Instructor's Manual *to Accompany*

Statics and Strength of Materials

For Architecture and Building Construction

Third Edition

Barry Onouye
Kevin Kane

Preface

This *Instructor's Manual* to accompany *Statics and Strength of Materials for Architecture and Building Construction*, was initially developed as a study guide for students taking my beginning structures classes. All of the problems were developed in sufficient detail to allow students to use these problems as additional examples, paralleling the content covered in the text. In the 3rd edition of *Statics and Strength of Materials for Architecture and Building Construction*, a CD is provided with approximately 250 additional problems and solutions for practice.

Although all of the problems have been worked and reworked and scrutinized very closely by many of the students over the years, errors are still inevitable. Alternate interpretations of certain problems are also quite possible. If you discover discrepancies and/or errors, please bring them to my attention. I appreciate hearing from you so that I will be able to incorporate the corrections in future editions. My e-mail address is:
barryo@u.washington.edu.

I hope that you find this *Instructor's Manual* helpful and feel free to allow students access to these problem solutions.

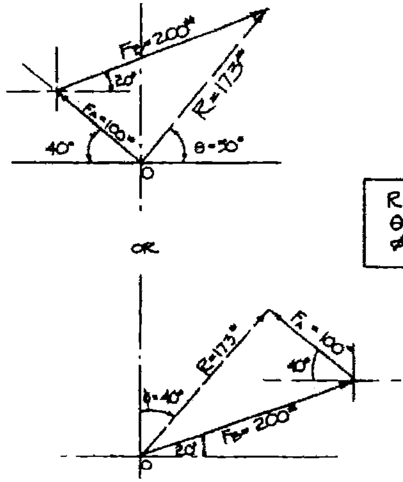
March 2006

Barry Onouye
University of Washington

Contents

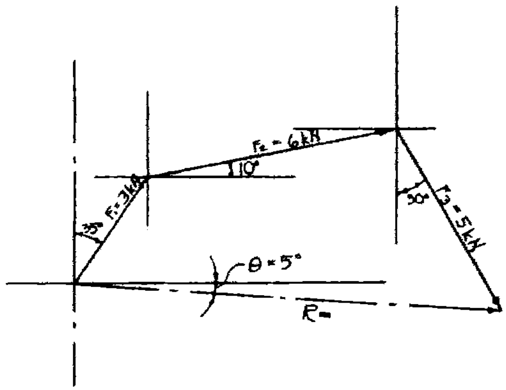
Solutions to Chapter Problems:

2.1



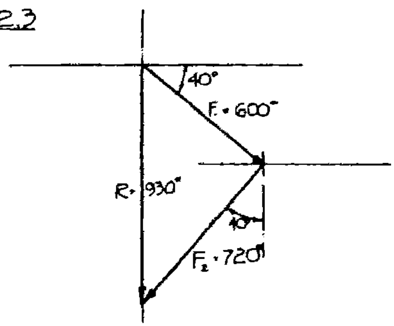
R = 173#
θ = 50° FROM HORIZ.
φ = 40° FROM VERT.

2.2

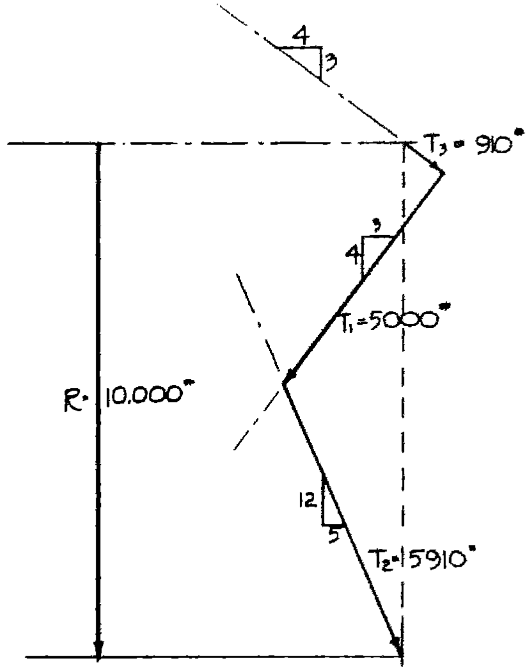


R = 10.2 kN
θ = 5°

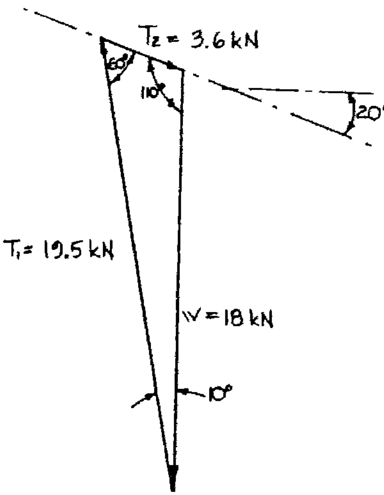
2.3



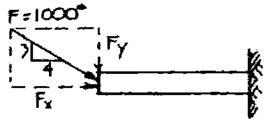
2.4


4
3
$T_3 = 910^{\#}$
3
4
$T_1 = 5000^{\#}$
$R = 10,000^{\#}$
12
5
$T_2 = 5910^{\#}$

2.5


$T_2 = 3.6$ kN
60°
110°
20°
$T_1 = 19.5$ kN
$W = 18$ kN
10°

2.6

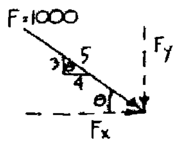


BY SIMILAR TRIANGLES:

$$\frac{F_x}{4} = \frac{F_y}{3} = \frac{F}{5}$$

$$\therefore\ F_x = \tfrac{4}{5}F = \tfrac{4}{5}(1000) = \underline{800^{\#}}$$

$$F_y = \tfrac{3}{5}F = \tfrac{3}{5}(1000) = \underline{600^{\#}}$$



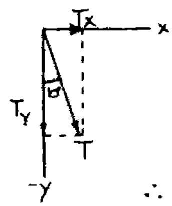
$$\sin\theta = \tfrac{3}{5}$$

$$\cos\theta = \tfrac{4}{5}$$

$$\therefore\ F_x = F\cos\theta = (1000^{\#})(\tfrac{4}{5}) = \underline{800^{\#}}$$

$$F_y = F\sin\theta = (1000^{\#})(\tfrac{3}{5}) = \underline{600^{\#}}$$

2.7



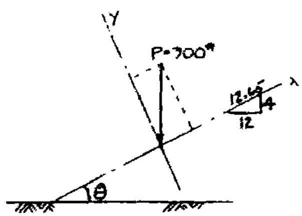
$$T_x = T\sin 10^\circ$$

$$T_y = T\cos 10^\circ$$

$$\therefore\ T = \frac{T_y}{\cos 10^\circ}$$

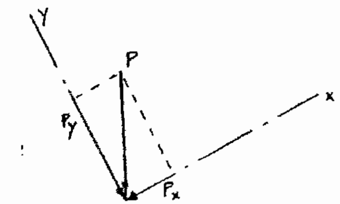
$$T = \frac{250\,N}{.985} = \underline{254\,N}$$

2.8



$$\theta = \tan^{-1}\left(\tfrac{4}{12}\right) = 18.43^\circ$$

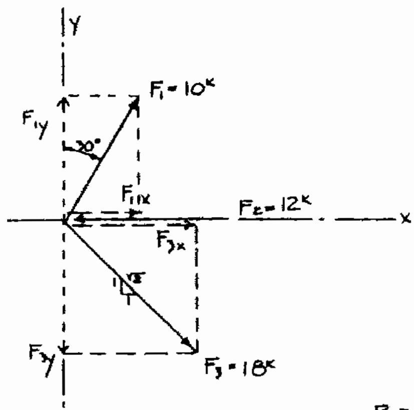
2.8



$$P_x = P\left(\frac{4}{12.65}\right) = 300^{\#}(.316 = \underline{\underline{94.9^{\#}}}$$

$$P_y = P\left(\frac{12}{12.65}\right) = 300^{\#}(.949) = \underline{\underline{285^{\#}}}$$

2.9



$$F_{1Y} = +F_1 \cos 30° = 10^K(.866) = 8.66^K$$

$$F_{1x} = +F_1 \sin 30° = 10^K(.5) = 5^K$$

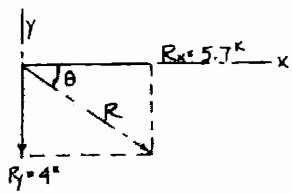
$$F_2 = -F_{2x} = -12^K$$

$$F_{3x} = +\frac{1}{\sqrt{2}} F_3 = +\frac{18^K}{\sqrt{2}}$$

$$F_{3y} = -\frac{1}{\sqrt{2}} F_3 = \frac{-18^K}{\sqrt{2}}$$

$$R_x = \Sigma F_x = +5.0^K - 12^K + \frac{18^K}{\sqrt{2}} = +5.7^K$$

$$R_Y = \Sigma F_Y = +8.66^K - \frac{18^K}{\sqrt{2}} = -4^K$$

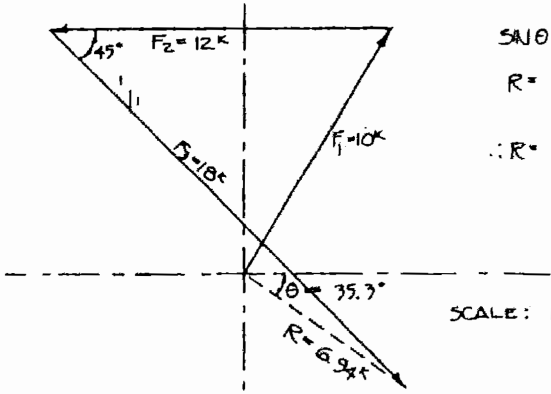


$$\tan\theta = \frac{R_Y}{R_x} = \frac{4}{5.7} = .702$$

$$\theta = \tan^{-1}(.702)$$

$$\therefore\ \theta = 35.1° \text{ FROM HORIZ.}$$

2.9



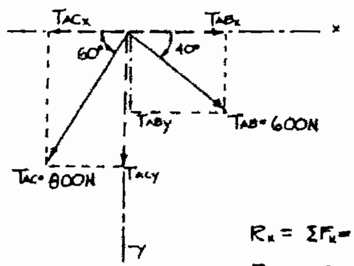
$$\sin\theta = \frac{R_y}{R}$$

$$R = \frac{R_y}{\sin\theta}$$

$$\therefore R = \frac{4^K}{.577} = \underline{\underline{6.94^K}}$$

SCALE: 1" = 4K

2.10



$$-T_{AC_x} = -T_{AC}\cos 60° = -.5\,T_{AC}$$

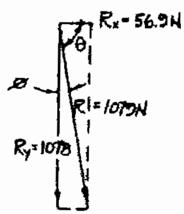
$$-T_{AC_y} = -T_{AC}\sin 60° = -.866\,T_{AC}$$

$$+T_{AB_x} = +T_{AB}\cos 40° = +.766\,T_{AB}$$

$$-T_{AB_y} = -T_{AB}\sin 40° = -.642\,T_{AB}$$

$$R_x = \Sigma F_x = -.5(800N) + .766(600N) = 56.9\text{ N}$$

$$R_y = \Sigma F_y = -.866(800N) - .642(600N) = -1078\text{N}$$

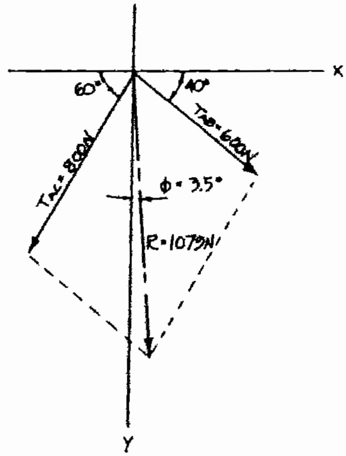


$$\theta = \tan^{-1}\left(\frac{1078}{56.9}\right) = \tan^{-1}(18.1) = 86.8°$$

$$\phi = \tan^{-1}\left(\frac{57.6}{1078}\right) = \tan^{-1}(.076) = 3.2°$$

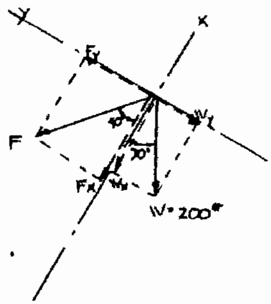
$$R = \sqrt{59.6^2 + 1078^2} = 1079\text{ N.}$$

2.10



SCALE: 1mm = 10N

2.11



ROTATE AXIS SO THAT THE RESULTANT THRU THE BOOM AXIS LIES ON THE X - AXIS.

THEN, $R_y = \Sigma F_y = 0$

$-W_x = -W \cos 30° = -.866W$

$-W_y = -W \sin 30° = -.5W$

$-F_x = -F \cos 40° = -.766F$

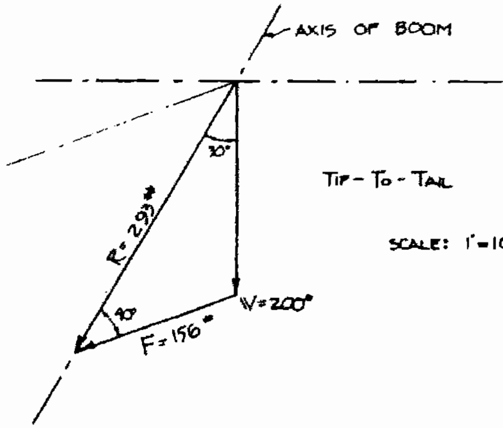
$+F_y = +F \sin 40° = +.642F$

$R_y = \Sigma F_y = 0 \qquad -.5(200^{\#}) + .642F = 0$

SOLVE FOR F; $\quad F = \dfrac{100^{\#}}{.642} = \underline{156^{\#}}$

$R = R_x = \Sigma F_x = -.866(200^{\#}) - .766(156^{\#}) = -173^{\#} - 120^{\#} = \underline{-293^{\#}}$

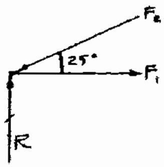
2.11



TIP - TO - TAIL

SCALE: 1" = 100#

2.12



$$-F_{2x} = -F_2 \cos 25°$$
$$-F_{2y} = -F_2 \sin 25°$$

SINCE THE RESULTANT MUST BE VERTICAL, THEN: $R_x = \Sigma F_x = 0$

$$-F_{2x} + F_1 = 0$$
$$\therefore \quad F_2 \cos 25° = F_1$$

FROM THIS EQUATION, IT IS SEEN THAT F_1 IS ONLY A FRACTION OF F_2, THEREFORE, $F_2 = 7\text{ kN}$

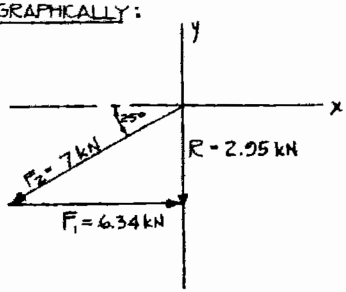
THEN; $F_1 = F_2 \cos 25° = 7\text{ kN}\,(.906)$

$$\underline{F_1 = 6.34\text{ kN}}$$

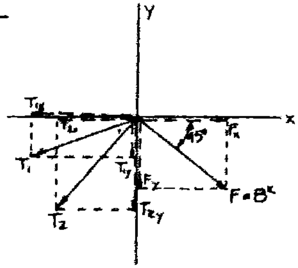
$$\underline{F_2 = 7\text{ kN}}$$

$$R = F_{2y} = 7\text{ kN}\,(\sin 25°)$$
$$R = 7\text{kN}\,(.422) = 2.95\text{ kN}$$

GRAPHICALLY:



2.13



$-T_{1x} = -T_1 \cos 30° = -.866 T_1$
$-T_{1y} = -T_1 \sin 30° = -.5 T_1$

$-T_{2x} = -T_2 \cos 60° = -.5 T_2$
$-T_{2y} = -T_2 \sin 60° = -.866 T_2$

$+F_x = +F \cos 45° = +.707(8) = +5.65^k$
$-F_y = -F \sin 45° = -.707(8) = -5.65^k$

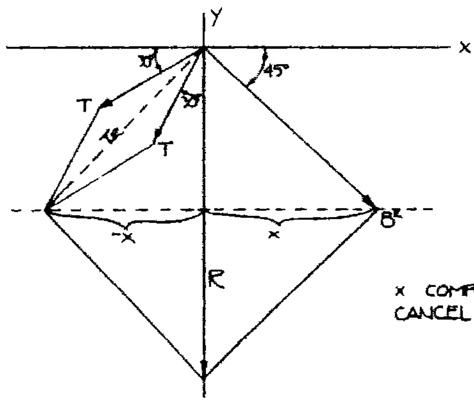
BUT $T_1 = T_2$

FOR RESULTANT TO BE VERTICAL, $R_x = \Sigma F_x = 0$

$\therefore -.866T - .5T + 5.65^k = 0$

SOLVING FOR T; $\underline{T = 4.14^k}$

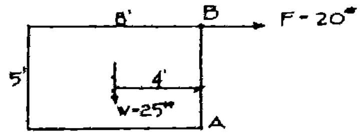
$R = R_y = \Sigma F_y = -.5(4.14^k) - .866(4.14^k) - 5.65^k = \underline{-11.3^k}$



x COMPONENTS MUST CANCEL SO THAT $R_x = 0$

USING PARALLELOGRAM LAW

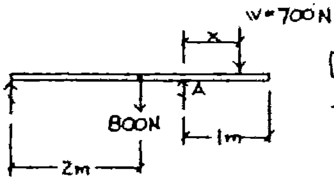
2.14



$M_A = -20^{\#}(5') + 25^{\#}(4') = -100^{\#\text{-}'} + 100^{\#\text{-}'} = \underline{0}$

BOX IS JUST ON THE VERGE OF TIPPING OVER.

2.15



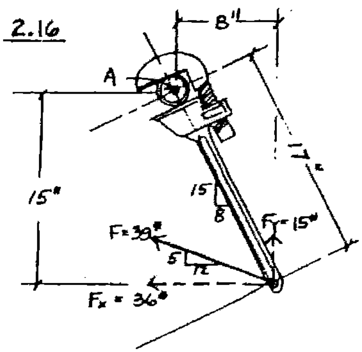
$[\Sigma M_A = 0]$

$+800\,N(1m) - 700\,N(x) = 0$

$x = \dfrac{(800N)(1m)}{700N} = \underline{\underline{1.14\,m}}$

Since $x > 1m$, man is OK.

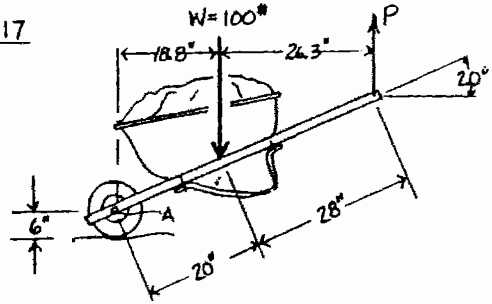
2.16



$\Sigma M_A = -36^{\#}(15") + 15^{\#}(8")$

$M_A = -540^{\#\text{-in}} + 120^{\#\text{-in}} = \underline{-420^{\#\text{-in}}}$

2.17

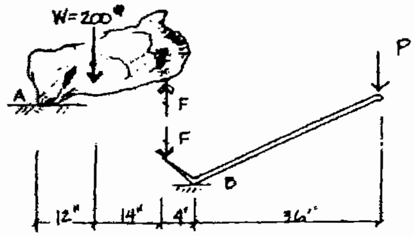


$\Sigma M_A = -W(18.8") = -100^{\#}(18.8") = \underline{-1880^{\#\text{-in}}}$ (clockwise)

$[\Sigma M_A = 0] \quad -100^{\#}(18.8") + P(45.1") = 0$

$$P = \frac{1880^{\#\text{-in}}}{45.1\text{ in}} = \underline{41.7^{\#}}$$

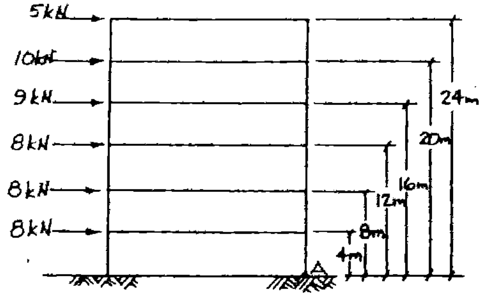
2.18



$[\Sigma M_A = 0] \quad -200^{\#} \times 12" + F(26") = 0; \quad \therefore \underline{F = 92.3^{\#}}$

$[\Sigma M_B = 0] \quad +F(4") - P(36") = 0; \quad \therefore \underline{\underline{P = 10.3^{\#}}}$

2.19

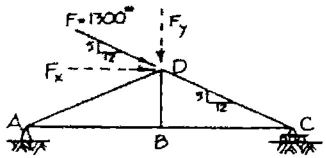


$M_A = -5kN(24m) - 10kN(20m) - 9kN(16m) - 8kN(12m) - 8kN(8m) - 8kN(4m)$

$M_A = -120\ kN\text{-}m - 200\ kN\text{-}m - 144\ kN\text{-}m - 96\ kN\text{-}m - 64\ kN\text{-}m - 32\ kN\text{-}m$

$M_A = \underline{\underline{-656\ kN\text{-}m}}$

2.20



$F_x = \frac{12}{13}(1300^{\#}) = 1200^{\#}$

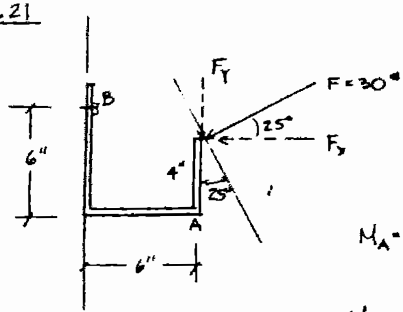
$F_y = \frac{5}{13}(1300^{\#}) = 500^{\#}$

$M_B = -F_x(5') + F_y(0) = -1200^{\#}(5') = \underline{-6000^{\#\text{-}'}}$

$M_C = -F_x(5') + F_y(12') = -1200^{\#}(5') + 500^{\#}(12')$

$M_C = -6000^{\#\text{-}'} + 6000^{\#\text{-}'} = \underline{0}$

2.21



$F_x = F\cos 25° = (30^{\#})(.906) = 27.2^{\#}$

$F_Y = F\sin 25° = (30^{\#})(.423) = 12.7^{\#}$

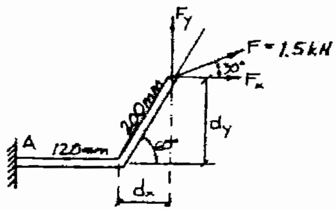
$M_A = +F_x(4") = 27.2^{\#}(4") = \underline{108.8^{\#\text{-}"}}$

$M_B = -F_Y(6") - F_x(2")$

$M_B = -12.7^{\#}(6") - 27.2^{\#}(2")$

$M_B = -76.2^{\#\text{-}"} - 54.4^{\#\text{-}"} = \underline{-130.6^{\#\text{-}"}}$

2.22



$F_x = F\cos 30° = 1.5kN(.866) = 1.3kN$

$F_Y = F\sin 30° = 1.5kN(.50) = 0.75kN$

$d_x = d\cos 60° = 200(.50) = 100mm$

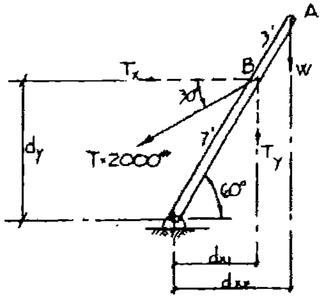
$d_y = d\sin 60° = 200(.866) = 173mm$

$M_A = -F_x(d_Y) + F_Y(120mm + d_x)$

$M_A = -1.3kN(173mm) + 0.75kN(120mm + 100mm)$

$M_A = -225\,kN\text{-}mm + 165\,kN\text{-}mm = \underline{-60kN\text{-}mm} = \underline{-0.06\,kN\text{-}m}$

2.23



$$T_x = T\cos 30° = 2000^{\#}(.866) = 1732^{\#}$$

$$T_y = T\sin 30° = 2000^{\#}(.50) = 1000^{\#}$$

$$d_{x_1} = 7'\cos 60° = 7'(.50) = 3.5'$$

$$d_{x_2} = 10'(.50) = 5'$$

$$d_y = 7'\sin 60° = 7'(.866) = 6.06'$$

$$[\Sigma M_c = 0] \quad +T_x(d_y) - T_y(d_{x_1}) - W(d_{x_2}) = 0$$

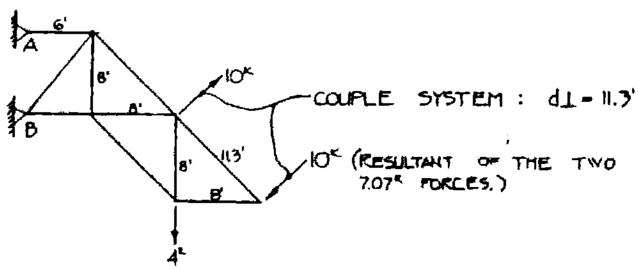
$$+1732^{\#}(6.06') - 1000(3.5') - W(5') = 0$$

$$5W = 10{,}500^{\#\text{-}'} - 3{,}500^{\#\text{-}'}$$

$$W = \frac{7000^{\#\text{-}'}}{5'}$$

$$\boxed{W = 1400^{\#}}$$

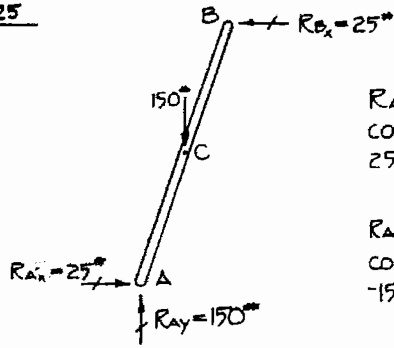
2.24



$$M_A = -(10^K)(11.3) - 4^K(14') = -113^{K\text{-}'} - 56^{K\text{-}'} = \underline{\underline{-169^{K\text{-}'}}}$$

$$M_B = -10^K(11.3') - 4^K(14') = \underline{\underline{-169^{K\text{-}'}}}$$

2.25



R_{A_x} & R_{B_x} CONSTITUTE A COUPLE SYSTEM.

$25^{\#}(12') = +300^{\#-'}$ COUNTER CLOCKWISE

R_{Ay} & THE 150# MAN AT C ALSO CONSTITUTE A COUPLE SYSTEM.

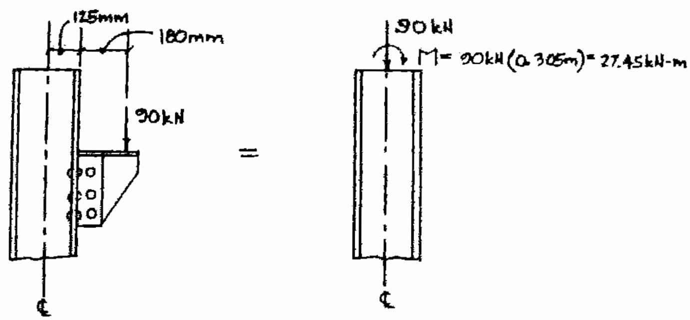
$-150^{\#}(2') = -300^{\#-'}$ CLOCKWISE

SINCE THE MOMENT OF A COUPLE SYSTEM IS A CONSTANT,

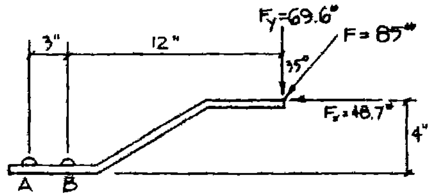
$$M_A = M_B = M_C$$

WHICH FOR THIS PROBLEM: $+300^{\#-'} - 300^{\#-'} = \underline{0}$

2.26 :



2.27

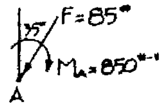


RESOLVING F INTO x- & y- COMPONENTS

$F_x = F \sin 35° = 85^{\#}(.573) = 48.7^{\#}$

$F_y = F \cos 35° = 85^{\#}(.819) = 69.6^{\#}$

@ A :

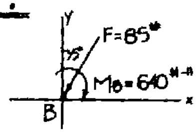


$M_A = -F_y(15") + F_x(4")$

$M_A = -69.6(15) + 48.7(4) = -1045 + 195$

$\underline{M_A = -850^{\#-"}}$

@ B :

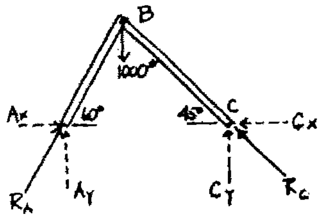


$M_B = -F_y(12") + F_x(4")$

$M_B = -69.6(12) + 195 = -835 + 195$

$\underline{M_B = -640^{\#-"}}$

2.28

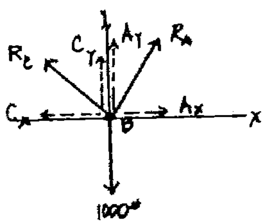


$A_x = A \cos 60° = .5A$

$A_Y = A \sin 60° = .866A$

$C_x = C \cos 45° = .707C$

$C_Y = C \sin 45° = .707C$



$[\Sigma F_x = 0] \quad -C_x + A_x = 0$

$-.707C + .5A = 0$

$C = \frac{.5A}{.707} = .707A$

$[\Sigma F_Y = 0] \quad +C_Y + A_Y - 1000^{\#} = 0$

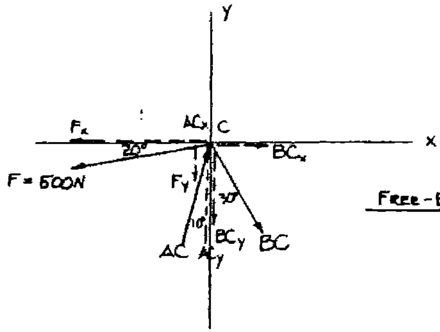
$.707(.707A) + .866A = 1000^{\#}$

$\therefore 1.37A = 1{,}000^{\#}$

$\underline{A = 732^{\#}}$

$\therefore C = .707(732^{\#}) = \underline{518^{\#}}$

2.29



FREE-BODY DIAGRAM

FORCE	MAGNITUDE	F_x	F_y
F	500 N	$-500N\cos 20° = -470N$	$-500N \sin 20° = -171N$
AC	?	$+AC \sin 10° = +.174AC$	$+AC\cos 10° = +.984\,AC$
BC	?	$+BC \sin 30° = +.5\,BC$	$-BC\cos 30° = -.866\,BC$

$[\Sigma F_x = 0]$ $\quad -470N + .174\,AC + .5\,BC = 0 \quad \ldots\ldots (1)$

$[\Sigma F_y = 0]$ $\quad -171N + .984\,AC - .866BC = 0 \quad \ldots\ldots (2)$

SOLVING EQUATIONS (1) AND (2) SIMULTANEOUSLY,

$.866 \times [.5BC + .174\,AC = 470N]; \quad .433BC + .15\,AC = 407\,N$

$.50 \times [-.866BC + .984\,AC = 171N]; \quad \underline{-.433BC + .492AC = 86N}$

$+.642\,AC = 493N$

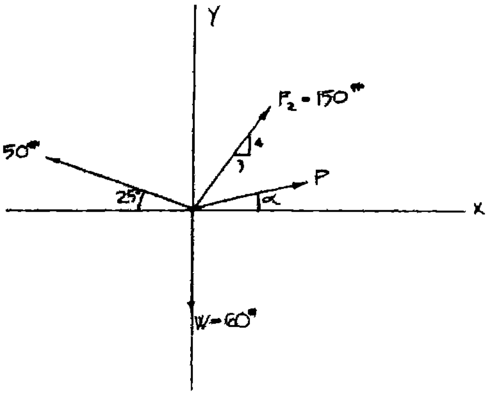
$\underline{\underline{AC = +768N}}$ (COMPRESSION ELEMENT)

(1) $\quad .5BC + .174(768N) = 470N$

$.5BC = 470N - 134N = 336N$

$\underline{\underline{BC = 672N}}$ (TENSION ELEMENT)

2:30



FORCE	MAG.	F_x	F_y
F_1	$50^{\#}$	$-50^{\#}\cos 25° = -50^{\#}(.906) = -45.3^{\#}$	$+50^{\#}\sin 25° = +50^{\#}(.422) = +21.1^{\#}$
F_2	$150^{\#}$	$+150^{\#}(3/5) = +90^{\#}$	$+150^{\#}(4/5) = +120^{\#}$
W	$60^{\#}$	0	$-60^{\#}$
P	?	$+P\cos\alpha$	$+P\sin\alpha$

$[\Sigma F_x = 0] \quad -45.3^{\#} + 90^{\#} + P\cos\alpha = 0 \quad \ldots\ldots (1)$

$[\Sigma F_y = 0] \quad +21.1^{\#} + 120^{\#} - 60^{\#} + P\sin\alpha = 0 \quad \ldots (2)$

(1) $P\cos\alpha = -44.7^{\#}$

(2) $P\sin\alpha = -81.1^{\#}$

(1) $P = \dfrac{-44.7^{\#}}{\cos\alpha}$; (2) $P = \dfrac{-81.1^{\#}}{\sin\alpha}$

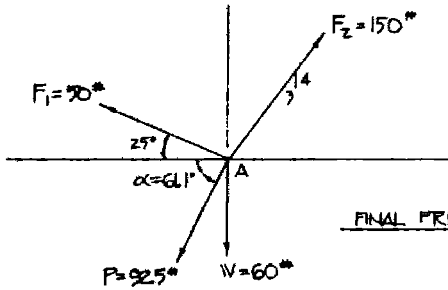
EQUATING: $\dfrac{-44.7^{\#}}{\cos\alpha} = \dfrac{-81.1^{\#}}{\sin\alpha}$; $\dfrac{\sin\alpha}{\cos\alpha} = \dfrac{-81.1}{-44.7} = +1.81$

$\dfrac{\sin\alpha}{\cos\alpha} = \tan\alpha = 1.81$; $\alpha = \tan^{-1}(1.81) = \underline{\underline{61.1°}}$

2:30 (CONT'D.)

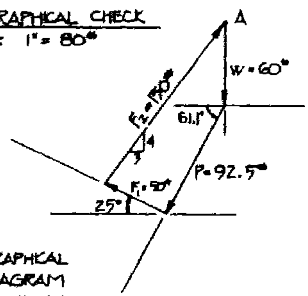
$$P = \frac{-44.7^{\#}}{\cos 61.1^\circ} = \frac{-44.7^{\#}}{0.483} = \underline{\underline{-92.5^{\#}}}$$

NOTE THE NEGATIVE SIGN FOR P. NEGATIVE SIGN INDICATES THE P IS ASSUMED IN THE WRONG DIRECTION.



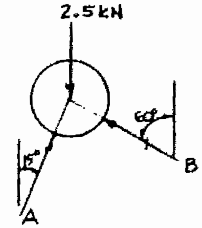
FINAL FREE BODY DIAGRAM

GRAPHICAL CHECK
SCALE: 1" = 80#



BY STARTING THE GRAPHICAL ANALYSIS AT A, THE DIAGRAM SHOULD RETURN TO A WITH THE DRAWING OF THE LAST FORCE.

2.31



FBD OF SPHERE

$[\Sigma F_x = 0]$ $A \sin 15^\circ - B \sin 60^\circ = 0$

$$A = \frac{B(.866)}{.259} = 3.346\,B$$

$[\Sigma F_y = 0]$ $A \cos 15^\circ + B \cos 60^\circ - 2.5\,\text{kN} = 0$

$$3.346\,B(.966) + .50\,B = 2.5\,\text{kN}$$

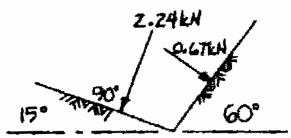
$$3.732\,B = 2.5\,\text{kN}$$

FORCES ON THE SPHERE

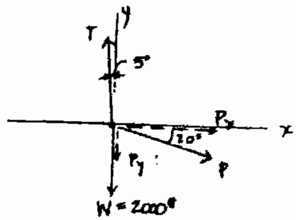
$\underline{B = 0.67\,\text{kN}}$

$\underline{A = 2.24\,\text{kN}}$

FORCES THE SPHERE EXERTS ON THE SMOOTH SURFACE.



2.32



$T_y = T\cos 5° = .996T$

$T_x = T\sin 5° = .087T$

$P_x = P\cos 20° = .940P$

$P_y = P\sin 20° = .342P$

$[\Sigma F_x = 0]\quad -.087T + .94P = 0$

$$T = \frac{.94P}{.087} = 10.8P$$

$[\Sigma F_y = 0]\quad +.996T - .342P - 2000^{\#} = 0$

Subsituting ;

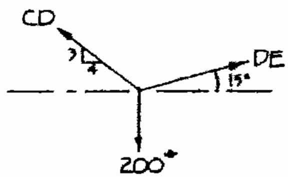
$.996(10.8P) - .342P = 2000^{\#}$

$(10.76 - .34)P = 2000^{\#}$

$\underline{P = 192^{\#}}$

$AB = T = 10.8(192^{\#}) = \underline{2074^{\#}}$

2.33



FBD AT JOINT 'D'

$\Sigma F_x = DE\cos 15° - \frac{4}{5}(CD) = 0$

$DE(.966) = \frac{4}{5}CD$

$\underline{\underline{DE = .828\,CD}}$

$\Sigma F_y = \frac{3}{5}CD + DE\sin 15° - 200^{\#} = 0$

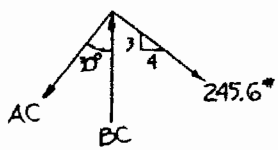
$\frac{3}{5}CD + .828CD\sin 15° - 200^{\#} = 0$

$\frac{3}{5}CD + .828CD(.259) = 200^{\#}$

$.6CD + .214CD = 200^{\#}$

$\underline{\underline{CD = 245.6^{\#}}}$ TENSION

$\underline{\underline{DE = 203.4^{\#}}}$ TENSION



FBD AT JOINT 'C'

$\Sigma F_x = AC\sin 30° - \frac{4}{5}(245.6^{\#}) = 0$

$AC\sin 30° = 196.5^{\#}$

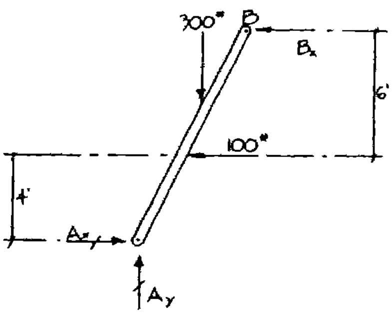
$\underline{\underline{AC = 392.9^{\#}}}$ TENSION

$\Sigma F_y = BC - 392.9^{\#}\cos 30° - 245.6^{\#}(\frac{3}{5}) = 0$

$BC - 340.3 - 147.4 = 0$

$\underline{\underline{BC = 487.7^{\#}}}$ COMPRESSION

2.34



$[\Sigma M_A = 0] \quad +100^{\#}(4') - 300^{\#}(3') + B_x(10') = 0$

$\underline{\underline{B_x = +50^{\#}}}$

$[\Sigma F_x = 0] \quad +A_x - 100^{\#} - B_x = 0$

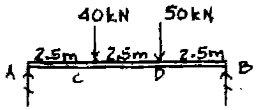
$+A_x - 100^{\#} - 50^{\#} = 0$

$\underline{\underline{A_x = +150^{\#}}}$

$[\Sigma F_y = 0] \quad +A_y - 300^{\#} = 0$

$\underline{\underline{A_y = +300^{\#}}}$

2.35



$[\Sigma M_A = 0] \quad -40\,kN(2.5m) - 50\,kN(5.0m) + B_y(7.5m) = 0$

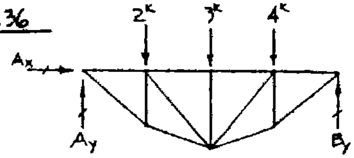
$\underline{\underline{B = 46.67\,kN}}$

$[\Sigma F_y = 0] \quad +A - 40kN - 50kN + 46.67kN = 0$

$\underline{\underline{A = 43.33\,kN}}$

No horizontal reaction necessary for this load case.

2.36



$[\Sigma F_x = 0]$ $\quad \underline{\underline{A_x = 0}}$ (NO FORCE TO BALANCE A_x, THEREFORE A_x MUST BE EQUAL TO ZERO.)

$[\Sigma M_A = 0]$ $\quad -2^k(20') - 3^k(40') - 4^k(60') + B_y(80') = 0$

$$B_y = \frac{40^{k-'} + 120^{k-'} + 240^{k-'}}{80'}$$

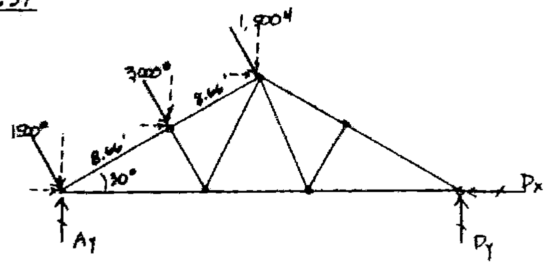
$$\underline{\underline{B_y = +5^k}}$$

$[\Sigma M_B = 0]$ $\quad +4^k(20') + 3^k(40') + 2^k(60') - A_y(80') = 0$

$$A_y = \frac{80^{k-'} + 120^{k-'} + 120^{k-'}}{80'}$$

$$\underline{\underline{A_y = +4^k}}$$

2.37



$[\Sigma M_A = 0]$ $\quad -1500^{\#}(17.33') - 3{,}000^{\#}(8.66') + D_y(30') = 0$

$$\underline{D_y = 1733^{\#}}$$

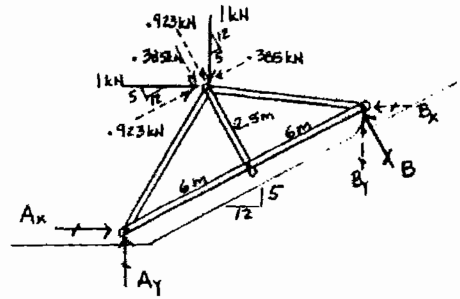
$[\Sigma F_y = 0]$ $\quad -1500^{\#}\cos 30° - 3000^{\#}\cos 30° - 1500^{\#}\cos 30° + A_y + 1733^{\#} = 0$

$$\underline{A_y = 3463^{\#}}$$

$[\Sigma F_x = 0]$ $\quad +1500\sin 30° + 3000^{\#}\sin 30° + 1500^{\#}\sin 30° - D_x = 0$

$$\underline{D_x = 3000^{\#}}$$

2.38



$\frac{5}{13}(1\,kN) = 0.385\,kN$

$\frac{12}{13}(1\,kN) = 0.923\,kN$

$[\Sigma M_A = 0]$ $+B(12m) - .923\,kN(2.5m) + .385\,kN(2.5m) - (.385\,kN + .923\,kN)(6m) = 0$

Solving for B; $\underline{B = 0.767\,kN}$, $B_x = \frac{5}{13}(.767\,kN) = 0.295\,kN$

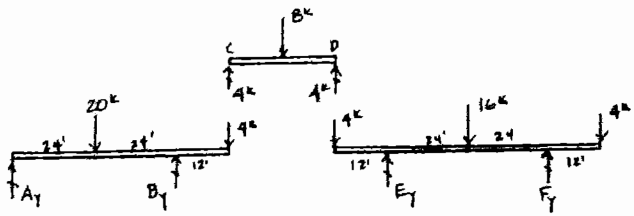
$B_Y = \frac{12}{13}(.767\,kN) = 0.707\,kN$

Reverting back to the unresolved forces:

$[\Sigma F_x = 0]$ $+A_x + 1\,kN - \underset{(B_x)}{.295\,kN} = 0$; $\therefore \underline{A_x = 0.705\,kN}$

$[\Sigma F_Y = 0]$ $+A_Y - 1\,kN + \underset{(B_Y)}{.707\,kN} = 0$; $\underline{A_Y = +0.293\,kN}$

2.39



$[\Sigma M_A = 0]$ $-20^k(24') - 4^k(60') - B_Y(48') = 0$

$\underline{B_Y = 15^k}$

$[\Sigma F_Y = 0]$ $+A_Y - 20^k + 15^k - 4^k = 0$

$\underline{A_Y = 9^k}$

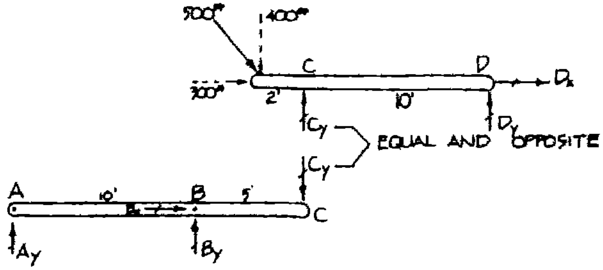
$[\Sigma M_E = 0]$ $+4^k(12') - 16^k(24') + F_Y(48') - 4^k(60') = 0$

$\underline{F_Y = 12^k}$

$[\Sigma F_Y = 0]$ $-4^k + E_Y - 16^k + 12^k - 4^k = 0$

$\underline{E_Y = 12^k}$

2.40



FREE BODY DIAGRAM

UPPER BEAM:

$$[\Sigma M_D = 0] \quad +400^{\#}(12') - C_y(10') = 0$$

$$\underline{\underline{C_y = +480^{\#}}}$$

$$[\Sigma F_y = 0] \quad -400^{\#} + C_y + D_y = 0$$

$$D_y = -480^{\#} + 400^{\#} = -80^{\#}$$

$$\underline{\underline{D_y = 80^{\#}}} \downarrow$$

$$[\Sigma F_x = 0] \quad +300^{\#} + D_x = 0 \qquad \underline{\underline{D_x = 300^{\#}}} \longleftarrow$$

LOWER BEAM:

$$[\Sigma M_B = 0] \quad -C_y(5') - A_y(10') = 0$$

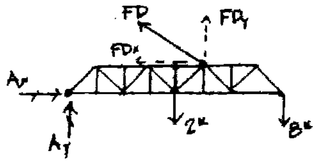
$$A_y = -240 \qquad \underline{\underline{A_y = 240^{\#}}} \downarrow$$

$$[\Sigma F_y = 0] \quad -240^{\#} + B_y - 480^{\#} = 0$$

$$\underline{\underline{B_y = +720^{\#}}}$$

$$[\Sigma F_x = 0] \quad \underline{\underline{B_x = 0}}$$

2.41



$FD_x = \frac{4}{5} FD$

$FD_Y = \frac{3}{5} FD$

$[\Sigma M_A = 0]$ $+FD_x(4') + FD_Y(20') - 2^k(16') - 8^k(32') = 0$

$\frac{4}{5} FD(4) + \frac{3}{5} FD(20) - 32^{k\text{-}'} - 256^{k\text{-}'} = 0$

$\frac{16}{5} FD + \frac{60}{5} FD = 288^{k'}$

$\underline{FD = 18.9^k}$

$FD_x = \frac{4}{5}(18.9) = 15.2^k$

$FD_Y = \frac{3}{5}(18.9) = 11.3^k$

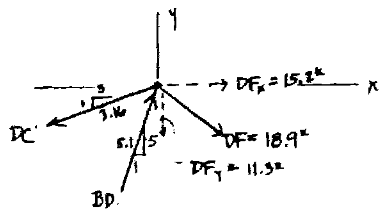
$[\Sigma F_x = 0]$ $+A_x - FD_x = 0$

$\therefore \underline{A_x = +15.2^k}$

$[\Sigma F_Y = 0]$ $+A_Y - 2^k - 8^k + 11.3^k = 0$

$\underline{A_Y = -1.3^k}$

$\therefore$ A_Y should be downward



$[\Sigma F_x = 0]$ $\underbrace{-\frac{3}{3.16} DC}_{DC_x} + \underbrace{\frac{BD}{5.1}}_{BD_x} + \underbrace{15.2^k}_{DF_x} = 0$

$[\Sigma F_Y = 0]$ $\underbrace{-\frac{DC}{3.16}}_{DC_Y} + \underbrace{\frac{5BD}{5.1}}_{BD_Y} - \underbrace{11.3^k}_{DF_y} = 0$

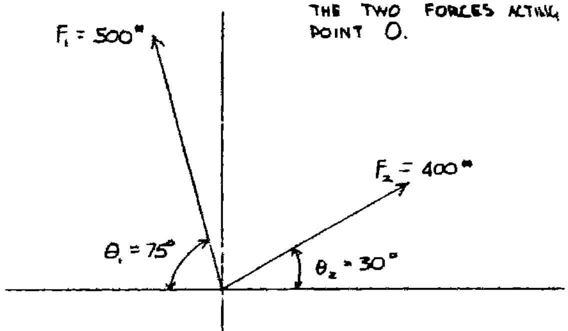
Solving simultaneously;

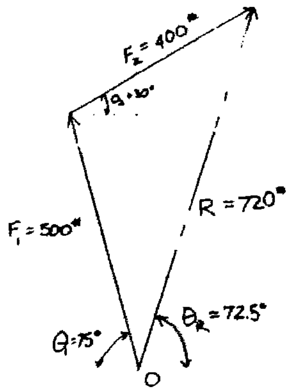
$\underline{BD = 17.2^k}$

$\underline{DC = 17.5^k}$

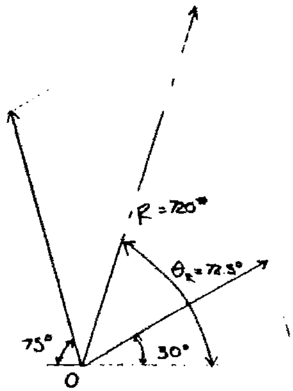
2.42

DETERMINE THE RESULTANT OF THE TWO FORCES ACTING AT POINT O.



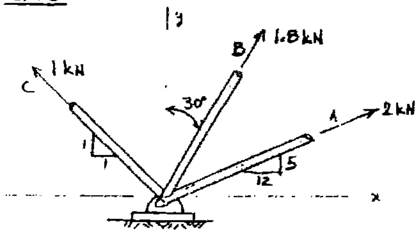


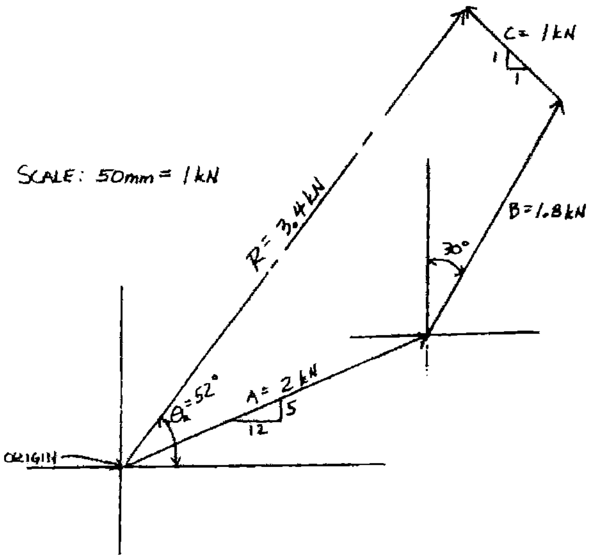
TIP-TO-TAIL METHOD



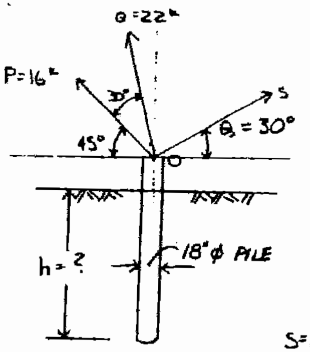
PARALLELOGRAM METHOD

2.43

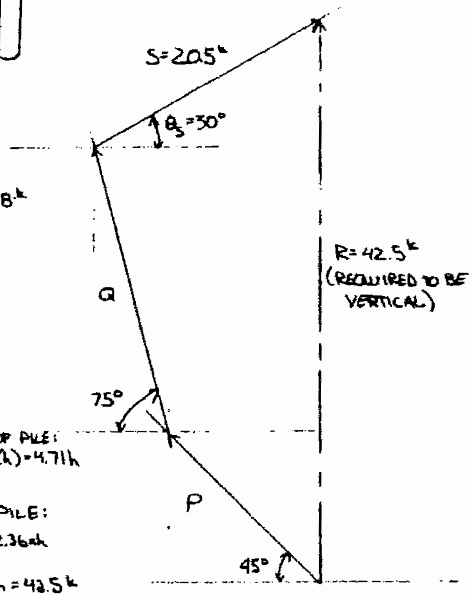

y
B
1.8kN
C
1kN
30°
A
2kN
1
1
5
12
x


C= 1kN
1
1
SCALE: 50mm = 1kN
R= 3.4kN
B=1.8kN
30°
θ=52°
A= 2kN
5
12
ORIGIN

2.44



SCALE : 1" = 8 k



SURFACE AREA OF PILE:
$\pi D \cdot h = 3.14(1.5')(h) = 4.71h$

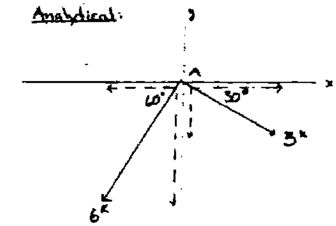
RESISTANCE OF PILE:
$4.71 \cdot h \times .50^k = 2.36 \cdot h$

EQUATING: $2.36 \cdot h = 42.5^k$

$h = 18'$

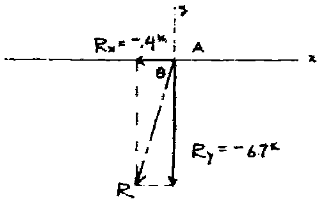
2.45

Analytical:



$$R_x = \Sigma F_x = -(6^k)\cos 60° + 3^k \cos 30°$$
$$R_x = -3^k + 2.6^k = -.4^k$$

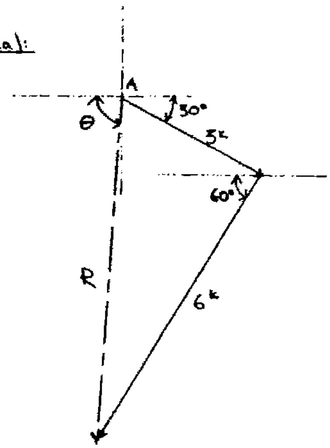
$$R_y = \Sigma F_y = -(6^k)\sin 60° - 3^k \sin 30°$$
$$R_y = -5.2^k - 1.5^k = -6.7^k$$



$$\theta = \tan^{-1}\left(\frac{R_y}{R_x}\right) = \tan^{-1}\left(\frac{6.7}{.4}\right)$$
$$\theta = \tan^{-1}(16.75) = \underline{86.6°}$$

$$R = \sqrt{R_x^2 + R_y^2} = \sqrt{(.4)^2 + (6.7)^2}$$
$$R = \underline{\underline{6.71^k}}$$

Graphical:

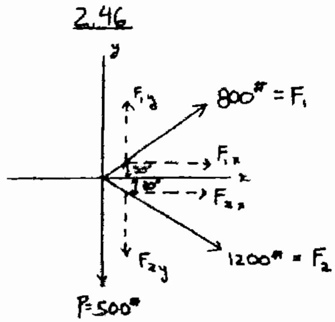


SCALE: $1'' = 2^k$

$R = 6.75^k$

$\theta = 86°$

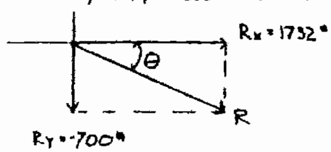
2.46



FORCE	F_x	F_y
P	0	$-500^{\#}$
F_1	$+F_1 \cos 30° = 800(.866) = 692.8^{\#}$	$+F_1 \sin 30° = 800(.5) = 400^{\#}$
F_2	$+F_2 \cos 30° = 1200(.866) = 1039.2^{\#}$	$-F_2 \sin 30° = -1200(.5) = -600^{\#}$

$R_x = \Sigma F_x = +692.8^{\#} + 1039.2^{\#} = 1732^{\#} \longrightarrow$

$R_y = \Sigma F_y = -500^{\#} + 400^{\#} - 600^{\#} = -700^{\#} \downarrow$



$R = \sqrt{R_x^2 + R_Y^2} = \sqrt{(1732)^2 + (-700)^2} = \underline{1868^{\#}}$

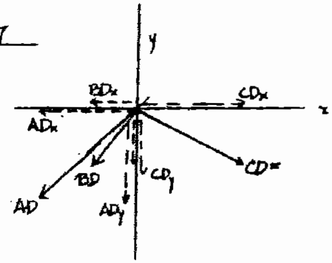
$\tan\theta = \frac{R_Y}{R_x}$; $\theta = \tan^{-1}\left(\frac{R_Y}{R_x}\right) = \tan^{-1}\left(\frac{700}{1732}\right)$

$\theta = \tan^{-1}(.404)$; $\underline{\underline{\theta = 22°}}$

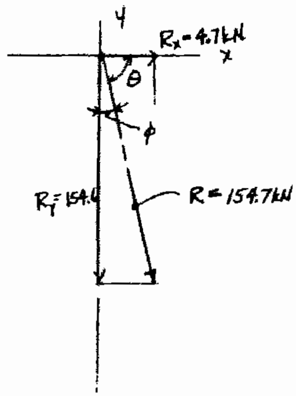
'R' CAN ALSO BE OBTAINED TRIGONOMETRICALLY:

$\sin\theta = \frac{R_Y}{R}$; $R = \frac{R_Y}{\sin\theta} = \frac{700^{\#}}{\sin 22°} = \frac{700^{\#}}{.375} = \underline{1867^{\#}}$

2.47



Force	F_x	F_y
$AD = 90\,kN$	$-AD_x = -\frac{AD}{\sqrt{2}} = -\frac{(90\,kN)}{\sqrt{2}} = -63.6\,kN$	$-AD_y = -\frac{AD}{\sqrt{2}} = -\frac{(90)}{\sqrt{2}} = -63.6\,kN$
$BD = 45\,kN$	$-BD_x = -\frac{3}{5}BD = -\frac{3}{5}(45\,kN) = -27\,kN$	$-BD_y = -\frac{4}{5}BD = -\frac{4}{5}(45) = -36\,kN$
$CD = 110\,kN$	$+CD_x = +CD\cos 30° = +(110\,kN)(.866) = +95.3\,kN$	$-CD_y = -CD\sin 30° = -(110\,kN)(0.5) = -55\,kN$
	$R_x = \Sigma F_x = +4.7\,kN$	$R_y = \Sigma F_y = -154.6\,kN$



$$R = \sqrt{R_x^2 + R_y^2}$$

$$R = \sqrt{(4.7)^2 + (154.6)^2}$$

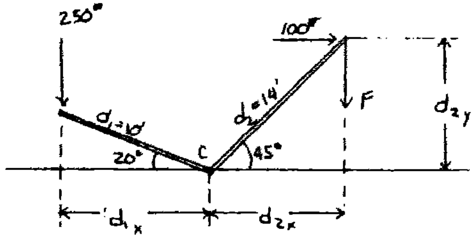
$$R = \sqrt{22.1 + 23{,}901}$$

$$\underline{\underline{R = 154.7\ kN}}$$

$$\theta = \tan^{-1}\left(\frac{R_y}{R_x}\right) = \tan^{-1}\left(\frac{154.6}{4.7}\right)$$

$$\theta = \tan^{-1}(32.9) = \underline{\underline{88.3°}}$$

2.48



$d_{2x} = d_2 \cos 45° = 14'(.707) = 9.9'$

$d_{2y} = d_2 \sin 45° = 14'(.707) = 9.9'$

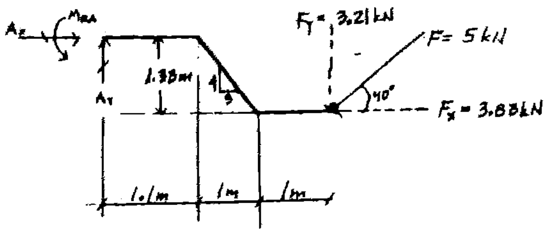
$d_{1x} = d_1 \cos 20° = 10'(.94) = 9.4'$

$\circlearrowleft + \; [\Sigma M_c = 0] \quad +250^{\#}(d_{1x}) - 100^{\#}(d_{2y}) - F(d_{2x}) = 0$

$$F = \frac{250^{\#}(9.4') - 100^{\#}(9.9')}{9.9'}$$

$$F = \frac{2350^{\#\text{-}\prime} - 990^{\#\text{-}\prime}}{9.9} = \frac{1360^{\#\text{-}\prime}}{9.9'} = \underline{\underline{137.4^{\#}}}$$

2.49



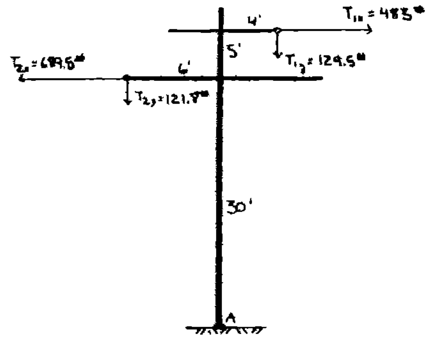
$[\Sigma F_x = 0] \quad +A_x - \underset{(F_x)}{3.83 \text{ kN}} = 0 \quad ; \quad \underline{\underline{A_x = 3.83 \text{ kN}}}$

$[\Sigma F_Y = 0] \quad +A_Y - \underset{(F_Y)}{3.21 \text{ kN}} = 0 \quad ; \quad \underline{\underline{A_Y = 3.21 \text{ kN}}}$

$M_A = +3.21 \text{ kN}(3.1 \text{ m}) + 3.83 \text{ kN}(1.33 \text{ m}) =$

$M_A = 9.95 \text{ kN-m} + 5.09 \text{ kN-m} = \underline{\underline{15.04 \text{ kN-m}}}$ ↻

2.50



FORCE	F_x	F_y
$T_1 = 500^{\#}$	$500^{\#}\cos 15^\circ = 483^{\#}$ (.966)	$500 \sin 15^\circ = 129.5^{\#}$ (.259)
$T_2 = 700^{\#}$	$700^{\#}\cos 10^\circ = 689.5^{\#}$ (.985)	$700^{\#}\sin 10^\circ = 121.8^{\#}$ (.174)

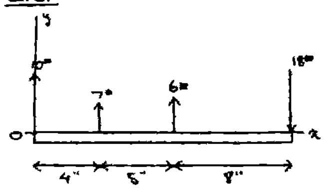
$$M_A = +T_{2x}(30') + T_{2y}(6') - T_{1x}(35') - T_{1y}(4')$$

$$= 689.5^{\#}(30') + 121.8^{\#}(6') - 483^{\#}(35') - 129.5^{\#}(4')$$

$$= 20{,}690^{\#\text{-}'} + 731^{\#\text{-}'} - 16910^{\#\text{-}'} - 518^{\#\text{-}'}$$

$$\underline{\underline{= +3990^{\#\text{-}'}}}$$

2.51



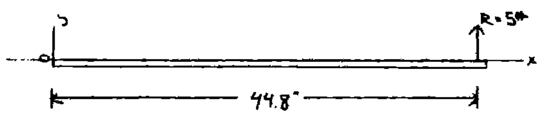
$$R = \Sigma F_y = 10^{\#} + 7^{\#} + 6^{\#} - 18^{\#} = +5^{\#} \uparrow$$

$$M_O = +7^{\#}(4") + 6^{\#}(9") - 18^{\#}(17")$$

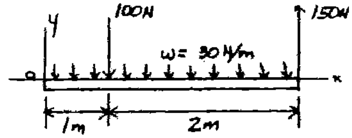
$$= +28^{\#\text{-}"} + 54^{\#\text{-}"} - 306^{\#\text{-}"}$$

$$= -224^{\#\text{-}"}$$

$$R(x) = 224^{\#\text{-}"} \;;\; x = \frac{224^{\#\text{-}"}}{5^{\#}} = 44.8"$$



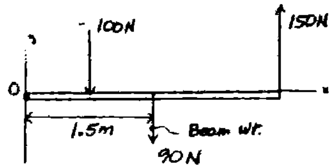
2.52



WT OF WOOD MEMBER

$w = 30 N/m$

ASSUME THE MEMBER WEIGHT IS LOCATED AT THE CENTER OF ITS LENGTH

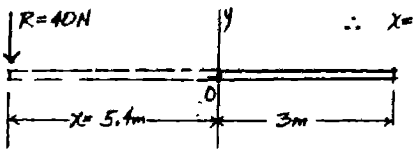


$R = \Sigma F_y = -100N - 90N + 150N$

$R = \underline{\underline{-40N}} \downarrow$

$\Sigma M_o = -100N\,(1m) - 90N(1.5m) + 150N(3m)$

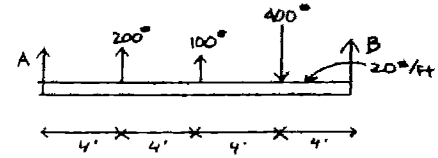
$M_o = \underline{\underline{+\,215\ N\text{-}m}}$ ↺ $\qquad R(x) = M_o$



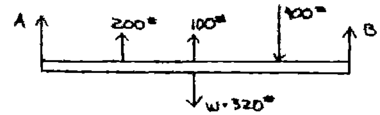
$\therefore\ X = \dfrac{215 N\text{-}m}{40N} = 5.4m$

For a 40N ↓ force to produce a moment going counter-clockwise, the R = 40N will be at an imaginary location where X = 5.4m to the left of the origin.

2.53



TOTAL BEAM WT
$= 20^{\#}/ft\ (16') = 320^{\#}$
@ CENTER OF
BEAM LENGTH



FOR THE BEAM TO REMAIN STATIONARY AND HORIZONTAL, THE MOMENTS TAKEN AT 'A' AND 'B' SHOULD BE BALANCED BY THE OPPOSING MOMENTS DUE TO 'B' AND 'A' RESPECTIVELY, RESULTING IN NO RESULTANT MOMENT. $(\Sigma_M = 0)$

$$\Sigma_{MA} = +200^{\#}(4') + 100^{\#}(8') - 320^{\#}(8') - 400^{\#}(12') - B(16') = 0$$

$$\therefore B = 360^{\#}$$

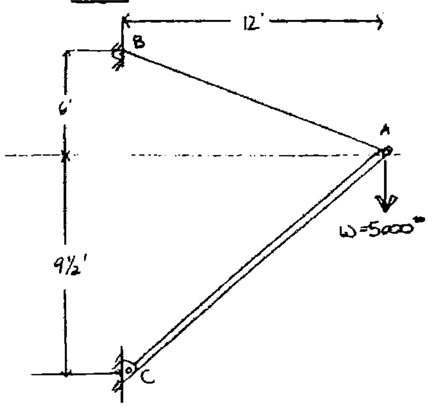
$$\Sigma_{MB} = +400^{\#}(4') + 320^{\#}(8') - 100^{\#}(8') - 200^{\#}(12') - A(16') = 0$$

$$\therefore A = 60^{\#}$$

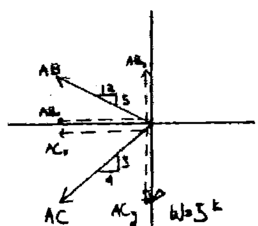
$$R_Y = \Sigma F_Y = +A + 200^{\#} + 100^{\#} - 320^{\#} - 400^{\#} + B = 0$$

$$= 60^{\#} + 200^{\#} + 100^{\#} - 320^{\#} - 400^{\#} + 360^{\#} = \underline{0}$$

2.54



ISOLATE THE CONCURRENT JOINT 'A'



NOTE: BOTH AB AND AC HAVE BEEN ASSUMED IN TENSION

2.54

FORCE	F_x	F_y
AB	$-\frac{12}{13}AB$	$+\frac{5}{13}AB$
AC	$-\frac{4}{5}AC$	$-\frac{3}{5}AC$
W	0	-5^k

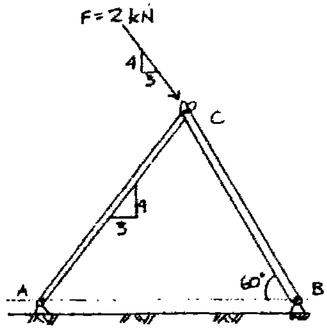
$[\Sigma F_x=0]\ -\frac{12}{13}AB-\frac{4}{5}AC=0;\quad \frac{12}{13}AB=-\frac{4}{5}AC;\quad AB=-\left(\frac{13}{12}\right)\left(\frac{4}{5}\right)AC=-\frac{13\,AC}{15}$

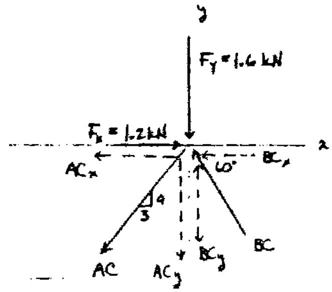
$[\Sigma F_y=0]\ +\frac{5}{13}AC-\frac{3}{5}AC-5^k=0;\quad +\frac{5}{13}\left(-\frac{13}{15}AC\right)-\frac{3}{5}AC=+5^k$

$-\frac{AC}{3}-\frac{3AC}{5}=5^k;\quad -.333AC-.6AC=5^k;\quad AC=\frac{-5^k}{.933}=-5.36^k$ COMPRESSION

$AB=\frac{-13}{15}(-5.36)=+4.64^k$ TENSION

2.55 - ANALYTICAL





FORCE	F_x	F_y
AC	$-\frac{3}{5}AC$	$-\frac{4}{5}AC$
BC	$-BC\cos 60°=-.5BC$	$+BC\sin 60°=.866BC$
F=2kN	$+\frac{3}{5}(2kN)=+1.2kN$	$-\frac{4}{5}(2kN)=-1.6kN$

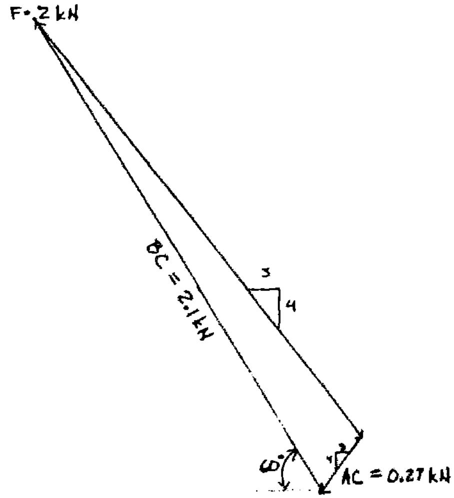
$[\Sigma F_x=0]=-\frac{3}{5}AC-.5BC+1.2kN=0;\quad \frac{3}{5}AC+.5BC=1.2kN$

$[\Sigma F_y=0]=-\frac{4}{5}AC+.866BC-1.6kN=0;\quad -\frac{4}{5}AC+.866BC=1.6kN$

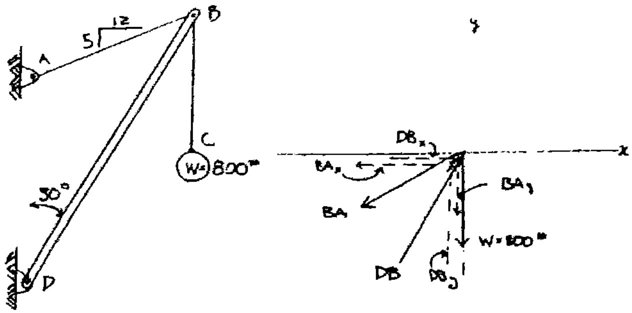
SOLVE SIMULTANEOUSLY: BC = 2.1kN (COMPRESSION)
AC = 0.27kN (TENSION)

2.55 - GEOMETRICAL

SCALE: 1 mm = 20 N



2.56



FORCE	F_x	F_y
BA	$-\frac{12}{13}BA$	$-\frac{5}{13}BA$
DB	$+DB\sin 30° = .5DB$ ($DB\cos 60°$)	$+DB\cos 30° = .866DB$ ($DB\sin 60°$)
W	0	-800#

2.56

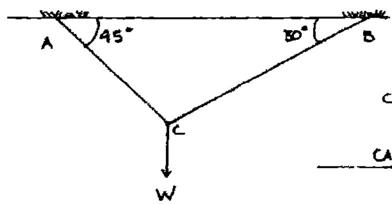
R_x: $[\Sigma F_x = 0]$ $-\frac{12}{13}BA + .5DB = 0$; $.5DB = \frac{12}{13}BA$; $DB = \frac{24}{13}BA$

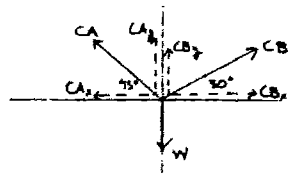
R_y: $[\Sigma F_y = 0]$ $-\frac{5}{13}BA + .866DB - 800^{\#} = 0$; $-\frac{5}{13}BA + .866\,DB = 800^{\#}$;

$$\frac{20.8}{13}BA - \frac{5}{13}BA = 800^{\#}$$

$\frac{15.8}{13}BA = 800^{\#}$; $\underline{\underline{BA = 658.2^{\#}}}$ $DB = \frac{24}{13}(658.2^{\#}) = \underline{\underline{1215.2^{\#}}}$

2.57





FORCE	F_x	F_y
CA	$-CA\cos 45° = -.707CA$	$+CA\sin 45° = +.707CA$
CB	$+CB\cos 30° = +.866CB$	$+CB\sin 30° = +.5CB$
W	0	$-W$

$[\Sigma F_x = 0]$ $-.707CA + .866CB = 0$; $.707CA = .866CB$;

$CA = \frac{.866CB}{.707}$; $CA = 1.22\,CB$

THIS RELATIONSHIP INDICATES THAT $CA > CB$

$\therefore$ $CA = 1.8\,kN$

THEN; $CB = \frac{CA}{1.22} = \frac{1.8\,kN}{1.22} = 1.48\,kN$

$[\Sigma F_y = 0]$ $.707CA + .5CB - W = 0$

$W = .707(1.8\,kN) + .5(1.48\,kN)$

$W = 1.27\,kN + 0.74\,kN$

$\underline{W = 2.0\,kN}$

2.58

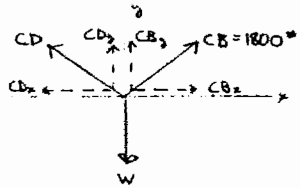
Joint B:

FORCE	F_x	F_y
$AB = 1560^{\#}$	$+\frac{12}{13}(1560) = 1440^{\#}$	$-\frac{5}{13}(1560) = -600^{\#}$
BE	0	$+BE$
BC	$-\frac{4}{5}BC$	$-\frac{3}{5}BC$

$[\Sigma F_x = 0]$ $+1440^{\#} - \frac{4}{5}BC = 0$; $BC = \frac{5}{4}(1440^{\#}) = \underline{1800^{\#}}$

$[\Sigma F_y = 0]$ $-600^{\#} + BE - \frac{3}{5}(1800^{\#}) = 0$; $BE = +600^{\#} + 1080^{\#} = \underline{1680^{\#}}$

Joint C:

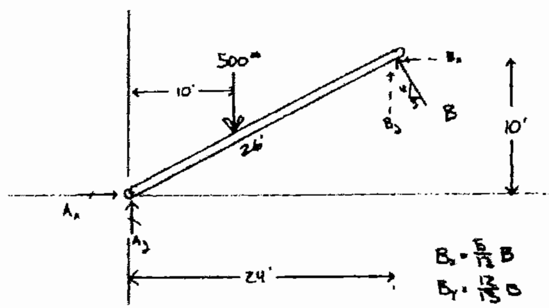


FORCE	F_x	F_y
CD	$-.707CD$	$+.707CD$
$CB = 1800^{\#}$	$+\frac{4}{5}(1800) = 1440^{\#}$	$+\frac{3}{5}(1800) = 1080^{\#}$
W	0	$-W$

$[\Sigma F_x = 0]$ $-.707CD + 1440^{\#} = 0$; $CD = \frac{1440^{\#}}{.707} = \underline{2037^{\#}}$

$[\Sigma F_y = 0]$ $+.707(2037^{\#}) + 1080^{\#} - W = 0$; $W = 1440^{\#} + 1080^{\#} = \underline{\underline{2520^{\#}}}$

2.59



$B_x = \frac{5}{13}B$

$B_y = \frac{12}{13}B$

$[\Sigma M_A = 0]$ $-500^{\#}(10') + \underbrace{\tfrac{5}{13}B}_{B_x}(10') + \underbrace{\tfrac{12}{13}B}_{B_y}(24') = 0$

$\frac{50B}{13} + \frac{288B}{13} = 5000^{\#\text{-}'}$; $B = \frac{13}{338}(5000) = \underline{192.3^{\#}}$

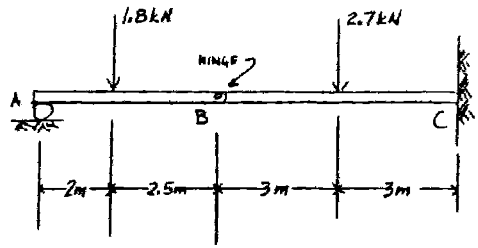
$B_x = 74^{\#}$

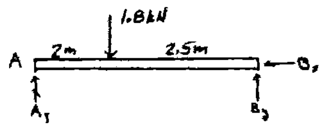
$B_y = 177.5^{\#}$

$[\Sigma F_x = 0]$ $+A_x - \underbrace{74^{\#}}_{B_x} = 0$; $\underline{A_x = 74^{\#}}$

$[\Sigma F_y = 0]$ $+A_y - 500^{\#} + \underbrace{177.5^{\#}}_{B_y} = 0$; $\underline{A_x = 322.5^{\#}}$

2.60





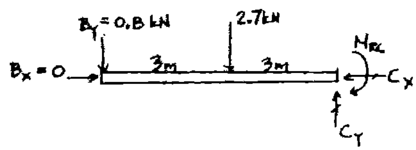
$[\Sigma F_x = 0]$ $\underline{B_x = 0}$

$[\Sigma M_B = 0]$ $-A_y(4.5m) + 1.8kN(2.5m) = 0$

$\underline{A_y = 1\ kN}$

$[\Sigma F_y = 0]$ $+1\ kN - 1.8\ kN + B_y = 0$

$\underline{B_y = 0.8\ kN}$



$[\Sigma F_x = 0]$ $\underline{C_x = 0}$

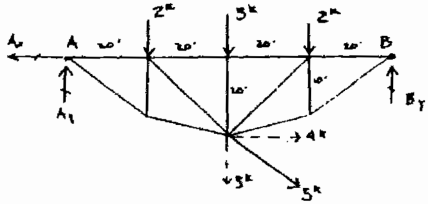
$[\Sigma F_y = 0]$ $-0.8kN - 2.7kN + C_y = 0$; $\underline{C_y = 3.5kN \uparrow}$

$[\Sigma M_C = 0]$ $-M_{RC} + 2.7kN(3m) + .8kN(6m) = 0$

$M_{RC} = 8.1$ kN-m $+ 4.8$ kN-m

$\underline{M_{RC} = 12.9\ \text{kN-m}}$ ↻

<u>2.61</u>



$[\Sigma F_x = 0]$ $-A_x + 4^k = 0$; $\underline{A_x = +4^k} \leftarrow$ (ASSUMED DIRECTION CORRECT)

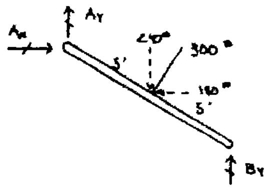
$[\Sigma M_A = 0]$ $-2^k(20') - 3^k(40') - 2^k(60') - 3^k(40') + 4^k(20') + B_Y(80') = 0$

$80 B_Y = 320^{k\text{-}'}$, $\underline{B_Y = +4^k \uparrow}$

$[\Sigma F_Y = 0]$ $+A_Y - 2^k - 3^k - 2^k - 3^k \overbrace{+4^k}^{B_Y} = 0$

$\underline{A_Y = +6^k \uparrow}$

2.62



$[\Sigma M_A = 0]$ $-300\#(5') + B_Y(8') = 0$

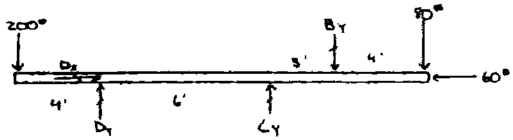
$\underline{B_Y = 187.5\# \uparrow}$

$[\Sigma F_x = 0]$ $+A_x - 180\# = 0$

$\underline{A_x = +180\# \rightarrow}$

$[\Sigma F_Y = 0]$ $+187.5\# - 240\# + A_Y = 0$

$\underline{A_Y = +52.5\# \uparrow}$



$[\Sigma M_D = 0]$ $+200\#(4') + C_Y(6') - 187.5\#(9') - 80\#(13') = 0$

$\underline{C_Y = +322\# \uparrow}$

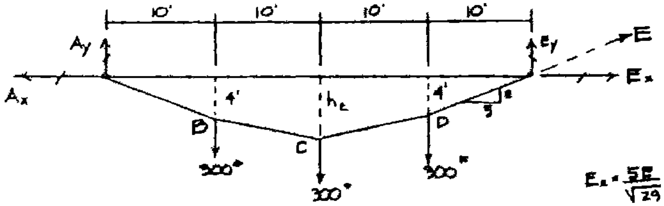
$[\Sigma F_x = 0]$ $+D_x - 60\# = 0$

$\underline{D_x = +60\# \rightarrow}$

$[\Sigma F_Y = 0]$ $-200\# + D_Y + 322\# - 187.5\# - 80\# = 0$

$\underline{D_Y = +145.5\# \uparrow}$

3.1



$E_x = \frac{5E}{\sqrt{29}}$

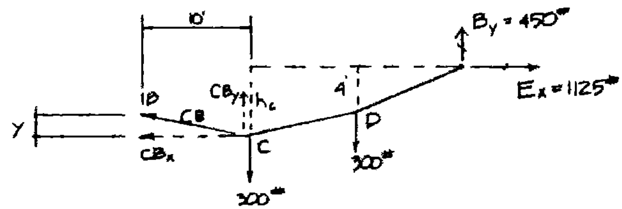
$E_y = \frac{2E}{\sqrt{29}}$

$[\Sigma M_A = 0]$ $\quad +\left(\frac{2E}{\sqrt{29}}\right)40' - 300^{\#}(30') - 300^{\#}(20') - 300^{\#}(10') = 0$

$\underline{\underline{E = +225\sqrt{29} = 1212^{\#}}}$

$\therefore \quad \underline{\underline{E_x = 1125^{\#}}}$

$\underline{\underline{E_y = 450^{\#}}}$



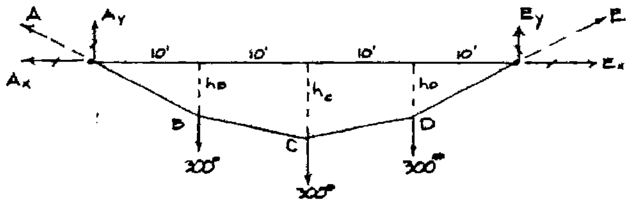
$[\Sigma F_x = 0]$ $\quad CB_x = E_x = 1125^{\#}$

$[\Sigma F_y = 0]$ $\quad +CB_y - 300^{\#} - 300^{\#} + 450^{\#} = 0 \; ; \; CB_y = +150^{\#}$

$\frac{y}{CB_y} = \frac{10'}{CB_x} \qquad y = \frac{(150^{\#})(10')}{1125^{\#}} = \underline{\underline{1.33'}}$

$\underline{h_c} = 4' + y = \underline{\underline{5.33'}}$

3.2

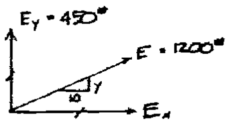


Assume: $E_{MAX} = 1200^{\#}$

Cable Force $DE = E$

$$\left[\Sigma M_A = 0\right] \quad -300^{\#}(10') - 300^{\#}(20') - 300^{\#}(30') + E_y(40') = 0$$

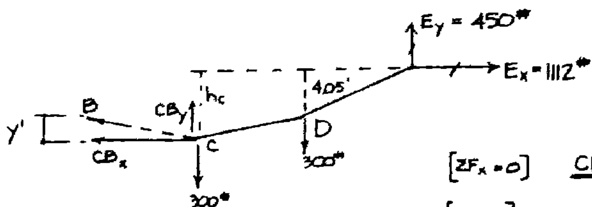
$$\underline{\underline{E_y = 450^{\#}}}$$



$$E_x = \sqrt{E^2 - E_y^2}$$

$$\underline{\underline{E_x = 1112^{\#}}}$$

$$\frac{y}{10} = \frac{450}{1112} \qquad \underline{\underline{y = 4.05'}}$$



$$\left[\Sigma F_x = 0\right] \qquad \underline{\underline{CB_x = 1112^{\#}}}$$

$$\left[\Sigma F_y = 0\right] \quad + CB_y - 300^{\#} - 300^{\#} + 450^{\#} = 0$$

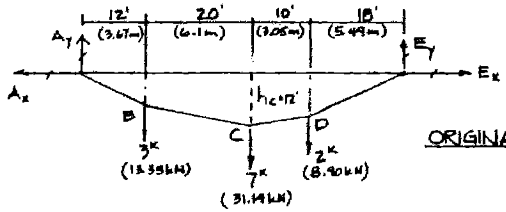
$$\underline{\underline{CB_y = +150^{\#}}}$$

$$\underline{\underline{CB = 1122^{\#} < 1200^{\#} \quad \therefore \text{OK}}}$$

$$\frac{y'}{10'} = \frac{CB_y}{CB_x} \qquad \underline{\underline{y' = 1.35'}}$$

$$h_c = y' + 4.05' = \underline{\underline{5.4'}}$$

3.3



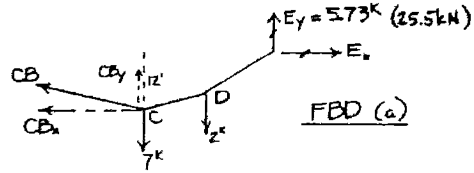
ORIGINAL FBD

$\left[\Sigma M_A = 0\right]$ $-3^K(12') - 7^K(32') - 2^K(42') + E_y(60') = 0$

$\underline{E_y = 5.73^K}$ (25.5 kN)

$\left[\Sigma F_y = 0\right]$ $+A_y - 3^K - 7^K - 2^K + 5.73^K = 0$

$\underline{A_y = 6.27^K}$ (27.9 kN)



FBD (a)

$\left[\Sigma M_C = 0\right]$ $-2^K(10') + 5.73^K(28') - E_x(12') = 0$

$\underline{E_x = 11.7^K}$ (52.1kN) $\quad \therefore$ $\underline{E = ED = 13.03^K}$ (58.0kN)

FROM ORIGINAL FBD;

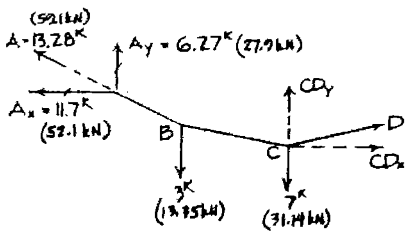
$\left[\Sigma F_x = 0\right]$ $\underline{A_x = 11.7^K}$ (52.1 kN) $\quad \therefore$ $\underline{A = BA = 13.27^K}$ (59.1kN)

FBD (a): w/ $E_x = 11.7^K$ and $E_y = 5.73^K$,

$\left[\Sigma F_x = 0\right]$ $\underline{CB_x = E_x = 11.7^K}$ (52.1kN)

$\left[\Sigma F_y = 0\right]$ $+CB_y - 7^K - 2^K + 5.73^K = 0$

$\underline{CB_y = 3.27^K}$ (14.6kN) $\quad$ $\underline{CB = 12.15^K}$ (54.1 kN)



$\left[\Sigma F_x = 0\right]$ $\underline{CD_x = 11.7^K}$ (52.1 kN)

$\left[\Sigma F_y = 0\right]$ $\underline{CD_y = 3.73^K}$ (16.6 kN)

$\therefore$ $\underline{CD = 12.28^K}$ (54.6 kN)

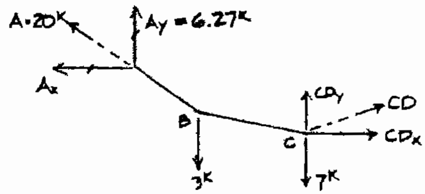
3.4

FROM SOLUTION (3.3) IT APPEARS THE FORCE IN CABLE AB IS MAXIMUM,

$\therefore$ ASSUME: REACTION @ $A = 20^K$

$AB = 20^K$

USING ORIGINAL FBD OF PROB 3.3, $A_y = 6.27^K$

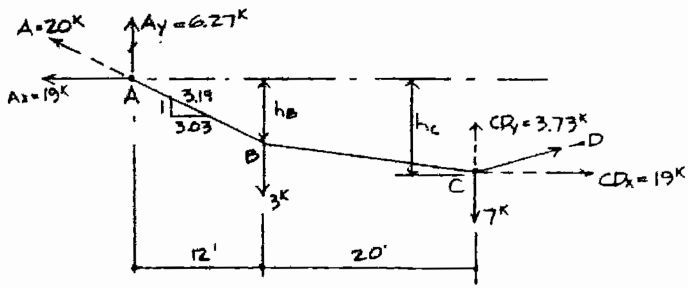


If: $A = 20^K$ and $A_y = 6.27^K$,

then, $A_x = \sqrt{A^2 - A_y^2} = 19^K$

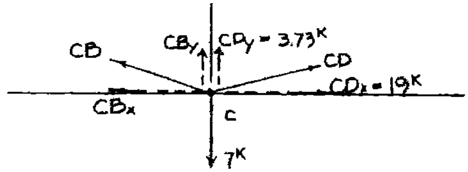
$\therefore$ $[\Sigma F_x = 0]$ $\overset{A_x}{-19^K} + CD_x = 0$ $\quad CD_x = 19^K$

$[\Sigma F_y = 0]$ $+6.27^K - 3^K - 7^K + CD_y = 0$ $\quad CD_y = 3.73^K$



3.4 (cont'd)

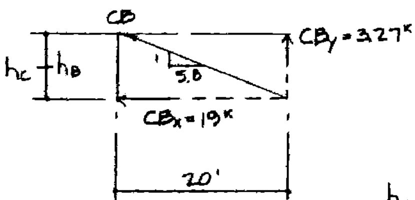
$$\frac{h_B}{1} = \frac{12}{3.03} \quad ; \quad \underline{\underline{h_B = 3.96'}}$$



$[\Sigma F_x = 0]$ $\underline{\underline{CB_x = 19^K}}$

$[\Sigma F_y = 0]$ $+CB_y + 3.73^K - 7^K = 0$

$\underline{\underline{CB_y = 3.27^K}}$



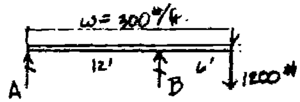
$$\frac{h_c - h_B}{20'} = \frac{CB_y}{CB_x} = \frac{3.27}{19}$$

$$(h_c - h_B) = 20\left(\frac{3.27}{19}\right) = 3.44'$$

$$\therefore \quad h_c = h_B + 3.44' = 3.96' + 3.44'$$

$$\underline{\underline{h_c = 7.40'}}$$

3.5



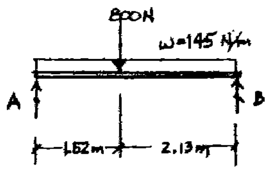
$[\Sigma M_A = 0]$ $-300\#/ft(18')(9') - 1200\#(18') + B(12') = 0$

$\underline{B = 5850\#} \uparrow$

$[\Sigma F_y = 0]$ $+A - 300\#/ft(18') - 1200\# + 5850\# = 0$

$\underline{A = 750\# \uparrow}$

3.6



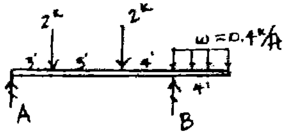
$[\Sigma M_A = 0]$ $-800N(1.52m) - (145\,N/m)(1.52m + 2.13m)(1.825m) + B(3.65m) = 0$

$\underline{B = 598\,N}$

$[\Sigma F_y = 0]$ $+A - 800N - (145\,N/m)(3.65m) + 598N = 0$

$\underline{A = 731\,N}$

3.7



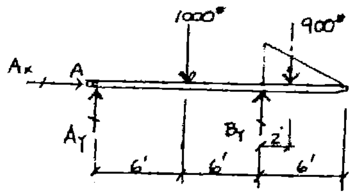
$[\Sigma M_A = 0]$ $-2^k(3') - 2^k(8') - .4^k(4')(14') - B(12') = 0$

$\underline{B = 3.7^k}$

$[\Sigma F_Y = 0]$ $+A - 2^k - 2^k - .4^k(4') + 3.7^k = 0$

$\underline{A = 1.9^k}$

3.8



$[\Sigma F_x = 0]$ $A_x = 0$

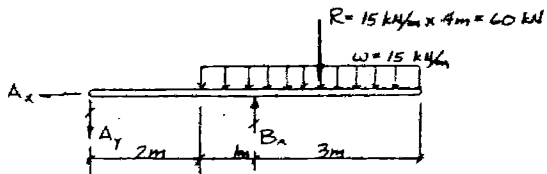
$[\Sigma M_A = 0]$ $-1000^{\#}(6') - 900^{\#}(14') + B_Y(12') = 0$

$B_Y = +1550^{\#}$

$[\Sigma F_Y = 0]$ $+A_Y - 1000^{\#} - 900^{\#} + 1550^{\#} = 0$

$A_Y = +350^{\#}$

3.9



$[\Sigma F_x = 0]$ $\underline{A_x = 0}$

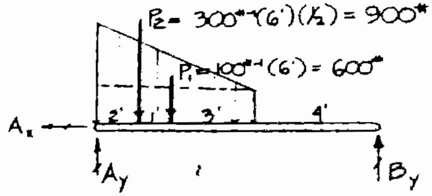
$[\Sigma M_A = 0]$ $B(3m) - 60kN(4m) = 0$

$\underline{B = 80kN}$

$[\Sigma F_y = 0]$ $-A_y + 80kN - 60kN = 0$

$\underline{A_y = 20kN}$

3.10



$[\Sigma F_x = 0]$ $\underline{\underline{A_x = 0}}$

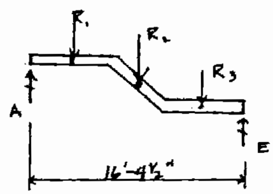
$[\Sigma M_A = 0]$ $-900^{\#}(2') - 600^{\#}(3') + B_y(10') = 0$

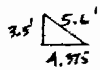
$\underline{\underline{B_y = 360^{\#}}}$

$[\Sigma M_B = 0]$ $+600^{\#}(7') + 900^{\#}(8') - A_y(10')$

$\underline{\underline{A_y = 1140^{\#}}}$

3.11





$R_1 = (\frac{8}{12})(1')(150^{\#}/ft^3)(6') + 100^{\#}/ft^2 \times 1' \times 6' = 1200^{\#}$

$R_2 = (\frac{12}{12})(1')(150^{\#}/ft^3)(5.6') + 100^{\#}/ft^2 \times 1' \times 5.6' = 1400^{\#}$

$R_3 = (\frac{8}{12})(1')(150^{\#}/ft^3)(6') + 100^{\#}/ft^2 \times 1' \times 6' = 1200^{\#}$

$[\Sigma M_A = 0]$ $-1200^{\#}(3') - 1400^{\#}(8.2') - 1200^{\#}(13.375') + E(16.375') = 0$

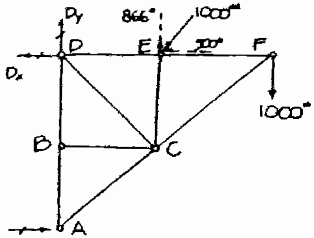
$E = 1900^{\#}$

$[\Sigma F_y = 0]$ $A - 1200^{\#} - 1400^{\#} - 1200^{\#} + 1900^{\#} = 0$

$A = 1900^{\#}$

3.12

STEP 1: FBD of Entire Truss



STEP 2: Solve for External Reactions

$[\Sigma M_D = 0]\ +A_x(20') - 866^{\#}(10') - 1000^{\#}(20') = 0$

$\underline{\underline{A_x = +1433^{\#}}}$

$[\Sigma F_x = 0]\ -D_x - 500^{\#} + 1433^{\#} = 0$

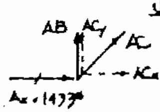
$\underline{\underline{D_x = +933^{\#}}}$

$[\Sigma F_y = 0]\ +D_y - 866^{\#} - 1000^{\#} = 0$

$\underline{\underline{D_y = 1{,}866^{\#}}}$

STEP 3 Joint Isolation

Joint A



$AC_x = .707\,AC$

$AC_y = .707\,AC$

$[\Sigma F_x = 0]\ +1433^{\#} + .707\,AC = 0$

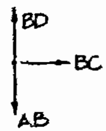
$\underline{\underline{AC = -2030^{\#}\ (C)}}$

$[\Sigma F_y = 0]\ +AB + AC_y = 0$

$AB = -(-.707 \cdot 2030^{\#})$

$\underline{\underline{AB = +1433^{\#}\ (T)}}$

JOINT B

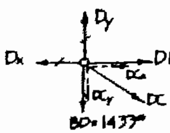


$[\Sigma F_x = 0]\ \ \underline{\underline{BC = 0}}$

$[\Sigma F_y = 0]\ +BD - 1433^{\#} = 0$

$\underline{\underline{BD = +1433^{\#}\ (T)}}$

JOINT D



$[\Sigma F_y = 0]\ +1866^{\#} - 1433^{\#} - .707\,DC = 0$

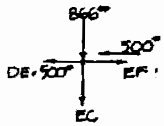
$\underline{\underline{DC = +612^{\#}\ (T)}}$

$[\Sigma F_x = 0]\ -933^{\#} + DE + (.707 \cdot 612^{\#}) = 0$

$\underline{\underline{DE = +500^{\#}\ (T)}}$

3.12 con't

Joint E



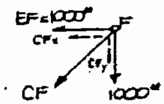
$[\Sigma F_y = 0]$ $-866^{\#} - EC = 0$

$\underline{\underline{EC = 866^{\#}\ (c)}}$

$[\Sigma F_x = 0]$ $-500^{\#} - 500^{\#} + EF = 0$

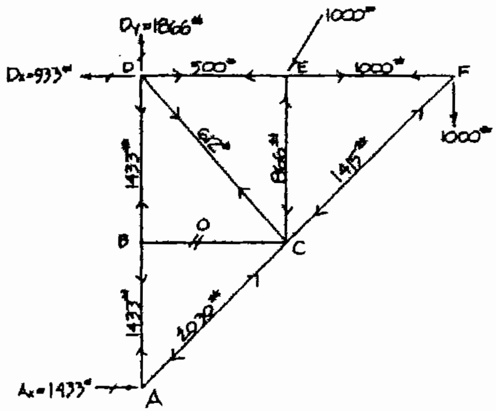
$\underline{\underline{EF = +1000^{\#}\ (T)}}$

JOINT F



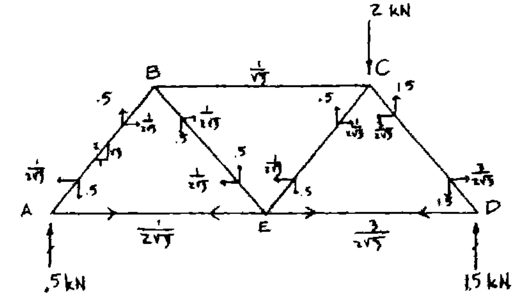
$[\Sigma F_y = 0]$ $-1000^{\#} - .707\,CF = 0$

$\underline{\underline{CF = -1415^{\#}\ (c)}}$

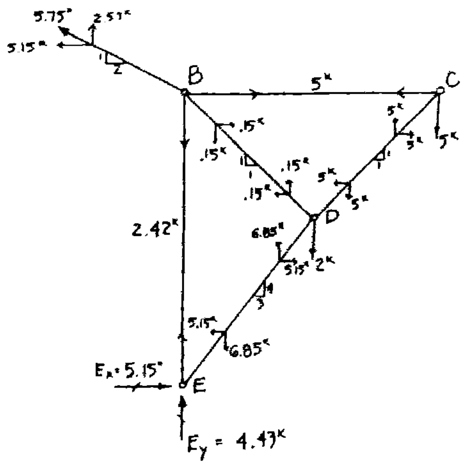


FORCE SUMMATION DIAGRAM

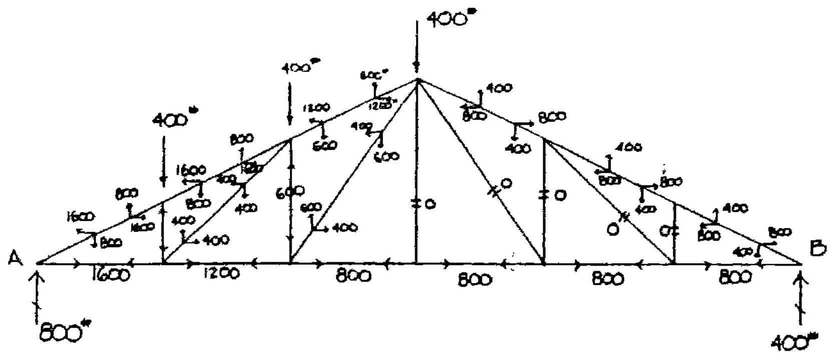
3.13


2 kN
B
C
A
D
E
.5 kN
1.5 kN

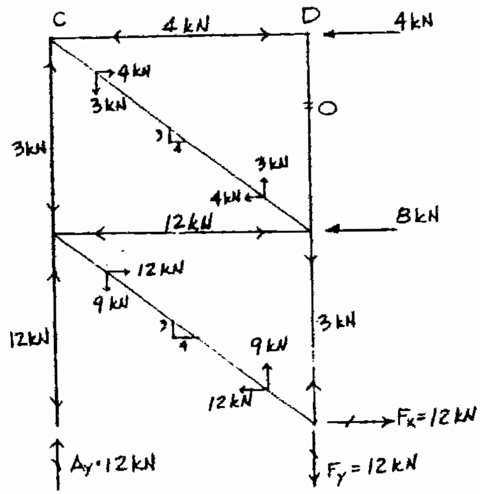
3.14


B
C
D
E
5ᴷ
2.42ᴷ
6.85ᴷ
Eₓ = 5.15ᴷ
E_y = 4.43ᴷ

3.15

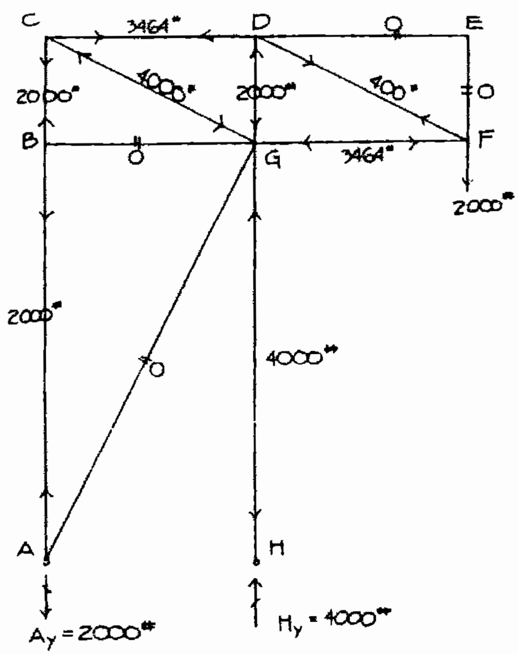

400#
A
B
800#
400#
1600
1200
800
800
800
800

3.16



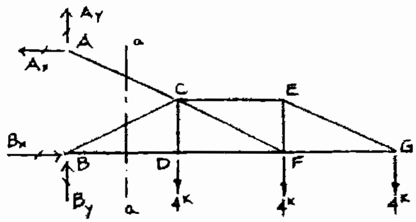
C
D
4 kN
4 kN
4 kN
3 kN
3kN
0
3 kN
4 kN
12 kN
8 kN
12 kN
9 kN
12kN
3 kN
9 kN
12 kN
$F_x = 12$ kN
$A_y \cdot 12$ kN
$F_y = 12$ kN

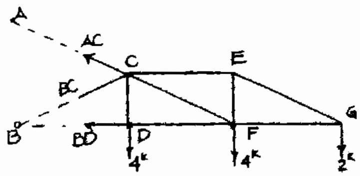
3.17



C
3464"
D
0
E
2000"
4000"
2000"
400"
0
B
0
G
3464"
F
2000#
2000"
0
4000#
A
H
$A_y = 2000$#
$H_y \cdot 4000$#

3.18





$$[\Sigma M_B = 0] \quad + \overbrace{\frac{2AC}{\sqrt{5}}}^{AC_x}(3') + \overbrace{\frac{AC}{\sqrt{5}}}^{AC_y}(6') - 4^k(6') - 4^k(12') - 2^k(18') = 0$$

$$\frac{12\,AC}{\sqrt{5}} = 24 + 48 + 36 = 108$$

$$AC = \frac{108\sqrt{5}}{12} = 9\sqrt{5} = \underline{\underline{20.1^k \ (T)}}$$

$$[\Sigma M_F = 0] \quad + \overbrace{\frac{2BC}{\sqrt{5}}}^{BC_x}(3') + \overbrace{\frac{BC}{\sqrt{5}}}^{BC_y}(6) + 4^k(6') - 2^k(6') = 0$$

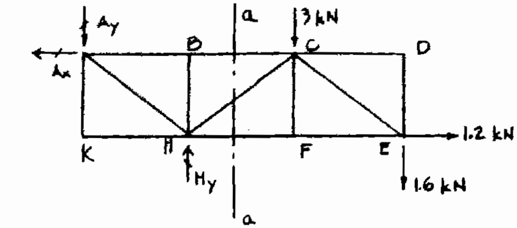
$$\frac{12\,BC}{\sqrt{5}} = 12 - 24 = -12$$

$$BC = -\sqrt{5}^{\,k} = \underline{\underline{-2.24^k \ (C)}}$$

$$[\Sigma M_C = 0] \quad - BD(3') - 4^k(6') - 2^k(12') = 0$$

$$BD = \underline{\underline{-16^k \ (C)}}$$

3.19



FIND: CH
BC
FH

$$[\Sigma M_A = 0] \quad H_y(2.5) - 3(5.0) + 1.2(2) - 1.6(7.5) = 0$$

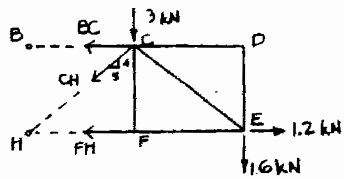
$$\underline{H_Y = 9.84 \text{ kN}}$$

$$[\Sigma F_Y = 0] \quad -A_Y - 3 - 1.6 + 9.84 = 0$$

$$\underline{A_Y = 5.24 \text{ kN}}$$

$$[\Sigma F_x = 0] \quad -A_x + 1.2 = 0$$

$$\underline{A_x = +1.2 \text{ kN}}$$



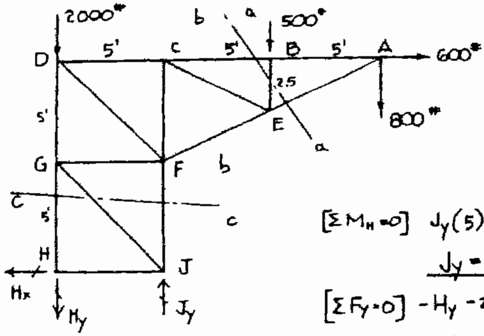
$$[\Sigma F_y = 0] \quad -3\text{kN} - 1.6\text{kN} - \underbrace{\frac{4}{6.4} CH}_{CH_y} = 0 \qquad \underline{CH = -7.35 \text{ kN (C)}}$$

$$[\Sigma M_H = 0] \quad +BC(2\text{m}) - 3(2.5\text{m}) - 1.6(5\text{m}) = 0 \qquad \underline{BC = +7.75 \text{ kN (T)}}$$

$$[\Sigma M_C = 0] \quad -FH(2\text{m}) + 1.2(2\text{m}) - 1.6(2.5\text{m}) = 0 \qquad \underline{FH = -.8 \text{ kN (C)}}$$

3.20

FIND BE, CE, FJ



$[\Sigma M_H = 0]$ $J_y(5) - 500(10) - 800(15) - 600(10) = 0$

$\underline{J_y = 4600^{\#}}$

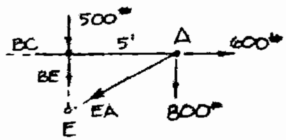
$[\Sigma F_y = 0]$ $-H_y - 2000 - 500 - 800 + 4600^{\#} = 0$

$\underline{H_y = 1300^{\#}}$

$[\Sigma F_x = 0]$ $-H_x + 600 = 0$

$\underline{H_x = 600^{\#}}$

SECT a-a:

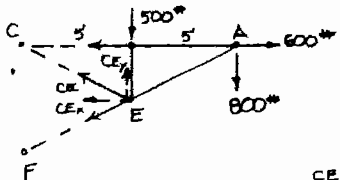


$[\Sigma M_A = 0]$

$+500(5') + BE(5) = 0$

$\underline{BE = -500^{\#}}$ (C)

SECT. b-b:



$[\Sigma M_A = 0]$

$+500(5') - CE_y(5') - CE_x(2.5') = 0$

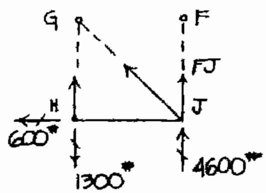
But: $CE_x = \frac{2}{\sqrt{5}} CE$

$CE_y = \frac{1}{\sqrt{5}} CE$

$\therefore \frac{CE}{\sqrt{5}}(5) + \frac{2CE}{\sqrt{5}}(2.5) = 5(500)$

$CE\left(\frac{5}{\sqrt{5}} + \frac{5}{\sqrt{5}}\right) = 5(500)$ $\therefore CE = \frac{5(500)(\sqrt{5})}{10}$

$\underline{CE = 250\sqrt{5}}$



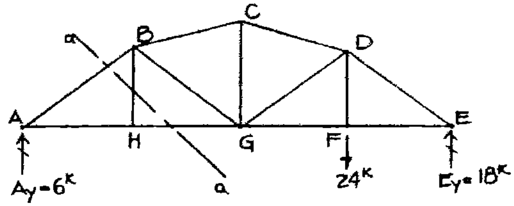
$[\Sigma M_G = 0]$

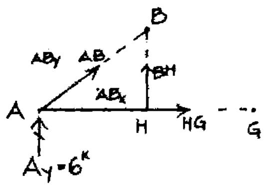
$-600(5) + FJ(5) + 4600(5) = 0$

$FJ = 600 - 4600^{\#}$

$\underline{FJ = -4000^{\#} \text{ (C)}}$

3.21





$AB_x = \frac{4}{5} AB$

$AB_y = \frac{3}{5} AB$

$[\Sigma M_H = 0]$ $-\frac{3}{5}AB(12) - 6^K(12) = 0$

$AB = -\frac{6(12)(5)}{3(12)} = -10^K$

$\therefore \underline{\underline{AB = 10^K \ (C)}}$

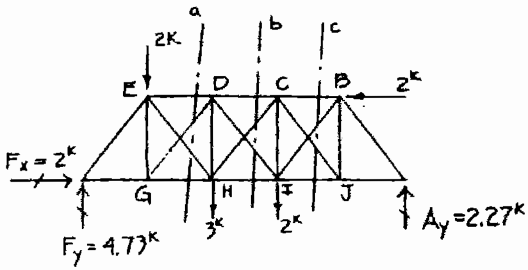
$[\Sigma M_A = 0]$ $BH(12) = 0$

$\therefore \underline{\underline{BH = 0}}$

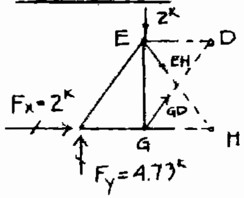
$[\Sigma M_B = 0]$ $+HG(9) - 6^K(12) = 0$

$\therefore \underline{\underline{HG = +8^K \ (T)}}$

3.22



Section a

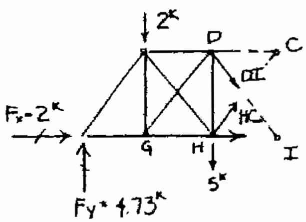


$[\Sigma F_y = 0]$ $\quad \overbrace{+4.73^k}^{F_y} - 2^k - EH_y = 0$

$EH_y = +2.73^k$

$EH = \frac{5}{4}(2.73^k) = \underline{\underline{3.41^k\ (T)}}$

Section b

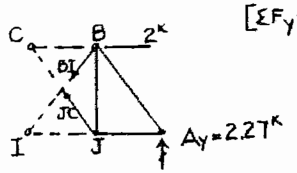


$[\Sigma F_y = 0]$ $\quad +4.73^k - 2^k - 3^k + HC_y = 0$

$HC_y = +.27^k$

$HC = \frac{5}{4}(.27^k) = \underline{\underline{+.34^k\ (T)}}$

Section C

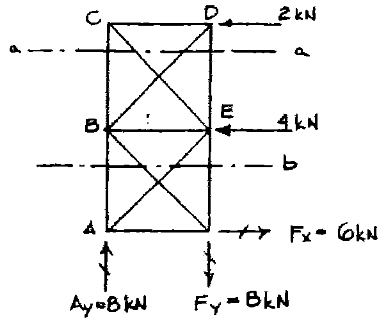


$[\Sigma F_y = 0]$ $\quad \overbrace{+2.27^k}^{A_y} - BI_y = 0$

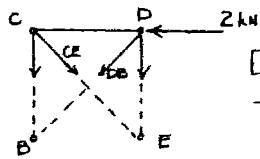
$BI_y = +2.27^k$

$BI = \frac{5}{4}(2.27) = \underline{\underline{+2.84^k\ (T)}}$

3.23



Section a



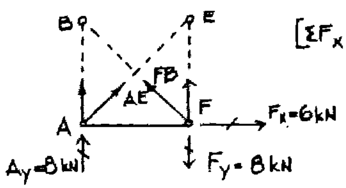
$[\Sigma F_x = 0]$

$-2\,\text{kN} + CE_x = 0$

$CE_x = +2\,\text{kN}$

$\underline{\underline{CE = +2\sqrt{2}\,\text{kN}\,(T)}}$

Section b

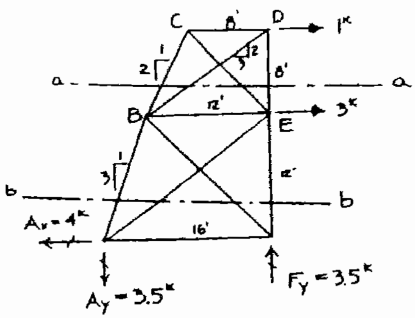


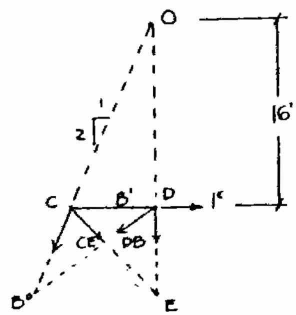
$[\Sigma F_x = 0] \quad \overbrace{+6\,\text{kN}}^{F_x} - FB_x = 0$

$FB_x = +6\,\text{kN}$

$\underline{\underline{FB = +6\sqrt{2}\,\text{kN}\,(T)}}$

3.24





SECTION a

$[\Sigma M_o = 0]$

ONLY DB CAN RESIST THE ROTATIONAL TENDENCY (COUNTER-CLOCKWISE) OF THE 1^k APPLIED LOAD.

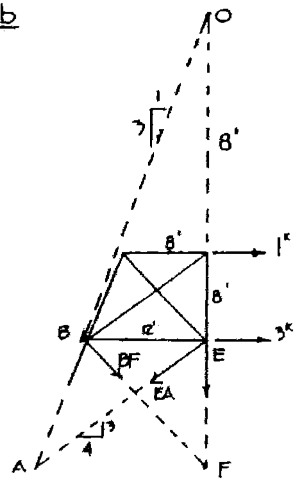
$$DB_y = \frac{2DB}{\sqrt{13}} \; ; \quad DB_x = \frac{3DB}{\sqrt{13}}$$

$$[\Sigma M_o = 0] \quad +1^k(16') - DB_x(16') = 0$$

$$DB_x = +1^k \; ; \quad DB = \frac{1^k(\sqrt{13})}{3} = \underline{\underline{1.2^k \;\; (T)}}$$

3.24 con't

SECTION b



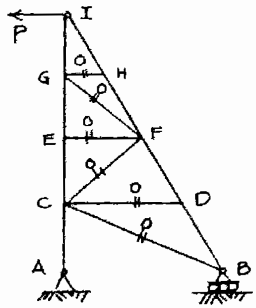
$$[\Sigma M_o = 0] \quad +1^K(28') + 3^K(36') - EA_x(36') = 0$$

$$EA_x = +3.8^K$$

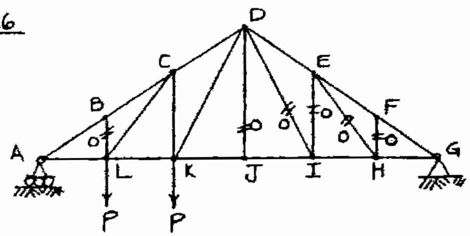
$$EA_x = \frac{4EA}{5} \quad ; \quad EA = \frac{5}{4}(3.8^K) = \underline{\underline{+4.7^K \ (T)}}$$

ZERO FORCE MEMBERS

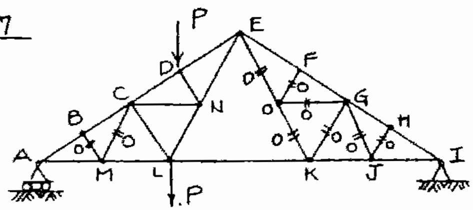
3.25



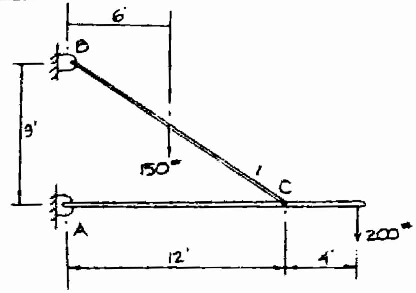
3.26

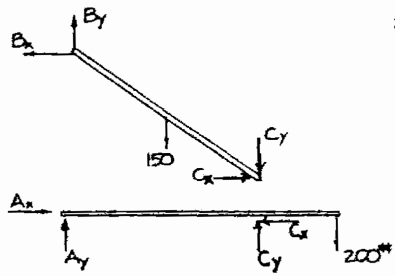


3.27



3.28





$\Sigma M_B = 0$ $\quad A_x \cdot 9 - 150 \cdot 6 - 200 \cdot 16 = 0$

$A_x = \frac{4100}{9}$

$\underline{A_x = +455^{\#}}$ →

$\Sigma F_x = 0$ $\quad \underline{C_x = 455^{\#}}$

FOR MEMBER BC:

$\Sigma F_x = 0$ $\quad \underline{B_x = 455^{\#}}$ ←

$\Sigma M_A = 0$ $\quad$ MEMBER AC:

$200(16) + 12\,C_y = 0$

$\underline{C_y = 267^{\#}}$

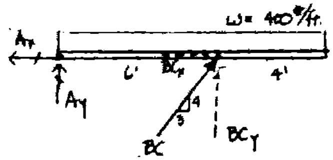
$\therefore A_y = C_y - 200$ $\quad \underline{A_y = -67^{\#}}$ ↓

FOR EQUILIBRIUM IN BC:

$B_y - 150 - C_y = 0$

$\underline{B_y = 417^{\#}}$ ↑

3.29



$BC_x = \frac{3}{5} BC$

$BC_Y = \frac{4}{5} BC$

$[\Sigma M_A = 0] \quad -400\text{#/ft}(10')(5') + \underbrace{\tfrac{4}{5}BC}_{BC_Y}(6') = 0$

$\underline{BC = 4167^{\#}}$

$BC_x = \frac{3}{5}(4167) = 2500^{\#}$

$BC_Y = \frac{4}{5}(4167) = 3334^{\#}$

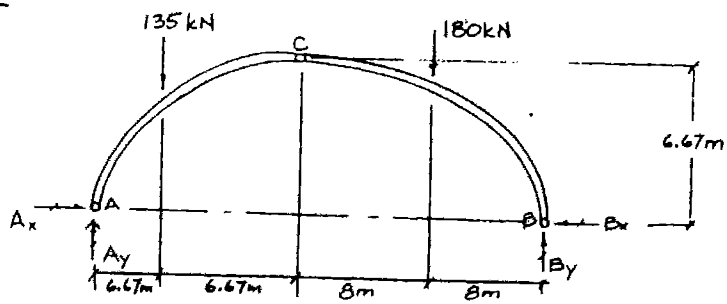
$[\Sigma F_x = 0] \quad -A_x + 2500^{\#} = 0$

$\underline{A_x = 2500^{\#} \leftarrow}$

$[\Sigma F_Y = 0] \quad +A_Y + 3334^{\#} - 400\text{#/ft}(10') = 0$

$\underline{A_Y = 666^{\#} \uparrow}$

3.30



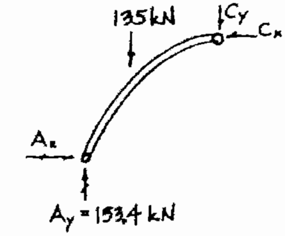
$[\Sigma M_B = 0] \quad +180\text{kN}(8\text{m}) + 135\text{kN}(22.67\text{m}) - A_Y(29.34\text{m}) = 0$

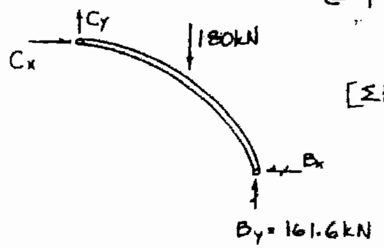
$\underline{A_Y = 153.4\text{ kN}}$

$[\Sigma F_Y = 0] \quad +153.4\text{kN} - 135\text{ kN} - 180\text{kN} + B_Y = 0$

$\underline{B_Y = 161.6\text{ kN}}$

3.30





$[M_C = 0]$ $+135\text{kN}(6.67\text{m}) - 153.4\text{kN}(13.33\text{m}) + A_x(6.67\text{m}) = 0;$

$$\underline{A_x = 171.6 \text{ kN}}$$

$[\Sigma F_x = 0]$ $+171.6\text{kN} - C_x = 0;$

$$\underline{C_x = 171.6 \text{ kN}}$$

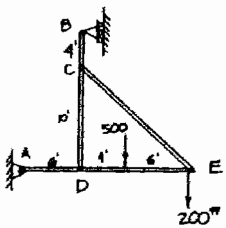
$[\Sigma F_y = 0]$ $+153.4\text{kN} - 135\text{kN} - C_y = 0$

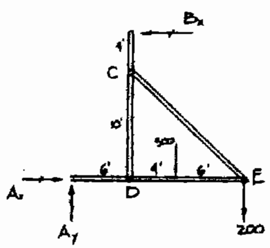
$$\underline{C_y = 18.4 \text{ kN}}$$

$[\Sigma F_x = 0]$ $+171.6\text{kN} - B_x = 0$

$$\underline{B_x = 171.6 \text{ kN}}$$

3.31





FBD ENTIRE FRAME

$[\Sigma M_A = 0]$ $+B_x(14) - 500(10) - 200(16') = 0$

$$\underline{B_x = 586^{\#} \leftarrow}$$

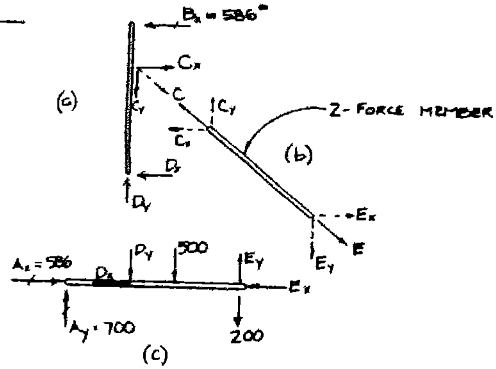
$[\Sigma F_x = 0]$ $+A_x - 586^{\#} = 0$

$$\underline{A_x = +586^{\#} \rightarrow}$$

$[\Sigma F_y = 0]$ $+A_y - 500 - 200 = 0$

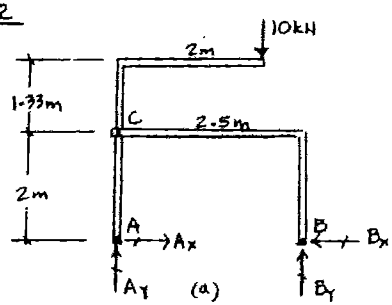
$$\underline{A_y = +700^{\#} \uparrow}$$

3.31



$C_x = 820^{\#}$
$C_y = 820^{\#}$
$D_x = 234^{\#}$
$D_y = 820^{\#}$
$E_x = 820^{\#}$
$E_y = 820^{\#}$

3.32



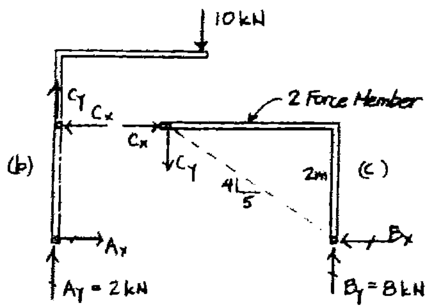
FBD(a)

$[\Sigma M_A = 0]\ -10kN(2m) + B_Y(2.5m) = 0$

$\underline{B_Y = 8kN}$

$[\Sigma F_Y = 0]\ -10kN + A_Y + 8kN = 0$

$\underline{A_Y = 2\ kN}$



FBD(c):

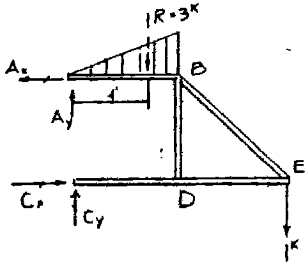
$[\Sigma M_c = 0]\ -B_x(2m) + 8kN(2.5m) = 0;\quad \underline{B_x = 10kN}$

$[\Sigma F_Y = 0]\ -C_Y + 8kN = 0;\quad \underline{C_Y = 8kN}$

$[\Sigma F_x = 0]\ +C_x - 10kN = 0;\quad \underline{C_x = 10kN}$

OR since member CB is a two force member use the slope relationship for C_x and C_Y.

3.33

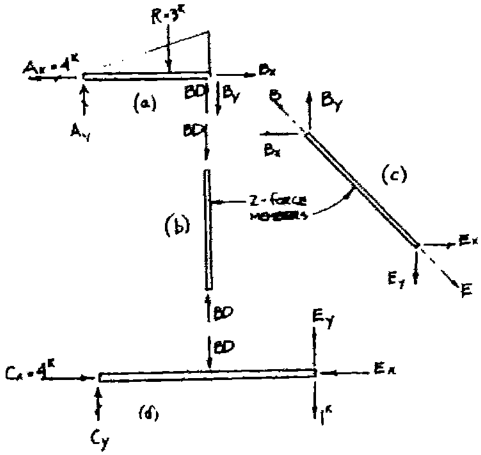


$[\Sigma M_C = 0] \quad -3^k(4') - 1^k(12') + A_x(6') = 0$

$\underline{A_x = +4^k} \leftarrow$

$[\Sigma M_A = 0] \quad -3^k(4') - 1^k(12') + C_x(6') = 0$

$\underline{C_x = +4^k} \rightarrow$



3.33 con't.

Part (a):

$[\Sigma M_B = 0] \quad +3^k(2') - A_y(6') = 0 \qquad \underline{A_y = 1^k \uparrow}$

Entire FBD:

$[\Sigma F_y = 0] \quad +1^k + C_y - 3^k - 1^k = 0 \qquad \underline{C_y = 3^k \uparrow}$

3.33

Part (d):

$[\Sigma M_E = 0]$ $\quad +BD(6') - 3^k(12') = 0 \qquad \underline{BD = +6^k}$

$[\Sigma F_y = 0]$ $\quad +3^k - 6^k + E_y - 1^k = 0 \qquad \underline{E_y = +4^k}$

$[\Sigma F_x = 0]$ $\quad +4^k - E_x = 0 \qquad \underline{E_x = 4^k}$

Part (c)

$[\Sigma F_y = 0]$ $\quad +B_y - 4^k = 0 \qquad \underline{B_y = 4^k}$

$[\Sigma F_x = 0]$ $\quad -B_x + 4^k = 0 \qquad \underline{B_x = 4^k}$

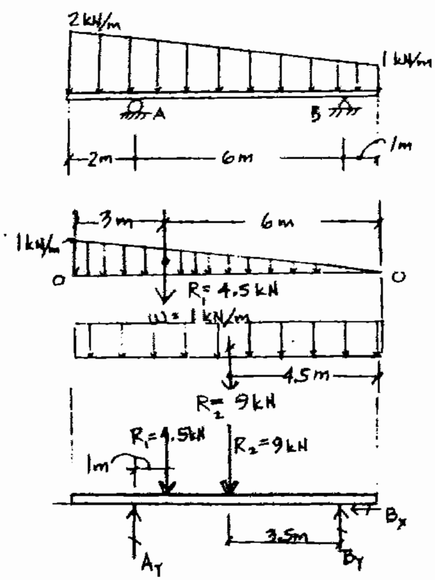
CHECK:

Part (a):

$[\Sigma F_x = 0]$ $\quad -\overset{A_x}{4^k} + \overset{B_x}{4^k} = 0$ ✓

$[\Sigma F_x = 0]$ $\quad +\overset{A_y}{1^k} - \overset{R}{3^k} + \overset{BD}{6^k} - \overset{B_y}{4^k} = 0$ ✓

3.34



Equivalent FBD

3.34

$[\Sigma F_x = 0]$ $\underline{B_x = 0}$

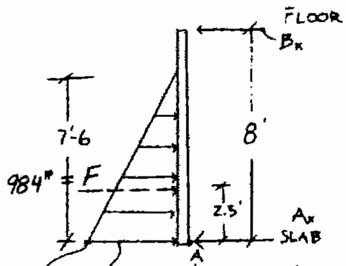
$[\Sigma M_B = 0]$ $+9\,kN(3.5m) + 4.5kN(5m) - A_Y(6m) = 0$

$$\underline{A_Y = 9\,kN}$$

$[\Sigma F_Y = 0]$ $\underset{(A_Y)}{+9\,kN} - 4.5kN - 9\,kN + B_Y = 0$

$$\underline{B_Y = 4.5\,kN}$$

3.35



$p = \gamma_{soil} h = 262.5^{\#}/ft^2$ $\quad \omega = p \times 1'\text{strip} = 262.5^{\#}/ft$

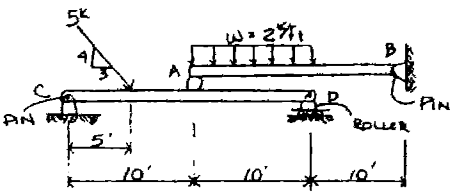
$F = \frac{wl}{2} = \frac{262.5(7.5)}{2} = 984^{\#}$

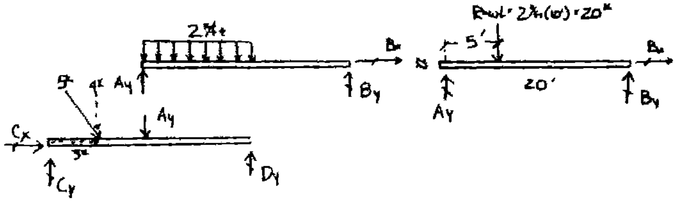
$[\Sigma M_A = 0]$ $B_x(8) - 984^{\#}(2.5) = 0$

$B_x = 308^{\#}$

$[\Sigma F_x = 0]$ $A_x = 984^{\#} - 308^{\#} = 676^{\#}$

3.36





UPPER BEAM: $[\Sigma F_x=0]$ $\underline{B_x=0}$

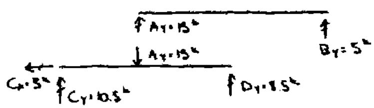
$[\Sigma M_B=0]$ $-A_y(20')+R(15')=0$ $\quad A_y=\frac{20^k(15')}{20'}=\underline{15^k}$

$[\Sigma M_A=0]$ $-20^k(5')+B_y(20')=0$ $\quad B_y=\underline{5^k}$

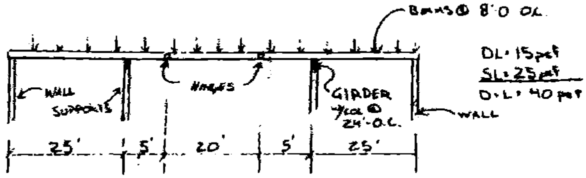
LOWER BEAM: $[\Sigma F_x=0]$ $+C_x+3^k=0$ $\therefore C_x=\underline{\underline{-3^k}}$ $\quad C_x=3^k\leftarrow$

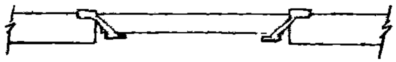
$[\Sigma M_C=0]$ $-4^k(5')-15^k(10')+D_y(20')=0$ $\quad \underline{D_y=8.5^k}$

$[\Sigma F_y=0]$ $+C_y-4^k-15^k+8.5^k=0$ $\quad C_y=\underline{10.5^k}$

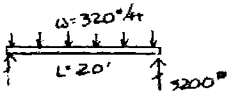


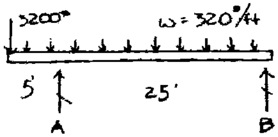
337





$\omega = 40\text{psf} \cdot 8' = 320^{\#}/\text{ft}$





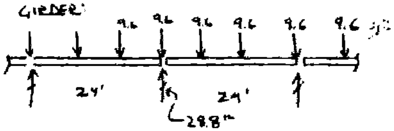
$[\Sigma M_B = 0]\quad -3200(30') - 320^{\#}/_{ft}(30')(15') + A(25') = 0$

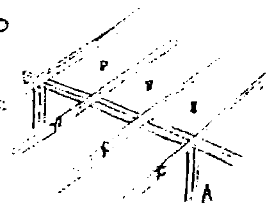
$\underline{A = 9600^{\#}}$

$[\Sigma F_y = 0]\quad -3200 - (320 \times 30) + 9600 + B = 0$

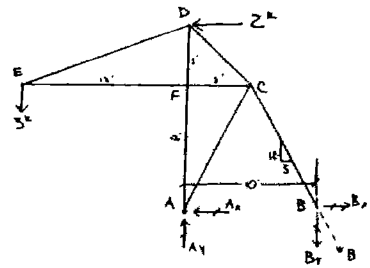
$\underline{B = 3200^{\#}}$

GIRDER:





3.38



LINE OF ACTION OF RESULTANT REACTION B IS KNOWN (2-FORCE MEMBER)

$B_x = \frac{5}{13}B$

$B_y = \frac{12}{13}B$

$[\Sigma M_A = 0]$ $+3^k(12') + 2^k(17') - \frac{12}{13}B(10') = 0$

$B = \frac{13}{12}\left(\frac{36+34}{10}\right)$ $\quad B = 7.6^k$ $\quad \underline{B_x = 2.91^k}$

$\underline{B_y = 7^k}$

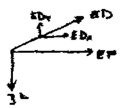
$[\Sigma F_x = 0]$ $-2^k - A_x + 2.91^k = 0$

$\underline{A_x = .91^k}$

$[\Sigma F_y = 0]$ $-3^k + A_y - 7^k = 0$

$\underline{A_y = +10^k}$

JOINT E:

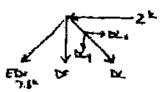


$ED_x = \frac{12}{13}ED \qquad ED_y = \frac{5}{13}ED$

$[\Sigma F_y = 0]$ $+\frac{5}{13}ED - 3^k = 0$ $\qquad \underline{ED = +7.8^k}$ (T)

$[\Sigma F_x = 0]$ $+\frac{12}{13}(7.8^k) + EF = 0$ $\qquad \underline{EF = -7.2^k}$ (C)

JOINT D:



$DC_x = .707DC \qquad DC_y = .707DC$

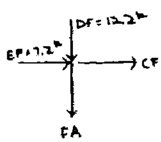
$[\Sigma F_x = 0]$ $-\frac{12}{13}(7.8^k) - 2^k + .707DC = 0$

$\underline{DC = 13^k}$ (T)

$[\Sigma F_y = 0]$ $-\frac{5}{13}(7.8^k) - DF - .707(13^k) = 0$

$\underline{DF = -12.2^k}$ (C)

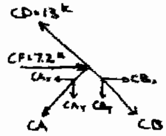
JOINT F:



$[\Sigma F_x = 0]$ $+7.2 + CF = 0$ $\quad \underline{CF = -7.2^k}$ (C)

$[\Sigma F_y = 0]$ $-12.2^k - FA = 0$ $\quad \underline{FA = -12.2^k}$ (C)

JOINT C:

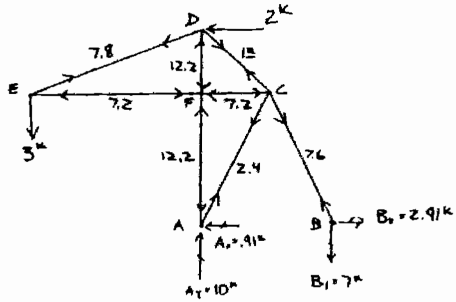


$$\left[\Sigma F_x = 0\right] \; +7.2^k - .707(13^k) - \tfrac{5}{13}CA + \tfrac{5}{13}CB = 0$$

$$\left[\Sigma F_y = 0\right] \; +.707(13^k) - \tfrac{12}{13}CA - \tfrac{12}{13}CB = 0$$

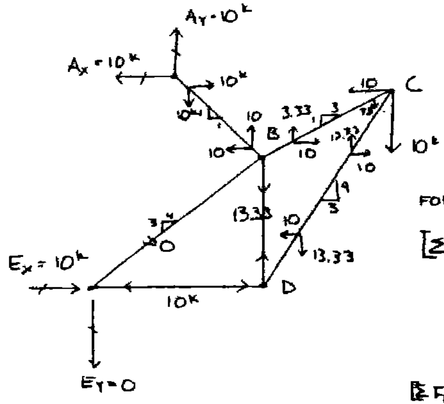
$\underline{CB = 7.6^k}$ (T)

$\underline{CA = 2.4^k}$ (T)



FORCE SUMMATION DIAGRAM

3.39



FOR SUPPORT REACTIONS:

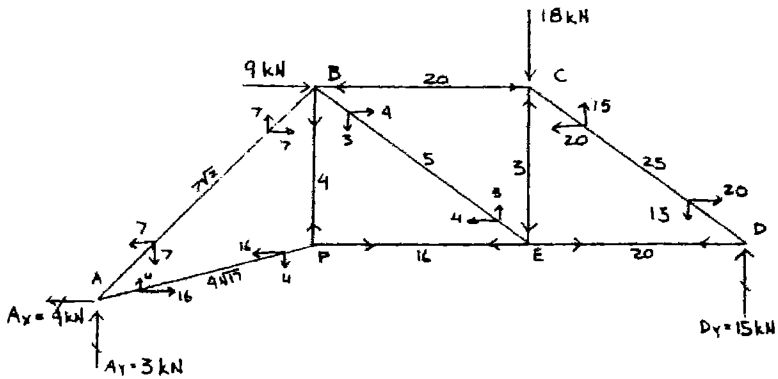
$$[\Sigma M_E = 0] \quad -10^k(14') + \underbrace{\tfrac{A}{\sqrt{2}}}_{A_x}(10') + \underbrace{\tfrac{A}{\sqrt{2}}}_{A_Y}(4') = 0$$

$\underline{A = 10\sqrt{2}^{\,k}}$; $\underline{A_x = 10^k}$; $\underline{A_Y = 10^k}$

$[\Sigma F_x = 0] \quad +E_x - 10^k = 0 \qquad \underline{E_x = 10^k \rightarrow}$

$[\Sigma F_Y = 0] \quad -E_Y + 10^k - 10^k = 0 \qquad \underline{E_Y = 0}$

3.40



$[\Sigma M_A = 0] \quad +D_Y(12\text{m}) - 18\text{kN}(8\text{m}) - 9\text{kN}(4\text{m}) = 0$

$\underline{D_Y = 15\text{kN}} \uparrow$

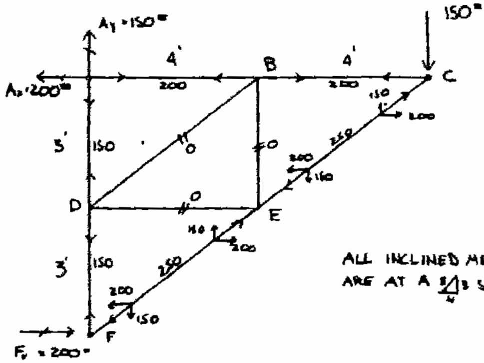
$[\Sigma F_Y = 0] \quad A_Y - 18\text{kN} + 15\text{kN} = 0$

$\underline{A_Y = 3\text{kN} \uparrow}$

$[\Sigma F_x = 0] \quad -A_x + 9\text{kN} = 0$

$\underline{A_x = 9\text{kN} \leftarrow}$

3.41



ALL INCLINED MEMBERS ARE AT A 3/4 SLOPE

$[\Sigma M_A = 0]$ $-150(8') + F_x(6') = 0$

$\underline{F_x = 200\#}$

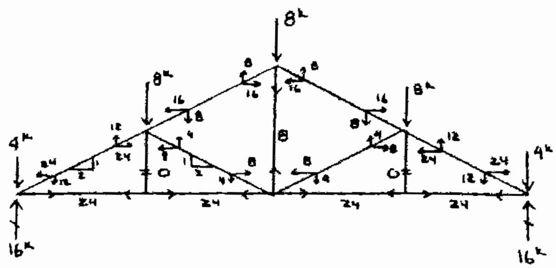
$[\Sigma F_x = 0]$ $200\# - A_x = 0$

$\underline{A_x = 200\#}$

$[\Sigma F_y = 0]$ $-150\# + A_Y = 0$

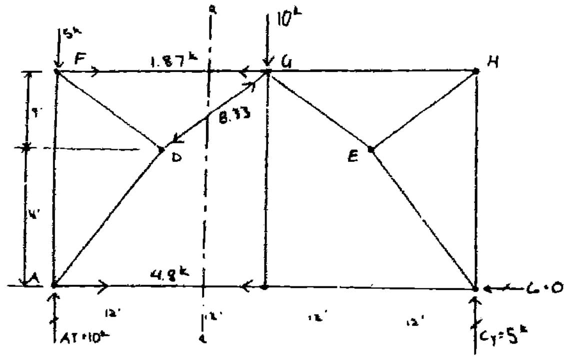
$\underline{A_Y = 150\#}$

3.42



SYMMETRICAL SO FORCES ARE EQUAL ON EACH SIDE

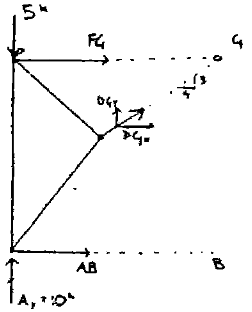
3.43



$[\Sigma F_x = 0]$ $\underline{C_x = 0}$

$[\Sigma M_A = 0]$ $-10^k(24') + C_y(48') = 0$ $\quad \underline{C_y = 5^k \uparrow}$

$[\Sigma F_y = 0]$ $-5^k - 10^k + 5^k + A_y = 0$ $\quad \underline{A_y = 10^k \uparrow}$



$DG_Y = \frac{3}{5} DG \qquad DG_X = \frac{4}{5} DG$

$[\Sigma F_Y = 0]$ $+DG_Y - 5^k + 10^k = 0$

$DG_Y = -5^k$

$\therefore$ DG is in compression

$DG = \frac{5}{3} DG_Y = \frac{5}{3}(-5) = -8.33^k\ (C)$

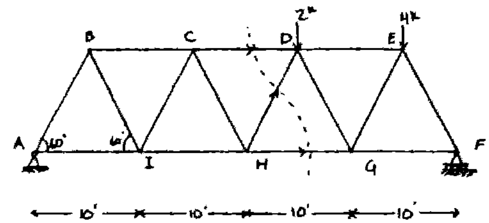
$[\Sigma M_G = 0]$ $+5^k(24') - 10^k(24') + AB(25') = 0$

$AB = \frac{240 - 120}{25} = +4.8^k\ (T)$

$[\Sigma F_x = 0]$ $+ FG + DG_x + AB = 0$

$FG = -(\frac{4}{5})(-5) - 4.8^k = 6.67^k - 4.8^k = 1.87^k\ (T)$

3.44



$\Sigma M_A = 0 \qquad 2(25') + 4(35') = F_y(40')$

$F_y = \frac{50 + 140}{40'} = \frac{19}{4} = 4.75^k$

$\therefore A_y = -6.0^k + 4.75^k = 1.25^k$

3.44

$\Sigma M_D = 0 \qquad 1.25(25') = GH(5\sqrt{3})$

$$GH = \frac{5(1.25)}{1.73} = 3.61^k \ (T)$$

$\Sigma M_H = 0 \qquad CD(5\sqrt{3}) = -20(1.25)$

$$CD = -25/5\sqrt{3} = -5/\sqrt{3} = -2.89^k \ (C)$$

$\Sigma M_C = 0 \qquad 1.25(15) - 5\sqrt{3}(DH) - 3.61(5\sqrt{3}) = 0$

$$5\sqrt{3}(DH) = 1.25(15) - 3.61(5\sqrt{3})$$

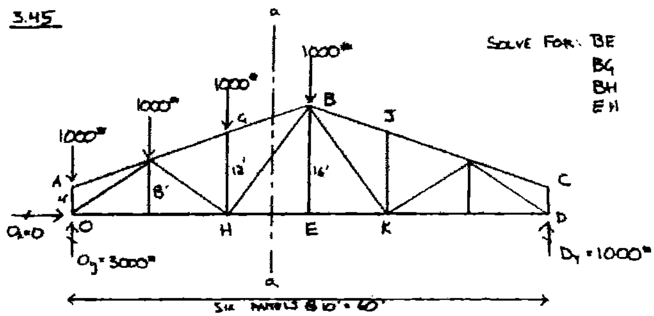
$$DH = \frac{1.25(15)}{5\sqrt{3}} - 3.61$$

$$= 1.25\sqrt{3} - 3.61$$

$$= 2.16 - 3.61$$

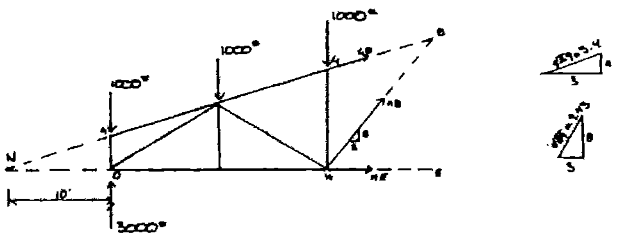
$$= -1.45^k \ (C)$$

3.45



Solve for: BE
BG
BH
EH

$\underline{BE = 0} \longrightarrow$ ZERO FORCE MEMBER



3.45

FOR BG: $BG_x = \frac{5}{5.4} BG$; $BG_y = \frac{2}{5.4} BG$

$[\Sigma M_H = 0]$ $-3000^{\#}(20') - \left(\frac{5BG}{5.4}\right)(12') + 1000(20') + 1000(10') = 0$ $\underline{BG = -2700^{\#} (C)}$

FOR HE:

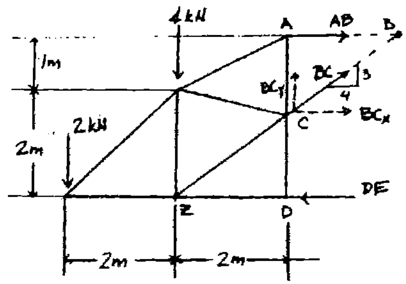
$[\Sigma M_B = 0]$ $-3000^{\#}(30') + HE(16') + 1000(10') + 1000(20') + 1000(30') = 0$

$\underline{HE = +1875^{\#} (T)}$

FOR HB: $HB_Y = \frac{8HB}{9.43}$

$[\Sigma M_H = 0]$ $+3000^{\#}(10') + \frac{8HB}{9.43}(30') = 0$ $\underline{HB = 1179^{\#} (T)}$

3.46



$$[\Sigma M_B = 0] \ +2\,kN(4m) + 4\,kN(2m) - DE\,(3m) = 0$$

$DE = \frac{16\,kN\text{-}m}{3m}$; $\underline{DE = 5.33\,kN}$ (comp.)

$$[\Sigma M_I = 0] \ +2\,kN(2m) - AB\,(3m) = 0$$

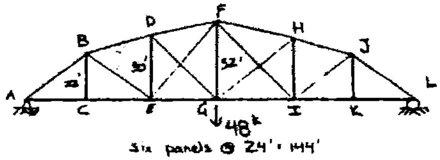
$\underline{AB = 1.33\,kN}$ (Tension)

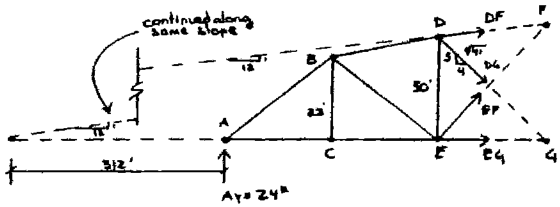
$$[\Sigma F_Y = 0] \ -2\,kN - 4\,kN + \tfrac{3}{5} BC = 0$$

$BC = \frac{5}{3}(6\,kN)$

$\underline{BC = 10\,kN}$ (Tension)

3.47





IN THIS CASE, A MOMENT EQUATION WILL BE USED TO DETERMINE EFFECTIVE TENSION COUNTER. $\therefore EF = 0$

COUNTER:

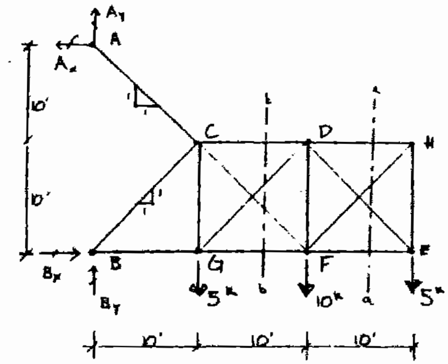
$[\Sigma M_O = 0]$ A_Y CAUSES A ↺ ROTATION ABOUT pt. O
THE ONLY COUNTER (IN TENSION) TO RESIST THIS IS DG WHICH GIVES A ↻ ROTATION ABOUT pt. O

$$\therefore [\Sigma M_O = 0]\ \underbrace{\frac{4DG}{\sqrt{41}}}_{DG_X}(30') - \underbrace{\frac{5DG}{\sqrt{41}}}_{DG_Y}(360') + A_Y(312') = 0 \qquad \underline{DG = +25^k\ (t)}$$

$$DF:\ [\Sigma M_G = 0]\ \underbrace{\frac{12DF}{\sqrt{145}}}_{DF_X}(30') - \underbrace{\frac{DF}{\sqrt{145}}}_{DF_Y}(24') - 24^k(72') = 0 \qquad \underline{DF = -54.2^k\ (c)}$$

$$EG:\ [\Sigma M_D = 0]\ -24^k(48') + EG(30') = 0 \qquad \underline{EG = +38.4^k\ (t)}$$

3.48



$A_x = \frac{A}{\sqrt{2}}$

$A_Y = \frac{A}{\sqrt{2}}$

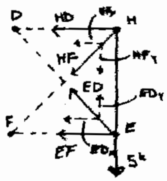
$[\Sigma M_B = 0]$ $-A_x(20') - 5^k(10') - 10'(20') - 5^k(30') = 0$

$\underline{A_x = 20^k}$ $\therefore$ $\underline{A_Y = 20^k}$ $\therefore$ $\underline{A = 20\sqrt{2}^{\,k}}$

$[\Sigma F_Y = 0]$ $+\underbrace{20^k}_{A_Y} - 5^k - 5^k - 10^k + B_Y = 0$

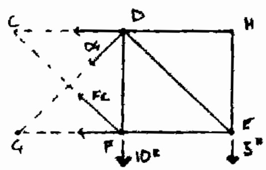
$\underline{B_Y = 0}$

$[\Sigma F_x = 0]$ $+B_x - \underbrace{20^k}_{A_x} = 0$ $\underline{B_x = 20^k}$



$[\Sigma F_Y = 0]$ $+ED_Y - 5^k = 0$

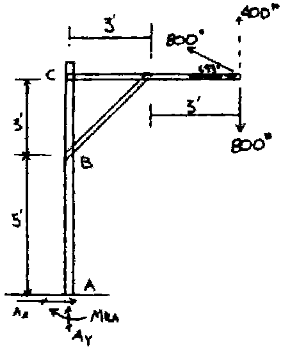
$\underline{ED_Y = 5^k}$; $\underline{ED = 5\sqrt{2}^{\,k}}$



$[\Sigma F_Y = 0]$ $+FC_Y - 10^k - 5^k = 0$

$\underline{FC_Y = 15^k}$; $\underline{FC = 15\sqrt{2}^{\,k}}$

3.49



$[\Sigma F_y=0]\ +A_Y+400-800=0$

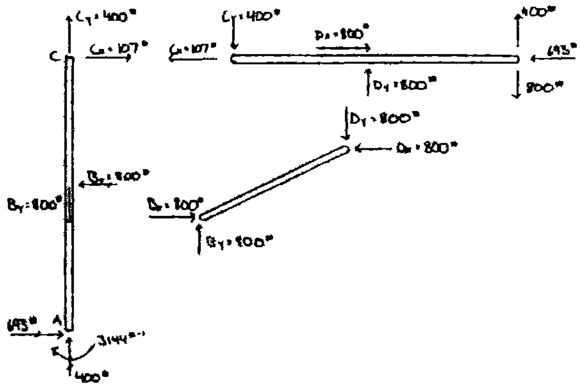
$\underline{A_Y=400^{\#}\ \uparrow}$

$[\Sigma F_x=0]\ +A_x-693^{\#}=0$

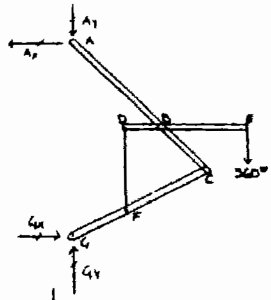
$\underline{A_x=693^{\#}\ \rightarrow}$

$[\Sigma M_A=0]\ -M_{RA}+693(8')+400(6')-800(6')=0$

$\underline{M_{RA}=+3144^{\#\text{-}'}}$



3.50



$[\Sigma M_G=0]\; +A_x(9') - 360\#(8') = 0$

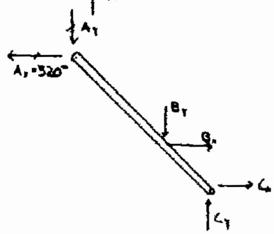
$\underline{A_x = 320\# \leftarrow}$

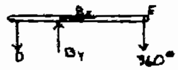
$[\Sigma F_x=0]\; \underline{G_x = 320\# \rightarrow}$

$\underline{G_Y = 320\# \downarrow}$

$[\Sigma F_Y=0]\; -A_Y - 320\# - 360\# = 0$

$\underline{A_Y = -680\# \uparrow}$





$[\Sigma F_x=0]\; \underline{B_x=0}$

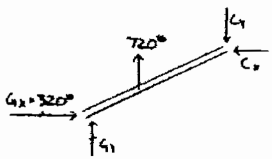
$[M_D=0]\; \underline{B_Y = 1080\#}$

$[\Sigma F_Y=0]\; \underline{D = 720\# = F}$

CHECK:

$[\Sigma F_Y=0]\; -(-680) - 1080 + 400 = 0$

$0=0$ ✓



$[\Sigma F_x=0]\; \underline{C_x = 320\#}$

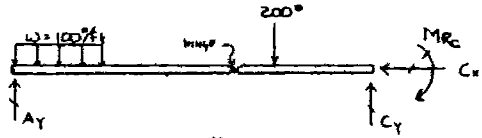
$[\Sigma M_C=0]\; -G_Y(6') + 320\#(3') - 720\#(4') = 0$

$\underline{G_Y = -320\#}$

$[\Sigma F_Y=0]\; -320\# + 720\# - C_Y = 0$

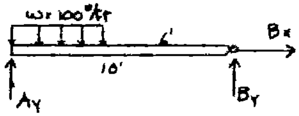
$\underline{C_Y = 400\#}$

3.51

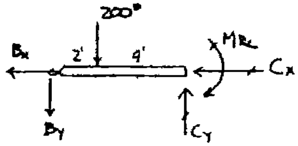


FBD(a)

SPLITTING INTO TWO SEGMENTS:



FBD(b)



FBD(c)

FBD(b)

$[\Sigma F_x = 0]$ $\underline{B_x = 0}$

$[\Sigma M_A = 0]$ $-100\#/ft(4')(2') + B_Y(10') = 0$

$\underline{B_Y = +80\#}$

$[\Sigma F_Y = 0]$ $+A_Y - 100\#/ft(4') + 80\# = 0$

$\underline{A_Y = 320\#}$

FBD(c)

$[\Sigma F_x = 0]$ $\underline{C_x = 0}$

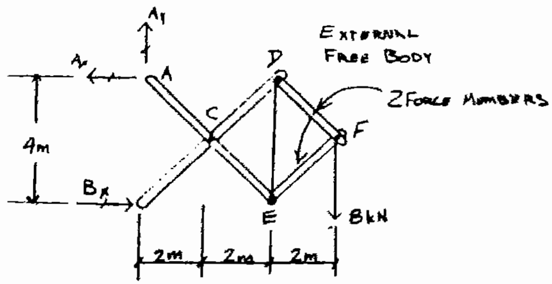
$[\Sigma F_Y = 0]$ $-80\# - 200\# + C_Y = 0$

$\underline{C_Y = 280\#}$

$[\Sigma M_C = 0]$ $+80\#(6') + 200\#(4') - M_{R_C} = 0$

$\underline{M_{R_C} = +1280\#\text{-ft}}$

3.52



$[\Sigma M_A = 0]$ $-8\,\text{kN}(6\,\text{m}) + B(4\,\text{m}) = 0$; $\underline{B_x = 12\,\text{kN}} \rightarrow$

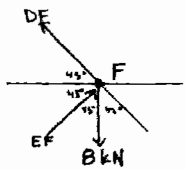
$[\Sigma F_x = 0]$ $-A_x + B_x = 0$; $\underline{A_x = 12\,\text{kN}} \leftarrow$

$[\Sigma F_y = 0]$ $+A_Y - 8\,\text{kN} = 0$; $\underline{A_Y = 8\,\text{kN}} \uparrow$

Joint F:

$[\Sigma F_x = 0]$ $-.707DF + .707EF = 0$; $DF = EF$

$[\Sigma F_Y = 0]$ $+.707DF + .707EF - 8\,\text{kN} = 0$

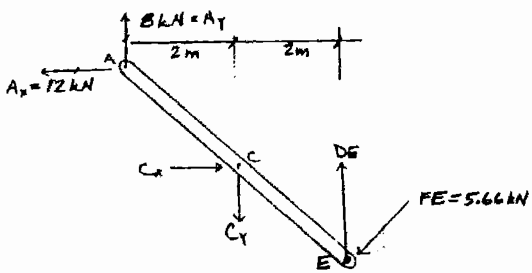


Since $DF = EF$

$2(.707DF) = 8\,\text{kN}$

$\underline{DF = 5.66\,\text{kN}\ \text{(Tension)}}$

$\underline{EF = 5.66\,\text{kN}\ \text{(Comp.)}}$



3.52

$[\Sigma M_C = 0]\ +12\,kN(2m) - 8\,kN(2m) + DE(2m) - 5.66\,kN(2\sqrt{2}\,m) = 0$

$\underline{DE = 8\,kN}$ (Tension)

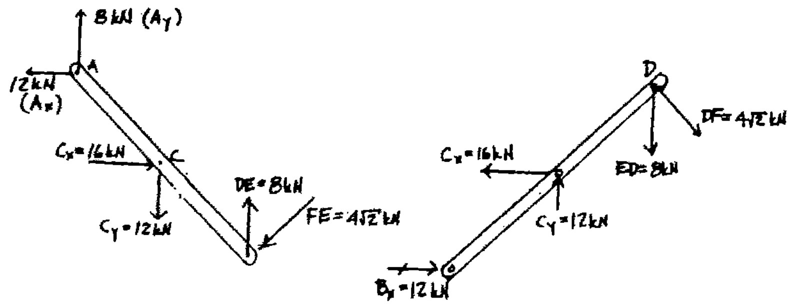
$[\Sigma F_x = 0]\ C_x - 12\,kN - (.707)(5.66\,kN) = 0$

$\underline{C_x = 16\,kN}$

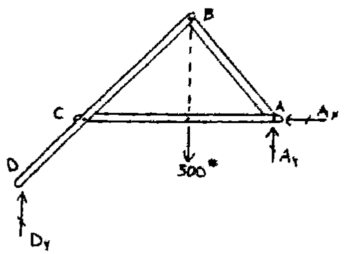
$[\Sigma F_y = 0]\ +\underset{(A_y)}{8\,kN} - C_y + \underset{(DE)}{8\,kN} - (.707)(5.66\,kN) = 0$

$\underline{C_y = 12\,kN}$

Solutions:



3.53



$[\Sigma F_x = 0]\ \underline{A_x = 0}$

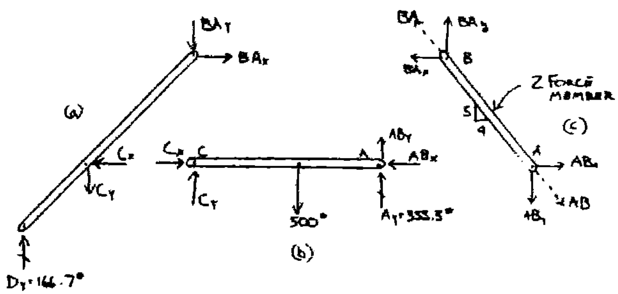
$[\Sigma M_A = 0]\ -D_y(12') + 500^{\#}(4') = 0$

$\underline{D_y = 166.7^{\#} \uparrow}$

$[\Sigma F_y = 0]\ +166.7^{\#} - 500^{\#} + A_y = 0$

$\underline{A_y = +333.3^{\#} \uparrow}$

RESOLVE FRAME INTO ITS COMPONENTS



353

FIG. (b): $[\Sigma M_A = 0]\ -C_Y(9') + 500^{\#}(4') = 0;\quad \underline{C_Y = 222.2^{\#}}$

$[\Sigma F_Y = 0]\ +222.2^{\#} - 500^{\#} - 333.3^{\#} + AB_Y = 0;\quad \underline{AB_Y = -55.5^{\#}}$

FIG (c): $[\Sigma M_B = 0]\ -55.5(4') + AB_x(5') = 0;\quad \underline{AB_x = -44.4^{\#}}$

$[\Sigma F_x = 0]\ -BA_x + AB_x = 0;\quad \underline{BA_x = -44.4^{\#}}$

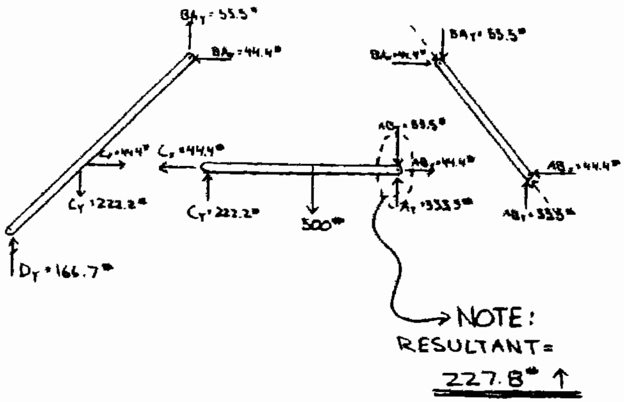
$[\Sigma F_Y = 0]\ +BA_Y - (-55.5^{\#}) = 0;\quad \underline{BA_Y = -55.5^{\#}}$

FIG (b): $[\Sigma F_x = 0]\ C_x - (44.4^{\#}) = 0;\quad \underline{C_x = -44.4^{\#}}$

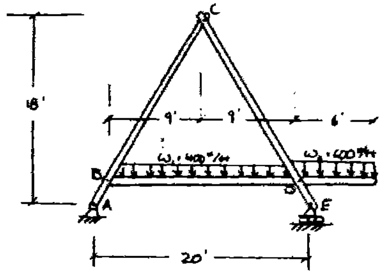
FIG (a): CHECK

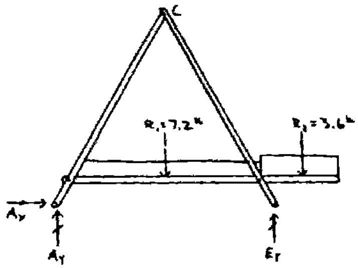
$[\Sigma F_Y = 0]\ \underset{D_Y}{+166.7^{\#}} - \underset{C_Y}{222.2^{\#}} - \underset{BA_Y}{(-55.5^{\#})} = 0$ CHECK

$[\Sigma F_x = 0]\ -\underset{C_x}{(-44.4^{\#})} + \underset{BA_x}{(-44.4^{\#})} = 0$ CHECK



3.54





$R_1 = 400^{\#}/ft\ (18') = 7{,}200^{\#}$
$R_2 = 600^{\#}/ft\ (6') = 3{,}600^{\#}$

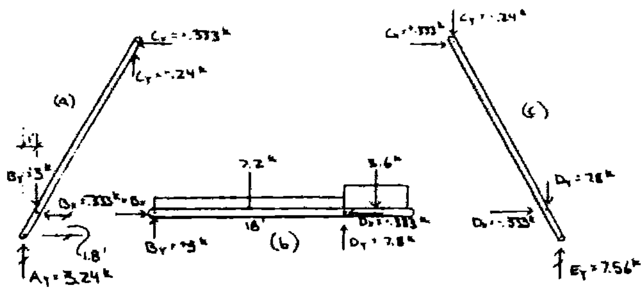
$[\Sigma M_A = 0]$ $E_Y(20') - 7.2^k(9') - 3.6^k(22') = 0$

$\underline{E_Y = 7.56^k}$

$[\Sigma F_Y = 0]$ $+A_Y - 7.2^k - 3.6^k + 7.56^k = 0$

$\underline{A_Y = 3.24^k}$

$[\Sigma F_x = 0]$ $\underline{A_x = 0}$



FBD (b): $[\Sigma M_D = 0]\ -B_Y(18') + 7.2(9') - 3.6(3') = 0;$ $\underline{B_Y = +3^k}$

$[\Sigma F_Y = 0]\ +3^k + D_Y - 3.6^k - 7.2^k = 0;$ $\underline{D_Y = 7.8^k}$

FBD (a): $[\Sigma F_Y = 0]\ +3.24 - 3^k + C_Y = 0;$ $\underline{C_Y = -.24^k}$

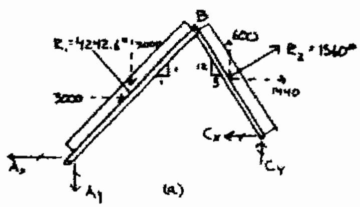
$[\Sigma M_B = 0]\ +C_x(16.2') - 3.24(1') + (-.24)(9') = 0$ $\underline{C_x = .333^k}$

$[\Sigma F_x = 0]\ -B_x - .333 = 0;$ $\underline{B_x = -.333^k}$

FBD (b): $[\Sigma F_x = 0]\ -.333 - D_x = 0;$ $\underline{D_x = -.333^k}$

CHECK: FBD (c) $\underbrace{+.333^k}_{C_x} + \underbrace{(-.333^k)}_{D_x} = 0;$ $0 = 0$

3.55



$R_1 = 100^{\#}/_{ft}\,(30' \cdot \sqrt{2}) = 4242.6^{\#}$

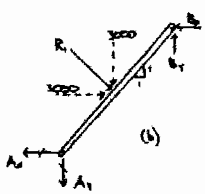
$R_2 = 60^{\#}/_{ft}\,(\tfrac{13}{12} \cdot 24') = 1560^{\#}$

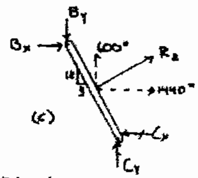
$R_{1x} = 3000^{\#}$

$R_{1y} = 3000^{\#}$

$R_{2x} = \tfrac{12}{13}(1560) = 1440^{\#}$

$R_{2y} = \tfrac{5}{13}(1560) = 600^{\#}$





<u>SOLVE SIMUTANEOUSLY</u>

$[\Sigma M_A = 0]\; -3000(15) - 3000(15) + B_x(30) - B_y(30) = 0$

$\underline{B_x = 286^{\#} \leftarrow}$

$\underline{B_y = 2714^{\#} \uparrow}$

$[\Sigma F_x = 0]\; +3000 - 286 - A_x = 0$

$\underline{A_x = 2714^{\#} \leftarrow}$

$[\Sigma F_y = 0]\; -3000 + 2714 - A_y = 0$

$\underline{A_y = 286^{\#} \uparrow}$

$[\Sigma M_C = 0]\; -600(5') - 1440(12') - B_x(24') + B_y(10') = 0$

$\underline{B_x = 286^{\#} \rightarrow}$

$\underline{B_y = 2714^{\#} \downarrow}$

$[\Sigma F_x = 0]\; +1440 + 286 - C_x = 0$

$\underline{C_x = 1726^{\#} \leftarrow}$

$[\Sigma F_y = 0]\; -2714 + 600 + C_y = 0$

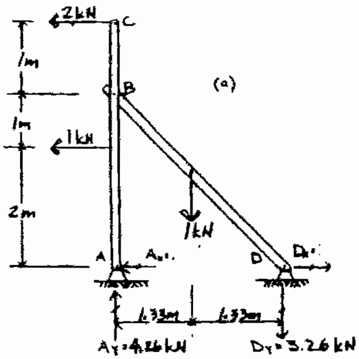
$\underline{C_y = 2114 \uparrow}$

CHECK; FBD (a)

$[\Sigma F_x = 0]\; +3000 + 1440 - \underbrace{2714}_{A_x} - \underbrace{1726}_{C_x} = 0$ ✓

$[\Sigma F_y = 0]\; -3000 + 600 + \underbrace{286}_{A_y} + \underbrace{2114}_{C_y} = 0$ ✓

3.56



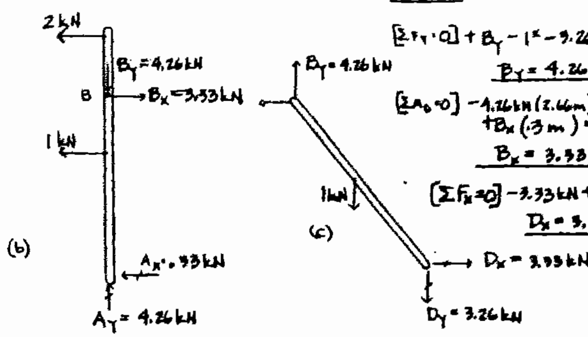
FBD (a)

$[\Sigma M_A = 0]$ $+2kN(4m) + 1kN(2m) - 1kN(1.33m) - D_Y(2.66m) = 0$

$D_Y = 3.26\ kN$

$[\Sigma F_Y = 0]$ $+A_Y - 1kN - 3.26\ kN = 0$

$A_Y = 4.26\ kN \uparrow$



FBD (c)

$[\Sigma F_Y = 0]$ $+B_Y - 1^k - 3.26kN = 0$

$B_Y = 4.26\ kN$

$[\Sigma M_D = 0]$ $-4.26kN(2.66m) + 1kN(1.33m) + B_x(3m) = 0$

$B_x = 3.33\ kN$

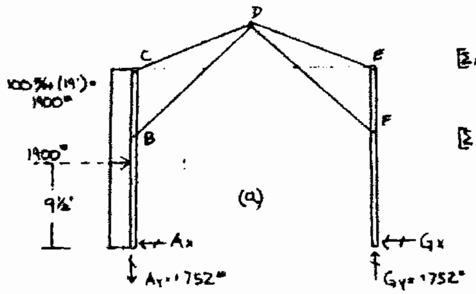
$[\Sigma F_x = 0]$ $-3.33kN + D_x = 0$

$D_x = 3.33\ kN$

$[\Sigma F_x = 0]$ $-2^k - 1^k + 3.33^k - A_x = 0$

$A_x = .33^k \leftarrow$

3.57

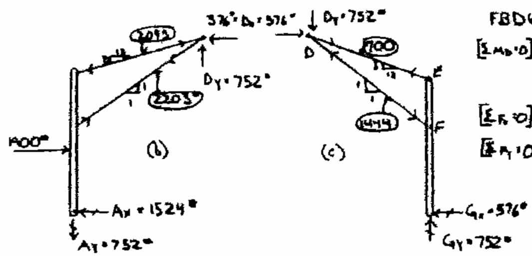


$[\Sigma M_A = 0]$ $-1900^{\#}(9.5') + G_Y(24') = 0$

$\underline{G_Y = 752^{\#}}$

$[\Sigma F_Y = 0]$ $-A_Y + 752^{\#} = 0$

$\underline{A_Y = 752^{\#}}$



FBD(c)

$[\Sigma M_D = 0]$ $+752^{\#}(12') - G_X(24') = 0$

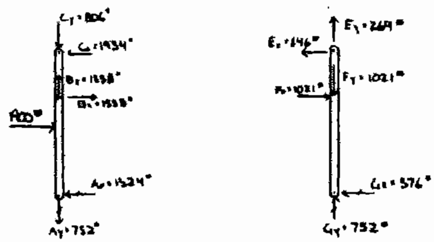
$\underline{G_X = 376^{\#}}$

$[\Sigma F_X = 0]$ $\underline{D_X = 376^{\#}}$

$[\Sigma F_Y = 0]$ $\underline{D_Y = 752^{\#}}$

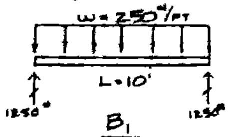
$[\Sigma F_X = 0]$ $+1900 - A_X - 376^{\#} = 0$

$\underline{A_X = 1524^{\#}}$

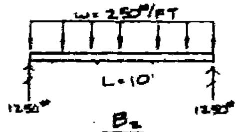


4.1

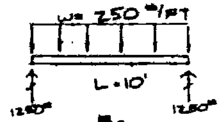
$$\omega = 50^{\#}/\text{FT}^2 \times 5' = \underline{250^{\#}/\text{FT}}$$



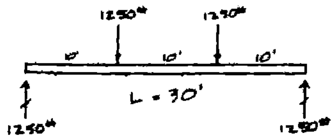
B1



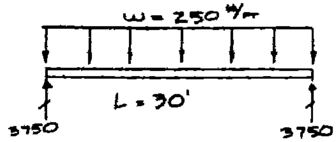
B2



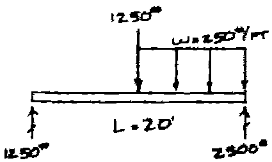
B3



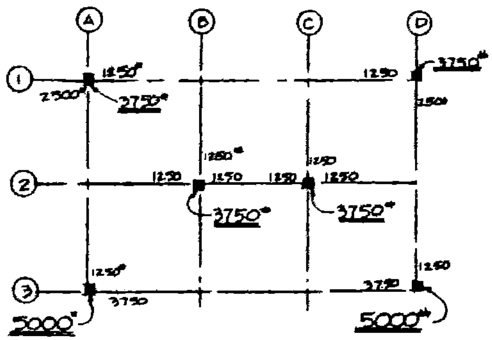
G1



G2



G3

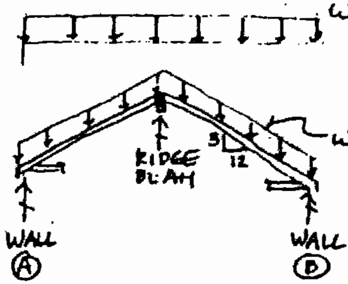


4.2

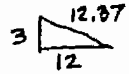
ROOF

$w_{snow} = 25\#/ft^2 \times 2' = 50\#/ft$

Rafter spacing



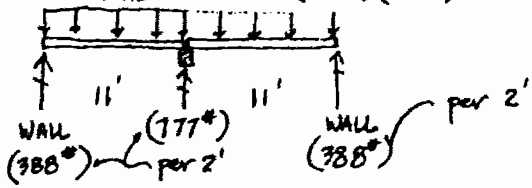
$w_{DL} = 10\,psf \times 2' = 20\#/ft.$



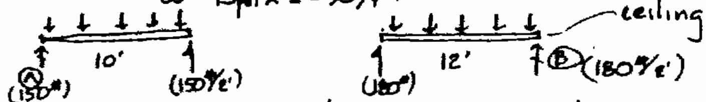
Slope conversion: $\frac{12.37}{12}$

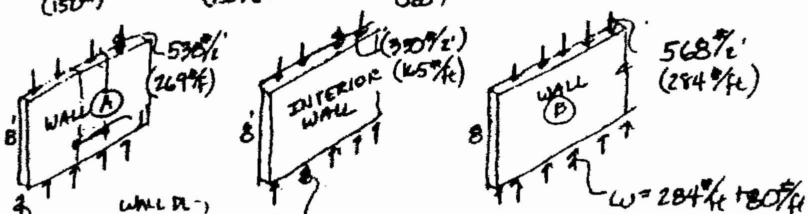
EQUIVALENT
Rafter projected horizontally

$w_{TOTAL} = 50\#/ft + \left(\frac{12.37}{12}\right)(20\#/ft) = 70.6\#/ft.$



$w = 15\,psf \times 2' = 30\#/ft.$





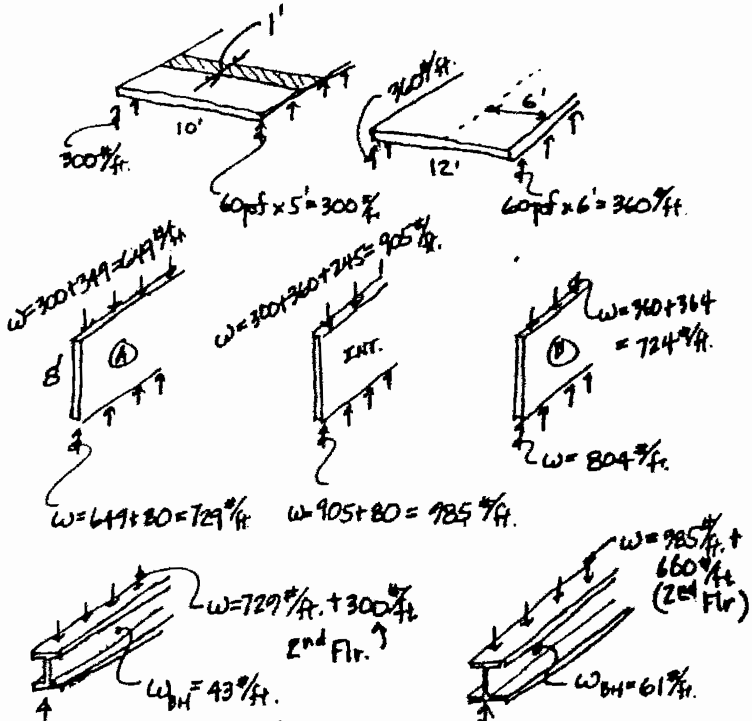
$w = 269\#/ft + 80\#/ft$
$w = 349\#/ft$

$w = 165\#/ft + 80\#/ft$
$w = 245\#/ft$

$w = 284\#/ft + 80\#/ft$
$w = 364\#/ft$

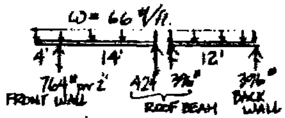
4.2

2ND FLOOR D+L = 60psf



ω_{TOTAL} = 1072#/ft.	ω_{TOTAL} = 1706#/ft.
L = 20'	L = 28'
Reaction = 10,720#	Reaction = 23,884#

4.3



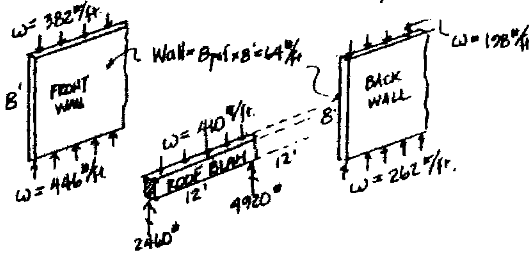
Roof Loads:

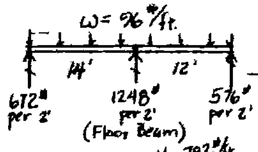
Snow = 20 psf

Roofing = 5 psf
Sheathing = 3 psf
Rafters = 3 psf
Ceiling = 2 psf
} 13 psf

DL+SL = 33 psf

ω = 33 psf × 2' = 66 #/ft.





Floor Joists

Floor Loads:

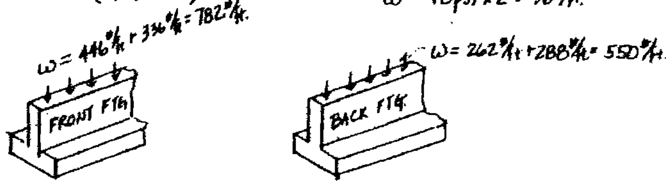
Occupancy = 40 psf

Floor = 5 psf

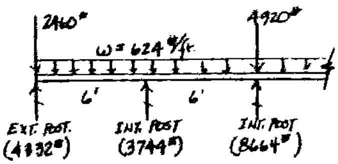
Joist = 3 psf

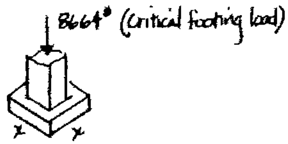
D+L = 48 psf

ω = 48 psf × 2' = 96 #/ft.



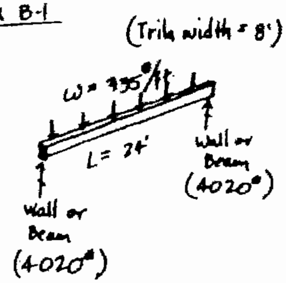
Floor Beam:





4.4

BEAM B-1



$SL = 25\text{psf} \times 8' = 200\text{#/ft.}$

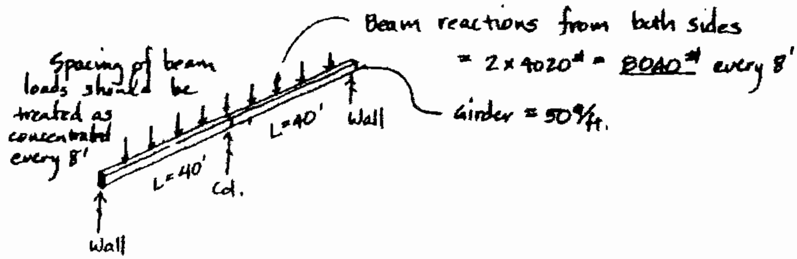
$DL = 15\text{psf} \times 8' = 120\text{#/ft}$

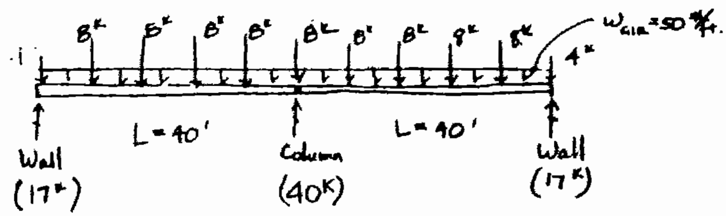
$W_{D+SL} = 320\text{#/ft.}$

$W_{BM} = 15\text{#/ft.}$

$W_{TOTAL} = 335\text{#/ft.}$

GIRDER G-1

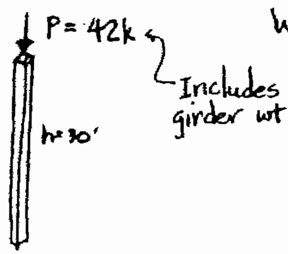




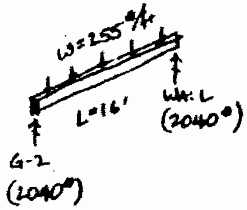
GIRDER WT. = $50\text{#/ft} \times 40\text{ft.}$

$W_{GIR} = 2000\# = 2k$

COLUMN



Beam B-2 : (Tributary width = 6')



ω_{SL} = 25 psf × 6' = 150 #/ft.

ω_{LL} = 15 psf × 6' = 90 #/ft.

ω_{BM} = 15 #/ft.

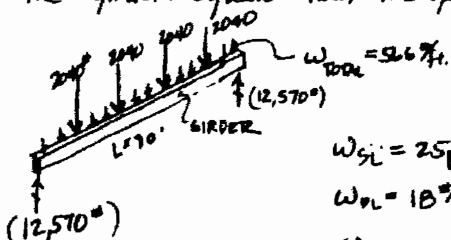
ω_{TOTAL} = 255 #/ft.

GIRDER G-2 :

Beam reactions are treated as concentrated loads spaced @ 6' o.c.

Truss joists are spaced close together (2' o.c. or less) therefore, may be treated as a distributed load on the girder G-2.

The tributary width of load from the truss joists onto the girder equals half the span or 12'.



ω_{SL} = 25 psf × 12' = 300 #/ft.

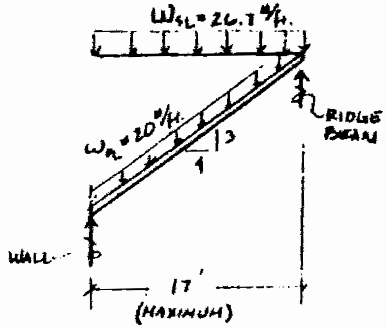
ω_{DL} = 18 #/ft² × 12' = 216 #/ft.

ω_{GIR} = 50 #/ft

ω_{TOTAL} = 566 #/ft.

4.5

CRITICAL ROOF JOIST: (16" o.c. spcg)



LOADS:

$DL = 12\#/ft^2 \times \left(\frac{16}{12}\right)' = 16\ \#/ft.$

$\text{JOIST WT} = \underline{4\ \#/ft}$

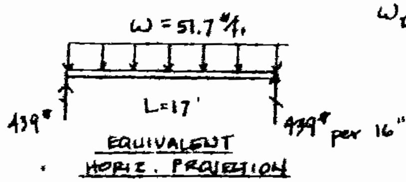
$20\ \#/ft.$

$w_{SL} = 20\#/ft^2 \left(\frac{16}{12}\right) = 26.7\ \#/ft.$

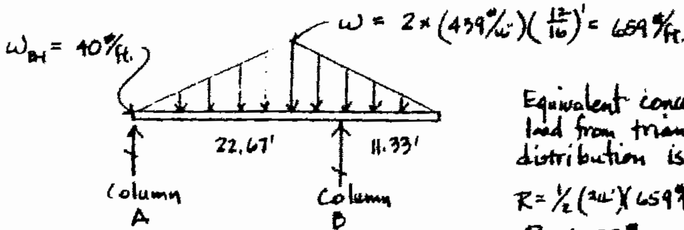
$w'_{DL} = \left(\frac{5}{4}\right)(20\#/ft) = 25\ \#/ft.$

(slope adj)

$w_{TOTAL} = w_{SL} + w'_{DL} = 51.7\ \#/ft$



RIDGE BEAM:



Equivalent concentrated load from triangular distribution is:

$R = \frac{1}{2}(34')(659\#/ft)$

$R = 11{,}200\#$

$[\Sigma M_A = 0]\quad -11{,}200\#(17') - 40\#/ft(34')(17') + B_y(22.67') = 0$

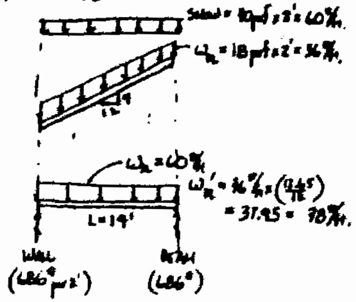
$\underline{B_y = 9420\#}$

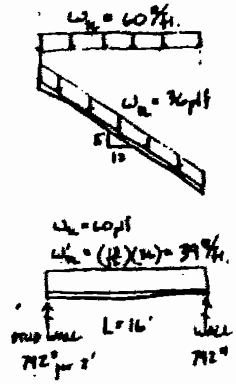
$[\Sigma F_y = 0]\quad -11{,}200\# - (40\#/ft)(34') + 9420\# + A_y = 0$

$\underline{A_y = 3140\#}$

4.6

a. Rafters –

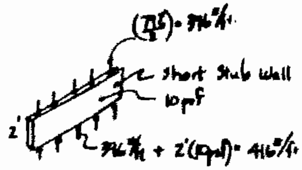


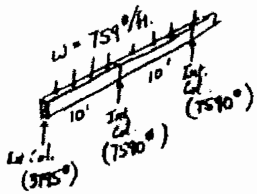


b. Roof Beam –

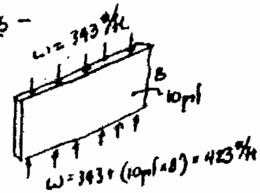
$W_{BM} = \frac{686}{2} + 416$ #/ft.

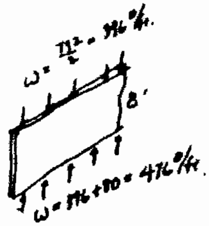
$W_{BM} = 759$ #/ft.





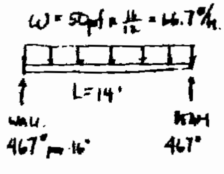
c. WALLS –

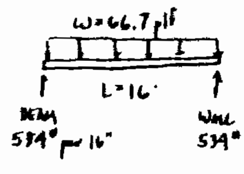




d) Interior Columns – See 'b' above

e) Floor Joists –

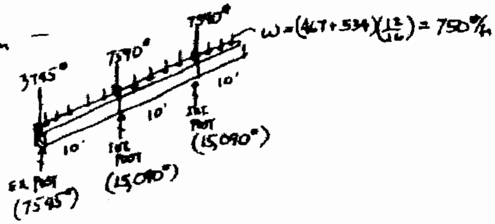




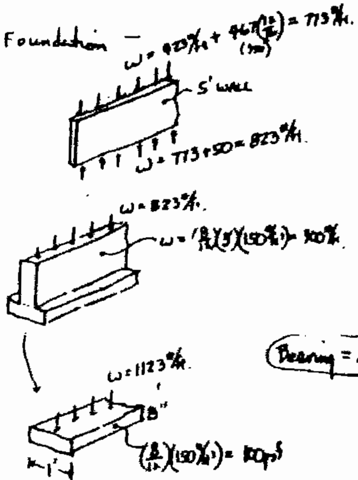
4.6

f) Floor Beam —

g)



h) Foundation —

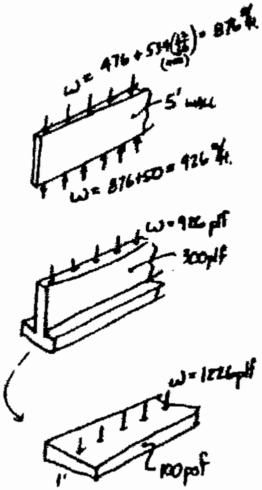


Bearing = 2000 psf

$q_{net} = 2000\,psf - 100 = 1900\,psf$

$\frac{P}{A} = \frac{1123}{1 \times 1} = 1123\,\#/ft^2 < 1900\,psf$

$\therefore$ OK

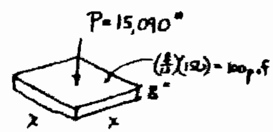


$q_{net} = 1900\,psf$

$\frac{P}{A} = \frac{1226}{1 \times 1} = 1226\,psf < 1900$

$\therefore$ OK

i) Pier Footing —



$q_{net} = 2000\,psf - 100\,psf = 1900\,psf$

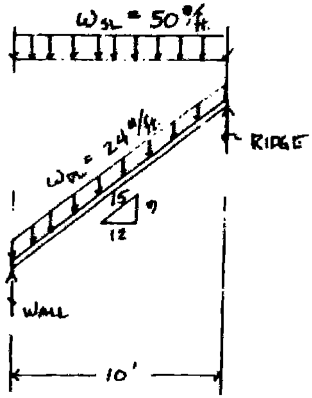
$\frac{P}{A} = \frac{15{,}090\#}{x^2} = 1900\,\#/ft^2$

$x^2 = 7.94\,ft^2; \quad x = 2.82'$

$\underline{x = 2'\text{-}10'' \text{ sq}}$

4.7

Jack rafter:



Roof DL:

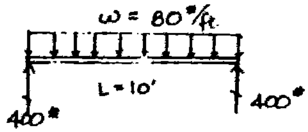
$\omega_{DL} = 12\#/ft^2 \times 2' = 24\#/ft.$

$\omega_{DL}' = \left(\frac{15}{12}\right)(24)\#/ft = 30\#/ft.$
(horiz. proj.)

Snow:

$\omega_{SL} \quad 25\#/ft^2 \times 2' = 50\#/ft.$

$\omega_{TOTAL} = \omega_{SL} + \omega_{DL}' = 80\#/ft.$
(Horiz. projected)



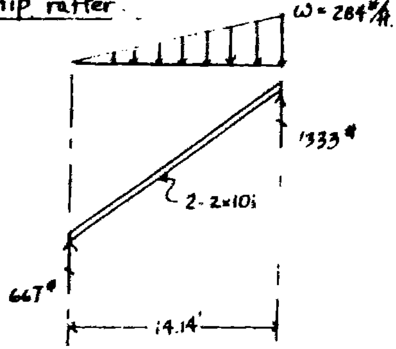
Horiz. Projected

This rafter represents the maximum load condition onto the hip rafter since other rafters diminish in length.

The spacing of the jack rafters along the length of the hip rafter is:

$2' \times \sqrt{2} = 2.82'$ o.c.

Hip rafter.



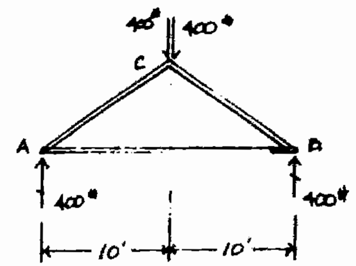
$\therefore \omega = 2 \times \frac{400\#}{2.82'} = 284\#/ft.$
(along hip rafter)

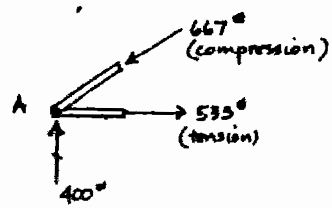
4.7

In addition to the vertically applied loads on both the jack and hip rafters, truss action develops due to the ceiling tie condition.

Examining the truss condition for each rafter case;

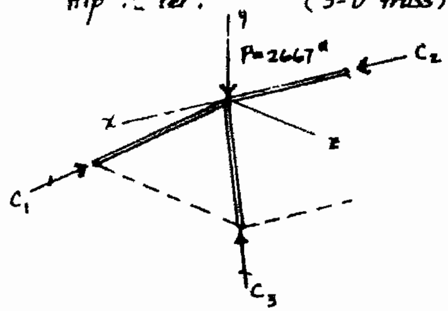
Jack rafter:





FBD Jt. A

Hip rafter: (3-D truss)



$P = 2 \times 1333^{\#} = 2667^{\#}$

Member	d_x	d_y	d_z	d	F_x	F_y	F_z
C_1	10'	7.5'	10'	16.01'	$.625C_1$	$.469C_1$	$.625C_1$
C_2	—	—	—	—	$-C_2$	0	0
C_3	10'	7.5'	−10'	16.01'	$.625C_3$	$.469C_3$	$-.625C_3$
P	—	—	—	—	0	−2667#	0

4.7

$[\Sigma F_z = 0]$ $\quad .625C_1 - .625C_3 = 0 \quad ; \quad C_1 = C_3$

$[\Sigma F_y = 0]$ $\quad .469C_1 + .469C_3 - 2667^{\#} = 0$

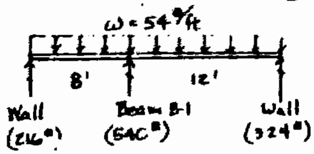
$C_1 = C_3 = 2846^{\#}$ (compression)

$[\Sigma F_x = 0]$ $\quad .625C_1 + .625C_3 - C_2 = 0$

$\therefore C_2 = 3558^{\#}$ (compression)

Ceiling Framing:

Joists: (2' o.c. spacing)

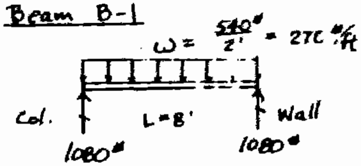


$\omega_{DL} = 7^{\#}/ft^2 \times 2' = 14^{\#}/ft.$

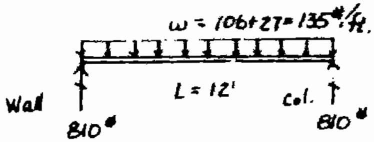
$\omega_{LL} = 20^{\#}/ft^2 \times 2' = 40^{\#}/ft.$

$\omega_{TOTAL} = 54^{\#}/ft.$

Beam B-1



Beam B-2

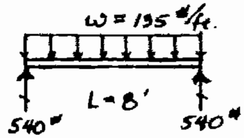


Joist Load: (Span = 8')

$\omega_{total} = 27^{\#}/ft^2 \times 4' = 108^{\#}/ft.$
(Trib. width)

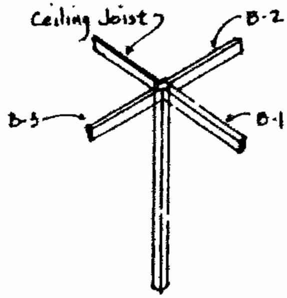
additional load from 1' trib. strip
$= 27^{\#}/ft^2 \times 1' = 27^{\#}$

Beam B-3



Load condition on B-3 is identical to B-2.

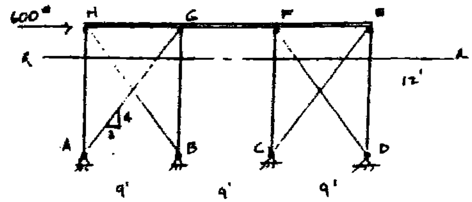
Interior column:



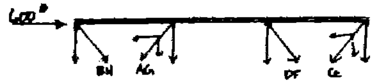
	Load to column
Ceiling joist :	216#/2' = 108#
Beam B-1 :	1080#
Beam B-2 :	810#
Beam B-3 :	540#

P = 2538#
(column load)

4.8



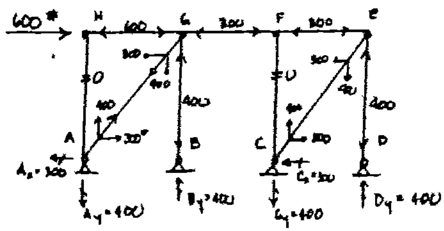
SECTION a-a

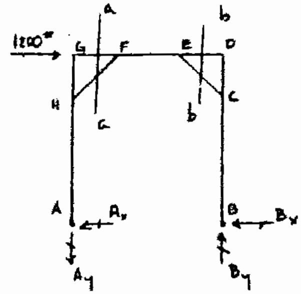


$[\Sigma F_x = 0]$ $+600^{\#} - AG_x - CE_x = 0$

But assume $AG_x = CE_x$

Then; $AG_x = CE_x = 300^{\#}$





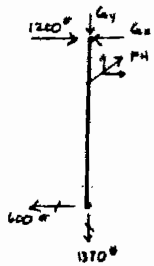
$[\Sigma M_A = 0]$ $B_y = \frac{1200(16)}{14} = 1370\#$

$[\Sigma F_y = 0]$ $A_y = 1370\#$ ↓

Assume $A_x = B_x$

Then; $A_x = B_x = 600\#$

Section a-a :



$[\Sigma M_G = 0]$ $FH_x(4') - 600\#(16') = 0$

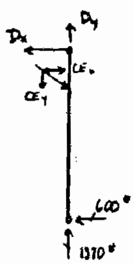
$FH_x = 2400\#$, $FH_y = 2400\#$

$[\Sigma F_y = 0]$ $-G_y + 2400\# - 1370\# = 0$; $G_y = 1030\#$

$[\Sigma F_x = 0]$ $+1200\# - G_x + 2400\# - 600\# = 0$

$G_x = 3000\#$

Section b-b :



$[\Sigma M_D = 0]$ $CE_x(4') - 600\#(16') = 0$

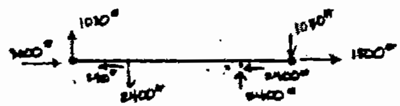
$CE_x = 2400\#$

$CE_y = 2400\#$

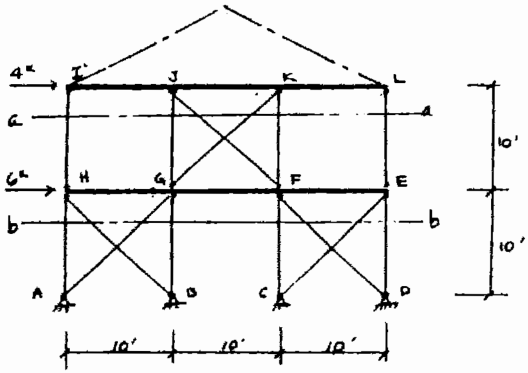
$[\Sigma F_x = 0]$ $-D_x + 2400\# - 600\# = 0$

$D_x = 1800\#$

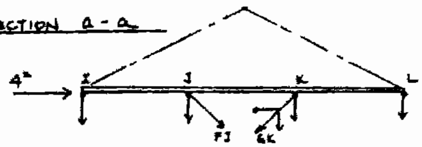
$[\Sigma F_y = 0]$ $+D_y - 2400\# + 1370\# = 0$ $D_y = 1030\#$



4.10



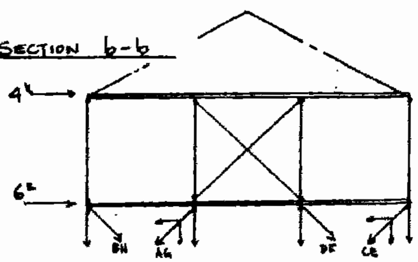
SECTION a-a



$[\Sigma F_x = 0]$ $\quad +4^k - GK_x = 0. \quad GK_x = 4^k$

$\therefore \; GK_Y = 4^k$

SECTION b-b

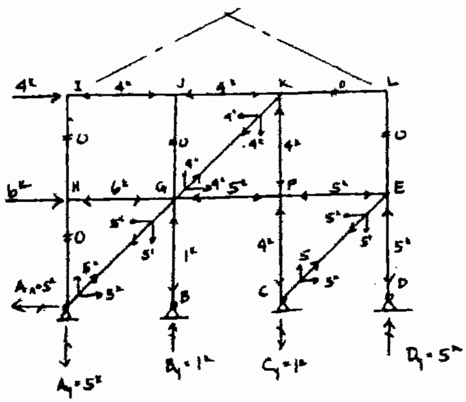


$[\Sigma F_x = 0]$

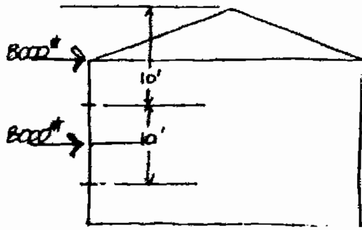
$+4^k + 6^k + AG_x + CE_x = 0$

Assume : $AG_x = CE_x$

$\therefore \; AG_x = CE_x = 5^k$



4.11

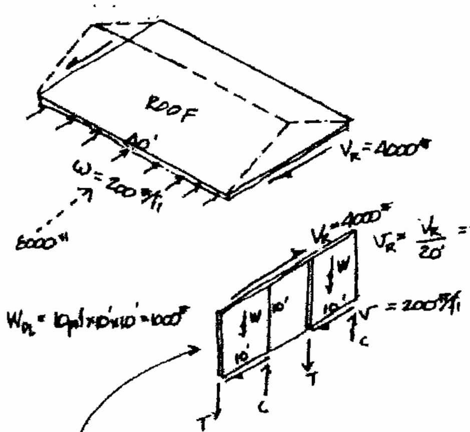


ROOF $(20\text{ psf} \times 10' = 200\#/\text{ft})$

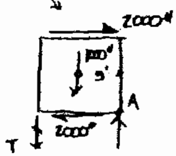
$F_R = 200\#/\text{ft} \times 40' = 8000\#$

2ND $(20\text{ psf} \times 10' = 200\#/\text{ft})$

$F_2 = 200\#/\text{ft}\,(40') = 8000\#$

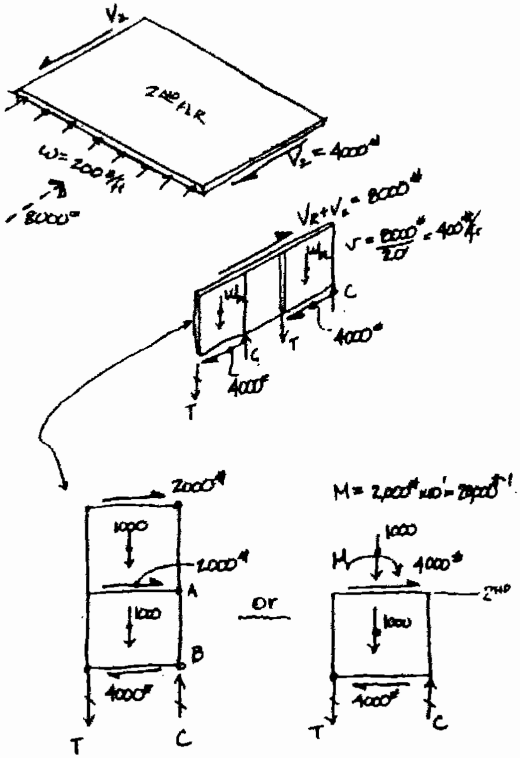


$V_R = \frac{V_R}{20'} = \frac{4000\#}{20'} = 200\#/\text{ft}$



$[\Sigma M_A = 0]\quad -2000\#(10) + 1000\#(5') + T(10') = 0$

$T = \frac{20{,}000 - 5000}{10'} = 1500\#$



$$\left[\Sigma M_B = 0\right] \; -2000^{\#}(20') - 2000^{\#}(10') + 2(1000^{\#})(5') + 10'(T) = 0$$

$$T = \frac{40{,}000^{\#\text{-}\prime} + 20{,}000^{\#\text{-}\prime} - 10{,}000^{\#\text{-}\prime}}{10'} = \underline{5000^{\#}}$$

or

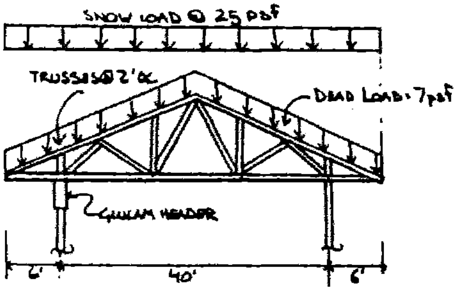
$$\left[\Sigma M_B = 0\right] \; -\overset{(M)}{20{,}000^{\#\text{-}\prime}} - 4{,}000^{\#}(10') + 2(1{,}000^{\#})(5') + T(10') = 0$$

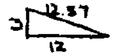
$$\underline{T = 5000^{\#}}$$

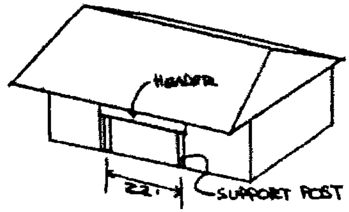
4.12

$SL = 25\ psf \times 2' = 50^{\#}/ft$

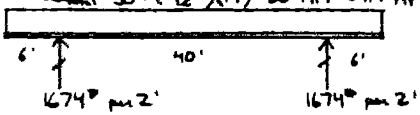
$DL = 7\ psf \times 7' = 14^{\#}/ft$





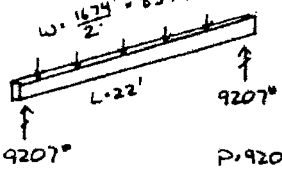


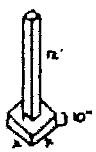
$w_{total} = 50 + \left(\frac{12.37}{12}\right)(14) = 50 + 14.4 = 64.4^{\#}/ft$



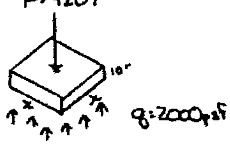
GLU-LAM

$w = \frac{1674^{\#}}{2'} = 837^{\#}/ft$





$P = 9207^{\#}$

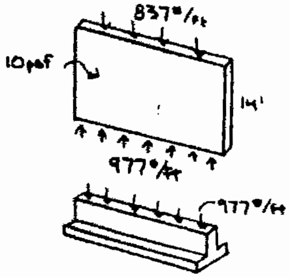


$q_{net} = 2000\ psf - \left(\frac{10}{12}\right)'(150\ pcf) = 1875^{\#}/ft$

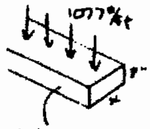
$A = x^2 = \frac{P}{q_{net}} = \frac{9207}{1875} = 4.91\ ft^2$

$x = 2.21' \approx \underline{2'3''\ SQ}$

WALL



$\left(\frac{8}{12}\right)\left(\frac{12}{12}\right)(150\text{pcf}) = 100\#/\text{ft}$



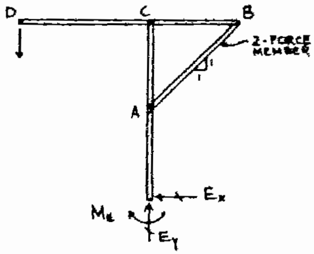
$\left(\frac{8}{12}\right)(150\text{pcf}) = 100\text{ psf}$

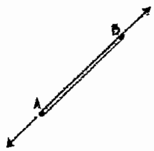
$q_{net} = 2000\text{psf} - 100\text{ psf} = 1900\text{ psf}$

$1077\# = (x)(1')(1900\text{psf})$

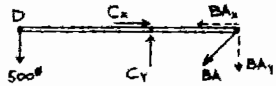
$\underline{x = .57'}$

5.1





ISOLATE MEMBER DCB



$$BA_x = \frac{BA}{\sqrt{2}}$$

$$BA_Y = \frac{BA}{\sqrt{2}}$$

$[\Sigma M_c = 0]$ $\quad +500^\#(3') - BA_Y(2') = 0$

$$BA_Y = \frac{500^\#(3')}{2'} = 750^\#$$

$$BA = 750\sqrt{2}^\#$$

$$P = 750\sqrt{2}^\#$$

$$A = 1/2'' \times 2'' = 1 in.^2$$

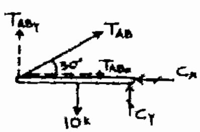
$$f_t = \frac{P}{A} = \frac{750\sqrt{2}^\#}{1 in^2} = 750\sqrt{2}\ ^\#/in.^2 = 750\sqrt{2}\ psi = \underline{\underline{1060.67 psi}}$$

5.2

TOTAL AREA OF MARQUEE = 20' × 10' = 200 ft.^{2}

TOTAL LOAD = 200 ft^2 × 100$^\#$/ft^2 = 20,000$^\#$

SINCE THE FRAMING IS SYMMETRICAL, EACH ROD CARRIES AN EQUAL AMOUNT OF THE LOAD.



$$T_{AB_Y} = T_{AB} \sin 30° = .5\,T_{AB}$$

$[\Sigma M_c = 0]$ $\quad +10^k(5') - \underbrace{.5\,T_{AB}}_{T_{AB_Y}}(10') = 0$

$$\underline{T_{AB} = 10^k}$$

5.2

$$\therefore f_t = \frac{P}{A}\ ; \quad A_{req'd} = \frac{P}{f_t} = \frac{10^k}{22^k/in^2} = 0.46\ in^2$$

CLOSEST SIZE AVAILABLE (TO NEAREST 1/16") = 13/16" ϕ

FOR 13/16" ϕ ROD, $A = \underline{0.5185\ in.^2}$

$$\therefore f_{t_{actual}} = \frac{10^k}{.5185\ in^2} = 19.2\ ksi < \underset{(allowable)}{22\ ksi} \quad \therefore \text{ O.K.}$$

5.3

a) $f_c = \frac{P}{A}\ ; \quad A_{req'd} = \frac{120^k}{13.5^k/in^2} = 8.9\ in^2$

FROM STEEL TABLES: USE $\underline{W8 \times 31}$ $(A = 9.12\ in^2)$
(Appendix)

b) $f_p = \frac{P}{A}\ ; \quad A_b = \frac{120^k}{.45^k/in^2} = 266.7\ in^2$

FOR SQUARE BASE PL:
USE: 16.3" × 16.3"
or
<u>16½" × 16½" PL</u>

c) $f_p = \frac{P}{A}\ ; \quad A_b = \frac{120^k}{3^k/ft^2} = 40\ ft^2$

<u>Use 6.32' sq. or 6'-4" sq. footing.</u>

5.4

a) TAKING A 1' (12") STRIP, $f = \frac{P}{A}$;

$$P = Af$$
$$= 48\ in^2 \times 150^{\#}/in^2 = 7200^{\#}$$

BUT: $P = \gamma_{BR.} \times A \times h$

$$h = \frac{P}{\gamma \times A}$$

$$h = \frac{7200^{\#}}{120^{\#}/ft^3 \times \left(\frac{48}{144}\right) ft^2} = \underline{180'}$$

5.4 (CONT'D)

b) TAKING A 1' (12") STRIP. $f = \frac{P}{A}$

$$P = Af$$
$$= 72\,in^2 \times 150\,\#/in^2 = 10{,}800\#$$

BUT: $P = \gamma_{BR.} \times A \times h$

$$h = \frac{P}{\gamma \times A}$$

$$h = \frac{10{,}800\#}{120\,\#/ft^3 \times \left(\frac{72}{144}\right) ft^2} = \underline{180'}$$

5.5

a) $P = 20{,}000\#$; $A = 64\,in.^2$

$$f_t = \frac{P}{A} = \frac{20{,}000\#}{64\,in.^2} = \underline{312.5\,\#/in.^2}$$

b) $P = 4000\#$; $A \neq \pi D^2/4$ SINCE ROD IS THREADED

$$A = .302\,in.^2$$
$$\therefore f_t = \frac{P}{A} = \frac{4000\#}{.302\,in.^2} = \underline{13{,}245\,\#/in^2}$$

c) $P = 4000\#$, $A = 4'' \times 4'' - \frac{\pi(7/8'')^2}{4} = 15.4\,in^2$

$$f_{brg} = \frac{P}{A} = \frac{4000\#}{15.4\,in^2} = \underline{259.7\text{ psi}}$$

d) $P = 15{,}000\#$, $A = 8'' \times 12'' = 96\,in^2$

$$f = \frac{15000\#}{96\,in^2} = \underline{156.3\text{ psi}}$$

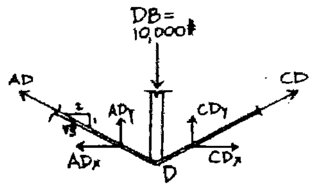
e) $P = 16{,}000\#$; $A = 8'' \times L$; $F_v = 120$ psi

$$A_{req'd} = \frac{P}{F_v} = \frac{16000\#}{120\,\#/in^2} = 133.3\,in^2$$

$$133.3\,in^2 = 8'' \times L$$

$$\underline{L = 16.7''}$$

5.6



a) $f_c = \frac{P}{A} = \frac{10000^{\#}}{\frac{\pi(2")^2}{4} - \frac{\pi(1")^2}{4}}$

$= \underline{4{,}2373 \text{psi}}$

b) $[\Sigma F_Y = 0]$ AT JOINT D:

$-10{,}000^{\#} + AD_Y + CD_Y = 0$

$AD_Y = CD_Y$

$\therefore\ 2CD_Y = 10{,}000^{\#}$

$CD_Y = 5{,}000^{\#}$

$CD = 5{,}000^{\#}\sqrt{5} = 11{,}180^{\#}$

$f_t = \frac{P}{A} = \frac{11{,}180^{\#}}{1 \text{in}^2} = \underline{11{,}180 \text{ psi}}$

c) $f_v = \frac{P}{2A} = \frac{11{,}180^{\#}}{2\pi(.75)^2/4} = \underline{12{,}661 \text{ psi}}$

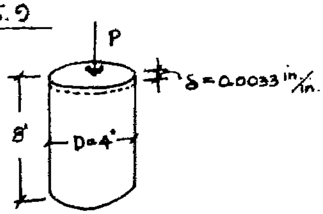
5.7

$\epsilon = \frac{\delta}{L} = \frac{0.0024"}{2.0"} = \underline{0.0012 \text{ in/in.}}$

5.8

$\epsilon = \frac{\delta}{L} = \frac{0.125"}{12' \times \left(\frac{12"}{1'}\right)} = \underline{.0009 \text{ in/in}}$

5.9



$\epsilon = \frac{\delta}{L}$

$\delta = \epsilon L = 0.0033 \text{ in/in} (8 \text{ in})$

$\delta = 0.0264 \text{ in.}$

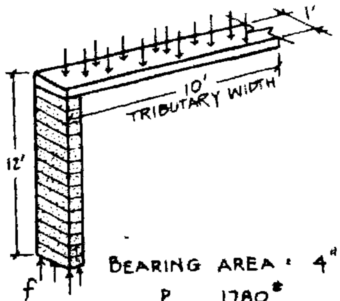
5.10

$\epsilon = \frac{\delta}{L}$; $\delta = \epsilon L$

$\delta = .005\ \text{in}/\text{in.}\ (500' \times 12''/') = 30\ \text{in.}$

5.11

CONSIDER A 1' LENGTH OF WALL



ROOF = $1' \times 10' \times 100\text{psf} = 1{,}000^{\#}$
SNOW = $1' \times 10' \times 30\text{psf} = \underline{300^{\#}}$
$1{,}300^{\#}/\text{ft.}$

BRICK = $1' \times 4/12' \times 12' \times 120^{\#}/\text{ft}^3 = 480^{\#}$

TOTAL LOAD AT BASE OF WALL $= 1780^{\#}$

BEARING AREA = $4'' \times 12'' = 48\text{in}^2$

$f_p = \frac{P}{A} = \frac{1780^{\#}}{48\text{in}^2} = 37.1\text{psi} < 125\text{psi}$ $\therefore$ O.K

5.12

a) WIRE WEIGHT (TOTAL) = $0.042^{\#}/\text{ft.} \times 300\text{ft.} = 12.6^{\#}$

$A = \frac{\pi D^2}{4} = \frac{\pi(.125)^2}{4} = 0.0123\text{in}^2$

$f_t = \frac{P}{A} = \frac{12.6^{\#}}{.0123\text{in}^2} = \underline{1024.4\text{ psi}}$

b) $F_{allow} = \frac{F_{ult}}{3} = \frac{65\text{ ksi}}{3} = 21.67\text{ ksi}$

S.F

P_{allow} = TOTAL LOAD = $F_{allow} \times A = 21.67\text{ksi} \times .0123\text{ in}^2 = 266.5^{\#}$

WIRE WEIGHT = $12.6^{\#}$

$\therefore$ MAXIMUM $W = P - 12.6^{\#} = \underline{253.9^{\#}}$

5.13

a) $\delta = \frac{PL}{AE} = \frac{(29{,}000^{\#})(25' \times 12''/')}{\left(\frac{3.14 \times (1\frac{1}{4}'')^2}{4}\right)(29 \times 10^6 \#/in^2)} = \underline{0.17 \text{ in.}}$

b) $\delta = \frac{PL}{AE}$; $A_{req'd} = \frac{PL}{\delta E} = \frac{(29{,}000^{\#})(25' \times 12''/')}{(.10)(29 \times 10^6 \#/in^2)} = \underline{3 \text{ in}^2}$

$$A = \frac{\pi D^2}{4} \; ; \; D^2 = \frac{4A}{\pi}$$

$$D = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4(3)}{3.14}} = \underline{1.95''}$$

COULD GO DIRECTLY TO THE TABLE IN THE AISC MANUAL

SAY: $\underline{2'' \; \phi \text{ ROD}}$

5.14

$A = 0.006 \text{ in}^2$ $\qquad P = 16^{\#}$ $\qquad E = 30 \times 10^6$ psi

a) $\delta = \frac{PL}{AE} = \frac{16^{\#}(100' \times 12''/')}{0.006 \text{ in}^2 (30 \times 10^6 \#/in^2)} = \underline{0.1067''}$

b) $f = \frac{P}{A} = \frac{16^{\#}}{.006 \text{ in}^2} = \underline{2667 \text{ psi}}$

–15

$L = 90' - 10'' = 1090''$; $P = 60^k$

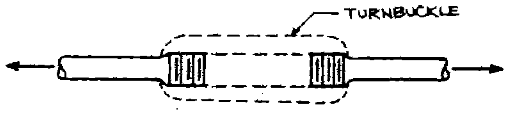
$F_t = 20$ ksi ; UPSET RODS; $E = 29 \times 10^3$ ksi

a) $A_{req'd} = \frac{P}{F_t} = \frac{60^k}{20^k/in^2} = 3 \text{ in}^2 = \frac{\pi d^2}{4}$

USE: $d = \sqrt{\frac{12}{\pi}} = \underline{1.95''}$

b) $\delta = \frac{PL}{AE} = \frac{F_t L}{E} = \frac{20^k/in^2 (1090'')}{29 \times 10^3 \, k/in^2} = 0.75''$

5.15 (CONT'D)

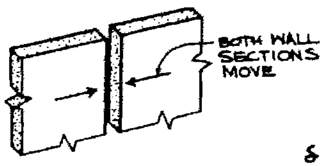


EACH TURN = 1/4" MOVEMENT PER ROD
(ONE THREAD)

$\therefore$ ONE TURN ON THE TURNBUCKLE = 1/2" MOVEMENT

NUMBER OF TURNS $= \dfrac{0.75"}{.5"} = \underline{1.5 \text{ TURNS}}$

5.16



$$\delta = \alpha L \Delta T = (6 \times 10^{-6}/°F)(2 \times 20' \times 12"/')(60°F)$$

$$\underline{\delta = 0.173"}$$

5.17

ASSUMING UNRESTRAINED MOVEMENT;

$$\delta_{AL} = \alpha_{AL} L \Delta T = 12.8 \times 10^{-6}/°F\,(L)(55°F) = 704 \times 10^{-6}(L)$$

$$\delta_{conc} = \alpha_c L \Delta T = 6.0 \times 10^{-6}/°F\,(L)(15°F) = 90.0 \times 10^{-6}(L)$$

RESTRAINED DEFORMATION IN THE ALUMINUM PANEL:
$\delta_{RESTRAINED} = \delta_{AL} - \delta_{conc} = 614 \times 10^{-6}(L)$

STRESS REQUIRED TO RESTRAIN THE ALUMINUM BY $614.6 \times 10^{-6}(L)$:

$$\delta = \frac{PL}{AE} = \frac{fL}{E} \quad ; \quad f = \frac{\delta E}{L}$$

$$f = \frac{614.0 \times 10^{-6}(L)(10 \times 10^{6}\,psi)}{(L)} = \underline{6{,}140 \text{ psi}}$$

5.18

a) $\delta = \alpha L \Delta T$

SET $\delta = 0.25''$

$$\therefore \quad \Delta T = \frac{\delta}{\alpha L} = \frac{0.25''}{(6.5\times10^{-6}/^\circ F)(60'\times12''/')} = \underline{53.4^\circ F}$$

$$\Delta T = T_{FINAL} - T_{ORIG} = 53.4^\circ F$$

$$\therefore \quad T_{FINAL} = 53.4^\circ F + 70^\circ F = \underline{123.4^\circ F}$$

(NO STRESS CONDITION)

b) @ $T = 150^\circ$

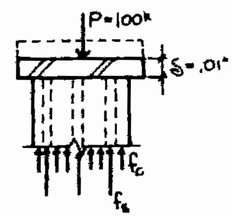
$$\delta = \alpha L \Delta T = 6.5\times10^{-6}(720'')(150^\circ - 123.4^\circ) = 0.124''$$

RESTRAINED DEFORMATION

$$\delta = \frac{fL}{E} \; ; \; f = \frac{\delta E}{L} = \frac{0.124''(29\times10^6 psi)}{720''} =$$

$$\underline{4994.4 \text{ psi}}$$

5.19



FROM THE EQUILIBRIUM CONDITION;

$$[\Sigma F_Y = 0] \quad f_s A_s + f_c A_c = 100^k$$

$$\delta_s = \delta_c = 0.01''$$

$$\delta = \frac{PL}{AE} = \frac{fL}{E}$$

$$f_s = \frac{\delta E_s}{L_s} = \frac{0.01''(29\times10^3 ksi)}{(10'\times12''/')} = 2.417 \text{ ksi}$$

$$f_c = \frac{\delta E_c}{L_c} = \frac{0.01''(3\times10^3 ksi)}{120''} = .25 \text{ ksi}$$

5.19

A_s ; $A_c = \frac{\pi (15")^2}{4} - A_s = 176.6 \text{ in}^2 - A_s$

$2.417(A_s) + 0.25(176.6 - A_s) = 100^k$

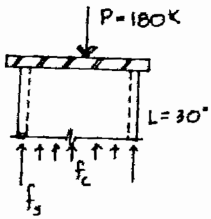
$2.417 A_s + 44.15^k - .25 A_s = 100^k$

$2.167 A_s = 55.85^k$

$A_s = \underline{25.8 \text{ in}^2}$

$A_c = \underline{150.8 \text{ in}^2}$

5.20



$A_{conc.} = \frac{\pi D^2}{4} = \frac{\pi (12.75" - 2 \ .375")^2}{4}$

$A_{conc.} = 113 \text{ in}^2$

$A_{steel} = \frac{\pi D_{o}^2}{4} - A_{conc.}$

$A_{STEEL} = \frac{\pi (12.75)^2}{4} - 113 \text{ in}^2 = 14.7 \text{ in}^2$

From equilibrium; $[\Sigma F_Y = 0]$

$f_c A_c + f_s A_s = 180^k$

$f_c(113 \text{ in}^2) + f_s(14.7 \text{ in}^2) = 180^k \quad . . . \quad (1)$

From deformation and strain relationship;

$\delta = \delta_s = \delta_c$; $\delta = \frac{fL}{E}$

$\therefore \quad \frac{f_c L}{E_c} = \frac{f_s L}{E_s}$; $f_s = \frac{E_s}{E_c} \times f_c = \frac{29 \times 10^3}{3 \times 10^3} f_c = 9.67 f_c \quad . . . (2)$

Subsituting relationship (2) into equation (1);

$113 f_c + 14.7(9.67 f_c) = 180^k$

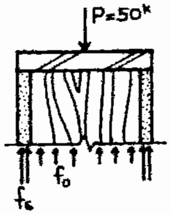
$113 f_c + 142 f_c = 180^k$;

$255 f_c = 180^k$; $\quad \underline{f_c = 0.71 \text{ ksi}}$; $\quad \underline{f_s} = 9.67(0.71) = \underline{6.87 \text{ ksi}}$

$\delta = \delta_s = \delta_c = \frac{fL}{E}$

$\delta_s = \frac{f_s L}{E_s} = \frac{6.87(30")}{29 \times 10^3 \text{ k/in}^2} = \underline{0.0071"}$

5.21

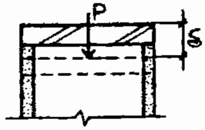


a) FROM EQUILIBRIUM:

$[\Sigma F_Y = 0]$ $P_s + P_o = 50^k$;
but: $P_s = f_s \times A_s$
$P_o = f_o \times A_o$

$\therefore f_s A_s + f_o A_o = 50^k \; \ldots\ldots (\text{Eq \#1})$

$A_s = 4 \text{ in}^2$
$A_o = 32 \text{ in}^2$



FROM ELASTIC DEFORMATION:

$\delta_s = \delta_o$ (SINCE LOAD IS SYMMETRICALLY APPLIED)

BUT; $\delta = \dfrac{PL}{AE}$ AND $\epsilon = \dfrac{\delta}{L}$ AND $L_s = L_o$

$\therefore \epsilon_s = \epsilon_o$

$\epsilon = \dfrac{f}{E}$ SO $\dfrac{f_s}{E_s} = \dfrac{f_o}{E_o}$; $f_s = \dfrac{E_s}{E_o} \times f_o = \dfrac{30 \times 10^6}{2 \times 10^6} f_o = 15 f_o$

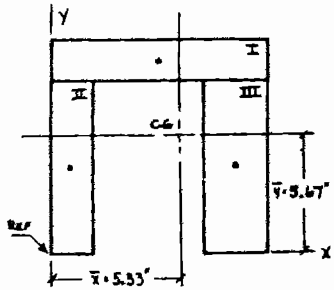
SUBSTITUTING IN (EQ.#1): $15 f_o (4 \text{ in}^2) + f_o (32 \text{ in}^2) = 50^k$

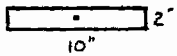
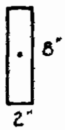
$\underline{f_o = .543 \text{ ksi}}$; $\underline{f_s = 8.15 \text{ ksi}}$

b) $\delta = \delta_s = \delta_o$; $\delta_s = \dfrac{f_s L}{E} = \dfrac{8.15 \text{ k/in}^2 (8 \text{ in})}{30 \times 10^3 \text{ k/in}^2}$

$\underline{= 0.002''}$

6.1

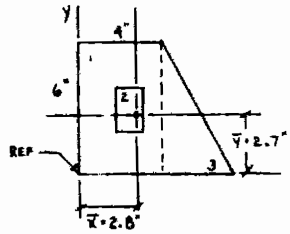


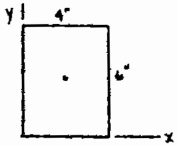
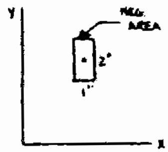
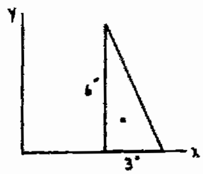
COMPONENT	ΔA	x	xA	y	yA
	20 in.²	5 in	100 in³	9 in	180 in³
	16 in²	1 in	16 in³	4 in	64 in³
	24 in²	8½ in.	204 in³	4 in	96 in³
	$\Sigma \Delta A = 60\,in^2$		$\Sigma x \Delta A = 320\,in^3$		$\Sigma y \Delta A = 340\,in^3$

$$\bar{x} = \frac{\Sigma x \Delta A}{A} = \frac{320\,in^3}{60\,in^2} = \underline{\underline{5.33''}}$$

$$\bar{y} = \frac{\Sigma y \Delta A}{A} = \frac{340\,in^3}{60\,in^2} = \underline{\underline{5.67''}}$$

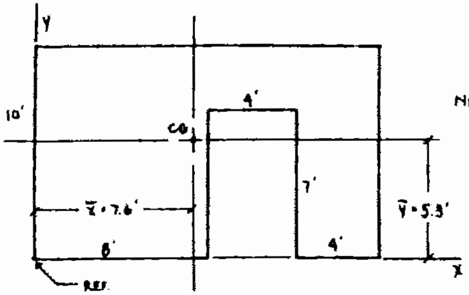
6.2



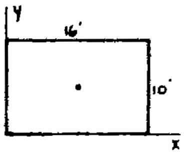
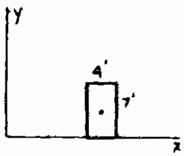
COMPONENT	ΔA	x	xΔA	y	yΔA
	$24 in^2$	2"	$+48 in^3$	3"	$72 in^3$
	$-2 in^2$	2½"	$-5 in^3$	3"	$-6 in^3$
	$9 in^2$	5"	$45 in^3$	2"	$18 in^3$
	$\Sigma \Delta A = 31 in^2$		$\Sigma x \Delta A = 88 in^3$		$\Sigma y \Delta A = 84 in^3$

$$\bar{x} = \frac{88 in^3}{31 in^2} = \underline{\underline{2.8"}} \qquad \bar{y} = \frac{84 in^3}{31 in^2} = \underline{\underline{2.7"}}$$

6.3

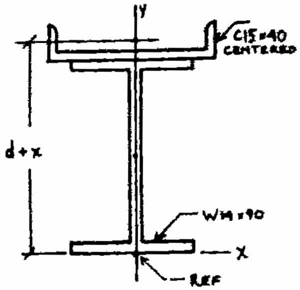


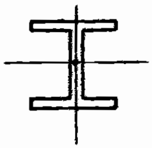
NEGATIVE AREA METHOD

COMPONENT	ΔA	x	$x\Delta A$	y	$y\Delta A$
	160 ft²	8'	1280 ft³	5'	800 ft³
	-28 ft²	10'	-280 ft³	3½'	-98 ft³
	$\Sigma\Delta A = 132\ ft^2$		$\Sigma x\Delta A = 1000\ ft^3$		$\Sigma y\Delta A = 702\ ft^3$

$$\bar{x} = \frac{1000\ ft^3}{132\ ft^2} = \underline{\underline{7.6'}} \qquad \bar{y} = \frac{702\ ft^3}{132\ ft^2} = \underline{\underline{5.3'}}$$

6.4

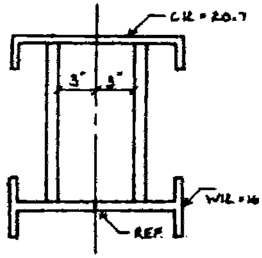


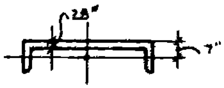
COMPONENT	ΔA	x	$x\Delta A$	y	$y\Delta A$
	$11.8\,in^2$	0	0	$14.02 + .78'' = 14.8''$	$174.6\,in^3$
	$26.5\,in^2$	0	0	$\frac{14.02}{2} = 7.01''$	$185.8\,in^3$
	$\Sigma\Delta A = 38.3\,in^2$		$\Sigma x\Delta A = 0$		$\Sigma y\Delta A = 360.4\,in^3$

$\bar{x} = \underline{\underline{0}}$

$$\bar{y} = \frac{360.4\,in^3}{38.3\,in^2} = \underline{\underline{9.4''}}$$

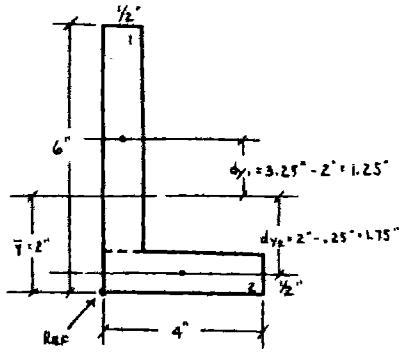
6.5

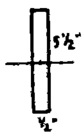
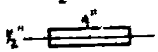


COMPONENT	ΔA	x	$x\Delta A$	y	$y\Delta A$
	$6.09\,in^2$	0	0	$\frac{.22}{2}+10+.28-.7 = 9.7''$	$59\,in^3$
	$2\times 5 = 10\,in^2$	0	0	$\frac{.22}{2}+\frac{10}{2} = 5.11''$	$51.1\,in^3$
	$4.71\,in^2$	0	0	0	0
	$\Sigma\Delta A = 20.8\,in^2$				$\Sigma y\Delta A = 110.1\,in^3$

$$\bar{y} = \frac{110.1\,in^3}{20.8\,in^2} = \underline{\underline{5.3''}}$$

6.6

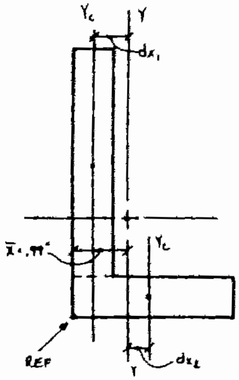


COMPONENT	ΔA	y	yA	Ixc	dy	Ady^2
	$2.75\ in^2$	3.25"	$8.94\ in^3$	$\frac{(1/2)(5\,1/2)^3}{12} = 6.93\ in^4$	1.25"	$4.3\ in^4$
	$2\ in^2$	.25"	$.50\ in^3$	$\frac{(4)(1/2)^3}{12} = .04\ in^4$	1.75"	$6.1\ in^4$
	$\Sigma A = 4.75\ in^2$		$\Sigma yA = 9.44\ in^3$	$\Sigma I_{xc} = 6.97\ in^4$		$\Sigma Ady^2 = 10.4\ in^4$

$$\bar{y} = \frac{\Sigma yA}{\Sigma A} = \frac{9.44}{4.75} = 2.0"$$

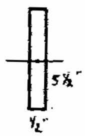
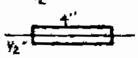
$$I_x = \Sigma I_{xc} + \Sigma A dy^2 = 7.0 + 10.4 = \underline{\underline{17.4\ in^4}}$$

6.6 (CONT'D)



$$d_{x_1} = \bar{x} - x_1 = .99" - .25" = .74"$$

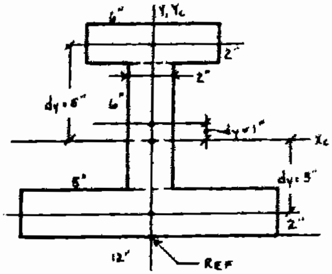
$$d_{x_2} = x_2 - \bar{x} = 2" - .99" = 1.01"$$

COMPONENT	ΔA	x	$x\Delta A$	I_{YC}	d_x	Ad_x^2
	2.75 in^2	$.25"$	$.69 \text{ in}^3$	$\frac{(5.5)(.5)^3}{12} = .057 \text{ in}^4$	$.74"$	1.5 in^4
	2 in^2	$2"$	4 in^3	$\frac{(.5)(4)^3}{12} = 2.67 \text{ in}^4$	$1.01"$	2.0 in^4
	$\Sigma \Delta A = 4.75 \text{ in}^2$		$\Sigma x\Delta A = 4.69 \text{ in}^3$	$\Sigma I_{Yc} = 2.7 \text{ in}^4$		$\Sigma A d_x^2 = 3.5 \text{ in}^4$

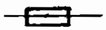
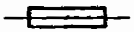
$$\bar{x} = \frac{\Sigma x \Delta A}{\Sigma \Delta A} = \frac{4.69}{4.75} = 0.99"$$

$$I_Y = \Sigma I_{YC} + \Sigma A d_x^2 = 2.7 + 3.5 = \underline{\underline{6.2 \text{ in}^4}}$$

6.7



MOMENT OF INERTIA

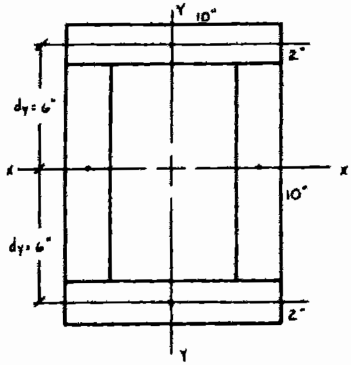
COMPONENT	A	y	yA	I_{xc}	dy	Ady^2	I_{yc}	dx	Adx^2
	12	9	108	$\frac{(6)(2)^3}{12} = 4$	9"−4"=5"	300	36	0	0
	12	5	60	$\frac{(2)(6)^3}{12} = 36$	5"−4"=1"	12	4	0	0
	24	1	24	$\frac{(12)(2)^3}{12} = 8$	4"−1"=3"	216	288	0	0
	$\Sigma A = 48 in^2$		$\Sigma yA = 192$	$\Sigma I_{xc} = 48$		$\Sigma Ady^2 = 528$	$\Sigma I_{yc} = 328$		

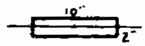
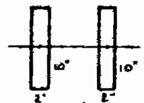
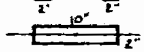
$$\bar{y} = \frac{192}{48} = 4"$$

$$I_{xx} = I_{xc} + \Sigma Ady^2 = 48 + 528 = \underline{\underline{576 \text{ in}^4}}$$

$$I_y = \underline{\underline{328 \text{ in}^4}}$$

6.8



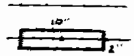
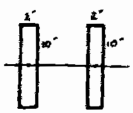
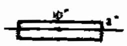
COMPONENT	A	dy	Ady^2	I_{xc}
	20 in^2	$+6"$	$+720 \text{ in}^4$	$\frac{(10)(2)^3}{12} = 6.67 \text{ in}^4$
	$2 \times 20 = 40 \text{ in}^2$	0	0	$2 \times \frac{(2)(10)^3}{12} = 333.33 \text{ in}^4$
	20 in^2	$-6"$	$+720 \text{ in}^4$	$\frac{(10)(2)^3}{12} = 6.67 \text{ in}^4$
			$\Sigma Ady^2 = 1440 \text{ in}^4$	$\Sigma I_{xc} = 346.7 \text{ in}^4$

$$I_{xx} = 346.7 + 1440 = \underline{\underline{1786.7 \text{ in}^4}}$$

BY FORMULA:

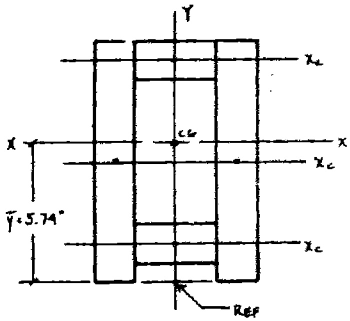
$$I_x = \frac{bh^3 - b_1 h_1^3}{12} = \frac{(10)(14)^3 - (6)(10)^3}{12}$$

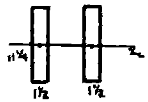
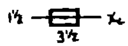
$$I_{xx} = \frac{27{,}400 - 6000}{12} = \underline{\underline{1787 \text{ in}^4}}$$

COMPONENT	I_{YC}	A	d_x	Ad_x^2
	166.7 in^4	20 in^2	0	0
	$2 \times 6.7 = 13.3 \text{ in}^4$	40 in^2	$4"$	640 in^4
	166.7 in^4	20 in^2	0	0
	$\Sigma I_{YC} = 346.7 \text{ in}^4$			$\Sigma Ad_x^2 = 640 \text{ in}^4$

$$I_Y = \Sigma I_{YC} + \Sigma Ad_x^2 = 346.7 + 640 = \underline{\underline{986.7 \text{ in}^4}}$$

6.9

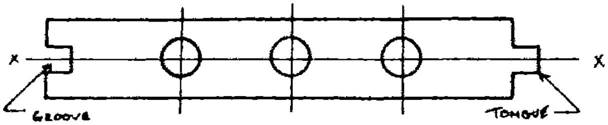


COMPONENT	A	y	yA	I_{xc}	dy	Ady^2
	$5.25 in^2$	$11.25 - .75 = 10.5"$	$55.13 in^3$	$\frac{3.5(1.5)^3}{12} = .98 in^4$	$y_1 - \bar{y} = 10.5 - 5.74 = 4.76"$	$119.0 in^4$
	$2 \times 16.88 = 33.76 in^2$	$\frac{11.25}{2} = 5.63"$	$190.1 in^3$	$\frac{2 \times 1.5(11.25)^3}{12} = 355.96 in^4$	$\bar{y} - y_2 = 5.74 - 5.63 = 0.11"$	$0.4 in^4$
	$5.25 in^2$	$1 + .75 = 1.75"$	$9.19 in^3$	$\frac{3.5(1.5)^3}{12} = .98 in^4$	$\bar{y} - y_3 = 5.74 - 1.75 = 3.99"$	$83.6 in^4$
	$\Sigma A = 44.3 in^2$		$\Sigma yA = 254.4 in^3$	$\Sigma I_{xc} = 357.9 in^4$		$\Sigma Ady^2 = 203 in^4$

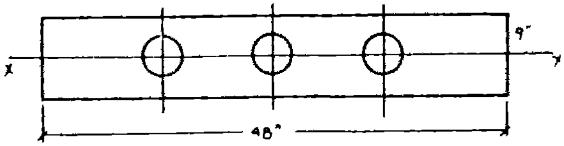
$$\bar{y} = \frac{\Sigma yA}{\Sigma A} = \frac{254.1 in^3}{44.3 in^2} = \underline{\underline{5.74"}}$$

$$I_x = \Sigma I_{xc} + \Sigma Ady^2 = 358 + 203 = \underline{\underline{561 in^4}}$$

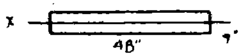
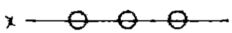
6.10



USE THE NEGATIVE AREA METHOD. ASSUME THAT THE TONGUE IS REMOVED AND PLACED INTO THE GROOVE.



NO CENTROID CALCULATION FOR THE MAJOR X AXIS IS NECESSARY BECAUSE OF THE SYMMETRY.

COMPONENT	A	I_{xc}
	$432\ in^2$	$\dfrac{48(9)^3}{12} = 2916\ in^4$
	$3 \times \dfrac{\pi(4")^2}{4} = 37.7\ in^2$	$-3 \times \dfrac{\pi(4")^4}{64} = -38\ in^4$
		$\Sigma I_{xc} = 2878\ in^4$

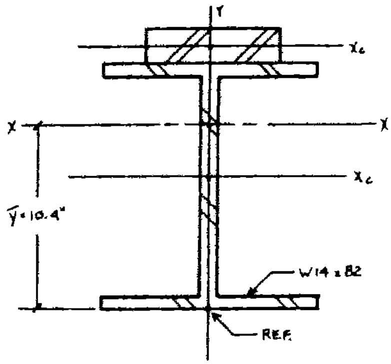
$$I_x = \Sigma I_{xc} + \Sigma A d_y^2$$

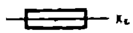
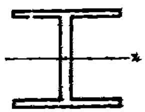
NO TRANSFER IS NECESSARY SINCE THE SOLID SLAB AND THE THREE HOLES ALL HAVE THEIR COMPONENT CENTROIDS ON THE MAJOR CENTROIDAL X-AXIS.

$$\therefore A d_y^2 = 0$$

$$I_x = \Sigma I_{xc} = \underline{\underline{2878\ in^4}}$$

6.11

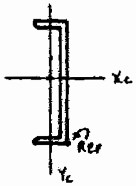


COMPONENT	A	y	yA	I_{xc}	dy	Ady^2
	16 in^2	$14.31+1 = 15.31"$	245 in^3	$\frac{8(2)^3}{12} = 5.33 \text{ in}^4$	$Y-\bar{Y} = 15.31-10.4 = 4.9"$	384 in^4
	24.1 in^2	$\frac{14.31}{2} = (7.16")$	172.6 in^4	882 in^4	$\bar{Y}-y = 10.4-7.2 = 3.2"$	247 in^4
	$\Sigma A = 40.1 \text{ in}^2$		$\Sigma yA = 417.6 \text{ in}^3$	$\Sigma I_{xc} = 887.5 \text{ in}^4$		$\Sigma Ady^2 = 631 \text{ in}^4$

$$\bar{y} = \frac{\Sigma yA}{\Sigma A} = \frac{417.6 \text{ in}^3}{40.1 \text{ in}^2} = \underline{\underline{10.4"}}$$

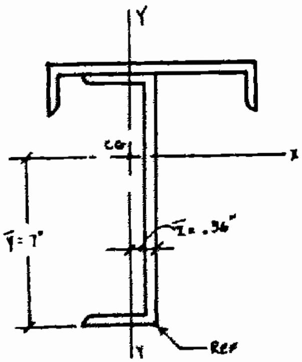
$$I_x = \Sigma I_{xc} + \Sigma Ady^2 = 887 + 631 = \underline{\underline{1518 \text{ in}^4}}$$

6.12

COMPONENT	A	x	xA	y	yA	I_{xc}	dy	Ady^2	I_{yc}	dx	Adx^2
	$3.38\,in^2$	0	0	$10" + .22" - .57" = 9.65"$	$32.6\,in^3$	$1.32\,in^4$	$2.65"$	$23.7\,in^4$	$32.6\,in^4$	$-.36"$	$.44\,in^4$
	$4.49\,in^2$	$-.634"$	$-2.85\,in^3$	$5"$	$22.45\,in^3$	$67.4\,in^4$	$2"$	$18.0\,in^4$	$2.28\,in^4$	$-.27"$	$.33\,in^4$
	$\Sigma A = 7.87\,in^2$		$\Sigma xA = -2.85\,in^3$		$\Sigma yA = 55.05\,in^3$	$\Sigma I_{xc} = 68.$		$\Sigma Ady^2 = 41.7\,in^4$	$\Sigma I_{yc} = 34.9\,in^4$		$\Sigma Adx^2 = .77\,in^4$

$$\bar{x} = \frac{-2.85\,in^3}{7.87\,in^2} = -0.36"$$

$$\bar{y} = \frac{55.05\,in^3}{7.87\,in^2} = 7.0"$$



$$dy_1 = y_1 - \bar{y} = 9.65" - 7" = 2.65"$$

$$dy_2 = \bar{y} - y_2 = 7" - 5" = 2"$$

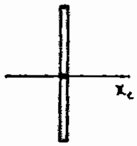
$$dx_1 = \bar{x} = -.36"$$

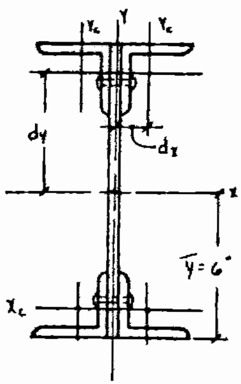
$$dx_2 = x_2 - \bar{x} = .634" - .36" = .27"$$

$$I_x = \Sigma I_{xc} + \Sigma Ady^2 = 68.7\,in^4 + 41.7\,in^4 = \underline{\underline{110.4\,in^4}}$$

$$I_y = \Sigma I_{yc} + \Sigma Adx^2 = 34.9\,in^4 + .8\,in^4 = \underline{\underline{35.7\,in^4}}$$

6.13

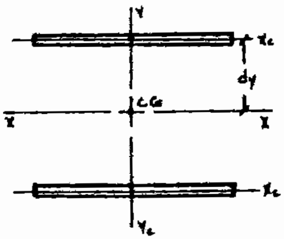
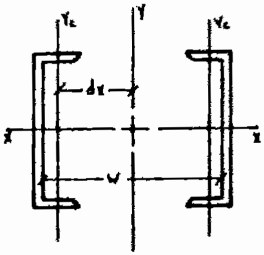
COMPONENT	A	I_{xc}	dy	Ady^2	I_{yc}	dx	Adx^2
	$2 \times 2.75 = 5.5 in^2$	$2 \times 2.22 = 4.44 in^4$	$6'' - .93'' = 5.07''$	$141.4 in^4$	$2 \times 2.22 = 4.44 in^4$	$.93'' + .25'' = 1.18''$	$7.66 in^4$
	$6 in^2$	$\frac{\frac{1}{2}(12)^3}{12} = 72 in^4$	0	0	$\frac{12(.5)^3}{12} = .13 in^4$	0	0
	$5.5 in^2$	$4.44 in^4$	$5.07''$	$141.4 in^4$	$4.44 in^4$	$1.18''$	$7.66 in^4$
		$\Sigma I_{xc} = 80.9 in^4$		$\Sigma Ady^2 = 282.8 in^4$	$\Sigma I_{yc} = 9.0 in^4$		$\Sigma Adx^2 = 15.3 in^4$



$$I_x = \Sigma I_{xc} + \Sigma Ady^2 = 80.9 in^4 + 282.8 in^4 = \underline{\underline{363.7 in^4}}$$

$$I_y = \Sigma I_{yc} + \Sigma Adx^2 = 9.0 in^4 + 15.3 in^4 = \underline{\underline{24.3 in^4}}$$

6.14

COMPONENT	I_{xc}	A	dy	Ady^2	I_{yc}	dx	Adx^2
	$2 \times \frac{16(3/4)^3}{12} = 1.1\,in^4$	$3/4 \times 16 = 12\,in^2$	$7\frac{1}{2}" + 3/8" = 7.88"$	$2 \times 745 = 1490\,in^4$	$\frac{2 \times (3/4)(16)^3}{12} = 512\,in^4$	0	0
	$2 \times 4C\,in^4 = E\ 8\,in^4$	$14.7\,in^2$	0	0	$2 \times 11 = 22\,in^4$	dx	$2 \times (14.7 dx^2) = 29.4 dx^2$
	$\Sigma I_{xc} = 809\,in^4$			$\Sigma Ady^2 = 1490\,in^4$	$\Sigma I_{yc} = 534\,in^4$		$\Sigma Adx^2 = 29.4 dx^2$

$I_x = 809\,in^4 + 1490\,in^4 = 2299\,in^4 \qquad I_Y = 534\,in^4 + 29.4\,dx^2$

BUT: $I_x = I_y \quad \therefore\ 2299\,in^4 = 534\,in^4 + 29.4\,dx^2$

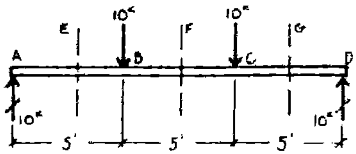
$29.4\,dx^2 = 1765\,in^4 \qquad dx^2 = \frac{1765}{29.4} = 60.2 \qquad dx = 7.8"$

$\frac{W}{2} = dx + x - t_w = 7.8" + .8" - .7" = 7.9"$

FROM AISC TABLE

$\therefore\ \underline{\underline{W = 15.8"}}$

7.1



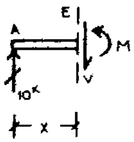
Sect E: $x = 0$ to $x = 5'$

$[\Sigma F_Y = 0]$ $V = +10^k$ (constant (+) shear)

$[\Sigma M_E = 0]$ $-10^k x = M$

$M = 10x$

@ $x = 0$, $M = 0$; @ $x = 5'$, $M = +50^{k\text{-}'}$



Sect F: $x = 5'$ to $x = 10'$

$[\Sigma F_Y = 0]$ $+10^k - 10^k - V = 0$

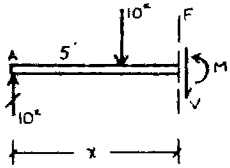
$V = 0$ (no shear)

$[\Sigma M_F = 0]$ $-10^k(x) + 10^k(x - 5') + M = 0$

$M = 10x - 10x + 50^{k\text{-}'}$

$M = +50^{k\text{-}'}$ (constant)

For $x = 5'$ to $x = 10'$



Sect. G: $x = 10'$ to $x = 15'$

$[\Sigma F_Y = 0]$ $+10^k - 10^k - 10^k + V = 0$

$V = 10^k$

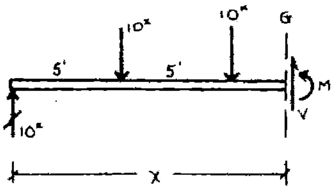
constant (−) shear

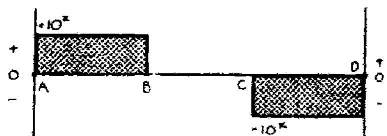
$[\Sigma M_G = 0]$ $-10^k(x) + 10^k(x - 5') + 10^k(x - 10') + M = 0$

$M = 10x - 10x + 50^{k\text{-}'} - 10x + 100^{k\text{-}'} = 0$

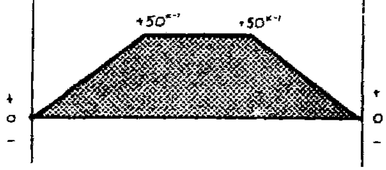
$M = 150^{k\text{-}'} - 10x$ (varies with x)

For $x = 10'$ to $x = 15'$



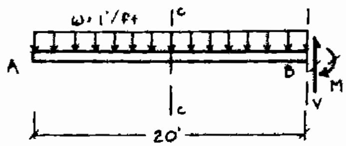


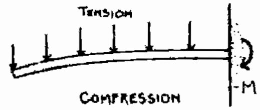
'V' DIAGRAM

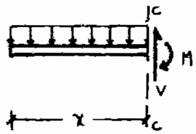


'M' DIAGRAM

7.2







SECT C: $x = 0$ to $x = 20'$

$[\Sigma F_y = 0]$ $-1^k/ft\,(x) + V = 0$

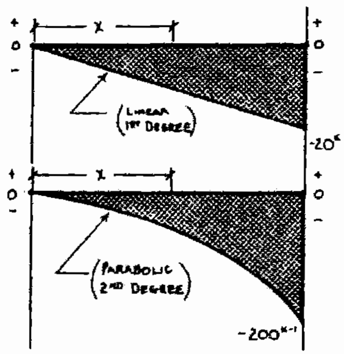
$V = 1^k/ft\,(x)$ (1st DEGREE FUNCTION)

VARIES AS A FUNCTION OF x (LINEAR)

@ $x = 0$, $V = 0$;

@ $x = 20$, $V = 20^k$

(NEGATIVE SHEAR)



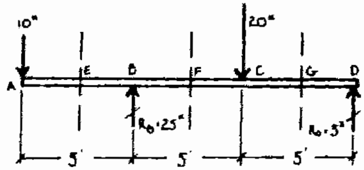
$[\Sigma M_c = 0]$ $+1^k/ft\,(x)(x/2) - M = 0$

$M = x^2/2$ (2ND DEGREE FUNCTION)

@ $x = 0$; $M = 0$ (PARABOLIC)

@ $x = 20'$; $M = 200^{k\text{-}'}$

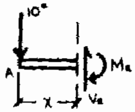
7.3



OVER-HANG BEAM WITH LOADS AS SHOWN. SOLVE FOR THE EXTERNAL REACTIONS. CUT BEAM AT SECTIONS.

$[\Sigma F_Y = 0]$ $V_E = 10^K$

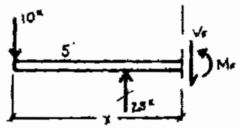
CONSTANT BETWEEN A & B.



$[\Sigma M = 0]$ $M_E = 10x$

M INCREASES AS x INCREASES.

$\boxed{x = 0 \text{ TO } 5'}$



$V_F = -10 + 25 = 15^K$

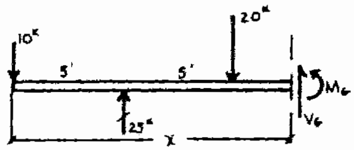
CONSTANT POSITIVE SHEAR BETWEEN B & C

$M = -10x + 25(x-5)$

$M = 15x - 125$

VARIES LINEAR WITH RESPECT TO x

$\boxed{x = 5' \text{ TO } 10'}$



$V_G = 5^K$ CONSTANT BETWEEN C & D

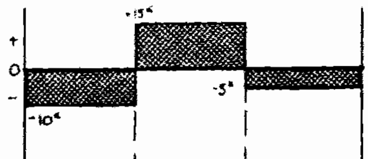
$M = -10(x) + 25(x-5) - 20(x-10)$

$= -10x + 25x - 125 - 20x + 200$

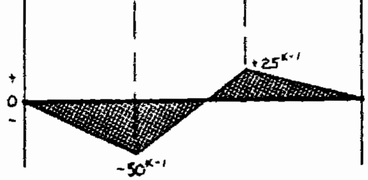
$M_G = -5x + 75$

LINEAR

$\boxed{x = 10' \text{ TO } 15'}$

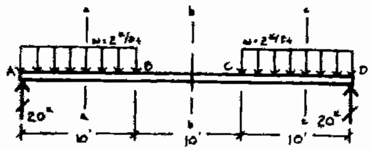


"V" DIAGRAM

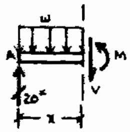


"M" DIAGRAM

7.4



A SIMPLY SUPPORTED BEAM IS LOADED WITH PARTIAL UNIFORM LOADS AS SHOWN. DRAW A FBD OF THE BEAM. SOLVE FOR THE EXTERNAL REACTIONS. SKETCH IN THE DEFLECTED SHAPES OF THE BEAM DUE TO THE APPLIED LOADS. THE BEAM WILL BE EXAMINED BY FBD'S AT SECTION CUTS a-a, b-b, AND c-c.



a-a

$x=0$ TO $x=10'$

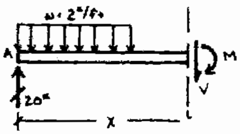
$[\Sigma F_y=0]$ $+20^k - wx - V=0$

$V=20^k-2x$ } SHEAR IS A FUNCTION OF X. AS X INCREASES, V DECREASES.

$[\Sigma M_a=0]$ $-20^k x + \frac{wx^2}{2} + M=0$

$M=20x-\frac{2x^2}{2}=20x-x^2$ } MOMENT IS A FUNCTION OF X.

M INCREASES → 2ND DEGREE CURVE



b-b

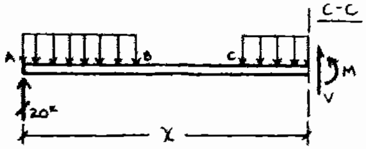
$x=10'$ TO $x=20'$

$[\Sigma F_y=0]$ $+20^k - 2^k/ft\,(10') - V=0$ $\underline{V=0}$ NO SHEAR BETWEEN 10' AND 20'

$[\Sigma M_b=0]$ $-20x + 2^k/ft\,(10')(x-5') - M=0$

$M=-20x+20x-100$ $\underline{M=-100^{k\text{-}'}}$

ASSUME DIRECTION ON FBD IS WRONG. SHOULD BE:



$x=20'$ TO $x=30'$

$[\Sigma F_y=0]$ $+20^k-2(10)-2(x-20')+V=0$

$V=-20+20+2x-40,\ 2x-40$ } V IS A FUNCTION OF X. INCREASES AS X INCREASES

$[\Sigma M_c=0]$ $-20^k(x)+2(10)(x-5')+2(x-20')\left(\frac{x-20}{2}\right)+M=0$

$M=-20x+20x-100+x^2-40x+400$

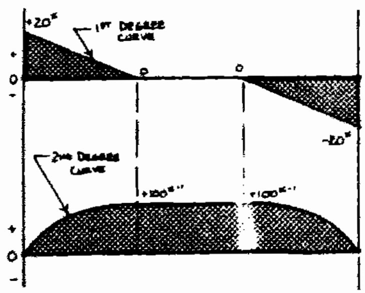
$-M=x^2-40x+300.$

M IS A FUNCTION OF X. 2ND DEGREE CURVE.

@ $x=10'$; $V=0$ ($V=20-2x$)

BETWEEN $x=10'$ TO $x=20'$; $V=0$

BETWEEN $x=20'$ TO $x=30'$; NEGATIVE V. GOES FROM 0 TO -20^k.



"V" DIAGRAM

"M" DIAGRAM

@ $x=0$, $M=0$ (NO MOMENT @ A HINGE)

BETWEEN $x=0$ TO $x=10'$ M IS INCREASING

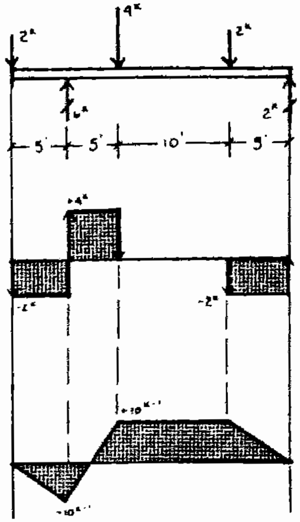
@ $x=10'$, $M=100^{k\text{-}'}$ (POSITIVE BENDING)

BETWEEN $x=10'$ TO $x=20'$ $M=100^{k\text{-}'}$ (CONSTANT)

BETWEEN $x=20'$ TO $x=30'$ M IS DECREASING

@ $x=30'$, $M=0$

7.5



"V" DIAGRAM

"M" DIAGRAM

INFLECTION POINT AT:

$\Delta M = V(\Delta x)$

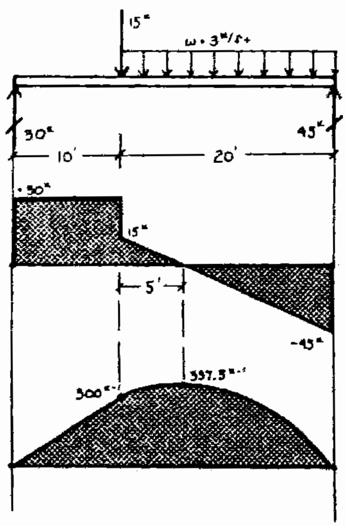
$10 = 4(x-5)$

$10 = 4x - 20$

$30/4 = x$

$x = 7.5'$

7.6



"V" DIAGRAM

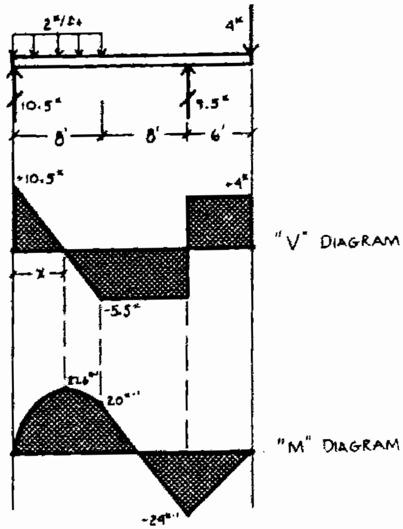
$\Delta V = \omega(\Delta x)$

$15 = 3^k/ft\,(x)$

$x = 15^k / 3^k/ft = 5'$

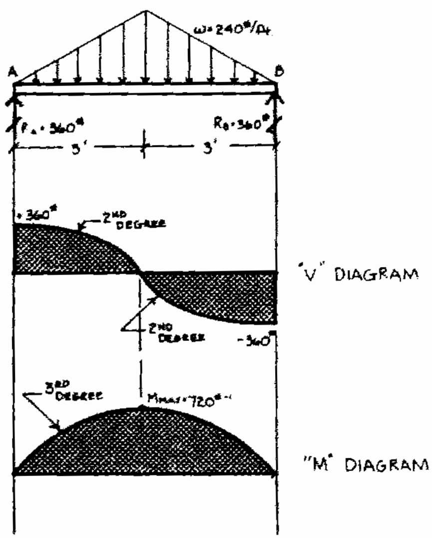
"M" DIAGRAM

7.7



$$x = \frac{10.5^K}{2^K/ft} = 5.25'$$

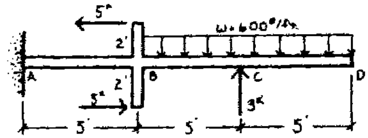
7.8



$$\tfrac{1}{2}(3')(240) = 360^{\#}$$

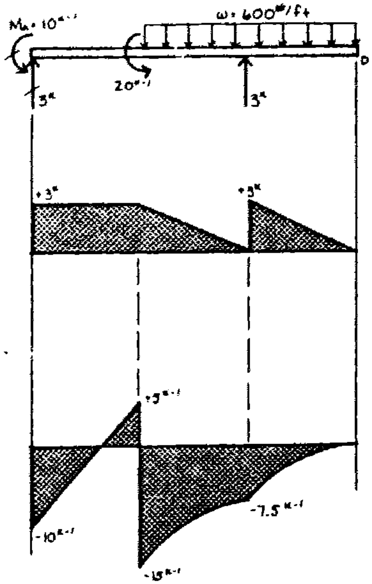
$$M_{MAX} = \tfrac{2}{3}(3')(360) = 720^{\#\text{-}'}$$

7.9



$M_A = 0.6^{k}/ft.\,(10')(10') - 3^{k}(10) - 20^{k\text{-}'}$

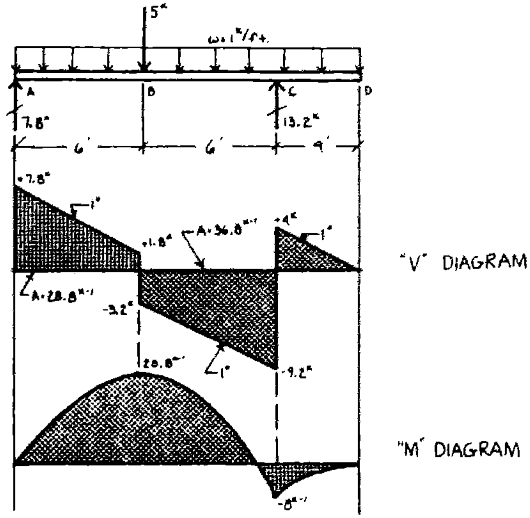
$M_A = 60^{k\text{-}'} - 30^{k\text{-}'} - 20^{k\text{-}'} = 10^{k\text{-}'}$



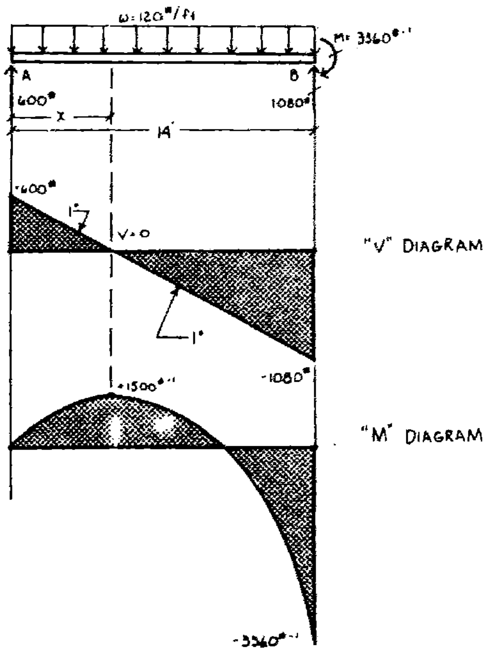
"V" DIAGRAM

"M" DIAGRAM

7.10



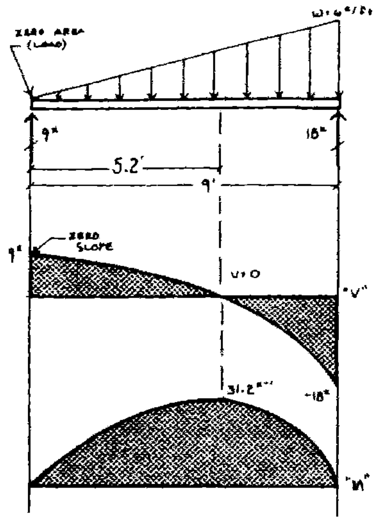
7.11



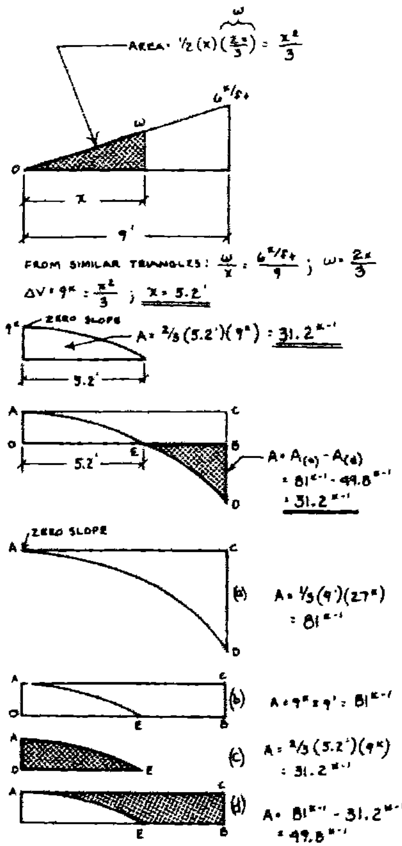
$\Delta V = 600^{\#} = 120^{\#}/ft\,(x)$

$x = \dfrac{600^{\#}}{120^{\#}/ft} = 5'$

7.12

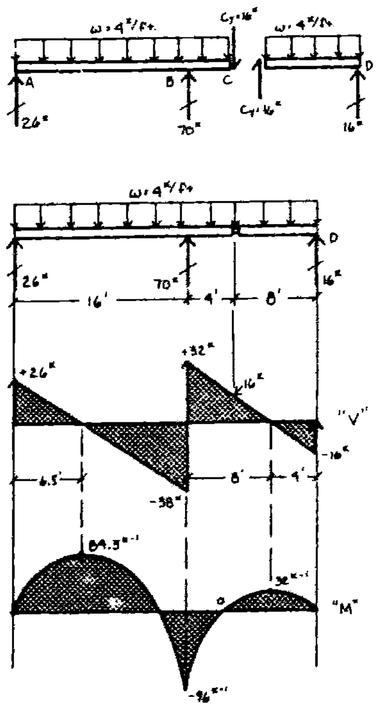


ω = 6 k/ft
ZERO AREA (LOAD)
9k
18k
5.2'
9'
9k
ZERO SLOPE
V = 0
"V"
-18k
31.2 k-ft
"M"



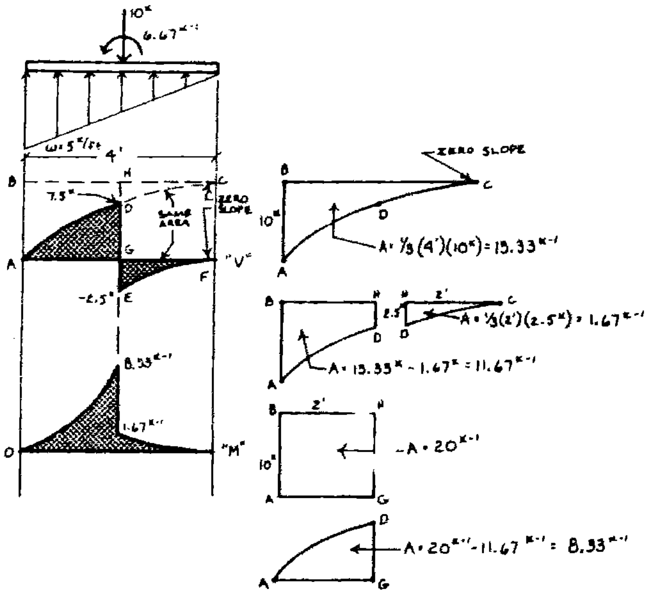
ω
AREA = 1/2 (x)(2x/3) = x²/3
6 k/ft
ω
0
x
9'
FROM SIMILAR TRIANGLES: ω/x = 6 k/ft / 9 ; ω = 2x/3
ΔV = 9k = x²/3 ; x = 5.2'
9k
ZERO SLOPE
A = 2/3 (5.2')(9k) = 31.2 k-ft
5.2'
A
C
0
B
E
D
5.2'
A = A(a) − A(d)
= 81 k-ft − 49.8 k-ft
= 31.2 k-ft
ZERO SLOPE
A
C
D
(a)
A = 1/3 (9')(27k)
= 81 k-ft
A
C
0
E
B
(b)
A = 9k × 9' = 81 k-ft
A
0
E
(c)
A = 2/3 (5.2')(9k)
= 31.2 k-ft
A
C
E
B
(d)
A = 81 k-ft − 31.2 k-ft
= 49.8 k-ft

7.13

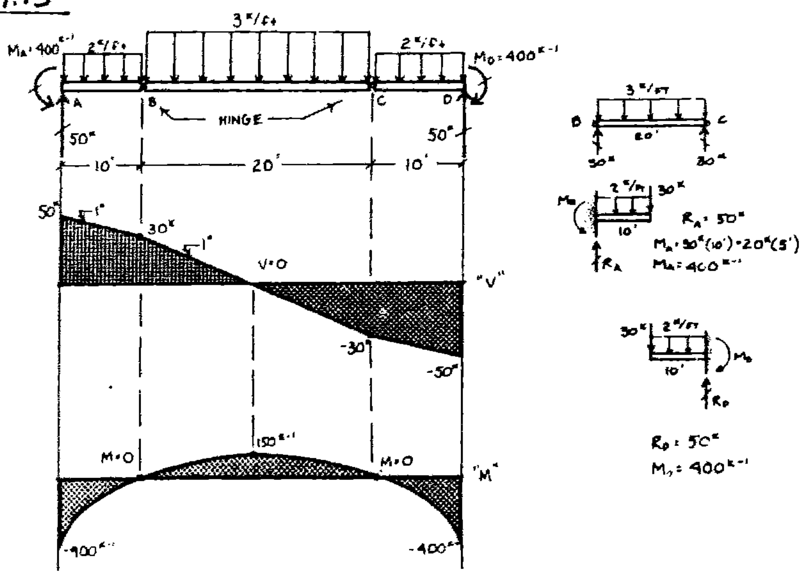


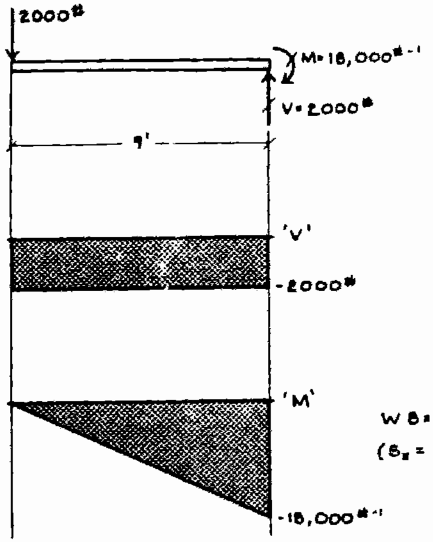
ω = 4 k/ft
Cy = 16k
A
B
C
D
26k
70k
16k
16'
4'
8'
+26k
+32k
16k
"V"
-16k
6.5'
-38k
8'
4'
84.5k-'
32k-'
"M"
-96k-'

7.14


10ᴷ
6.67ᴷ⁻'
ω=5ᴷ/ft
4'
ZERO SLOPE
SAME AREA
7.5ᴷ
-2.5ᴷ
"V"
8.33ᴷ⁻'
1.67ᴷ⁻'
"M"
A = 1/3 (4')(10ᴷ) = 13.33ᴷ⁻'
A = 1/3(2')(2.5ᴷ) = 1.67ᴷ⁻'
A = 13.33ᴷ - 1.67ᴷ = 11.67ᴷ⁻'
A = 20ᴷ⁻'
A = 20ᴷ⁻' - 11.67ᴷ⁻' = 8.33ᴷ⁻'

7.15


3ᴷ/ft
2ᴷ/ft
Mₐ = 400ᴷ⁻'
M_D = 400ᴷ⁻'
HINGE
50ᴷ
10'
20'
30ᴷ
V=0
"V"
-30ᴷ
-50ᴷ
M=0
150ᴷ⁻'
"M"
-400ᴷ⁻'
Rₐ = 50ᴷ
Mₐ = 50ᴷ(10') - 20ᴷ(5')
Mₐ = 400ᴷ⁻'
R_D = 50ᴷ
M_D = 400ᴷ⁻'



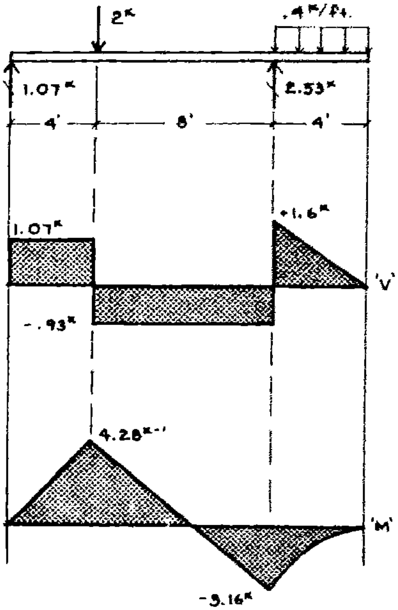
W 8×18

(S_x = 15.2 in³)

$$\sigma = \frac{M}{S} = \frac{18^{k-'} \times 12^{"/'}}{15.2\,in^3} = 14.2\text{ ksi} \; < \; \underset{(F_b)}{22\text{ ksi}}$$

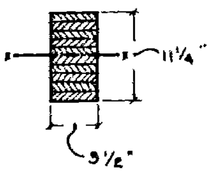
∴ O.K., NOT OVERSTRESSED

8.2



$V_{MAX} = 1.6^K$

$M_{MAX} = 4.28^{K\text{-}'}$



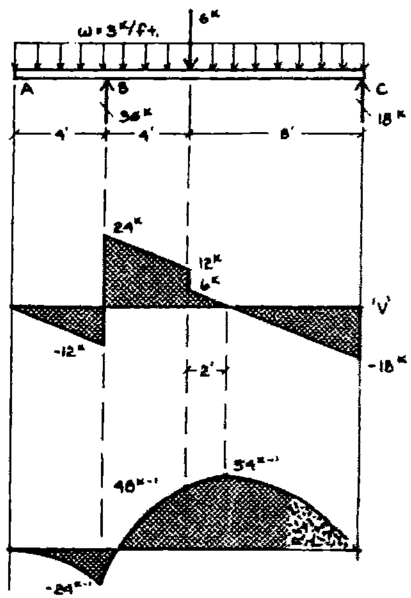
$S_x = 73.8 \text{ in}^3$

$f = \frac{MC}{I} = \frac{M}{S} = \frac{4.28^{K\text{-}'} \times 12''/'}{73.8 \text{ in}^3} = \underline{.696 \text{ ksi}}$

$f_b = 696 \text{ psi} < \underset{(F_b)}{1{,}300 \text{ psi}}$ $\quad \underline{\underline{\therefore \text{ O.K.}}}$

THE BEAM IS SAFE

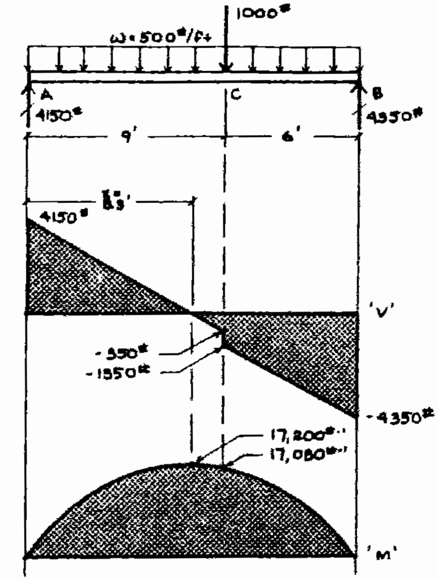
8.3



W8 × 35 ; $I_x = 127$, $S_x = 31.2\ in^3$, $d = 8.12''$, $c = 4.06''$

$$f = \frac{Mc}{I} = \frac{M}{S} = \frac{54^{k\text{-}'} \times 12''/'}{31.2\ in^3} = \underline{20.8\ ksi} < 22\ ksi$$

$\therefore$ O.K.



$\Delta V = \omega \Delta X$

$\Delta x = \dfrac{4150^{\#}}{500^{\#}/ft} = 8.3'$

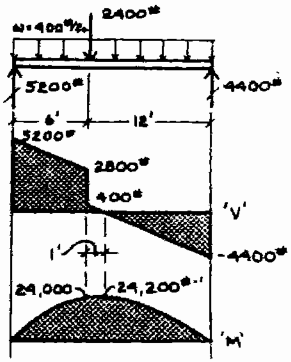
$M_{MAX} = 17.2^{k-'}$

$f = \dfrac{M_{MAX}}{S}$; $S_{MIN} = \dfrac{M_{MAX}}{F_b} = \dfrac{17.2^{k-'} \times 12''/'}{22\ ^{k}/in^2} = \underline{9.38\ in^3}$

SCAN THE W8 SECTIONS UNTIL YOU FIND ONE THAT HAS AN S EQUAL TO OR GREATER THAN THE S_{MIN} VALUE ABOVE.

$\therefore$ USE : **W8 × 15** ($S_x = 9.91\ in^3$)

B5



W 8×18

$d = 8.14''$; $c = d/2 = 4.07''$

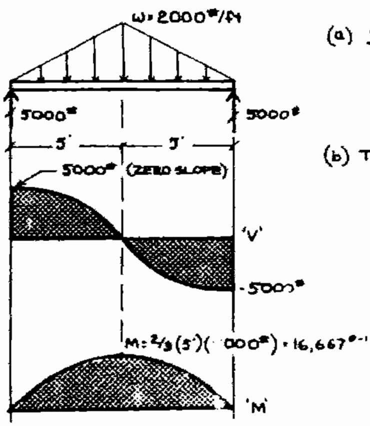
$I_x = 61.9\ in^4$; $S_x = 15.2\ in^3$

$$f = \frac{Mc}{I} = \frac{M}{S} = \frac{24.2^{k\text{-}'} \times 12''/'}{15.2\ in^3} = \underline{\underline{19.1\ k/in^2}}$$

$I/c = S$ $\qquad F_b = 22\ k/in^2 > 19.1\ k/in^2$

$\therefore$ O.K.

B.6



(a) W 8×15

$S_x = 11.8\ in^3$

$$f = \frac{M}{S} = \frac{16.67^{k\text{-}'} \times 12''/'}{11.8\ in^3} \cong \underline{\underline{17\ k/in^2}}$$

$F_b = 22$ ksi $\quad \therefore$ O.K.

(b) TIMBER BEAM REQUIRED:

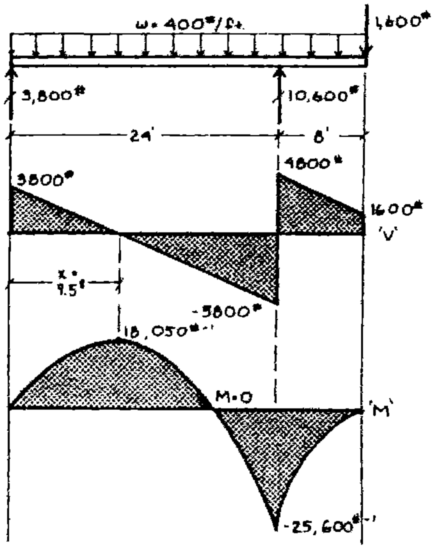
$S_{req'd} = M/F_b$

$$S_{req'd} = \frac{16.67 \times 12}{1.6\ k/in^2} = \underline{\underline{125\ in^3}}$$

FROM TABLE:

8 × 12 S4S ($S_x = 165.3\ in^3$)

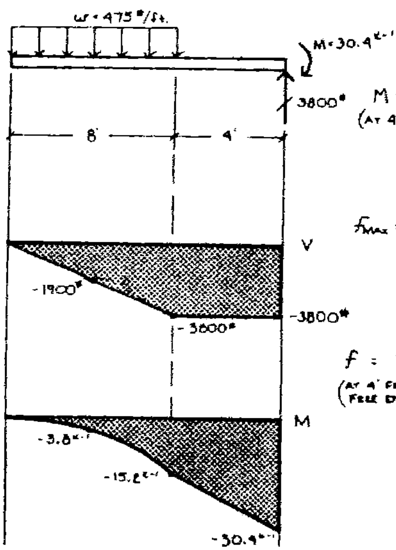
8.7



$M_{MAX} = 25,600^{\#-'}$

$f = \dfrac{M}{S} = \dfrac{25.6^{k-'} \times 12''/'}{162 \text{ in}^3} = 1.9 \text{ ksi} < 2.4 \text{ ksi allow} \quad \therefore \text{O.K.}$

8.8

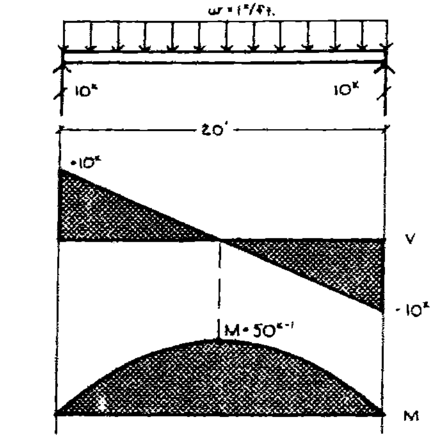


$M_{(\text{AT } 4')} = \frac{1}{2}(1900)(4) = 3,800^{\#-'}$

$f_{MAX} = \dfrac{M}{S} = \dfrac{30.4^{k-'} \times 12''/'}{24.3 \text{ in}^3} = \underline{\underline{15 \text{ ksi}}}$

$f_{(\text{AT } 4' \text{ FROM FREE END})} = \dfrac{M}{S} = \dfrac{3.\ ' \times 12}{24.3} = \underline{\underline{1.88 \text{ ksi}}}$

8.9



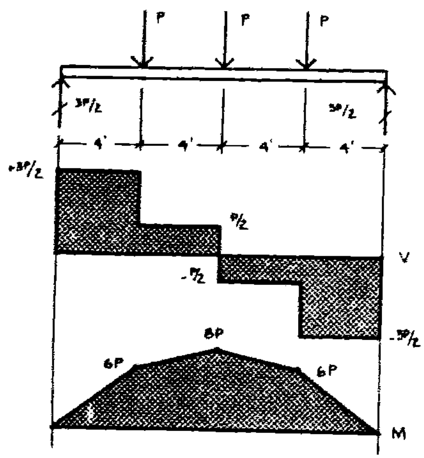
$$f_b = \frac{M}{S}$$

$$S_{req'd} = \frac{M}{F_b} = \frac{50^{k-'} \times 12}{22} = 27.3 \text{ in}^3$$

USE: $\underline{\underline{W14 \times 22}}$

$(S = 29.0)$

8.10



$\underline{W18 \times 40}$

$(S = 68.4 \text{ in}^3)$

$$f_b = \frac{M}{S}$$

$$M_{MAX} = F_b \times S_x$$

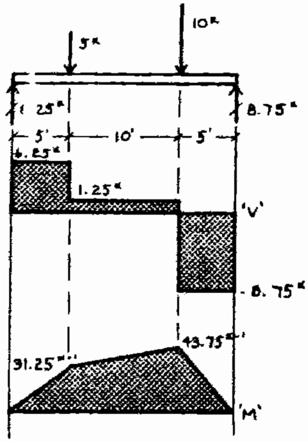
$$M = 22 \text{ k/in}^2 (68.4 \text{ in}^3) = 1504.8^{k\text{-}in}$$

$$M = \frac{1504.8}{12} = 125.4^{k\text{-}ft}$$

$$8P = 125.4^{k\text{-}'}$$

$$P = \frac{125.4}{8} = \underline{\underline{15.68^{k}}}$$

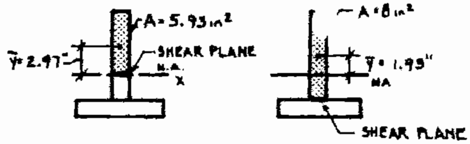
8.11

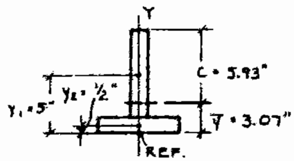


$$f_b = \frac{Mc}{I} = \frac{(43.75 \times 12)^{k\text{-}"}(5.93")}{113.2\ in^4} = 27.5\ ksi$$

$F_b = 30$ ksi ∴ O.K.

$$f_{v_{NA}} = \frac{VQ}{Ib} = \frac{(8.75)(\overset{A}{5.93} \times \overset{\bar{y}}{2.97})}{(113.2)(1")} = 1.36\ ksi$$



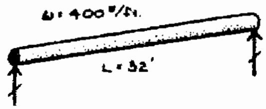


$$f_{v\,@\,FLANGE} = \frac{(8.75)(8 \times 1.93)}{(113.2)(1)} = 1.19\ ksi$$

COMP.	A	y	yA	I_{xc}	dy	dy^2	Ady^2
x_c	8	5	40	$\frac{(1)(8)^3}{12} = 42.7$	1.93"	3.8	30.4
x_c	6	½	3	$\frac{(6)(1)^3}{12} = .5$	2.57"	6.6	39.6
	$\Sigma A = 14$		$\Sigma yA = 43$	$\Sigma I_{xc} = 43.2$			$\Sigma Ady^2 = 70$

$\bar{y} = \frac{43}{14} = 3.07"$ $\quad I_x = \Sigma I_{xc} + \Sigma Ady^2 = 43.2 + 70 = \underline{113.2\ in^4}$

8.12

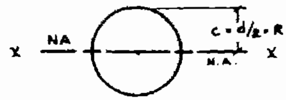


$F_b = 1200$ psi

$F_v = 100$ psi

$$V_{MAX} = \frac{wL}{2} = \frac{400(32)}{2} = 6400\#$$

$$M_{MAX} = \frac{wL^2}{8} = \frac{400(32)^2}{8} = 51{,}200\#$$



BENDING

$$f_b = \frac{Mc}{I}$$

$$1200\#/in^2 = \frac{(51{,}200^{\#\text{-}'} \times 12)(R)}{\pi R^4/4}$$

$$I = \frac{\pi D^4}{64} = \frac{\pi R^4}{4}$$

$$R^3 = \frac{(51{,}200 \times 12)(4)}{3.14\,(1200)} =$$

$$R^3 = \frac{(512)(4)}{3.14} = 655$$

R = 8.67" (BENDING) SAY 9"

$$A = \frac{\pi R^2}{2}$$

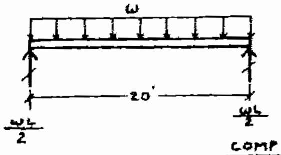
SHEAR

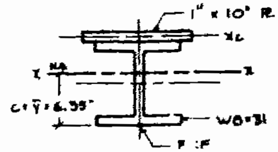
$$f_v = \frac{VQ}{Ib} \; ; \quad 100\#/in^2 = \frac{6400\#\left(\frac{\pi R^2}{2}\right)\left(\frac{4R}{3\pi}\right)}{\left(\frac{\pi R^4}{4}\right)(2R)} = \frac{4(6400)(R^3)}{3(\pi)(R^5)}$$

$$R^2 = \frac{4(6400)}{3(3.14)(100)} = \frac{4(64)}{3(3.14)} = 27.2 \; ; \quad R = 5.2"$$

USE: <u>18" DIAMETER LOG</u>

8.13





$V_{MAX} = \frac{\omega L}{2}$

$M_{MAX} = \frac{\omega L^2}{8}$

COMP	A	y	yA	I_{xc}	dy	Ady^2
plate	10	8.5	85	$\frac{(10)(1)^3}{12} = .833$	2.15	46
W section	9.13	4	36.4	110	2.35	50.3
	$\Sigma A = 19.13$		$\Sigma yA = 121.4$	$\Sigma I_{xc} = 111$		$\Sigma Ady^2 = 96.3$

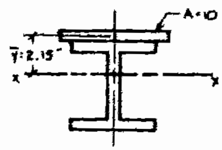
$\bar{y} = \frac{121.4}{19.13} = 6.35''$ $\qquad I_x = 111 + 96.3 = 207.3 \text{ in}^4$

$f_b = \frac{Mc}{I}\ ; \quad M_{ALLOW} = \frac{F_b \times I_x}{c} = \frac{(22\ ^k/\text{in}^2)(207.3\text{ in}^4)}{6.35''} = 720^{k\text{-in}}$

$M_{MAX} = M_{ALLOW}\ ; \quad \therefore \frac{\omega L^2}{8} = \frac{720^{k\text{-in}}}{12''/'}$

$\omega = \left(\frac{720}{12}\right) \times \frac{8}{L^2} = \left(\frac{720}{12}\right)\left(\frac{8}{20^2}\right) = \underline{1.2\ ^k/\text{ft.}}$

@ FLANGE $f_v = \frac{VQ}{Ib}$

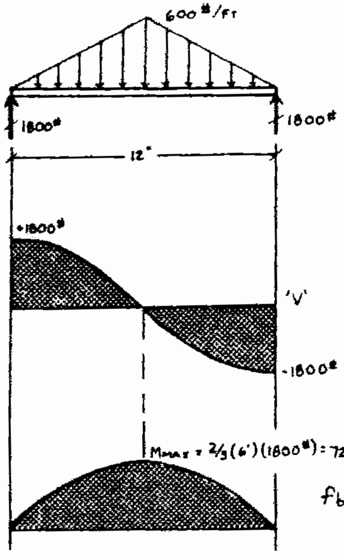


$V_{MAX} = \frac{\omega L}{2} = \frac{(1.2\ ^k/\text{ft})(20')}{2} = 12^k$

$f_v = \frac{(12^k)(\overset{A}{10\text{ in}^2} \times \overset{\bar{y}}{2.15\text{ in}})}{(207.3\text{ in}^4)(8\text{ in})} = \underline{\underline{.156\ ^k/\text{in}^2}} < 14.5 \text{ ksi}$

$\therefore$ O.K.

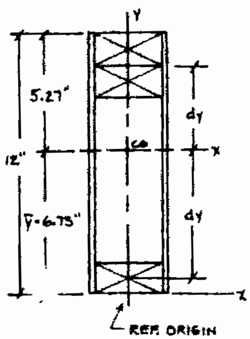
8.14



$R = \frac{1}{2}(6')(600^{\#}/\text{FT}) = 1800^{\#}$

$M_{MAX} = \frac{2}{3}(6')(1800^{\#}) = 7200^{\#\text{-}'}$

$$f_b = \frac{Mc}{I} = \frac{(7{,}200^{\#\text{-}'} \times 12''/')(6.73'')}{496.9\text{ in}^4} = \underline{1170\text{ psi}}$$

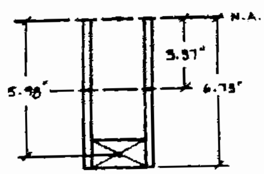


COMP	A	y	Ay	I_{xc}	dy	Ad_y^2
⊠	10.5	10.5	110.5	$\frac{(3.5)(3)^3}{12} = 7.89$	3.77	149.5
‖	12	6	72	$\frac{2(\frac{1}{2})(12)^3}{12} = 144$	.73	6.4
⊠	5.25	.75	3.9	$\frac{(3.5)(1.5)^3}{12} = .99$	5.98	188
	$\Sigma A = 27.75\text{ in}^2$		$\Sigma Ay = 186.5$	$\Sigma I_{xc} = 152.9\text{ in}^3$		$\Sigma Ad_y^2 = 344\text{ in}^4$

$$\bar{y} = \frac{186.5}{27.75} = 6.73''$$

$$I_x = \Sigma I_{xc} + \Sigma Ad_y^2 = 152.9 + 344 = 469.9\text{ in}^4$$

$$C_{MAX} = 6.73''$$

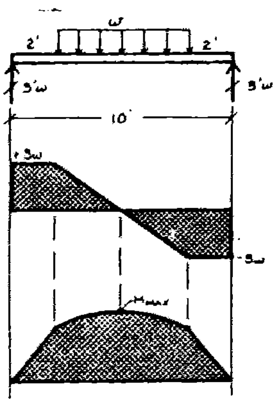


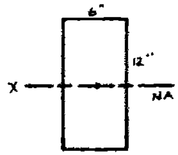
$Q = A\bar{y}$

COMP	A	y	$Q = A\bar{y}$
‖	6.73 in^2	3.37 in	22.7 in^3
⊠	5.25 in^2	5.98 in	31.4 in^4
			$Q = 54.1\text{ in}^3$

$$f_v = \frac{VQ}{Ib} = \frac{1800^{\#}(54.1\text{ in}^3)}{(496.9\text{ in}^4)(1'')} = \underline{\underline{196\text{ psi}}}$$

8.15





$V_{MAX} = 3\omega$

$M_{MAX} = 6\omega + \tfrac{1}{2}(3)(3\omega) = 10.5\,\omega$

$A = 72\ in^2$

$I = \dfrac{(6)(12)^3}{12} = 864\ in^4$

$c = 6''$

$S = \dfrac{864}{6} = 144\ in^3$

$f_{b(MAX)} = \dfrac{Mc}{I_x} = \dfrac{M}{S_x}$;

$M_{ALLOW} = F_b \times S = 1.6\ ^K/_{in^2} \times 144\ in^3 = 230^{K\text{-}in}$

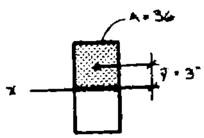
$M_{ALLOW} = \dfrac{230^{K\text{-}in}}{12\ ^{in}/_{FT}} = 19.2^{K\text{-}FT}$

$M_{MAX} = 10.5\omega = 19.2^{K\text{-}FT.}$

$\omega_{(BENDING)} = \dfrac{19.2}{10.5} = 1.83\ ^K/_{FT}$

$f_{v_{max}} = \dfrac{VQ}{Ib}$; $\quad V_{ALLOW} = \dfrac{F_v I b}{Q} = \dfrac{(.085\ ^K/_{in^2})(864\ in^4)(6\ in)}{(36\ in^2 \times 3\ in)} = 4.08^K$

(@ N.A)



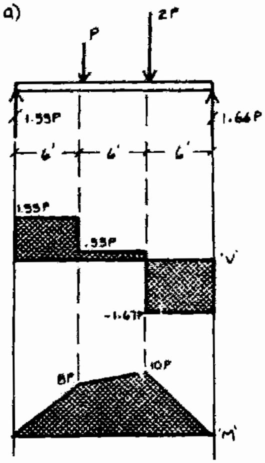
$V_{MAX} = 3\omega = 4.08^K$

$\underset{(SHEAR)}{\omega} = \dfrac{4.08^K}{3} = 1.36\ ^K/_{FT}$

SHEAR GOVERNS : $\underline{\underline{\omega = 1.36\ ^K/_{FT.}}}$

8.16

a)



$V_{MAX} = 1.67P$

$M_{MAX} = 10P$

4 x 12 S4S
(S_x = 73.8, A = 39.4)

$f_b = \frac{M}{S}$

$M_{MAX} = F_b \times S_x = 1.6^{K}/_{in^2} \times 73.8\ in^3$

$M_{MAX} = 118^{K\text{-}in} = 9.85^{K\text{-}FT}$

$10P = 9.85^{K\text{-}'}$ $\quad \underline{\underline{P = .985^{K} = 985^{\#}}}$

$\underset{@\ N.A.}{\underset{(MAX)}{f_v}} = \frac{1.5\,V_{MAX}}{A}$

$V_{MAX} = \frac{F_v\ (A)}{1.5} = \frac{85^{\#}/_{in^2}\,(39.4\,in^2)}{1.5} = 2230^{\#}$

$2230^{\#} = 1.67P;$ $\quad \underline{\underline{P = 1340^{\#}}}$

$\therefore$ $\underline{\underline{P = 985^{\#} \quad \text{BENDING GOVERNS}}}$

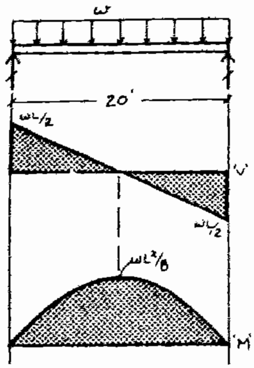
b) $V_{@4'} = 1.33P = 1.33(985^{\#}) = 1315^{\#}$

$M_{@4'} = 1.33P(4') = 5.33P = 5.33(985^{\#}) = 5250^{\#\text{-}'}$

$f_v = \frac{1.5V}{A} = \frac{1.5(1315^{\#})}{39.4\,in^2} = \underline{50.2\ psi}$

$f_b = \frac{M}{S} = \frac{5250^{\#\text{-}'} \times 12''/'}{73.8\,in^3} = \underline{854\ psi}$

8.17



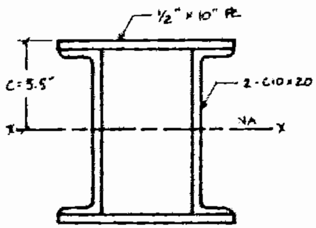
$$M_{MAX} = \frac{\omega L^2}{8}$$

$$M_{MAX} = F_b \times S_x = 22^{K}/in^2 \times 79\ in^3 = 1735^{K\text{-}in}$$

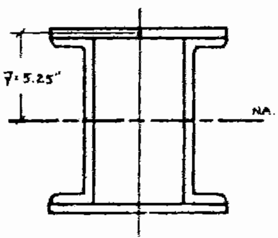
$$M_{MAX} = \frac{1735^{K\text{-}in}}{12\ ^{in}/_{Ft}} = 145^{K\text{-}Ft.}$$

$$\frac{\omega L^2}{8} = 145^{K\text{-}Ft.}$$

$$\omega = \frac{145(8)}{(20)^2} = \underline{\underline{2.9\ ^{K}/_{Ft.}}}$$



COMP	I_{xc}	A	dy	Ady^2
	.1	5	5.25	138
	157.8	11.8	0	0
	.1	5	5.25	138
	$\Sigma I_{xc} = 158$			$\Sigma Ady^2 = 276$



$I_x = 158 + 276 = \underline{434\ in^4}$; $c = 5.5''$

$S_x = I/c = 434/5.5 = 79\ in^3$

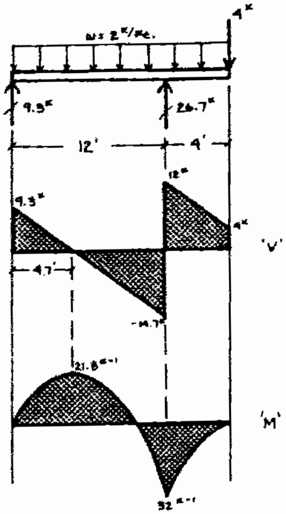
$V = \omega L/2 = 2.9(20)/2 = 29^K$

$b = 2 \times 2.74 = 5.48''$

$Q = A\bar{y} = (5\ in^2)(5.25'') = 26.3\ in^3$

$$f_v = \frac{VQ}{Ib} = \frac{29^K(26.3\ in^3)}{(434\ in^4)(5.48'')} = \underline{\underline{0.32\ ksi}}$$

8.18



$M_{MAX} = 32^{k\text{-}'} = 384^{k\text{-}in}$

$S_{REQ'D} = \dfrac{M}{F_b} = \dfrac{384^{k\text{-}in}}{22\ ^{k}/in^2} = 17.5\ in^3$

FROM TABLES:

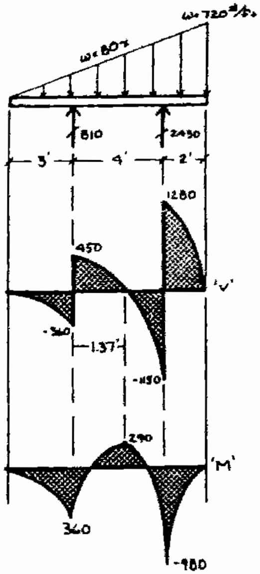
USE: W12 × 19 ($S_x = 21.3\ in^3$)
DOES NOT ACCOUNT FOR BEAM WEIGHT

OR W10 × 19 ($S_x = 18.8\ in^3$)

$f_{v\,(AVE)} = \dfrac{V_{MAX}}{t_w h} = \dfrac{14.7^k}{(.235)(12.16")} = 5.14\ ksi < 14.5\ ksi$

∴ O.K.

B.19

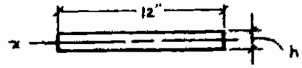


$F_b = 1200$ psi

$F_v = 100$ psi

$V_{MAX} = 1280^{\#}$

$M_{MAX} = 980^{\#\text{-}'}$



PLANK CROSS-SECTION

$$I = \frac{bh^3}{12} = \frac{12h^3}{12} = h^3$$

$$A = 12h$$

BENDING

$$f_b = \frac{Mc}{I} \; ; \qquad 1200 = \frac{(980 \times 12)(h/2)}{h^3} = \frac{5880}{h^2}$$

$$h^2 = \frac{5880}{1200} = 4.9 \text{ in}^2 \; ; \qquad \underline{h = 2.2''}$$

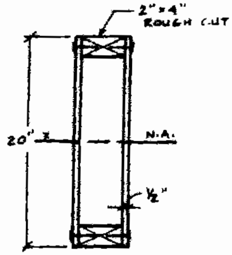
SHEAR

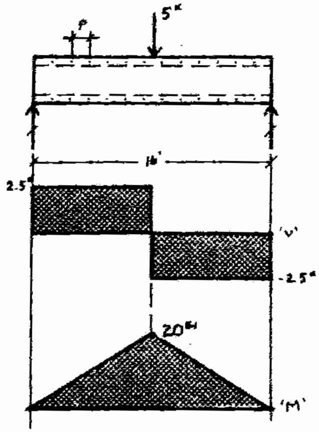
$$f_v = \frac{1.5V}{A} \; ; \qquad 100 = \frac{1.5\,(1280)}{12h}$$

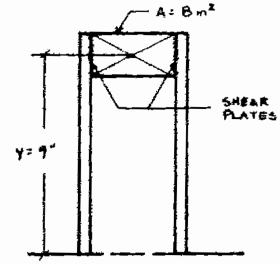
$$h = \frac{1.5\,(1280)}{1200} = \underline{1.6''}$$

$\therefore$ BENDING CONTROLS: $\underline{\underline{h = 2.2''}}$

8.20







$F = f_v b p = bp \times VQ/Ib$

$F = bp = p \cdot VQ/I$

F = CAPACITY OF 2 NAILS AT THE FLANGE REPRESENTING 2 SHEAR SURFACES

$I_x = 5''(20)^3/12 - 4''(16'')^3/12 = 1965 \text{ in}^4$

$Q = A\bar{y} = 8 \text{ in}^2 (9'') = 72 \text{ in}^3$

$V = 2500^{\#}$

p = PITCH OR SPACING $\quad p = FI/VQ$

$$p = \frac{(2 \text{ NAILS} \times 80^{\#}/\text{NAIL})(1965 \text{ in}^4)}{(2{,}500^{\#})(72 \text{ in}^3)} = \underline{\underline{1.75''}}$$

USE $\underline{\underline{1\tfrac{3}{4}''}}$ SPACING

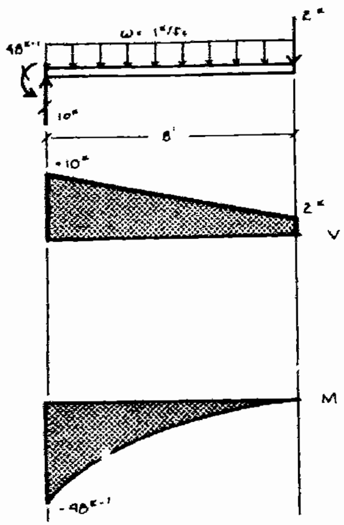
ALTERNATE METHOD: $f_v = \frac{VQ}{Ib} = \frac{(2500)(72)}{1965\,(4)} = 22.8 \text{ psi}$

$$f_v = \frac{F}{A} \longrightarrow A = \frac{F}{f_v}$$

$F = 160 \; ; \; A = 2'' \times 2p = 4p$

$$\therefore \quad 4p = \frac{F}{f_v} = \frac{160}{22.8} \; ; \; \underline{\underline{p = 1.75''}}$$

8.21



$F_b = 22\text{ ksi}$ $\quad E = 29 \times 10^3$

$F_v = 14.5\text{ ksi}$

$V_{MAX} = 10\text{ k}$ $\quad M_{MAX} = 48^{k\text{-}'}$

$$S_{req'd} = \frac{M}{F_b} = \frac{48^{k\text{-}'} \times 12''/'}{22\,^{k}/_{in^2}} = 26.2\text{ in}^2$$

TRY: W8 × 31

$(S_x = 27.5,\ d\ 8'',\ t_w = .285'',\ I_x = 110\text{ in}^4)$

$$M_{add} = \frac{wL^2}{2} = \frac{31\,^{\#}/_{ft}\,(8')^2}{2} = 992^{\#\text{-}'}$$

$$S_{add} = \frac{M_{add}}{F_b} = \frac{.992^{k\text{-}'} \times 12''/'}{22\,^{k}/_{in^2}} = 0.54\text{ in}^3$$

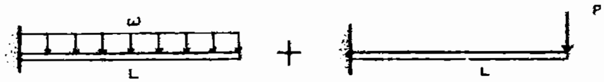
$$S_{TOTAL} = 26.2 + .54 = 26.74\text{ in}^3 < 27.5\text{ in}^3$$

$\therefore$ O.K.

$$f_{v_{ave}} = \frac{V}{t_w h} = \frac{10^k}{(.285'')(8'')} = 4.38\,^{k}/_{in^2}$$

$4.38\,^{k}/_{in^2} < F_v = 14.5\text{ ksi}$ $\therefore$ O.K.

DEFLECTION



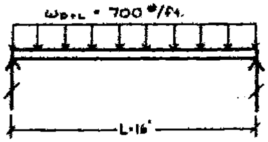
$$\Delta_{TOTAL} = \frac{wL^4}{8EI} + \frac{PL^3}{3EI}$$

$$\Delta_{TOTAL} = \frac{(1.031\,^{k}/_{ft})(8')^4(1728)}{8(29 \times 10^3)(110)} + \frac{(2^k)(8')^3(1728)}{3(29 \times 10^3)(110)}$$

$$\Delta_{TOTAL} = 0.286'' + 0.185'' = \underline{\underline{0.47''}}$$

8.22

$$M_{MAX} = \frac{wL^2}{8} = \frac{700\#/ft\,(16')^2}{8} = 22{,}400\#\text{-}'$$



$$S_{req'd} = \frac{M}{F_b} = \frac{22{,}400\#\text{-}' \times 12''/'}{1300\#/in^2} = \underline{207\ in^3}$$

$$V_{MAX} = \frac{wL}{2} = \frac{(700)(16)}{2} = 5600\#$$

$$A_{req'd} = \frac{1.5V}{F_v} = \frac{1.5(5600\#)}{85\#/in^2} = \underline{98.8\ in^2}$$

TRY: 8 × 14 S4S
$A = 101.25in^2$, $S = 227.8in^3$, $I = 1538in^4$
$w = 25.5\#/ft$

*NOTE: $w = .252 \times A$

CHECK: $V_{add} = \frac{w_{bm}L}{2} = \frac{25.5(16)}{2} = 204\#$

$$A_{add} = \frac{1.5V}{F_v} = \frac{1.5(204\#)}{85\#/in^2} = 3.6\ in^2$$

$A_{TOTAL} = 98.8 + 3.6 = 102.4in^2 > 101.3in^2$ ∴ N.G.

TRY: 8 × 16 S4S ($A = 116.25in^2$, $S = 300.3in^3$, $I = 2527in^4$, $w = 29.3\#/ft$)

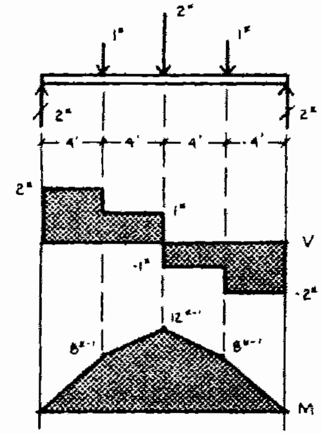
$$\Delta_{ALLOW} = L/360 = \frac{16 \times 12}{360} = 0.53''$$

$$\Delta_{ACTUAL\,(LL)} = \frac{5w_{LL}L^4}{384EI} = \frac{5(400\#/ft)(16')^4(1728\,in^3/ft^3)}{384(1.6 \times 10^6)(2527in^4)} = 0.16'' < .53''$$

∴ O.K.

USE: 8 × 16 S4S

8.23



$V_{MAX} = 2000^{\#}$

$A_{req'd} = 1.5V/F_v = \frac{1.5(2000^{\#})}{110^{\#}/in^2} = 27.3\,in^2$

$M_{max} = 12{,}000^{\#-'}$

$S_{req'd} = \frac{M}{F_b} = \frac{12000^{\#-'} \times 12''/'}{1550^{\#}/in^2} = 92.9\,in^3$

TRY: 4 × 14 S4S

(A = 46.4, S = 102.4, I = 678.5, ω = 12 #/ft)

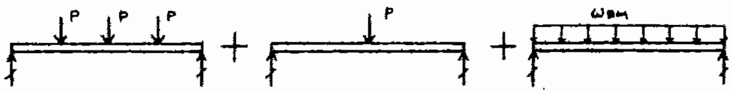
$M_{add} = \frac{w_{bm}L^2}{8} = \frac{12(16)^2}{8} = 384^{\#-'}$

$S_{add} = \frac{M_{add}}{F_b} = \frac{384.4 \times 12}{1550} = 2.9\,in^3$

$S_{TOTAL} = 2.9 + 92.9 = 95.8\,in^3 < 102.4\,in^3$

∴ O.K.

$\Delta_{ALLOW} = L/240 = \frac{16 \times 12}{240} = 0.8''$



$\Delta_{ACTUAL} = \frac{PL^3}{20.1\,EI} + \frac{PL^3}{48\,EI} + \frac{5 w_{BM} L^4}{384\,EI}$

$\Delta_{ACTUAL} = \frac{(1^k)(16')^3(1728)}{20.1(1.6 \times 10^3)(678.5)} + \frac{(1^k)(16)^3(1728)}{48(1.6 \times 10^3)(678.5)} + \frac{5(0.012)(16)^4(1728)}{384(1.6 \times 10^3)(678.5)}$

$\Delta_{ACTUAL} = 0.324'' + 0.136'' + 0.016'' = 0.48'' < 0.8''$ ∴ O.K.

CHECK BEARING STRESS:

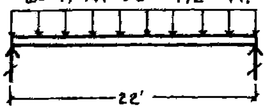
$f_p = \frac{P}{A_{brg}} = \frac{(2000^{\#} + \overset{\text{BEAM WT.}}{96^{\#}})}{(5.5'' \times 3.5'')} = 109\,psi < F_{c\perp} = 410\,psi$ ∴ O.K.

USE 4 × 14 S4S

8.24

BEAM B1

$w = 99\#/ft^2 \times 8' = 792\#/ft.$



LOADS:

CONC	$4/12' \times 150\#/ft^3$	$= 50\#/ft^2$
METAL DECK		$= 4\#/ft^2$
PLASTER CEIL		$= 5\#/ft^2$
	DL	$= 59\#/ft^2$
	LL	$= 40\#/ft^2$
	TOTAL	$= 99\#/ft^2$

$$M_{MAX} = \frac{wL^2}{8} = \frac{792\#/ft\,(22')^2}{8} = 48000^{\#\text{-}'}$$

$$S_{req'd} = \frac{M}{F_b} = \frac{48^{k\text{-}'} \times 12''/'}{22\ ^k/in^2} = 26.2\ in^3$$

TRY: W14 × 22 $\quad (S_x = 29\,in^3\ A = 6.49\,in^2\ I = 199\,in^4)$

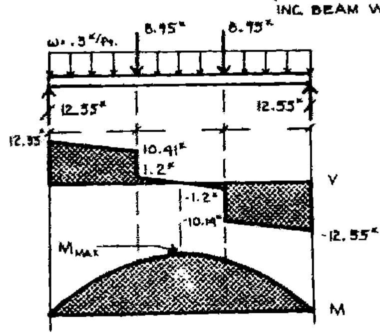
DEFLECTION CHECK:

$$\Delta_{\underset{(LL)}{ALLOW}} = \frac{L}{360} = \frac{22' \times 12''/'}{360} = 0.73''$$

$$\Delta_{\underset{(LL)}{ACTUAL}} = \frac{5w_{LL}L^4}{384\,EI} = \frac{5(40\#/ft^2)(8')(22')^4(1728\ in^3/ft^3)}{384\,(29 \times 10^6\ \#/in^2)(199)} = 0.29'' < .733''\ \therefore \text{O.K.}$$

$$\boxed{\begin{array}{c}\text{USE: W14×22 FOR B1}\\ \text{(or W16×26)}\end{array}}$$

(BEAM B1 REACTION INC. BEAM WT.)



BEAM SB1

$M_{MAX} = 95.6^{k\text{-}'}$

$$S_{req'd} = \frac{M}{F_b} = \frac{95.6 \times 12}{22} = 52.1\,in^3$$

TRY: W16 × 36
$(S = 56.5\,in^3,\ A = 10.6\,in^2,\ I = 448\,in^4)$

$$\Delta_{ACTUAL} = \frac{5wL^4}{384\,EI} + \frac{PL^3}{28.2\,EI} \qquad \Delta_{\underset{(D+L)}{ALLOW}} = \frac{L}{240} = \frac{24 \times 12}{240} = 1.2''$$

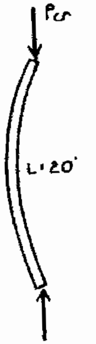
$$\Delta_{ACTUAL} = \frac{5(.336)(24)^4(1728)}{384\,(29 \times 10^3)(448)} + \frac{(8.95)(24)^3(1728)}{28.2\,(29 \times 10^3)(448)}$$

$$\Delta_{ACTUAL} = 0.193'' + 0.584'' = 0.78'' < 1.2'' \quad \therefore \text{O.K.}$$

$$f_{v_{ave}} = \frac{12.55^k}{(.295'')(15.86'')} = 2.7\,ksi < F_v = 14.5\,ksi \quad \therefore \text{O.K.}$$

$$\boxed{\therefore \text{USE: W16×36 FOR SB1}}$$

9.1



$$P_{cr} = \frac{\pi^2 EI}{L^2} = \frac{3.14^2(29\times10^3)(37.1)}{(20'\times 12''/')^2} = 184.2^k$$

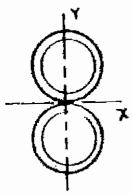
W8×31

$I_Y = 37.1\ in^4$
(MIN)

$A = 9.13\ in^2$

$$f_{cr} = \frac{P_{cr}}{A} = \frac{184.2^k}{9.13\ in^2} = \underline{\underline{20.2\ ksi}}$$

9.2



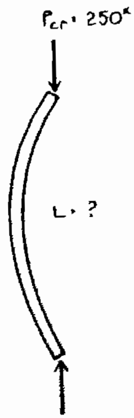
2 - 3½" Φ STANDARD PIPE

$I_Y = 2\times I = 2\times 4.79\ in^4 = 9.58\ in^4$
(MIN)

$L = 24' = 288''$

$$P_{cr} = \frac{\pi^2 EI}{L^2} = \frac{3.14^2(29\times10^3)(9.58)}{288^2} = \underline{\underline{33^k}}$$

9.3



W10×54

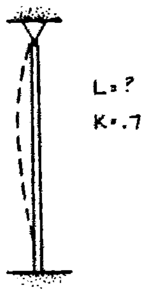
$I_{MIN} = 103\ in^4$

$$P_{cr} = \frac{\pi^2 EI}{L^2}$$

$$L^2 = \frac{\pi^2 EI}{P_{cr}} = \frac{3.14^2(29\times10^3)(103\ in^4)}{250^k}$$

$L^2 = 117{,}803\ in^2;\quad L = 343.2'' = \underline{\underline{28.6'}}$

9.4



8" DIAMETER POLE:

$$A = \frac{\pi D^2}{4} = 50.3 \text{ in}^2$$

$$I = \frac{\pi D^4}{64} = 201 \text{ in}^4$$

$P_{cr} = 25^k$; $E = 1 \times 10^3$ ksi

$$P_{cr} = \frac{\pi^2 EI}{(KL)^2} \; ; \; (KL)^2 = \frac{\pi^2 EI}{P_{cr}}$$

$$(KL)^2 = \frac{3.14^2(10^3)(201)}{25^k} = 79{,}376$$

$KL = 281.7''$; $\quad L = \dfrac{281.7''}{.7} = 402.5'' = \underline{\underline{33.5'}}$

9.5

$8 \times 6 \times 3/8''$ RECT. TUBE ($A = 9.58 \text{ in}^2$; $r_y = 2.36''$, $I_y = 53.5 \text{ in}^4$)

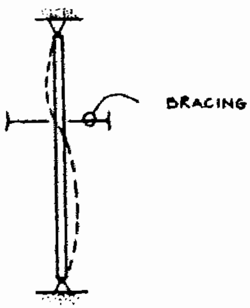
$$\frac{KL}{r_y} = \frac{(1)(38' \times 12''/')}{2.36''} = 193.2 \qquad KL = 456''$$

$$P_{cr} = \frac{\pi^2 EI_y}{(KL)^2} = \frac{3.14^2 (29 \times 10^3 \text{ k/in}^2)(58.5 \text{ in}^4)}{(456'')^2} = \underline{\underline{73.64^k}}$$

$$f_{cr} = \frac{P_{cr}}{A} = \frac{73.64^k}{9.58 \text{ in}^2} = \underline{\underline{7.7 \text{ ksi}}}$$

9.6

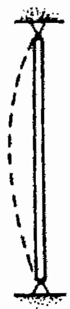
WEAK AXIS



$L_e = 16'$

$$\frac{L_e}{r_y} = \frac{16' \times 12"/1}{1.61"} = 119.25$$

STRONG AXIS



$L = L_B = 26'$

$$\frac{L_e}{r_x} = \frac{26' \times 12"/1}{3.42"} = 91.25$$

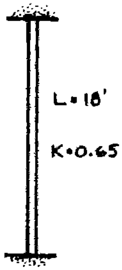
WEAK AXIS GOVERNS:

$$P_{cr} = \frac{\pi^2 E I_Y}{L_e^2} = \frac{3.14^2 (29 \times 10^3)(18.3 \text{ in}^4)}{(16' \times 12"/1)^2} = \underline{\underline{142^k}}$$

$$f_{cr} = \frac{P_{cr}}{A} = \frac{142^k}{7.08 \text{in}^2} = \underline{\underline{20.1 \text{ ksi}}}$$

97

a)



W12×65 $\quad r_x = 5.28''$, $\quad r_y = 3.02''$

$A = 19.1\ in^2$

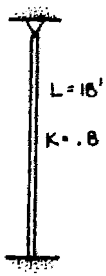
$$\frac{KL}{r_y} = \frac{0.65\,(18' \times 12'')}{3.02} = 46.5$$

$F_a = 18.66$ ksi

$P_a = F_a \times A = 18.66\ ^k/in^2 \times 19.1\ in^2 = \underline{\underline{356.4^k}}$

$KL = .65 \times 18' = 11.7 \qquad \underline{\underline{P_a = 356^k}}$

b)



$$\frac{KL}{r_y} = \frac{.8(18 \times 12)}{3.02} = 57.2$$

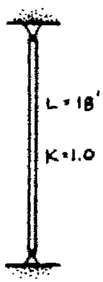
$F_a = 17.69$ ksi

$P_a = 17.69\ ^k/in^2 \times 19.1\ in^2 = \underline{338^k}$

$KL = 14.4'$

$\underline{\underline{P_a = 339^k}}$

c)



$$\frac{KL}{r_y} = \frac{(1)(18' \times 12'')}{3.02} = 71.5$$

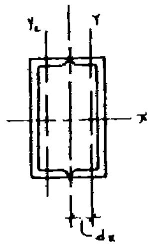
$F_a = 16.28$ ksi

$P_a = 16.28\ ^k/in^2 \times 19.1\ in^2 = \underline{311^k}$

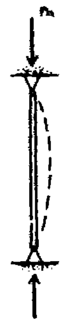
$KL = 18'$

$\underline{\underline{P_a = 311^k}}$

9.8



A36 STEEL



L = 20'

K = 1.0

2 - C12 × 20.7

$d_x = b_f - \bar{x} = 2.94'' - .70'' = 2.24''$

COMP	A	I_{xc}	I_{yc}	d_x	Ad_x^2
[	6.09	129	3.88	2.24"	30.6 in⁴
]	6.09	129	3.88	2.24"	30.6 in⁴
		$\Sigma I_{xc} = 258$	$\Sigma I_{yc} = 7.76$		$\Sigma Ad_x^2 = 61.2$

$I_x = \Sigma I_{xc} = 258 \text{ in}^4$

$I_y = \Sigma I_{yc} + \Sigma A d_x^2 = 7.8 + 61.2 = \underline{\underline{69 \text{ in}^4}}$ (CRITICAL AXIS)

$r_y = \sqrt{\frac{I_y}{A}} = \sqrt{\frac{69 \text{ in}^4}{12.2 \text{ in}^2}} = \underline{\underline{2.38 \text{ in}}}$

$\frac{KL}{r} = \frac{(1)(20' \times 12''/')}{2.38 \text{ in}} = 100.8$

$F_a = 12.88 \text{ ksi}$

$P_a = 12.88 \text{ k/in}^2 \times 12.2 \text{ in}^2 = \underline{\underline{157^k}}$

9.9

L $5 \times 3\frac{1}{2} \times \frac{1}{2}''$ $\quad (A = 4\,in^2,\ r_z = 0.755'')$

SINCE TRUSSES ARE ASSUMED PIN CONNECTED, K = 1.0

$$\frac{KL}{r_z} = \frac{(1)(7 \times 12)}{0.755} = 111.25\,; \qquad F_a = 11.5\ ksi$$

MIN. RADIUS OF GYRATION

$$P_a = F_a \times A = 11.5\ ^{k}/in^2 \times 4\,in^2 = \underline{\underline{46^{k}}}$$

9.10

5″ Φ STD. WT. PIPE

$A = 4.3\,in^2\,; \qquad r = 1.88''$

$P = 60^{k}\,;$

$$F_a = \frac{P}{A} = \frac{60^{k}}{4.3\,in^2} = 13.95\ ksi$$

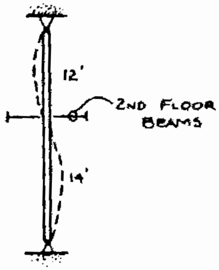
$$\frac{KL}{r} = 92.2$$ ⟵ FROM TABLE

$$L = \frac{r}{K} \times 92.2 = \frac{1.88}{0.8} \times 92.2 = 216.7''$$

$$\underline{\underline{L = 18'}}$$

9.11

WEAK AXIS



W 12 × 106 ; $A = 31.2^{2}$, $r_x = 5.47$, $r_y = 3.11$

$KL = 14'$

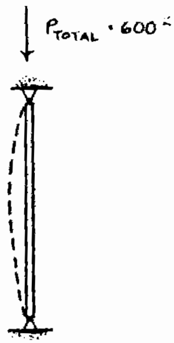
$$\frac{KL}{r_y} = \frac{14 \times 12}{3.11} = 54$$

$F_a = 17.99$ ksi

$P_a = 17.99 \times 31.2 = 561.3^{K} > 500^{K}$

$\therefore$ OK

STRONG AXIS



(ASSUMES THE 2ND FLOOR BEAM LOADS ARE APPLIED AT THE TOP OF THE COLUMN - CONSERVATIVE CONDITION)

$$\frac{KL}{r_x} = \frac{(1)(26 \times 12)}{5.47} = 57$$

$F_a = 17.71$ ksi

$P_a = 17.71 \times 31.2 = 553^{K} > 500^{K}$

$\therefore$ OK

9.12

$L = 20'$

$KL = 20'$

$P = 30^k$

try 5" ϕ STD PIPE : $A = 4.3 in^2$

$r = 1.88$

$$\frac{KL}{r} = \frac{20'(12^{in}/ft)}{1.88} = 127.7$$

enter table C-36

$F_{allow} = 9.17\ ksi$

$P_{allow} = F_{allow} * A = 9.17(4.3 in^2) = 39.4^k$

$P_{allow}\ (39.4^k) > P_{actual}\ (30^k)$

$\therefore$ OK

9.13

$L = 20'$

$KL = 20'$

$P = 30^k$

try W8×18 $A = 5.26 in^2$

$r_y = 1.23$

$$\frac{KL}{r} = \frac{20'(12^{in}/ft)}{1.23} = 195$$

enter table C-36

$F_{allow} = 3.93\ ksi$

$P_{allow} = F_{allow} * A = 3.93^{ksi} \times 5.26 in^2 = 20.7^k$

$P_{allow}\ (20.7^k) < P_{actual}\ 30^k$

$\therefore$ NG

9.13

try W8×24 $A = 7.08\ in^2$, $r_y = 1.61$

$$\frac{KL}{r} = \frac{20'(12\ in/ft)}{1.61} = 149$$

enter table C-36

$F_{allow} = 6.73$ ksi

$P_{allow} = F_{allow} \times A = 6.73\ ksi \times 7.08\ in^2 = 47.6^k$

$P_{allow}\ (47.6^k) > P_{actual}\ (30^k)$

$\therefore$ OK

USE W8×24

9.14

$P = 350^k$

try W14×74 $A = 21.8\ in^2$

WEAK

$L = 12'$

$KL = 12'$

$r_y = 2.48$

$$\frac{KL}{r} = \frac{12'(12\ in/ft)}{2.48} = 58$$

STRONG

$L = 24'$

$KL = 24'$

$r_x = 6.04$

$$\frac{KL}{r} = \frac{24'(12\ in/ft)}{6.04} = 47.7$$

WEAK AXIS GOVERNS

$KL/r = 58$

enter table C-36

$F_{allow} = 17.62$ ksi

$P_{allow} = F_{allow} \times A = 17.62\ ksi \times 21.8\ in^2 = 384^k$

$P_{allow}\ (384^k) > P_{actual}\ (350^k)$ $\therefore$ OK

$$\text{Efficiency}: \frac{P_{actual}}{P_{allow}}(100) = \frac{350^k}{384^k}(100) = 91.15\%$$

9.14

try for more efficient:

W14×68 $A = 20.0\,in^2$

WEAK

$KL = 12'$

$r_y = 2.46$

$$\frac{KL}{r} = \frac{12'(12^{in}/ft)}{2.46} = 58.5$$

STRONG

$KL = 24'$

$r_x = 6.01$

$$\frac{KL}{r} = \frac{24'(12^{in}/ft)}{6.01} = 47.9$$

WEAK AXIS GOVERNS

$KL/r = 58.5$

$F_{allow} = 17.57\,ksi$

$P_{allow} = F_{allow} \times A = 17.57\,ksi\,(20.0\,in^2) = 351.4^k$

$P_{allow}\,(351.4^k) > P_{actual}\,(350^k)\;\therefore$ OK

$$\text{Efficiency}: \frac{P_{actual}}{P_{allow}} = \frac{350^k}{351.4^k}(100) = 99.6\%$$

USE W14×68

9.15

ROOF LOAD: $\left.\begin{array}{l} DL = 80\ psf \\ LL = 40\ psf \end{array}\right\rangle 120\ psf \times 500 ft^2 = 60^k$

EACH FLOOR LOAD: $\left.\begin{array}{l} DL = 100\ psf \\ LL = 125\ psf \end{array}\right\rangle 225\ psf \times 500 ft^2 = 112.5^k / floor$

THE THIRD FLOOR COLUMN SUPPORTS THE 4^{th}, 5^{th}, AND 6^{th} FLOORS PLUS THE ROOF. THE COLUMN LOAD IS THEREFORE:

$P = 3 \times 112.5^k + 60^k = 397.5^k$

$KL = 16'$

try W12×79 $\quad A = 23.2\ in^2$

$r_y = 3.05$

$$\frac{KL}{r} = \frac{16'(12^{in}/ft)}{3.05} = 63$$

$F_{allow} = 17.14\ ksi$

$P_{allow} = F_{allow} \times A = 17.14\ ksi\ (23.2\ in^2) = 397.6^k$

$P_{allow}\ (397.6^k) > P_{actual}\ (397.5^k)\ \therefore OK$

THE GROUND FLOOR SUPPORTS AN ADDITIONAL TWO FLOORS OF LOAD:

$P = 5 \times 112.5^k + 60^k = 622.5^k$

$KL = 20'$

USE W12 SECTION FOR BEST TRANSITION TO W12×79 USED ABOVE

try W12×136 $\quad A = 39.9\ in^2$

$r_y = 3.16$

$$\frac{KL}{r} = \frac{20'(12^{in}/ft)}{3.16} = 76$$

$F_{allow} = 15.79\ ksi$

$P_{allow} = F_{allow} \times A = 15.79\ ksi \times 39.9\ in^2 = 630^k$

$P_{allow}\ (630^k) > P_{actual}\ (622.5^k)\ \therefore OK$

9.16

6×6 S4S $A = 30.25\ in^2$

SOUTHERN PINE $E = 1600\ ksi$

$F_c = 975\ psi$

$$\frac{l_e}{d} = \frac{14'\,(12^{in}/_{ft})}{5.5''} = 30.5$$

$$F_{cE} = \frac{0.3\,(E)}{(l_e/d)^2} = \frac{0.3\,(1.6\times10^6 psi)}{(30.5)^2} = 516\ psi$$

$$F_c^* = F_c\,C_D$$

$$= 975 psi\,(1.25) = 1218.75\ psi$$

$$\frac{F_{cE}}{F_c^*} = \frac{516 psi}{1218.75 psi} = .423$$

enter table 9-5D

$C_p = .377$

$$F_c' = F_c^* \cdot C_p = 1218.75 psi \times .377 = 459.5\ psi$$

$$P_{allow} = A \times F_c' = 30.25 in^2 \times 459.5\ psi = 13{,}900^{\#}$$

9.17

8x8 S4S $\qquad A = 56.25\ in^2$

DOUGLAS-FIR $\qquad E = 1600\ ksi$

$F_c = 1000\ psi$

$$\ell_e/d = \frac{13.5'\,(12\ ^{in}/_{ft})}{7.5''} = 21.6$$

$$F_{cE} = \frac{.3\,(E)}{(\ell_e/d)^2} = \frac{.3\,(1.6\times10^6\ psi)}{(21.6)^2} = 1029\ psi$$

$$F_c^* = F_c C_D = 1000\ psi\ (1.00) = 1000\ psi$$

$$\frac{F_{cE}}{F_c^*} = \frac{1029}{1000} = 1.03$$

enter table 9-ED

$C_P = .701$

$$F_c' = F_c^* C_P = 1000\ psi \times .701 = 701\ psi$$

$$P_{allow} = F_c' \times A = 701\ psi \times 56.25\ in^2 = 39.4^k$$

$P_{allow}\,(39.4^k) > P_{actual}\,(32^k)$

$\therefore$ OK

9.18

GLU-LAM (6¾ × 10½)

$E = 1800$ ksi

$F_c = 1650$ psi

$A = 70.88$ in²

weak: $\ell_e/d = \frac{11'(12''/ft)}{6\,3/4''} = 19.55$

strong: $\ell_e/d = \frac{22'(12''/ft)}{10\,1/2''} = 25.15$

STRONG AXIS GOVERNS

$$F_{cE} = \frac{.418(E)}{(\ell_e/d)^2} = \frac{.418(1.8 \times 10^6 \text{ psi})}{(25.15)^2} = 1190 \text{ psi}$$

$$F_c^* = F_c C_D = 1650 \text{ psi}(1.00) = 1650 \text{ psi}$$

$$\frac{F_{cE}}{F_c^*} = \frac{1190 \text{ psi}}{1650 \text{ psi}} = .72$$

enter table 9-ED

$C_P = .619$

$$F_c' = F_c^* C_P = 1650 \text{ psi} \times .619 = 1021 \text{ psi}$$

$$P_{allow} = F_c' \times A = 1021 \text{ psi} \times 70.88 \text{ in}^2 = 72.37^k$$

9.19

HEM-FIR: $E = 1400\,ksi$

$F_c = 1050\,psi$

$A = 5.25\,in^2$

$$\ell_e/d = \frac{7.5'(12^{in}/ft)}{3.5^{in}} = 25.7$$

$$F_{cE} = \frac{.3E}{(\ell_e/d)^2} = \frac{.3\,(1.4\times10^6\,psi)}{(25.7)^2} = 636\,psi$$

$$F_c^* = F_c C_D = 1050\,psi\,(1.0) = 1050\,psi$$

$$\frac{F_{cE}}{F_c^*} = \frac{636\,psi}{1050\,psi} = .606$$

$$C_P = .504$$

$$F_c' = F_c^* C_P = 1050\,psi \times .504 = 529.2\,psi$$

$$P_{allow} = F_c' \times A = 529.2\,psi \times 5.25\,in^2 = 2778.3^{\#}$$ (per stud; every 16")

$$\omega = 2778.3^{\#} \times 12/16 = 2083.7^{\#}/ft$$

BEARING STRESS

$F_{c\perp} = 405\,psi$

$$P_{allow} = F_{c\perp} \times A = 405\,psi \times 5.25\,in^2 = 2126.25^{\#}$$

P_{allow}(Bearing) < P_{allow} (Compression)

∴ BEARING STRESS GOVERNS

9.20

4x8 S4S $\quad A = 25.38\,in^2$

DOUGLAS-FIR $\quad E = 1600$ ksi

$F_c = 1000$ psi

<u>weak</u>: $l_e = KL = .8(8')(12\,in/ft) = 76.8''$

slenderness ratio $= l_e/d = \frac{76.8''}{3\frac{1}{2}''} = 21.9$

<u>strong</u>: $l_e = KL = 1.0(10')(12\,in/ft) = 120''$

slenderness ratio $= l_e/d = \frac{120''}{7\frac{1}{4}''} = 16.55$

WEAK AXIS GOVERNS

$$F_cE = \frac{.3(E)}{(l_e/d)^2} = \frac{.3(1.6\times10^6)}{(21.9)^2} = 1001\text{ psi}$$

$$F_c^* = F_cC_D = 1000\text{psi}\,(1.00) = 1000\text{psi}$$

$$\frac{F_cE}{F_c^*} = \frac{1001}{1000} = 1.00$$

enter table 9-ED

$C_p = .691$

$F_c' = F_c^* C_p = 1000\text{ psi} \times .691 = 691\text{ psi}$

$P_{allow} = F_c' \cdot A = 691\text{ psi} \times 25.38\,in^2 = 17538^{\#}$

$$A_{trib.} = \frac{P_{allow}}{DL+LL} = \frac{17538^{\#}}{50\text{psf}} = 350.76\,ft^2$$

9.21

SOUTHERN PINE $E = 1600 ksi$

$F_c = 975\ psi$

try: 6"x6" $A = 30.25\ in^2$

$$\ell_e/d = \frac{16'(12''/ft)}{5\tfrac{1}{2}''} = 34.9$$

$$F_cE = \frac{.3(E)}{(\ell_e/d)^2} = \frac{.3(1.6\times10^6\ psi)}{(34.9)^2} = 394\ psi$$

$$F_c^* = F_c C_D = 975\ psi\,(1.00) = 975\ psi$$

$$\frac{F_cE}{F_c^*} = \frac{394\ psi}{975\ psi} = .404$$

$C_p = .363$

$$F_c' = F_c^* C_p = 975\ psi \times .363 = 354\ psi$$

$$P_{allow} = F_c' \cdot A = 354\ psi\,(30.25\ in^2) = 10.7^k < 25^k \therefore NG$$

try: 8"x8" $A = 56.25\ in^2$

$$\ell_e/d = \frac{16'(12''/ft)}{7\tfrac{1}{2}''} = 25.6$$

$$F_cE = \frac{.3(E)}{(\ell_e/d)^2} = \frac{.3(1.6\times10^6)}{(25.6)^2} = 732.4\ psi$$

$$F_c^* = F_c C_D = 975\ psi\,(1.00) = 975\ psi$$

$$\frac{F_cE}{F_c^*} = \frac{732.4\ psi}{975\ psi} = .75$$

$C_p = .585$

$$F_c' = F_c^* C_p = 975\ psi \times .585 = 570.4\ psi$$

$$P_{allow} = F_c' \times A = 570.4\ psi \times 56.25\ in^2 = 32^k > 25^k \therefore OK$$

9.22

GLU-LAM $6\frac{3}{4}'' \times$ _____

$E = 1.8 \times 10^6$ psi

$F_c = 1650$ psi

$$\ell/d = \frac{18'(12''/ft)}{6\frac{3}{4}''} = 32$$

$$F_{cE} = \frac{.418(E)}{(\ell_e/d)^2} = \frac{.418(1.8 \times 10^6 \text{ psi})}{(32)^2} = 735 \text{ psi}$$

$$F_c^* = F_c C_D = 1650 \text{ psi}(1.00) = 1650 \text{ psi}$$

$$\frac{F_{cE}}{F_c^*} = \frac{735 \text{ psi}}{1650 \text{ psi}} = .45$$

$$C_p = .420$$

$$F_c' = F_c^* C_p = 1650 \text{ psi} \times .420 = 693 \text{ psi}$$

$$A_{req} = P/F_c' = \frac{15000\#}{693 \text{ psi}} = 21.6 \text{ in}^2$$

use $6\frac{3}{4}'' \times 7\frac{1}{2}''$; $A = 50.63 \text{ in}^2$

10.1

SHEAR: DOUBLE A325-SC $\quad P_v = 10.4\ ^{k}/_{bolt} \times 2\text{ bolts} = \underline{20.8k}$ (Table 10.1)

BEARING: THICKNESS = 3/4"

$A_p = 5/8" \times 3/4" = \underset{(\text{per bolt})}{0.469\ in^2}$; $\quad F_p = 1.2F_u = 1.2(58\text{ ksi}) = 69.6\text{ ksi}$

$P_p = 2\text{ bolts} \times (.469\ in^2) \times 69.6\ k/in^2 = \underline{65.2k}$

NET TENSION: $d = 5/8" + 1/16" = 11/16" = 0.688\text{ in.}$

$A_{NET} = 3/4"(4" - .688") = 2.48\ in^2$

$F_t = 0.5F_u = 0.5(58\text{ ksi}) = 29\text{ ksi}$

$P_t = 29\ k/in^2 \times 2.48\ in^2 = \underline{71.2k}$

PLATE TENSION:

$A_{GROSS} = 4" \times 3/4" = 3.0\ in^2$; $\quad F_t = 0.6F_y = 22\text{ ksi}$

$P_t = 22\ k/in^2 \times 3.0\ in^2 = \underline{66k}$

SHEAR GOVERNS: $P_{ALLOW} = 20.8k \leftarrow$

10.2 $P = 28k$; A325-X bolts in double shear;

a) Based on shear (Table 10.1): 14k/bolt requirement

$\underline{2 - 5/8"\phi\ \text{A325-X bolts}\ (P_v = 18.4k/\text{bolt} = 36.8k)}$

Capacity of 2-5/8"φ bolts in bearing:

$P_p = \underset{(\text{bolts})}{2} \times \underset{A_p}{(5/8" \times 7/8")}\underset{F_p}{(69.6\ k/in^2)} = \underline{32.6k}$; ∴ OK

b) Based on net tension: $d = 5/8" + 1/16" = 0.688\text{ in.}$

$A_{net} = t(W - d) = 7/8"(W - .688")$

$P_{t_{net}} = \underset{(.5F_u)}{F_t} \times A_{net} = 29\ k/in^2 \times 7/8"(W - .688") = 28k$

$\underline{W = 3.26"}$

$A_{gross} = t \times W = 7/8" \times W$; $\quad F_{t_{gross}} = 0.6F_y = 22\text{ ksi}$

$P_{gross} = F_t \times A_{gross} = 22\ k/in^2 \times (7/8" \times W) = 28k$; $\underline{W = 3.4"} \leftarrow$ governs

10.3 Group A bolts: 3-$\frac{3}{4}$"ϕ A325-X in double shear

Shear: $P_v = 3 \times 26.5$ k/bolt $= \underline{79.5\text{k}}$
(Table 10.1)

Bearing: $P_p =$ 3 bolts $\times$ 26.1 k/bolt $= \underline{78.3\text{k}}$
(Table 10.2) $(t = \frac{1}{2}")$

Net Tension: $F_t = .5F_u = .5(58\text{ksi}) = 29$ ksi

$A_{net} = (2 \text{ plates} \times \frac{5}{16}")(8" - 2 \times \frac{13}{16}") = 3.98 \text{ in}^2$

$\underbrace{\frac{13}{16}"}_{d + \frac{1}{16}"}$

$P_t = F_t \times A_{net} = 29 \text{ k/in}^2 \times 3.98 \text{ in}^2 = \underline{115.5\text{k}}$

Group B bolts: 2-$\frac{7}{8}$"ϕ A325-X in double shear

Shear: $P_v = 2 \times 36.1$ k/bolt $= \underline{72.2\text{k}}$
(Table 10.1)

Bearing: $P_p =$ 2 bolts $\times$ 30.5 k/bolt $= \underline{61\text{ k}}$
(Table 10.2) $(t = \frac{1}{2}")$

Net Tension: $F_t = 29$ ksi; $d + \frac{1}{16}" = \frac{15}{16}"$

$P_t = 29 \text{ k/in}^2 \times \frac{1}{2}"(3" - \frac{15}{16}") = \underline{29.9\text{ k}}$ ⟵ governs

Tension capacity of the $\frac{1}{2}$" x 3" bar:

$P_t = F_t \times A = 22 \text{ k/in}^2 \times (\frac{1}{2}" \times 3") = \underline{33\text{k}}$
$(.6F_y)$

Net tension in the $\frac{1}{2}$" x 3" bar is critical.

$\therefore P_{max} = 29.9\text{k}$

10.4 Each member will be checked for shear and bearing only.

Member a: $P = 105k - 63k = 42k$

$\frac{3}{4}$"φ A325-X (NSL) – A36 steel.

Shear: (double) $n = \frac{42k}{26.5^k/bolt} = 1.6 \sim 2$ bolts

Bearing: ($t = \frac{3}{8}$") $n = \frac{42k}{19.6^k/bolt} = 2.14 \sim$ 3 bolts ← governs

Member b: $P = 26k$

Shear: (Single) $n = \frac{26k}{13.3^k/bolt} = 1.95 \sim 2$ bolts

Bearing: ($t = \frac{3}{16}$") $n = \frac{26k}{9.8^k/bolt} = 2.65 \sim$ 3 bolts ← governs

Member c: $P = 26k$.

Shear: (single) $n = \frac{26k}{13.3^k/bolt} = 1.95 \sim 2$ bolts

Bearing: ($t = \frac{1}{4}$") $n = \frac{26k}{13.1^k/bolt} = 1.98 \sim$ 2 bolts ← governs

Member d: $P = 42k$

Shear: (Single) $n = \frac{42k}{13.3^k/bolt} = 3.16 \sim 4$ bolts

Bearing: ($t = \frac{1}{4}$") $n = \frac{42k}{13.1^k/bolt} = 3.21 \sim$ 4 bolts ← governs

10.5 4 - $\frac{3}{4}$"φ A325-SC (STD) w/ A36 steel

Shear: (Double) $P_v = 15^k/bolt$ (Table 10.1) $\times$ 4 bolts = 60 k ← governs

Bearing: ($t = \frac{1}{2}$") $P_p = 26.1^k/bolt$ (Table 10.2) $\times$ 4 bolts = 104.4 k

Net Tension: $A_{net} = (8" - 2 \times \frac{13}{16}")(\frac{1}{2}") = 3.19 in^2$

$\frac{13}{16}" = (\frac{3}{4}" + \frac{1}{16}")$

$F_t = .5F_u = 29 ksi$

$P_t = F_t \times A_{net} = 29^k/in^2 \times 3.19 in^2 = 89.9 k$

10.6 $\longrightarrow$ 1- $1\frac{3}{8}"\phi$ A490X

Shear: (Double) $P_v = 119\,k$ (Table 10.1)

Bearing: ($t = 1"$) $P_p = F_p \times A_p$

$F_p = 1.2F_u = 1.2\,(58) = 69.6\,k/in^2$

$A_p = (2 \times \frac{1}{2}" \times 1\frac{3}{8}") = 1.375\,in.^2$

$P_p = 69.6\,k/in.^2 \times 1.375\,in.^2 = 95.7\,k$

Net Tension: Hole diameter $= 1\frac{3}{8}" + \frac{1}{16}" = 1\frac{7}{16}"$

$A_{net} = 2 \times \frac{1}{2}"\left(5\frac{1}{2}" - 1\frac{7}{16}"\right) = 4.06\,in.^2$

$P_t = \underset{(.5F_u)}{F_t} \times A_{net} = 29\,k/in.^2 \times 4.06\,in.^2 = 117.8\,k$

Bearing governs the design.

$\underline{P_{max.} = 95.7k}$

10.7 Beam reaction = 210 k.

5 - A490 x bolts ;

Using Table 10.3;

5 - $\frac{7}{8}"\phi$ A490X bolts carry 242k in shear.

clip angle thickness is $\frac{5}{8}"$

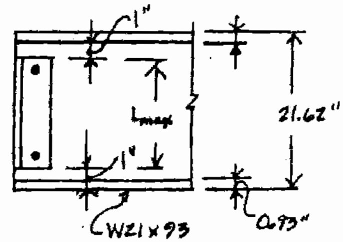
Angle length = $14\frac{1}{2}"$ (it fits within beam flanges)

10.8 $\frac{3}{4}$"ϕ A325-SC @ 3" o.c.

a) Maximum clearance:

$L_{max} = 21.62" - 2(.93") - 2(1")$

$L_{max} = 17.76"$



From Table 10.3:

Using $L = 17\frac{1}{2}$"

$n = 6$ bolts.

6-$\frac{3}{4}$"ϕ A325-SC ; $\underline{P_v = 90.1\ k}$

10.9

PLATE CAPACITY: $P_{PL} = F_t \times A = 22\ ^{K}/_{in^2} \times (6" \times \frac{3}{8}") = 49.5^{K}$

MINIMUM WELD SIZE = $\frac{3}{16}$" ; MAXIMUM WELD SIZE = $\frac{5}{16}$"

$L_{TOTAL} = 12"$; $\frac{49.5^{K}}{12"} = 4.13\ ^{K}/_{in}$

USE: $\frac{5}{16}$" WELD ($S = 4.64\ ^{K}/_{in}$) Table 10.4

10.10

$P_{PL} = 22\ ^{K}/_{in^2} \times (5 \times \frac{5}{16}) = 34.88^{K}$

MINIMUM WELD SIZE = $\frac{3}{16}$" ($S = 2.78\ ^{K}/_{in}$)

MAXIMUM WELD SIZE = $\frac{1}{4}$" ($S = 3.71\ ^{K}/_{in}$) Table 10.4

$L_{MIN} = 5"$ (DISTANCE BETWEEN LONGITUDINAL WELDS)

TOTAL MINIMUM WELD LENGTH = 15"

REQUIRED STRENGTH $S = \frac{34.38^{K}}{15"} = 2.29\ ^{K}/_{in}$

∴ USE: $\frac{3}{16}$" WELD WITH $L = 5"$

10.11 Using the maximum weld size: $t - \frac{1}{16}'' = \frac{5}{16}'' - \frac{1}{16}'' = \frac{1}{4}''$

$L = ?$ $\quad P_{allow} = L \times 3.71\ k/in. = 3.71L$

(Based on weld) (Table 10.4)

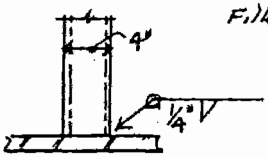
Plate capacity: $P_{P\!L} = F_t \times A = 22\ k/in.^2 \times (\frac{5}{16}'' \times 3'')$

$P_{P\!L} = 20.6k$

Equating: $3.71L = 20.6k$

$\underline{L = 5.6''}$

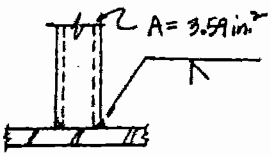
10.12



Fillet: $\frac{1}{4}''$ weld = 3.71 k/in.

Total weld length $= 4 \times 4'' = 16''$

Weld capacity $= 3.71\ k/in. \times 16'' = \underline{59.4k}$



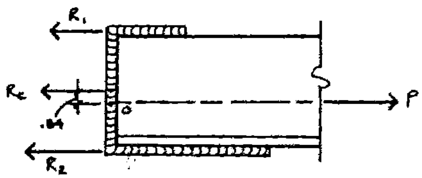
Full Penetration weld:

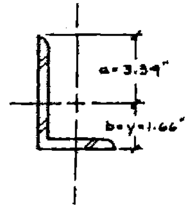
Capacity is equal to the tensile capacity of the square tube.

$\therefore P_t = A \times F_t = 3.59\ in.^2 \times 22\ k/in^2$

$\underline{P_t = 79\ k}$

10.13





$[\Sigma F_x = 0]$ $\quad R_1 + R_2 + R_c = P$

$$P = F_t \times A = 22\ ^{k}/_{in^2} \times 4.0\,in^2 = 88^k$$

$[\Sigma M_o = 0]$ $\quad R_1(3.34") + R_c(.84") - R_2(1.66") = 0$

MINIMUM WELD: 3/16"

MAXIMUM WELD: 7/16"

TRY 3/16" WELD: $S = 2.78\ ^{k}/_{in}$

$$R_c = S \times L_c = 2.78\ ^{k}/_{in} \times 5" = 13.9^k$$

RETURNING TO THE MOMENT EQUILIBRIUM EQUATION;

$$R_1(3.34) + (13.9^k)(.84") = R_2(1.66)$$

$$R_2 = \frac{R_1(3.34) + 11.68^{k\text{-}in}}{1.66"} = 2.01R_1 + 7.04$$

SUBSTITUTING INTO THE $[\Sigma F_x = 0]$ EQUATION;

$$R_1 + (2.01R_1 + 7.04) + 13.9 = 88^k$$

$R_1 + 2.01R_1 = 67.06^k$; $\quad R_1 = 22.28^k$

$R_2 = 51.82^k$

$R_c = 13.9^k$

$$R_1 = S \times L_1\ ;\quad L_1 = \frac{22.28^k}{2.78} = \underline{\underline{8.01"}}$$

$$R_2 = S \times L_2\ ;\quad L_2 = \frac{51.82^k}{2.78} = \underline{\underline{18.64"}}$$