FAP Route 327 (US 50)
Section 21-I-1, 27-I
Clinton County
At FAS Route 1784 (Shattuc Road)

We have reviewed the pavement selection for the above captioned section, which was submitted with your memorandum dated August 16, 2011. Based on the life-cycle analysis, the HMA pavement design was found to be more economical.

The approved pavement design for both widening and new construction is as follows:

11 inches of Full Depth HMA Pavement with 8 inch HMA Shoulders
12 inches Lime Modified Sub-grade

If you have any questions, please contact Paul Niedermhofer at (217) 524-1851.
SPECIAL DESIGN = NO
- NEW CONSTRUCTION/RECONSTRUCTION = NO
- PAVEMENT WIDENING ≥ 6" = YES (TYPICAL SHOWS 6" & VARIES (0'-18'))
- SHORT SEGMENT (ASSUME < 4500 ft) = YES
- BENEFICIAL TO MATCH EXISTING PAVEMENT = NO (EXISTING TYPICAL SHOWS 3" OF SURFACE ALREADY COULD HAVE BEEN 2 RESURFACINGS)
- WIDENING WITH RESURFACING = YES

NEED:
1. MECHANISTIC DESIGN: FULL DEPTH HMA
2. MODIFIED AASHTO DESIGN: FLEXIBLE
3. COMPOSITE PAVEMENT DESIGN

→ PERFORM FIRST-COST ANALYSIS AND SELECT PAVEMENT TYPE AND DESIGN BASED ON LOWEST FIRST COST
⇒ MECHANISTIC DESIGN (FULL DEPTH) IS THE LOWEST BY $1,377,740

(EN: CLASS II ROAD)

ADT (DESIGN YEAR, TRAFFIC): 3,900 (2010); 4,000 (2013); 4,900 (2023)
PV = 3,124 (2010); 3,204 (2013); 3,925 (2023); 3,564 (2023)
SU = 203 (2010); 208 (2013); 255 (2023); 231 (2023)
MU = 573 (2010); 588 (2013); 720 (2023); 654 (2023)
SUBGRADE SUPPORT RATING (SSR) = F000
ILLINOIS BEARING RATIO (IBR) = 2.0
HMA MIXTURE TEMPERATURE = 79.2°F (FIG. 54.5.2) ROUND TO 79°F

DETERMINE:
- MECHANISTIC DESIGN: FULL DEPTH ⇒ 11 in FULL-DEPTH FLEXIBLE
  $1,377,740
- MODIFIED AASHTO DESIGN: FLEXIBLE ⇒ 2.5 in HMA Surface Course
  $1,377,740
- COMPOSITE PAVEMENT DESIGN ⇒ 2.5 in HMA Surface Course
  $8,725 in PCC Base Course

⇒ PERFORM A FIRST-COST ECONOMIC ANALYSIS.
MECHANISTIC - FLEXIBLE

* DETERMINE TRAFFIC FACTORS - ACTUAL & MINIMUM

\[
TF_{F(\text{ACTUAL})} = 20 \left( \frac{0.15 \times 0.50 \times 3.524}{1 \times 10^4} \right) + (1.206 \times 0.50 \times 23) + (385.44 \times 0.50 \times 654) \quad 89 \text{ SF-S} 2
\]

\[
TF_{F(\text{MINIMUM})} = 20 \left( \frac{112.06 \times 0.50 \times 230}{1 \times 10^6} \right) + (385.44 \times 0.50 \times 750) \quad 89 \text{ SF-S} 2
\]

\[
TF_{F(\text{MINIMUM})} = 3.17
\]

USE \(TF_{F(\text{MINIMUM})} = 3.17\)

* DETERMINE DESIGN EHMMA FROM FIG 54.5.D AND ROUND TO NEAREST 10.

DESIGN EHMMA = 580 \(\text{ (FIG. 54.5.D)}\) \(\text{Assume: Use PG 64-22, PG 70-22 or PG 74-22}\)

CLASS II EQUIVALENCY FACTORS (FLEX PAVEMENT)

- PV: 0.0004 \(\Rightarrow 3564 \times 0.0004 = 1.4256\)
- SU: 0.307 \(\Rightarrow 2.31 \times 0.307 = 0.70917\)
- MU: 1.050 \(\Rightarrow 0.54 \times 1.050 = 0.56264\)

\[
\text{Total} = 2.692357
\]

* DETERMINE THE DESIGN HMA STRAIN USING THE \(TF_{F(\text{MINIMUM})}\) AND FIGURE 54.5.E

DESIGN HMA STRAIN = 85

* USING THE DESIGN EHMMA AND THE DESIGN HMA STRAIN, DETERMINE THE FLEXIBLE THICKNESS FROM FIG 54.5.F FOR A POOR SUBGRADE AND ROUND UP TO THE NEAREST 0.25 in.

THICKNESS = 11 in \(\text{, which is less than 16.5" max part thickness from FIG 54.5.1}\)
Note: The minimum design HMA mixture temperature will be 73°F.

HMA MIXTURE TEMPERATURE
(Mechanistic Design: Flexible Pavement)

Figure 54-5.C

HARD COPIES UNCONTROLLED
DESIGN HMA STRAIN
(Mechanistic Design: Flexible Pavement)

Figure 54-5.E
Figure 54-5.F

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

Poor Subgrade
USDA Textural Class
Loam
Silt
Silt
Notes: High Water Table Conditions are Assumed.

(HMA Stain (microns))
6 8 10 12 14 16 18

100 200 300 400

HMA Thickness (inches)
**Modified AASHTO Design**

1. $T_F(k) = 2.78$ (determined from mechanistic calculation)

2. $S_{NF} = 5.38$; from Fig. 54-5.4 which is greater than 4.0 from Fig. 54-5.5(suitable for two-lane State primary highways)

3. Using Equation 54 - 5.4, determine the layer thickness of the surface course, base course, and subbase course.

   $S_{NF} = a_1 D_1 + a_2 D_2 + a_3 D_3$

   From Fig. 54-5.0

   - $a_1 = 0.40$ (HMA)
   - $a_2 = 0.30$ (Assumes HMA's stabilized granular material 1,500 MS)
   - $a_3 = 0.11$ (Assumes granular material, Type B)
   - $D_1 = 2.5$ in (Policy: resurfacing w/ widening)
   - $D_3 = 4$ in (Assumed)

   $5.38 = 0.40(2.5) + 0.30 D_2 + (0.11)(4)$

   $D_2 = 15.13$ in; use 13.25 in

   Check:

   $2.5 \times 0.4 = 1.00$
   $13.25 \times 0.3 = 3.975$
   $4 \times 0.11 = 0.44$

   From Fig. 54-5.5, minimum $D_2 = 10$ in

   $5.415 > 5.38 \checkmark$

   $\checkmark$
**Composite Pavement Design**

* \[ T_{E_{r}(a)} = \frac{20(0.15 \cdot 0.50 \cdot 3564) + (135.78 \cdot 0.5 \cdot 23) + (567.21 \cdot 0.5 \cdot 654)}{1 \times 10^6} \]  
  \[ T_{E_{r}(a)} = 4.03 \]

* From Fig. 54-6.3, determine the composite pavement structural number (SC).
  \[ S_{N_{c}} = 3.83 \]

**Using Eq. 54-6.3, determine the layer thickness**

\[ S_{N_{c}} = 0.40D_s + 0.33D_b \]

where:
- \( S_{N_{c}} \) = composite pavement structural number
- \( D_s \) = thickness of HMA overlay (inches)
- \( D_b \) = thickness of new PCC base course (inches)

\[ S_{N_{c}} = 0.40(2.5) + 0.33D_b \]

\[ D_b = 8.64\text{ in use } 8.75\text{ in } > 7\text{ in } \text{min thickness from Fig. 54-6.4} \]
COMPOSITE PAVEMENT DESIGN NOMOGRAPH
(Class II, III, and IV Facilities)

Figure 54-6.B
**NEW PAVEMENT AREA** (see attached sheet) = 1630 sqyd

**EXISTING PAVEMENT AREA**

STA 698+44.57 TO STA 711+12.13 = 1267.16' x 24' = 30,411.81 sqyd

**HMA SHOULDERS (EAST TO WEST)**

<table>
<thead>
<tr>
<th>LT</th>
<th>STA</th>
<th>STA</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT</td>
<td>698+44.57</td>
<td>703+60</td>
</tr>
<tr>
<td>LT</td>
<td>702+60</td>
<td>703+75</td>
</tr>
<tr>
<td>LT</td>
<td>703+75</td>
<td>704+44</td>
</tr>
<tr>
<td>LT</td>
<td>705+43.88</td>
<td>710+62.29</td>
</tr>
<tr>
<td>LT</td>
<td>710+62.29</td>
<td>711+12.08</td>
</tr>
</tbody>
</table>

**RT** STA 698+61.50 TO STA 699+07.21 = 45.71' x 3' = 137.13 sqyd

**RT** STA 699+07.21 TO STA 710+62.18 = 115497' x 3' = 3464931 sqyd

**RT** STA 710+62.18 TO STA 711+12.07 = 49.39' x (3/2) = 74.88 sqyd

**LT + RT:** (1414.9 + 408.6) sqyd = 1823.5 sqyd

**SURFACE (OVER EXISTING & NEW PAVEMENT) (2.5")**

\[ \frac{1630 \text{ sqyd} + 3373.1 \text{ sqyd}}{1967.6 \text{ sqyd} \times (0.056 \text{ tons/sqyd/inch}) (2.5 \text{ inch})} = 225.4 \text{ TONS} \]

**SURFACE (OVER EXISTING PAVEMENT)**

\[ 3373.1 \text{ sqyd} \times (0.056 \text{ tons/sqyd/inch}) (2.5 \text{ inch}) = 473.07 \text{ TONS} \]

**MODIFIED ASPHALT (FLEX)**

**BINDER (NEW PAVEMENT)**

\[ \frac{1630 \text{ sqyd} \times (0.056 \text{ tons/sqyd/inch}) (13.25 \text{ inch})}{1209.46 \text{ TONS}} \approx 1209.46 \text{ TONS} \]
SHATTUCK RD (County Road)

- Special Design → NO
- New Construction/Reconstruction → YES
- Are Supplemental Designs, Viable Options? → NO
- Consider Only New Pavement Designs
  - Need:
    1. Mechanistic Design JPCP
    2. Mechanistic Design Full-Depth HMA

→ Perform Life-Cycle Cost Analysis

→ Life Cycle Cost Difference > 10% →

\[
\frac{73,054}{500,371} = 0.146 = 14.6\% \text{ which is less than } 10\% \\
\]

Therefore, the lowest Life-Cycle Cost is Selected (HMA FD)

VEN: CLASS II ROAD

\[
\begin{align*}
\text{Art. (Design Year Traffic):} & \quad 2,650 (2010) \quad 2,650 (2013) \quad 3,250 (2033) \\
\text{PV} = & \quad 2,448 (2010) \quad 2,344 (2013) \quad 2,832 (2023) \quad 3,120 (2033) \\
\text{SU (24%)} = & \quad 61 (2010) \quad 64 (2013) \quad 71 (2023) \quad 78 (2033) \\
\text{MU (16%)} = & \quad 41 (2010) \quad 42 (2013) \quad 47 (2023) \quad 52 (2033) \\
\text{Subgrade Support Rating (SSR): Poor} \\
\text{Illinois Bearing Ratio (IBR):} & \quad 2.0 \\
\end{align*}
\]

HMA Mixture Temperature = 79.2°F (Fig. 54-56), Rounded to 79°F

Determine:
- Mechanistic Design JPCP: 9.00 in. U1 tied PCC shoulders

- Mechanistic Design Full-Depth HMA: 11 in. Full-Depth HMA Paving
  12 in. Lime-Modified Subgrade

→ Perform a 45-Year Life-Cycle Cost Analysis

HMA FD: $560,371 ($58,751 TOTAL COST PER MILE)
PCC: $573,425 ($67,181 TOTAL COST PER MILE)
Determine Traffic Factors - Actual & Minimum

\[ TF_{(\text{act})} = 20 \left( (0.15 \cdot 0.5 \cdot 0.2832) + (35.78 \cdot 0.5 \cdot 0.71) + (567.21 \cdot 0.5 \cdot 0.17) \right) \times 10^6 \approx 54.42 \]

\[ TF_{(\text{act})} = 0.37 \]

\[ TF_{(\text{min})} = 20 \left( (35.78 \cdot 0.5 \cdot 2.35) + (567.21 \cdot 0.5 \cdot 0.75) \right) \times 10^6 \]

\[ TF_{(\text{min})} = 8.59 \]

Use \( TF_{(\text{min})} = 8.59 \)

Using the \( TF_{(\text{min})} \) and Fig. 54-4.5 for a poor subgrade, determine the rigid thickness. Round up to the nearest 0.25 in.

Thickness = 9.00 in for field shoulder (8.88 rounded up to 9.0)
Note: Use of untied shoulder design requires BDE approval.

RIGID PAVEMENT DESIGN CHART
(Mechanistic Design: SSR = Poor)

Figure 54-4.E
**MECHANISTIC DESIGN (FLEXIBLE)**

- **DETERMINE TRAFFIC FACTORS - ACTUAL & MINIMUM**

\[
TF_{F(A)} = 20 \left( 0.15 \times 0.5 \times 283.2 + (112.06 \times 0.5 \times 7) + (385.44 \times 0.5 \times 47) \right) \times 10^2 \\
TF_{F(A)} = 0.26
\]

\[
TF_{F(A)} = 20 \left( 112.06 \times 0.5 \times 250 + (385.44 \times 0.5 \times 75) \right) \times 10^2 \\
TF_{F(A)} = 3.17
\]

**USE TF_{F(A)} = 3.17**

- **DETERMINE DESIGN E_{HMA} FROM FIG. 54-5.1D AND ROUND TO NEAREST 10**

**DESIGN E_{HMA} = 880** (FIG. 54-5.1D). Assume: USE PG 64-22, PG 70-22, or PG 76-22

- **DETERMINE THE DESIGN HMA STRAIN USING THE TF_{F(A)} AND FIG. 54-5.5**

**DESIGN HMA STRAIN = 86**

- **USING THE DESIGN E_{HMA} AND THE DESIGN HMA STRAIN, DETERMINE THE FLEXIBLE THICKNESS FROM FIG. 54-5.5F FOR A POOR SUBGRADE AND ROUND UP TO THE NEAREST 0.25 IN.**

**THICKNESS = 11 IN.** which is less than 16.5 in. max. permit. thickness from FIG 54-5.5.
HMA MIXTURE MODULUS \((E_{mm})\) (Mechanistic Design: Flexible Pavement)

Design Pavement HMA Mixture Temperature \((F)\)

Design HMA Mixture Modulus \((E_{mm})\)

Figure 54-5.D

800 700 600 500 400 300 72 73 74 75 76 77 78 79 80 81 82 83

PG 64-22
PG 70-22
PG 70-28
PG 76-22
PG 76-28

54-5.6 HARD COPIES UNCONTROLLED
HMA Thickness Design Chart (Mechanistic Design: Flexible Pavement; SSR = Poor)

Figure 54-5.5

Note: High Water Table Conditions are assumed.

HMA Strain (micrometers)

400 300 200 150 100 50 40 30 20

6 8 10 12 14 16 18

HMA Thickness (inches)

400 psi 500 psi 600 psi 700 psi 800 psi

Poor Subgrade
USDA Textural Class
Loam
Silt Loam
Silt
CL

c

54-5.8

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### SHATTUC RD

**Sideroad to Old SHATTUC RD @ STA 89+15**
- STA 10+12 to STA 11+25.5 = 113.1' x 24' (4' lanes) = 319.5 

**STA 81+50 to STA 100+28.93 = 1878.93' x 24' = 45,095 

**STA 100+28.93 + STA 101+29.54 = (measured by CADD) = 4,255 

\[
52.545 \text{ yd}^3 \div (1 \text{ yd}^3/27 \text{ ft}^3) = 1583.8 \text{ yd}^3
\]

**Shoulders:** (NEW ROAD & NOT A HEAVILY TRAVELED RD. BY TRUCKS
- USE MIN. THICKNESS OF 6")

**STA 81+50 to 101+29.53 = 1979.53' x 2 sides = 3959.06 

\[
3959.06' \times 4' \text{ width} = 15836.24 	ext{ yd}^3 = 17596.3 \text{ yd}^3
\]

**Lime Modified Soil (12")**
- Pavement & Shoulders

\[
5838.3 + 17596.3 = 75979 \text{ yd}^3 \times 7600 \text{ ssyds}
\]

\[
(7600 \text{ ssyds})(1.4415 \text{ ton}) = 3659.4 \text{ tons} \approx 3660 \text{ tons}
\]
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<th>QUANTITY</th>
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<th>YEAR</th>
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<td>PAVEMENT (SQ YDS)</td>
<td>5,278</td>
<td>$40.00</td>
<td>$210,600</td>
<td>10</td>
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<td>SUB BASE (SQ YDS)</td>
<td>6,938</td>
<td>$15.00</td>
<td>$104,111</td>
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<tr>
<td>SHOULDER (SQ YDS)</td>
<td>1,798</td>
<td>$80.00</td>
<td>$143,385</td>
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<tr>
<td>SURFACE GRAN. MAT'L TY C (TONE)</td>
<td>241</td>
<td>$131.00</td>
<td>$31,609</td>
<td>10</td>
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<tr>
<td>SHOULDER SEAL (LN FT)</td>
<td>3,369</td>
<td>$11.00</td>
<td>$37,049</td>
<td>10</td>
</tr>
</tbody>
</table>

Initial Costs:

- CONSTRUCTION INITIAL COST: $491,385
- CONSTRUCTION ANNUAL COST: $26,704
- TOTAL LIFE CYCLE COST - ANNUAL COST PER MILE: $577,425
- ANNUAL COST PER MILE: $577,425

Maintenance Costs:

- SHOULDER JOINT ROUTE AND SEAL (FT): $0.88
- CENTERLINE JOINT ROUTE AND SEAL (FT): $0.88
- PAVEMENT PATCHING (SQ YDS): $160.00
- SHOULDER PATCHING (SQ YDS): $150.00
- ROLED DRILLED (EACH): $31.00
- GROUT BULK (CU FT): $200.00
- PAVEMENT BINGING (SQ YDS): $8.00
- POLICY IMA OVERLAY - PAVT (SQ YDS) - 2.25" THICKNESS: $10.00
- POLICY IMA OVERLAY - SHLDR (SQ YDS) - 2.25" THICKNESS: $22.00
- PARTIAL DEPTH PATCHING - REM & REPLACE (SQ YDS) - 2.5" THICK: $45.00

- YEAR 10: FD PATCHING 0.1% (SQ YD): 5 $150.00 $750
- FD SHOULDER PATCH 1.0% (SQ YD): 10 $150.00 $1,500
- FD SHOULDER PATCH 1.0% (SQ YD): 10 $150.00 $1,500
- YEAR 15: FD PATCHING 0.2% (SQ YD): 11 $150.00 $1,650
- YEAR 20: FD PATCHING 2.0% (SQ YD): 106 $150.00 $16,060
- FD SHOULDER PATCH 0.5% (SQ YD): 11 $150.00 $1,650
- FD SHOULDER PATCH 1.0% (SQ YD): 2 $150.00 $300
- FD SHOULDER PATCH 2.0% (SQ YD): 1 $150.00 $150

- YEAR 25: FD SHOULDER PATCH 1.0% (SQ YD): 10 $150.00 $1,500
- FD PATCHING 3.0% (SQ YD): 159 $150.00 $23,850
- YEAR 30: FD PATCHING 4.0% (SQ YD): 211 $150.00 $31,650
- FD PATCHING 5.0% (SQ YD): 286 $150.00 $43,470
- FD PATCHING 6.0% (SQ YD): 290 $150.00 $43,050
- FD PATCHING 7.0% (SQ YD): 294 $150.00 $43,640
- FD PATCHING 8.0% (SQ YD): 298 $150.00 $44,230

- YEAR 35: RANDOM CRACK SEAL 50.0% (LN FT): 49 $100.00 $4,900
- CENTERLINE JT 100.0% (LN FT): 3,000 $0.00 $3,000
- SHOULDER JT 100.0% (LN FT): 3,000 $0.00 $3,000
- FD PATCHING 0.1% (SQ YD): 6 $150.00 $900

- YEAR 40: FD PATCHING 0.2% (SQ YD): 20 $150.00 $3,000
- FD PATCHING 0.5% (SQ YD): 20 $150.00 $3,000
- RANDOM CRACK SEAL 50.0% (LN FT): 40 $100.00 $4,000
- CENTERLINE JT 100.0% (LN FT): 3,000 $0.00 $3,000
- SHOULDER JT 100.0% (LN FT): 3,000 $0.00 $3,000

Maintenance Life Cycle Cost: $92,049
Maintenance Annual Cost: $3,497
### Full-Depth Flexible Pavement Maintenance Costs

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<th>Quantity</th>
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<td>FAM - 327/FAD 1784</td>
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<td>214-1, 27-1</td>
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<td>1=URBAN, 2=URBAN</td>
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<td>PAVER WIDTH</td>
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<tr>
<td><strong>Initial Costs</strong></td>
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<tr>
<td><strong>Surface (sq yds)</strong></td>
<td></td>
<td>729 tons @ 2.25'</td>
<td>5,278</td>
<td>$4.48</td>
</tr>
<tr>
<td><strong>Binder (sq yds)</strong></td>
<td></td>
<td>2623 tons @ 0.76'</td>
<td>5,262</td>
<td>$44.45</td>
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<td><strong>Shoulder (sq yds)</strong></td>
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<td><strong>Subbase Gran. Mat. (ton)</strong></td>
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<tr>
<td><strong>Construction Initial Cost</strong></td>
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<tr>
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<td>$50,971</td>
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<td>59,751</td>
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<tr>
<td><strong>Shoulder, Joint Route and Seal (ft)</strong></td>
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<tr>
<td><strong>Centerline Joint Route and Seal (ft)</strong></td>
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<tr>
<td><strong>Traffic Crack (cracks route and seal (ft)</strong></td>
<td></td>
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<td></td>
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<tr>
<td><strong>Pavement Patching (sq yds)</strong></td>
<td></td>
<td>$150.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Shoulder Patching (sq yds)</strong></td>
<td></td>
<td>$120.00</td>
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<tr>
<td><strong>Overlay (ton)</strong></td>
<td></td>
<td>$99.00</td>
<td></td>
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</tr>
<tr>
<td><strong>Milling (sq yds)</strong></td>
<td></td>
<td>$25.00</td>
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<tr>
<td><strong>Partial Depth Patching - Rem &amp; Replace (sq yds)</strong></td>
<td></td>
<td>$40.00</td>
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<tr>
<td><strong>Material Type Percentage</strong></td>
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<td>ASPHALT</td>
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<td>14.3%</td>
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<tr>
<td><strong>Total Life Cycle Cost</strong></td>
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<tr>
<td><strong>Maintenance Cost per Mile</strong></td>
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<tr>
<td><strong>Shoulder, Joint Route and Seal (ft)</strong></td>
<td></td>
<td>$1.00</td>
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<td></td>
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<tr>
<td><strong>Centerline Joint Route and Seal (ft)</strong></td>
<td></td>
<td>$1.00</td>
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<tr>
<td><strong>Traffic Crack (cracks route and seal (ft)</strong></td>
<td></td>
<td>$1.00</td>
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<tr>
<td><strong>Pavement Patching (sq yds)</strong></td>
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<td>$40.00</td>
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<tr>
<td><strong>Shoulder Patching (sq yds)</strong></td>
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<td><strong>Overlay (ton)</strong></td>
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<tr>
<td><strong>Milling (sq yds)</strong></td>
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<tr>
<td><strong>Partial Depth Patching - Rem &amp; Replace (sq yds)</strong></td>
<td></td>
<td>$10.00</td>
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</tr>
</tbody>
</table>

**Summary:**
- **Initial Costs:** $338,999
- **Construction Annual Cost:** $41,269
- **Total Life Cycle Cost:** $500,971
- **Maintenance Cost per Mile:** $59,751
- **Maintenance Costs:** $60,741
  - **Shoulder, Joint Route and Seal (ft):** $1.00
  - **Centerline Joint Route and Seal (ft):** $1.00
  - **Traffic Crack (cracks route and seal (ft):** $1.00
  - **Pavement Patching (sq yds):** $150.00
  - **Shoulder Patching (sq yds):** $120.00
  - **Overlay (ton):** $99.00
  - **Milling (sq yds):** $25.00
  - **Partial Depth Patching - Rem & Replace (sq yds):** $40.00

**Maintenance Life Cycle Costs:** $411,792
**Maintenance Annual Cost per Mile:** $27,315