National Examinations – May 2012

98-Civ-B7, Highway Engineering

3 Hour Duration

NOTES

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper a clear statement of any assumptions made.

2. Any data, not given but required, can be assumed.

3. This is an **"OPEN BOOK"** examination. Any non-communicating calculator is permitted.

4. A total of **five** solutions is required. Only the first five as they appear in your answer book will be marked.

5. All questions are of equal value.

1. **Superelevation development**

Given the following data for a horizontal highway circular curve with a transition spiral:
Deflection angle = 20^0 to the right
Radius of the curve = 400 m
Station A is at 4+100.000 m (the distance between stations is 1000 m)
Elevation of the centerline of the road at Station A = 100.000 m
Two-lane road, 7.5 m wide
Normal cross-slope = 0.02 m/m
Length of spiral = 50 m
Superelevation = 0.050 m/m

The superelevation is developed as shown in Figure 1 (b), (c), (d) by revolving the pavement about the centerline, revolving the pavement about the inside edge, and revolving the pavement about the outside edge, respectively.

Referring to Figure 1(b), determine the stations at B, C and D for the three cases shown in Figures 1(b), (c) and (d). Also determine the **elevations of the centerline, inside edge and outside edge** at stations A, B, C, and D.

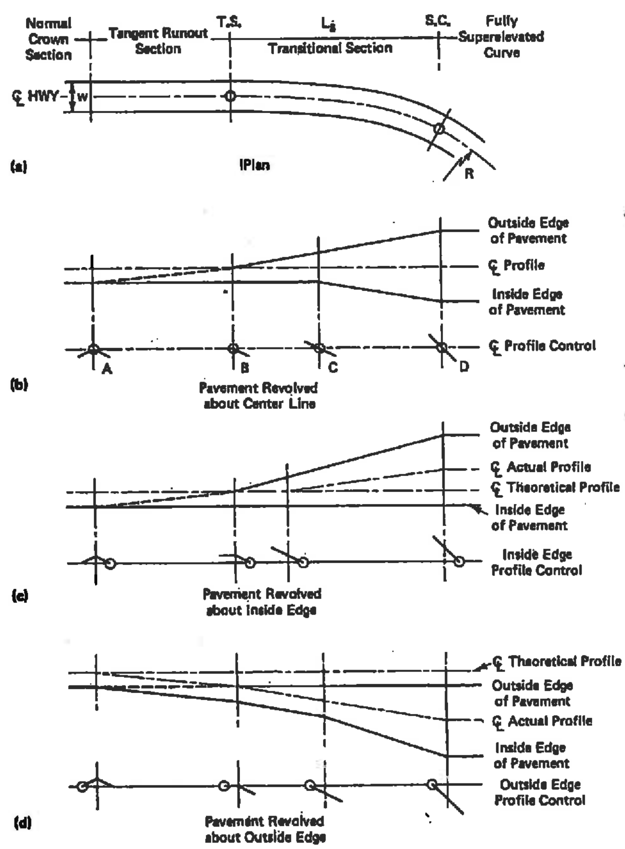


Figure 1

2. **Sag vertical curve**

PVI= 7+50.000 m (Each station is 100 m)
Elevation of PVI = 200.000
Length of vertical curve = 400 m
g1 = -3% and g2 =+2%

(a) Compute the elevation of the curve at every 50 m.
(b) Locate the station and elevation of the lowest point.
(c) What is the rate of change of grade?

3. **Blending of aggregates to meet specification limits**

(a) The following table shows the grain size distribution for two aggregates and the specification limits for an asphalt concrete. Determine the minimum and maximum proportions of the two aggregates to satisfy the specification limits.

Percent passing									
Sieve size									
	19 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	0.60 mm	0.30 mm	0.15 mm	0.075 mm
Spec. limits	100	80-100	70-90	50-70	35-50	20-30	15-25	10-15	5-10
Aggregate A	100	100	100	80	65	40	35	20	10
Aggregate B	100	90	55	25	5	0	0	0	0

(b) On a semi-log gradation graph (attached), plot the gradations of
(i) aggregate A,
(ii) aggregate B,
(iii) the selected blend and
(iv) the specification limits.

4. **Earthwork**

The following are the end areas. Calculate the volumes of cut and fill between stations 352 + 00 and 353 + 50 by **the average end area method or pyramid volume** as appropriate. If the material shrinks 10 %, how much excess cut or fill is there?

	End area, m^2	
Station	Cut	Fill
352 + 00		60
352 + 50		50
352 + 75	0	25
353 + 00	10	5
353 25	15	0
353 + 50	35	

5. **Asphalt binders**

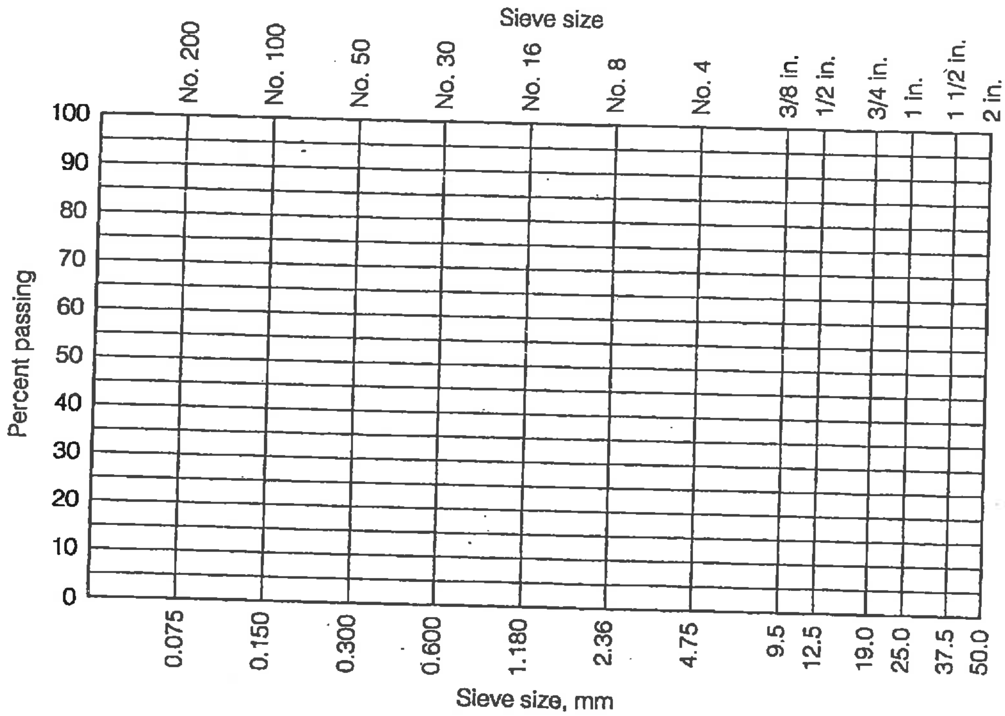
(a) Distinguish between hot mix asphalt and cold mix.
(b) Distinguish between CRS-2 and SS-1.
(c) Discuss how asphalt emulsions work as a binder in asphalt mixes.
(d) For asphalt concrete, explain (with sketches if necessary) (i) air voids, (ii) voids in mineral aggregate, and (iii) voids filled with asphalt.
(e) What are the ingredients of asphalt cutbacks?
(f) What are the ingredients of asphalt emulsions?
(g) Why is asphalt emulsion preferred over asphalt cutback?
(h) Are soft asphalt cements used in cold climates or hot climates?
(i) Define the four methods used to grade asphalt binders?
(j) Why is it important to have optimum binder content in hot mix asphalt? What would happen if less or more than the optimum value is used?

6. **Asphalt mix analysis**

A compacted asphalt mixture has bulk specific gravity of 2.329.
Specific gravity of asphalt = 1.015
Binder = 5% by weight of total mix
Aggregate effective specific gravity = 2.731
Aggregate bulk specific gravity = 2.705
Calculate
(a)Percentage of binder by weight of aggregate
(b) maximum specific gravity of the mix
(c) Percent voids in mineral aggregate
(d) Percent voids filled with asphalt
(e) Percentage of absorbed binder

7. **Concrete pavement thickness design**

(a) Why is air-entrained concrete used for concrete pavements?
(b) What is the modulus of subgrade reaction?
(c) Distinguish between transverse contraction joints, transverse construction joints, transverse expansion joints and longitudinal joints. State clearly the purpose of each of the joints.
(d) Explain pumping of joints.
(e) What are the criteria for the thickness of concrete pavements?
(f) Define modulus of rupture of concrete.
(g) What are the advantages of slip form paving?
(h) Why is curing of concrete necessary? What are the various methods of curing of concrete pavements?
(i) Concrete mix design depends on the fineness modulus of fine aggregate. Define fineness modulus.
(j) The third point loading flexural strength test was performed on a concrete beam having a cross-section of 150 mm x 150 mm and a span of 450 mm. If the load at failure was 36 kN, calculate the modulus of rupture of concrete.



Semi-log aggregate gradation chart.

10 MM/CM

10 MM/CM

10 MM/CM