國立交通大學 106 學年度第 1 學期

博士班資格考筆試考試試題

土木工程學系 結構組(甲)　　科目：**結構動力學**　　選考學生數 1　　考試時間: 90min

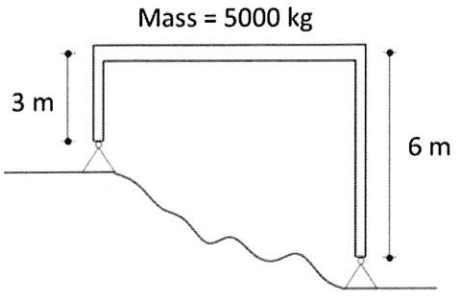
1. (25%) A small one-story reinforced-concrete building shown in Fig. 1(a) is idealized as a massless frame supporting a total dead load of 5000 kg at the beam level. Each 250 mm-square column is hinged at the base; the beam may be assumed to be rigid in flexure; and E = 30 GPa.

   (a) Determine the natural vibration period of the building (note: the lateral stiffness of a column hinged at the base is $k = 3EI/L^3$) (10%)

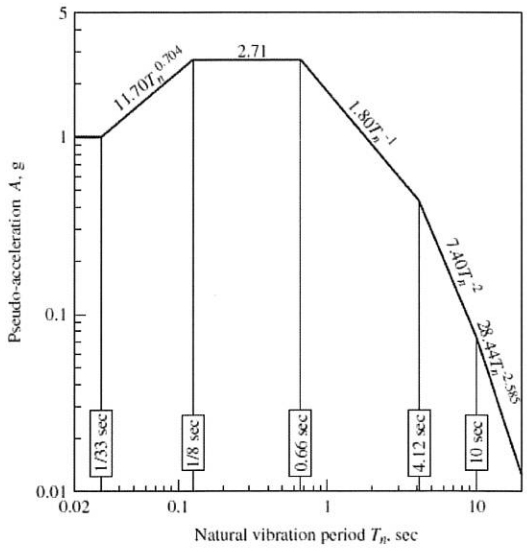
   (b) Determine the peak (pseudo) acceleration and displacement responses of this structure to ground motion characterized by the design spectrum of Fig. 1(b) scaled to 0.2g peak ground acceleration. (5%)

   (c) Determine the peak base shear. (5%)

   (d) Draw the bending moment diagram resulted from the peak responses obtained above. (5%)



(a)



(b)

Fig. 1

國立交通大學 106 學年度第 1 學期

博士班資格考筆試考試試題

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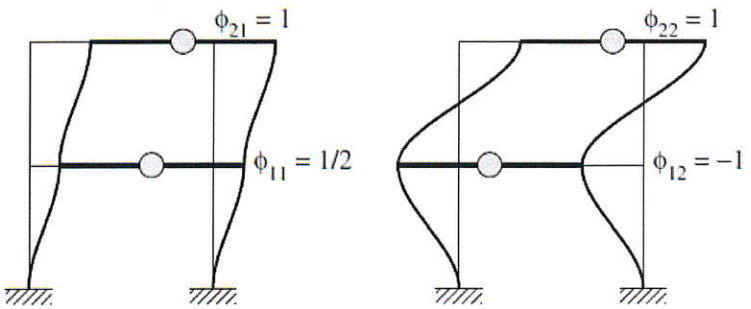
2. (25%) A base-excited lumped-mass, shear-beam type 2 degree-of-freedom system has the natural periods, {T}, modal participation factors, {Γ} and mode shapes, {ϕ}, shown in Fig. 2.

   (a) With the information provided, do you think it is possible to determine what is the associated diagonal mass matrix, $\boldsymbol{M} = \begin{bmatrix} m_1 & 0 \\ 0 & m_2 \end{bmatrix}$, and the associated stiffness matrix, $\boldsymbol{K} = \begin{bmatrix} k_1 + k_2 & -k_2 \\ -k_2 & k_2 \end{bmatrix}$? If so, how would you calculate the elements of each matrix? (15%) (Hints: ①natural frequency $\omega_n = 2\pi/T_n$ is obtained from the eigenvalue problem $[\boldsymbol{K} \quad \omega_n^2 \boldsymbol{M}] \cdot \boldsymbol{\phi}_n = \boldsymbol{0}$; ② $\Gamma_n = L_n/M_n$; where $L_n = \sum_{j=1}^{N} m_j \phi_{jn}$ and $M_n = \sum_{j=1}^{N} m_j \phi_{jn}^2$)

   (b) If you conclude that the information provided is not sufficient to determine unique values of [M] and [K], then what additional information is needed? (10%)

$$\boldsymbol{T} = \begin{Bmatrix} T_1 \\ T_2 \end{Bmatrix} = \begin{Bmatrix} 0.2 \\ 0.1 \end{Bmatrix}; \quad \boldsymbol{\Gamma} = \begin{Bmatrix} \Gamma_1 \\ \Gamma_2 \end{Bmatrix} = \begin{Bmatrix} 4/3 \\ -1/3 \end{Bmatrix}; \quad \boldsymbol{\phi} = [\boldsymbol{\phi}_1 \quad \boldsymbol{\phi}_2] = \begin{Bmatrix} 1/2 & -1 \\ 1 & 1 \end{Bmatrix}$$



First mode　　Second mode

Fig. 2

3. (25%) Consider a based isolated single-story building with weight of 300tf and 200tf for the super structure and base, respectively. The dynamic characteristics of the system identified from eigen analysis are given as

$T_1 = 2.0\,\text{sec}$ ； $\xi_1 = 10\%$ ； $\boldsymbol{\varphi}_1{}^T = [1.041 \quad 1.000]$

$T_2 = 0.25\,\text{sec}$ ； $\xi_2 = 5\%$ ； $\boldsymbol{\varphi}_2{}^T = [-0.641 \quad 1.000]$

The site-specific design spectrum in terms of S_{aD} is defined as：

$$S_{aD} = \frac{0.6}{B_S} \qquad 0.2\,\text{sec} < T \le 1.0\,\text{sec}$$

$$= \frac{0.6}{TB_1} \qquad 1.0\,\text{sec} < T \le 2.5\,\text{sec}$$

where，the damping modification factor B_S and B_1 are summarized as：

Effective damping ξ (%)	B_S	B_1
5	1.00	1.00
10	1.33	1.25
20	1.60	1.50

Perform response analysis with SRSS synthesis to derive：

(a) Maximum displacement of the base（10%）

(b) Maximum story-drift （5%）

(c) Maximum shear force in the isolation system （10%）

4. (25%) The system shown in Fig.4 consists of a spring-mass (k, M) and a pendulum of length l with a mass m suspended from its center of gravity. Represent the degrees of freedom in terms of u for the spring-mass and θ for the pendulum. Don't assume small displacement,

   (a) Find the total potential energy of the system including the strain energy in the spring and the potential energy gain due to gravity at the displaced position. (5%)

   (b) Find the kinetic energy of the system. (5%)

   (c) Write the virtual work done (δW) by the external forces (P) at the positions shown (see Fig. 4) in the displaced position due to virtual displacements (δu) and define the generalized non-conservative forces (Q). (5%)

   (d) Write the equation of motion of the system using the Lagrange's equations. (5%)

   (e) If the rotation θ is considered to be small, write the linearized equation of motion in a matrix form. (5%)

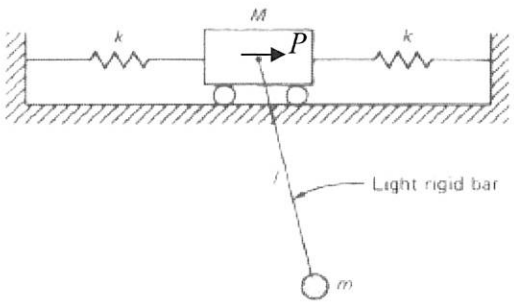


Fig. 4

國立交通大學 106 學年度第 1 學期

博士班資格考筆試考試試題

土木工程學系 結構組(甲)　　科目：**高等結構學**　　選考學生數 1　　考試時間：90min

1. The beam is subjected to a uniform dead load of 1.2 kN/m and a single live load of 40kN. Use the influence line method to determine (a) the maximum moment created by these loads at C, and (b) the maximum positive shear at C. Assume A is a pin, and B is a roller. (25%)

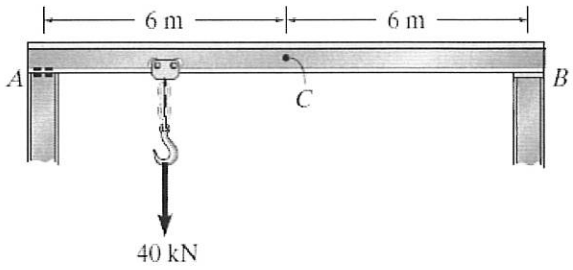


Fig. 1

2. Draw the influence line for the force in member CO of the Baltimore truss. (25%)

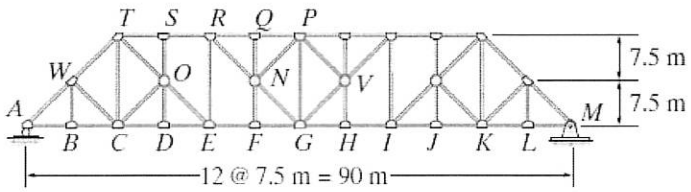


Fig. 2

3. Two absolute rigid bars connected by a hinge at point B and supported with two springs of stiffness k and αk, as illustrated in Fig. 3. Taking the vertical displacements u_1 and u_2 respectively at B and C as the degrees of freedom of the system,
   (a) Plot the free-body diagram of the assumed shape and specify the reaction forces in the springs. (5%)
   (b) Write the stability equations by taking moments with respect to support A and internal hinge B, respectively, and express them in a matrix form as $A\mathbf{u}=0$ where $\mathbf{u}=\begin{pmatrix}u_1\\u_2\end{pmatrix}$. (10%)
   (c) For nontrivial solutions $\mathbf{u}$ of the stability equation, find the possible critical loads and the corresponding deformed shapes (5%)
   (d) If $\alpha=2$, what is the critical load and the corresponding deformed shape that would first occur? (5%)

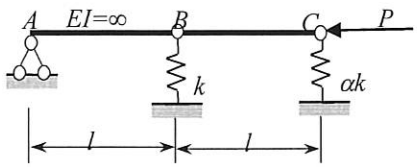


Fig.3

4. Design diagram of a nonsymmetrical three-hinged arch is presented in Fig.4. Construct the influence lines for

(a) Thrust H. You need to specify the peak value of H. (10%)

(b) Bending moment M_k at section k using the nil point method (5%)

(c) Shear force Q_k at section k using the nil point method (5%) [You need to specify the angle φ_n on the design diagram]

(d) Axial force N_k at section k using the nil point method (5%)

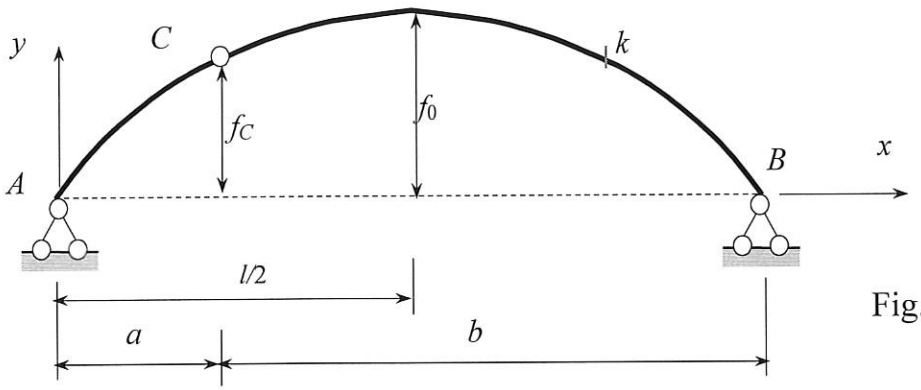


Fig.4

國立交通大學 106 學年度第 1 學期

博士班資格考筆試考試試題

土木工程學系 《組別》(甲)　　科目：高等鋼結構　　選考學生數：1　　考試時間：90min

1. 挫屈束制斜撐應用於鋼結構建築日漸增多，試回答下列問題。
   (a) 挫屈束制斜撐（buckling-restrained brace, BRB）之原理。
   (b) 繪挫屈束制斜撐受力變形之遲滯迴圈，並說明遲滯迴圈之特點。
   (c) 設計不良之挫屈束制斜撐有何非預期的破壞?
   (25%)

2. 鋼結構特殊彎矩構架(Special Moment Frame, SMF)，其梁柱接頭為彎矩接頭，試回答下列問題。
   (a) 美國北嶺地震與日本阪神地震時發現甚多破壞，試說明有那些破壞。
   (b) 試說明造成破壞的原因。
   (c) 之後有多種改良型式的梁柱接頭，舉例至少四種並說明其設計原理。
   (25%)

3. 試計算圖 1 的斷面降伏彎矩 M_y 及塑性斷面彎矩 M_P。
   (25%)

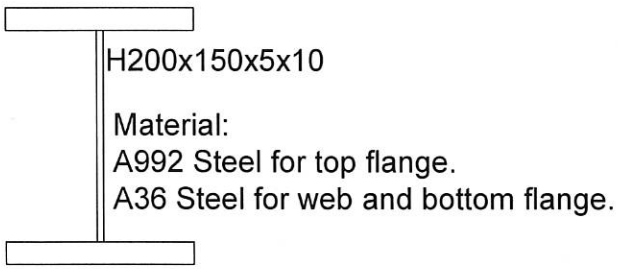


圖 1

4. 如圖 2 所示之 EBF 構架，試回答下列問題。
   (a) 請寫出連桿塑性變形轉角與樓層變位角的關係。
   (b) 請檢核此連桿屬於剪力連桿或是彎矩連桿。
   (c) 請說明連桿與其相鄰構件在設計上應注意事項。
   (25%)

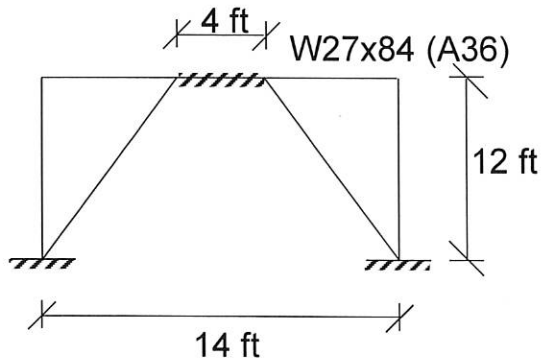


圖 2

國立交通大學 106 學年度第 1 學期
博士班資格考筆試考試試題

土木工程學系 結構組(甲)　科目：鋼筋混凝土行為　選考學生數：1　考試時間: 90min

1.

a. 試申論鋼筋混凝土採用鋼筋與混凝土之分別原因，及使用兩者搭配之原因。

b. 試說明何謂平面保持平面 (Plane sections remain plane) ，並據此推導開裂彎矩 M_{cr}

c. 何謂平衡鋼筋比，以單筋梁為例，試推導之並說明鋼筋比大於或小於平衡鋼筋比時，中性軸之變化情形

d. 依照現行之混凝土工程設計規範，說明應如何考慮強度折減因子$\emptyset$，其變化範圍及上下限分別為何

e. 試繪製柱之軸力-彎矩互製圖，並於圖上至少標註五點及說明力學特性(Hint:純彎矩 純軸力 etc)

(25%)

2. 有一矩形斷面之鋼筋混凝土簡支梁如圖所示，已知f'_c=280(kgf/cm^2)，f_{yt}=2800(kgf/cm^2)，此梁除承受均佈使用淨載重(含梁自重)w_D = 2.5(tf/m)及活載重w_L = 5(tf/m)之作用，試依下列條件設計此梁距支承處40cm與100cm處之剪力鋼筋間距。

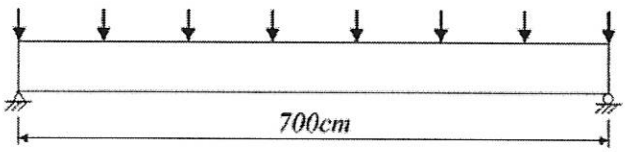
a. 在梁軸承受N_u=20tf 之設計軸拉力

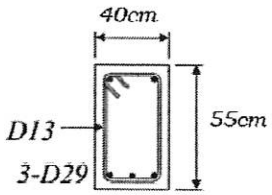
b. 在梁軸承受N_u=55tf 之設計軸壓力

c. (25%)

$$V_c = 0.53\sqrt{f'_c}b_w d(1+\frac{N_u}{140A_g})$$

$$V_c = 0.53\sqrt{f'_c}b_w d(1+\frac{N_u}{35A_g})$$





鋼筋

D10 d_b=0.95 cm, A_b= 0.71 cm^2

D13 d_b=1.27 cm, A_b= 1.27 cm^2

D32 d_b=3.22 cm, A_b= 8.14 cm^2

D36 d_b=3.58 cm, A_b= 10.07 cm^2