THE OPEN UNIVERSITY OF SRI LANKA
DIPLOMA IN TECHNOLOGY (CIVIL) - LEVEL 4
FINAL EXAMINATION - 2006/2007

CEX 4236 - HIGHWAY ENGINEERING

Time allowed : Three hours

Date : Friday, 20th April 2007 **Time : 9:30 - 12:30**

Answer any five questions. All questions carry equal marks. Write down your Index Number clearly on the answer script.

(01)

The table below indicates the speed range and mean speeds of 150 spot speed measurements taken at a specific location.

Speed Class (km/h)	Mean Speed (km/h)	Number of Vehicles
30 - 39.9	34.6	18
40 - 49.9	47.8	32
50 - 59.9	53.7	48
60 - 69.9	65.2	38
70 - 79.9	73.3	14
	TOTAL	**150**

From the data given in the above table draw the following.

(a) Histogram and frequency distribution curve of the spot speeds. (8 marks)

(b) Cumulative frequency curve of spot speeds, clearly indicating the 15^{th} and 85^{th} percentile speeds on the curve. (8 marks)

(c) Above spot speeds were obtained by using a standard velocity radar gun. What are the precautions you should take to obtain accurate measurements from the radar gun? (4 marks)

(02)

(a) Giving examples, explain the functions of (i) Anionic Emulsifiers, and (ii) Cationic Emulsifiers. (6 marks)

(b) What are the three (3) groups that emulsions can be classified into depending on their setting time? Write down the characteristics and uses of these different groups. (6 marks)

(c) Explain briefly the softening point test carried out to evaluate the consistency of bitumen, indicating the type of apparatus used in the laboratory. (4 marks)

(d) Describe how the softening point of bitumen affects its behaviour when used on road pavements. (4 marks)

(03)

Two alternative road systems (A & B) had to be compared when preparing a Master Plan for a new township. This comparison was to be conducted through US system known as the *saturation system (or maximum utility system).* Following field data were collected for this exercise.

	Total Road Length (km)	Productivity		Number of population centres with following population figures	
		Agriculture (Tonnes)	Industry (Tonnes)	00 to 2500	2500 - 5000
Alternative (A)	30	10	08	5	2
Alternative (B)	28	06	12	4	3

Use following units for your calculations:
Every 5 tonnes of agricultural produce to be assigned one unit.
Every 10 tonnes of industrial produce to be assigned one unit.
Population group - 00 to 2500, take as 0.5 unit.
Population group - 2500 to 5000, take as 1.0 unit.

(a) Calculate the agricultural, industrial, and population utility factors for each alternative. (4 marks)

(b) Calculate the (i) total utility factor, and (ii) average utility factor for each alternative. (8 marks)

(c) Which alternative [(A) or (B)] should be chosen for implementation? Give reasons for your answer. (4 marks)

(d) Briefly describe how you would develop a phased program in proposing an optimum road system. (4 marks)

(04)

Traffic accidents cost our nation largely in both human and financial terms.

(a) Describe the following in relation to road safety, using sketches where necessary. Accidents due to (i) poor pedestrian behaviour, (ii) poor mechanical condition of vehicles, and (iii) bad road conditions. (6 marks)

(b) Name the <u>four</u> (4) categories of road accidents, briefly explaining each of them. (8 marks)

(c) Briefly explain what a 'collision diagram' means, and describe how it can be used to reduce accidents on a particular stretch of road. (6 marks)

(05)

(a) Draw a neat diagram of a cross-section of a highway with three-lane, dual carriageway that runs along a hillside (cut and fill section), clearly indicating and labelling all the important elements. (8 marks)

(b) Indicate on a neat sketch how lane marking should be done along the carriageway of the above highway. (4 marks)

(c) Write down its expected functions if this highway constitutes an 'access controlled' facility. (4 marks)

(d) When a carriageway is to be widened on a curve, what are the four main considerations to be taken in to account? (4 marks)

(06)

(a) Explain the following terms related to highways

(i). through road (ii). by pass road

(iii). ribbon development (iv). toll road (8 marks)

(b) Parking supply survey can be considered to be made up of three parts; an on-street road space inventory, an off-street space inventory and a road regulation inventory. What information is collected in the on-street road space inventory? (6 marks)

(c) Discuss the advantages and disadvantages of the three-wheeler as an urban passenger-carrying vehicle in a developing country. (6 marks)

(07)

(a) Write down the rational formula used for calculating the peak runoff from a catchment, and explain all the terms involved. (4 marks)

(b) List down the factors which the runoff coefficient (C) depends on. (4 marks)

(c) Briefly discuss the advantages and limitations of the rational formula. (6 marks)

(d) Table below gives the average rain fall intensities for different periods of time of the heavy rains experienced in August last year at a proposed bridge site in Kurunegala area.

Duration of storm (hours)	Rainfall intensity (in/hr)
0.5	8.5
1.0	7.5
1.5	6.0
2.0	5.5
2.5	4.0
3.0	3.5

The time of concentration of the catchment of the stream above the bridge site is 75 minutes. What is the average rainfall intensity that has to be used to determine the flood runoff by the rational formula? (6 marks)

(08)

Design a flexible pavement with 'wet and dry bound macadam' surfacing for a two-way two-lane road where the following parameters exist. Subgrade has a CBR value of 4%. Each direction has a daily traffic flow of 80 passages of 4-axle vehicles with loads of 9000 kg each on the two rear axles 7000 kg on the second axle and 2700 kg on the front axle; 150 passages of 3-axle vehicles with loads of 9000 kg each on the two rear axles and 2000 kg on the front axle; and 250 passages of 2-axle vehicles with loads of 7500 kg on the rear axle and 2500 kg on the front axle. Design the road for a life of 20 years assuming zero growth of traffic.

Find the required thicknesses (i) sub base, (ii) base, and (iii) surfacing.

Assume following equivalence factors for different axles for the three types of vehicles.

(a).	4-axle vehicles	Equivalence factor
	Front axle	= 0.01
	Second axle	= 0.53
	Two rear axles	= 1.50
(b).	3-axle vehicles	Equivalence factor
	Front axle	= 0.004
	Two rear axles	= 1.5
(c).	2-axle vehicles	Equivalence factor
	Front axle	= 0.009
	Rear axle	= 0.7

(20 marks)

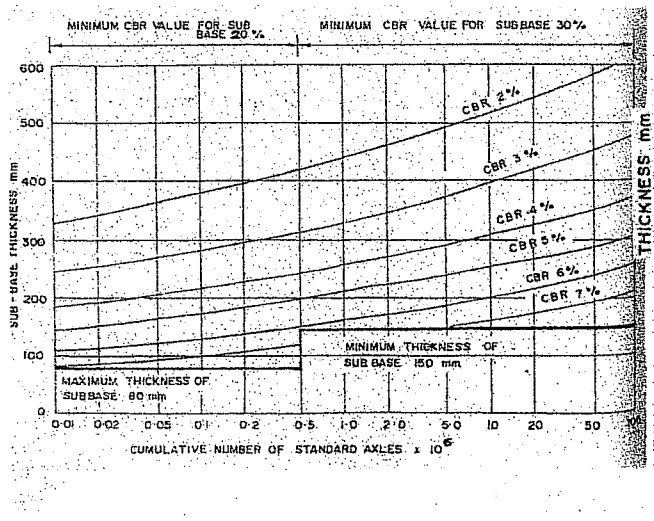

Fig 1 – Flexible pavement design curves for sub base

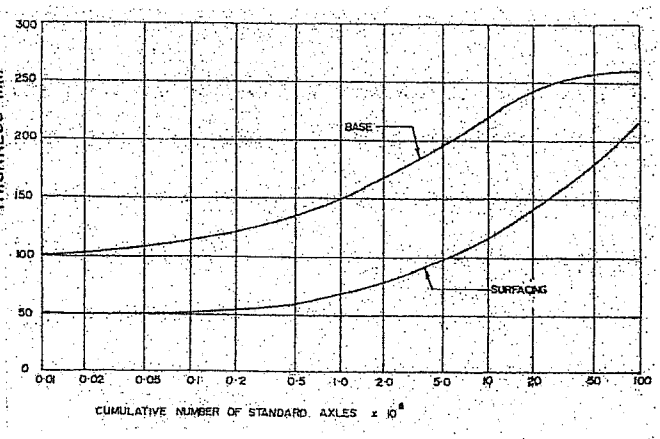

Fig 2 - Flexible pavement design curves for base & surfacing base material 'wet mix & dry bound macadam'