National Examinations – December 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 required, but not given, 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.

Grading Scheme:

Question 1: 20 marks

Question 2: 20 marks

Question 3 (a): 15 marks
Question 3 (b): 5 marks

Question 4(a): 8 marks
Question 4(b): 12 marks

Question 5(a): 8 marks
Question 5(b): 12 marks

Question 6: 20 marks

Question 7(a): 8 marks
Question 7(b): 12 marks

1. A 300-m sag parabolic vertical curve has a PVC at station 2+600.000 and elevation 320.0 00 m. The initial grade is -4.0% (minus four percent) and the final grade is +1.0% (plus one percent). Determine the stationing and elevation of PVI, PVT and the lowest point on the curve. Also calculate the stationing and elevation of the curve at -3%, -2%, -1 % and 0% grades.

2. A horizontal curve on a two-lane highway is designed with 600 m radius, 3.5 m wide lanes and 100 km/h speed. Draw a sketch and determine the distance that must be cleared from the inside edge of the inside lane to provide sufficient stopping sight distance.

3. (a) Vehicle time headways and vehicle space headways were measured at a point along a highway over the course of two hours. The average time headway is 2.0 seconds/vehicle and the average space headway is 50 m/vehicle. Assuming linear speed-density relationship, calculate (i) the volume of traffic per hour, (ii) the density of vehicles per kilometre, and (iii) the average speed of traffic in km/h.

(b) A highway has a free-flow speed of 100 km/h and a capacity of 4,000 vehicles per hour. At a specified point on this highway, 2,000 vehicles were counted in one hour. Assuming linear speed-density relationship, estimate the space mean– speed of these vehicles.

4. For a proposed highway, the following areas in square metres were obtained. Determine the total volume of cut and fill between stations 840+000.000 m and 844+000.000 m using

(a) average end area method and

(b) the prismoidal formula

Station (m)	Cut area (m^2)	Fill area (m^2)
840+000.000	80	
841+000.000	70	
842+000.000	0	0
843+000.000		60
844+000.000		70

5. (a) A sample of wet aggregate weighed 300.0 N and its oven-dry weight is 280.0 N. If the absorption of the aggregate is 2.0%, calculate the percent of free water in the original wet sample.

(b) Calculate the percent passing through each sieve from the data given in the table below. Plot the percent passing versus sieve size on a 0.45 power gradation chart (attached).

Sieve size, mm	Amount retained, g
25	0
19	400
12.5	900
9.5	500
4.75	1000
2.36	900
1.18	900
0.60	700
0.30	600
0.15	600
0.075	200
Pan	50

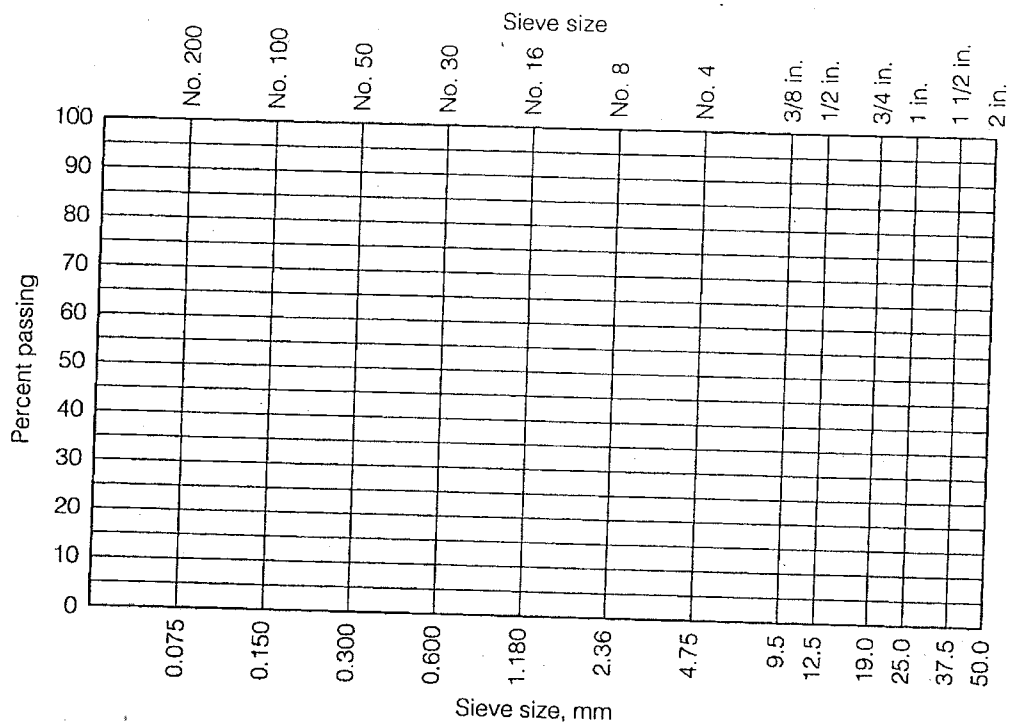
6. Determine the slab thickness for a jointed plain concrete pavement with asphalt shoulders, given the following:

Subgrade – the water drains out of the pavement in two days.
Pavement structure becomes saturated less than 5% of the time.
Estimated ESALs over the design period = $5 * 10^6$
Modulus of subgrade reaction = 30 MPa/m
Subgrade resilient modulus = 150 MPa
Design reliability = 95%
Standard error in predicting serviceability = 0.50
Modulus of rupture of concrete = 2.5 MPa
Young's modulus of elasticity of concrete = 30,000 MPa
Initial pavement serviceability index = 4.5
Final pavement serviceability index = 2.0

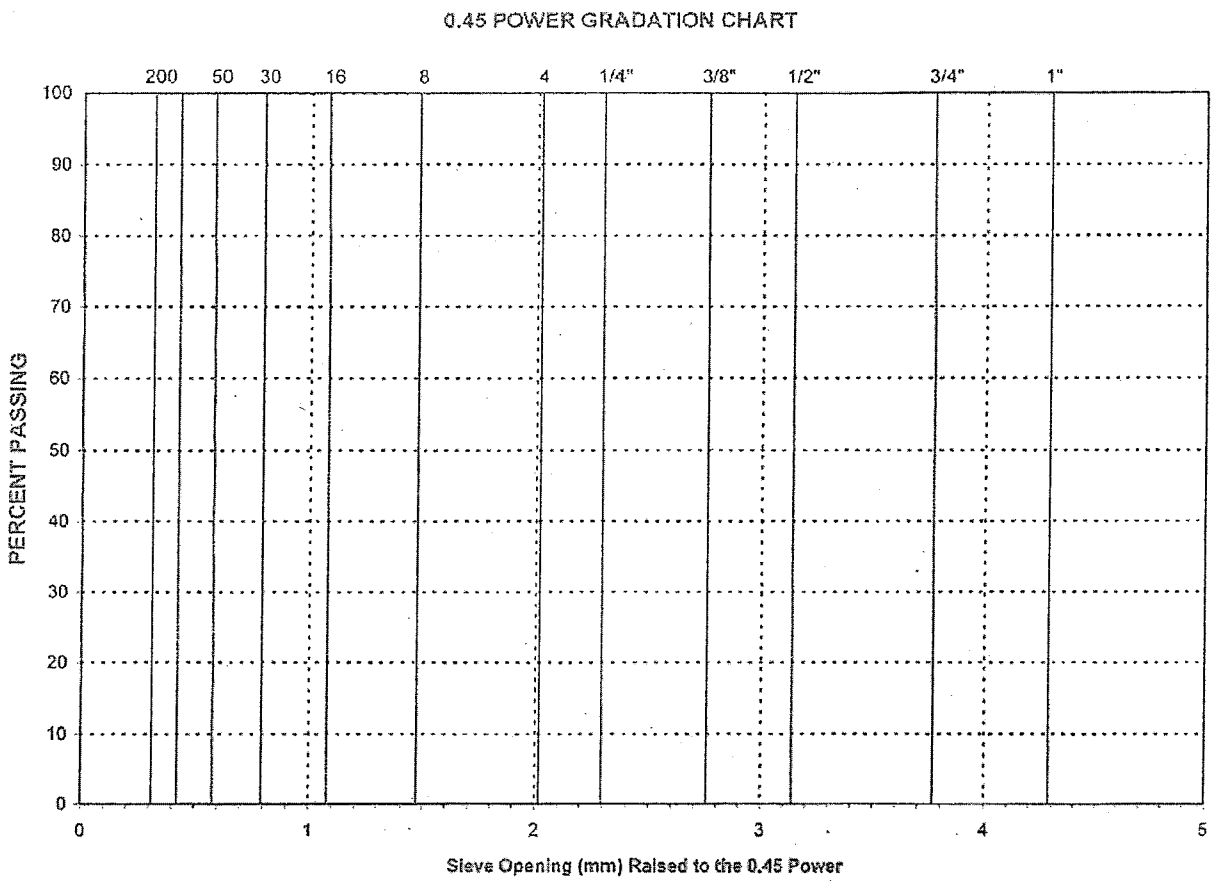
7. (a) The following table shows the grain size distribution for two aggregates and the specification limits for an asphalt concrete. Determine, graphically or otherwise, the minimum and maximum proportions of the two aggregates to satisfy the specification limits.

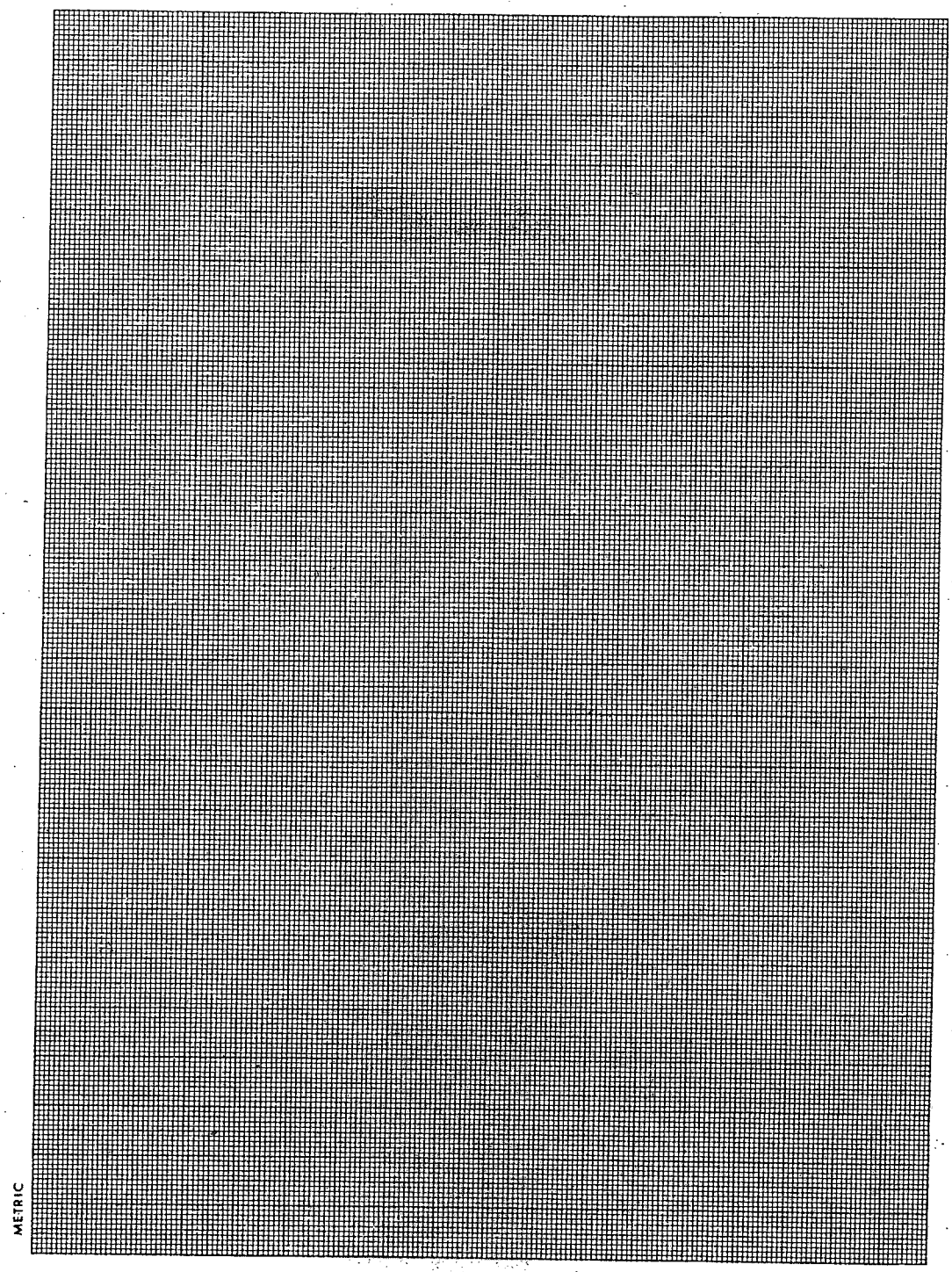
	Percent passing								
	Sieve size								
	19 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	0.60 mm	0.30 mm	0.15 mm	0.075 mm
Spec. limits	100	80-100	75-95	55-65	35-45	25-35	15-25	10-15	5-10
Aggregate A	100	100	95	70	50	40	30	20	10
Aggregate B	100	90	60	30	10	0	0	0	0

(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.



Semi-log aggregate gradation chart.


0.45 POWER GRADATION CHART
200
50
30
16
8
4
1/4"
3/8"
1/2"
3/4"
1"
100
90
80
70
60
50
40
30
20
10
0
PERCENT PASSING
0
1
2
3
4
5
Sieve Opening (mm) Raised to the 0.45 Power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