國立交通大學 101 學年度第 2 學期

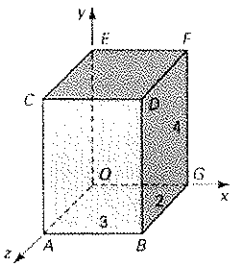
博士班資格考筆試考試試題

土木工程學系 結構組(甲)　科目：**高等材料力學**　選考學生數：2　考試時間：90min

請選三題作答。超過三題將依序以前三題改。

1. The stress at a point in the Cartesian coordinate is given by

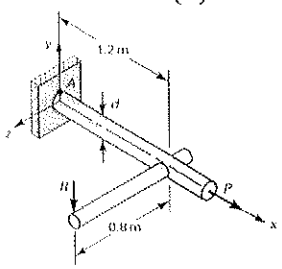
$$\begin{bmatrix} 100 & 40 & 0 \\ 40 & 60 & 80 \\ 0 & 80 & 20 \end{bmatrix} MPa$$



Referring to the parallelepiped shown above, calculate the normal stress σ_n and the shear stress σ_s at point Q for the surface parallel to the following planes:

(a) CEBG, (b) ABEF, and (c) AEG.

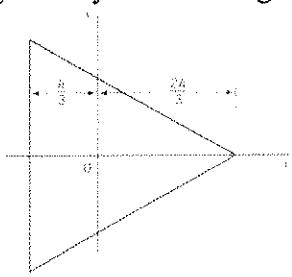
2. A steel rod of diameter $d = 50mm\left(\sigma_{yp} = 260MPa\right)$ supports an axial load $P = 50R$ and vertical load R acting at the end of a 0.8m long arm. Given a factor of safety $n = 2$, compute the largest permissible value of R using the following criteria: (a) maximum shear-stress criterion and (b) distortional energy density criterion.



3. The torsional rigidity of a circle, an ellipse, and an equilateral triangle are denoted by C_c, C_e, and C_t, respectively. If the cross-sectional areas of these sections are equal, find the following coefficients A and B to relate the torsional rigidity of different geometry:

$C_e = AC_c$, $C_t = BC_c$

where a and b are the semi-axes of the ellipse in the x and y directions, and the geometry of the triangle is given below:



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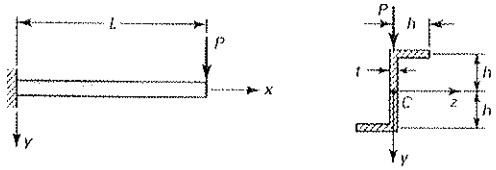
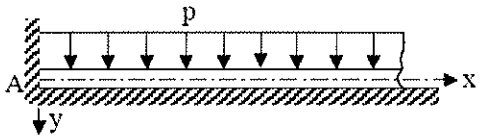
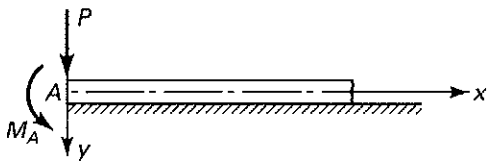
4. A cantilever beam has a Z section of uniform thickness for which $I_y=\frac{2}{3}th^3$, $I_z=\frac{8}{3}th^3$, and $I_{yz}=-th^3$. Determine the maximum bending stress in the beam subjected to a load P at its free end.



5. What are the reactions acting on a semi-infinite beam built in at the left end and subjected to a uniformly distributed loading p?



Given:



$$v=\frac{2\beta}{k}\left[Pf_4(\beta x)+\beta M_A f_3(\beta x)\right]$$

$$\theta=-\frac{2\beta^2}{k}\left[Pf_1(\beta x)+2\beta M_A f_4(\beta x)\right]$$

$$M=\frac{P}{\beta}f_2(\beta x)+M_A f_1(\beta x)$$

$$V=-Pf_3(\beta x)+2\beta M_A f_2(\beta x)$$

$$f_1(\beta x)=e^{-\beta x}(\cos\beta x+\sin\beta x)$$

$$f_2(\beta x)=e^{-\beta x}\sin\beta x$$

$$f_3(\beta x)=e^{-\beta x}(\cos\beta x-\sin\beta x)$$

$$f_4(\beta x)=e^{-\beta x}\cos\beta x$$

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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：3　　考試時間: 90min

選三題作答，作答超過三題以解題順序前三題給分。

1. Please compare the seismic behavior of the following structural systems and explain their energy dissipation mechanism: 1) concentrically-braced frame system, 2) buckling-restrained-braced frame system and 3) steel-plate-shear-wall system.

2. Please calculate M_y and M_P of the following section corresponding to its neutral axis.

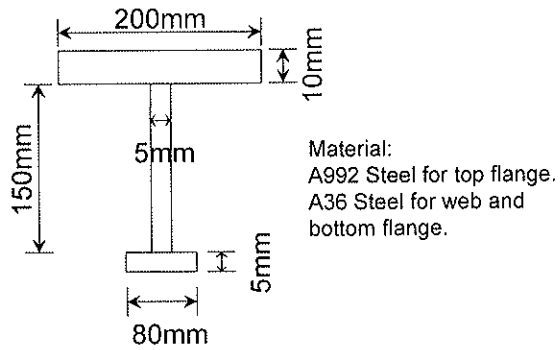

Figure 1

3. An EBF structure is shown in Figure 2.

(1) Please check if the link is a shear link or moment link.

(2) If the drift ratio under design earthquake (θ_e) is 0.004 rad., what is the link rotation demand of the EBF? What are the code requirements about the link rotation? Does the link rotation satisfy the code requirements?

(3) Please describe the design procedure and considerations to design brace and beam segment outside of link in EBF.

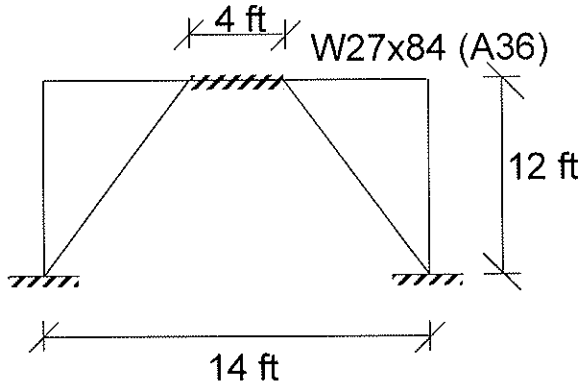

Figure 2

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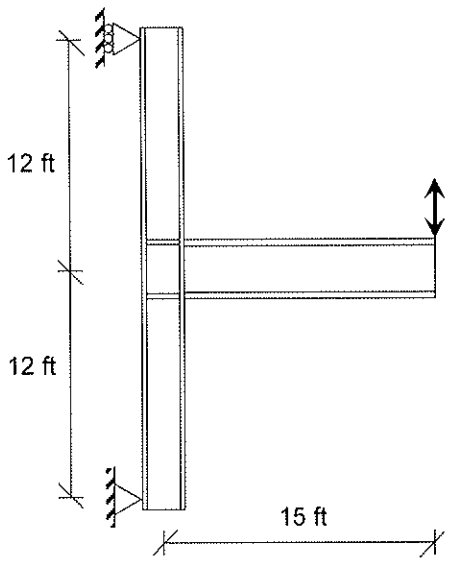
博士班資格考筆試考試試題

土木工程學系 《組別》(甲)　　科目：高等鋼結構　　選考學生數：3　　考試時間: 90min

4. (1) Please describe the design philosophy of the RBS connections.
   (2) A structure (shown in Figure 3) is composed of a beam and a column and subjected to seismic load in the beam end. Please design the dimension of *a*, *b* and *c* in a RBS connection. Hint: make reasonable assumptions if necessary.



Column:	Beam:
W14x120	W27x84
$d \times b_f \times t_w \times t_f$ =	$d \times b_f \times t_w \times t_f$ =
14.5x14.7x0.59x0.94	26.7x10x0.46x0.64
(unit: inch)	(unit: inch)
$I_x = 1380$ in^4	$I_x = 2850$ in^4
$S_x = 190$ in^3	$S_x = 213$ in^3
$r_x = 6.24$ in	$r_x = 10.7$ in
$Z_x = 212$ in^3	$Z_x = 244$ in^3
$I_y = 495$ in^4	$I_y = 106$ in^4
$S_y = 67.5$ in^3	$S_y = 21.2$ in^3
$r_y = 3.74$ in	$r_y = 2.07$ in
$Z_y = 102$ in^3	$Z_y = 33.2$ in^3

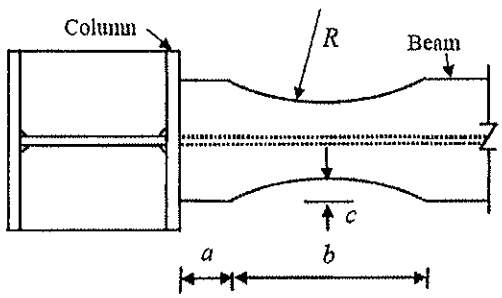


Figure 3

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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：3　　考試時間: 90min

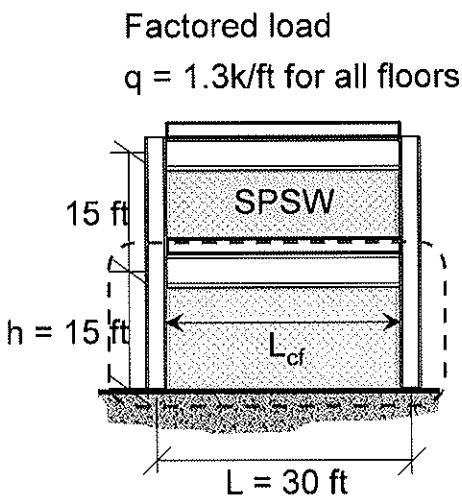
5. A steel plate shear wall structure is shown in Figure 4. Two stories have the same steel plate thickness. The shear demand for the marked steel plate is 410 kips.

(1) Assume the beam and column are well designed and have proper sizes. Please determine the thickness of the steel plate and the inclined angle of tension field strut α in the marked story.

(2) Assume the beam and column sizes are not finalized.

(a) Please check if the given section of VBE in the first story is appropriate. Please check the stiffness requirement. Please calculate moment demand M_u and compare M_u with φM_p, ($\varphi = 0.9$).

(b) Please check if the given section of HBE in Figure 3 is appropriate. Please calculate moment demand M_u and compare M_u with φM_p, ($\varphi = 0.9$)



Column:
W14x211
$A_c = 62$ inch^2
$I_c = 2660$ inch^4
$d_c = 14$ inch
$F_y = 50$ ksi
$Z_x = 390$

Beam:
W16x50
$A_b = 14.7$ inch^2
$F_y = 50$ ksi
$Z_x = 92$

Steel Plate
$F_y = 36$ ksi
$R_y = 1.3$

Figure 4

For $0.8 < L/h \le 2.5$
$V_u \le \phi V_n$, $\varphi = 0.9$

$V_n = 0.42 F_y t_w L_{cf} (\sin 2\alpha)$

For $h/t_w > 300$

$$\tan^4 \alpha = \frac{1 + \frac{t_w L}{2A_c}}{1 + t_w h\left(\frac{1}{A_b} + \frac{h^3}{360 I_c L}\right)}$$

Tension Field Strength Forces = $W \cdot t_w \cdot R_y \cdot F_y$

W: width of the tension strip
$=(L \cdot \cos\alpha + H \cdot \sin\alpha)/N$

$I_c \ge 0.0031\, t_w h^4/L$

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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. Given an inverted L-shaped frame with lumped masses shown in Fig.1.

   (a) Determine the shape functions of the frame due to a unit force acting horizontally at the end in the direction of u_1. (10%)

   Hint: 1. Consider a third-order polynomial for the column ($\Psi_C(x)$) and first-order for the beam ($\Psi_B(x)$).

   2. You need to determine the deflection and rotation at the top of the column first, and the vertical deflection at the end of the beam as well. Use them as the boundary conditions in finding the coefficients of the polynomials. The mode shapes are normalized so that the lateral displacement at the top of the column is 1 (i.e. $\psi_C(L)=1$)

   (b) Determine the equivalent stiffness of the frame using the shape functions obtained in (a). (10%)

   (c) Establish the kinetic energy of the system and define the mass using the concept of Lagrange's equation. (10%)
   Hint: You need to consider the masses move in both horizontal and vertical directions.

   (d) Calculate the vibration frequency based on the equivalent stiffness and mass derived in (b) and (c). (10%)

   (e) The equation of motion of this inverted L-shaped frame in terms of the two degree of freedom is

$$\begin{bmatrix} 3m & 0 \\ 0 & m \end{bmatrix}\begin{pmatrix} \ddot{u}_1 \\ \ddot{u}_2 \end{pmatrix}+\frac{6EI}{7L^3}\begin{bmatrix} 8 & -3 \\ -3 & 2 \end{bmatrix}\begin{pmatrix} u_1 \\ u_2 \end{pmatrix}=\begin{pmatrix} 0 \\ 0 \end{pmatrix}$$

   Find the exact fundamental frequency (1st mode) of the system by performing eigen-analysis. (10%)

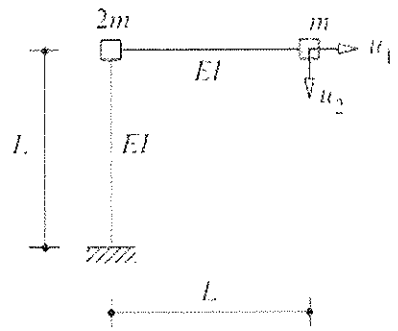

Fig.1

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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

2. A five-story frame with rigid beams shown in Figure. 2-1 is subjected to ground acceleration $\ddot{u}_g(t)$; k_j are story stiffnesses.

(a) Establish the equation of motion of the building by Lagrange's equation. (20%)

Hint: 1. Find the kinetic energy and potential energy of the system first.

2. Note that absolute velocities should be considered in deriving the kinetic energy.

(b) Find the natural frequency of the system assuming the displacements to increase linearly with height above the base. (10%)

(c) Determine the floor displacements due to ground motion characterized by the design spectrum of Fig. 2-2 scaled to peak ground acceleration of 0.32g (10%)

(d) Determine the base shear of the building. (10%)

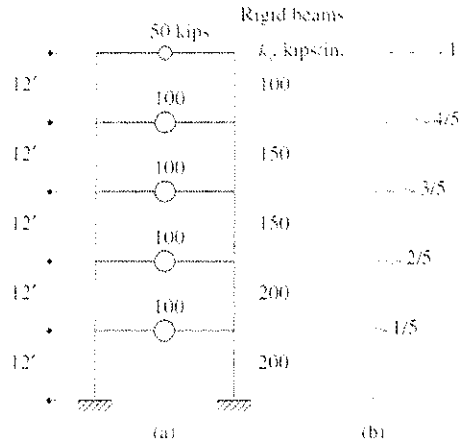

Fig. 2-1

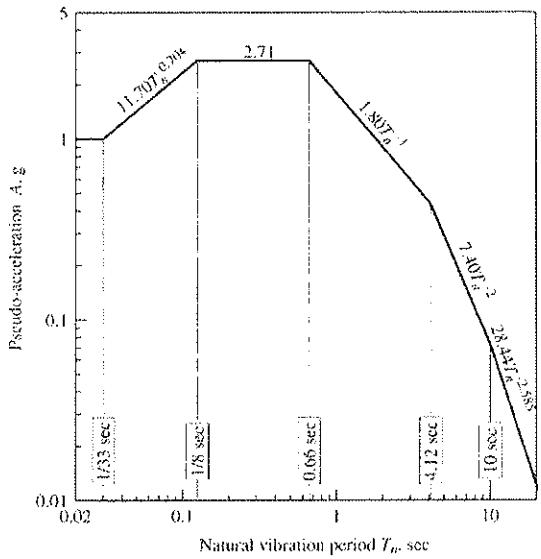

Fig. 2-2

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博士班資格考筆試考試試題

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

1. For concrete specimens test according to standards(20%)
   a. What are the constituents?
   b. What is the size of standard specimens?
   c. What is the curing condition?
   d. What is the age at test?
   e. What is the compressive test loading rate?
2. For pozzolans(15%)
   a. What is the definition of pozzolan materials
   b. Describe the origin, function of fly ash
   c. Describe the origin, function of steel slag
3. About shrinkage, (15%)
   a. What is shrinkage?
   b. What are the factors affecting shrinkage?
   c. How to mitigate(reduce) shrinkage?
   d. How to predict shrinkage?
   e. For a column of 60x60cm, if the steel ratio is 0.06 and the ultimate shrinkage for plain concrete is $800x10^{-6}$, what will be the final shrinkage and the stress in steel? Assume that the concrete strength is 4000 psi and the steel strength is 600000 psi. The Young's modulus of concrete is $57000(f'c)^{1/2}$ psi and $29x10^{6}$ psi for steel. (10%)
4. About creep(15%)
   a. What is creep
   b. What are the factors affecting creep?
   c. How to predict creep?
   d. What are the effects of creep on structures?
   e. How to mitigate creep?
   f.
5. For concrete tests, what are the effects of the following parameters?(15%)
   a. Size
   b. Loading rate
   c. Curing
   d. Aspect ratio
   e. Age
6. What are the main requirements on mixing water based on standard. (10%)
7. Describe the following(10%)
   a. The effect of biaxial stress state
   b. The effect of strength on the properties of concrete
   c. The main failure criteria of concrete

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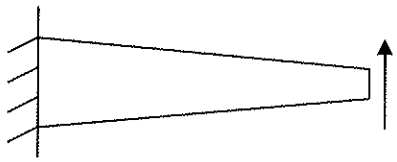
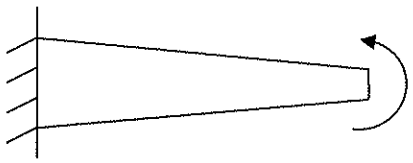
土木工程學系 結構組(甲)　科目：高等結構學　選考學生數：2　考試時間：90min

1. The displacements for a cantilever taper beam are shown as illustrated:

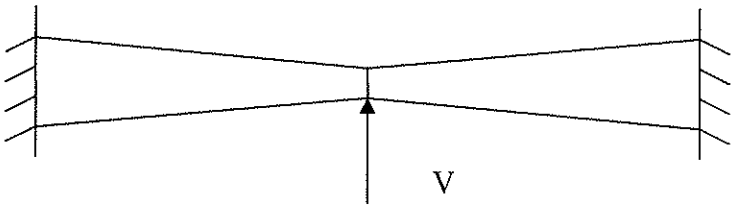


$$\delta = \frac{29VL^3}{96EI}, \theta = \frac{13ML^2}{32EI}$$



$$\delta = \frac{13ML^2}{32EI}, \theta = \frac{5ML}{8EI}$$

Two similar taper beams are arranged as shown in the figure. Derive the vertical displacement at the loading point.



2. Truss structure as shown. EA/L is constant for all members

(a) Determine the local stiffness matrix K for each member in global coordinate.

(b) Determine the structure stiffness matrix S.

(c) Given displacement solution as

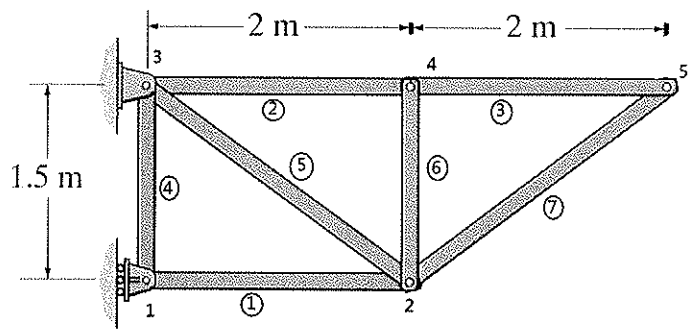
$v_1 = 0.24mm$

$u_2 = 1.22mm\ v_2 = 2.73mm$

$u_4 = 0.78mm\ v_4 = 3.21mm$

$u_5 = 2.62mm\ v_5 = 3.48mm$

Find the axial force for member 2 and 5. $EA/L = 200\ kN/mm$.



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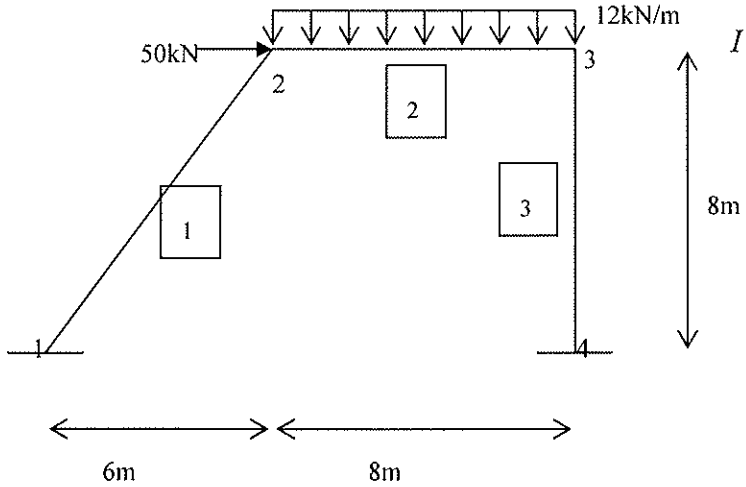
3. The displacement for joint 2 is (6.233mm,-4.7mm, -0.000388rad), and for joint 3 is (6.151mm, -0.158mm, 0.000202rad), find the member forces Q (in local coordinate) and F (in global coordinate) for member 1,2. Then check the joint equilibrium for joint 2.

E, A, I = constant

E = 200GPa

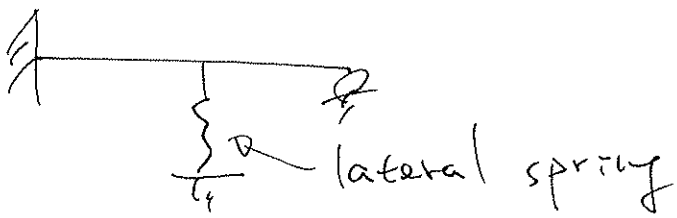
A = $20000mm^2$

$I = 1250 \times 10^6 mm^4$

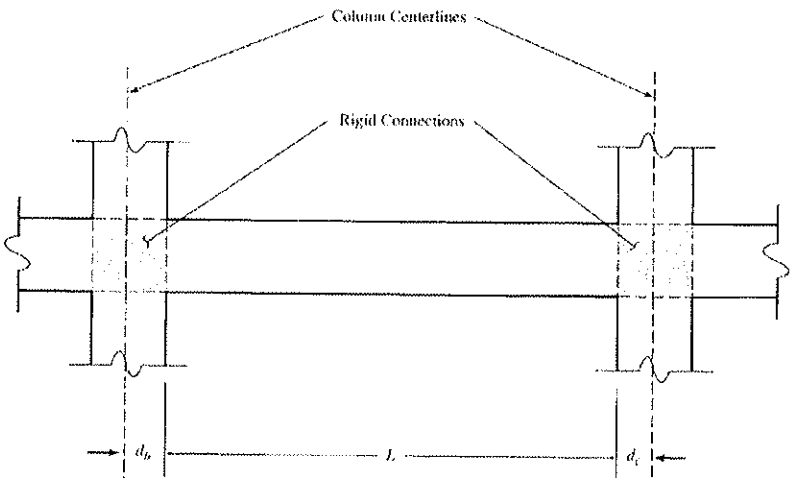


4. (a) How to include the effect of shear deformation?

(b) How to consider a lateral spring as shown?



(c) How to consider offset connection (rigid connection) as shown?



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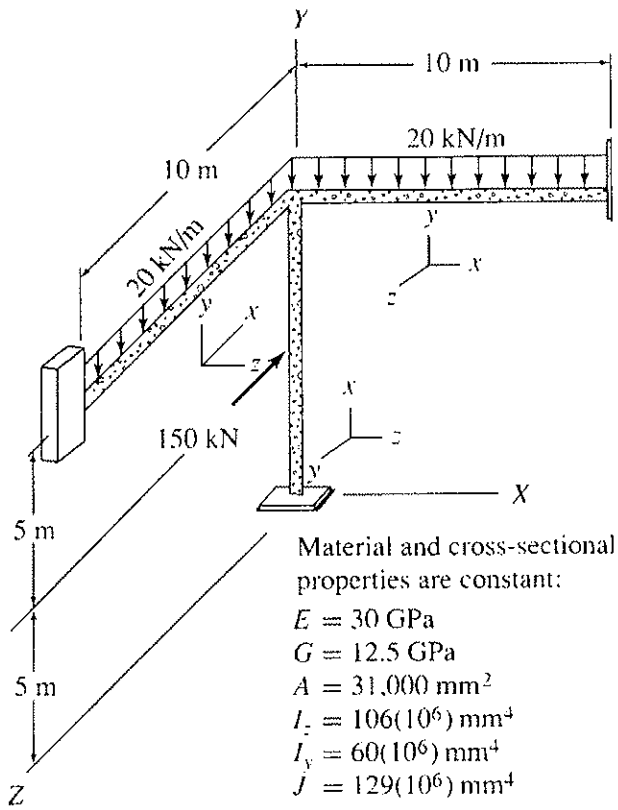
5. Assemble the global stiffness matrix of the space frame as shown. If the effect of axial deformation is neglected, what will the stiffness matrix?



Material and cross-sectional properties are constant:

$E = 30$ GPa
$G = 12.5$ GPa
$A = 31{,}000$ mm^2
$I_z = 106(10^6)$ mm^4
$I_y = 60(10^6)$ mm^4
$J = 129(10^6)$ mm^4

The stiffness matrix for a member of space frame is shown as follow.

$$\mathbf{k} = \frac{E}{L^3}\begin{bmatrix}
AL^2 & 0 & 0 & 0 & 0 & 0 & -AL^2 & 0 & 0 & 0 & 0 & 0 \\
0 & 12I_z & 0 & 0 & 0 & 6LI_z & 0 & -12I_z & 0 & 0 & 0 & 6LI_z \\
0 & 0 & 12I_y & 0 & -6LI_y & 0 & 0 & 0 & -12I_y & 0 & -6LI_y & 0 \\
0 & 0 & 0 & \frac{GJL^2}{E} & 0 & 0 & 0 & 0 & 0 & -\frac{GJL^2}{E} & 0 & 0 \\
0 & 0 & -6LI_y & 0 & 4L^2I_y & 0 & 0 & 0 & 6LI_y & 0 & 2L^2I_y & 0 \\
0 & 6LI_z & 0 & 0 & 0 & 4L^2I_z & 0 & -6LI_z & 0 & 0 & 0 & 2L^2I_z \\
-AL^2 & 0 & 0 & 0 & 0 & 0 & AL^2 & 0 & 0 & 0 & 0 & 0 \\
0 & -12I_z & 0 & 0 & 0 & -6LI_z & 0 & 12I_z & 0 & 0 & 0 & -6LI_z \\
0 & 0 & -12I_y & 0 & 6LI_y & 0 & 0 & 0 & 12I_y & 0 & 6LI_y & 0 \\
0 & 0 & 0 & -\frac{GJL^2}{E} & 0 & 0 & 0 & 0 & 0 & \frac{GJL^2}{E} & 0 & 0 \\
0 & 0 & -6LI_y & 0 & 2L^2I_y & 0 & 0 & 0 & 6LI_y & 0 & 4L^2I_y & 0 \\
0 & 6LI_z & 0 & 0 & 0 & 2L^2I_z & 0 & -6LI_z & 0 & 0 & 0 & 4L^2I_z
\end{bmatrix}$$