UNIVERSITI SAINS MALAYSIA

1st. Semester Examination
2005/2006 Academic Session

October / November 2006

EAS 664/4 – Principle of Structural Design

Duration: 3 hours

Instructions to Candidates:

1. Ensure that this paper contains **EIGHT (8)** printed pages including appendices before you start your examination.
2. This paper contains **SIX (6)** questions. Answer **FIVE (5)** questions only. Marks will be given to the **FIRST FIVE (5)** questions put in order on the answer script and **NOT** the **BEST FIVE (5).**
3. Each question carries equal mark.
4. All questions **CAN BE** answered either in English or Bahasa Malaysia.
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) Derive the partial differential equation in X, Y and Z direction for three dimensional stress strain based on Figure 1.

(12 marks)

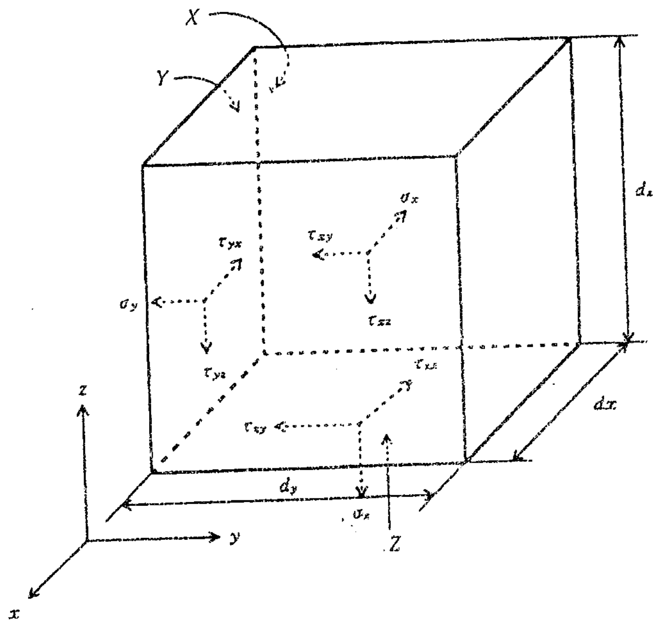

Figure 1

(b) Using Von Karman notation, show that the equation of equilibrium in (a) can be written as:-

$$\sigma_{ij,\,j} + F_i = \rho a_i$$

where a_i is component of acceleration and ρ is density.

(3 marks)

(c) Using stress-strain relationship, sketch the Bauchinger effect for homogenous material. Hence, explain what is homogenous material.

(5 marks)

2. (a) List the major differences and similarities between Elastic-Perfectly Plastic model and Elastic-Exponential Hardening model. Also sketch the relationship between stress-strain for these models.

(12 marks)

(b) Prove that Von Mises and Tresca yield criteria is ellipse and hexagon, respectively. Assume $\sigma_3 = 0$.

(8 marks)

3. (a) Participative design is defined as the involvement of persons in planning and controlling a significant number of their work activities. These persons possess sufficient knowledge and capacity to exercise an influence on both processes and results to achieve desired aims. Discuss the possible benefits of participation that can be achieved towards a safe design.

(15 marks)

(b) BS 8110 does not permit shear reinforcement to be provided entirely in the form of bent-up bars. Why?

(5 marks)

4. (a) Torsional reinforcement is to be designed for a simply supported beam with an ultimate torsional moment, T_{sd} = 65 kNm and shear force, V_{sd} = 250kN. The beam cross-section is shown in Figure 2. Assume steel grade $f_{y1k} = 410\ N/mm^2$, the characteristic strength of concrete is $f_{ck} = 30\ N/mm^2$ and the mild steel links is $f_{y2k} = 250\ N/mm^2$. The span of the simply supported beam is 6.5m.

(15 marks)

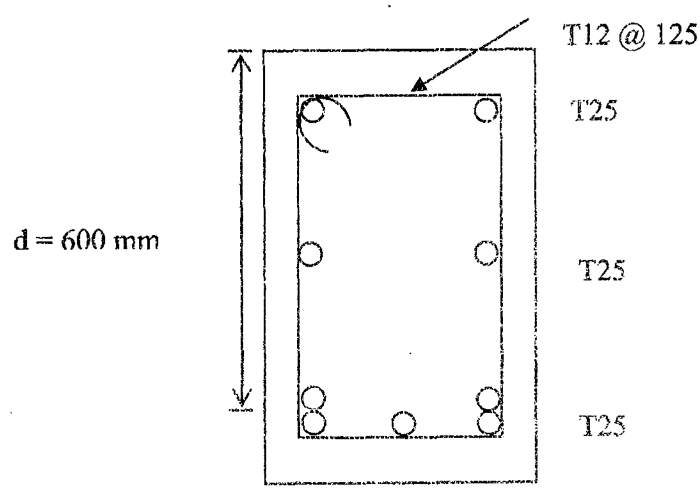

Figure 2: Rectangular cross section beam (300 mm x 700 mm)

(i) Based on the calculated ultimate torsional moment (Tsd), check the maximum torsional moment that can be carried by the section given in Figure 2.
(ii) Check the adequacy of beam cross section
(iii) Check the additional reinforcement (A_{s1}) provided.

(b) Briefly describe the roles of shear reinforcement in reducing a sudden and catastrophic failure, which often occurs in beams without shear reinforcement.

(5 marks)

5. (a) Briefly describe **FIVE (5)** factors influencing the wind load calculation in codes of practice.

(5 marks)

(b) A ten-storey rigid frame building as shown in Figure 3 is situated at Johor Baharu in the terrain category 3 with a basic wind speed of 33.5 m/s. Calculate the value of the design wind force from first floor to roof level of the frame as shown in Figure 3 in accordance with MS1553:2002. The typical storey height is 3.0 m, to give a total height of 30m. The frames are spaced at 6m. Indicate all assumed values used in the calculations.

(12 marks)

(c) State the minimum design wind pressure in MS1553:2002. How do you get the value of wind pressures for complex structures which are not covered by the codes of practice?

(3 marks)

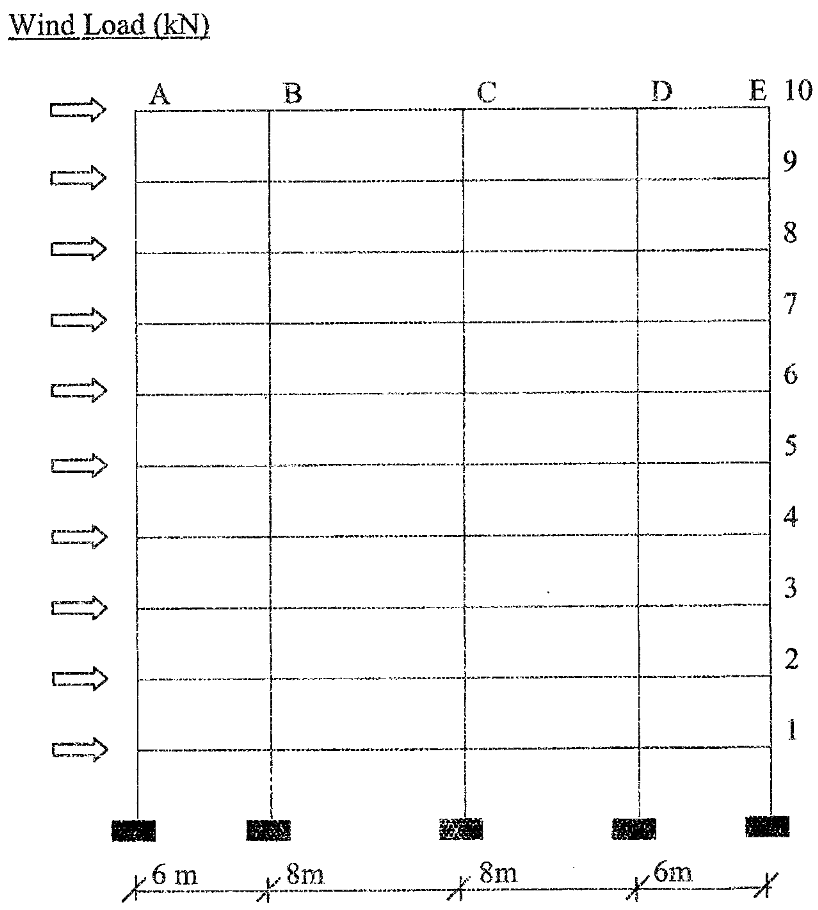

Figure 3

6. (a) The elastic theory may not be an appropriate tool to analyse a deep beam. With the aid of suitable sketches, discuss briefly **THREE (3)** major behavioural differences between deep and shallow continuous deep beam.

(8 marks)

(b) Figure 4 shows a test specimen profile of a single span deep beam with fixed end support. Calculate the predicted failure load using the following data:-

Concrete

f_{cu} = $38.5\ N/mm^2$
f_t = $2.26\ N/mm^2$
E_c = $18.6\ kN/mm^2$
f_{tc} = $f_{cu}/21\ N/mm^2$

Reinforcement

A_{st} = $402\ mm^2$
A_{sb} = $628\ mm^2$
A_h = $283\ mm^2$
A_v = $452\ mm^2$
F_y = $460\ N/mm^2$ *(for all reinforcement)*
E_s = $200\ kN/mm^2$ *(for all reinforcement)*
f_s = $19.7\ N/mm^2$

Beam

h = 600 mm
d = 542 mm
b = 75 mm
d_e = 570 mm

(12 marks)

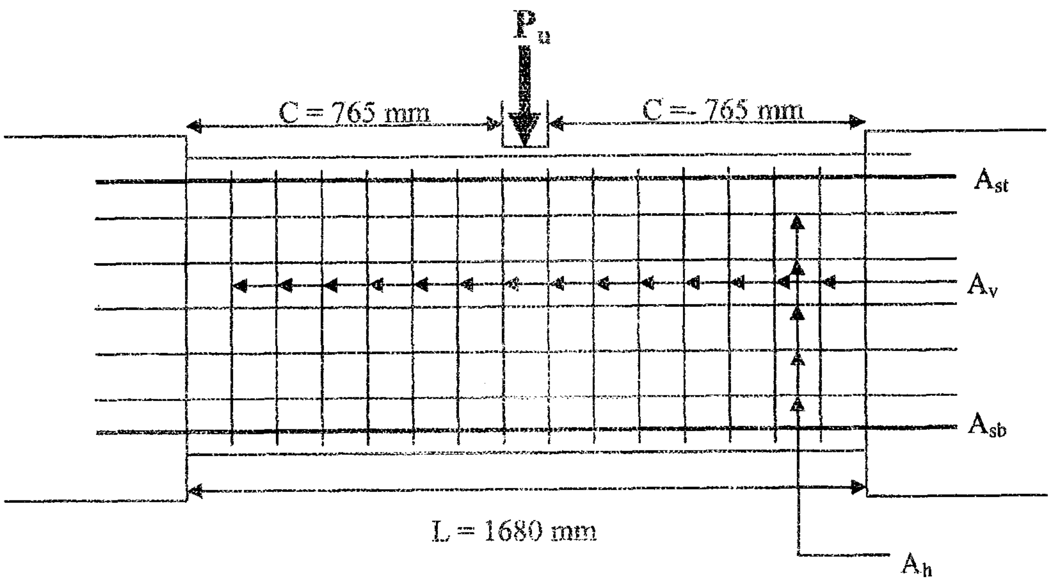

Figure 4 : Specimen Profile

APPENDIX A

$$T_{sd} \leq V_{sd} b_w / 4.5$$

$$V_{sd}[1 + (4.5T_{sd} / V_{sd} b_w)] \leq V_{Rd1}$$

$$V_{Rd1} = [\tau_{Rd} k(1.2 + 40_{\rho 1})] b_w d$$

$$\tau = 0.035 f_{ck}^{2/3}$$

$k = (1.6 - d)$ with d in metres

$d \geq$ 0.6m or if more than 50 per cent of the bottom reinforcement is curtailed $k = 1.0$

$\rho_1 =$ A_s/bd for the tension reinforcement which extends not less than d + $\ell_{b.net}$ beyond the section considered, $\ell_{b.net}$ being the anchorage bond length.

$$\left(\frac{T_{sd}}{T_{Rd1}}\right)^2 + \left(\frac{V_{sd}}{V_{Rd2}}\right)^2 \leq 1.0$$

where $T_{Rd1} = 1.33 v f_{ck} t A_k / (\cot\theta + \tan\theta)$

and $v = 0.7(0.7 - f_{ck}/200) \not< 0.35$

for closed stirrups in both walls of the actual or equivalent hollow section.

The value of cot θ is permitted to be taken between

$$0.67 \leq \cot\theta \leq 1.5$$

The value taken should be used throughout the design.

The calculation for V_{Rd2} should be based on the Variable Strut Inclination Method (equation 5.8) such that

$$V_{Rd2} = b_w z v f_{ck} / [1.5(\cot\theta + \tan\theta)]$$

$$v = 0.7 - f_{ck}/200 \not< 0.5$$

and $z = 0.9d$

$$\frac{A_{sw}}{s} = \frac{T_{sd}}{2A_k 0.87 f_{yk} \cot\theta}$$

$$A_{s1} = \frac{T_{sd} u_k \cot\theta}{2A_k 0.87 f_{y1k}}$$

APPENDIX B

Notation (Reference for Question No. 6)

b	is the width beam
c	is the clear shear span
d	is the distance between c/c of top and bottom bars
d_e	is the effective depth (distance from top surface of concrete to centre of bottom bars)
d'	is the depths of covers to centres of top and bottom bars
h	is the overall height of beam
L	is the span
m	is the modular ratio: $E_{s\ web}/E_c$
f_{cu}, f_y, f_s bars)	are the characteristic strengths (concrete, main bars and web
f_{tc}	is the limiting tensile strength of concrete in biaxial compression- tension ($=f_{cu}/21$)
f_s, f_s'	is the modular ratio x f_{tc} with respect to web and main bars
ft	is the tensile strength of concrete from cylinder splitting test
A_{st}, A_h, A_v, A_{sb}	are the total areas of reinforcement (top main, web horizontal, web vertical and bottom main)
C, C_{b1}, C_{b2}	are the compressive forces
C_c	is the concrete crushing force at upper 'notional hinge' ($=0.67 f_{cu} bd'$)
C_t, V_t	is the horizontal and vertical components of C_c
$E, E_b, E_t, E_c,$ $E_{sh}, E_{st}, E_{s\ web},$ $E_{s\ top}, E_{s\ bot}$	are the moduli of elasticity (reinforcing bars, bottom bars, top bars, concrete, horizontal bars, main bars, web bars, top main bars and bottom main bars)
F_{ct}, F_{steel}	are the concrete forces and steel forces at support section

Cont'd.....

H, H_w	are the web steel forces at support section: maximum value of $H = A_h f_{sy}$
M_o, M_r	are the moments about O (due to forces in the inclined failure plane, due to forces in the support section (restoring moment)
P_l, P_2	are the support reaction sources
P_v, P_h	are the forces in the web bars (vertical and horizontal)
P_{add}	is the additional force at the 'notional hinge' required for moment equilibrium in case of flexure plus shear mode of failure
$P_{u\,ana}$	is the predicted failure load from analysis
$P_{u\,test}$	is the actual failure load from a test
S_h, S_v	is the spacing of web bars (horizontal and vertical)
V_b	is the vertical component of concrete crushing force at lower 'notional hinge'

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