Composite Overlay Pavement Design Example
1993 AASHTO Pavement Design

Project Name and Location:
Route 123, MP 7.3 – 11.0
Hometown, NJ

Description:
This project will consist of the construction of a flexible overlay of an existing concrete
pavement to extend Route 123 to intersect with Route I-80 in North Jersey.

General Information:

<table>
<thead>
<tr>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Serviceability, $p_o$</td>
</tr>
<tr>
<td>Terminal Serviceability, $p_t$</td>
</tr>
<tr>
<td>Reliability Level, R</td>
</tr>
<tr>
<td>Overall Standard Deviation, $S$</td>
</tr>
<tr>
<td>Performance Period</td>
</tr>
</tbody>
</table>

Design Overlay Thickness, $D_{OL}$

Step 1: Exiting pavement design

| Existing slab thickness, inch | 9 |
| Type of load transfer         | Mechanical - Doweled |
| Type of shoulder              | bituminous |

Step 2: Traffic Analysis

Traffic Data and Analysis:

<table>
<thead>
<tr>
<th>Initial AADT</th>
<th>30,127</th>
<th>Based on data supplied by the NJ DOT Project Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final AADT</td>
<td>47,179</td>
<td></td>
</tr>
<tr>
<td>CAR%</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>$CAR_f$</td>
<td>0.0006</td>
<td></td>
</tr>
<tr>
<td>LT%</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>$LT_f$</td>
<td>0.163</td>
<td></td>
</tr>
<tr>
<td>HT%</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>$HT_f$</td>
<td>1.655</td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Days</td>
<td>365</td>
<td></td>
</tr>
<tr>
<td>$D_0%$</td>
<td>58</td>
<td>II-7 &amp; NJ Directional Distribution</td>
</tr>
<tr>
<td>$D_L%$</td>
<td>90</td>
<td>II-7, 8 &amp; NJ Lane Distribution</td>
</tr>
</tbody>
</table>

- Calculate ESALs based on load equivalency factors for rigid pavements

References:
Accumulated ESALs Over 20 years in all lanes in each directions:

\[ \omega_{18} = \left( \frac{AADT_i + AADT_f}{2} \right) \times \left( Car\% \times Carf + LT\% \times LTf + HT\% \times HTf \right) \times Years \times 365 \text{ day/year} \]

\[ \omega_{18} = \left( \frac{30,127 + 47,179}{2} \right) \times (84\% \times 0.00068\% \times 0.1638\% \times 1.655) \times 20 \times 365 \text{ day/year} \]

= 41,180,566

Design ESALs (in Design Lane) Initial Performance Period:

Design ESALs = Accumulated ESALs * D_D * D_L

41,180,566 * 0.580 * 0.90 = 21,496,255

Step 3: Condition Survey (Existing pavement)

JPCP/JRCP:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Number of deteriorated transverse joints per mile</td>
</tr>
<tr>
<td>(2)</td>
<td>Number of deteriorated transverse cracks per mile</td>
</tr>
<tr>
<td>(3)</td>
<td>Number of full-depth AC patches, exception-ally wide joints (greater than 1 inch), and expansion joints per mile (except at bridges)</td>
</tr>
<tr>
<td>(4)</td>
<td>Presence and overall severity of PCC durability problems</td>
</tr>
<tr>
<td></td>
<td>“D” cracking: low severity (cracks only), medium severity (some spalling), high severity (severe spalling)</td>
</tr>
<tr>
<td></td>
<td>Reactive aggregate cracking: low, medium, high severity</td>
</tr>
<tr>
<td>(5)</td>
<td>Evidence of faulting, or pumping of fines or water at joints, cracks, and pavement edge</td>
</tr>
</tbody>
</table>

Step 4: Deflection Testing

(With FWD or HWD set up with sensors at \(d_0, d_{12}, d_{24}, \) and \(d_{36}\) and 5.9 inch radius plate and normalized to 9,000lb.)

\[ \text{AREA} = 6 \times \left[ 1 + 2 \left( \frac{d_{12}}{d_0} \right) + 2 \left( \frac{d_{24}}{d_0} \right) + \left( \frac{d_{36}}{d_0} \right) \right] \]

Backcalculated effective Dynamic k-value for subbase and subgrade combination:

(based on \(d_0\) and AREA for 1 test per slab)

(1) Average dynamic k-value: 300 pci
(2) Average static k-value: 300/2 = 150 pci

(3) Estimated PCC slab elastic modulus: \(E_D^3 = 1.5 \times 10^9\), therefore \(E_{pcc} = 2,057,613\) psi
Joint Load Transfer

\[
\Delta L = 100 \left( \frac{\Delta u_l}{\Delta l} \right) \times B
\]

\[ B = \frac{d_0}{d_{12}} \text{ center slab deflections} \]

Average Percent Load Transfer: 62 J: 3.5
(Use load transfer restoration to improve load transfer efficiency >70%)
Restored Average Percent Load Transfer: 73 J: 3.5

Step 5: Coring and Material Testing
(based on backcalculations)

(1) PCC modulus of rupture (S’c):

\[ S'c = 43.5 \left( \frac{E}{10^6} \right) + 488.5 = S'c = 43.5 \left( \frac{2057613}{10^6} \right) + 488.5 = 578 \text{ psi} \]

Step 6: Determination of required slab thickness for future traffic, (Df)

(1) Effective static k-value beneath existing PCC slab:

150 psi
(from backcalculation in step 4)

(2) Design PSI loss: 2.0

(3) J, load transfer factor of PCC slab:

3.2
(from backcalculation in step 4)

(4) PCC modulus of rupture of existing slab:

578 psi
(based on backcalculations in step 5)

(5) Elastic modulus of existing PCC slab:

2,057,613 psi
(based on backcalculations in step 4)

(6) Loss of support of existing PCC slab:

(assume LS=0)

(7) Overlay design reliability, R: 90%

(8) Overlay standard deviation, So: 0.35

(9) Subdrainage capacity of existing slab, Cd: 1.0

**Required slab thickness for future traffic, (Df):** 11.7

*If the required slab thickness <= the existing slab thickness, no structural improvement is needed. To improve the functional ability of the pavement (ride quality), we need to consider...*
quality, skid resistance, etc), use a 4 inch overlay with longitudinal and transverse saw-and-seal]

Step 7: Determination effective slab thickness of existing pavement, \(D_{\text{eff}}\)

\[
D_{\text{eff}} = F_{\text{jc}} \cdot F_{\text{dur}} \cdot F_{\text{fat}} \cdot D
\]

Where: 
\(D\), existing PCC slab thickness, inch

(1) \(F_{\text{jc}}\), Joint and crack adjustment factor: 0.97

(2) \(F_{\text{dur}}\), Durability adjustment factor: 1.0

(3) \(F_{\text{fat}}\), Fatigue Damage Adjustment factor 0.97

\[
D_{\text{eff}} = 0.97 \cdot 1.0 \cdot 0.97 \cdot 9 = 8.46 \text{ inch}
\]

Step 8: Determination the required overlay thickness, \(D_{\text{OL}}\)

\[
D_{\text{OL}} = A(D_r-D_{\text{eff}})
\]

\[
A = 2.2233 + 0.0099(D_r-D_{\text{eff}})^2 - 0.1534(D_r-D_{\text{eff}})
\]

\[
= 2.2233 + 0.0099(11.7-8.46)^2 - 0.1534(11.7-8.46) = 1.83
\]

\[
D_{\text{OL}} = 1.83(11.7-8.46) = 5.9 \text{ inch, use 6.0 inch}
\]