

**National Examinations – May 2013**

**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. (a) Calculate the storage capacity of a rectangular pond given the following:

Bottom elevation 100.000 m with cross sectional dimensions 100 m x 50 m

Top elevation 120.000 m with cross sectional dimensions 200 m x 100 m

Straight sloping sides.

What are the cross-sectional dimensions at elevations 105.000, 110.000, and 115.000?

Use this cross-sectional data to calculate the storage capacity.

- (b) The cross-sectional areas along a proposed embankment as obtained with a planimeter are as follows:

Station	End area (m <sup>2</sup> )
50+000	640
51+000	1500
52+000	800

Calculate the total volume of fill in cubic metres between stations 50+000 and 52+000 using

(i) the average end area method and

(ii) the prismatic formula.

(Note: The distance between each station is 1000 m.)

2. A compacted asphalt mixture has bulk specific gravity of 2.329.

Specific gravity of asphalt = 1.017

Binder = 6% by weight of total mix

Aggregate effective specific gravity = 2.730

Aggregate bulk specific gravity = 2.715

Calculate

- Percentage of binder by weight of aggregate
- maximum specific gravity of the mix
- Percent voids in mineral aggregate
- Percent voids filled with asphalt
- Percentage of absorbed binder

3. With respect to concrete pavements:

- (a) Why is air-entrained concrete used?
- (b) What is the modulus of subgrade reaction?
- (c) What are transverse contraction joints? What is their purpose?
- (d) What are transverse construction joints? What is their purpose?
- (e) What are transverse expansion joints? What is their purpose?
- (f) What are longitudinal joints? What is their purpose?.
- (g) Explain pumping of joints.
- (h) Why is curing of concrete necessary?
- (i) What are the various methods of curing of concrete pavements?
- (j) Define fineness modulus of fine aggregate..

4(a) From comfort consideration, what is the minimum length of a parabolic sag vertical curve connecting a -4% and +3% grades? Running speed of vehicle = 80 km/h  
Permissible centripetal acceleration =  $0.3 \text{ m/s}^2$

4 (b) CBR Test results:

Stress (MPa)	Penetration (mm)
50*0.0069	0.05*25.4
75*0.0069	0.075*25.4
125*0.0069	0.1*25.4
400* 0.0069	0.2*25.4
700*0.0069	0.3*25.4
860*0.0069	0.4*25.4
890*0.0069	0.5*25.4

- (i) Plot stress-penetration curve using the data from the above table
- (ii) Correct for concave upward shape. Redefine the origin.
- (iii) Using the corrected curve, what is the stress corresponding to corrected 0.1\*25.4 mm penetration?
- (iv) If the standard stress causing 0.1\*25.4 mm penetration is 1000\*0.0069 MPa, calculate the CBR value of the sample.

### 5. 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 2.80, 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	4,150	10.0
2	4,210	11.0
3	4,320	12.0
4	4,420	13.0
5	4,410	14.0
6	4,360	15.0

### 6. Vertical curve

- A plus 4% grade intersects a minus 3% grade at station 15 + 00 m (distance between stations is 100 m) at an elevation of 400.00 m. Given that 1000 m length of vertical curve connects the two grades, determine the station and elevation of PVC and PVT.
- Calculate the elevations at 100 m intervals
- What is the available stopping sight distance on the curve?
- Locate the station and elevation of zero grade on the curve.
- What is the rate of change of grade?

7. Design the thickness of a jointed concrete pavement with untied asphalt shoulders, given the following:

Four lane divided rural highway

Design life = 2 years

First year traffic estimated = 150,000 ESAL

Expected traffic growth = 4%

Design reliability = 95%

Overall standard deviation = 0.4

Initial serviceability index = 4.5

Terminal serviceability index = 2.5

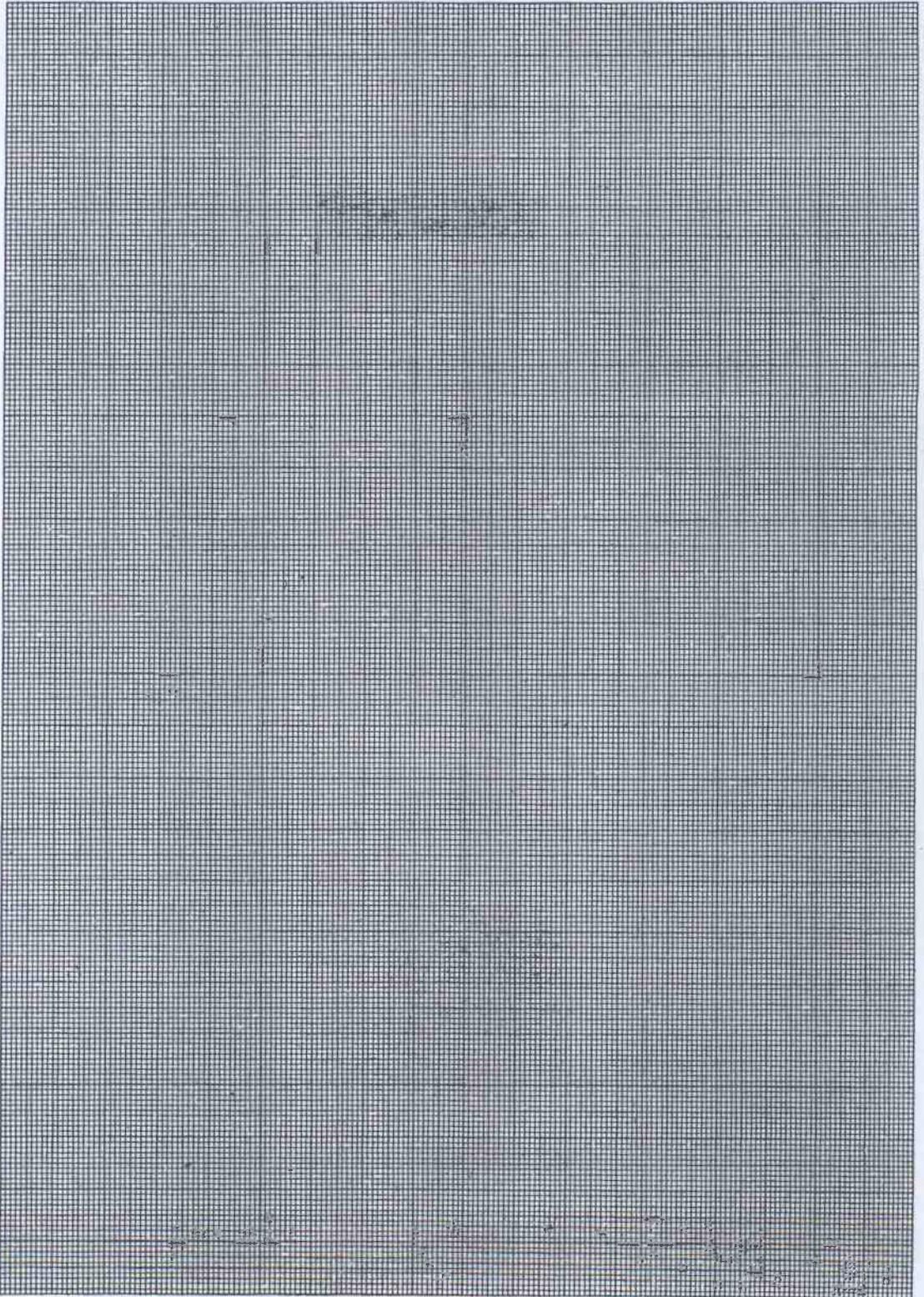
Subbase is granular material

Compressive strength of concrete = 35 MPa

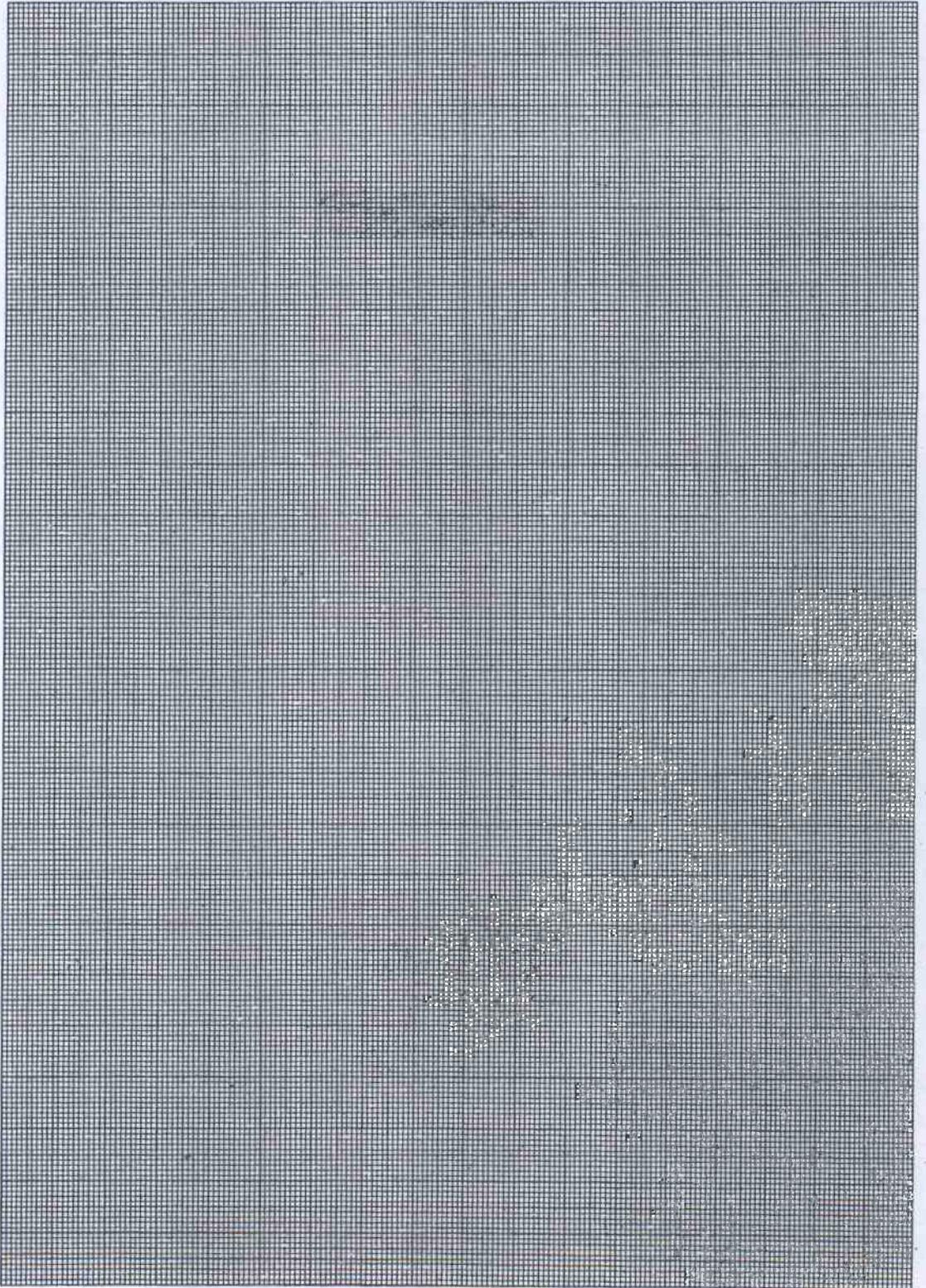
Modulus of rupture = 4.0 MPa

Modulus of subgrade reaction = 1.0 MPa

Drainage is fair (moisture levels approaching saturation 10% of the time)



METRIC



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**Grading Scheme**

- 1 (a) 10 marks  
(b) 10 marks
  
- 2 (a) through (e) – 4 marks each
  
- 3 (a) to (j) – 2 marks each
  
- 4 (a) 10 marks  
(b) 10 marks
  
- 5 (a) 10 marks  
(b) 10 marks
  
- 6 (a) through (e) – 4 marks each
  
7. 20 marks