

$$\sum M/A = 0 \Rightarrow M_A - 4F - 2q(2) = 0$$

$$\Rightarrow M_A = 4(20) + 4(40) = 240kN \cdot m$$

$$\sum F/y = 0 \Rightarrow -F - 2q + V_A = 0$$

$$\Rightarrow V_A = 20 + 2(40) = 100kN$$

$0 \leq x \leq 1$

$$T(x) = -F = -20kN$$

$$M(x) = -F \cdot x = -20 \cdot x$$

$$M(0) = 0; M(1) = -20kN \cdot m$$

$1 \leq x \leq 3$

$$T(x) = -F - q(x - 1) = -40x + 20$$

$$T(1) = -20kN; T(3) = -100kN$$

$$M(x) = -F \cdot x - \frac{1}{2}q(x - 1)^2 = -20x^2 + 20x - 20$$

$$M(1) = -20kN \cdot m; M(3) = -140kN \cdot m$$

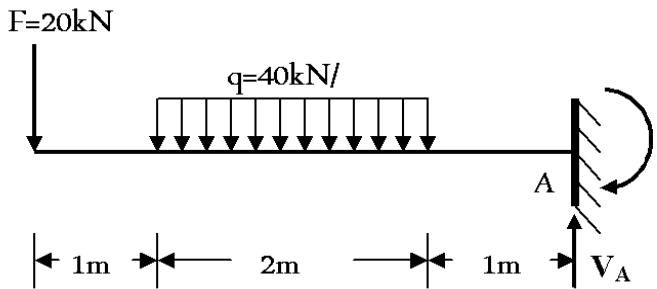
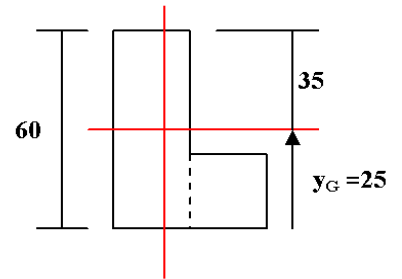
$3 \leq x \leq 4$

$$T(x) = -V_A = -100kN$$

$$M(x) = -M_A + V_A(4 - x)$$

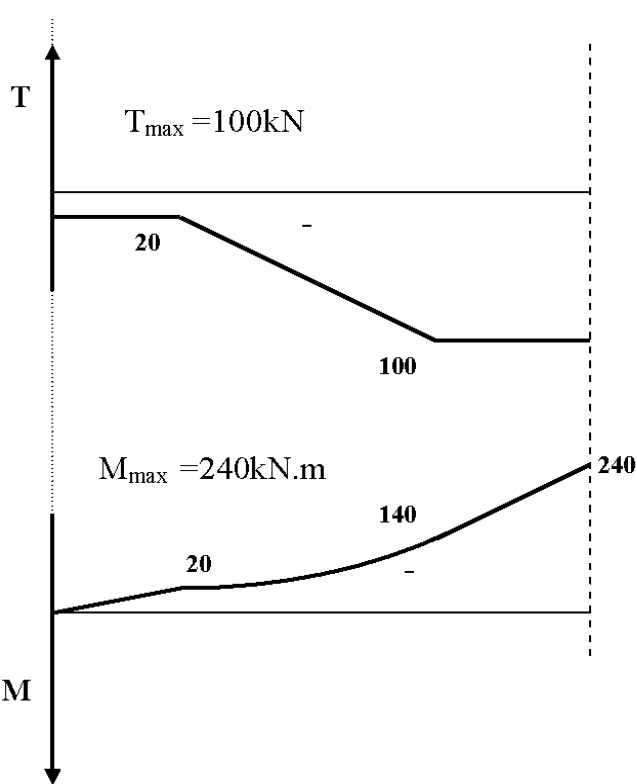
$$M(x) = -240 + 100(4 - x)$$

$$M(3) = -140; M(4) = -240kN \cdot m$$



$$x_G = \frac{s_1 x_1 + s_2 x_2}{s_1 + s_2} = \frac{(60 \cdot 20)10 + (20 \cdot 20)30}{(60 \cdot 20) + (20 \cdot 20)} = 15cm$$

$$y_G = \frac{s_1 y_1 + s_2 y_2}{s_1 + s_2} = \frac{(60 \cdot 20)30 + (20 \cdot 20)10}{(60 \cdot 20) + (20 \cdot 20)} = 25cm$$



$$I_x = \frac{20(60)^3}{12} + (60 \cdot 20)(5)^2 + \frac{20(20)^3}{12} + (20 \cdot 20)(15)^2$$

$$I_x = 493333,33cm^4$$

$$\sigma_{max} = \frac{M}{I_x} \cdot y_{max} = \frac{240 \cdot 10^4}{493333,33} \cdot 35 = 170,27daN / cm^2 \leq \bar{\sigma}$$

$$\sin \alpha = 0,8$$

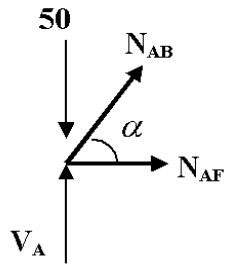
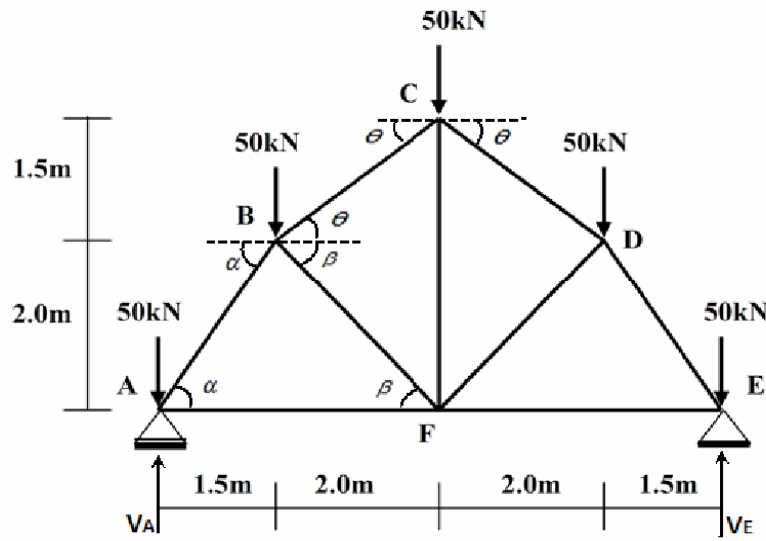
$$\sin \beta = \cos \beta = 0.707$$

$$b = 2n - 3 = 9 = 2(6) - 3 = 9$$

$$\cos \alpha = 0,6$$

$$\sin \theta = 0,6 \quad \cos \theta = 0,8$$

$$V_A = V_E = \frac{\Sigma F}{2} = \frac{5(50)}{2} = 125kN$$



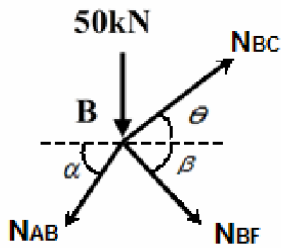
$$\Sigma F / y = 0 \Rightarrow N_{AB} \sin \alpha - 50 + V_A = 0$$

$$\Rightarrow N_{AB} = \frac{50 - 125}{0,8} = -93,75kN$$

$$\Sigma F / x = 0 \Rightarrow N_{AF} + N_{AB} \cos \alpha = 0$$

$$\Rightarrow N_{AF} = -N_{AB} \cos \alpha = 93,75(0,6)$$

$$\Rightarrow N_{AF} = 56,25kN$$



$$\Sigma F / x = 0 \Rightarrow N_{BC} \cos \theta + N_{BF} \cos \beta - N_{AB} \cos \alpha = 0$$

$$\Rightarrow N_{BC} \cos \theta + N_{BF} \cos \beta = N_{AB} \cos \alpha$$

$$\Rightarrow 0,8N_{BC} + 0,707N_{BF} = -93,75(0,6)$$

$$\Rightarrow 0,8N_{BC} + 0,707N_{BF} = -56,25 \dots (1)$$

$$\Sigma F / y = 0 \Rightarrow N_{BC} \sin \theta - N_{BF} \sin \beta - N_{AB} \sin \alpha - 50 = 0$$

$$\Rightarrow N_{BC} \sin \theta - N_{BF} \sin \beta = N_{AB} \sin \alpha + 50$$

$$\Rightarrow 0,6N_{BC} - 0,707N_{BF} = -93,75(0,8) + 50$$

$$\Rightarrow 0,6N_{BC} - 0,707N_{BF} = -25 \dots (2)$$

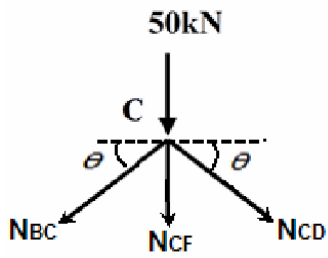
$$\begin{cases} 0,8N_{BC} + 0,707N_{BF} = -56,25 \dots (1) \\ 0,6N_{BC} - 0,707N_{BF} = -25 \dots (2) \end{cases}$$

$$1,4N_{BC} = -81,25 \Rightarrow N_{BC} = -\frac{81,25}{1,4} = -58,04kN$$

$$0,6N_{BC} - 0,707N_{BF} = -25 \dots (2)$$

$$0,707N_{BF} = 0,6N_{BC} + 25 \Rightarrow N_{BF} = \frac{0,6N_{BC} + 25}{0,707}$$

$$\Rightarrow N_{BF} = \frac{0,6(-58,04) + 25}{0,707} = -13,89kN$$



بالتناظر $N_{BC} = N_{CD}$

$$\begin{aligned} \sum F / y = 0 &\Rightarrow -N_{CF} - 2N_{BC} \sin \theta - 50 = 0 \\ \Rightarrow N_{CF} &= -2N_{BC} \sin \theta - 50 = -2(-58,04)(0,6) - 50 \\ \Rightarrow N_{CF} &= 19,64kN \end{aligned}$$

$$\begin{aligned} \sigma_{\max} \leq \bar{\sigma} &\Rightarrow \frac{N_{AB}}{S} \leq \bar{\sigma} \Rightarrow S \geq \frac{N_{AB}}{\bar{\sigma}} \\ \Rightarrow S &\geq \frac{93,75 \cdot 10^2}{1875} = 5cm^2 \end{aligned}$$

الطبيعة	الشدة	القضبان
ضغط	93.75	AB
ضغط	58.04	BC
شد	56.25	AF
ضغط	13.89	BF
شد	19.64	CF
ضغط	93.75	DE
ضغط	58.04	CD
شد	56.25	EF
ضغط	13.89	EF

التمرين الثالث:

$$L_{BC} = \sqrt{(X_C - X_B)^2 + (Y_C - Y_B)^2} \Rightarrow L_{BC} = \sqrt{20^2 + (-40)^2} = 44,72m$$

$$L_{BM} = \frac{L_{BC}}{2} = \frac{44,72}{2} = 22,36m$$

$$\begin{cases} \Delta X_{BC} = 20 \\ \Delta Y_{BC} = -40 \end{cases} \Rightarrow G_{BC} = 200 - g$$

$$tg(g) = \left| \frac{\Delta X_{BC}}{\Delta Y_{BC}} \right| = \frac{20}{40} = 0,5 \Rightarrow g = 29,52gr$$

$$\Rightarrow G_{BC} = 200 - 29,52 = 170,48gr$$

$$\Rightarrow G_{BC} = G_{BM} = 170,48gr$$

$$X_M = X_B + L_{BM} \sin G_{BM} = 40 + 22,36 \sin 170,48gr = 50$$

$$Y_M = Y_B + L_{BM} \cos G_{BM} = 60 + 22,36 \cos 170,48gr = 40$$

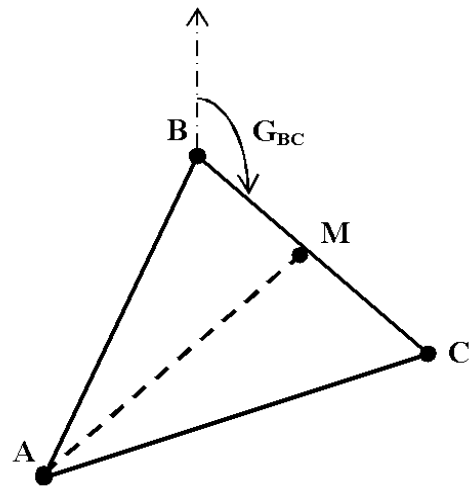
$$M(50; 40)$$

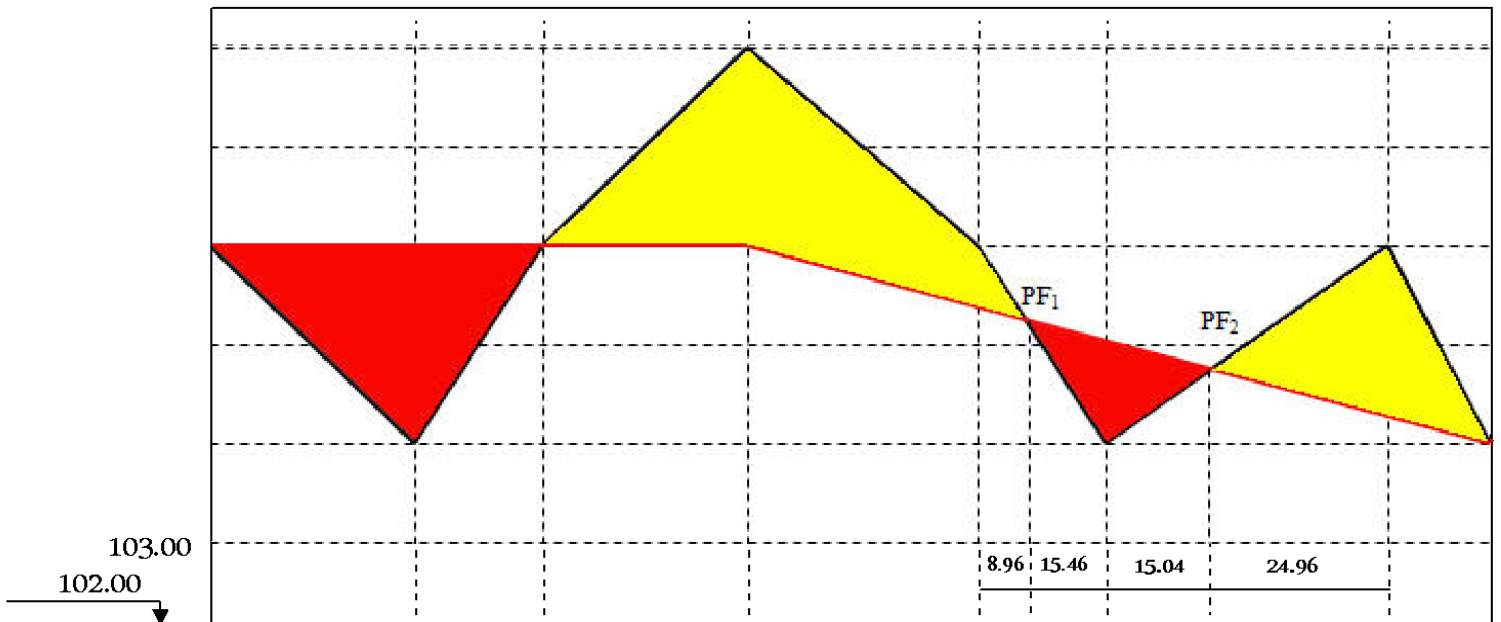
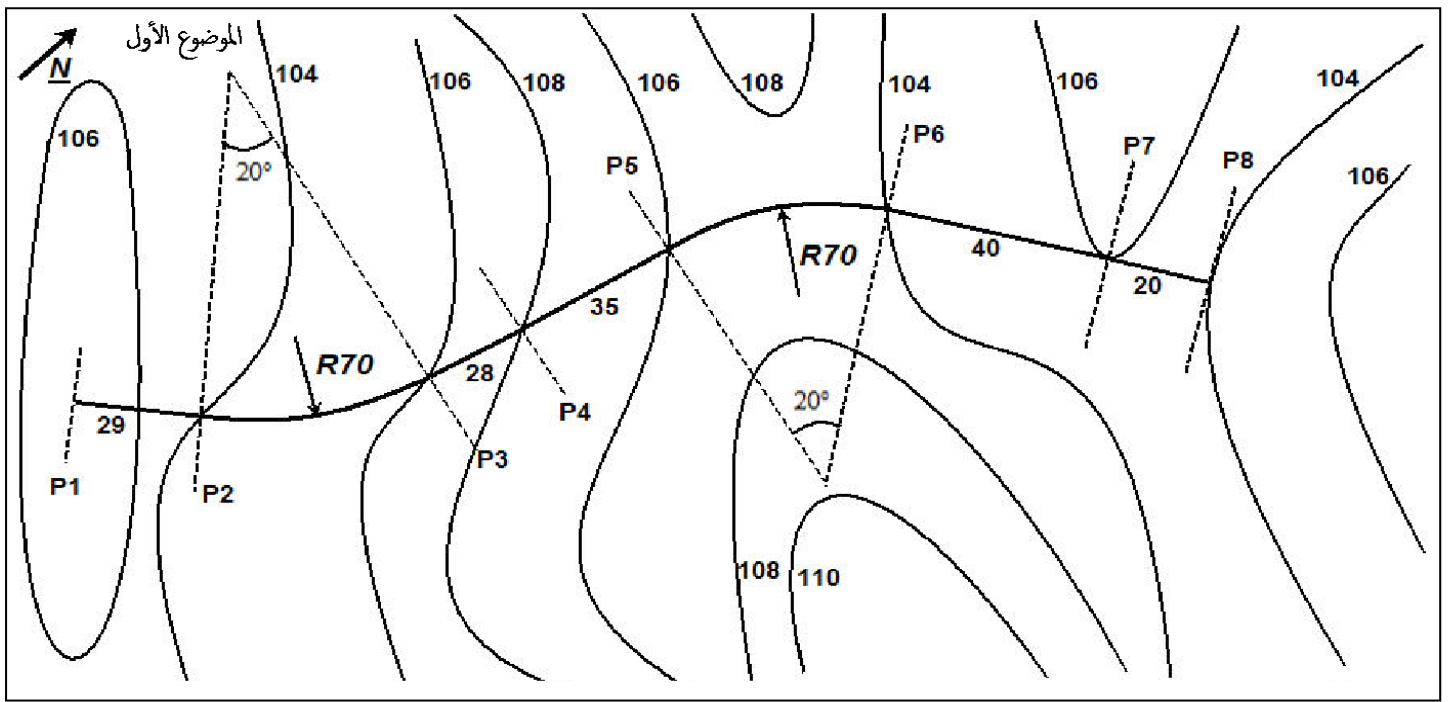
$$S_{ABM} = \frac{1}{2} [x_A (y_M - y_B) + x_B (y_A - y_M) + x_M (y_B - y_A)]$$

$$S_{ABM} = \frac{1}{2} [10(40 - 60) + 40(10 - 40) + 50(60 - 10)] = 550m^2$$

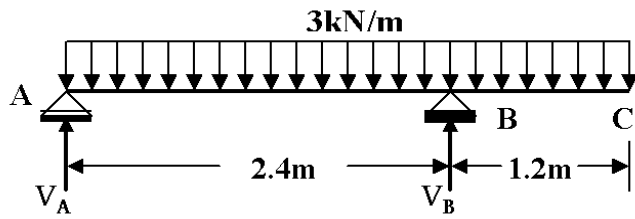
$$S_{AMC} = S_{ABC} - S_{ABM} = 1100 - 550 = 550m^2$$

	A	B	C
X	10	40	60
Y	10	60	20





أرقام المظاهر	1	2	3	4	5	6	7	8
منسوب خط التربة	106.00	104.00	106.00	108.00	106.00	104.00	106.00	104.00
منسوب خط المشروع	106.00	106.00	106.00	106.00	105.42	105.00	104.34	104.00
المسافات الجزئية	29.00	24.42	28.00	35.00	24.42	40.00	20.00	
المسافات المتراكمة	0.00	29.00	53.42	81.42	116.42	140.84	180.84	200.84
ميل المشروع	0.00%			1.67%				
المستقيمت و المتعرجات	استقامة على طول 29.00m		L=24.42 R=70 α=20°		استقامة على طول 63.00m		L=24.42 R=70 α=20°	



$$0 \leq x \leq 2,4$$

$$T(x) = -3x + 2,7$$

$$T(0) = 2,7kN ; T(2,4) = -4,5kN$$

$$T(x) = 0 \Rightarrow -3x + 2,7 = 0 \Rightarrow x = 0,9$$

$$2,4 \leq x \leq 3,6$$

$$T(x) = 3(3,6 - x) = -3x + 10,8$$

$$T(2,4) = 3,6kN ; T(3,6) = 0kN$$

$$\Sigma M /_A = 0 \Rightarrow 2,4V_B - 3(3,6)(1,8) = 0$$

$$\Rightarrow V_B = 8,1kN$$

$$\Sigma F /_y = 0 \Rightarrow V_A + V_B - 3(3,6) = 0$$

$$V_A = 10,8 - 8,1 = 2,7kN$$

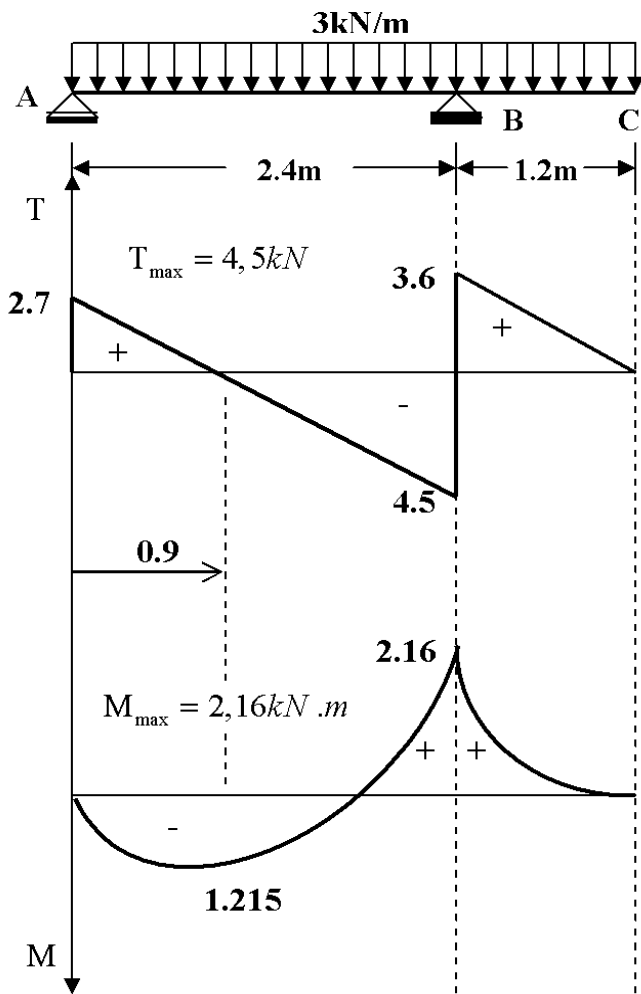
$$M(x) = -\frac{3}{2}x^2 + 2,7x$$

$$M(0) = 0 ; M(2,4) = -2,16kN.m$$

$$M(0,9) = 1,215kN.m$$

$$M(x) = -\frac{3}{2}(3,6 - x)^2$$

$$M(2,4) = -2,16kN.m ; M(3,6) = 0$$



$$W_x = \frac{\frac{bh^3}{12}}{\frac{h}{2}} = \frac{bh^3}{12} \cdot \frac{2}{h} = \frac{bh^2}{6}$$

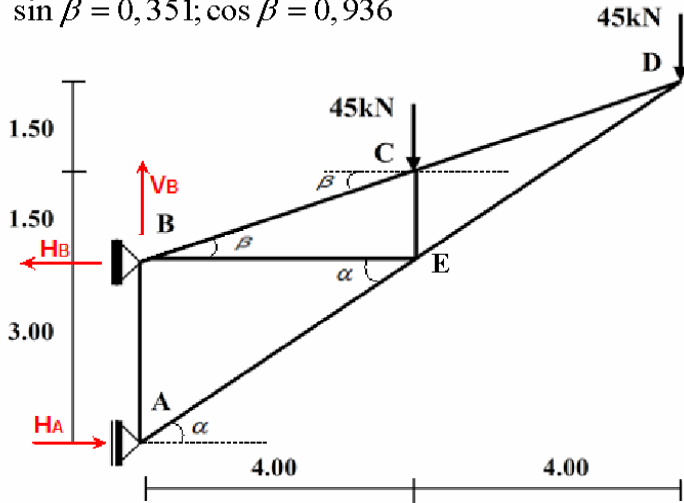
$$\sigma_{\max} \leq \bar{\sigma} \Rightarrow \frac{M_{\max}}{W_x} \leq \bar{\sigma} \Rightarrow \frac{W_x}{M_{\max}} \geq \frac{1}{\bar{\sigma}} \Rightarrow W_x \geq \frac{M_{\max}}{\bar{\sigma}}$$

$$\frac{bh^2}{6} \geq \frac{M_{\max}}{\bar{\sigma}} \Rightarrow b \geq \frac{6M_{\max}}{h^2 \bar{\sigma}}$$

$$b \geq \frac{6 \cdot 2,16 \cdot 10^3}{(0,15)^2 \cdot 12 \cdot 10^6} = 0,048m = 48mm$$

$\sin \alpha = 0,6; \cos \alpha = 0,8$

$\sin \beta = 0,351; \cos \beta = 0,936$



$b = 2n - 3 \Rightarrow 7 = 2(5) - 3 = 7$

$\Sigma M /_B = 0 \Rightarrow 3H_A + 4(45) + 8(45) = 0$

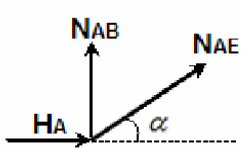
$\Rightarrow H_A = \frac{12(45)}{3} = 4(45) = 180kN$

$\Sigma F /_y = 0 \Rightarrow V_B - 45 - 45 = 0$

$\Rightarrow V_B = 90kN$

$\Sigma F /_x = 0 \Rightarrow H_A - H_B = 0$

$\Rightarrow H_B = H_A = 180kN$

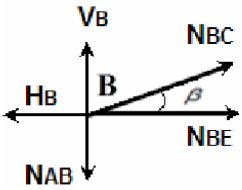


$\Sigma F /_x = 0 \Rightarrow N_{AE} \cos \alpha + H_A = 0$

$\Rightarrow N_{AE} = -\frac{H_A}{\cos \alpha} = -\frac{180}{0,8} = -225kN$

$\Sigma F /_y = 0 \Rightarrow N_{AE} \sin \alpha + N_{AB} = 0$

$\Rightarrow N_{AB} = -N_{AE} \sin \alpha = -(-225)(0,6) = 135kN$



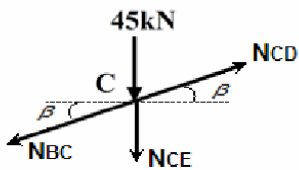
$\Sigma F /_y = 0 \Rightarrow N_{BC} \sin \beta - N_{AB} + V_B = 0$

$\Rightarrow N_{BC} = \frac{N_{AB} - V_B}{\sin \beta} = \frac{135 - 90}{0,351} = 128,21kN$

$\Sigma F /_x = 0 \Rightarrow N_{BE} + N_{BC} \cos \beta - H_B = 0$

$\Rightarrow N_{BE} = -N_{BC} \cos \beta + H_B$

$\Rightarrow N_{BE} = -128,21(0,936) + 180 = 60kN$

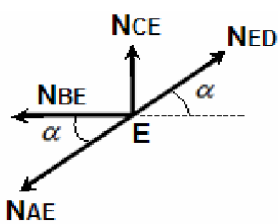


$\Sigma F /_x = 0 \Rightarrow N_{CD} \cos \beta - N_{BC} \cos \beta = 0$

$\Rightarrow N_{CD} = N_{BC} = 128,21kN$

$\Sigma F /_y = 0 \Rightarrow -N_{CE} - 45 = 0$

$\Rightarrow N_{CE} = -45kN$



$\Sigma F /_x = 0 \Rightarrow N_{ED} \cos \alpha - N_{AE} \cos \alpha - N_{BE} = 0$

$\Rightarrow N_{ED} = \frac{N_{AE} \cos \alpha + N_{BE}}{\cos \alpha} = \frac{-225(0,8) + 60}{0,8} = -150kN$

$\sigma = \frac{N_{AE}}{S} \leq \bar{\sigma} \Rightarrow S \geq \frac{N_{AE}}{\bar{\sigma}} = \frac{225 \cdot 10^2}{7300} = 3,08 \Rightarrow 40 \times 4$

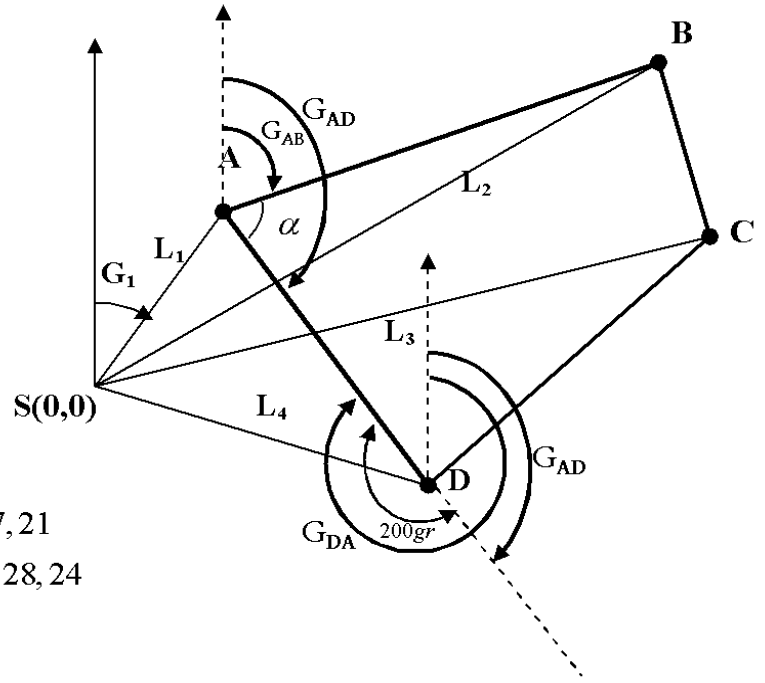
الطبيعة	الشدة	القضبان
شد	135	AB
ضغط	225	AE
شد	128.21	BC
شد	60	BE
شد	128.21	CD
ضغط	45	CE
ضغط	150	DE

$$S = \frac{1}{2} \begin{bmatrix} (29,15)(91,15)\sin(59,16-15,91) \\ + (91,15)(85,90)\sin(78,92-59,16) \\ + (85,90)(52,48)\sin(117,70-78,92) \\ + (52,48)(29,15)\sin(15,91-117,70) \end{bmatrix} = 2555,52m^2$$

$$G_{AB} = G_{AD} - \alpha = (G_{DA} - 200) - \alpha$$

$$\Rightarrow G_{AB} = (349,65 - 200) - 73,35$$

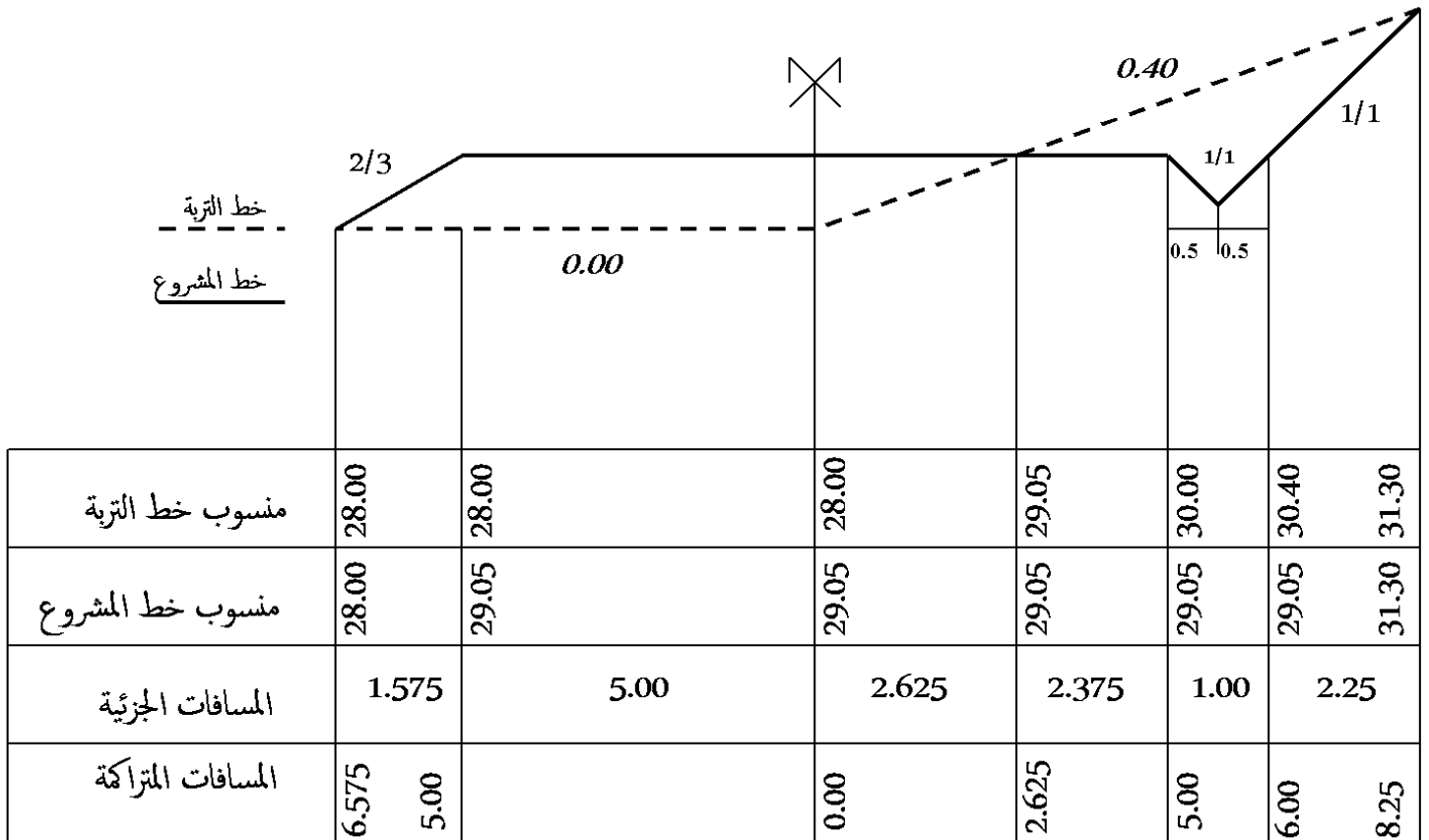
$$\Rightarrow G_{AB} = 149,65 - 73,35 = 76,30gr$$



$$x_A = x_S + L_{SA} \sin G_{SA} = 0 + 29,15 \sin 15,91 = 7,21$$

$$y_A = y_S + L_{SA} \cos G_{SA} = 0 + 29,15 \cos 15,91 = 28,24$$

$$S = \frac{1}{2} \begin{bmatrix} 7,21(-14,14 - 54,31) + 73,20(28,24 - 27,67) \\ + 81,32(54,31 + 14,14) + 50,54(27,67 - 28,24) \end{bmatrix} = 2542,87m^2$$



المساحة	الردم: S = 6.08 m2	الحفر: S = 0	الردم: S = 1.38m2	الحفر: S = 4.05m2
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