National Examinations – May 2014
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: (10+4+6) marks

Question 2: (4+3+5+3+4+1) marks

Question 3: (3+3+3+5+6) marks

Question 4: (3+4+3+ 4+ 3+3) marks

Question 5: (6 + 4+ 10) marks

Question 6: (12+ 8) marks

1. (a) A concrete trapezoidal channel has a bottom width of 5 m and side slopes of 1 vertical to 3 horizontal. The channel has a 2-percent longitudinal slope and is flowing at a constant depth of 2 m throughout its length. Using Manning's equation, calculate the volume of flow in cubic metres per day.

(b) Explain Entrance minor loss and Exit minor loss with respect to culvert hydraulics.

(c) Draw hydraulic profiles for the following three cases for a culvert operating under inlet control conditions:

(i) Inlet and outlet unsubmerged
(ii) Inlet unsubmerged and outlet submerged
(iii) Inlet submerged and outlet unsubmerged.

2. (a) List four purposes of joints in concrete pavements.

(b) List three reasons for concrete pavement cracking.

(c) List five things to be considered by the designer to determine proper jointing spacing of concrete pavements.

(d) What are dowel bars? Where are they used? What is their purpose?

(e) What are the four types of joints in concrete pavements?

(f) What is the purpose of joint sealant in concrete pavements?

3. (a) What is the "station" of the ending point of a surveyed line originating at "station 23 + 045" that has a measured length of 412 m?

(b) A section of a road rises 18.50 m in 435 m. What is the percentage of slope for this section of the road (to the nearest three decimal places)?

(c) What are the curve length, tangent length, and long chord length for a horizontal circular curve with a radius of 750.000 m and a deflection angle of 11^0 14' 21"?

(d) Given the following data, calculate the slopes of the forward and backward tangents for an equal tangent vertical curve:

Length of the vertical curve = 1200 m
BVC at Station 88+75 m
Elevation of BVC = 789.94 m
Elevation of PVI = 801.64 m
Elevation of EVC = 788.74 m

(e) Calculate the station and elevation of the highest point on the curve in Problem 3 (d).

4. (a) Briefly describe the three types of HMA (Hot Mix Asphalt) mixes along with their advantages and disadvantages.

(b) List seven specific mix design objectives.

(c) What are the three properties of asphalt pavement which will be improved by increasing Asphalt binder content and what are the two properties that are adversely affected?

(d) What is SMA (stone mastic (matrix) asphalt)? List its advantages and disadvantages.

(e) A hot mix asphalt has excess binder, excess medium size sand and rounded aggregate. State their effects on stability, durability, permeability, workability and fatigue resistance of the asphalt pavement.

(f) A hot mix asphalt has low binder content, high void content and water susceptible aggregate. State their effects on stability, durability, permeability, workability and fatigue resistance of the asphalt pavement.

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 3.0%, calculate the percent of free water in the original wet sample.

(b) Describe maximum size, nominal maximum size, maximum density line, and Primary Control Sieve (PCS) control point, with respect to Superpave mix design method.

(c) The following are the properties of the aggregate and compacted HMA. Calculate the density, air voids, VMA, VFA and dust proportion.

Effective specific gravity of the aggregate = 2.726

Specific gravity of the binder =1.030

Bulk specific gravity of the mix = 2.360

Maximum specific gravity of the mix = 2.520

Binder content = 5.0 percent of the weight of total mix.

Aggregate passing 0.075 μm (No. 200) sieve = 5.3%

6. (a) The following table shows the grain size distribution for two aggregates and the specification limits for an asphalt concrete. Determine, graphically or algebraically **(and not by trial and error)**, 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
Specification limits	100	80-100	70-90	50-60	30-40	20-30	10-20	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

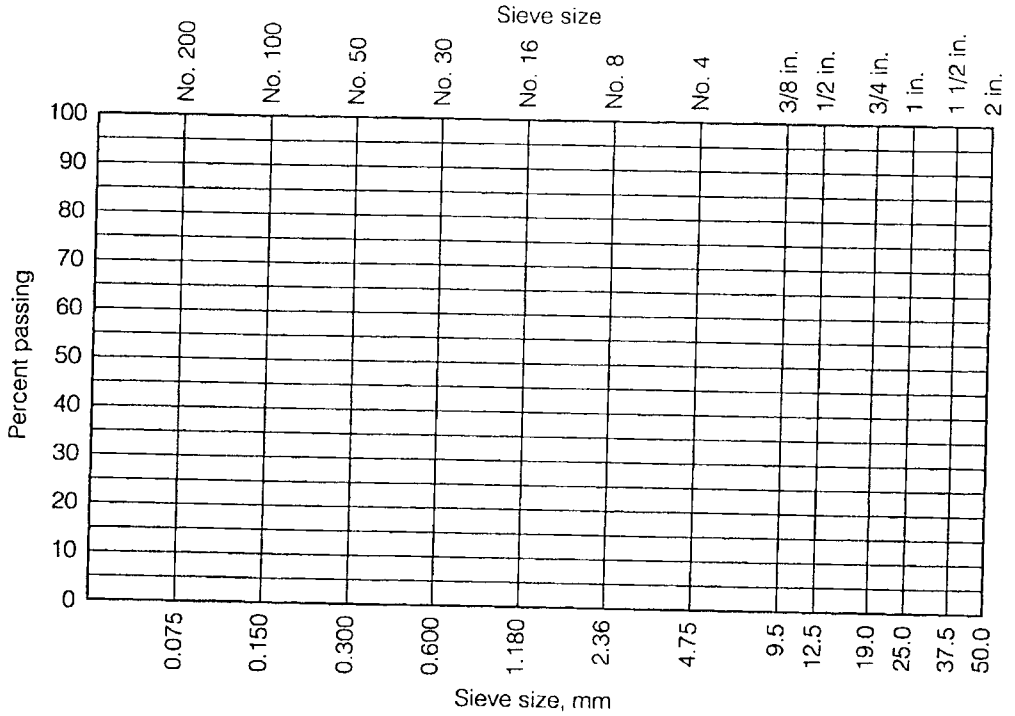
(b) On a semi-log gradation graph (attached), plot the gradations of

(i) aggregate A,

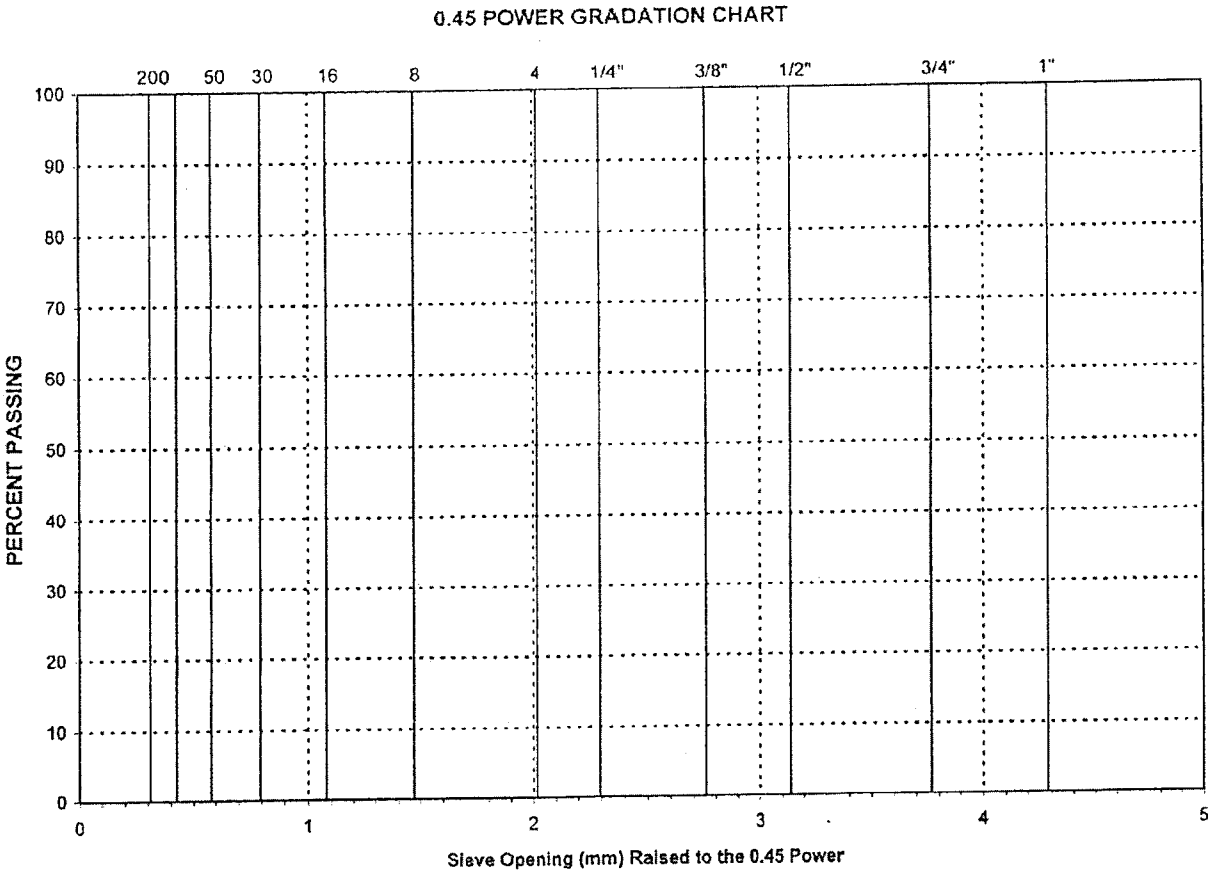
(ii) aggregate B,

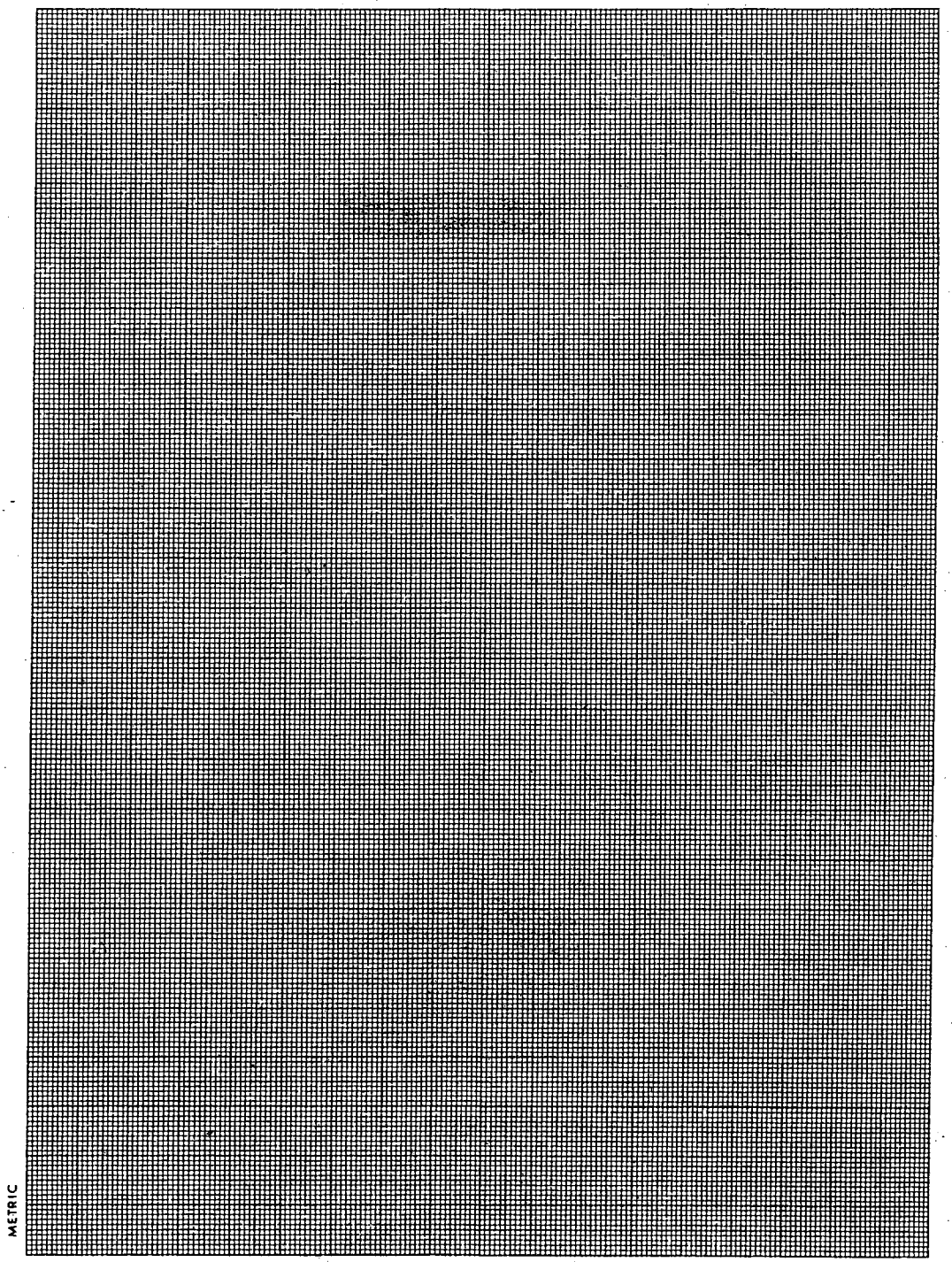
(iii) the selected blend and

(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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