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.

\[
\text{Mass of mould} = 2,450 \text{ g}
\]

<table>
<thead>
<tr>
<th>Trial #</th>
<th>Mass of compacted soil + mould (g)</th>
<th>Moisture content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4,140</td>
<td>9.5</td>
</tr>
<tr>
<td>2</td>
<td>4,200</td>
<td>11.0</td>
</tr>
<tr>
<td>3</td>
<td>4,310</td>
<td>13.0</td>
</tr>
<tr>
<td>4</td>
<td>4,410</td>
<td>14.0</td>
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<tr>
<td>5</td>
<td>4,400</td>
<td>16.0</td>
</tr>
<tr>
<td>6</td>
<td>4,350</td>
<td>17.0</td>
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</table>

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  
\( e_{\text{max}} = 10\% \)  
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%

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>Cut (m³)</th>
<th>Fill (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>500</td>
<td></td>
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<tr>
<td>100</td>
<td>900</td>
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<td></td>
<td>400</td>
</tr>
<tr>
<td>1000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 on 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.
National Examinations – December 2011

98 – Civ – B7, Highway Engineering

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