Composite Overlay Pavement Design Example
<u>1993 AASHTO Pavement Design</u>

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:

		Reference:
Initial Serviceability, p_o	4.5	II-10 & NJ serviceability loss
Terminal Serviceability, p_t	2.5	II-10 & NJ serviceability loss
Reliability Level, R	90%	I-53 to I-64 or II-9, III-82 & NJ Reliability
Overall Standard Deviation, S	0.35	I-62 or II-9 & NJ Standard Deviation
Performance Period	20 years	II-5 to II-8 & NJ Performance Period

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:

Initial AADT	30,127	Based on data supplied by the NJDOT Project Manager
Final AADT	47,179	
CAR%	84	
CAR_f	0.0006	
LT%	8	
LT_f	0.163	
HT%	8	
HTf	1.655	
Year	20	
Days	365	
D_D%	58	II-7 & NJ Directional Distribution
D_L%	90	II-7, 8 & NJ Lane Distribution

- Calculate ESALs based on load equivalency factors for rigid pavements

II-7 to II-9 & D-12 to D-20 &
& NJ Directional and Lane Distribution Factors

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

$$w_{18} = \left(\frac{AADT_i + AADT_f}{2}\right) * (Car\% * Carf + LT\% * LTf + HT\% * HTf) * Years * 365 \quad day/year$$

$$w_{18} = \left(\frac{30{,}127 + 47{,}179}{2}\right) * (84\% * 0.0006 + 8\% * 0.163 + 8\% * 1.655) * 20 * 365 \, day/year$$

= 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:

(1)	Number of deteriorated transverse joints per mile	
(2)	Number of deteriorated transverse cracks per mile	
(3)	Number of full-depth AC patches, exception-ally wide joints (greater than 1 inch), and expansion joints per mile (except at bridges)	
(4)	Presence and overall severity of PCC durability problems (a) "D" cracking: low severity (cracks only), medium severity (some spalling), high severity (severe spalling) (b) Reactive aggregate cracking: low, medium, high severity	
(5)	Evidence of faulting, or pumping of fines or water at joints, cracks, and pavement edge	

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.)

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

<u>Backcalculated effective Dynamic k-value for subbase and subgrade combination</u>:
(based on d_0 and AREA for 1 test per slab)

Figure 5.10, page III-118 and
Figure 5.11, page III-119

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

(3) Estimated PCC slab elastic modulus: ED^3=1.5x10^9 , therefore E_{pcc}=2,057,613 psi

(4) Joint Load Transfer

$$\Delta LT = 100 * \left(\frac{\Delta ul}{\Delta l} \right) * B \qquad B = \frac{d_0}{d_{12}} \textit{ center slab deflections}$$

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, (D_f)

(1) Effective static k-value beneath existing PCC slab: (from backcalculation in step 4)	150 pci
(2) Design PSI loss:	2.0
(3) J, load transfer factor of PCC slab: (from backcalculation in step 4)	3.2
(4) PCC modulus of rupture of existing slab: (based on backcalculations in step 5)	578 psi
(5) Elastic modulus of existing PCC slab: (based on backcalculations in step 4)	2,057,613 psi
(6) Loss of support of existing PCC slab:	(assume LS=0)
(7) Overlay design reliability, R	90%
(8) Overlay standard deviation, S_o	0.35
(9) Subdrainage capacity of existing slab, C_d	1.0

Required slab thickness for future traffic, (D_f): 11.7 Figure 3.7, Page II-45 &46

***[If the required slab thickness <= the existing slab thickness, no structural improvement is needed. To improve the functional ability of the pavement (ride**

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_{eff})

$D_{eff}=F_{jc}*F_{dur}*F_{fat}*D$

Where: D, existing PCC slab thickness, inch

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

Figure 5.12, page III124

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

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

$D_{eff}=F_{jc}*F_{dur}*F_{fat}*D$ =0.97*1.0*0.97*9= 8.46 inch

Step 8: Determination the required overlaythickness, (D_{OL})

$D_{OL} = A(D_f-D_{eff})$

$A = 2.2233+0.0099(D_f-D_{eff})^2-0.1534(D_f-D_{eff})$
$= 2.2233+0.0099(11.7-8.46)^2-0.1534(11.7-8.46) = 1.83$

$D_{OL} = A(D_f-D_{eff}) = 1.83(11.7-8.46) = 5.9$ inch, use 6.0 inch