THE OPEN UNIVERSITY OF SRI LANKA
DIPLOMA IN TECHNOLOGY (CIVIL) - LEVEL 4
FINAL EXAMINATION - 2009/10

CEX 4236 - HIGHWAY ENGINEERING

Time allowed : Three hours

Date : Saturday, 06th March 2010   Time : 9:30 - 12:30

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

01. (a). Distinguish between "time headway" and "space headway".   (04 marks)

(b). Vehicle time headways and space headways were measured at a point along a highway, from a single lane, over the period of an hour. The average values were calculated as 2.5 s/veh for headway, and 60 m/veh for spacing. (i) Calculate the average speed of the traffic. (ii) Obtain the average speed of traffic directly from average headway and spacing value.   (10 marks)

(c). In a uniform single lane traffic flow, where the headway between any two adjacent vehicles is 15 meters and length of each vehicle is 5 metres, the following speed measurements were recorded in a particular instant. 10 vehicles at 30 km/h, 15 vehicles at 35 km/h, and 25 vehicles at 40 km/h.

Calculate the following for this vehicular flow.
(i) vehicle density, (ii) space mean speed, and (iii) traffic volume.   (06 marks)

02. (a). Explain the difference between Average Daily Traffic (ADT) and Annual Average Daily Traffic (AADT). State examples where ADT and AADT data is used in practical applications.   (06 marks)

(b). Name and briefly describe the <u>three</u> (3) components of traffic increase during the design life span of a highway.   (06 marks)

(c). To estimate the future traffic needs along Kandy-Jaffna road an origin and destination survey was conducted in the year 2005 on traffic existed on a section between Medawachchiya and Vavunia of this road. The annual average daily traffic (AADT) was found to be 2000 vehicles in 2005. From a travel forecast of the area, the normal growth is found to be 35% of the year 2005 traffic. Generated traffic on the basis of previous experience in the area is estimated to be 40%. Due to development in traffic it is expected that an increase of 1500 vehicle trips per day will occur by the year 2020. Determine the average daily traffic in 2020.

You may consider that AADT of future is equal to AADT of present multiplied by the projection factor.
ie.,

AADT (future) = {AADT (Present)} × { 1 + normal traffic growth +
                                      generated traffic + development traffic }

(08 marks)

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03.

(a). Give at-least <u>three</u> (3) reasons under each of the following categories; (i) driver expectations, and (ii) pedestrian's point of view, for providing street lighting along a suburban road. (06 marks)

(b). Write down <u>five</u> (5) different types of lamps used for street lighting. (05 marks)

(c). Explain briefly what is meant by 'glare', and describe how glare from luminaries can be controlled when recommending street luminaries. (05 marks)

(d). Indicate clearly 'overhang', 'outreach' and 'mounting height' of a street lamp with the help of a neat sketch. (04 marks)

04.

(a). Discuss the advantages and disadvantages of the following traffic management measures.

    (i). Enforce bans on certain categories of vehicles. (03 marks)
    (ii). Grade separation of intersections. (03 marks)
    (iii). Making certain roads one-way. (03 marks)
    (iv). Introducing Stop/Giveway controls, at intersections. (03 marks)

(b). Name the <u>three</u> (3) different types of 'time limit parking' adopted commonly, and describe each type briefly. (04 marks)

(c). Describe briefly the precautions to be taken in setting the locations of entrances and exits of large car parks adjacent to main roads. (04 marks)

05.

(a). Culverts are structures used to facilitate passing drainage water under the roadway when water paths cross it. With the help of a clear diagram indicate all the important features, both up-stream and down-stream, of a culvert.
(06 marks)

(b). Explain the terms (i) outlet control, and (ii) inlet control conditions that are considered in design of culverts. You may draw clear illustrations to explain the difference.
(08 marks)

(c). A culvert has to be designed to discharge 2.5 m³/s. The inlet is submerged, while the outlet is free. The headwater level should not rise more than 1.5 m from the centre of the culvert inlet. Determine the size of a suitable precast concrete pipe.
(06 marks)

06. Write down the formula that can be used to determine the cumulative number of standard axles used for pavement design explaining each of the terms involved.

(02 marks)

Design a flexible pavement with 'wet mix and dry bound macadam' surfacing for a two-lane road leading to a warehouse complex where the subgrade has a CBR value of 5%. The daily traffic in each direction is expected to be 120 passages of 4-axle vehicles with 9500 kg each on the two rear axles, 7500 kg on the second axle and 3000 kg on the front axle; 100 passages of 3-axle vehicles with loads of 9000 kg each on the two rear axles and 2000 kg on the front axle; and 50 passages of 2-axle vehicles with loads of 8000 kg on the rear axle and 2500 kg on the front axle. Design the road for a life of 20 years assuming 2% annual growth of traffic. You may use curves indicated in Figures 1 and 2.

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

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

(a). 4-axle vehicles Equivalence factor
        Front axle = 0.015
        Second axle = 0.65
        Two rear axles = 2.00

(b). 3-axle vehicles Equivalence factor
        Front axle = 0.004
        Two rear axles = 1.55

(c). 2-axle vehicles Equivalence factor
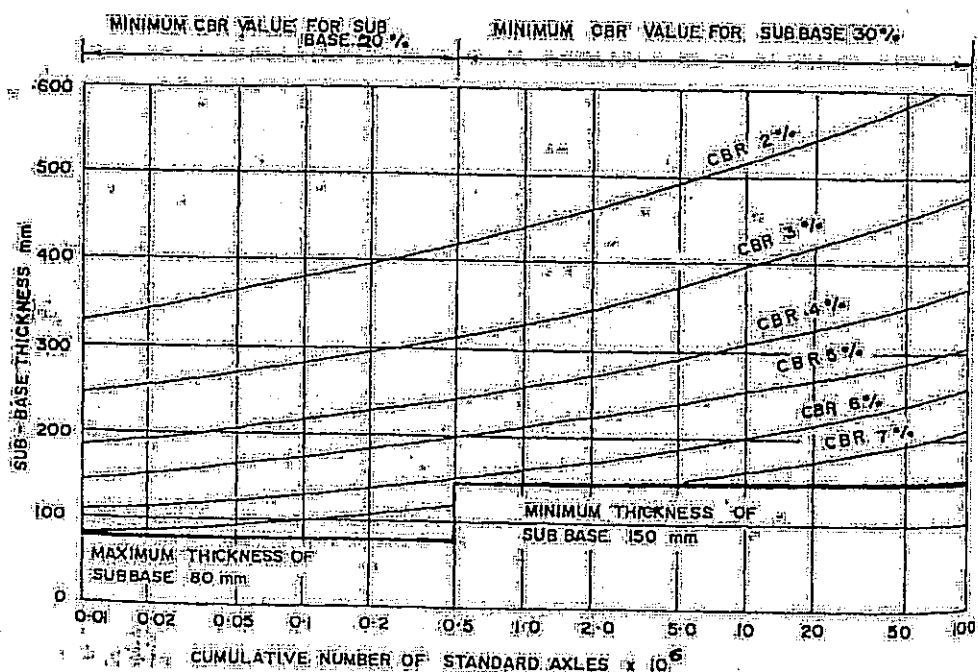   Front axle = 0.009
        Rear axle = 0.90

(18 marks)

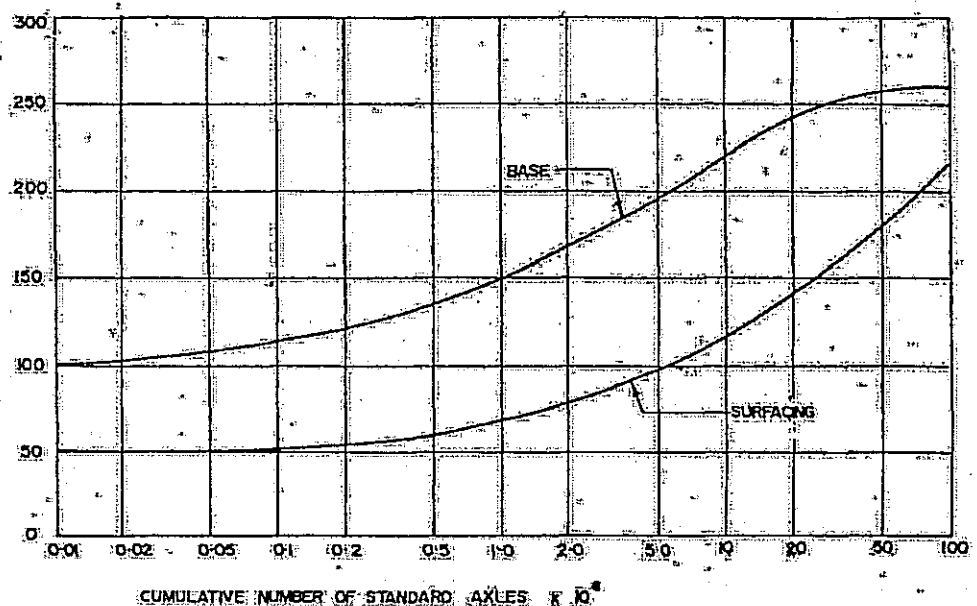**Figure 1 –** Flexible Pavement Design Curves for Sub Base

(P.T.O)

Figure 2 – Flexible Pavement Design Curves for Base and Surfacing Base Material – Wet Mix and Dry Bound Macadam

07.

(a) Briefly explain the following terms used to describe partical size distribution of coarse grained soils, (i). well graded, (ii). poorly graded, and (iii). uniformly graded soils. You may draw neat sketches to describe these. (06 marks)

(b) Define the terms 'degree of saturation', and 'porosity' of a soil. (04 marks)

(c) Explain briefly the meaning of 'textural classification' based on main three (3) groups of soil components. Draw a 'triangle textural classification diagram' neatly and indicate clearly on it the results of a sieve analysis of a certain soil indicated by 35% clay, 40% silt, and 25% sand. (04 marks)

(d) Natural rock aggregates have been classified by geologists into three (3) main groups as; (i) igneous, (ii) sedimentary, and (iii) metamorphic rocks, based on their method of origin. Briefly explain the three (3) categories.

(06 marks)

08.

(a) Distinguish between 'road emulsions' and 'cut-back bitumen'. (06 marks)

(b) What do you understand by 80/100 grade of bitumen based on penetration test?
(04 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. (06 marks)

(d) The ductility of a bituminous binder is expressed as the distance in centimetres a standard briquette will elongate at a temperature of 25 ^{0}C before breaking. Explain why knowledge of ductility is important when bitumen is used in flexible pavements.

(04 marks)