National Examinations – December 2010

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

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

4. All questions are of equal value.

5. For non-numerical questions, clarity and organization of the answer are important.

1. (a) A plus (+) 5.1% grade intersects a plus (+)2.4% grade at station 50.250 km (elevation +622.400 m). A parabolic crest vertical curve 200 m long joins the two grades. Calculate the elevation of the road at 50.175 km, 50.275 km, and 50.325 km. Calculate also the grade of the road at those locations.

   (b) Based on stopping sight distance consideration and comfort control, calculate (do not use the tabulated values) the length of a parabolic sag vertical curve connecting minus (-) 2% and plus (+) 1% grades. Design speed = 80 km/h.

2. A two-lane highway RCU 100 is 7.5 m wide and has a cross-slope of 0.02 m/m. At station 10+000.000 km, there is a point of intersection (P.I.) with a deflection angle of 20^0. A horizontal circular curve with transition spirals at the ends connects the two tangents. Design the curve and develop the superelevation by rotating about the outside pavement edge. Show the chainage at all critical locations. What is the chainage at the end of the transition spiral and at the end of the circular curve? Use the graph sheet provided and choose proper scale for the drawing.

3. It is desired to combine two materials A and B whose sieve analysis is given below. Determine graphically (using the graph sheet provided) the maximum percentage of material B which satisfies the specification limits shown.

Sieve size (mm)	Percent passing (by weight)		Specification limits
	Material A	Material B	
25	90	100	95-100
9.5	60	75	50-75
4.75	40	30	40-60
2.0	30	20	20-30
0.425	10	10	10-30
0.075	10	5	6-8

4. (a) Marshall Stability test results:
   Weight in air = 12.820 N
   Weight in water = 7.834 N
   Saturated surface dry weight in air = 12.857 N
   (i) What is the bulk volume of the above specimen?
   (ii) What is the bulk specific gravity of the compacted mix?
   (iii) Define Marshall Stability Number and Flow Value of asphalt cement concrete mix.
   (iv) Two asphalt cements AC-5 and AC-20 are available. Which do you recommend for a cold climate and why?
   (v) What are the two design criteria for asphalt pavements?

(b) An asphalt concrete surface course mixture is being designed by the Marshall method. The aggregate combination in the trial mixture contains 40% coarse aggregate, 50% fine aggregate, and 10% mineral filler. Bulk specific gravities of the materials are 2.671, 2.698, and 2.789 respectively. Specific gravity of asphalt cement is 1.010.

Test on a paving mixture sample with 5% asphalt cement by weight of total mixture gave the following data:

(i) Weight of specimen in air = 12.936 N
(ii) Weight of specimen in water = 7.960 N
(iii) Weight in air of saturated surface dry sample = 12.940 N
(iv) Maximum specific gravity of paving mixture sample = 2.607

Determine percent air voids and percent voids in mineral aggregate in the sample.

5. (a) Distinguish between major and minor interchanges
(b) Distinguish between boulevards and border areas.
(c) The cross-slope of a Portland cement concrete pavement is less than that of a gravel or crushed stone pavement. Why?
(d) What is the purpose of a spiral transition curve?
(e) Why is a minimum longitudinal gradient necessary for curbed roadways?
(f) Why are shoulders necessary at the edges of travelled lanes?
(g) Why are parabolas used as vertical curves?
(h) List three considerations in the design of transition spirals.
(i) State the assumptions on which the minimum passing sight distances are calculated.
(j) What are the most common types of joints in concrete pavements?
(k) How is the load transferred in pavements with no dowels?
(l) At what depth are dowels usually placed?
(m) Sketch a dowelled transverse construction joint and a dowelled transverse contraction joint.
(n) What type of reinforcement is used in longitudinal contraction joints?

6. A four-lane municipal (curbed) collector road is to be designed in concrete (no dowels). Soil tests have established CBR value of 8.5 for the subgrade material. A subbase consisting of 100-mm layer of granular material is to be placed and compacted. A CSA specification 30 MPa air-entrained concrete is to be used. The design mix was laboratory tested and yielded a modulus of rupture of 4.4 MPa.

Axle load (kN)	Expected repetitions
Single axles	
116	103
107	2,340
98	3,815
89	9,728
80	24,372
71	35,039
62	70,078
53	171,322
Tandem axles	
196	1,708
176	11,386
160	56,917
142	80,349
125	65,192
107	45,105
89	66,027
71	86,938

(a) What is the design thickness of the concrete pavement?

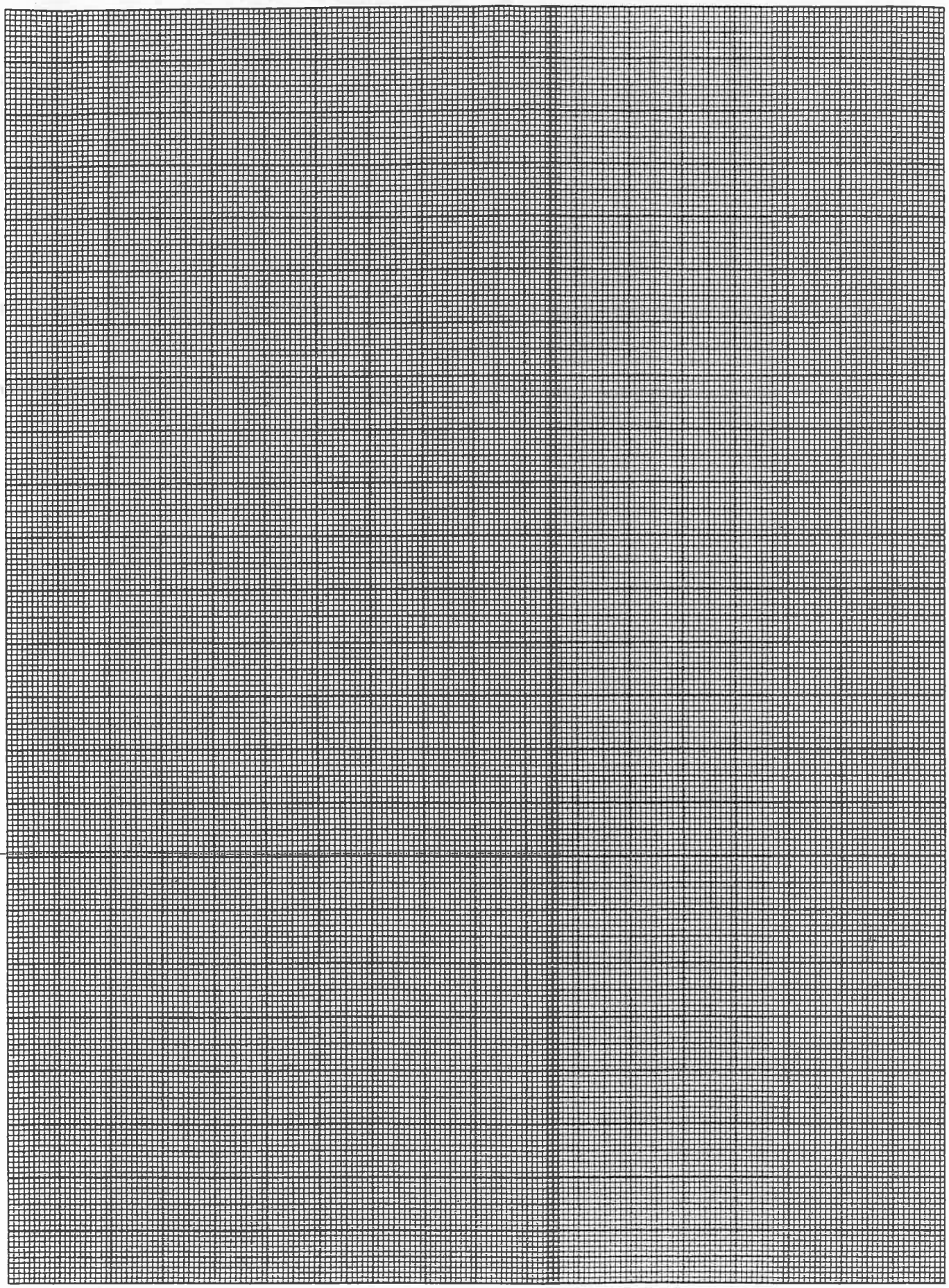
(b) If it is desired to have a 100-mm thick lean concrete subbase (on top of the 100 mm granular subbase) with a modulus of rupture value of 1.0 MPa (non-monolithic construction), determine the thickness of surface course.

(c) If it is desired to have a 100-mm thick surface course over a monolithically cast lean concrete subbase with a modulus of rupture of 1.0 MPa, determine the required thickness of subbase.

7. (a) Given the following end areas in cut and fill, complete the earthwork calculation, using a shrinkage factor of 20%. Prepare the mass diagram (use the graph paper provided) and indicate the direction of haul and whether you have to borrow or waste any material in order to complete the project.

Station (100 m spacing)	End areas (m^2)	
	Cut	Fill
286	60	15
287	54	22
288	48	50
289	24	70
290	12	53
291	0	66

(b) Using the Rational Method, determine the amount of runoff that would occur for a paved parking lot that is 100 m x 100 m and is uniformly sloped in one direction only from one edge to the other edge at a rate of 2.0%. The time of concentration for this parking lot is five (5) minutes. The five-year storm with duration of 5 minutes has an intensity of 15 mm per hour. The runoff coefficient for this parking lot is 0.80.



10 MM/CM