UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2009/2010

November 2009

EAS 665/4 – Bridge Engineering

Duration : 3 hours

Please check that this examination paper consists of **SIX (6)** printed pages before you begin the examination.

Instructions: Answer all **FIVE (5)** questions.

You may answer the question in English.

Each question carry equal marks.

All questions **MUST BE** answered on a new page.

Write the answered question numbers on the cover sheet of the answer script.

1. (a) Define HA and HB loading with respect to highway bridge live loads.

(5 Marks)

(b) Define permanent and superimposed dead loads for bridge loading.

(5 Marks)

(c) Find the HA loading and associated bending moment for a bridge deck with a carriageway of 6m wide and the deck span of 34m (centre to centre of bearings for a simply supported single span) use γ_{fL} = 1.50 (ULS – Load combination 1).

(10 Marks)

2. (a) Explain briefly **FIVE (5)** general rules for choosing a grillage mesh based on deck and load characteristics.

(5 Marks)

(b) Construct using grillage analogy, the layout and load distribution of a simply supported non-skewed reinforced concrete bridge experiencing:

i) Axle A of HB Load as per Figure 1 (a) and (b)

ii) Critical Knife Edge Load (KEL)

Sketch all critical sections.

<u>Proposed Bridge Data</u>

Span	:	21 meter
Width	:	14 meter
Beam	:	Seven precast rectangular beams at 2 meter spacing
Beam Section	:	300 mm (width) x 1550 mm (Depth)
Slab thickness	:	200 mm
Diaphragm	:	200 mm (width) x 1500 mm (Depth) located at both abutments and at midspan.

(Refer to Appendix A, B and C)

(15 Marks)

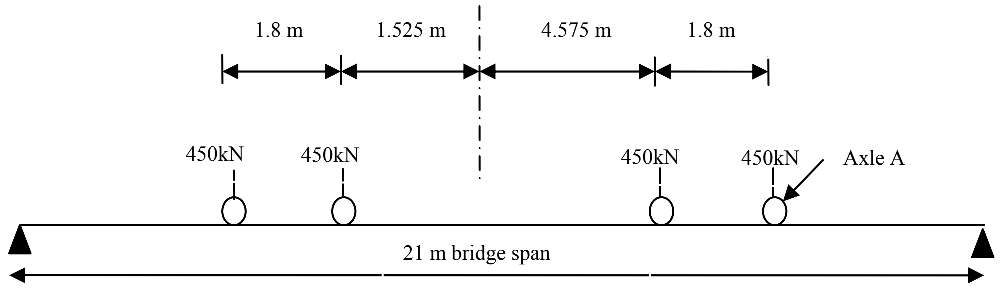

Figure 1 (a): Elevation of HB Loading

Figure 1 (b): Plan View of HB Loading

3. (a) A solid slab highway bridge, with cross-section as shown in Figure 2, has a right (total width) of 12m, a structural depth of 600mm and skew angle of 30°. The specified highway loading is HA and 45 units of HB. The nominal superimposed dead load is equivalent to a uniformly distributed load of 2.5 kN/m^2, and the nominal parapet loading is 3.5 kN/m along each free edge. Calculate the moment of resistance for bottom reinforcement placed parallel to the slab edges by yield line theory for load combination 1. Neglect the contribution of top reinforcement towards strength. Use the following data below.

Load	**γf_3**	**γf_2**
Dead	1.15	1.2
Surfacing	1.15	1.75
Parapet	1.15	1.75
HA (alone)	1.1	1.5
HA (with HB)	1.1	1.3
HB	1.1	1.3
Footway	1.1	1.5

γf_2 partial safety factors applied to load, γf_3 partial safety factor applied to load effects.

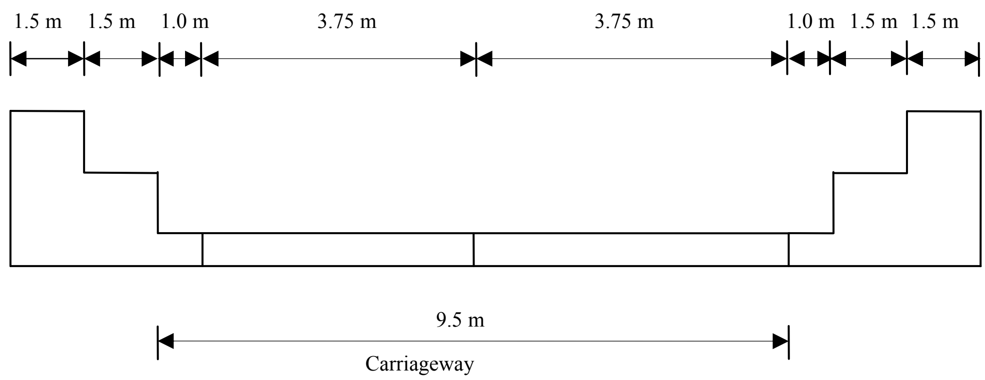

Figure 2: Cross-Section of Carriageway

(20 Marks)

4. The selection and specification of bearings for bridges are very important to ensure effective load transfer to the substructure and to allow permissible movement. Figure 3 shows a laminated bearing pad to be used in the design of rubber bearing. Given the date below :-

Vertical Reaction (DL)	=	80 tons
Vertical Reaction (LL)	=	40 tons
Max. Rotation	=	0.010 radian
Max. Movement	=	35mm

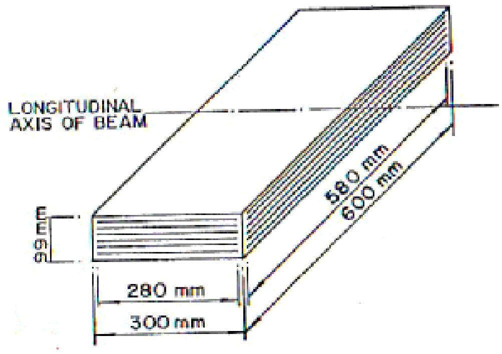

Figure 3

From Table 1 (BE 1/76) for IRHD = 55,

E = 3.25 N/mm^2

G = 0.81 N/mm^2

K = 0.64

E_∞ = 2000 N/mm^2

Elongation at break = 600%

Use bearing 600 x 300 x 99

B = 580

L = 280

t outer layer = 6mm

t inner layer = 12mm

t plate = 4.5mm

number of steel plates = 6

i) Determine the total ec, for inner slab and outer slab.

(6 Marks)

ii) Determine the permissible total shear strain due to compression and horizontal movement of slab.

(6 Marks)

iii) Calculate the overall vertical compressive stiffness, K_c

(6 Marks)

iv) Compute the horizontal thickness of slab.

(2 Marks)

5. Figure 4 shows the top slab of beam and slab bridge which has been designed at the ultimate limit state. The characteristic strengths of reinforcement and concrete are 425 and 30 N/mm^2, respectively. The local bending moments and global effects at mid-way between the beam are given in Table 1. The effects due to HB include those due to associated HA. Check the requirement of slab to satisfy the serviceability limit state criteria under load combination 1.

(20 Marks)

Table 1

a) Local moments (KNm/m)

Load	Transverse	Longitudinal
Dead	0.45	0.0
Superimmposed dead	0.22	0.0
HA wheel	10.8	7.20
45 HB units	11.7	7.65
25 HB units	7.56	5.26

Global effects

Load	Tranverse moment (KNm/m)	Longitudinal Compressive stress in slab (n/mm^2)	
		Top	Botton
Superimposed dead	0.0	0.33	0.14
HA	0.0	3.90	1.60
HA Wheel	6.0	0.61	0.25
45 HB units	43.0	6.24	2.55
25 HB units	23.3	3.63	1.48

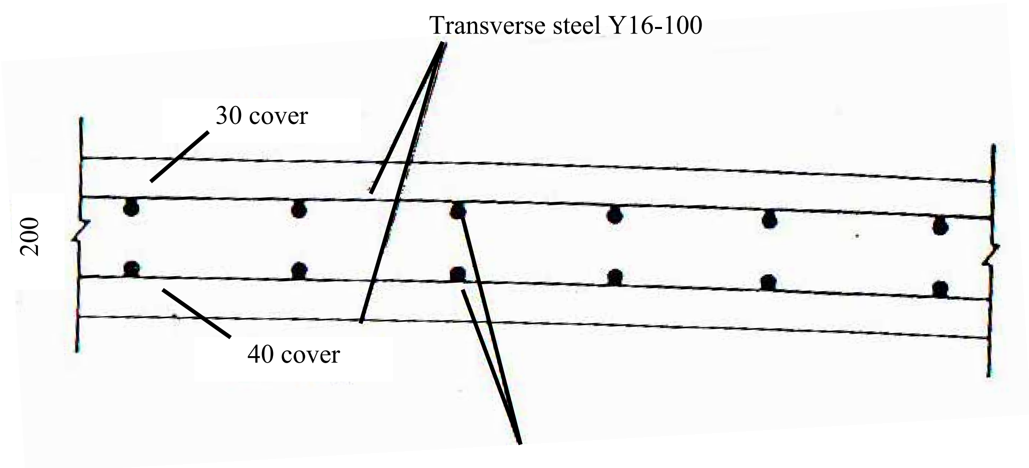

Figure 4

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