Subject: Sa Su Mo Tue Wed Thu Fri

Date: / /

فصل ۳ تمرین ۸

$$K_1 = \frac{AE}{L}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} = \frac{۲۰۰\times۱۰^{۹}\times۲\times۱۰^{-۴}}{۱}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} = ۸\times۱۰^{۷}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$

$$K_2 = \frac{۷۰\times۱۰^{۹}\times۲\times۱۰^{-۴}}{۱}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} = ۱,۴\times۱۰^{۷}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$

۳گره ← هرکدام یک درجه آزادی ← $\bar{K}\ [۳\times۳]$

$$\begin{bmatrix} F_1 \\ F_2 \\ F_3 \end{bmatrix} = \begin{bmatrix} ۸\times۱۰^{۷} & -۸\times۱۰^{۷} & ۰ \\ -۸\times۱۰^{۷} & ۹,۴\times۱۰^{۷} & -۱,۴\times۱۰^{۷} \\ ۰ & -۱,۴\times۱۰^{۷} & ۱,۴\times۱۰^{۷} \end{bmatrix}\begin{bmatrix} u_1 \\ u_2 \\ u_3 \end{bmatrix}$$

u_1 مقید شده است $\Rightarrow u_1 = ۰$

$$\rightarrow \begin{bmatrix} F_2 \\ F_3 \end{bmatrix} = \begin{bmatrix} ۹,۴\times۱۰^{۷} & -۱,۴\times۱۰^{۷} \\ -۱,۴\times۱۰^{۷} & ۱,۴\times۱۰^{۷} \end{bmatrix}\begin{bmatrix} u_2 \\ u_3 \end{bmatrix}$$

$$F_2 = ۰ = ۱۰^{۷}(۹,۴u_2 - ۱,۴u_3) \rightarrow u_3 = \frac{۹,۴}{۱,۴}u_2$$

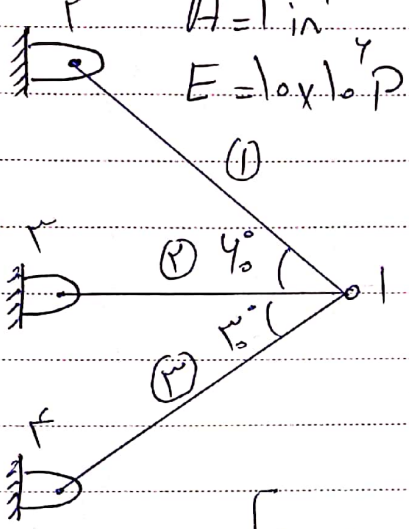
$$F_3 = -۴۰۰۰۰ = ۱۰^{۷}(-۱,۴u_2 + ۱,۴u_3)$$

$$\rightarrow -۴\times۱۰^{-۳} = (۹,۴-۱,۴)u_2 \rightarrow u_2 = -۰,۵\ mm$$

$$u_3 = \frac{۹,۴}{۱,۴}u_2 = -۳,۳۵\ mm$$

$$F_1 = -۸\times۱۰^{۷}\times u_2 = -۸\times۱۰^{۷}\times(۰,۵)\times۱۰^{-۳} = ۴۰۰۰۰\ N = ۴۰\ kN$$

فصل ۳ سوال ۲۲



$A = 1\ in^2$

$E = 10 \times 10^6\ psi$

$$[C] = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & \cos\theta & -\sin\theta \\ 0 & 0 & \sin\theta & \cos\theta \end{bmatrix}$$

$$\text{Global}: \quad \overline{k} = [C][k_e][C]^T$$

$$\overline{k} = \frac{AE}{L} \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & \cos\theta & -\sin\theta \\ 0 & 0 & \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \cos\theta & \sin\theta & 0 & 0 \\ -\sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & \cos\theta & \sin\theta \\ 0 & 0 & -\sin\theta & \cos\theta \end{bmatrix}$$

$$\overline{k} = \frac{AE}{L} \begin{bmatrix} \cos^2 & \cos\sin & -\cos^2 & -\cos\sin \\ \cos\sin & \sin^2 & -\sin\cos & -\sin^2 \\ -\cos^2 & -\cos\sin & \cos^2 & \cos\sin \\ -\cos\sin & -\sin^2 & \cos\sin & \sin^2 \end{bmatrix}$$

$\theta = \frac{2}{3}$

$$\overline{k}^1 = \frac{AE}{4L} \begin{bmatrix} 1 & -\sqrt{3} & -1 & \sqrt{3} \\ -\sqrt{3} & 3 & \sqrt{3} & -3 \\ -1 & \sqrt{3} & 1 & -\sqrt{3} \\ \sqrt{3} & -3 & -\sqrt{3} & 3 \end{bmatrix}$$

$\cos 45$

$\theta = \pi$

$$\overline{k}^2 = \frac{AE}{L} \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$\theta = \frac{\sqrt{\pi}}{4}$

$$\overline{k}^3 = \frac{AE}{4L} \begin{bmatrix} 3 & \sqrt{3} & -3 & -\sqrt{3} \\ \sqrt{3} & 1 & -\sqrt{3} & -1 \\ -3 & -\sqrt{3} & 3 & \sqrt{3} \\ -\sqrt{3} & -1 & \sqrt{3} & 1 \end{bmatrix}$$

$\cos 30$

گره ۲، ۳، ۴ $\rightarrow$ $u_1 = v_1 = u_3 = v_3 = u_4 = v_4 = 0$

u_1 , v_1 → مجهول

$$\begin{bmatrix} ۱۰۰۰ \\ ۱۰۰۰ \end{bmatrix} = \frac{AE}{L} \begin{bmatrix} \frac{۱}{۸}+۱+\frac{۳\sqrt{۳}}{۸} & \frac{-\sqrt{۳}}{۸}+\frac{۳}{۸} \\ \frac{-\sqrt{۳}}{۸}+\frac{۳}{۸} & \frac{۳}{۸}+\frac{\sqrt{۳}}{۸} \end{bmatrix} \begin{bmatrix} u_1 \\ v_1 \end{bmatrix}$$

$$\rightarrow \begin{bmatrix} u_1 \\ v_1 \end{bmatrix} = \frac{L}{AE} \times \frac{۱}{۱٫۷۷۴۵ \times ۰٫۵۹۲ - ۰٫۱۵۸۵ \times ۰٫۱۵۸۵} \begin{bmatrix} ۰٫۵۹۲ & -۰٫۱۵۸۵ \\ -۰٫۱۵۸۵ & ۱٫۷۷۴۵ \end{bmatrix} \begin{bmatrix} ۱۰۰۰ \\ ۱۰۰۰ \end{bmatrix}$$

$$\rightarrow u_1 = \frac{۱۰۰}{۱۰ \times ۱۰^{۶}} \times \frac{۱}{۱٫۰۲۵۳۸} \times ۴۳۳٫۵ = ۰٫۰۰۴۲۲۷۷ \text{ in}$$

$$v_۲ = \frac{۱۰۰}{۱۰ \times ۱۰^{۶}} \times ۱۵۷۴ = ۰٫۰۱۵۷۴ \text{ in}$$

الان!

$$[\bar{F}_1] = [k'][\bar{d}_e] \rightarrow f_{۲x} = \frac{-۱}{۴ \times ۲} \times ۴۲۲٫۷۷ + \frac{\sqrt{۳}}{۴ \times ۲} \times ۱۵۷۴$$

$$= ۲۸۷ \text{ lb}$$

$$f_{۲y} = \frac{\sqrt{۳}}{۴ \times ۲} \times ۴۲۲٫۷۷ + \frac{-۳}{۴ \times ۲} \times ۱۵۷۴$$

$$\rightarrow f_{۲y} = -۴۹۷ \text{ lb}$$

$$\rightarrow f = \sqrt{f_x^{۲} + f_y^{۲}} \rightarrow f' = ۵۷۴۱ \text{ lb} \rightarrow \sigma' = ۵۷۴۱ \text{ lb}$$

المثال ۲

$$[\bar{F}_2] = [\bar{k}^2][\bar{d}_e]$$

$$f_{2x} = -1 \times 444.7 = -444.7\,lb \qquad f_{2y} = 0$$

$$\Rightarrow f_2 = -444.7\,lb \Rightarrow \sigma = -444.7\,psi$$

المثال ۳

$$[\bar{F}_3] = [\bar{k}^3][\bar{d}_e]$$

$$f_{3x} = \frac{\sqrt{3}}{2} \times \frac{-3}{4} \times 444.77 - \frac{\sqrt{3}}{4} \times \frac{\sqrt{3}}{2} \times 1574 = -854.8\,lb$$

$$f_{3y} = \frac{\sqrt{3}}{2} \times \frac{-\sqrt{3}}{4} \times 444.7 - \frac{\sqrt{3}}{2} \times \frac{1}{4} \times 1574 = -694\,lb$$

$$\Rightarrow f_3 = 994\,lb \Rightarrow \sigma_3 = 994\,psi$$

فصل ۳ سوال ۲۴

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از سوال قبل می دانیم : $[\bar{k}] = \begin{bmatrix} \cos^2 & \cos\sin & -\cos^2 & -\cos\sin \\ \cos\sin & \sin^2 & -\sin\cos & -\sin^2 \\ -\cos^2 & -\cos\sin & \cos^2 & \cos\sin \\ -\cos\sin & -\sin^2 & \cos\sin & \sin^2 \end{bmatrix}$

$\theta_1 = \pi$, $\theta_2 = \pi$, $\theta_3 = \theta_4 = \frac{\pi}{2}$, $\theta_5 = \tan^{-1}\frac{15}{20} = 36.87^\circ$, $\theta_6 = 143.13^\circ$

$k_1 = \frac{AE}{20}\begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$, $k_4 = \frac{AE}{15}\begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 \end{bmatrix}$

$k_2 = \frac{AE}{20}\begin{bmatrix} 1 & -1 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$, $k_3 = \frac{AE}{15}\begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 \end{bmatrix}$

$k_3 = \frac{AE}{25}\begin{bmatrix} 0.64 & -0.48 & -0.64 & 0.48 \\ -0.48 & 0.36 & 0.48 & -0.36 \\ -0.64 & -0.48 & 0.64 & -0.48 \\ 0.48 & -0.36 & -0.48 & 0.36 \end{bmatrix}$

$k_4 = \frac{AE}{25}\begin{bmatrix} 0.64 & 0.48 & -0.64 & -0.48 \\ 0.48 & 0.36 & -0.48 & -0.36 \\ -0.64 & -0.48 & 0.64 & 0.48 \\ -0.48 & -0.36 & 0.48 & 0.36 \end{bmatrix}$

$u_1 = v_1 = u_4 = v_4 = 0$ $\qquad [k_e] = [4 \times 4]$

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$$\begin{bmatrix} F_{1x} \\ F_{1y} \\ F_{2x} \\ F_{2y} \end{bmatrix} = \begin{bmatrix} 0.0704 & -0.0192 & 0 & 0 \\ -0.0192 & 0.0811 & 0 & 0 \\ 0 & 0 & 0.0704 & 0.0192 \\ 0 & -0.0704 & 0.0192 & 0.0811 \end{bmatrix} \begin{bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \end{bmatrix}$$

$F_{2x} = 1000\,lb$ ←

$F_{2y} = 1000\,lb$ ←

Matlab ⟶ $v_1 = \frac{1.0521}{AE}$, $v_2 = \frac{1.0521}{AE}$

$$u_1 = \frac{2470}{AE} \quad , u_2 = -\frac{2470}{AE}$$

(1)

$$\begin{Bmatrix} f_{1x} \\ f_{1y} \end{Bmatrix} = \frac{AE}{20} \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{Bmatrix} u_1 \\ v_1 \\ 0 \\ 0 \end{Bmatrix} \rightarrow f_{1x} = 1233\,lb \quad f_{1y} = 0$$

$\rightarrow f_1 = 1233\,lb$

(2)

$$\begin{Bmatrix} f_{2x} \\ f_{2y} \end{Bmatrix} = \frac{AE}{20} \begin{bmatrix} -0.48 & -0.48 & 0.48 & 0.48 \\ -0.48 & -0.48 & 0.48 & 0.48 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ u_2 \\ v_2 \end{bmatrix}$$

$\rightarrow f_{2x} = -1233\,lb$, $f_{2y} = -1000\,lb \rightarrow f_2 = 1577\,lb$

(3)

$$\begin{Bmatrix} f_{3x} \\ f_{3y} \end{Bmatrix} = \frac{AE}{20} \begin{bmatrix} 0.48 & -0.48 & -0.48 & 0.48 \\ -0.48 & 0.48 & 0.48 & -0.48 \end{bmatrix} \begin{bmatrix} u_1 \\ v_1 \\ 0 \\ 0 \end{bmatrix}$$

$\rightarrow f_{3x} = 1233\,lb \quad f_{3y} = 1000\,lb \rightarrow f_3 = 1577\,lb$

(4)

$$\begin{Bmatrix} f_{4x} \\ f_{4y} \end{Bmatrix} = \frac{AE}{10} \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -1 \end{bmatrix} \begin{Bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \end{Bmatrix} \rightarrow f_4 = 0$$

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(5)

$$\begin{Bmatrix} f_{2x} \\ f_{2y} \end{Bmatrix} = \frac{AE}{20} \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{Bmatrix} u_2 \\ v_2 \\ 0 \\ 0 \end{Bmatrix} \rightarrow f_{2x} = -1233\,lb \quad f_{2y} = 0\,lb$$

$\rightarrow f_5 = 1233\,lb$

(6)

$$\begin{Bmatrix} f_{4x} \\ f_{4y} \end{Bmatrix} = \frac{AE}{10} \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \rightarrow f_4 = 0$$

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element 1 → $L = 50\ ft$ → $\theta = 53^\circ$

element 2 → $L = 50\ ft$ → $\theta = 127^\circ$

element 3 → $L = 20\ ft$ → $\theta = 90^\circ$

$$k^1 = \frac{AE}{50}\begin{bmatrix} 0.324 & 0.432 & -0.324 & 0.432 \\ 0.432 & 0.576 & -0.432 & -0.576 \\ -0.324 & -0.432 & 0.324 & -0.432 \\ 0.432 & -0.576 & -0.432 & 0.576 \end{bmatrix}$$

$$k^2 = \frac{AE}{50}\begin{bmatrix} 0.324 & -0.432 & -0.324 & 0.432 \\ -0.432 & 0.576 & 0.432 & -0.576 \\ -0.324 & 0.432 & 0.324 & -0.432 \\ 0.432 & -0.576 & -0.432 & 0.576 \end{bmatrix}$$

$$k^3 = \frac{AE}{20}\begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 \end{bmatrix}$$

$u_1 = u_2 = u_4 = v_1 = v_2 = v_4 = 0$

$[\bar{k}] = [2 \times 2]$

$$\rightarrow \bar{K} = \sum K_e = AE\begin{bmatrix} \frac{0.72}{50} + \frac{1}{20}(0) & \frac{1}{20} \\ \frac{1}{20} & \frac{1.728}{50} + \frac{1}{20} \end{bmatrix}$$

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$$\rightarrow [\bar{F}] = [\bar{k}][\bar{d}]$$

$$\rightarrow \begin{bmatrix} 0 \\ -20 \end{bmatrix} = AE\begin{bmatrix} \frac{0.72}{50} & 0 \\ 0 & \frac{2.728}{50} \end{bmatrix}\begin{Bmatrix} u_2 \\ v_2 \end{Bmatrix}$$

$$\rightarrow 0 = AE\,\frac{0.72}{50}\,u_2 \rightarrow u_2 = \frac{50000 \times 50 \times \frac{1}{12}}{0.72 \times \frac{3}{12 \times 12} \times 30 \times 10^6}$$

$$\rightarrow u_2 = 0.0644\ in$$

$$-20 = AE\,\frac{2.728}{50}\,v_2 \rightarrow v_2 = \frac{-20 \times 50 \times 10^3}{1728 \times \frac{3}{12} \times 30 \times 10^6}$$

$$v_2 = -0.0257\ in$$

element 1 : $\begin{Bmatrix} f_{1x} \\ f_{2x} \end{Bmatrix} = \frac{AE}{50} \begin{bmatrix} 0.4 & 0.8 & -0.4 & -0.8 \\ -0.4 & -0.8 & 0.4 & 0.8 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ u_3 \\ v_3 \end{bmatrix}$

$\rightarrow f_{1x}^{1} = +0.057 \text{ kips}$

element 2 : $\begin{Bmatrix} f_{2x} \\ f_{3x} \end{Bmatrix} = \frac{AE}{50} \begin{bmatrix} -0.4 & 0.8 & 0.4 & -0.8 \\ 0.4 & -0.8 & -0.4 & 0.8 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ u_3 \\ v_3 \end{bmatrix}$

$\rightarrow f_{2x}^{2} = 8.391 \text{ kips}$

element 3 : $\begin{Bmatrix} f_{3x} \\ f_{4x} \end{Bmatrix} = \frac{AE}{20} \begin{bmatrix} 0 & 1 & 0 & -1 \\ 0 & -1 & 0 & 1 \end{bmatrix} \begin{bmatrix} u_3 \\ v_3 \\ 0 \\ 0 \end{bmatrix}$

$\rightarrow f_{3x}^{3} = -12.32 \text{ kips}$

فصل ۳ سوال ۳۳

a)

element 1 $\rightarrow \theta = 150^\circ$, $L = 5\,m$

element 2 $\rightarrow \theta = 180^\circ$, $\theta = 10\,m$

$$[\bar{k}_1] = \frac{210\times10^9 \times 5\times10^{-4}}{5} \begin{bmatrix} 0,5 & -0,5 & -0,5 & 0,5 \\ -0,5 & 0,5 & 0,5 & -0,5 \\ -0,5 & 0,5 & 0,5 & -0,5 \\ 0,5 & -0,5 & -0,5 & 0,5 \end{bmatrix}$$

$$= 10,5\times10^5 \begin{bmatrix} 1 & -1 & -1 & 1 \\ -1 & 1 & 1 & -1 \\ -1 & 1 & 1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix}$$

$$[\bar{k}_2] = \frac{210\times10^9 \times 5\times10^{-4}}{10} \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} = 10,5\times10^5 \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$\theta_2 = 270^\circ$

$$\bar{k}_2 = 20\times10^5 \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 \end{bmatrix} \quad 0 = u_1 = v_1 = u_2 = v_2 = u_3 = v_3 = u_4 = v_4$$

$$\bar{K} = [2\times2]$$

$$\rightarrow \begin{bmatrix} F_{1x} \\ F_{1y} \end{bmatrix} = 10^5 \begin{bmatrix} 210 & -105 \\ -105 & 150 \end{bmatrix} \begin{Bmatrix} u_1 \\ v_1 \end{Bmatrix}$$

$$0 = 210u_1 - 105v_1 \rightarrow v_1 = 2u_1$$

$$-100000 = 10^5 [-105u_1 + 150(2u_1)] \rightarrow u_1 = -2,222\,mm$$

$$v_1 = -4,194\times10^{-2}\,m$$

$$0 = 210u_1 - 105v_1 \rightarrow v_1 = 2u_1$$

$$-100000 = 10^5 [-105u_1 + 150(2u_1)] \rightarrow u_1 = -4,9\,mm$$

$$v_1 = -12,8\,mm$$

$$\rightarrow \sigma_1 = \frac{210\times10^9}{5} \begin{bmatrix} 0,70 & -0,70 & -0,70 & 0,70 \end{bmatrix} \begin{bmatrix} -4,9\times10^{-2} \\ -12,8\times10^{-2} \\ 0 \\ 0 \end{bmatrix}$$

$$\rightarrow \sigma_1 = 20,27\,MPa$$

$$\sigma_2 = \frac{210\times10^9}{10} \begin{bmatrix} 1 & 0 & -1 & 0 \end{bmatrix} \begin{bmatrix} -4,9\times10^{-2} \\ -12,8\times10^{-2} \\ 0 \end{bmatrix} \rightarrow \sigma_2 = 12,8\,MPa$$

b)

$$K^1 = \frac{2.1}{4} \times 10^7 \begin{bmatrix} 1 & -\sqrt{3} & -1 & \sqrt{3} \\ -\sqrt{3} & 3 & \sqrt{3} & -3 \\ -1 & \sqrt{3} & 1 & -\sqrt{3} \\ \sqrt{3} & -3 & -\sqrt{3} & 3 \end{bmatrix}$$

$$K^2 = \frac{2.1}{4} \times 10^7 \begin{bmatrix} 1 & \sqrt{3} & -1 & -\sqrt{3} \\ \sqrt{3} & 3 & -\sqrt{3} & -3 \\ -1 & -\sqrt{3} & 1 & \sqrt{3} \\ -\sqrt{3} & -3 & \sqrt{3} & 3 \end{bmatrix}$$

$$K^3 = 4 \times 10^3 \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 \end{bmatrix} \quad 0 = u_1 = u_2 = u_3 = u_4 = u$$

$$\rightarrow \begin{Bmatrix} F_{1u} \\ F_{2u} \end{Bmatrix} = \begin{bmatrix} 0.250 \times 10^7 + 0.250 \times 10^7 & 0 \\ 0 & 1.050 \times 2 \times 10^7 + 4000 \end{bmatrix} \begin{Bmatrix} u_1 \\ u_2 \end{Bmatrix}$$

$$\rightarrow u_1 = F_{1u} = 0 \;,\; -10^5 = 3.150 \times 10^7 u_1 \rightarrow u_1 = -3.17 \text{ mm}$$

$$\rightarrow \sigma = \frac{AE}{L} \begin{bmatrix} -\cos\theta & -\sin\theta & \cos\theta & \sin\theta \end{bmatrix} \begin{bmatrix} 0 \\ -3.17 \times 10^{-3} \\ 0 \\ 0 \end{bmatrix}$$

$$\rightarrow \begin{cases} \sigma_1 = 1.100 \times 10^8 = 110 \text{ MPa} \\ \sigma_2 = \frac{210 \times 10^9}{5} \times \frac{\sqrt{3}}{2} \times 0.00317 = 110 \text{ MPa} \end{cases}$$