UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2007/2008

April 2008

EAS 454/4 – Advanced Structural Engineering
[Kejuruteraan Struktur Lanjutan]

Duration: 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of **ELEVEN (11)** pages of printed material including appendix before you begin the examination.
*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **SEBELAS (11)** muka surat bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.]*

Instructions: This paper contains **SIX (6)** questions. Answer **FIVE (5)** questions. All questions carry the same marks.

*[**Arahan**: Kertas ini mengandungi **ENAM (6)** soalan. Jawab **LIMA (5)** 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) Develop the stiffness matrices for member 1 and 2 for the truss shown in Figure 1.

Bentukkan matrik kekukuhan struktur di anggota 1 dan 2 bagi kekuda dalam Rajah 1.

(4 marks / *4 markah*)

(b) Figure 2 shows a beam with moment of inertias of EI and 2EI for member 1 and 2, respectively. The beam is supported by rollers at nodes 1 and 2 and fixed at node 3. The beam is subjected to a 20 kN/m uniformly distributed load on member 1 and two concentrated loads, 30 kN and 50 kN on member 2.

(i) Determine the moment developed at fixed support using stiffness method.
(ii) Determine reactions at supports.

All solutions should be based on member, node and degree of freedom as labelled in Figure 1 and 2.

Rajah 2 menunjukkan satu rasuk yang mempunyai momen inersia EI dan 2EI masing-masing bagi anggota 1 dan 2. Rasuk disokong rola di nod 1 dan nod 2 dan diikat tegar di sambungan 3. Rasuk tersebut menanggung beban teragih seragam 20 kN/m di anggota 1 dan dua beban titik 30 kN dan 50 kN di anggota 2.

(i) Tentukan momen yang terhasil di penyokong tegar menggunakan kaedah kekukuhan.
(ii) Tentukan tindakbalas di penyokong.

Penyelesaian yang dibuat mestilah berdasarkan kepada anggota, sambungan dan darjah kebebasan yang telah dilabelkan dalam Rajah 1 dan 2.

(16 marks / *16 markah*)

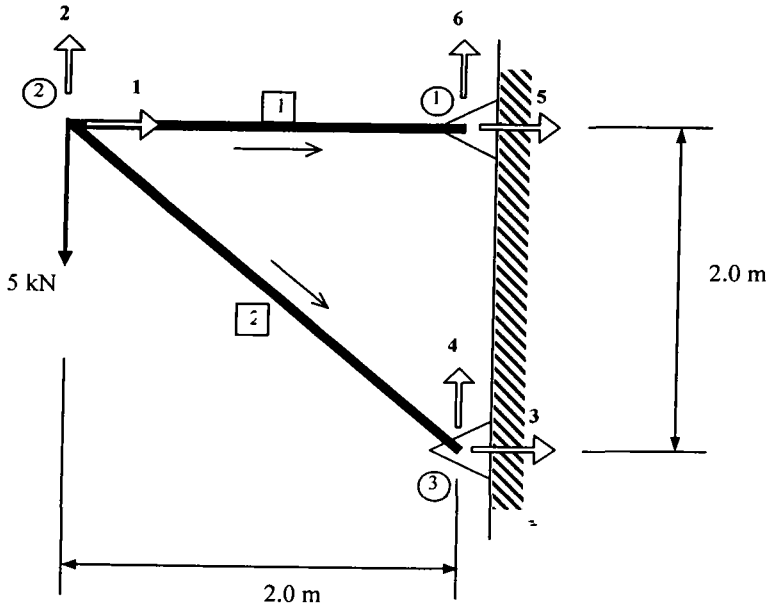


Figure 1 / Rajah 1

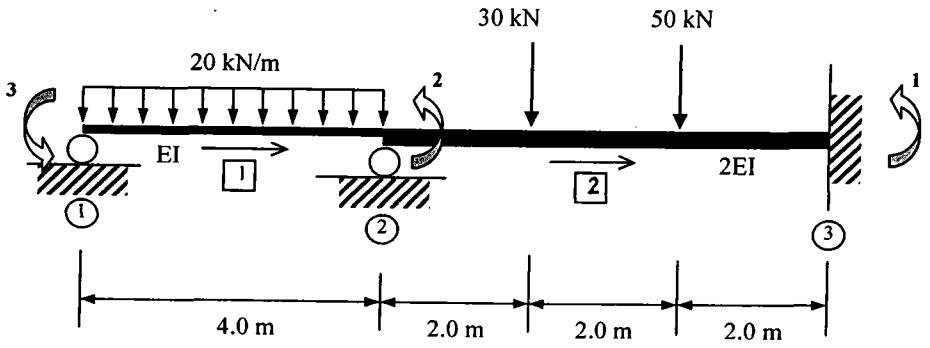


Figure 2 / Rajah 2

2. (a) Design and provide all relevant detailing for a pile cap carrying 1200kN dead load and 600kN live load based on the following requirements :-

Self weight of pile cap	= 50 kN
Concrete grade, fcu	= 30 N/mm^2
Concrete cover	= 50 mm
Pile size	= 300 mm diameter
Pile spacing, L	= 900 mm
Allowable pile working load	= 500 kN
Pile embedded length	= 75 mm
Characteristic strength of reinforcement, fy	= 460 N/mm^2
Main reinforcement size	= 16 mm diameter
Pile cap edge distance	= 150 mm
Pile cap overall depth, H	= 900 mm

Use Table 1 to determine the appropriate tension force.

Table 1 : Tension Force, T (Truss Analogy)

PILE GROUP	**TENSION FORCE, T (kN)**
2	$\frac{NL}{4d}$
3	$\frac{NL}{9d}$
4	$\frac{NL}{8d}$
N = Ultimate Column Load d = Effective Depth L = Pile spacing	

(a) *Rekabentuk dan sediakan semua perincian satu tetopi cerucuk yang menanggung 1200 kN beban mati dan 600 kN beban hidup berdasarkan keperluan berikut :-*

Berat kendiri tetopi cerucuk	*= 50 kN*
Gred konkrit, fcu	*= 30 N/mm²*
Penutup konkrit	*= 50 mm*
Saiz cerucuk	*= 300 mm garispusat*
Selaan cerucuk, L	*= 900 mm*
Beban kerja cerucuk dibenarkan	*= 500 kN*
Benaman cerucuk	*= 75 mm*
Kekuatan ciri tetulang, fy	*= 460 N/mm²*
Saiz tetulang utama	*= 16 mm garispusat*
Jarak tepi tetopi cerucuk	*= 150 mm*
Kedalaman keseluruhan tetopi cerucuk, H	*= 900 mm*

(16 marks */16 markah)*

Guna Jadual 1 untuk menentukan daya tegangan yang bersesuaian.

Jadual 1 : Daya Tegangan, T (Analogi Kerangka)

KUMPULAN CERUCUK	*DAYA TEGANGAN, T (kN)*
2	$\frac{NL}{4d}$
3	$\frac{NL}{9d}$
4	$\frac{NL}{8d}$
N = Beban tiang muktamad *d = Kedalaman berkesan* *L = Selaan cerucuk*	

(b) State **ONE (1)** advantage and **ONE (1)** disadvantage of using Yield-Line theory in reinforced concrete slab design. Use suitable sketch.

*Nyatakan **SATU (1)** kelebihan dan **SATU(1)** kelemahan penggunaan teori Garis-Alah apabila merekabentuk papak konkrit bertetulang. Gunakan lakaran yang sesuai.*

(4 marks / *4 markah*)

3.(a) Discuss briefly **THREE (3)** main differences between spring, trusses and beam element in the finite element modelling.

*Bincang secara ringkas **TIGA** (3) perbezaan utama antara elemen pegas, kekuda dan rasuk dalam pemodelan kaedah elemen terhingga.*

(6 marks / *6 markah*)

(b) For the beam-spring system with arbitrarily numbered nodes shown in Figure 3 , given k = 15 MN/m, EI = 7.5 MNm^2, P = 500 kN and L = 2.0 m, determine:

(i) the global stiffness matrix
(ii) displacement and rotation of node 2
(iii) the reaction forces at nodes 1, 3 and 4

Untuk sistem pegas dan rasuk dengan nombor sembarangan yang ditunjukkan di Rajah 3, diberi nilai k = 15 MN/m, EI = 7.5 MNm^2, P = 500 kN dan L = 2.0 m, tentukan:

(i) Matriks kekukuhan global
(ii) Anjakan dan putaran di nod 2
(iii) Daya tindakbalas di nod 1, 3 dan 4

(14 marks / *14 markah*)

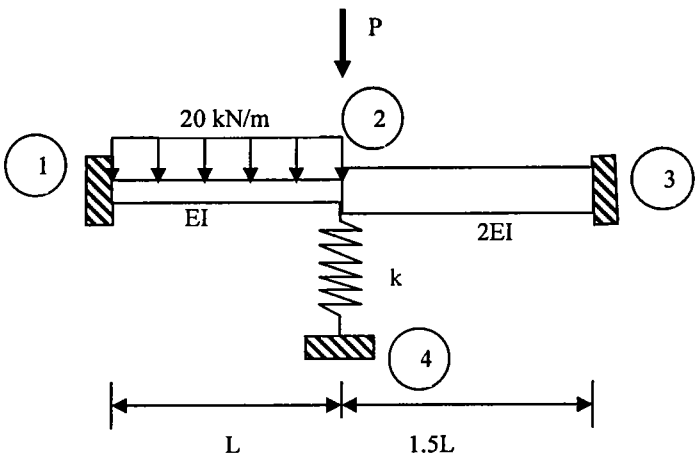


Figure 3 / Rajah 3

4. (a) Briefly describes **FIVE (5)** factors influencing the wind loads calculation in codes of practice.

*Nyatakan **LIMA** (5) faktor yang mempengaruhi pengiraan nilai beban angin dalam kod piawaian.*

(5 marks / *5 markah*)

(b) A reinforced concrete building will be built at Malacca (Zone II) in the terrain category 2 with the basic wind speed of 32.5 m/s^2 as shown in Figure 4. Calculate the value of design wind pressure on the W(windward) surface. Design data can be extracted from MS1553 (2002).

Sebuah bangunan konkrit bertetulang yang akan dibina di Melaka (Zon II) dalam kategori rupa bumi 2 dengan beban angin asas sebanyak 32.5 m/s^2 seperti yang ditunjukkan dalam Rajah 4. Kira nilai tekanan angin rekabentuk di permukaan W(arah angin). Data rekabentuk boleh diperolehi dari MS1553 (2002).

(15 marks / *15 markah*)

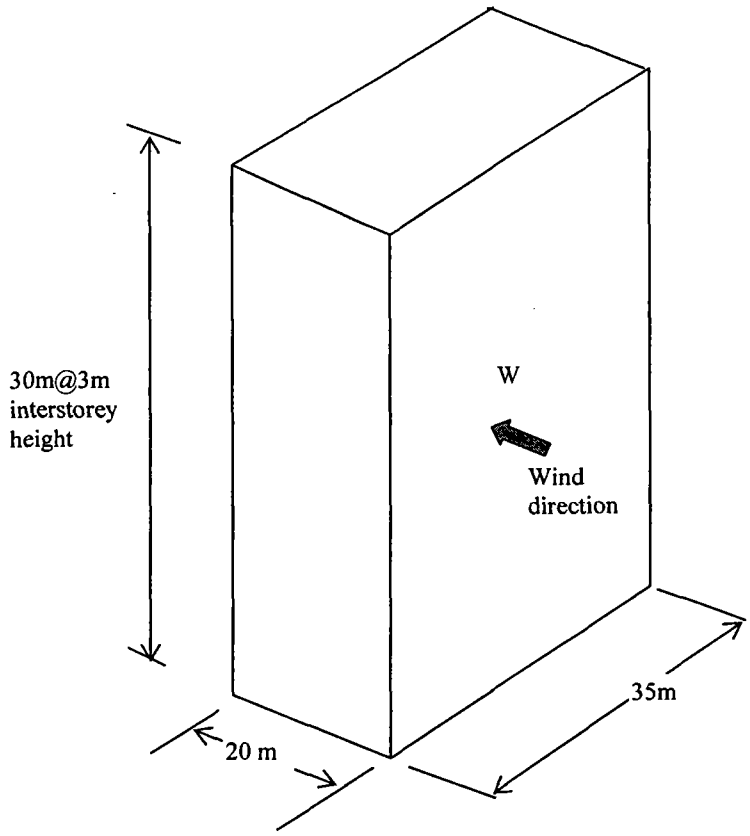


Figure 4 / Rajah 4

5. (a) Derive the equation of motion for the 1-dof mass spring model given in Figure 5 where k is stiffness of the system, m is mass of the system, p(t) is time varying external load acting on the system and v(t) is displacement of the system. Take the self-weight of the mass block into consideration in the derivation. Show clearly the reference position of the time varying displacement v(t) with the aid of diagram.

Terbitkan persamaan gerakan untuk model jisim-pegas 1-dof seperti yang ditunjukkan dalam Rajah 5 iaitu k ialah kekukuhan sistem, m ialah jisim sistem, p(t) ialah daya luar bertindak yang berubah dengan masa dan v(t) ialah anjakan sistem. Pertimbangkan berat blok jisim di dalam terbitan tersebut. Tunjukkan dengan jelas kedudukan rujukan untuk anjakan yang berubah dengan masa, v(t) dengan bantuan gambarajah.

(5 marks / *5 markah*)

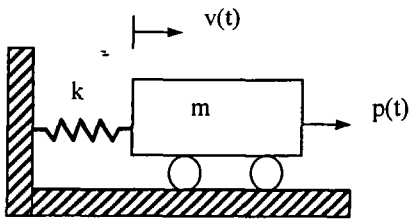


Figure 5

(b) A free vibration test has been carried out on the frame as shown in Figure 6. When a lateral jacking force of 85kN is applied onto the girder, a lateral displacement of 7.5mm was recorded. Subsequently, as the girder is instantaneously released from this initial position, it is observed that the time recorded for the frame to swing back is 1.20s. The maximum displacement on the return swing is 4.5mm. Using this data, compute the followings:

(i) Effective weight of the girder, W (kN).
(ii) Frequency of vibration, f (Hz)
(iii) Damping ratio ξ.
(iv) Time taken in order for the amplitude of vibration to decrease to 10% of the initial amplitude.

Satu ujian getaran bebas telah dijalankan ke atas kerangka yang ditunjukkan dalam Rajah 6. Ujian menunjukkan apabila satu daya sisi bicu 85 kN dikenakan ke atas galang kerangka, anjakan sisi sebanyak 7.5mm direkodkan. Didapati bahawa masa yang diambil untuk galang menghayun balik apabila galang dilepaskan serta merta dari kedudukan awal ialah 1.20s. Anjakan maksima hayunan balik ialah 4.5mm. Dengan menggunakan data yang diberikan, kira:

(i) Berat berkesan galang, W (kN)
(ii) Frekuensi getaran, f (Hz)
(iii) Nisbah redaman ξ
(iv) Masa yang diambil untuk amplitud getaran menjadi 10% daripada amplitud awal.

(15 marks / *15 markah*)

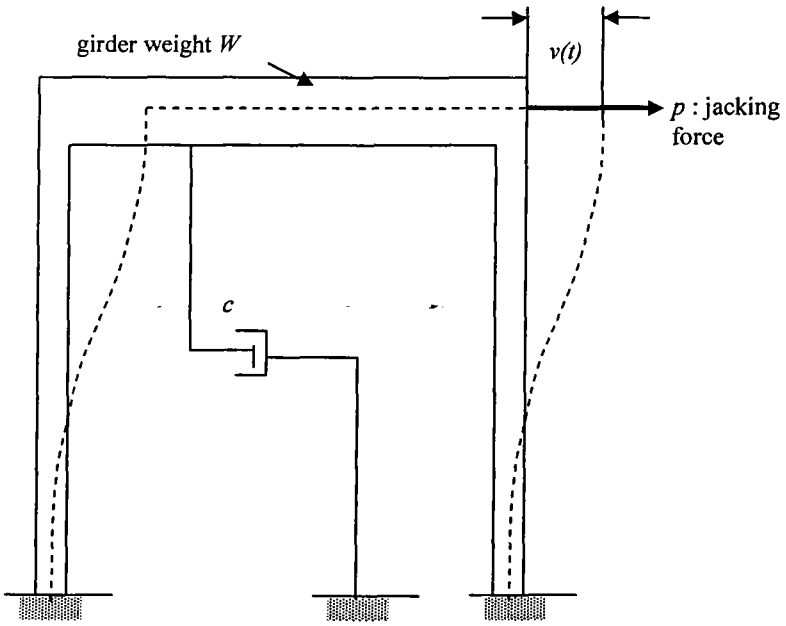


Figure 6 / Rajah 6

6. (a) Briefly explain **THREE (3)** criteria for the design of tall building.

*Terangkan dengan ringkas **TIGA** (3) kriteria untuk rekabentuk bangunan tinggi.*

(3 marks / *3 markah*)

(b) Briefly explain the advantages and disadvantages of rigid frame structural system and shear wall structures.

Nyatakan kelebihan dan kekurangan sistem struktur kerangka tegar dan struktur dinding ricih.

(6 marks / *6 markah*)

(c) Figure 7 shows a continuous beam forming part of the rigid frames. Determine the maximum moment at each supports using two-cycle moment distribution method. Ignore the calculation for the maximum mid-span moments.

Rajah 7 menunjukkan satu rasuk selanjar yang membentuk sebahagian dari kerangka tegar. Tentukan nilai momen lentur maksima di setiap penyokong dengan menggunakan kaedah agihan momen dua kitaran. Abaikan pengiraan momen maksima di pertengahan rentang.

(11 marks / *11 markah*)

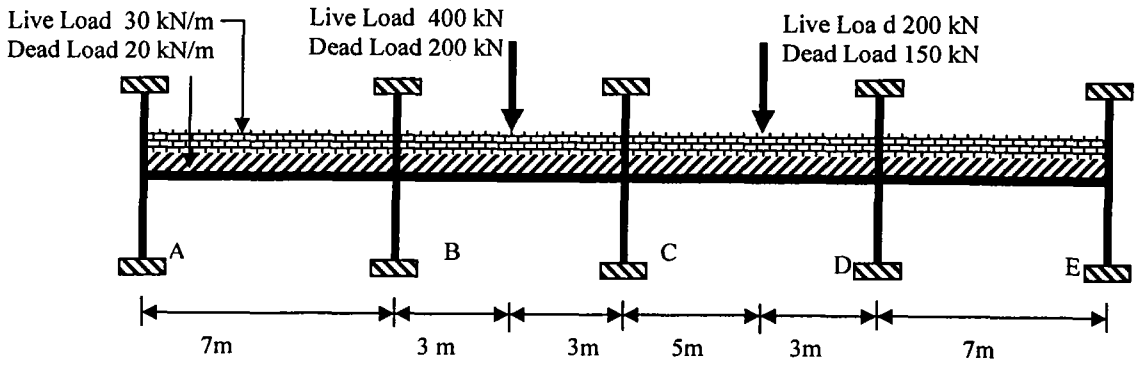
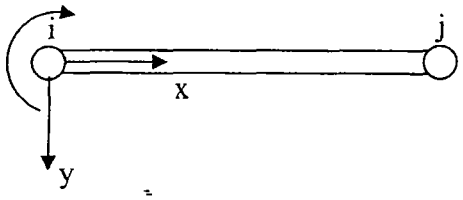


Figure 7 / Rajah 7

- ooo O ooo -

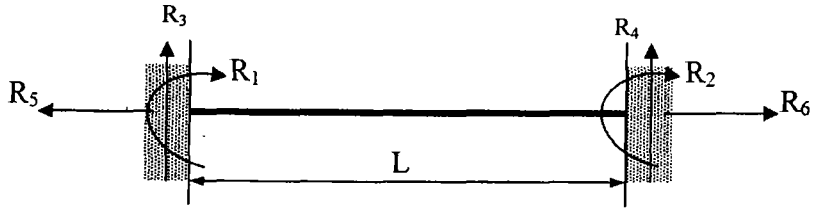
a. Element stiffness matrix of a beam element :

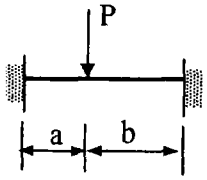
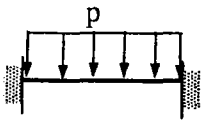
$$\boldsymbol{k} = EI_z \begin{bmatrix} \frac{12}{L^3} & \frac{6}{L^2} & -\frac{12}{L^3} & \frac{6}{L^2} \\ \frac{6}{L^2} & \frac{4}{L} & -\frac{6}{L^2} & \frac{2}{L} \\ -\frac{12}{L^3} & -\frac{6}{L^2} & \frac{12}{L^3} & -\frac{6}{L^2} \\ \frac{6}{L^2} & \frac{2}{L} & -\frac{6}{L^2} & \frac{4}{L} \end{bmatrix}$$



where E : modulus of elasticity , I_z : moment of inertia of section with respect to z-axis (an axis pointing towards the plane of the paper) and L : length of element

b. Fixed end forces



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