Example: A 6 in. layer of cement-treated granular material is to be used as subbase for a rigid pavement. The monthly values for the roadbed soil resilient modulus and the subbase elastic (resilient) modulus are given in columns 2 and of Table 2.11. If the rock depth is located 5 ft. below the subgrade surface and the projected slab thickness is 9 in. Estimate the effective modulus of subgrade reaction using the AASHTO method

Table 2.11

Month	Roadbed Modulus M_r (Ib/in^2	Subbase Modulus E_{SB} (Ib/in^2	Composite k Value (Ib/in2) Figure 2.24	k Value (E_{SB}) on Rigid Foundation Figure (2.26)	Relative Damage u_r Figure (2.27)
Jan	20,000	50,000	**1100**	**1350**	**0.35**
Feb.	20,000	50,000	**1100**	**1350**	**0.35**
Mar.	2,500	15,000	**160**	**230**	**0.86**
Apr	4,000	15,000	**230**	**300**	**0.78**
May	4,000	15,000	**230**	**300**	**0.78**
Jun.	7,000	20,000	**400**	**500**	**0.6**
Jul.	7,000	20,000	**400**	**500**	**0.6**
Aug.	7,000	20,000	**400**	**500**	**0.6**
Sep	7,000	20,000	**400**	**500**	**0.6**
Oct.	7,000	20,000	**400**	**500**	**0.6**
Nov.	4,000	15,000	**230**	**300**	**0.78**
Dec.	20,000	15,000	**1100**	**1350**	**0.35**
Total					**7.25**

Type: Granular

Thickness of subbase (in) = 6

Loss of Support, L.S=1.0

Depth to rigid foundation (ft) =5

Projected Slab thickness (in) = 9

Average: $\bar{u}_r = \frac{\sum u_r}{n} = \frac{7.25}{12} = 0.6$

Therefore, Effective modulus of subgrade reaction *k* (Ib/in^2) =500

Corrected for loss of support: *k* (Ib/in^2) = 170

Concrete properties

Flexural strength (modulus of rupture) and elastic modulus at 28-day is used to represent the property of concrete.

Drainage

The concept of introducing the drainage into pavement design guide is similar to that discussed previously in flexible pavement design. However, the drainage coefficient (C_d) is determined from Table 2.12

Table 2.12: Recommended values for drainage coefficient Cd for rigid pavements

Quality of Drainage	Percent of Time Pavement Structure is Exposed to Moisture Levels Approaching Saturation			
	Less Than 1%	1–5%	5–25%	Greater Than 25%
Excellent	1.2–1.20	1.20–1.15	1.15–1.10	1.10
Good	1.20–1.15	1.15–1.10	1.10–1.00	1.00
Fair	1.15–1.10	1.10–1.00	1.00–0.90	0.90
Poor	1.10–1.00	1.00–0.90	0.90–0.80	0.80
Very poor	1.00–0.90	0.90–0.80	0.80–0.70	0.70

SOURCE: Adapted from *AASHTO Guide for Design of Pavement Structures*, American Association of State Highway and Transportation Officials, Washington, D.C., 1993. Used with permission.

Reliability

This concept is as discussed in flexible pavement design

Structural pavement design

AASHTO pavement design guide suggest the following equation to determine the slab thickness

$$\log_{10} W_{18} = Z_R S_o + 7.35 \log_{10}(D+1) - 0.06 + \frac{\log_{10}[\Delta PSI/(4.5-1.5)]}{1 + [(1.624 \times 10^7)/(D+1)^{8.46}]} + (4.22 - 0.32P_t)\log_{10}\left\{\frac{S'_c C_d}{215.63J}\left(\frac{D^{.75} - 1.132}{D^{.75} - [18.42/(E_c/k)^{.25}]}\right)\right\}$$

Where:

Z_R = standard normal variant corresponding to the selected level of reliability
S_o = overall standard deviation (see flexible pavement design)
W_{18} = predicted number of 18 kip ESAL applications that can be carried by the pavement structure after construction
D = thickness of concrete pavement to the nearest half-inch
ΔPSI = design serviceability loss = $p_i - p_t$
p_i = initial serviceability index
p_t = terminal serviceability index
E_c = elastic modulus of the concrete to be used in construction (lb/in^2)
S'_c = modulus of rupture of the concrete to be used in construction (lb/in^2)
J = load transfer coefficient = 3.2 (assumed)
C_d = drainage coefficient

The above equation can be solved to obtain the thickness (*D*) in inches by using either a computer program or the two charts in Figure 2.28 and Figure 2.29.

Example: Design a rigid pavement using AASHTO method using following Data:

Effective modulus of subgrade reaction, k = 72 Ib/in^3

Mean concrete modulus of rupture, S_c' = 650 Ib/in^2

Load transfer coefficient, J= 3.2

Drainage coefficient, C_d= 1.0

These values are used to determine a value on the match line as shown in Figure 2.28 (Segment 1), (Sold line ABCDEF)

Input parameters for segment 2 (Figure 2.29) on the chart are:

Match line value determined in segment 1 (74)

Design serviceability loss ΔPSI = 4.5-2.5=2

Reliability, *R%* =95% (Z_R= 1.645)

Overall standard deviation, $S_\circ$ = 0.29

Cumulative 18 kip ESAL = 5* 10^6

Based on above values, the required thickness slab is then obtained as shown in figure 2.29, as 10 in. (nearest half-inch)

Q: it is required to design a flexible pavement structure for a rural highway to carry a traffic load of 6*106, expressed in terms of ESAL. Experiemental results showed that the water takes about a month to drain from within the pavement structure. Weather forecasts indicated that the pavement structure may be saturated for 10% of the time. All other required information resulted from basic characterization is shown in figure below. Using ASSHTO 1993 pavement design guide to estimate thicknesses of pavement layers. Use P_i =4.5, p_t=2.5 and $S_\circ$=0.45