UNIVERSITI SAINS MALAYSIA

1st. Semester Examination
2005/2006 Academic Session

November 2005

EAS 665/4 – Bridge Engineering

Duration: 3 hours

Instructions to Candidates:

1. Ensure that this paper contains **NINE (9)** printed pages including appendices before you start your examination.

2. This paper contains **FIVE (5)** questions. Answer **ALL (5)** questions.

3. Each question carry equal marks.

4. All questions **CAN BE** answered in English or Bahasa Malaysia or combination of both languages.

5. Each question **MUST BE** answered on a new sheet.

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

1. (a) There are three principal and two secondary load combinations in analysing bridge loading. List out all the load combinations and briefly describe the loads to be considered.

(10 marks)

(b) Using the data below, calculate the total ultimate limit state loads for steel girders 1, 2, 7 and 8. The cross-section of the bridge is shown in Figure 1.0. (Appendix).

<u>Data</u>:

Span	160.0 m
Skew	0^o
Carriageway	11.0 m
Surfacing	100 mm thick minimum (including waterproofing)
Walkway/cycle	3.8 m wide each side
Design life	120 years

Loadings,

Unit weights	concrete 25 kN/m^3
	surfacing 24 kN/m^3
Formwork	0.5 kN/m^2 allowance for possible permanent formwork
Temperature	Minimum temperature 28^{o}C
Wind	Maximum mean hourly wind speed 35 m/s.

(10 marks)

2. (a) Figure 2.0 shows the design moment trial, at the ultimate limit state in the obtuse corner of a reinforced concrete skew slab bridge.

M_x = -2.500 MNm/m
M_y = 1.140 MNm/m
M_{xy} = -1.000 MNm/m

Calculate the required moments of resistance in the reinforcement directions, if the latter are:

i. parallel and perpendicular to the abutments
ii. parallel to the slab edges

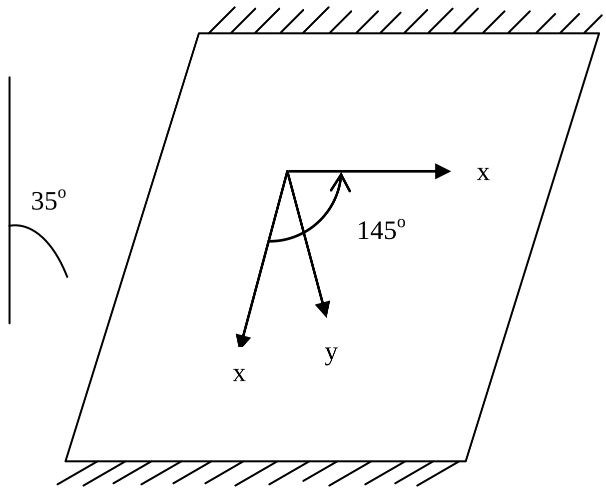

Figure 2.0 : Skew Slab Axes

(10 marks)

(b) Briefly describe the differences between traffic lanes and notional lanes.

(4 marks)

(c) (i) Describe the general principles of expansion joints.
(ii) Give **SIX** (6) function of bridge expansion joints.

(6 marks)

3. Figure 3.0(a) shows a bridge deck which consists of pretensioned precast standard beams at 1m centres acting compositely with a 160 m thick in-situ concrete top slab. The characteristic strengths of the shear reinforcement to be designed and of the precast and in-situ concrete are 250 N/mm^2, 50 N/mm^2 and 30N/mm^2, respectively. Four tendons are deflected at the quarter points and the tendon patterns at mid-span and at a support are shown in Figure 3.0(b). The total tendon force after all losses have been considered is 3450 kN. The span is 25 m, and the overall beam length is 25.5m with the nominal values of the beam is critical shear forces and moments at the support and at quarter span for load combination 1 given in Table 1.0. Design the reinforcement for both vertical and interface shear at the two sections.

Load	Support		Quarter Span	
	Shear force (kN)	Moment (kNm)	Shear force (kN)	Moment (kNm)
Self weight	163	0	81	763
Parapet	27	0	14	132
Surfacing	29	0	15	135
HB + associated HA	332	0	196	1333

Table 1 : Nominal values of stress resultants

Property	Precast	Composite
Area (mm^2)	393450	-
Height of centroid above bottom fibre (mm)	454	642
Second moment of area (mm^4)	65.19 x 10^9	124.55 x 10^9
First moment of area above composite centroid (mm^3)	44.4 x 10^6	116.0 x 10^6
First moment of area above interface (mm^3)		71.6 x 10^6

Table 2 : Section Properties

(20 marks)

4. (a) Discuss briefly the concept to construct an equivalent grillage skew deck.

(6 marks)

(b) Using the data provided below, construct the layout of a simply supported non-skew reinforced concrete bridge and provide all critical sections:

Span : 18meter
Width : 11 meter
Beam : Six precast rectangular beams at 2000 mm spacing
Beam section : 300 mm (Width) x 1250 mm (Depth)
Slab thickness : 200 mm
Diaphragm : 300 mm width located at abutments and at midspan

(6 marks)

4. (c) Calculate the torsional inertia at every critical sections.

(4 marks)

(d) Using the grillage layout above and HB loading given in Figures 4(a) and (b), distribute the load to the surrounding nodes. State all the results from an equivalent grillage that are required for design.

(4 marks)

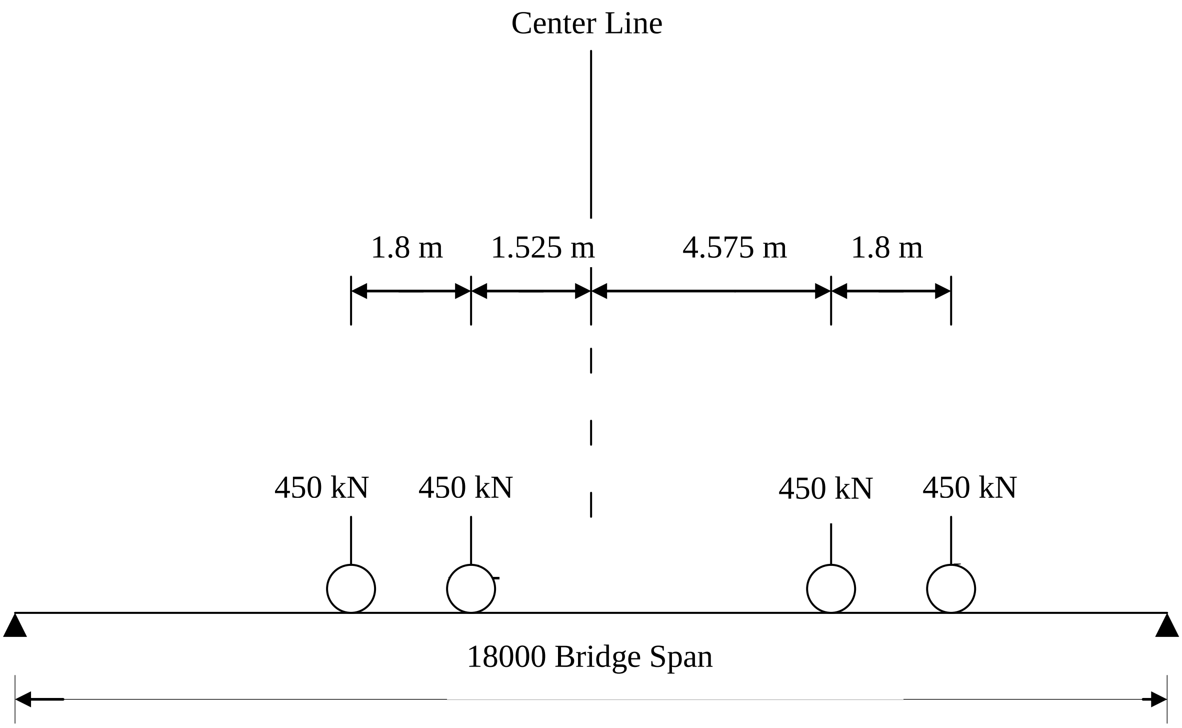

Figure 4(a) : Elevation of HB Loading

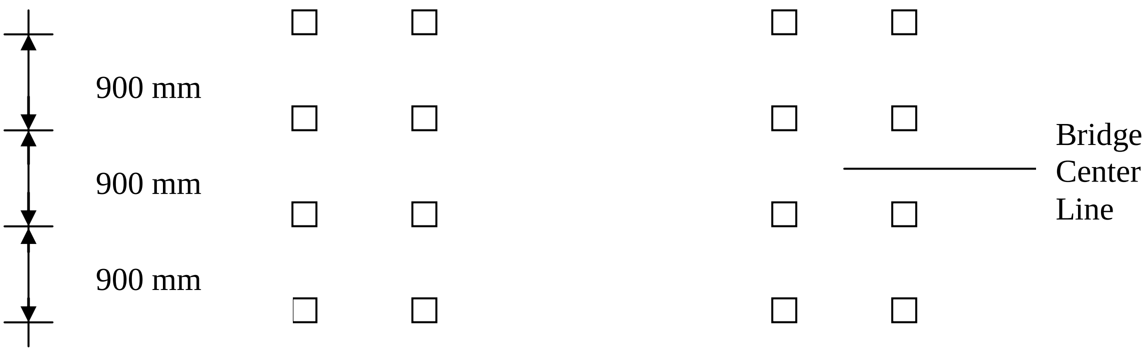

Figure 4(b) : Plan View of HB Loading

5. (a) Figure 5 shows a simplified sketch of a bridge deck. Explain the reason why a bridge deck as shown in Figure 5 will be subjected to both bending and torsion under general loading condition. Use suitable sketches in your explanation.

(6 marks)

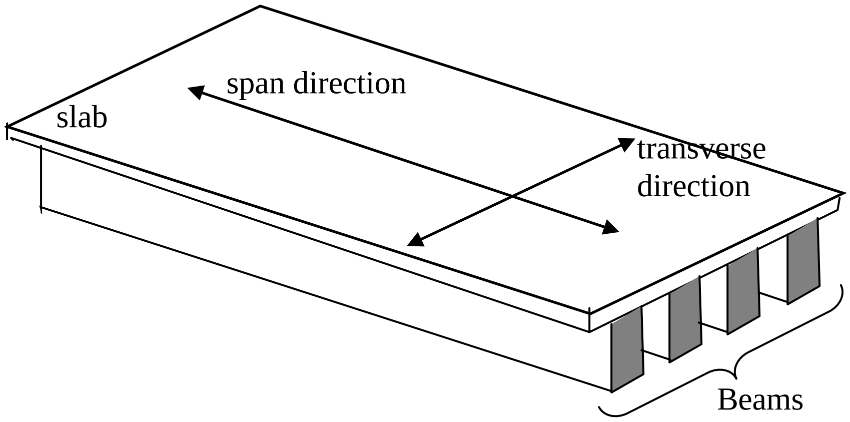

Figure 5

(b) Explain how a structural member in a grillage transfer loading. Stiffness equation for a grillage element as shown in Figure 6 in local coordinate system is given as follows:

$$\begin{Bmatrix} M_{xi} \\ M_{yi} \\ W_i \\ M_{xj} \\ M_{yj} \\ W_j \end{Bmatrix} = \begin{bmatrix} GJ/L & 0 & 0 & -GJ/L & 0 & 0 \\ 0 & 4EI/L & -6EI/L^2 & 0 & 2EI/L & 6EI/L^2 \\ 0 & -6EI/L^2 & 12EI/L^3 & 0 & -6EI/L^2 & -12EI/L^3 \\ -GJ/L & 0 & 0 & GJ/L & 0 & 0 \\ 0 & 2EI/L & -6EI/L^2 & 0 & 4EI/L & 6EI/L^2 \\ 0 & 6EI/L^2 & -12EI/L^3 & 0 & 6EI/L^2 & 12EI/L^3 \end{bmatrix} \begin{Bmatrix} \theta_{xi} \\ \theta_{yi} \\ w_i \\ \theta_{xj} \\ \theta_{yj} \\ w_j \end{Bmatrix}$$

where G:shear modulus, J:torsional constant, L:length of member, E:elastic modulus, and I:second moment area of section. Explain the derivation process of the above stiffness equations. Use suitable sketches in your explanation.

(8 marks)

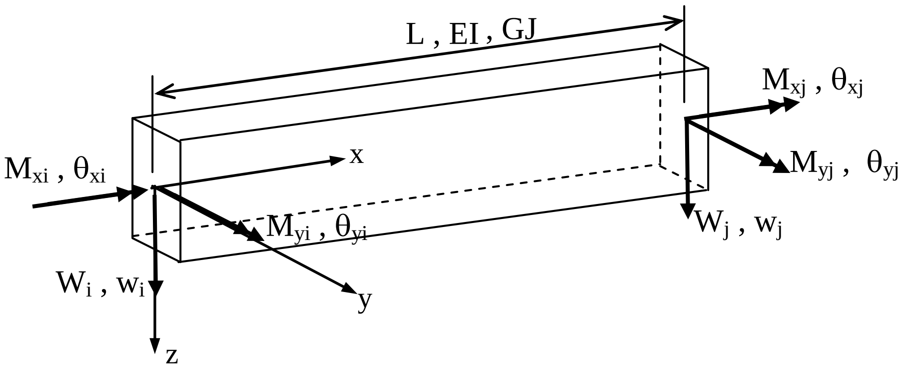

Figure 6

(c) Figure 7 shows a box section which could be used as a possible choice for forming bridge deck. Derive the expression for the maximum shear stress in the section due to torsional moment T for the case of $t_w=t_f/2$, $b=d/2$ and $t_f=d/20$. Indicate the portion of the box section where maximum shear stress will occur.

(6 marks)

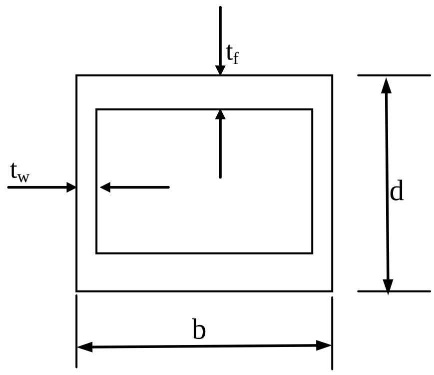

Figure 7

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APPENDIX

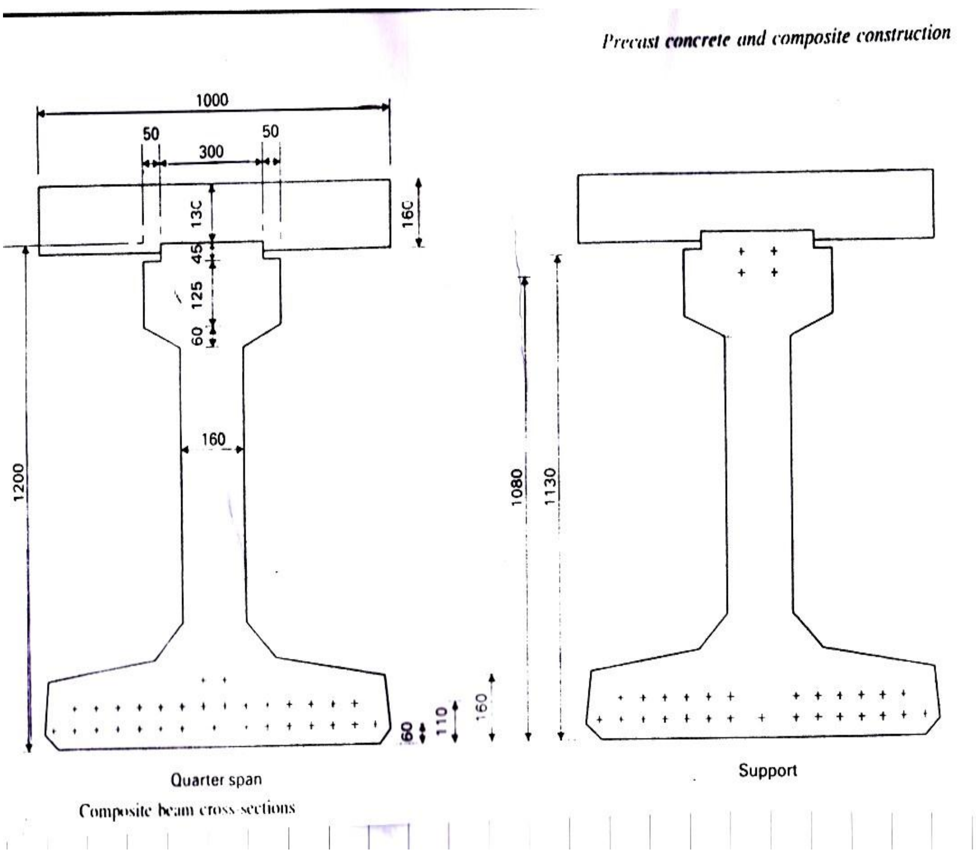

Table 3.0(a) Table 3.0(b)

APPENDIX