IQRA National University

Civil Engineering Department

MS Water Resources Engineering & Management

Advanced Mechanics of Materials

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Question # 01

Given Data :-

Force (F) = 14478N

Elastic Limit = 207,000 KPa

E = 223 x 10^6 kPa

n = 0.14

Diameter of the shaft (D) = ?

Factor of Safety (N) = 1

Dimensions (x) = 14+5 = 19 cm

(Y) = 14cm

Sol :-

Here

The total dimension =

x + Y = 19 + 14

= 33 cm

Moment about Force =

F = 14478 N

r = Y = 14cm

M = 14478 x 14

= 202692 N·cm

= 2026.9 N·m

Area = 14 x 19 = 266 cm^2

Shear stress (τ) =

14478/226 = 64.06 N/cm^2

Q. NO (02):

Solution:

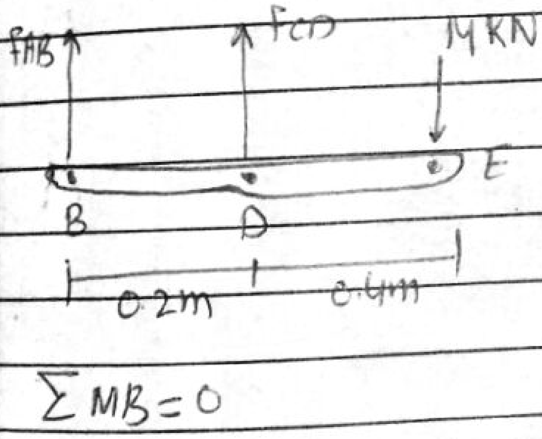
* Apply a free-body analysis to the bar BDE to find the forces exerted by links AB and DC.

* Evaluate the deformation of links AB and DC or the displacement of B and D.

* work out the geometry to find the deflection at E given the defections at B and D.

Solution:

Free-body diagram: Bar BDE



$\Sigma M_B = 0$

$0 = -(14\,KN * 0.6m) + (F_{CD} * 0.2m)$

$F_{CD} = 42\,KN$ tension.

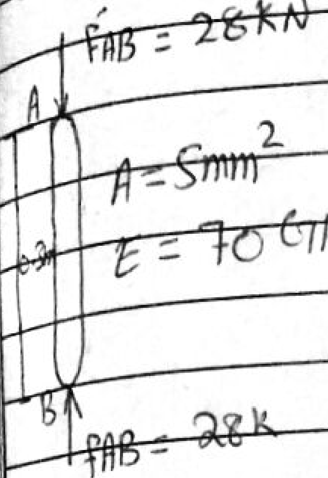
$\Sigma M_D = 0$

$0 = -(14 * 0.4\,m) - F_{AB} * 0.2m$

$F_{AB} = -28\,KN$ compression.

Q. No(02):

Displacement of B:



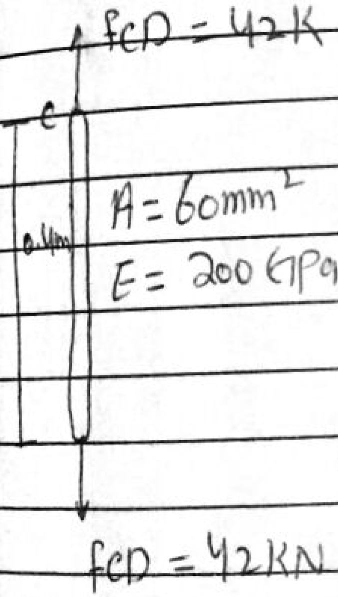
$$\delta_B = \frac{PL}{AE}$$

$$= \frac{(-28 * 10^3 N)(0.3m)}{(5 * 10^{-6} m^2)(70 * 10^9 Pa)}$$

$$= -0.024m$$

$$\delta_B = 24\,mm \uparrow$$

Displacement of D:



$$\delta_D = \frac{PL}{AE}$$

$$= \frac{(42 * 10^3 N)(0.4m)}{(60 * 10^{-6} m^2)(200 * 10^9 GPa)}$$

$$= 1.4 \times 10^{-3} m$$

$$\delta_D = 1.4\,mm \downarrow$$

Question #3:

Given Data:

$G = 14 \times 10^6$ psi

Allowable shearing stress = 10 ksi

Determine:

a) largest torque to that may be applied to the end of short AB.

b) Corresponding Angle through which end A of short AB rotates.

Dimensions = 14 + 10 = 24 in.

Solution:

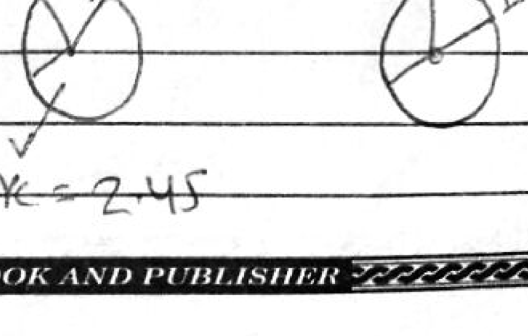
Step # 1

~~Apply~~ Apply a static Equilibrium analysis on ~~the~~ two shafts to find relationship b/w T_{CD} and T_0.

$\Sigma M_B = 0 = F(0.875\,in) - T_0$

$\Sigma M_C = 0 = F(2.45\,in) - T_{CD}$

$T_{CD} = 2.8\,T_0$.



$r_c = 2.45$

Step # 2 Q. No. (3)

Apply a kinematic Analysis to relate the regular rotations the gears.

By using formula.

$r_B \phi_B = r_C \phi_C$

$\phi_B = \frac{r_C}{r_B} \phi_C = \frac{2.45}{0.875} \phi_C$

$\phi_B = 2.8 \phi_C$

Step #3

find the max. Allowable torque (To) on each shaf
- choose the smallest.

By formula:

$\tau_{max} = \frac{J_{ABC}}{J_{AB}} = 10000psi - \frac{T_o(0.375)in}{\pi/2\ (0.375)in^4}$

$10000psi - T_o(12.07)$

$T_o = 1000/12.07$

$T_o = 828.5\ lb.in$

$\tau_{max} = \frac{J_{CDC}}{J_{CD}} = 10000psi = \frac{2.8\ T_o(0.5in)}{\pi/2\ (0.5in)^4}$

$10000psi = 14.26\ T_o$

$T_o = 701.2\ lb\text{-}in$

Step #4

Find the corresponding angle of twist for each shaft and the net regular rotation of end A.

$$\phi A/B = \frac{T_{AB} L}{J_{AB} G} = \frac{(701.2)(24)}{\pi/2\,(0.375)(14\times10^6)} = 0.0386 \text{ rad} = 2.21^\circ$$

$$\phi C/D = \frac{T_{CD} L}{J_{CD} G} = \frac{2.8(701.24)(24)}{\pi/2\,(0.5)^4\,(14\times10^6)} = 0.0342 \text{ rad}$$

$$1.95^\circ$$

$$\phi B = 2.8\,\phi C = 2.8\,(1.95) = 5.46^\circ$$

$$\phi A = \phi B + \phi A/B = 2.21 + 5.46 = \boxed{7.67^\circ}$$

Q. NO 4: Solution:

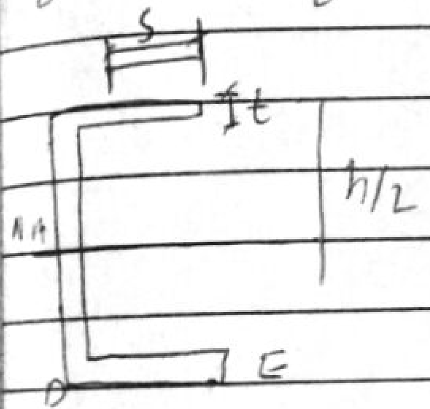
given Data:

$b = 4in$

$h = 6in$

$t = 0.15in$

$V = 3\ kips$



$e = Fh/I$

where

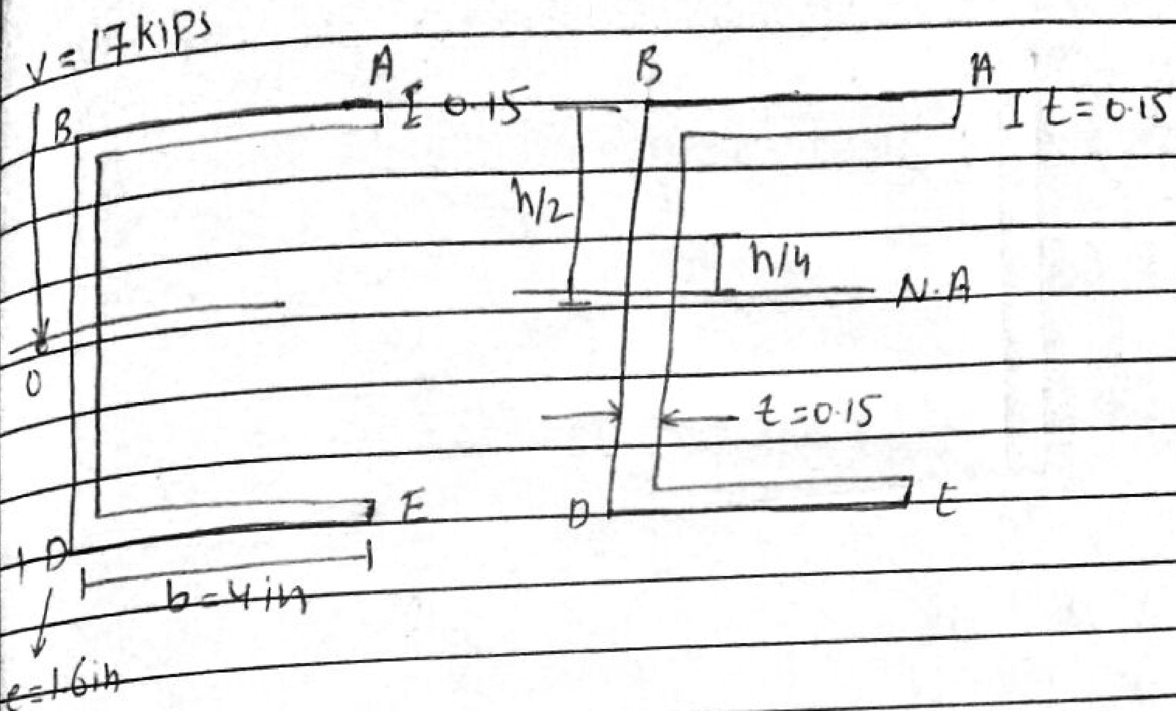
$$F = \int_0^b q\,ds = \int_0^b \frac{VQ}{I}\,ds = \frac{V}{I}\int_0^b st\,h/2\,ds$$

$$= \frac{Vthb^2}{4I}$$

$$I = I_{web} + 2I_{flange} = \frac{1}{12}th^3 + 2\left[\frac{1}{12}bt^3 + bt\left(h/2\right)^2\right]$$

$$\simeq \frac{1}{12}th^2(6b+h)$$

$$e = \frac{b}{2 + h/3b} = \frac{4in.}{2 + \frac{6in}{3(4)}} = \boxed{1.6\ in}$$



solution:

* Determin the stress distribution for = V = 17 kips.

* Shearing stresses in the flange.

$$\tau = VQ/It = \frac{V}{It}(st)\,h/2 = \frac{Vh}{2I}s$$

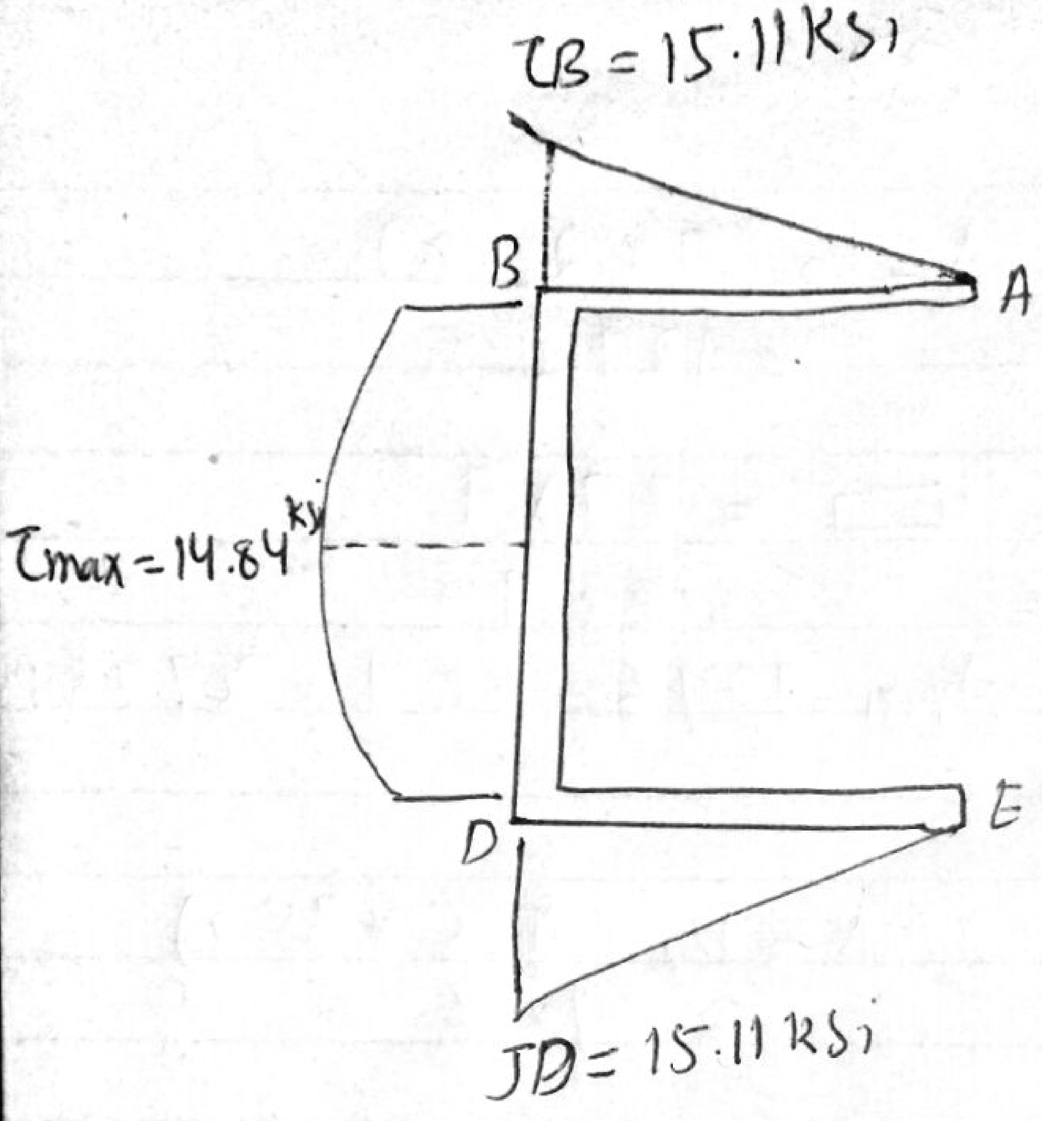
$$\tau_B = \frac{Vhb}{2(1/12\,th^2)(6b+h)} = \frac{6Vb}{th(6b+h)} = \frac{6(17)(4)}{(0.15)(6)(6*4+6in)}$$

$= \boxed{15.11\ ksi}$

* Shearing stress in the web.

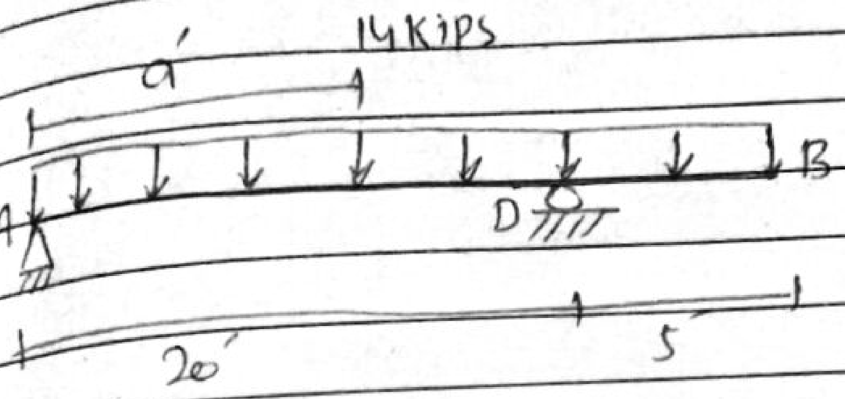
$$\tau_{max} = \frac{VQ}{It} = \frac{V(1/8\,ht)(4b+h)}{1/12\,th^2(6b+h)t} = \frac{3V(4b+h)}{2th(6b+h)}$$

$$= \frac{3(17\ kips)(4*4in+6in)}{2(0.15in)(6in)(6\times 6in+6in)} = \boxed{14.84\ ksi}$$



τB = 15.11 ksi
B
A
τmax = 14.84 ksi
D
E
τD = 15.11 ksi

Q. No(05). ①



a) Determine the reactions at A and D.

first we draw its free body Diagram.

$\Sigma f_x = 0$

$A_x = 0$

$\Sigma F_y = 0 \uparrow^{+}$

$A_y + D_y = 14 + 80 = 94$ kips.

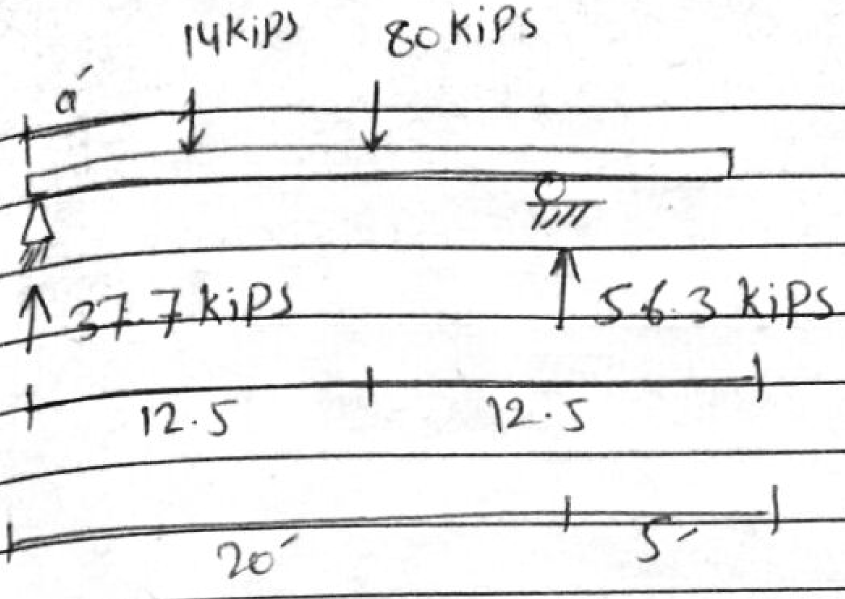
$\Sigma M_D = 0$ $+\circlearrowright$

$A_y(20) - 14(11) - 80(7.5) = 0$

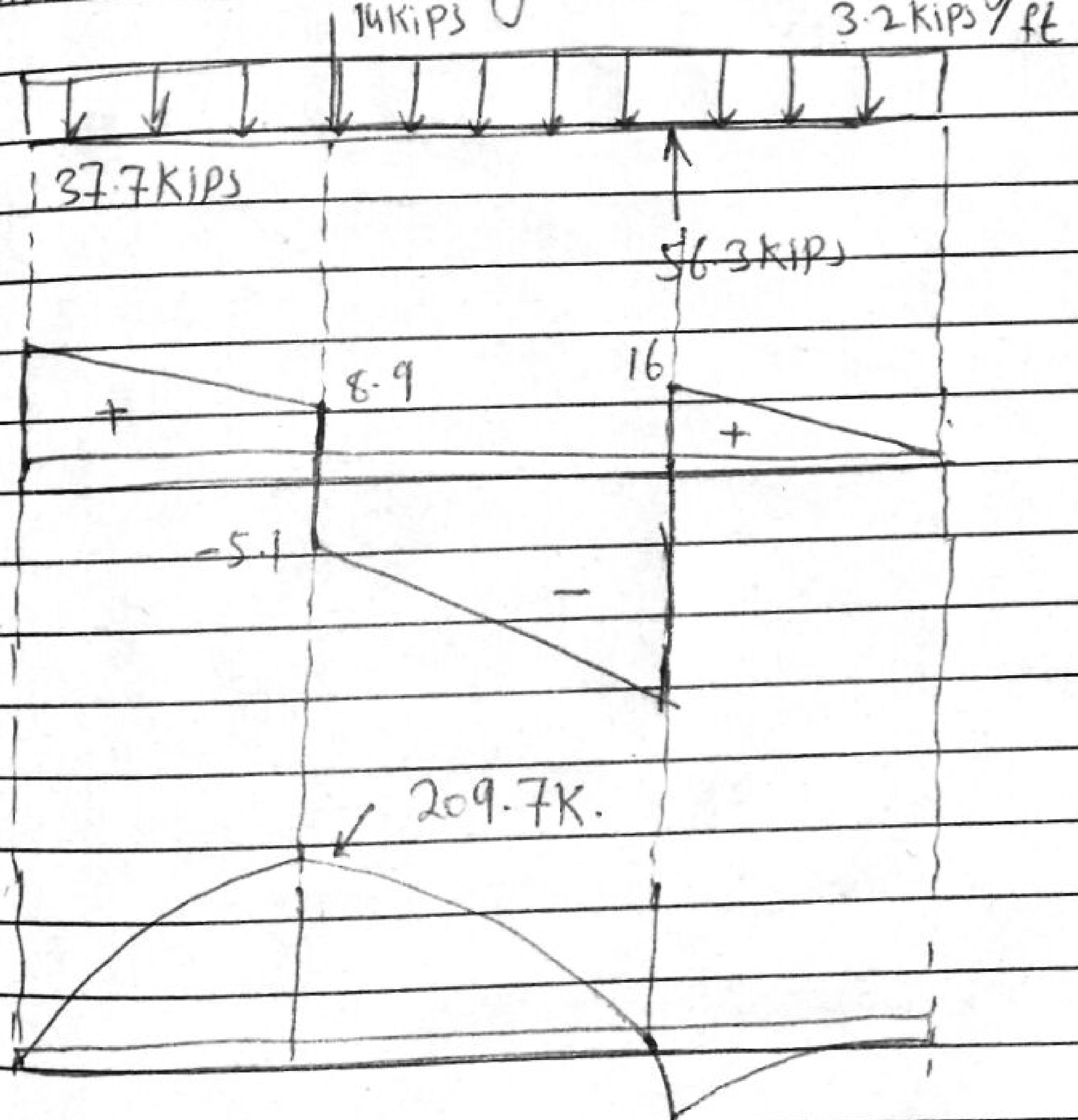
$20 A_y = 154 + 600$

$20 A_y = 754$ $\boxed{A_y = 37.7 \text{ kips}}$ $\Rightarrow$ $\boxed{B = 56.3}$

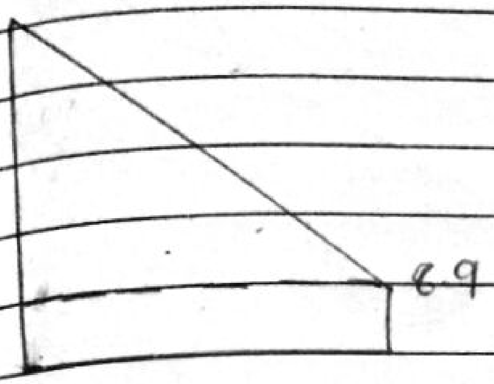
②



b) Shear and Bending Moment diagram.



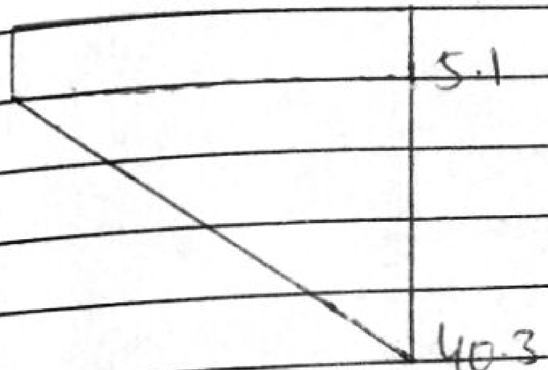
(3)



$\Delta = 1/2 (9 \times 28.8)$
$= 129.6$

$\square = 8.9 \times 9$
$= 80.1$

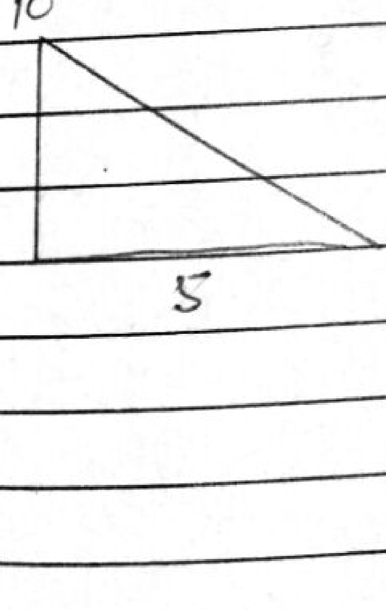
Area $= 129.6 + 80.1 = 209.7$ kips



$\Delta = 1/2 (8.5 * 35.2)$
$= 193.6$

$\square = 5.1 * 11$
$= 56.1$

Area $= 193.6 + 56.1 = 249.7$



$= 1/2 (5 \times 16)$

$= 40$

Q. No (5) ④

Now the maximum and bending moment is:

From Diagram:

$|M|_{max}$ = 209.7 kips - inch with v = 8.9k
$M|_{max}$ = 40.3 kips

(Part c)

Calculate required section modulus and select appropriate beam section.

Given that:

$\sigma_{all} = 14 + 4 = 18$ ksi

$\tau_{all} = 14 + 1 = 15$ ksi

By using formula

$$S_{min} = \frac{|M|_{max}}{\sigma_{all}} = \frac{209.7 \times 12}{18} = 139.8 \, in^3$$

Select. **W 18 X 76.**