National Examinations – December 2011

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. **Proctor Compaction Test**

(a) The following information is from a compaction test performed in the laboratory by the Standard Proctor compaction procedure. Show all the calculations and draw the moisture-density curve and determine the optimum moisture content and maximum density for this soil.

(b) Assuming that the above soil has a specific gravity of 2.75, make the necessary calculations and draw "the zero air voids curve" on the same moisture-density curve drawn above.

Mass of mould = 2,450 g

Trial #	Mass of compacted soil + mould (g)	Moisture content (%)
1	4,140	9.5
2	4,200	11.0
3	4,310	13.0
4	4,410	14.0
5	4,400	16.0
6	4,350	17.0

2. **Development of superelevation**

A two-lane two-way road with a circular curve of radius 600 m to the right is superelevated by revolving the travelled way about the centerline.

Design speed = 100 km/h

Horizontal curve length = 300 m

e_{max} = 10%

Pavement cross-slope = 2%

Chainage at the beginning of the curve (PC) = 14+100.000 m

(Distance between stations is 1000 m)

Assume one-third of the superelevation run-off transition is in the curve.

(a) Calculate the chainage at

(i) the beginning of the tangent run-out

(ii) beginning of the superelevation run-off

(iii) beginning of the circular curve

(iv) end of the circular curve

(v) end of the superelevation run-off, and

(vi) end of tangent run-out.

(b) Draw the development of superelevation on a graph sheet using suitable scale.

3. Earthwork

Draw to a suitable scale the mass haul diagram with the following data.
Assume swell is 10% and shrinkage is 20%

Distance (m)	Cut (m^3)	Fill (m^3)
0		
	500	
100		
	900	
200		
	1,000	
300		
	300	
380		
		100
400		
		200
500		
		700
600		
		1,200
700		
		1,000
800		
		100
830		
	200	
900		
	400	
1000		

4. **Vertical curve**
   (a) A plus 3% grade intersects a minus 2% grade at station 3 + 20 m (distance between stations is 100 m) at an elevation of 320.00 m. Given that 200 m length of vertical curve connects the two grades, determine the station and elevation of PVC and PVT.
   (b) Calculate the elevations at 20 m intervals and locate the station and elevation of zero grade on the curve.
   (c) What is the available stopping sight distance on the curve?

5. **Concrete pavement thickness design**

   Determine the slab thickness for a jointed plain concrete pavement with asphalt shoulders, given the following:
   (a) Subgrade – the water drains out of the pavement in two days.
   (b) Pavement structure becomes saturated less than 5% of the time.
   (c) Estimated ESALs over the maximum performance period = $4 * 10^6$
   (d) Modulus of subgrade reaction = 40 MPa/m
   (e) Subgrade resilient modulus = 170 MPa
   (f) Design reliability = 95%
   (g) Standard error in predicting serviceability = 0.50
   (h) Modulus of rupture of concrete = 3.0 MPa
   (i) Young's modulus of elasticity of concrete = 30,000 MPa
   (j) Initial pavement serviceability index = 4.5
   (k) Final pavement serviceability index = 2.0

6. **Asphalt pavement design**

   Calculate the required layer thicknesses for a new asphalt concrete pavement for the data given in Problem 6.

7. **Design of tie bars based o subgrade drag theory**

   (a) Compute the total area of steel required per metre length for a 300 mm thick concrete slab with a 4.5 m transverse joint spacing over an unbound base for a highway consisting of two 3.75 m wide lanes tied together at the centerline joint. Yield stress of tie bars is 400 MPa. Assume the allowable stress in steel is two-thirds of the yield strength. The unbound base coefficient of friction is 1.5.
   (b) Compute the tie bar spacing required for M15 deformed bars.

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Grading of Examination Paper

1. Marks: 10 + 10
2. 20 marks.
3. 20 marks
4. Marks. 6 + 10 + 4
5. 20 marks
6. 20 marks
7. Marks : 15 + 5