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

Subject: Highway Eng. Class: 3rd
Branch: Construction Eng. & Management Time : 3 Hours
Examiner: Ali M. K. Date : 4/6/2011

Note: Attempt four questions only

Q1: (a) Define or explain each of the following: **(15 marks)**
(1) Asphalt grade, (2) Softening point, (3) Trip generation, (4) Capacity, (5) Liquid asphalt.

(b) What are the factors that affect the determination of Passing Sight Distance (PSD)? **(5 marks)**

(c) What are the factors that the adhesion failure of the asphalt concrete depends on? **(5 marks)**

Q2: The aggregate mix used for the design of an asphaltic concrete mixture consists of 45% coarse aggregate, 50% fine aggregate, and 5% mineral fillers. If the respective bulk specific gravities of these materials are 2.60, 2.71, and 2.69, determine the optimum asphalt content as a percentage weight of the total mix to product an asphaltic concrete mixture complying with the specifications shown below. The test results obtained using the Marshall method and the maximum specific gravity of paving mixture are shown below. The specific gravity of asphalt is 1.02. **(25 marks)**

Specifications: Min. Stability=8 kN, Flow (mm)=2-4, % Air Voids=3-5%, Min. %VMA=10.0%.

% by wt. of asphalt	Wt. of sample in air (gm)	Wt. of sample in water (gm)	Stability (kN)	Flow (mm)	Max. specific gravity of mixture
4.0	1325.3	785.6	9.57	3.25	2.57
4.5	1330.1	793.3	9.80	3.50	2.55
5.0	1336.2	800.8	9.93	4.00	2.53
5.5	1342.0	804.5	9.70	5.00	2.51
6.0	1347.5	805.1	9.10	6.25	2.49

Q3: For the end areas of highway earthwork construction shown below, complete the calculations to find the cumulative volume of the earthwork for 10% shrinkage factor, and draw the mass haul diagram and the longitudinal profile of the highway. If you know that the waste volume and free haul distance in this earthwork is 2766m^3 and 500m respectively, find the freehaul volume, overhaul volume, Limit of Economic Haul, and borrow volume. **(25 marks)**

Station	14+00	18+00	20+00	24+00	28+00	30+00
Cut area (m^2)	0	0	1	0	16	22
Fill area (m^2)	4	2.5	0	7.8	0	0

Q4: According to AASHTO guide for structural design of flexible pavement 1993, design a suitable pavement structure for an urban freeway highway to carry the traffic volumes shown below on the design direction with a design lane factor of 45% for a design period of 30 years. It is estimated that the quality of drainage of pavement layers is good and the pavement structure will exposed to moisture levels approaching saturation for 30% of time. The CBR values of subgrade, subbase, and base materials are 5%, 30%, 100% respectively, and the resilient modulus of asphalt concrete surface layer is

$450*10^3$ psi. The expected annual traffic growth rate is 3% for all types of vehicles. **(25 marks)**

Type of vehicle	Passenger cars	Truck veh. type 1	Truck veh. type 2	Truck veh. type 3
No. of vehicles	700 veh./day	250 veh./day	350 veh./day	300 veh./day
Truck factor	?	0.90	4.25	3.00

Q5: (a) A driver traveling at a speed of 80 kph is trying to overtake the vehicle in front of him. The speed of the overtaken vehicle is 60 kph. The acceleration rate of the overtaking vehicle is 3.1 km/hr/sec, and the vehicle spent 0.05 minutes to move to the opposing lane and 0.15 minutes traveling on it. If you know that the distance between the overtaking and the opposing vehicles before the beginning of the overtaking process is 500 meters. Is this distance adequate to complete the overtaking process? Show that by calculations. **(15 marks)**

(b) The relationship between volume (Q) and speed (V) on a given highway was found to be: $Q = 35.4V - 0.65V^2$. Calculate the capacity of this highway. **(10 marks)**

Functional classification	Recommended level of reliability	
	Urban	Rural
Interstate/freeways	85–99.9	80–99.9
Principal arterials	80–99	75–95
Collectors	80–95	75–95
Local	50–80	50–80

TABLE 3.25 Recommended m_i Values for Modifying Structural Layer Coefficients of Untreated Base and Subbase Materials in Flexible 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	1.40–1.35	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

Source: *Guide for Design of Pavement Structures*, American Association of State Highway and Transportation Officials, Washington, D.C., 1993, with permission.

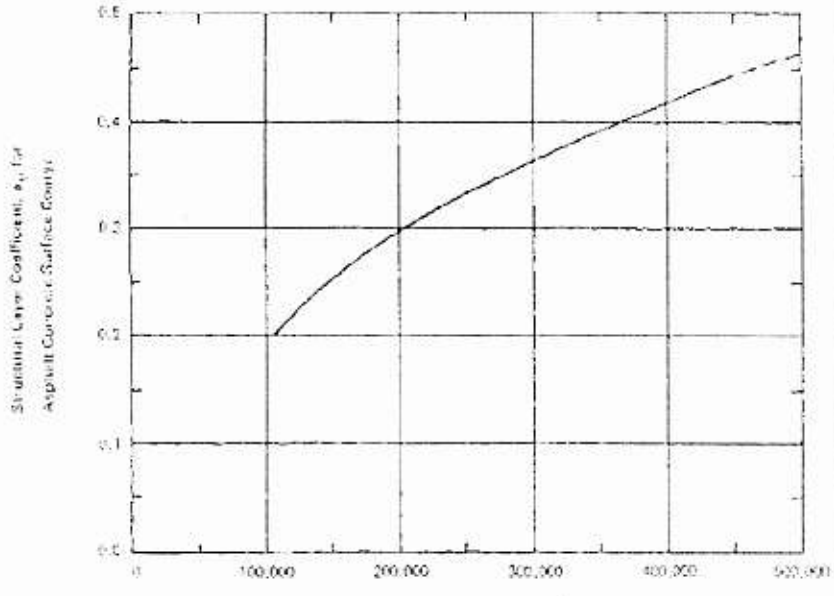
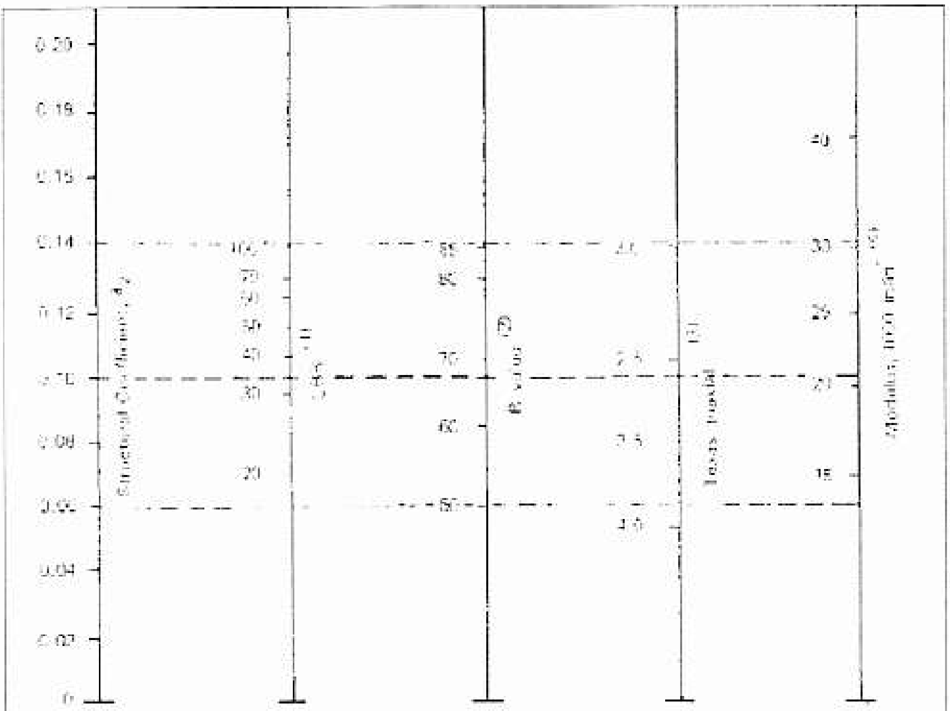
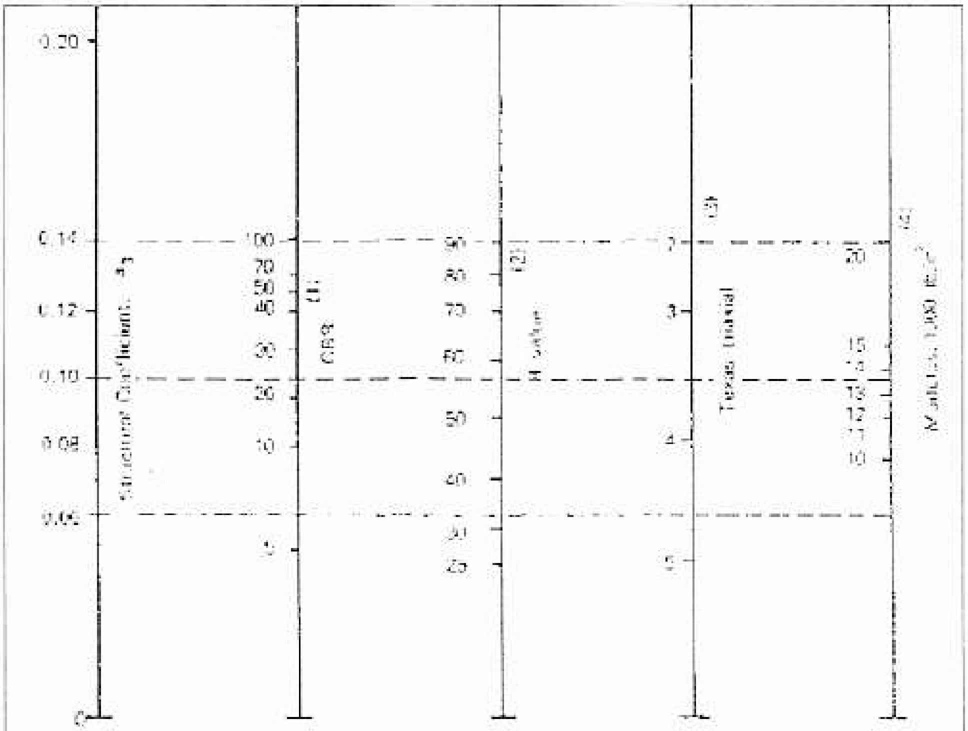


FIGURE 3.18 Chart for estimating structural layer coefficient for dense-graded asphalt concrete based on its resilient modulus (*Guide for Design of Pavement Structures*, American Association of State Highway and Transportation Officials, Washington, D.C., 1993, with permission).



(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.

FIGURE 3.19 Variation in granular base layer coefficient (a_2) with various base strength parameters. (From Guide for Design of Pavement Structures, American Association of State Highway and Transportation Officials, Washington, D.C., 1993, with permission.)

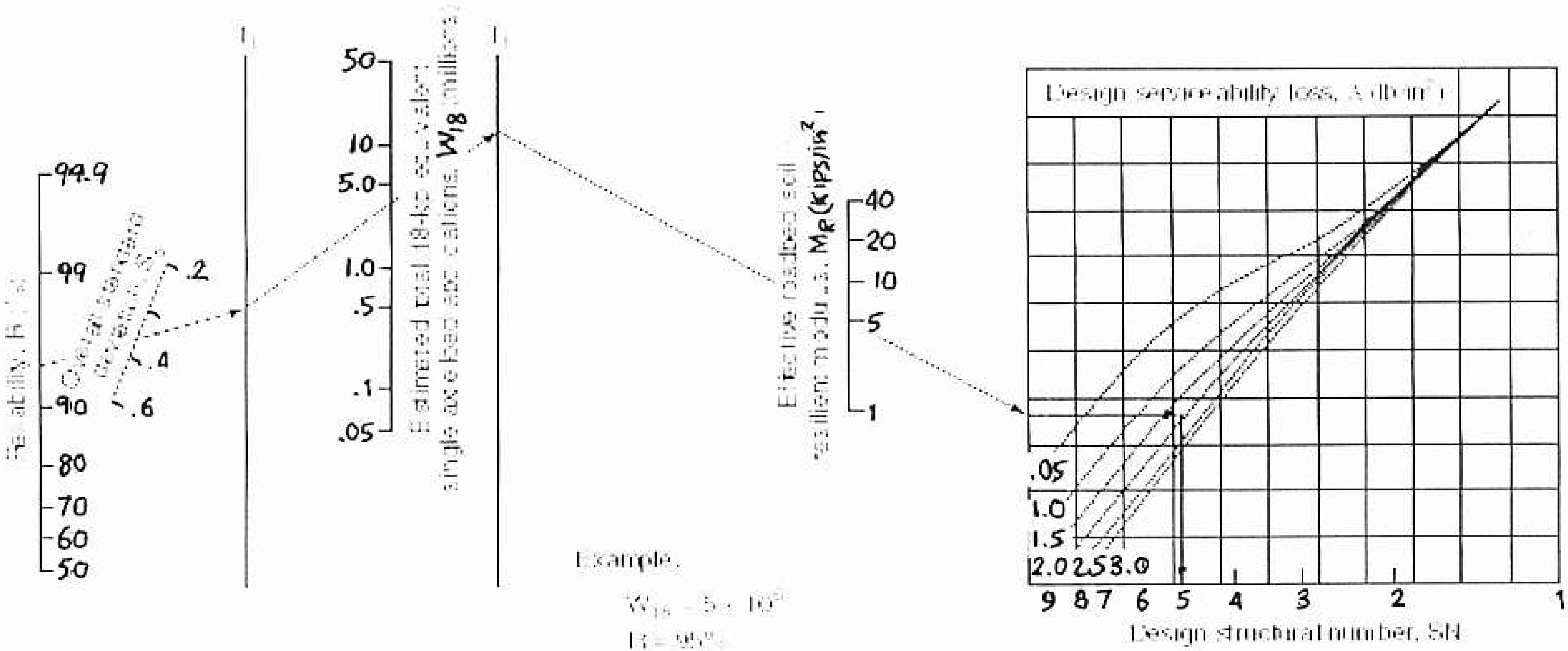


(1) Scale derived from correlations from Illinois.
(2) Scale derived from correlations obtained from the Asphalt Institute, California, New Mexico, and Wyoming.
(3) Scale derived from correlations obtained from Texas.
(4) Scale derived on NCHRP project.

FIGURE 3.20 Variation in granular subbase layer coefficient (a_3) with various subbase strength parameters. (From Guide for Design of Pavement Structures, American Association of State Highway and Transportation Officials, Washington, D.C., 1993, with permission.)

Nomograph solves:

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



Example:

$W_{18} = 5 \times 10^6$

$R = 95\%$

$S_o = 0.35$

$M_R = 5000$ lb/in²

$\Delta PSI = 1.9$

Solution: SN = 5.0

FIGURE 3.19 Design chart for flexible pavements based on using mean values for each variable. (From Guide for Design of Pavement Structures, American Association of State Highway and Transportation Officials, Washington, D.C., 1993. With permission.)

Good Luck…