measured deflection without any regard to the shape of the deflection basin which determines the actual state of stresses and strains in the pavements. Also, different "types" of flexible pavements have been shown to have different deflection-traffic curves (e.g., cement-treated base, full-depth AC, lean concrete base). Different climates also result in different performance: contrast the AASHTO Road Test's (Illinois') wet-freeze climate to that of Southern California's dry-nonfreeze climate. Finally, this method does not directly consider the material properties of the existing pavement or of the proposed overlay.

## 6.0 RIGID OVERLAYS FOR FLEXIBLE PAVEMENTS

The structural overlay analysis procedure for this overlay method uses the existing flexible pavement as the composite foundation support for a new rigid pavement. Some milling and/or level-up of the existing AC pavement may be necessary if severe distortions exist. The design analysis consists of determining the design (composite) modulus of reaction ($k_c$) of the existing pavement and then following the AASHTO procedures to design the PCC overlay as a new rigid pavement.

NDT deflection testing is the most efficient means to evaluate the composite modulus of reaction ($k_c$) of the existing pavement. In this situation, it is not necessary to examine the entire deflection basin as only the maximum deflection under the load is used to establish the $k_c$ value. The maximum deflection value is corrected for temperature and used to determine the composite modulus of reaction. Specific details for determining $k_c$ is discussed in Reference 1. Once the $k_c$ value has been obtained, the overlay design is treated as a new rigid pavement design.

## 7.0 EXAMPLE PROBLEMS

### 7.1 AASHTO Design Procedure

Note: this is a simplified example in that the procedures to determine the inputs are not considered or illustrated. See the AASHTO Design Guide (1) for further details.

**Step 1 -- Collect basic information and design criteria**

Two-lane highway, age = 15 years

Existing pavement: 4 inches AC surface
10 inches crushed stone base
10 inches gravel sand subbase

Roadbed soil: Silty clay

Existing serviceability index: 2.6

Accumulated 18-kip ESAL: 1.3 million one direction

Design period: 10 years

Design 18-kip ESAL: 5 million one direction

See Figure 20 for illustration.

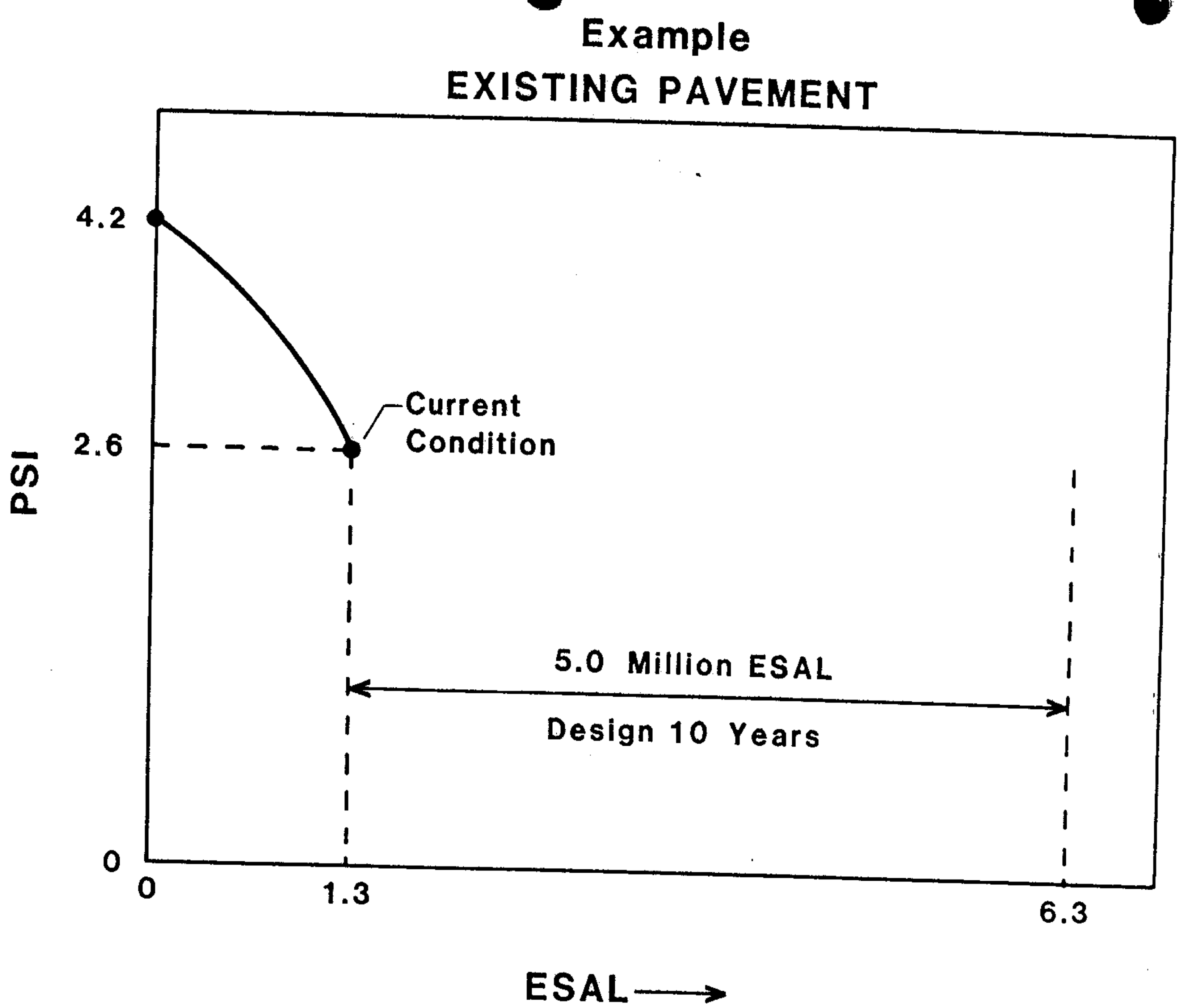


Figure 20. Design Criteria for AASHTO Design Example.

**Step 2 -- Determine required $SN_y$ for 10 year design period**

Use Figure 2 AASHTO thickness design nomograph to determine $SN_y$.

Design reliability = 95 percent
Overall standard deviation = 0.35
Design 18-kip ESAL over 10 years = 5 million
Roadbed soil effective resilient modulus = 5000 psi
Loss of serviceability = 4.4 (after overlay) - 2.5 (terminal) = 1.9

Solution: $SN_y = 5.0$

**Step 3 -- Determine the effective SN of the existing pavement**

$$SN_{xeff} = a_1D_1 + a_2D_2m_2 + a_3D_3m_3$$

where:

$D_i$ = layer thickness determined from coring/boring
$a_1$ = structural coefficient determined from deflection testing and backcalculation of E's for layers
$m_i$ = drainage coefficients determined from:
(1) drainage time of layer
(2) percent time layer is saturated

Corings and borings through the depth of the pavement and into the roadbed soil were taken along the project. Falling Weight Deflectometer (FWD) tests were also conducted along project and the deflection basins analyzed. The moduli of the pavement and roadbed soil layers were backcalculated using an elastic layer procedure. Results of these tests are as follows (all values are averages obtained):

| Layer | Core/Bore Thickness | Backcalculated Modulus | Estimated $a_i$ |
|---|---|---|---|
| AC | 4.1 inches | 405,000 psi | 0.42* |
| Crushed Stone | 9.8 inches | 30,000 psi | 0.14* |
| Gravel Sand | 10.5 inches | 11,000 psi | 0.08* |
| Roadbed soil | | 7,500 psi | |

* The structural coefficients were determined by modulus correlations using Figures 4, 5 and 8.

The deflection data were taken during the early summer period and only an adjustment in the resilient modulus of the roadbed soil is deemed necessary. The effective resilient modulus was determined to be 5000 psi using the procedure recommended in the AASHTO Design Guide.

Drainage coefficients were estimated for the base and subbase layers as follows using Figure 3.

| Layer | Quality of Drainage | Percent Time Saturation | $m_i$ |
|---|---|---|---|
| Crushed Stone | Fair | > 25 % | 0.8 |
| Gravel Sand | Poor | > 25 % | 0.6 |

$SN_{xeff} = (0.42 \times 4.1) + (0.14 \times 9.8 \times 0.8) + (0.08 \times 10.5 \times 0.6) = 3.3$

**Step 4 -- Determine the remaining life factor, $F_{RL}$**

The $F_{RL}$ depends upon: $R_{Lx}$ = percent remaining life of existing pavement (0 - 100)

$R_{Ly}$ = percent remaining life of overlaid pavement (0 -100)

The plot in Figure 21 shows the concepts and calculation of $R_{Lx}$, percent remaining life of the existing pavement.

The plot in Figure 22 shows the concepts and calculation of $R_{Ly}$, percent remaining life of the overlaid pavement.

The $F_{RL}$ is then determined using Figure 13 (it is recommended to ignore the upward curve of the ends of the lines and simply extend them horizontally).

$$F_{RL} = 0.64$$

**Step 5 -- Computation of final overlay design thickness**

$$SN_{ol} = 5.0 - (0.64 \times 3.3) = 2.9$$

$$SN_{ol} = a_{ol} D_{ol}$$

The overlay thickness is computed assuming its elastic modulus is 450,000 psi at 68$^{o}$F. The structural coefficient is 0.44 for asphalt concrete (see Figure 4).

$$D_{ol} = 2.9 / 0.44 = 6.5 \text{ ins.}$$