University Of Technology
Building and Construction Eng. Dept.
Final Exam – First Attempt – 2010/2011

Subject : Pavement Design — Class: 3rd Class
Highways and Bridges Branch — Time : 3 Hours
Date : 15/6/ 2011

Note: Answer FOUR questions only.
(Question 1 must be included)

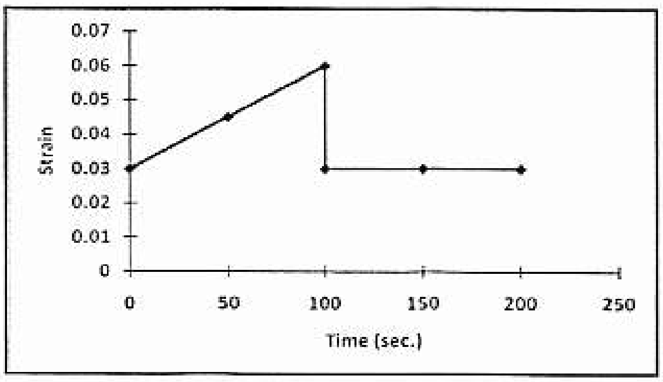
Q1:

A flexible pavement for a rural interstate highway is to be designed using the 1993 AASHTO guide procedure to carry a design ESAL of 5×10^6. It is estimated that it takes about one day for water to be drained from within the pavement and the pavement structure will be exposed to moisture levels approaching saturation for 35% of the time. The following additional information is available:

Resilient modulus of asphalt concrete at 68 ^{0}F = 450 000 lb/in^2.
CBR value of base course material = 100, M_r = 31 000 lb/in^2.
CBR value of subbase course material = 22, M_r = 13 500 lb/in^2.
M_r of subgrade = 5 000 lb/in^2.
Standard deviation (S_0) = 0.35, Reliability level (R%) = 95 %.
Initial serviceability index P_i = 4.5
Terminal serviceability index P_t = 2.6
Determine a suitable pavement structure.

Q2:

a. **The following figure represents the strain-time relationship for paving material after applying a shear stress of 300 dyne/cm^2. Show the model representing this behavior and determine the constants for this model with units.**



b. **prove that:**

$$\% \, Air \, voids = \left[1 - \frac{bulk \, G_M}{\max . G_M}\right] \times 100$$

Q3:

a. The percent passing of available aggregate is as presented in table below. The specification requirements of each sieve also presented in the table. Show the final aggregate gradation to satisfy the job mix formula requirements:

Sieve size	% Passing	
	Available aggregate	Specification
1"	100	100
3/4	95	90-100
3/8	80	70-90
No.4	40	60-70
No.50	30	20-50
No.200	5	4-10

b. Draw a relation represents the temperature susceptibility of asphalt.

Q4:

a. Explain the procedure for stabilizing soils with cement.
b. By the aid of drawing compare between contraction and expansion joints in rigid pavements.

Q5:

Design of a flexible pavement consisting of asphalt concrete surface and lime treated base, using the California (Hveem) method. The ESAL is 4×10^6, the results of a stabilometer test on the subgrade soil are:

Moisture content (%)	R value	Exudation pressure (lb/in^2)	Expansion pressure (lb/in^2)	GE (ft) from equation	Expansion pressure thickness (ft)
19.8	62	575	1.03	1.3	1.00
22.1	45	435	0.30	1.9	0.15
24.9	9	165	0.00	3.1	0.10

Assume the R value for the lime treated base of 80.

Material	G_f
Lime – treated base	1.2
Untreated aggregate base	1.1
Aggregate subbase	1.0
Asphalt concrete for TI of ≤ 5.0	2.54
5.5-6.0	2.32

Material	G_f
6.5-7.0	2.14
7.5-8.0	2.01
8.5-9.0	1.89
9.5-10.0	1.79
10.5-11.0	1.71

Table1: Standard Normal Deviation (Z_R) Values Corresponding to Selected Levels of Reliability

Reliability (R%)	Standard Normal Deviation (Z_R)	Reliability (R%)	Standard Normal Deviation (Z_R)
50	0.000	93	-1.476
60	-0.253	94	-1.555
70	-0.524	95	-1.645
75	-0.674	96	-1.751
80	-0.841	97	-1.881
85	-1.037	98	-2.054
90	-1.282	99	-2.327
91	-1.340	99.9	-3.090
92	-1.405	99.99	-3.750

Table2: Standard Deviation Values for Pavements.

	Standard Deviation S_0
Flexible pavement	0.4 – 0.5
Rigid pavement	0.3 – 0.4

Table3: Suggested Levels of Reliability for Various Functional Classification

Recommended Level of Reliability		
Functional Classification	Urban	Rural
Interstate and other freeways	85-99.9	80-99.9
Other principal arterials	80-99	75-95
Collectors	80-95	75-95
Local	50-80	50-80

Table4: Definition of Drainage Quality:

Quality of Drainage	Water Removed Within
Excellent	2 hours
Good	1 day
Fair	1 week
Poor	1 month
Very poor	Water will not drain

Table5: Recommended m_i Values

Percent of time pavement structure is exposed to moisture levels approaching saturation				
Quality of drainage	Less than 1 percent	1-5 percent	5-25 percent	Greater than 25 percent
Excellent	1.40-1.35	1.35-1.30	1.30-1.20	1.20
Good	1.35-1.25	1.25-1.15	1.15-1.00	1.00
Fair	1.25-1.15	1.15-1.05	1.00-0.80	0.80
Poor	1.15-1.05	1.05-0.80	0.80-0.60	0.60
Very poor	1.05-0.95	0.95-0.75	0.75-0.40	0.40

NOMOGRAPH SOLVES:

$$\log_{10} W_{18} = Z_R{*}S_o + 9.36{*}\log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32{*}\log_{10}M_R - 8.07$$

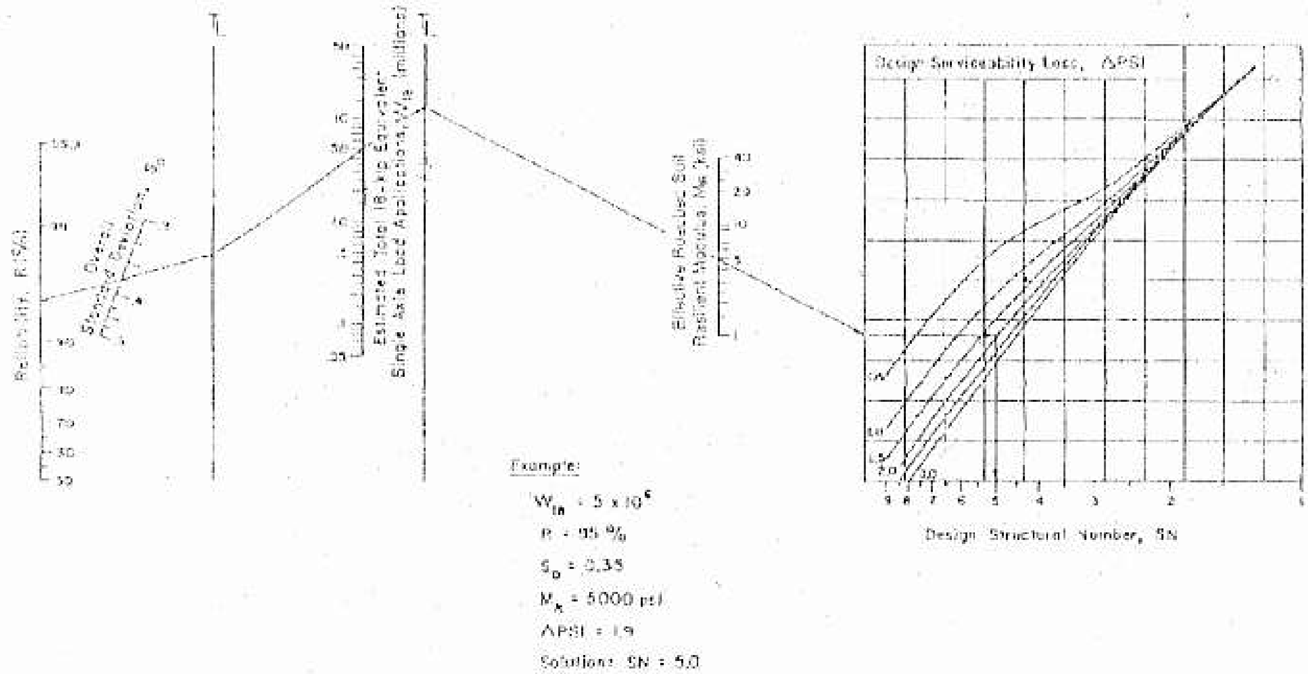


Figure 1 Design Chart for Flexible Pavements Based on Using Mean Values for Each Input

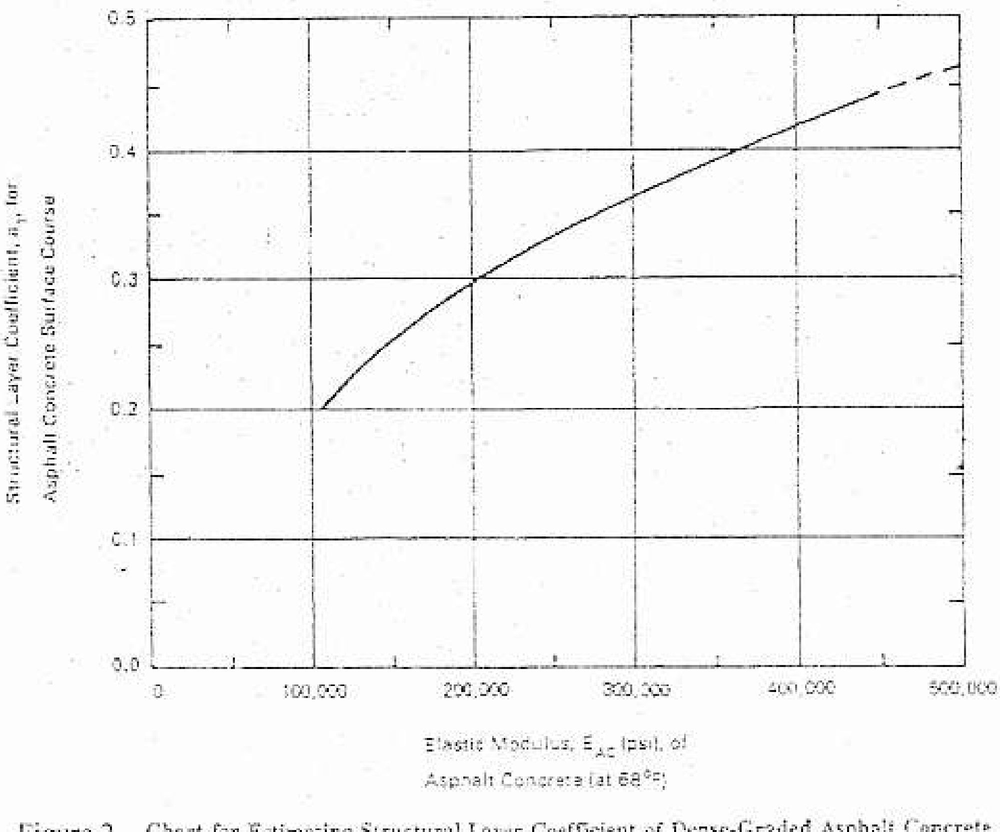
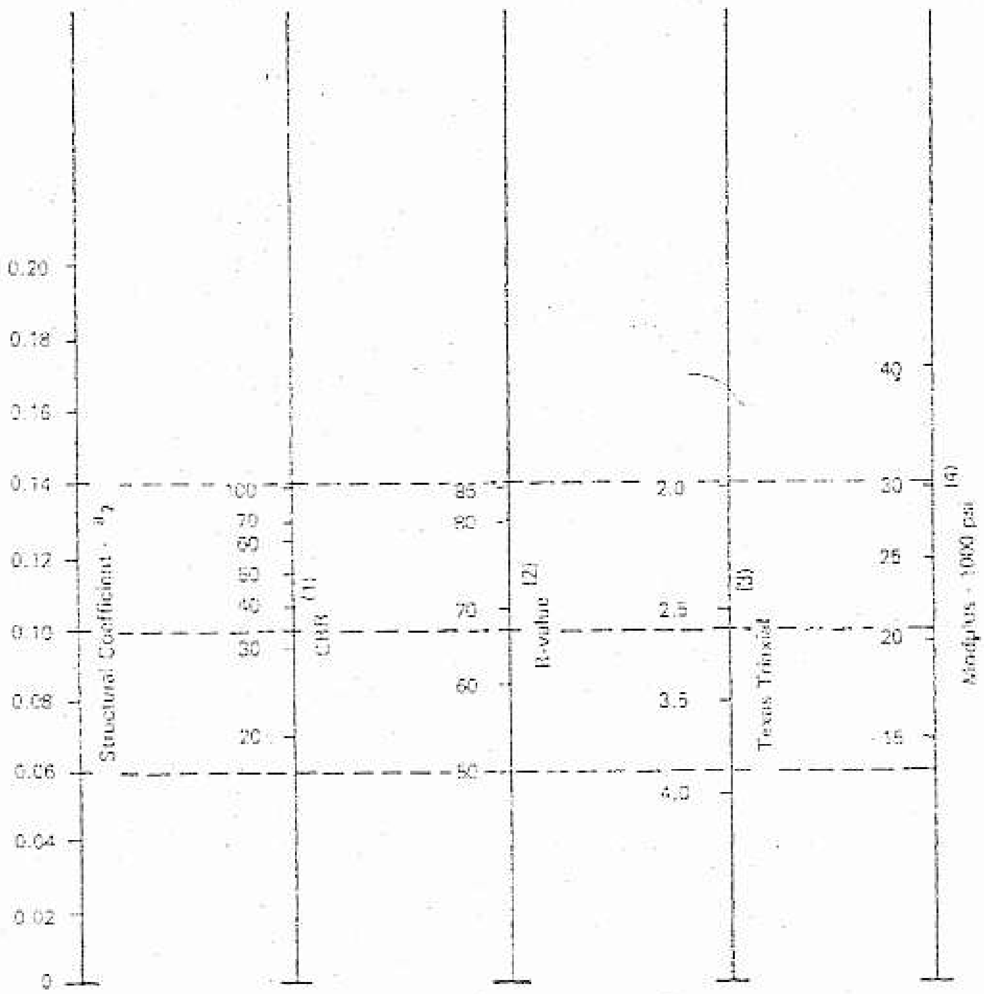
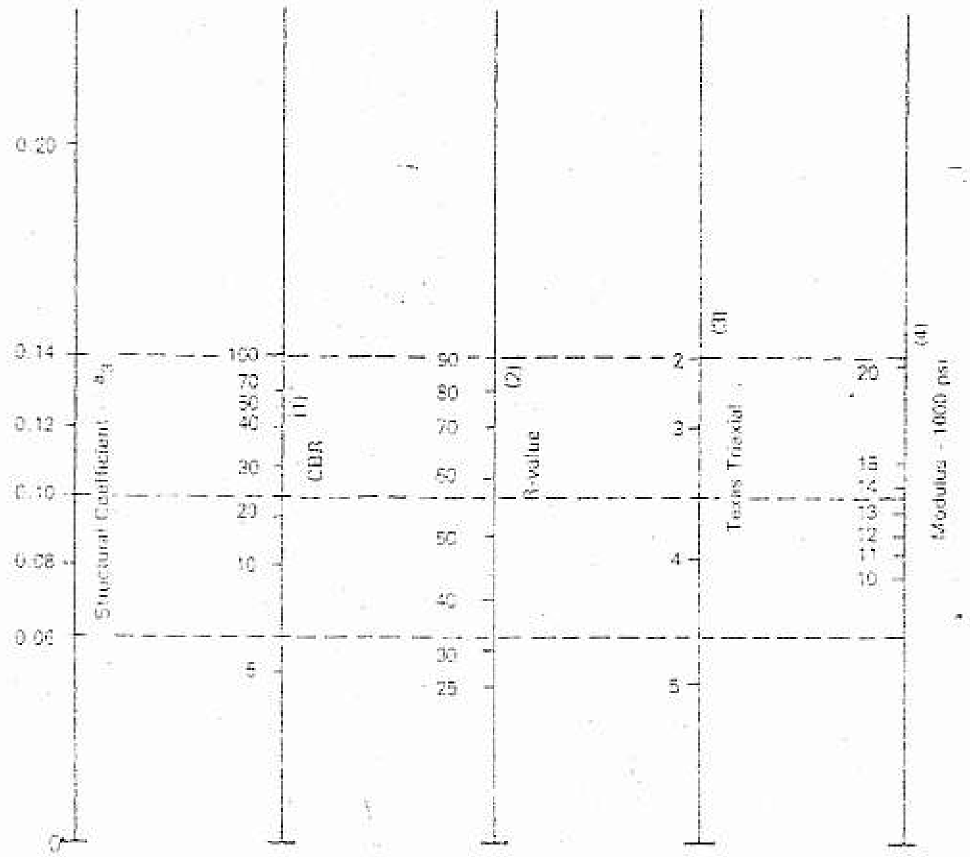


Figure 2 Chart for Estimating Structural Layer Coefficient of Dense-Graded Asphalt Concrete Based on the Elastic (Resilient) Modulus (3)



(1) Scale derived by averaging correlations obtained from Illinois
(2) Scale derived by averaging correlations obtained from California, New Mexico and Wyoming
(3) Scale derived by averaging correlations obtained from Texas
(4) Scale derived on NCHRP project (3).

Figure 3 Variation in Granular Base Layer Coefficient (a_2) with Various Base Strength Parameters (3)



(1) Scale derived from correlations from Illinois

(2) Scale derived from correlations obtained from The Asphalt Institute, California, New Mexico and Wyoming.

(3) Scale derived from correlations obtained from Texas

(4) Scale derived on NCHRP project (3).

Figure 4 Variation in Granular Subbase Layer Coefficient (a_3) with Various Subbase Strength Parameters (3)