
UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Kedua
Sidang Akademik 2004/2005

Mac 2005

EMM 462E/3 – ANALISIS TEGASAN

Masa : 3 jam

ARAHAN KEPADA CALON :

Sila pastikan bahawa kertas soalan ini mengandungi **TUJUH (7)** mukasurat dan **ENAM (6)** soalan yang bercetak serta **DUA (2)** halaman lampiran sebelum anda memulakan peperiksaan.

Jawab **LIMA** soalan sahaja.

Pelajar dibenarkan menjawab semua soalan dalam **Bahasa Inggeris ATAU Bahasa Malaysia ATAU** kombinasi kedua-duanya.

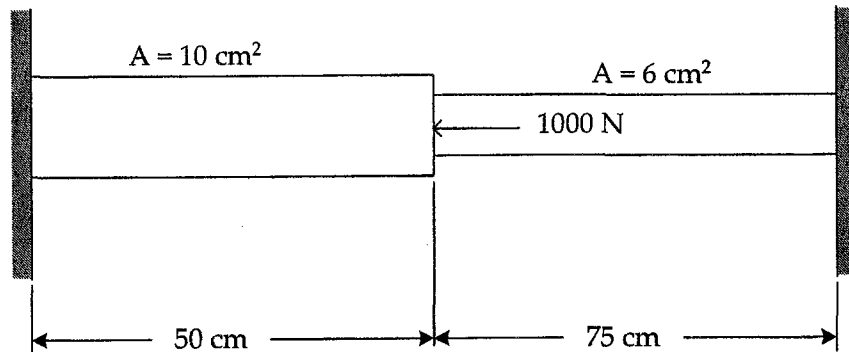
Lampiran :

1. Summary of Important Relationships [2 mukasurat]

Jawapan bagi setiap soalan hendaklah dimulakan dengan mukasurat yang baru.

- S1. [a] Kirakan daya paksi pada setiap anggota sistem struktur seperti yang ditunjukkan dalam Rajah S1[a] jika diberi Modulus Young, $E = 20 \times 10^6 \text{ N/cm}^2$ dan pekali pengembangan haba, $\alpha = 11 \times 10^{-6} / ^\circ\text{C}$. Kenaikan suhu untuk sistem tersebut ialah 15°C .

Calculate the axial force in each member of the structural system shown in Figure Q1[a] if Young Modulus $E = 20 \times 10^6 \text{ N/cm}^2$ and coefficient of thermal expansion, $\alpha = 11 \times 10^{-6} / ^\circ\text{C}$. The temperature rise for the system is 15°C .

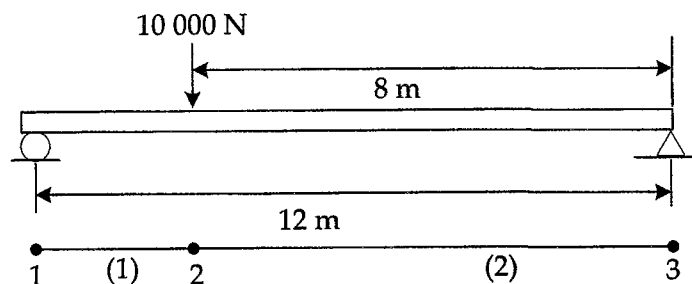


Rajah S1[a]
Figure Q1[a]

(50 markah)

- [b] Satu rasuk yang dikenakan beban sebanyak 10 000 N ditunjukkan dalam Rajah S1(b). Dengan menggunakan elemen dan nod seperti yang ditunjukkan di bawah rajah, dapatkan persamaan elemen dan tunjukkan matrik gabungan selepas memasukkan persamaan elemen sempadan dan beban. Jangan selesaikan persamaan-persamaan tersebut. Ambil modulus Young, $E = 20 \times 10^6 \text{ N/cm}^2$ dan momen inersia $I = 8\,000 \text{ cm}^4$ dalam soalan ini.

A beam with a loading of 10 000 N is shown in Figure Q1[b]. By using the element and nodes shown under the figure, obtain the element equations and show the assembly matrix after incorporating the boundary equations and the loading. Do not solve the equations. Use Young's modulus, $E = 20 \times 10^6 \text{ N/cm}^2$ and moment of inertia, $I = 8\,000 \text{ cm}^4$ in this question.



Rajah S1[b]
Figure Q1[b]

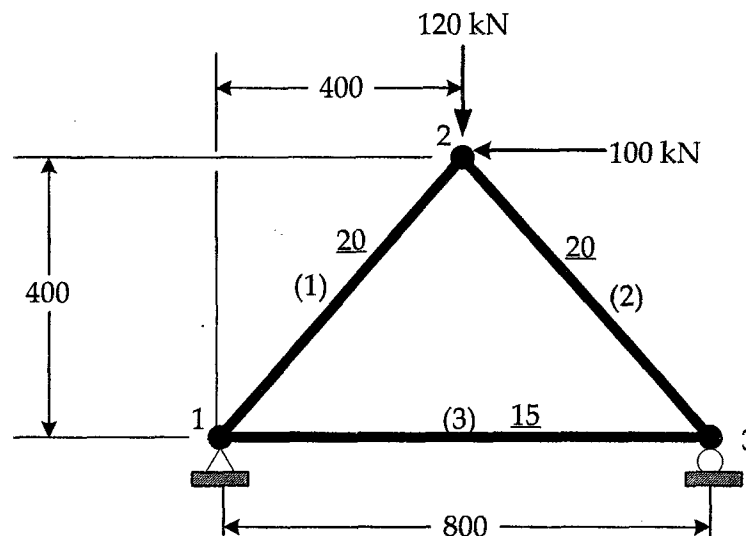
(50 markah)

S2. Satu sistem struktur yang dikenakan beban seperti ditunjukkan dalam Rajah S2. Nombor nod dan elemen diberikan. Luas keratan rentas untuk setiap anggota dalam cm^2 digariskan. Setiap anggota diperbuat daripada keluli dengan modulus Young, $E = 20 \times 10^6 \text{ N/cm}^2$ dan setiap ukuran adalah di dalam sentimeter. Tiada perubahan suhu dalam kes ini.

- [i] Kira anjakan nod
- [ii] Kira daya paksi dalam setiap anggota
- [iii] Tunjukkan bagaimana keseimbangan sistem dipuaskan.

A structural system with two loadings at joint is shown in Figure Q2. The node numbers and element numbers are given. The cross-sectional area of each member in cm^2 is underlined. Each member is made from steel with Young's modulus, $E = 20 \times 10^6 \text{ N/cm}^2$. All lengths are given in centimeters. There is no temperature changes.

- [i] Calculate the unknown nodal displacements
- [ii] Calculate the axial force in each member
- [iii] Show how the system equilibrium is satisfied.



Rajah S2
Figure Q2

(100 markah)

- S3. Untuk pengiraan tegasan termal, ianya perlu untuk dikira suhu pada sesuatu elemen. Untuk elemen segitiga, nilai-nilai nod diberikan seperti di dalam Jadual S3.

For a calculation of a thermal stresses, it is necessary to calculate the temperature in the element. For a triangular element, the details of the nodal variables are given in Table Q3.

- (i) Kirakan nilai suhu, T pada lokasi $x = 0.18$ cm dan $y = 0.05$ cm.

Calculate the value of the temperatures T at the location $x = 0.18$ cm and $y = 0.05$ cm.

- (ii) Tentukan nilai koordinat (x,y) di mana garisan kontur, 170°C memotong garisan kawasan elemen.

Determine the (x, y) coordinates where the contour line of 170°C intersects the element boundaries.

- (iii) Kirakan pembezaan $\frac{\partial T}{\partial x}$ dan $\frac{\partial T}{\partial y}$ pada elemen tersebut.

Evaluate the derivatives $\frac{\partial T}{\partial x}$ and $\frac{\partial T}{\partial y}$ within the element.

| Node | x cm | y cm | $T^{\circ}\text{C}$ |
|------|------|------|---------------------|
| 1 | 0.13 | 0.01 | 190 |
| 2 | 0.25 | 0.06 | 160 |
| 3 | 0.13 | 0.13 | 185 |

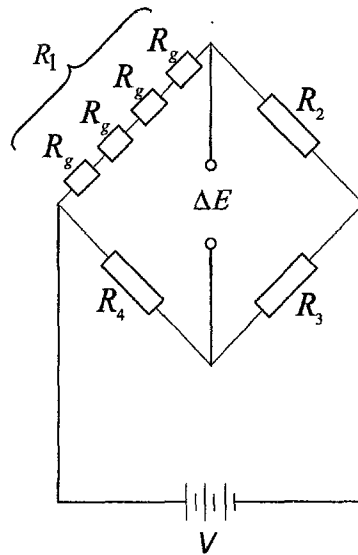
Jadual S3

Table Q3

(100 markah)

- S4. [a] Empat tolok terikan diletakkan bersiri pada lengan R_1 dalam titian Wheatstone suku voltan tetap seperti yang ditunjukkan dalam Rajah S4[a]. Andaikan keempat-empat tolok tersebut mengalami terikan yang sama. Tentukan sensitiviti litar dan bandingkan dengan nilai yang didapat jika hanya satu tolok yang digunakan dalam lengan R_1 .

Four strain gages are placed in series in arm R_1 of a fixed-voltage quarter Wheatstone bridge, shown in Figure Q4[a]. Assume that these four gages experience the same strains. Determine the circuit sensitivity and compare it with the value obtained if a single gage is placed in arm R_1 .

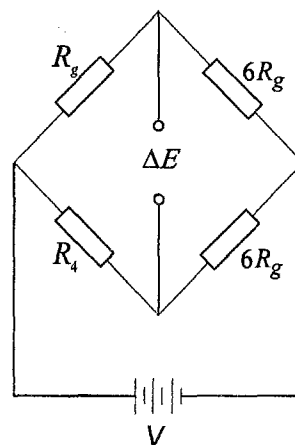


Rajah S4[a]
Figure Q4[a]

(50 markah)

- [b] Untuk meningkatkan sensitiviti litar, voltan boleh diubah dalam titian suku, seperti yang ditunjukkan dalam Rajah S4[b]. Tolok terikan aktif $350\text{-}\Omega$ melepaskan kuasa 0.05 W dengan faktor tolak 2.12 . Kirakan voltan yang perlu dikenakan pada titian dan sensitiviti litar yang terhasil.

To increase the circuit sensitivity, the voltage can be varied in the quarter bridge, shown in Figure Q4[b]. The active gage is a $350\text{-}\Omega$ gage dissipating 0.05-W power with a gage factor of 2.12 . Calculate the required voltage to be applied to the bridge and the resulting circuit sensitivity.



Rajah S4[b]
Figure Q4[b]

(50 markah)

- S5. [a] Dengan bantuan rajah yang sesuai, terangkan dengan ringkas prosedur untuk menentukan pemalar fotokekenyalan bagi sesuatu bahan dwibiasan.

With the aid of diagrams, briefly explain the procedure to determine the photoelastic constant of birefringent material.

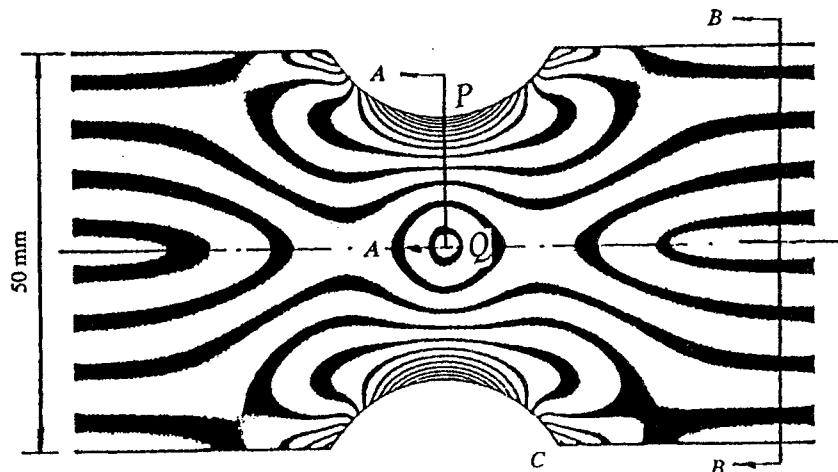
(30 markah)

- [b] Rajah S5[b] menunjukkan corak isokromatik untuk kambi cetek dalam lenturan. Kedalaman rasuk ialah 50 mm, jarak PQ ialah 32 mm, dan lebar d (bersudut tepat dengan satah kertas soalan) ialah 5 mm.

- (i) Plotkan aturan corak lawan dengan posisi sepanjang PQ
(ii) Tentukan faktor penumpuan tegasan.

Figure Q5[b] shows the isochromatic pattern of a beam with shallow grooves in pure bending. The depth of the beam is 50 mm, distance PQ is 32 mm, and the width d (perpendicular to the paper) is 5 mm.

- (i) Plot the fringe order versus the position along PQ.
(ii) Determine the stress concentration factor.



Rajah S5[b]
Figure Q5[b]

(70 markah)

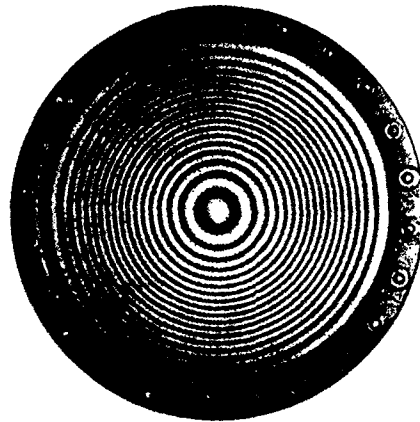
- S6. [a] Dengan bantuan rajah yang sesuai, terangkan dengan ringkas penyusunan dan langkah yang perlu diambil untuk pengukuran terikan dengan menggunakan kaedah holografi.

With the aid of sketches, briefly explain the arrangements and steps to be taken for measuring strain by using holography method.

(40 markah)

- [b] Tentukan lengkung bengkakan disepanjang garisan jejari untuk kepingan bulat yang diikat dan dikenakan beban paksi. Aturan corak dua pendedahan holografi ditunjukkan dalam Rajah S6[b]. Jejari (diukur daripada pusat bolt ke pusat kepingan) kepingan ialah 3.5 cm dan panjang ialah 24.91×10^{-6} cm.

Determine the deflection value along a radial line for a clamped circular plate subjected to a lateral loading. The double-exposure holographic fringe pattern (the directions of illumination and observation are normal to the plate) is shown in Figure Q6[b]. The radius (measured from the center of bolts to the plate center) of the plate is 3.5 cm, and the wavelength is 24.91×10^{-6} cm.



Rajah S6[b]
Figure Q6[b]

(60 markah)

-00000000-

Summary of Important Relationships

Strain-stress relationships in 3D :

$$\varepsilon_x = \frac{1}{E} [\sigma_x - \nu(\sigma_y + \sigma_z)], \quad \varepsilon_y = \frac{1}{E} [\sigma_y - \nu(\sigma_z + \sigma_x)], \quad \varepsilon_z = \frac{1}{E} [\sigma_z - \nu(\sigma_x + \sigma_y)]$$

$$\gamma_{xy} = \frac{2(1+\nu)}{E} \tau_{xy}, \quad \gamma_{yz} = \frac{2(1+\nu)}{E} \tau_{yz}, \quad \gamma_{zx} = \frac{2(1+\nu)}{E} \tau_{zx}$$

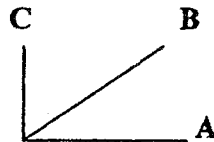
$$\sigma_x = \frac{E}{(1+\nu)(1-2\nu)} [(1-\nu)\varepsilon_x + \nu(\varepsilon_y + \varepsilon_z)], \quad \sigma_y = \frac{E}{(1+\nu)(1-2\nu)} [(1-\nu)\varepsilon_y + \nu(\varepsilon_z + \varepsilon_x)]$$

$$\sigma_z = \frac{E}{(1+\nu)(1-2\nu)} [(1-\nu)\varepsilon_z + \nu(\varepsilon_x + \varepsilon_y)]$$

For plane stress, $\sigma_z = \tau_{yz} = \tau_{zx} = 0$,

$$\sigma_x = \frac{E}{1-\nu^2} (\varepsilon_x + \nu\varepsilon_y), \quad \sigma_y = \frac{E}{1-\nu^2} (\nu\varepsilon_x + \varepsilon_y), \quad \tau = G\gamma, \quad G = \frac{E}{2(1+\nu)}$$

For a 3 element rectangular rosette :



$$\varepsilon_B = \frac{1}{2} (\varepsilon_x + \varepsilon_y + \gamma_{xy}) = \frac{1}{2} (\varepsilon_A + \varepsilon_C + \gamma_{xy})$$

Correction for the two-gage rectangular rosette :

$$\varepsilon_x = \frac{1-\nu K_t}{1-K_t^2} (\hat{\varepsilon}_A - K_t \hat{\varepsilon}_B), \quad \varepsilon_y = \frac{1-\nu K_t}{1-K_t^2} (\hat{\varepsilon}_B - K_t \hat{\varepsilon}_A), \quad \hat{\varepsilon} = \text{indicated strain}$$

A change in resistance due to applied strain :

$$\frac{\Delta R}{R} = S_g \varepsilon_{xx}$$

A change in resistance in a biaxial strain field, $\varepsilon_a, \varepsilon_t$:

$$\frac{\Delta R}{R} = S_a (\varepsilon_a + K_t \varepsilon_t), \quad \varepsilon_y = -\nu \frac{\sigma_x}{E}$$

The sensitivity of the circuit :

$$S_c = \frac{\Delta E}{\varepsilon}$$

Summary of Important Relationships

Summary of the potentiometer circuit :

$$E = \frac{1}{1+r}V, \quad \Delta E = \frac{r}{(1+r)^2} \left(\frac{\Delta R_1}{R_1} - \frac{\Delta R_2}{R_2} \right) (1-\eta)V, \quad \eta = 1 - \frac{1}{1 + \left[\frac{1}{(1+r)} \right] \left[\frac{\Delta R_1}{R_1} + r \left(\frac{\Delta R_2}{R_2} \right) \right]}$$

$$V = \sqrt{P_g R_g} (1+r), \quad S_c = \frac{r}{1+r} S_g \sqrt{P_g R_g}, \quad E' = \frac{Rm}{\sqrt{R_m^2 + \left(\frac{1}{\omega C} \right)^2}} (E + \Delta E)$$

Summary of the Wheatstone Bridge circuit

$$\Delta E = V \frac{R_1 R_2}{(R_1 + R_2)^2} \left(\frac{\Delta R_1}{R_1} - \frac{\Delta R_2}{R_2} + \frac{\Delta R_3}{R_3} - \frac{\Delta R_4}{R_4} \right), \quad \Delta E = V \frac{r}{(1+r)^2} \left(\frac{\Delta R_1}{R_1} - \frac{\Delta R_2}{R_2} + \frac{\Delta R_3}{R_3} - \frac{\Delta R_4}{R_4} \right),$$

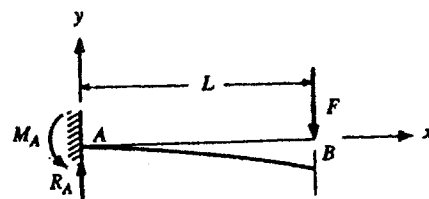
$$S_c = V \frac{r}{(1+r)^2} n S_g,$$

Basic photoelastic equation : $\sigma_1 - \sigma_2 = \frac{N\lambda}{kt} \quad N = 0, 1, 2, \dots$

Reflection photoelasticity : $\sigma_1 - \sigma_2 = \frac{CN}{2t}$

Approximate corrective equation : $\varepsilon_1 - \varepsilon_2 = \frac{fN}{C_1}$

Cantilever loading:



$$M = FL;$$

$$\varepsilon = \frac{My}{EI}, \quad y = \frac{h}{2}, \quad I = \frac{1}{12}bh^3$$