384.35	CLASS VI (2 OR 3 LANES WITH
0.15	127.75	555.90		0.15	9.86	78.84	CLASS VI (2 OR 3 LANES WITH

MINIMUM TRAFFIC FOR MECHANISTIC DESIGN					
FACILITY TYPE	PV		SU		MU
INTERSTATE OR SUPL FREEWAY	0		500		1,500
OTHER MARKED STATE ROUTE	0		250		750
UNMARKED STATE ROUTE	----		----		----

RURAL				URBAN			NUMBER OF LANES
P	S	M		P	S	M	
1.00	1.00	1.00		1.00	1.00	1.00	1 LANE (RAMP)
0.50	0.50	0.50		0.50	0.50	0.50	1, 2 OR 3 LANES
0.32	0.45	0.45		0.32	0.45	0.45	4 OR 5 LANES
0.20	0.40	0.40		0.08	0.37	0.37	6 OR MORE LANES

RIGID

$$TF\ (actual) = 20 \times \left[\frac{(CVP \times P \times PV) + (CSU \times S \times SU) + (CMU \times M \times MU)}{1{,}000{,}000} \right] = 1.37 \checkmark$$

$$TF\ (Min) = 20 \times \left[\frac{(0.15 \times 0.50 \times 0) + (135.78 \times 0.50 \times 250) + (567.21 \times 0.50 \times 750)}{1{,}000{,}000} \right] = \boxed{4.59} \checkmark$$

FLEXIBLE

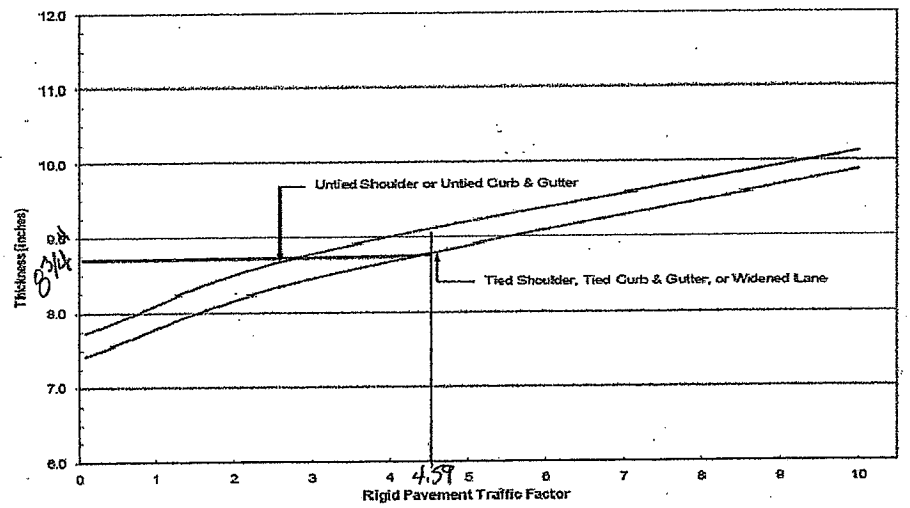
$$T.F\ (actual) = 20 \times \left[\frac{(0.15 \times 0.50 \times 4{,}597) + (112.06 \times 0.50 \times 288) + (385.44 \times 0.50 \times 172)}{1{,}000{,}000} \right] = 0.99 \checkmark$$

$$TF\ (Min) = 20 \times \left[\frac{(0.15 \times 0.50 \times 0) + (112.06 \times 0.50 \times 250) + (385.44 \times 0.50 \times 750)}{1{,}000{,}000} \right] = \boxed{3.17} \checkmark$$

- Using equation 54-4.2 of the BDE manual for a Class II facility

$TF_{R(actual)}$ = 1.37
$TF_{F(min)}$ = 4.59 (Controls)

From figure54-4 E PCC Thickness



- Using a poor SSR grade and a traffic factor of 4.59 The PCC pavement thickness is **8.75** "

MECHANISTIC DESIGN: (Full Depth HMA)

A. Given:

- 6,405 Feet of New Pavement
- Sub grade Support Rating (SSR) = poor
- Asphalt Binder Type = PG 64-22

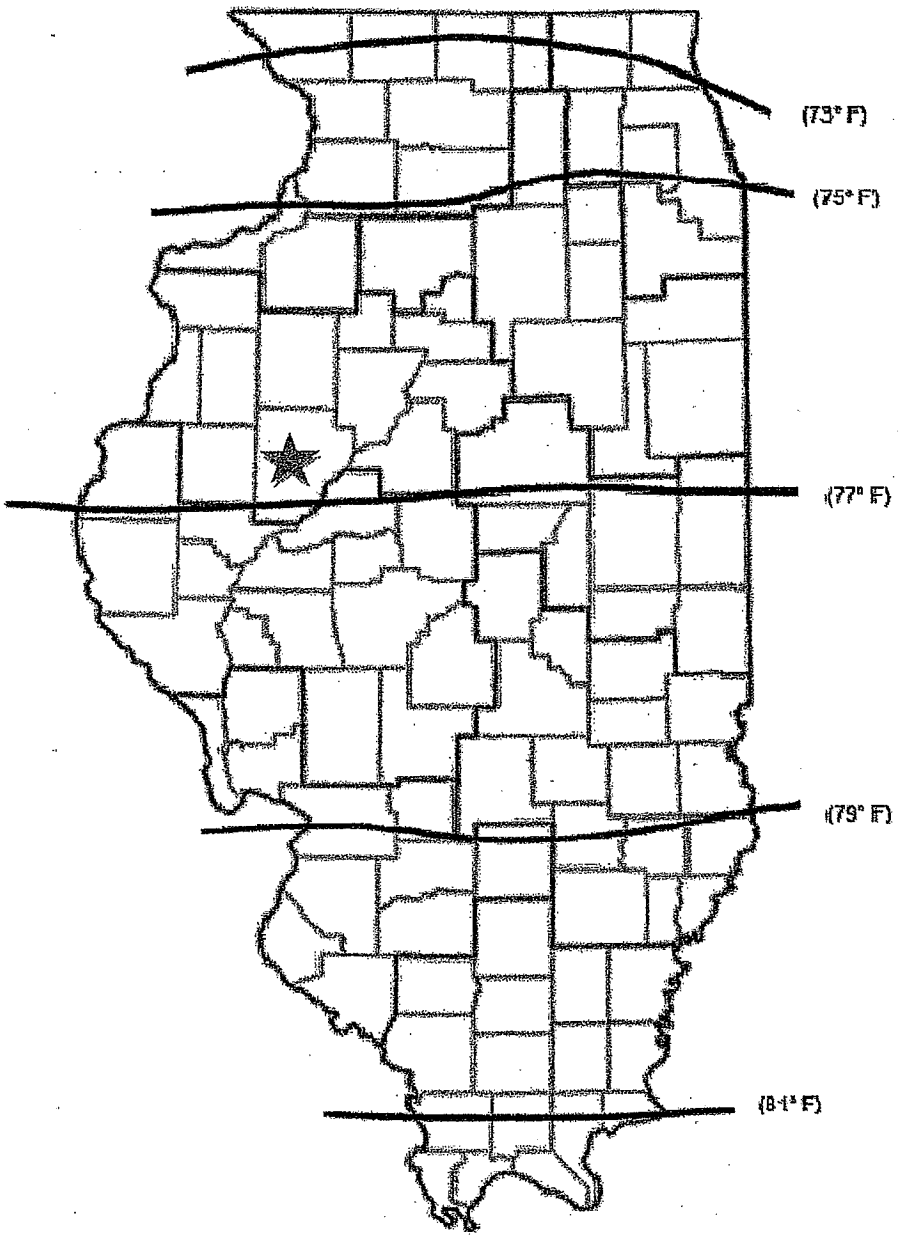
B. Solutions:

1. Traffic Factor

Class II	$TF=DP\left[\frac{(0.15 \bullet P \bullet PV)+(112.06 \bullet S \bullet SU)+(385.44 \bullet M \bullet MU)}{1x10^6}\right]$	Equation 54-5.2 ✓

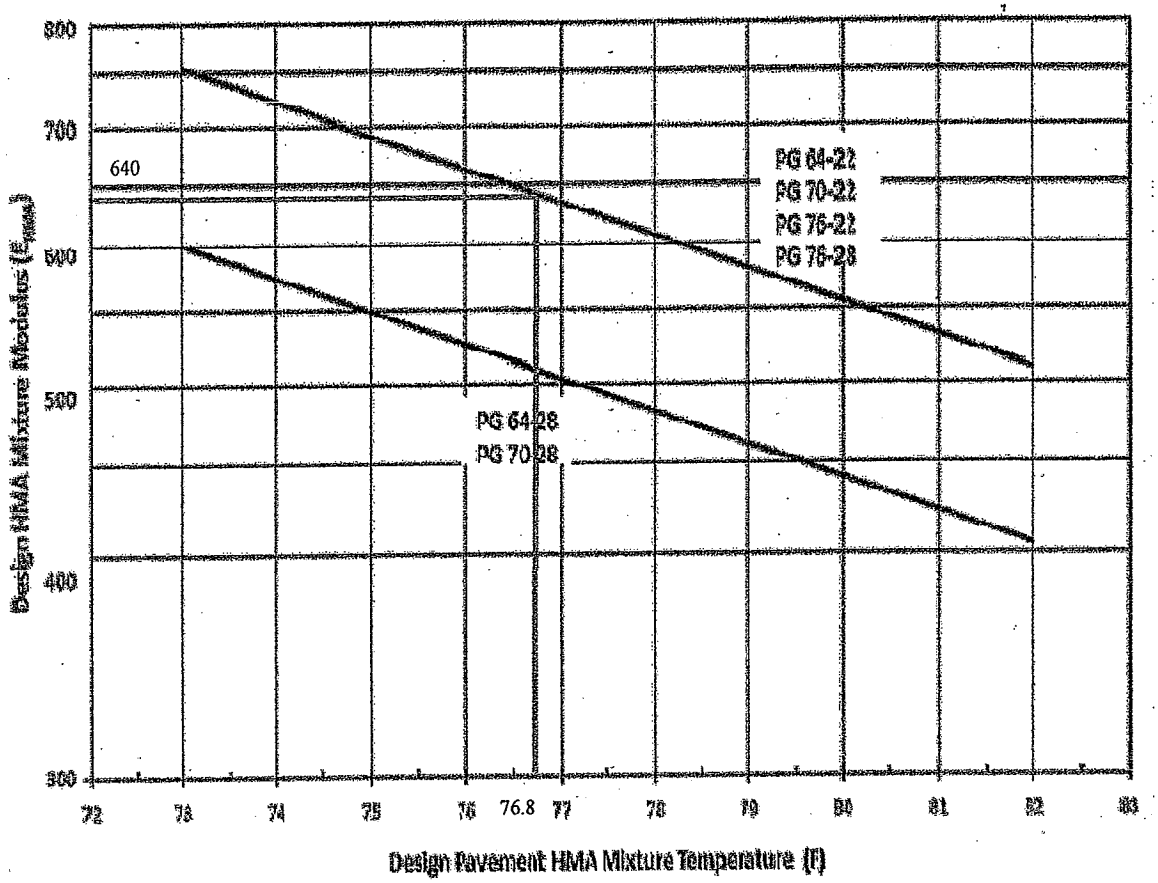
- Using equation 54-5.2 of the BDE manual for a Class II facility
  $TF_{F(actual)}$ = 0.99
  $TF_{F(min)}$ = 3.17 (Controls)

2. AC Mix Temperature
   - From figure 54-5.C of the BDE manual, use temperature = **76.8°F**



Note: The minimum design HMA mixture temperature will be 73°F.

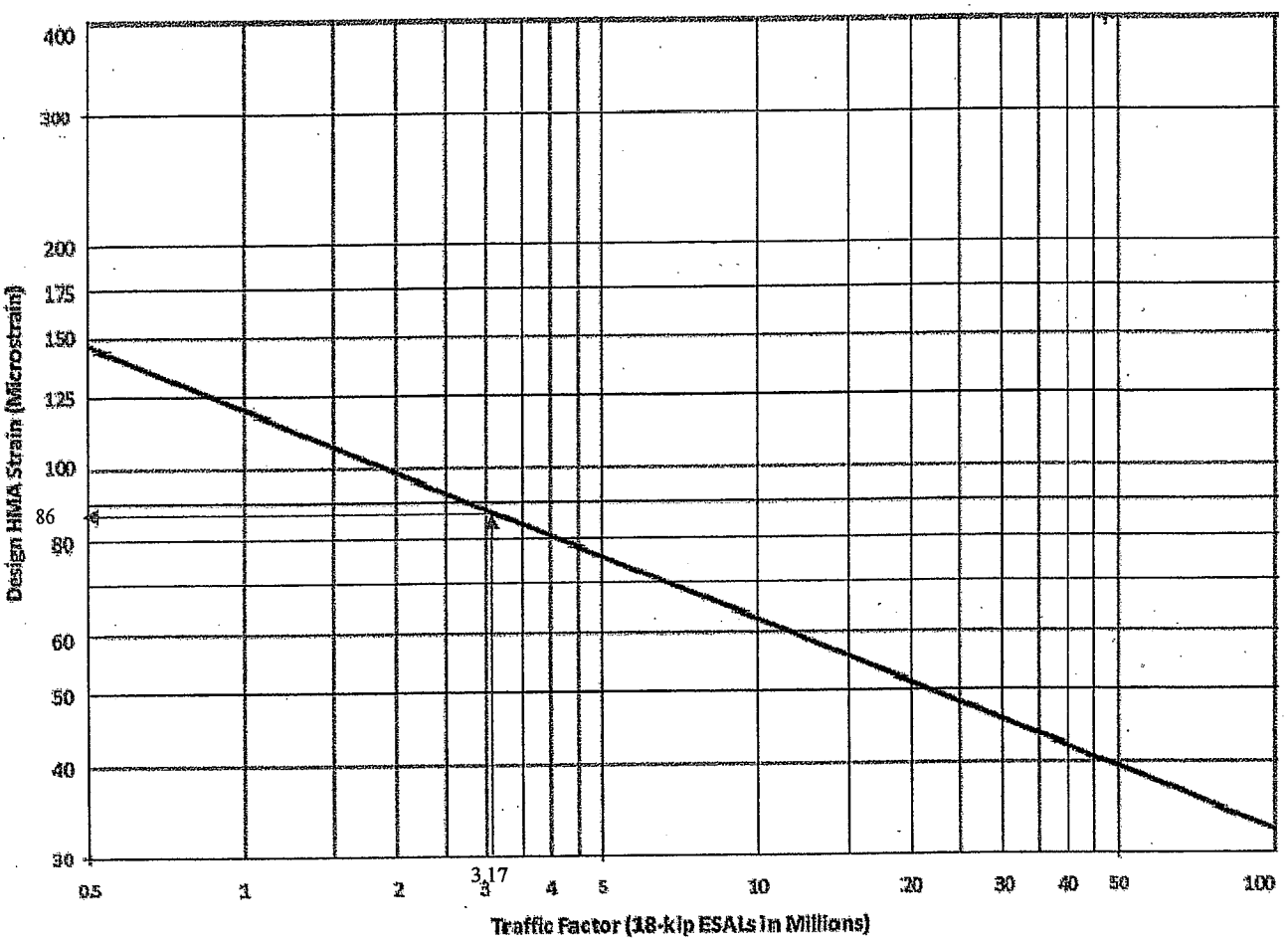
3. Design E_{HMA}
   - From figure 54-5.D of the BDE manual, E_{HMA} = **640 ksi**



HMA MIXTURE MODULUS (E_{HMA})
(Mechanistic Design: Flexible Pavement)

Figure 54-5.D

4. Design HMA strain :
   - From figure 54-5.E of the BDE manual, HMA Strain = **86**



DESIGN HMA STRAIN
(Mechanistic Design: Flexible Pavement)

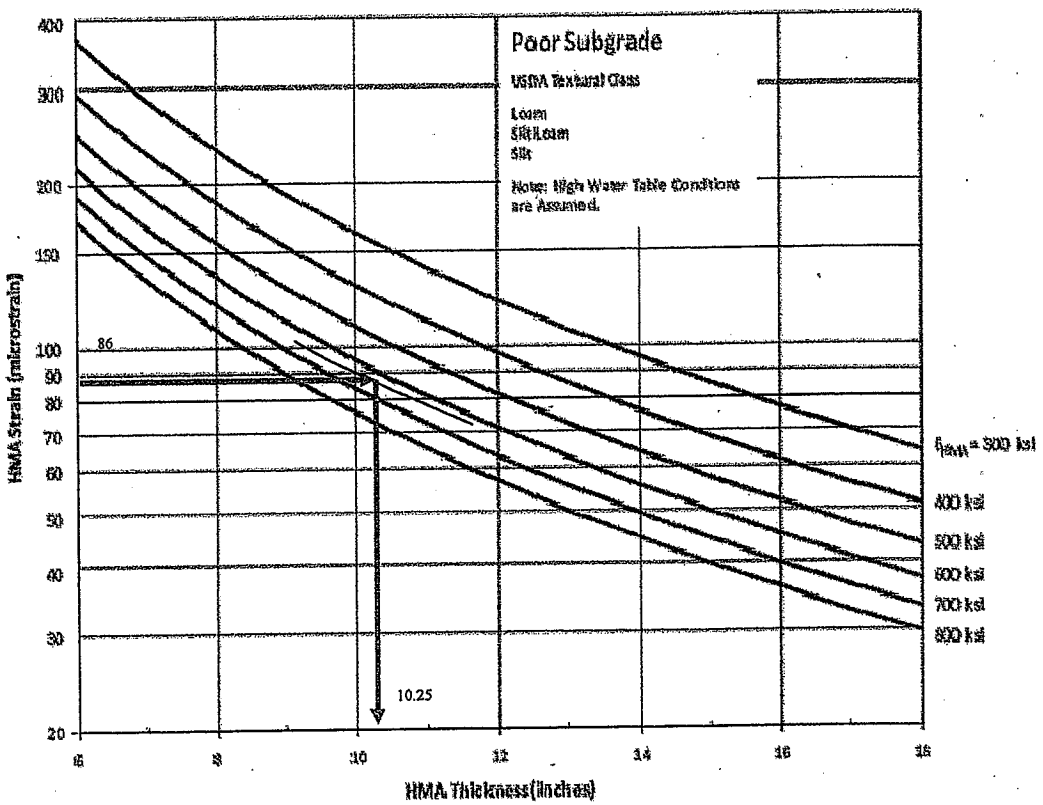
Figure 54-5.E

5. Thickness

   a. For Flexible design:

      - From figure 54-5.F of the BDE Manual

         - Thickness= **10.25 inches**



HMA THICKNESS DESIGN CHART
(Mechanistic Design: Flexible Pavement: SSR = Poor)

Figure 54-5.F

RESULTS:

A) Mechanistic Design (Rigid)

- 8.75" PCC Pavement (21,350 SQ YDS)
- 6" Sub-base granular material Type A (7,295 Tons) with geotechnical fabric

B) Mechanistic Design Full Depth HMA

- 10.25" Full Depth Bituminous using PG 64-22 (17,080 SQ YDS)
- HMA Shoulders 10.25" (2,451 Tons)
- 6" Sub-base granular material Type A (7,295 Tons) with geotechnical fabric

PAVT	1.2131 miles		# OF	# OF	# OF LONG.	AREA
	L (FT)	W (FT)	LANES	EDGES	CONSTR. JT.	(SQ YD)
	6,405	15	2	2	2	21,350

SHLDR		LT	RT	# OF	# OF	AREA
	L (FT)	W (FT)	W (IN)	LT	RT	(SQ YD)
	6,405	0	0	1	1	0

MAINTENANCE AND REHABILITATION ACTIVITY SCHEDULE

JOINTED PLAIN CONCRETE PAVEMENT — **RIGID**

AND UNBONDED JOINTED PAIN CONCRETE OVERLAY

	ITEM	QUANTITY	UNIT	UNIT PRICE	PRES CONST COST	PRES CONST COST/MILE
8.75	" PCC PAVEMENT 8.75"	21,350	SQ YD	$44.48	$949,648	
	" STABILIZED SUB-BASE 4"	0	SQ YD	$0.00	$0	
	" CONCRETE SHOULDERS 8.75"	0	SQ YD	$0.00	$0	
6	" SUB-BASE GRAN MATRL TYPE A (6")	7,295	TON	$20.02	$146,038	
	LONGITUDINAL JOINT ROUTING AND SEALING	25,620	LIN FT	$2.00	$51,240	
21,350	Geotechnical Fabric	21,350	SQ YD	$1.50	$32,025	
	LIME 4% (120 LBS/CU FT OF SOIL)	820,481	TON	$0.00	$0	
	PRESENT CONSTRUCTION COSTS OVER THE PERIOD OF 40 YEARS				$1,178,951	$971,875

	ACTIVITIES		QUANT	UNIT	UNIT PRICE	FUT REHAB COST	FUT REHAB COST/MILE	PRES REHAB COST/MILE
	ACTIVITY 1 ---- YEAR 10	PWF10= 0.7441						
0.10%	CLASS B PAVEMENT PATCHING		21	SQ YD	$175.00	$3,736	$3,080	$2,292
	ACTIVITY 2 ---- YEAR 15	PWF15= 0.6419						
0.20%	CLASS B PAVEMENT PATCHING		43	SQ YD	$175.00	$7,473	$6,160	$3,954
	ACTIVITY 3 ---- YEAR 20	PWF20= 0.5537						
2.00%	CLASS B PAVEMENT PATCHING		427	SQ YD	$175.00	$74,725		
0.50%	CLASS C SHOULDERS PATCHING		0	SQ YD	$100.00	$0		
100%	LONGITUDINAL EOP JOINT ROUTING AND SEALING		12,810	LIN FT	$2.00	$25,620		
100%	LONG. CONSTR. JOINT ROUTING AND SEALING		12,810	LIN FT	$2.00	$25,620		
						$125,965	$103,840	$57,496
	ACTIVITY 4 ---- YEAR 25	PWF25= 0.4776						
0.30%	CLASS B PAVEMENT PATCHING		64	SQ YD	$175.00	$11,209		
1.00%	CLASS C SHOULDERS PATCHING		0	SQ YD	$100.00	$0		
						$11,209	$9,240	$4,413
	ACTIVITY 5 ---- YEAR 30	PWF30= 0.4120						
4.00%	CLASS B PAVEMENT PATCHING		854	SQ YD	$175.00	$149,450		
1.50%	CLASS C SHOULDERS PATCHING		0	SQ YD	$100.00	$0		
2.25	" HMA OVERLAY OF PAVEMENT		2,690	TON	$85.00	$228,659		
1.50	" HMA OVERLAY OF SHOULDERS		0	TON	$75.00	$0		
						$378,109	$311,696	$128,419
	ACTIVITY 6 ---- YEAR 35	PWF35= 0.3554						
100%	LONGITUDINAL EOP JOINT ROUTING AND SEALING		12,810	LIN FT	$2.00	$25,620		
100%	LONG. CONSTR. JOINT ROUTING AND SEALING		12,810	LIN FT	$2.00	$25,620		
50%	RANDOM CRACK ROUTE & SEAL		6,405	LIN FT	$2.00	$12,810		
40%	REFLEC TRANSVERSE CRACK ROUTE & SEAL		5,124	LIN FT	$2.00	$10,248		
0.10%	PARTIAL-DEPTH PAVEMENT PATCHING		21	SQ YD	$15.00	$320		
						$74,618	$61,512	$21,861
	ACTIVITY 7 ---- YEAR 40	PWF40= 0.3066						
0.50%	CLASS B PAVEMENT PATCHING		107	SQ YD	$175.00	$18,681		
100%	LONGITUDINAL EOP JOINT ROUTING AND SEALING		12,810	LIN FT	$2.00	$25,620		
100%	LONG. CONSTR. JOINT ROUTING AND SEALING		12,810	LIN FT	$2.00	$25,620		
60%	REFLEC TRANSVERSE CRACK ROUTE & SEAL		7,686	LIN FT	$2.00	$15,372		
50%	RANDOM CRACK ROUTE & SEAL		6,405	LIN FT	$2.00	$12,810		
0.50%	PARTIAL-DEPTH PAVEMENT PATCHING		107	SQ YD	$15.00	$1,601		
						$99,705	$82,192	$25,200
	PRESENT REHAB COST PER MILE FOR THE PERIOD OF 40 YEARS							$243,635
	TOTAL PRESENT COST PER MILE FOR THE PERIOD OF 40 YEARS							$1,215,510
	PRESENT COST PER MILE PER YEAR	CRF40= 0.0433						$52,632

PAVT	1.2131 miles		# OF LANES	# OF EDGES	# OF C LINES	AREA (SQ YD)
	L (FT)	W (FT)				
	6,405	12	2	2	1	17,080

SHLDR	LENGTH L(FT)	LT WIDTH (FT)	RT WIDTH (FT)	# OF LT	# OF RT	AREA (SQ YD)
	6,405	8	8	2	1	4,270

FULL-DEPTH HMA PAVEMENT

FLEXIBLE

	ITEM	QUANTITY	UNIT	UNIT PRICE	PRES CONST COST	PRES CONST COST/MILE
2	" Polymerized HMA Surface Couse Mix "D" N50	1,913	TON	$89.85	$171,841	
2.25	" Polymerized H M A Binder Course IL-12.5, N50	2,152	TON	$80.85	$166,865	
6	" H M A Binder Course IL-19.0, N50 6"	5,739	TON	$79.93	$458,709	
10.25	" HMA SHOULDERS 10.25"	2,451	TON	$79.94	$195,931	
6	" SUB-BASE GRAN MATRL TYPE A 6"	7,295	TON	$20.02	$146,038	
21,350	Geotechnical Fabric	21,350	SQ YD	$1.50	$32,025	
		984,577	TON	$0.00	$0	
	PRESENT CONSTRUCTION COSTS OVER THE PERIOD OF 40 YEARS				$1,191,409	$982,145

	ACTIVITIES	QUANT	UNIT	UNIT PRICE	FUT REHAB COST	FUT REHAB COST/MILE	PRES REHAB COST/MILE
	ACTIVITY 1 ---- YEAR 5 PWF5= 0.8626						
100%	LONGITUDINAL SHOULDER JOINT ROUTING & SEALING	12,810	LIN FT	$2.00	$25,620		
100%	CL JOINT ROUTING & SEALING (SINGLE LANE PAVING)	6,405	LIN FT	$2.00	$12,810		
50%	RANDOM/THERMAL CRACK ROUTING & SEALING (SEE NOTE)	7,046	LIN FT	$2.00	$14,091		
0.10%	PARTIAL-DEPTH PAVEMENT PATCHING (MILL & FILL SURFACE)	17	SQ YD	$15.00	$256		
					$52,777	$43,507	$37,529
	ACTIVITY 2 ---- YEAR 10 PWF10= 0.7441						
100%	LONGITUDINAL SHOULDER JOINT ROUTING & SEALING	12,810	LIN FT	$2.00	$25,620		
100%	CENTERLINE JOINT ROUTING & SEALING	6,405	LIN FT	$2.00	$12,810		
50%	RANDOM/THERMAL CRACK ROUTING & SEALING (SEE NOTE)	7,046	LIN FT	$2.00	$14,091		
0.50%	PARTIAL-DEPTH PAVEMENT PATCHING (MILL & FILL SURFACE)	85	SQ YD	$15.00	$1,281		
					$53,802	$44,352	$33,002
	ACTIVITY 3 ---- YEAR 15 PWF15= 0.6419						
2	" MILLING-PAVEMENT AND SHOULDERS	21,350	SQ YD	$2.00	$42,700		
1.0%	PARTIAL-DEPTH PAVEMENT PATCHING (MILL AND FILL ADDITIONAL 2 IN.)	171	SQ YD	$15.00	$2,562		
2	" HMA OVERLAY SURFACE POLYMER MIX "D"	1,913	TON	$85.00	$162,602		
2	" HMA OVERLAY SHOULDERS	478	TON	$75.00	$35,868		
					$243,732	$200,922	$128,972
	ACTIVITY 4 ---- YEAR 20 PWF20= 0.5537						
100%	LONGITUDINAL SHOULDER JOINT ROUTING & SEALING	12,810	LIN FT	$2.00	$25,620		
100%	CENTERLINE JOINT ROUTING & SEALING	6,405	LIN FT	$2.00	$12,810		
50%	RANDOM/THERMAL CRACK ROUTING & SEALING (SEE NOTE)	7,046	LIN FT	$2.00	$14,091		
0.10%	PARTIAL-DEPTH PAVEMENT PATCHING (MILL & FILL SURFACE)	17	SQ YD	$15.00	$256		
					$52,777	$43,507	$24,090
	ACTIVITY 5 ---- YEAR 25 PWF25= 0.4776						
100%	LONGITUDINAL SHOULDER JOINT ROUTING & SEALING	12,810	LIN FT	$2.00	$25,620		
100%	CENTERLINE JOINT ROUTING & SEALING	6,405	LIN FT	$2.00	$12,810		
50%	RANDOM/THERMAL CRACK ROUTING & SEALING (SEE NOTE)	7,046	LIN FT	$2.00	$14,091		
0.50%	PARTIAL-DEPTH PAVEMENT PATCHING (MILL & FILL SURFACE)	85	SQ YD	$15.00	$1,281		
					$53,802	$44,352	$21,183
	ACTIVITY 6 ---- YEAR 30 PWF30= 0.4120						
2	" MILLING PAVEMENT AND SHOULDERS	21,350	SQ YD	$2.00	$42,700		
2.0%	PARTIAL-DEPTH PAVEMENT PATCHING (MILL AND FILL)	342	SQ YD	$15.00	$5,124		
1.0%	PARTIAL-DEPTH SHOULDERS PATCHING (MILL AND FILL)	43	SQ YD	$15.00	$641		
3.75	" HMA OVERLAY-PAVT POLYMER MIX "D"	3,587	TON	$85.00	$304,878		
1.75	" HMA OVERLAY-SHOULDRES	418	TON	$75.00	$31,385		
					$384,727	$317,152	$130,667
	ACTIVITY 7 ---- YEAR 35 PWF35= 0.3554						
100%	LONGITUDINAL SHOULDER JOINT ROUTING & SEALING	12,810	LIN FT	$2.00	$25,620		
100%	CENTERLINE JOINT ROUTING & SEALING	6,405	LIN FT	$2.00	$12,810		
50%	RANDOM/THERMAL CRACK ROUTING & SEALING (SEE NOTE)	7,046	LIN FT	$2.00	$14,091		
0.10%	PARTIAL-DEPTH PAVEMENT PATCHING (MILL & FILL SURFACE)	17	SQ YD	$15.00	$256		
					$52,777	$43,507	$15,462
	ACTIVITY 8 ---- YEAR 40 PWF40= 0.3066						
100%	LONGITUDINAL SHOULDER JOINT ROUTING & SEALING	12,810	LIN FT	$2.00	$25,620		
100%	CENTERLINE JOINT ROUTING & SEALING	6,405	LIN FT	$2.00	$12,810		
50%	RANDOM/THERMAL CRACK ROUTING & SEALING (SEE NOTE)	7,046	LIN FT	$2.00	$14,091		
0.50%	PARTIAL-DEPTH PAVEMENT PATCHING (MILL & FILL SURFACE)	85	SQ YD	$15.00	$1,281		
					$53,802	$44,352	$13,598
	PRESENT REHAB COST PER MILE FOR THE PERIOD OF 40 YEARS						$404,503
	TOTAL PRESENT COST PER MILE FOR THE PERIOD OF 40 YEARS						$1,386,648
	PRESENT COST PER MILE PER YEAR CRF40= 0.0433						$60,042