UNIVERSITI SAINS MALAYSIA

KSCP EXAMINATION
Academic Session 2007/2008

June 2008

EAS 665/4 – Bridge Engineering

Duration: 3 hours

Please check that this examination paper consists of **NINE (9)** printed pages including appendix before you begin the examination.
*[Sila pastikan kertas peperiksaan ini mengandungi **SEMBILAN (9)** muka surat bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.]*

Instructions: This paper consists of **FIVE (5)** questions. Answer **ALL** questions. All questions carry the same marks.
*[**Arahan**: Kertas ini mengandungi **LIMA (5)** soalan. Jawab **SEMUA** soalan. Semua soalan membawa jumlah markah yang sama.]*

You may answer the question either in Bahasa Malaysia or English.
[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

All questions **MUST BE** answered on a new page.
*[Semua soalan **MESTILAH** dijawab pada muka surat baru.]*

Write the answered question numbers on the cover sheet of the answer script.
[Tuliskan nombor soalan yang dijawab di luar kulit buku jawapan anda.]

1. (a) Briefly describe the effects of creep of concrete structures to overall bridge components.

[5 marks]

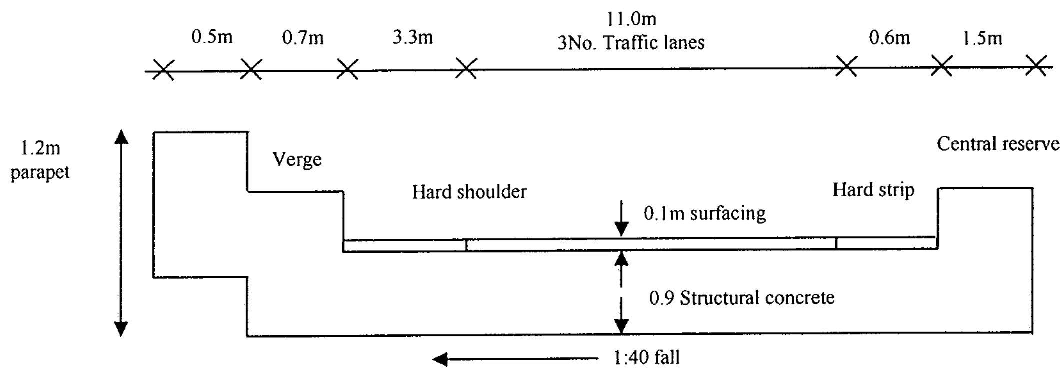


Figure 1.0 : Cross Section of highway bridge

A highway underbridge of composite slab is shown in Figure 1.0. The bridge is constructed for Nibong Tebal Highway at a site which is 120m above sea level. There are no considerations of special funneling, gust or frost conditions in the design calculation. The effective temperature of bridge at the setting time of bearing is 18^0C. Assume open parapet.

(i) Calculate the diameter at neutral axis when subjected to HA and HB loading.

(ii) Summarize the load on central reserve and verge, longitudinal, skidding and collision to parapet.

(iii) Calculate the average at intensity on footway loading.

[15 marks]

2. (a) Figure 2.0 shows the cross-section of reinforced concrete beam for bridge structures. Determine the amount of stirrups to resist an ultimate shear force of 560kN applied to the section. The grade of concrete is 40MPa.

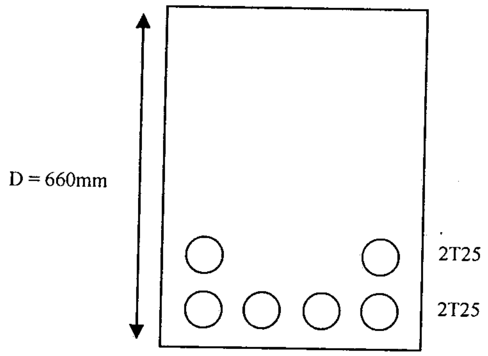
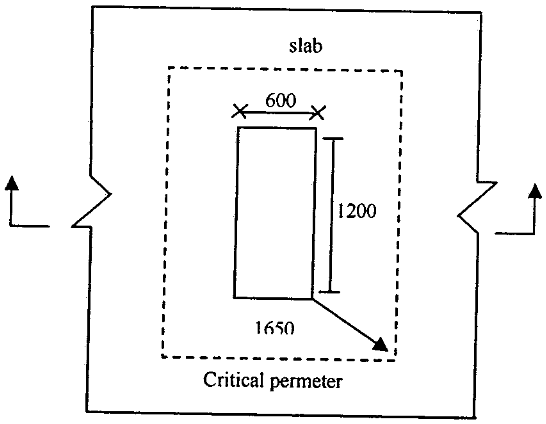


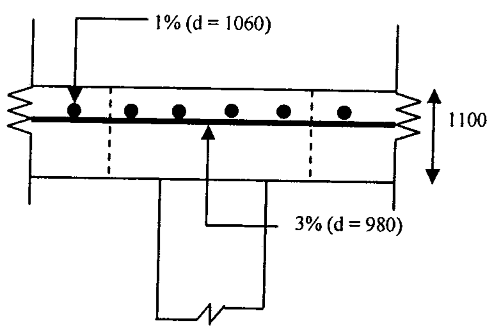
Figure 2.0 cross – section of reinforced concrete beam

[10 marks]

(b) A concrete slab as shown in Figure 3(a) and 3(b) resist punching shear. Calculate the required amount of reinforcement. The characteristic strength of steel and concrete are $460N/mm^2$ and $40N/mm^2$ respectively. The ultimate limit state load to be carried is 15MN.



(a) Plan



(b) Section A- A

Figure 3 : (a) and 3 (b)

[10 marks]

3. (a) List the main advantages to be gained using continuous deck against simply supported deck.

[5 marks]

(b) The purpose of bridge bearing is to accommodate movement and rotation of the member and finally transmit it to the other structural member. Describe two (2) types of bearing with and without rotation to overcome the abovementioned actions.

[10 marks]

(c) List **FIVE (5)** factors influencing the wind pressure on a bridge.

[5 marks]

4. (a) The bridge deck in Figure 4 is subjected to the distributed loading as shown in Figure 5. Explain why the bridge deck will experience both bending and torsional deformation. Use suitable sketches in your explanation.

[4 marks]

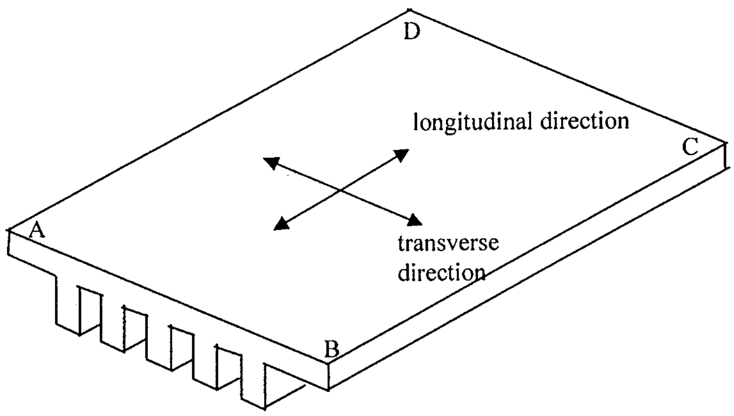


Figure 4

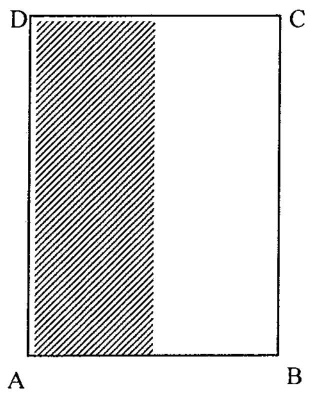


Figure 5 : Distributed load acting over a portion of the deck

(b) Figure 6 shows a grillage structure lying in x-y plane. A uniformly distributed load of 7.5kN/m in the direction of z-axis (pointing towards the paper) acts along member 1-2 and 2-3. Points 1 and 3 are fixed. Cross-section for all the members in the grillage is as shown in Figure 7. By using the element connectivity data in Table 1, obtain the structure stiffness equation for the grillage based on matrix method. If point 2 is next prevented from moving in z-direction and subjected to additional twisting load as shown in Figure 8, calculate the twisting and rotational angle at point 2 (note that axis y is pointing away from the paper). Assume elastic modulus as E = 30GPa and shear modulus as G =12.5GPa. Make use of Appendix 1 in your calculation.

[16 marks]

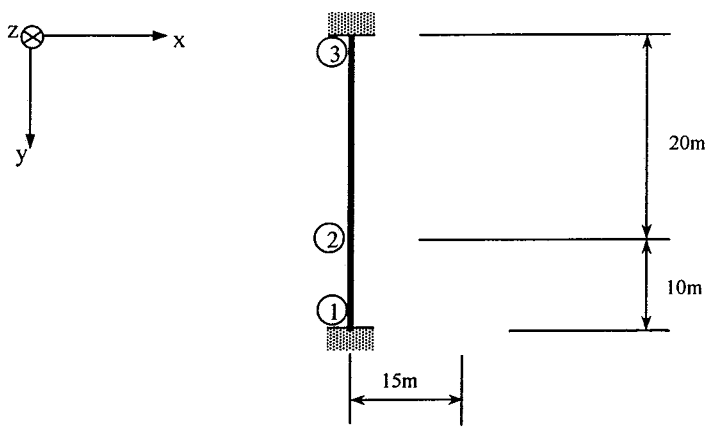


Figure 6

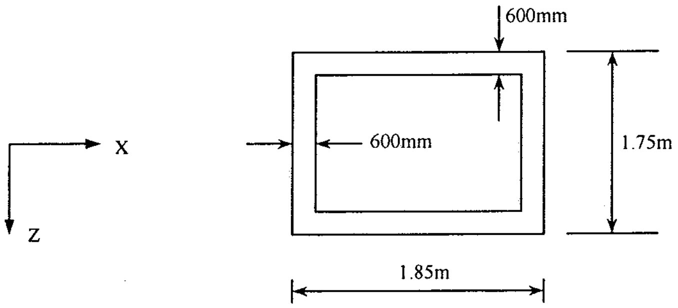


Figure 7

Table 1

Element	Node i	Node j
1	1	2
2	3	2

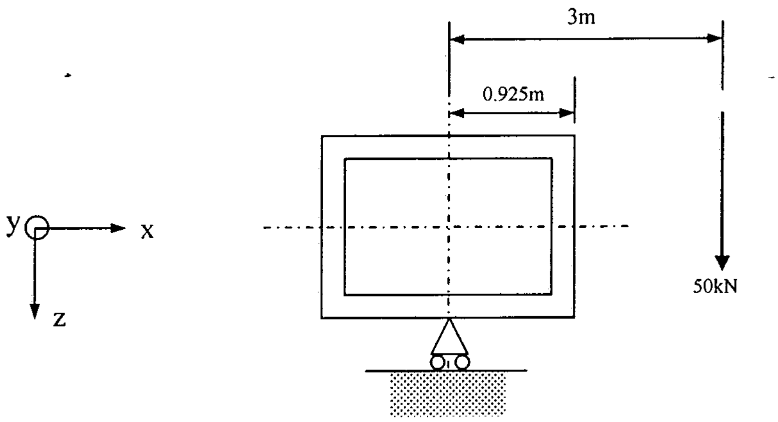


Figure 8

5. (a) An 18 meter single span non-skew bridge is subjected to a Knife Edge Load (KEL) exactly at the middle of the bridge span. Construct the equivalent grillage and provide marking for all major elements, sketch all critical sections, mark the notional lanes and disperse the KEL to the appropriate nodes. The cross section of the bridge is shown in Figure 9.

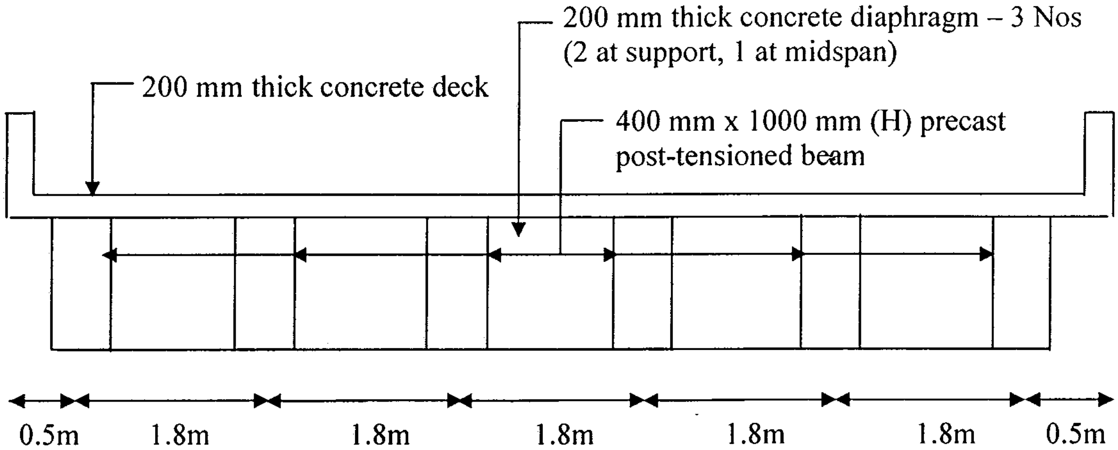


Figure 9 : Typical Cross Section

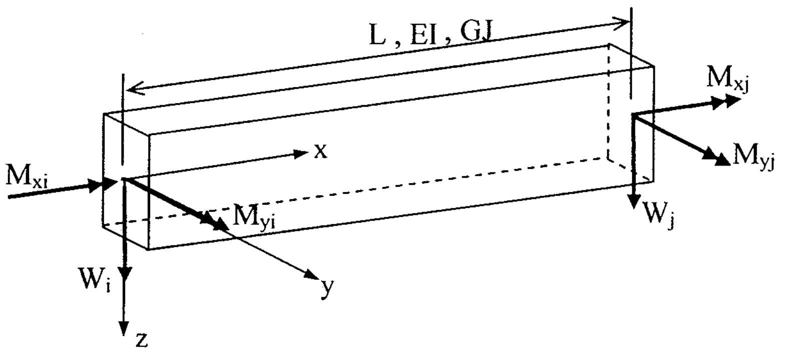
[15 Marks]

(b) State **FIVE (5)** general rules for constructing an appropriate grillage mesh by considering the deck and load characteristics.

[5 Marks]

Appendix 1

a. Element stiffness matrix of a grillage element in global coordinate system



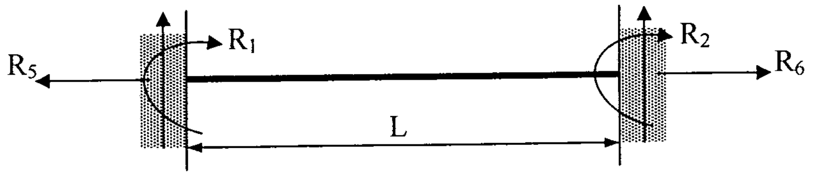
$$\begin{matrix} \theta_{\bar{x}i} & \theta_{\bar{y}i} & \bar{w}_i & \theta_{\bar{x}j} & \theta_{\bar{y}j} & \bar{w}_j \end{matrix}$$

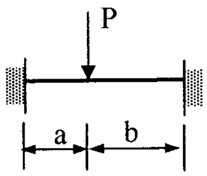
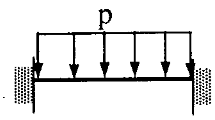
$$\bar{\boldsymbol{k}} = \begin{bmatrix} \frac{GJe^2}{L}+\frac{4EI_yf^2}{L} & & & & & \\ \left(\frac{GJ}{L}-\frac{4EI_y}{L}\right)ef & \frac{GJf^2}{L}+\frac{4EI_ye^2}{L} & & & \textit{Symmetric} & \\ \frac{6EI_yf}{L^2} & -\frac{6EI_ye}{L^2} & \frac{12EI_y}{L^3} & & & \\ \frac{-GJe^2}{L}+\frac{2EI_yf^2}{L} & -\left(\frac{GJ}{L}+\frac{2EI_y}{L}\right)ef & \frac{6EI_yf}{L^2} & \frac{GJe^2}{L}+\frac{4EI_yf^2}{L} & & \\ -\left(\frac{GJ}{L}+\frac{2EI_y}{L}\right)ef & \frac{-GJf^2}{L}+\frac{2EI_ye^2}{L} & -\frac{6EI_ye}{L^2} & \left(\frac{GJ}{L}-\frac{4EI_y}{L}\right)ef & \frac{GJf^2}{L}+\frac{4EI_ye^2}{L} & \\ -\frac{6EI_yf}{L^2} & \frac{6EI_ye}{L^2} & -\frac{12EI_y}{L^3} & -\frac{6EI_yf}{L^2} & \frac{6EI_ye}{L^2} & \frac{12EI_y}{L^3} \end{bmatrix}$$

where e=cosα , f=sinα and α : angle made by local axis of grillage member with global x-axis in the plane of grillage(measured in clockwise direction), L: length of grillage element, J: torsional constant of section, I_y: section moment inertia with respect to bending about y-axis, E: elastic modulus and G: shear modulus.

Appendix 1

b. Fixed end forces



Type of loading	Moments	Vertical forces	Horizontal forces
	$R_1 = -Pab^2/L^2$ $R_2 = -Pa^2b/L^2$	$R_3 = Pb(L^2+ab-a^2)/L^3$ $R_4 = Pa(L^2+ab-b^2)/L^3$	$R_5 = 0$ $R_6 = 0$
	$R_1 = -pL^2/12$ $R_2 = pL^2/12$	$R_3 = pL/2$ $R_4 = pL/2$	$R_5 = 0$ $R_6 = 0$

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