

# 國立陽明交通大學 114 學年度第一學期 博士班資格考筆試考試試題

土木工程學系 結構組 科目：高等材料力學 選考學生數：1 考試時間：90 min

共 1 頁，第 1 頁

1. (40%) In Fig. 1, three bars with three cross sections are subjected to the same torques  $T_0$  and are made of the same material. Compute the angles of twist per unit length  $\beta$  for each cross section and compare results, using symbols of  $G$ ,  $T_0$ ,  $R$ , and  $t$ .

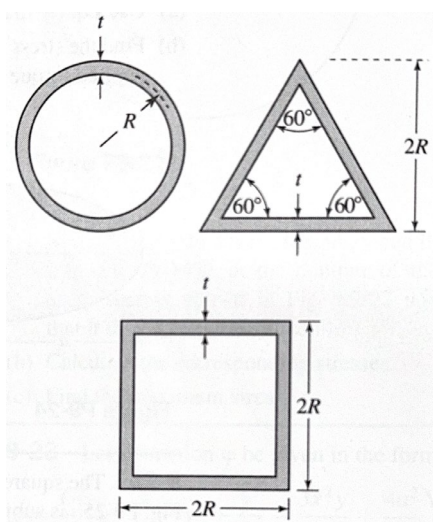


Fig. 1

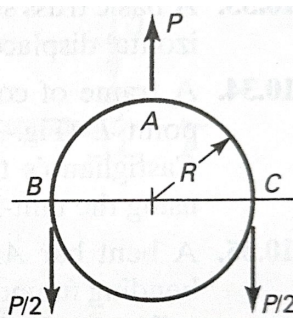
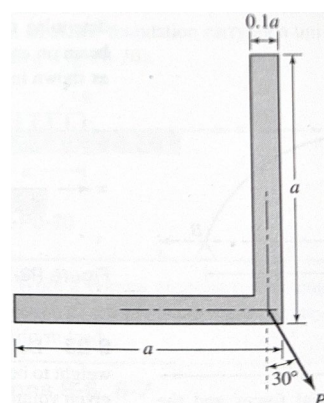


Fig. 2



Given:  $a = 0.2\text{m}$

Fig. 3

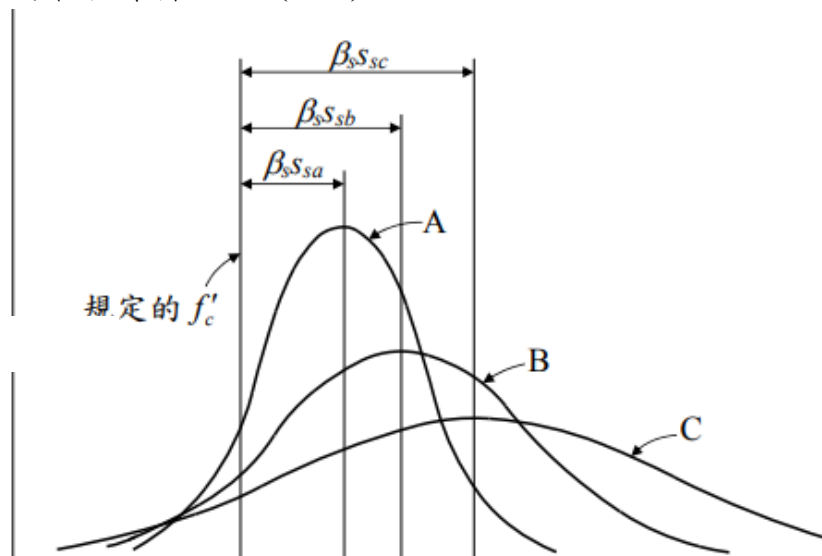
2. (20%) In Fig. 2, a large ring is loaded. By considering the strain energy associated with bending, determine the bending moment and the normal force within the ring at the point of application of  $P$  by using Castigliano's theorem. Express results by  $R$  and  $P$ .
3. (40%) A 2m long cantilever beam is subjected to a load  $P = 5\text{kN}$  at the tip making an angle of  $\phi = 30^\circ$  with the vertical axis. The equal angle section is shown in Fig. 3.
- (a) Find the centroid  $C$  of the cross section. (5%)
  - (b) Find the orientation of principal axes and principal moment of inertia of the cross section. (20%)
  - (c) Determine the maximum tensile and compressive normal stresses in the beam. (15%)

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土木工程學系 結構組 科目：高等混凝土 選考學生數：1 考試時間：90 min

共 頁，第 頁

1. 下圖為混凝土品管根據不同控制程度下之強度頻率曲線及平均強度，x 軸是抗壓強度，y 軸是抗壓強度頻率值。請問 A、B、C 三條曲線中，何者品質的管控最嚴格。(25%)



2. 下圖為雙軸應力狀態下的混凝土強度，已知混凝土強度  $f'_c$  為  $210 \text{ kgf/cm}^2$ 。
- (a) 若施加  $f_2 = 63 \text{ kgf/cm}^2$  壓應力，計算  $f_1$  為多少壓應力時混凝土將破壞。(12%)
- (b) 若施加  $f_2 = 0 \text{ kgf/cm}^2$ ，計算  $f_1$  為多少拉應力時混凝土將破壞。

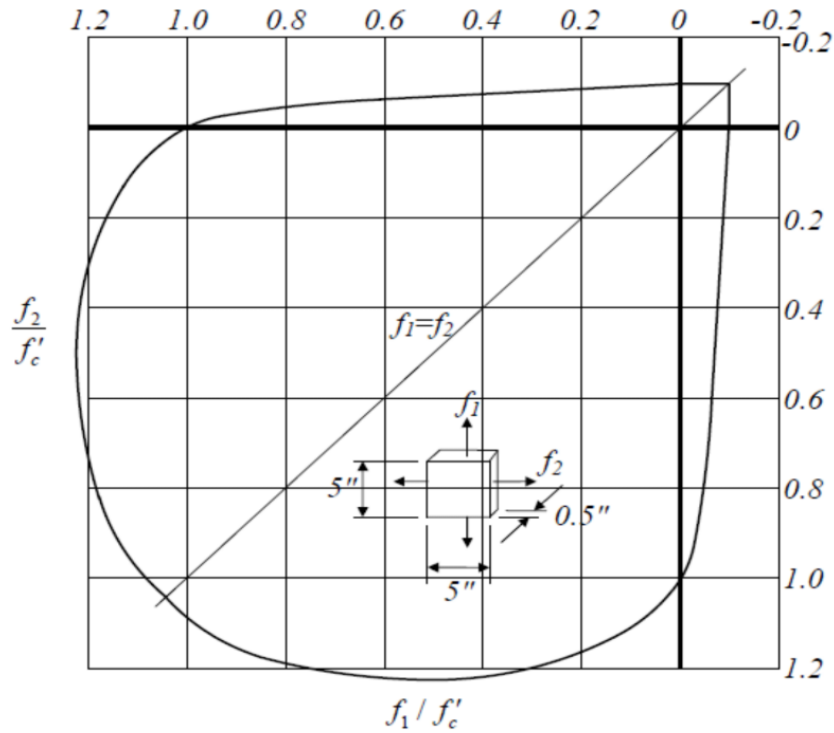


圖2.8 雙軸應力狀態下的混凝土強度<sup>[2.39]</sup>

(13%)

3. 一矩形梁，斷面如下圖所示，

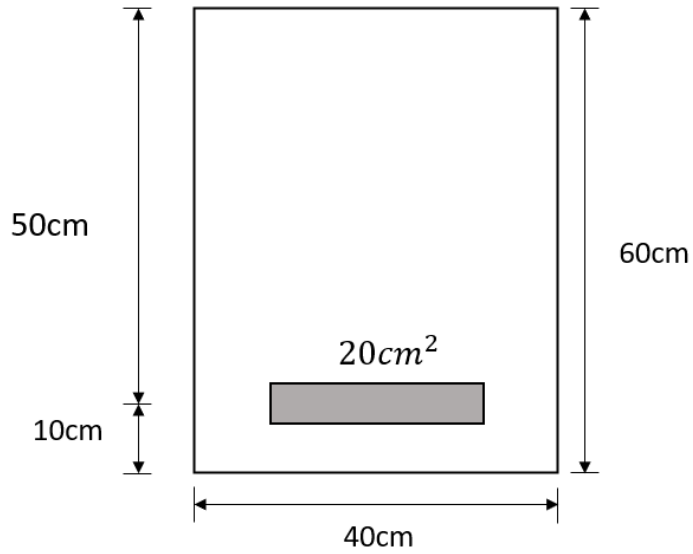
已知： $A_s = 20 \text{ cm}^2$ ， $f_y = 4200 \text{ kgf/cm}^2$ ， $f'_c = 280 \text{ kgf/cm}^2$ ，

假設彈性模數比  $n=8$ 。試求：

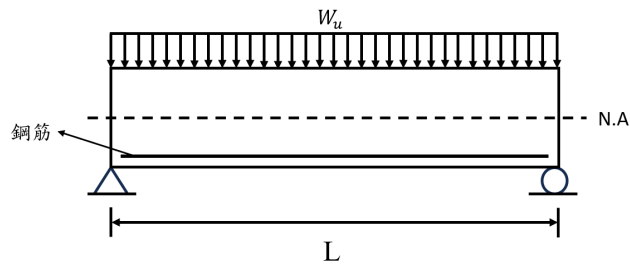
(a)  $M_{cr}$  為多少  $\text{tf-m}$ ? (5%)

(b) 當  $M = M_{cr}$  時，鋼筋應力  $f_s$  與最大混凝土應力  $f_c$ 。(10%)

(c) 當  $M=20 \text{ tf-m}$  時，鋼筋應力  $f_s$  與最大混凝土應力  $f_c$ 。(10%)



4. 撓曲裂縫、腹剪裂縫及撓剪裂縫為鋼筋混凝土梁承受垂直載重作用時，可能產生的相關裂縫。請繪製出該梁之剪力、彎矩圖(10%)，試說明其裂縫走向、造成原因(10%)，並標示出撓曲裂縫、腹剪裂縫與撓剪裂縫的發生位置(5%)。(Hint: 搭配摩爾圓說明)



# 國立陽明交通大學 114 學年度第一學期

## 博士班資格考筆試考試試題

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

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共 頁，第 頁

1. 請針對鋼結構特殊彎矩構架(Special Moment Frame, SMF)系統，回答下列問題：
  - (a) 請說明其耐震原理及其優缺點。(15%)
  - (b) 請說明其常見之破壞模式及可能成因。(15%)
  - (c) 請列出三種改良型式梁柱接頭(其中一種需為 RBS)，並說明其設計原理(15%)
  
2. 請針對偏心斜撐構架(Eccentrically Braced Frame, EBF)系統，回答下列問題：
  - (a) 請說明剪力連桿與彎矩連桿行為特性。(15%)
  - (b) 請列出三種 EBF 連桿的配置方式，並推導連桿轉角與構架層間位移角的關係。(15%)
  
3. 請針對挫屈束制斜撐構架(Buckling-Restrained Braced Frame, BRBF)系統，回答下列問題：
  - (a) 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，請特別說明拉壓強度是否相同，為什麼？(15%)
  - (b) 設計不良之挫屈束制斜撐有何非預期的破壞？(10%)

# 國立陽明交通大學 114 學年度第一學期 博士班資格考筆試考試試題

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

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共 5 頁，第 1 頁

## Problem 1 (25%)

A simply supported beam of span  $L$  and constant flexural rigidity  $EI$  is assumed to be massless. A linear spring of stiffness  $k$  is attached at the midspan of the beam, and a concentrated mass  $m$  is suspended from the spring. (Equivalently, the suspended weight is  $w = mg$ .)

- Using a rigorous modeling approach (e.g., compatibility and force equilibrium, energy methods, or Lagrange's equations), derive the equation of motion for small vertical vibrations about the static equilibrium position.
- Obtain a closed-form expression for the natural circular frequency  $\omega_n$  (and/or  $f_n$ ) in terms of  $k$ ,  $EI$ ,  $L$ , and  $m$ .
- Verify your expression by checking limiting cases and physical consistency.

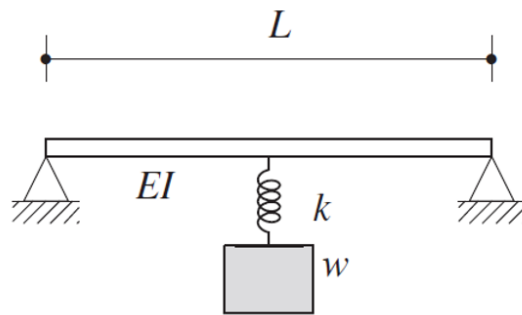


Figure 1

**Problem 2 (25%)**

A single-degree-of-freedom oscillator consists of a mass  $m$  connected to a fixed wall by a spring  $k_1$  and a viscous damper  $c$  acting in parallel. The mass is also connected to a moving support by a spring  $k_2$ , as shown.

The support motion is prescribed by the velocity  $\dot{u}(t) = A \sin(Bt)$ , with  $u(0) = 0$ . The mass is initially at rest.

**Given:**

$$k_1 = 20.5 \text{ kip/in,}$$

$$k_2 = 25.5 \text{ kip/in,}$$

$$w = 10 \text{ kips} \left( m = \frac{w}{g} \right),$$

$$c = 0.250 \text{ kip}\cdot\text{s/in,}$$

$$g = 386.4 \text{ in/s}^2$$

- (a) Determine the support displacement  $u(t)$ .
- (b) Derive the equation of motion using the absolute displacement  $x(t)$  of the mass.
- (c) Derive the equation of motion using the relative displacement  $y(t) = x(t) - u(t)$ , and obtain the corresponding effective forcing function  $F(t)$ , with all coefficients evaluated numerically.
- (d) Verify that the formulations obtained in parts (b) and (c) are mathematically equivalent

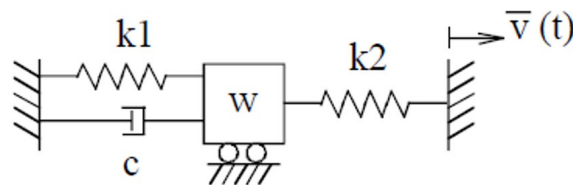


Figure 2

**Problem 3 (25%)**

The single-story frame shown in Fig. 3 consists of two identical steel columns of height  $H$  connected by a rigid girder of span  $L$ . The girder is rigid in-plane and carries essentially all of the system mass (column mass is negligible). The bases are fixed, and the girder-to-column joints are rigid. The structure is displaced laterally by an unspecified method and then released to undergo free vibration.

Geometry:  $L = 38$  ft,  $H = 16$  ft.

Column properties:  $E = 29,000$  ksi,  $I_c = 146$  in<sup>4</sup>,  $A_c = 11.8$  in<sup>2</sup>.

Assume linear elastic behavior and viscous damping. An accelerometer mounted on the rigid girder recorded the lateral acceleration response  $a(t)$  shown in Fig. 4.

- (a) From the free-vibration record, estimate  $\omega_d$ ,  $\zeta$ , and  $\omega_n$ .
- (b) Model A (translation-only SDOF): Neglect column axial deformation ( $EA \rightarrow \infty$ ). Derive the lateral stiffness  $k_A$  and compute the girder weight  $W_A$ .
- (c) Model B (translation + rigid body rotation): Allow the girder to have a lateral translation  $\Delta(t)$  and a rigid-body rotation  $\theta(t)$ . Include column axial deformation ( $EA < \infty$ ). For a lateral force applied through the girder centroid with zero applied moment, derive the effective lateral stiffness  $k_B$  and compute  $W_B$ .
- (d) Compute  $c_{cr}$  and  $c$ , and verify the overall results using unit checks and internal cross-checks.

*Note:* You may treat the acceleration peaks as proportional to the response amplitude for the purpose of logarithmic decrement.

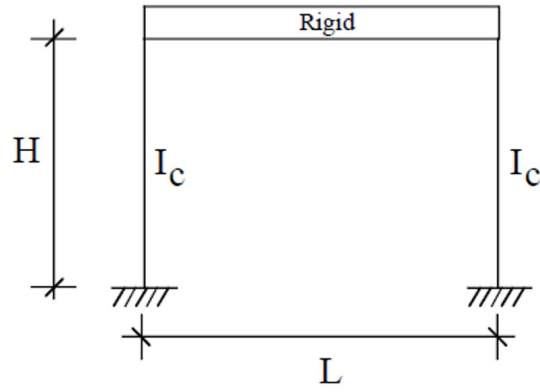


Figure 3

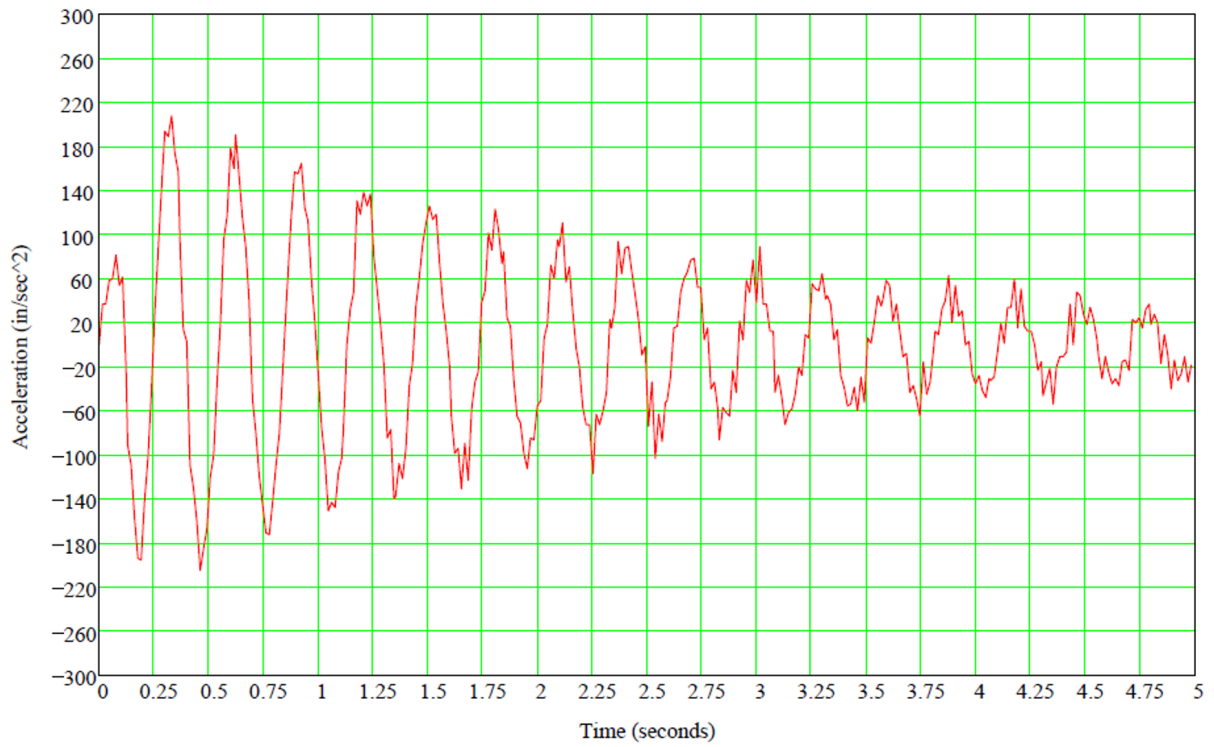


Figure 4

**Problem 4 (25%)**

- (a) Define the response spectrum in linear structural dynamics. For a linear single-degree-of-freedom system subjected to a prescribed ground acceleration  $\ddot{u}_g(t)$ :
- Write the governing equation of motion in relative coordinates.
  - Clearly define the response quantity used to construct an acceleration response spectrum, and state the assumptions inherent in this definition.
- (b) Explain how an acceleration response spectrum is generated from a given ground acceleration record. Your answer should address:
- the role of damping,
  - the definition of maximum response,
  - the physical meaning of the acceleration response spectrum, and
  - at least two fundamental limitations of the response spectrum method.