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B&C POLE TIP CARRIAGE

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LAWRENCE RADIATION LABORATORY - UNIVERSITY OF CALIFORNIA

ENGINEERING NOTE

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C. PETERS	MECH. ENGR.	LBL	11-20-79

PROGRAM — PROJECT — JOB
PEP-4

MAGNET CORE

TITLE
POLE TIP CARRIAGE

A Revision 2/23/81
B Revision 3/19/81
C Revision 4/20/81

THE PURPOSE OF THIS NOTE IS TO DETERMINE STRESSES AND SAFETY FACTORS WITHIN MEMBERS AND JOINTS OF THE POLE TIP CARRIAGE UNDER STATIC LOADS AND UNDER EARTHQUAKE LOAD CONDITIONS.

REV "A" 2-23-81 P. Pingel

ADDED OVERTURNING CALCULATIONS AND TIE DOWN REQUIREMENTS FOR A .7g EARTHQUAKE.

WITHOUT TIE DOWN THE ACCELERATION "g" AT WHICH ONE SET OF ROLLERS WOULD START TO LIFT IS:

DIRECTION OF FORCE (SEE PAGE 2)

	TO FRONT	BACK	SIDE
CARRIAGE & POLE TIP ASSY	.28g	.50g	.46g
CARRIAGE & POLE TIP ASSY + CONCRETE BLOCK	.32g	.50g	.49g

IF THE CARRIAGE IS RESTRAINED AGAINST A .7g EARTHQUAKE THE BOLTS HOLDING PART 1C69914 "CARRIAGE ROLLER OUTER SLEEVE" TO THE FRAME HAVE TO BE SAE Gr 5. THE BOLTS SHOULD BE CHECKED AND REPLACED IF REQUIRED.

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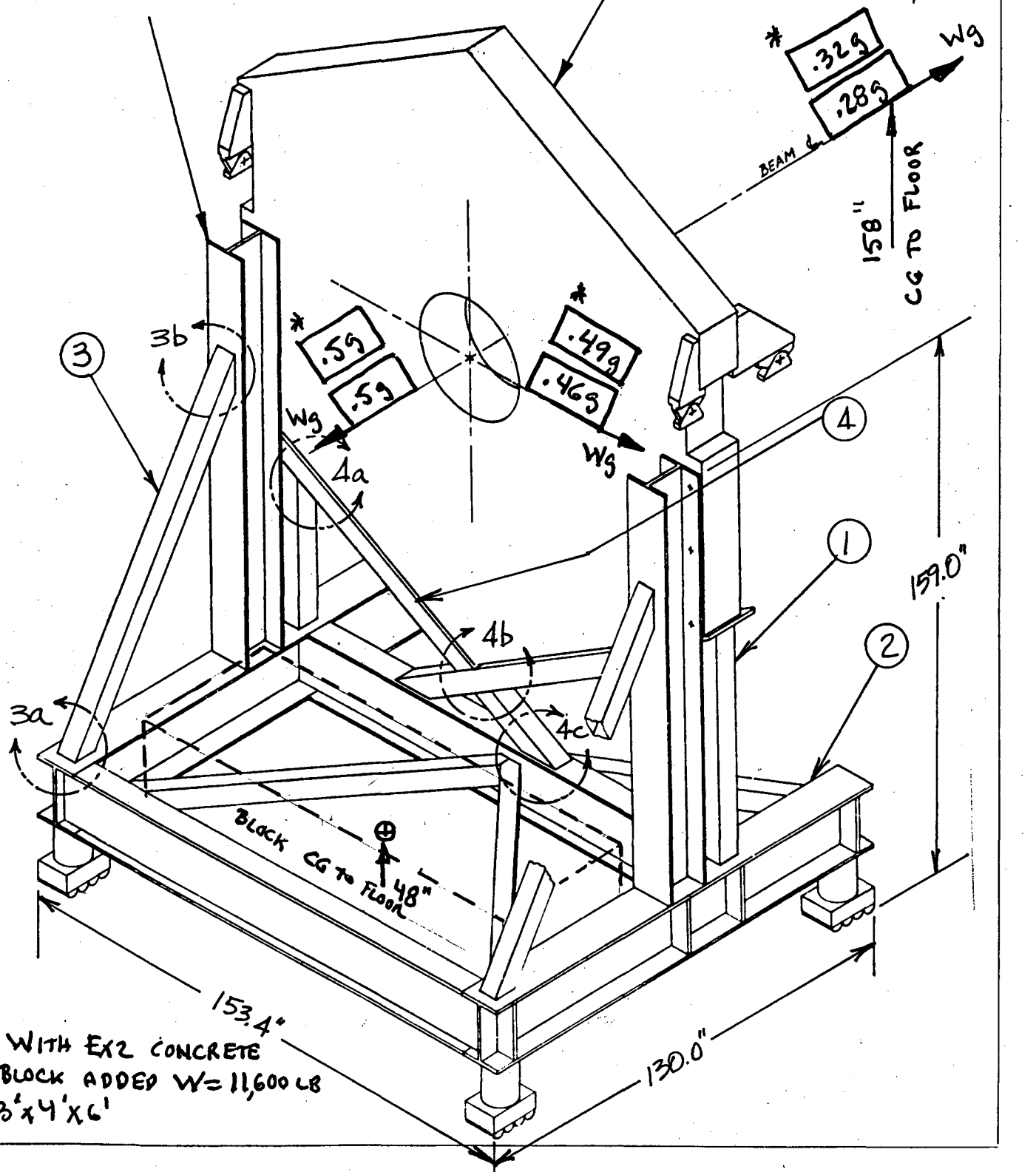
PROGRAM — PROJECT — JOB

TITLE

POLE TIP CARRIAGE

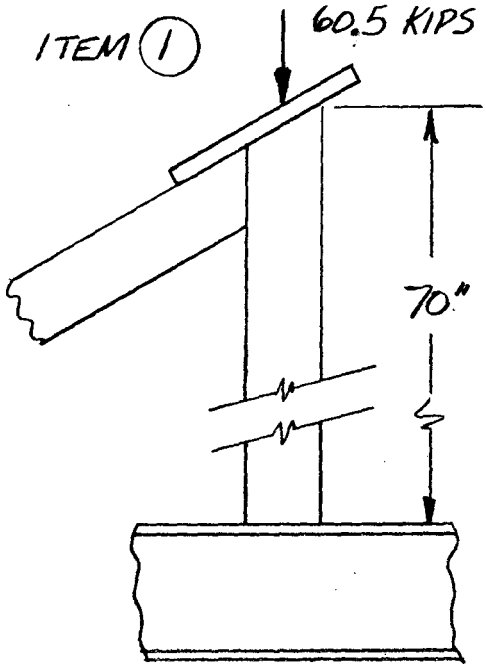
POLE TIP ASSY.
TYP. ASSY. WT. = 121,000 LBS.



* WITH EX2 CONCRETE BLOCK ADDED W= 11,600 LB 3'x4'x6'

I) STATIC LOAD CONDITIONS

ITEM (1)

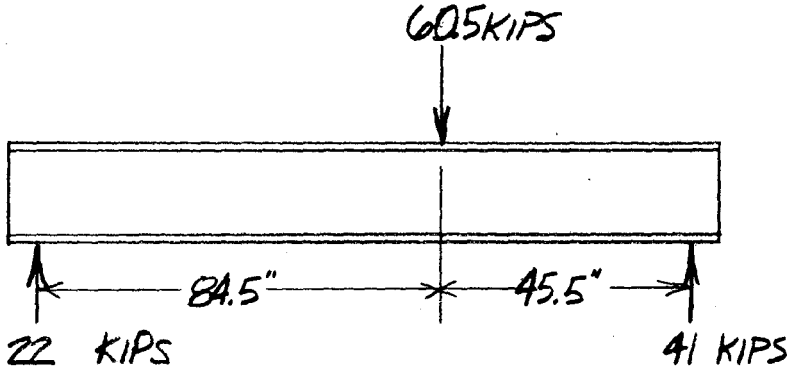


6"x6"x ½" STL. TUBE

MAX. ALLOWABLE AXIAL LOAD (KL = 6' & 46 KSI YIELD) = 269 KIPS (RYERSON DATA)

FACTOR OF SAFETY = $\frac{269}{60.5}$ = **4.29**

ITEM (2) WF 18" X 105 LBS.



$\sigma_b = MC/I$ $I = 1850\ IN^4$

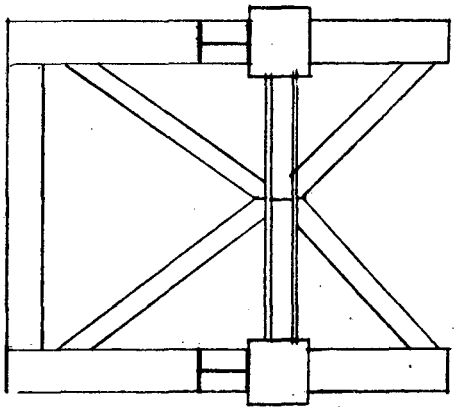
$M = 1789$ IN-KIP

$C = 9$ IN

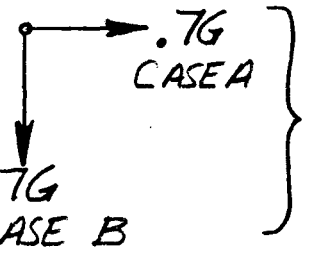
$\sigma_b =$ **8,705 PSI**

II. EARTHQUAKE LOAD CONDITIONS

TWO CASES:

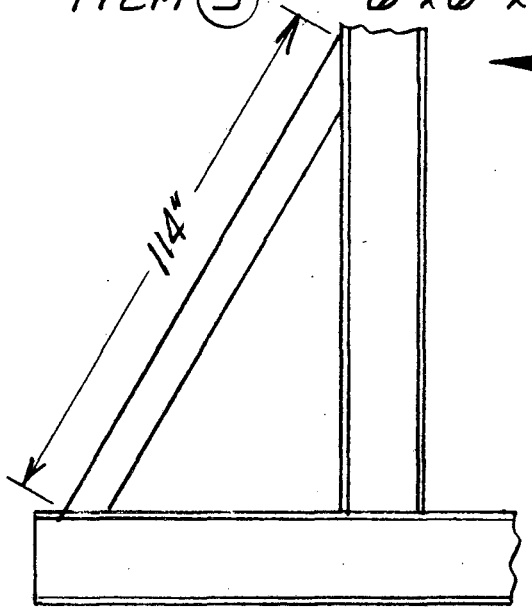


CARRIAGE PLAN VIEW



CASE A:

ITEM (3) 6"x6"x½" STL. TUBE.



← FORCE DUE TO ACCEL. = 58 KIPS

COMPRESSIVE FORCE IN TUBE = $\frac{58 \text{ KIPS}}{\cos 60^\circ}$

= 116 KIPS

MAX. ALLOWABLE AXIAL LOAD
(KL = 10' & 46 KSI YIELD) = 248 KIPS
(RYERSON DATA)

FACTOR OF SAFETY = $\frac{248}{116} = \boxed{2.14}$

AUTHOR C. PETERS | DEPARTMENT MECH. ENGR. | LOCATION LBL | DATE 11-20-79

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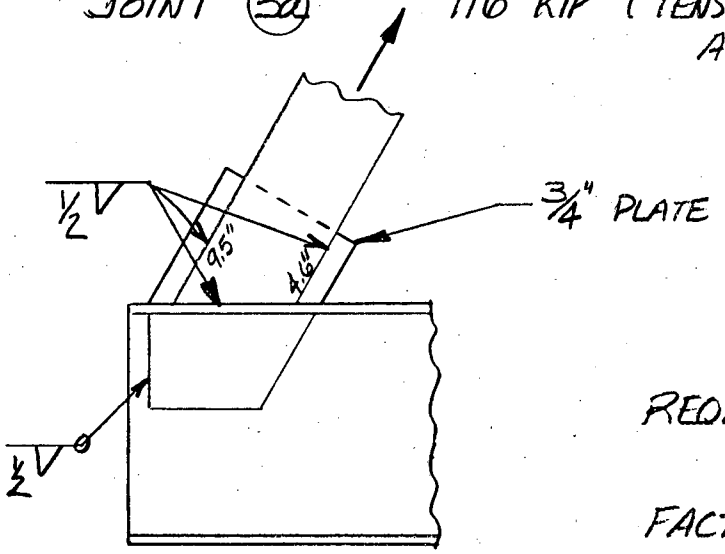
JOINT (3a) 116 KIP (TENSION WHEN ACCEL. IS OPPOSITE AS SHOWN PG. 4)



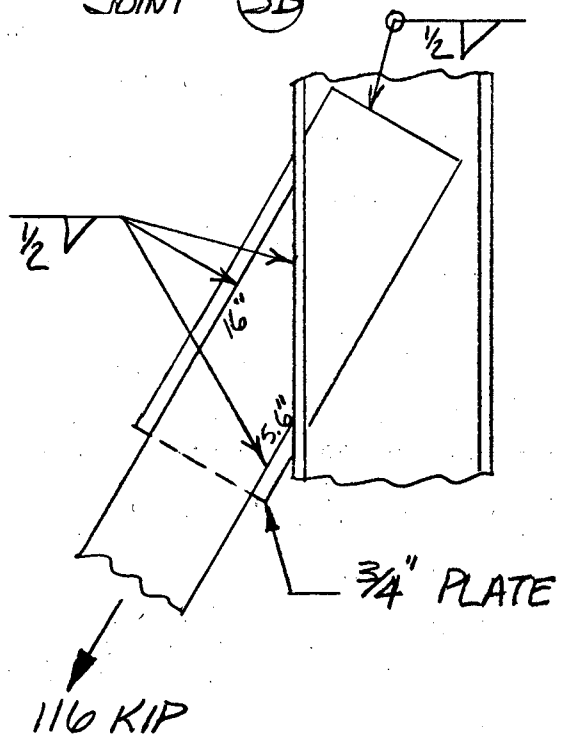
LENGTH OF WELD = $2(9.2+4.6+6+4) = 47.6$ IN

FORCE ON WELD = $\frac{116 \text{ KIP}}{47.6 \text{ IN}} = 2.43 \frac{\text{KIP}}{\text{IN}}$

REQR. WELD SIZE = $\frac{2.43}{9.6} = .25$ IN (AWS)

FACTOR OF SAFETY = $\frac{.50}{.25} = \boxed{2.00}$

JOINT (3b)



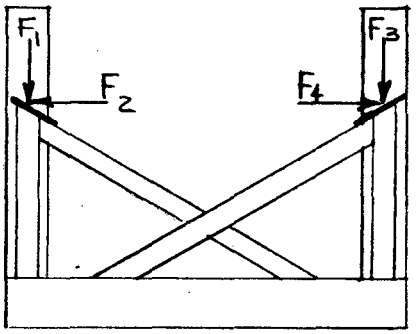
LENGTH OF WELD = $2(16+5.6+4+6) = 63.2$ IN

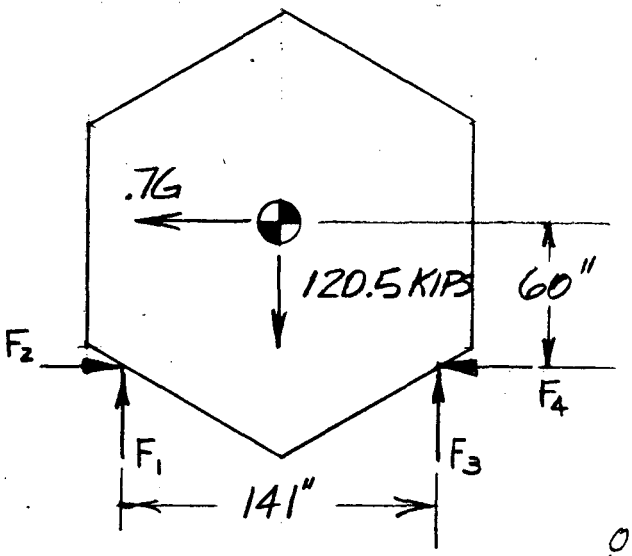
FORCE ON WELD = $\frac{116 \text{ KIP}}{63.2 \text{ IN}} = 1.83$ KIP/IN

REQR. WELD SIZE = $\frac{1.83}{9.6} = .19$

FACTOR OF SAFETY = $\frac{.50}{.19} = \boxed{2.62}$

CASE B:





$\Sigma F_x = ma_x$

$F_4 - F_2 = (.7)(120.5)$

$= 84.3$ KIP

ASSUME $F_2 \sim 0$

$F_4 = 84.3$ KIPS

$\Sigma F_Y = Ma_Y$

$F_1 + F_3 = 120.5$ KIPS

$\Sigma M = \bar{I}\ddot{\theta}^{0} + M\bar{a}d$

$\Sigma M_{3,4}$:

$(F_1)(141) - \frac{(120.5)(141)}{2} =$

$-(120.5)(.7)(60)$

$F_1 = 96.1$ KIPS

$F_3 = 24.9$ KIPS

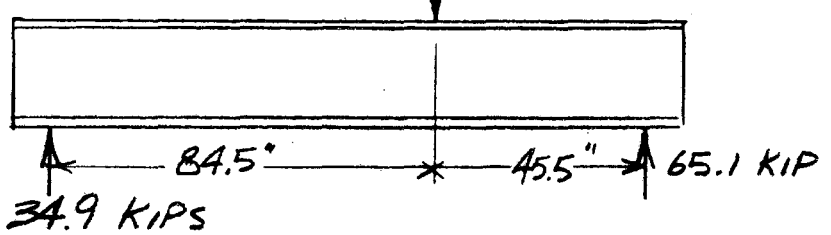
ITEM (1) 6"X 6"X 1/2" STL. TUBE

MAX. ALLOWABLE AXIAL LOAD (KL = 6' & 46 KSI YIELD) = 269 KIPS (RYERSON DATA)

FACTOR OF SAFETY $= \frac{269}{F_1} =$ **2.79**

ITEM (2) WF 18"X 105 LBS

$F_1 =$ 96.1 KIPS



$\sigma_b = MC/I$ $M = 2842$ KIP IN

$C = 9$ IN

$I = 1850$ IN^4

$\sigma_b =$ **13,827 PSI**

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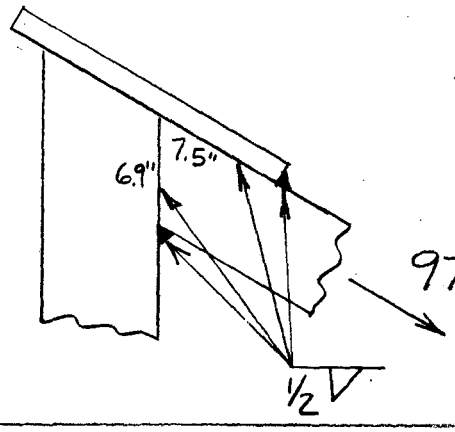
ITEM (4) 6"X6"X ½" STL. TUBE

TENSION FORCE IN TUBE (WHEN ACCEL. OPPOSITE SHOWN) = $\frac{84.3}{\cos 30°}$ = 97.3 KIP

JOINT (4a)



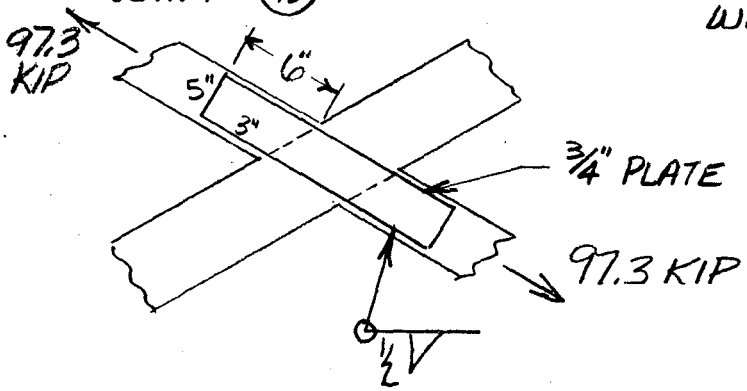
WELD LENGTH = (7.5+6.9+6)2 = 41 IN.

FORCE ON WELD = $\frac{97.3 \text{ KIPS}}{41 \text{ IN}}$ = 2.37 $\frac{\text{KIP}}{\text{IN}}$

REQ'R. WELD SIZE = $\frac{2.37}{9.6}$ = .25 IN

FACTOR OF SAFETY = $\frac{.50}{.25}$ = **2.0**

JOINT (4b)



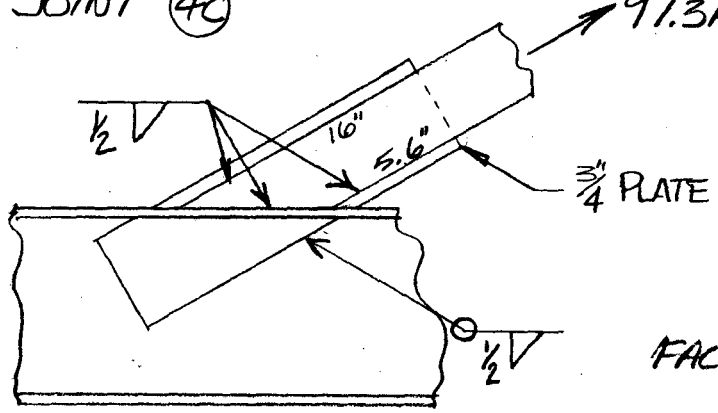
WELD LENGTH = (6+6+5+3)2 = 40 IN.

FORCE ON WELD = $\frac{97.3 \text{ KIP}}{40 \text{ IN}}$ = 2.43 $\frac{\text{K.}}{\text{IN}}$

REQ'R. WELD SIZE = $\frac{2.43}{9.6}$ = .25 IN

FACTOR OF SAFETY = $\frac{.50}{.25}$ = **2.0**

JOINT (4c)



WELD LENGTH = 2(16+5.6+6+4) = 63.2 IN.

FORCE ON WELD = $\frac{97.3 \text{ KIP}}{63.2 \text{ IN}}$ = 1.54 KIP/IN

REQ'R. WELD SIZE = $\frac{1.54}{9.6}$ = .16 IN

FACTOR OF SAFETY = $\frac{.50}{.16}$ = **3.12**

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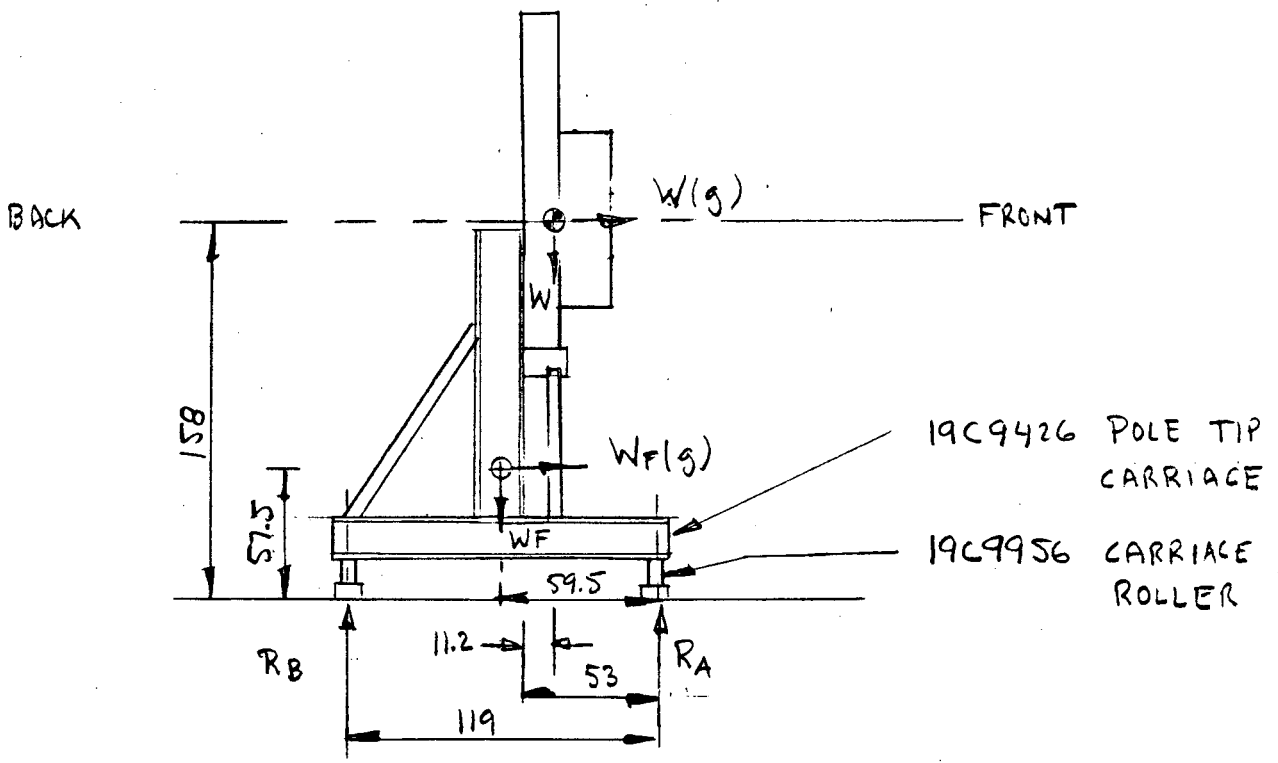
FOR POLE TIP ASSY CG LOCATION SEE ENG NOTE M5267

POLE TIP ASSY WT = W = 130 K

CARRIAGE WT = W_F = 8.0 K



CHECK OVERTURNING IN WORST DIRECTION

(+ ΣM AROUND R_A

CHECK g FOR OVERTURNING $R_B = 0$

$$130^K(g)\,158 + 8^K(g)\,57.5 - 8^K(59.5) - 130^K(53-11.2) = 0$$

$$g = \frac{8(59.5) + 130(41.8)}{130(158) + 8(57.5)} = \frac{5910}{21000} = \boxed{.28}$$

HOLD DOWN FORCE REQUIRED AT R_B FOR g = .7

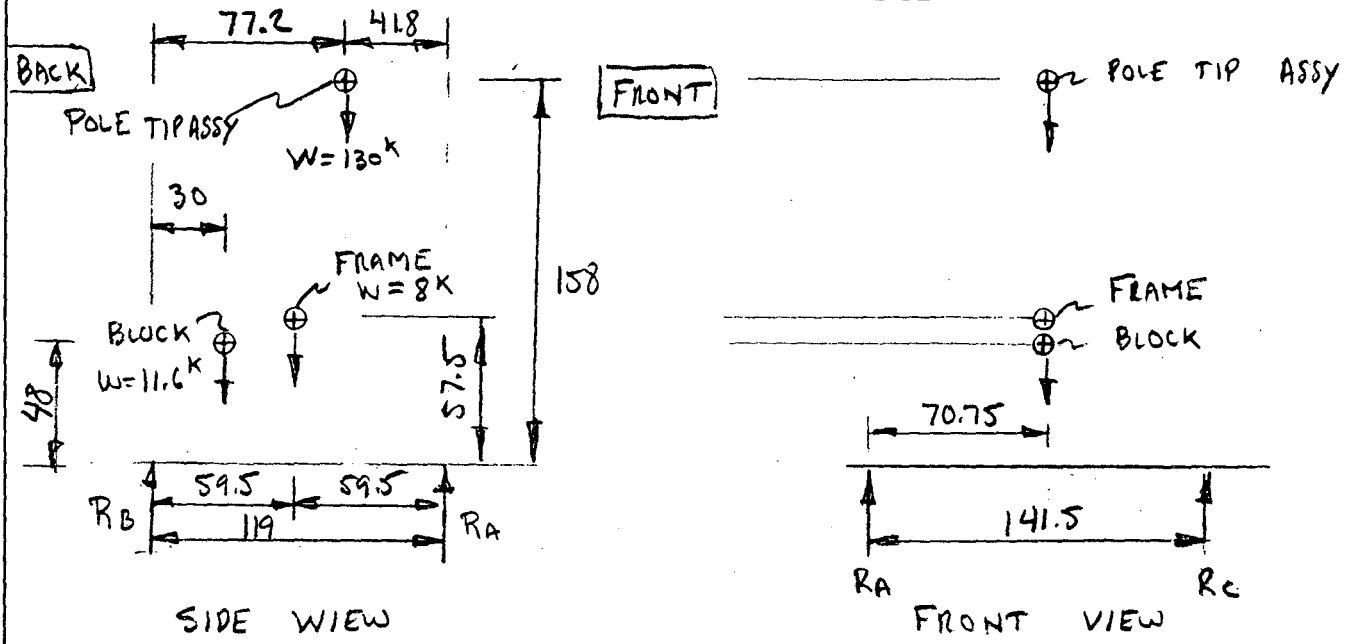
$$R_B(119) + 21000(.7) - 5910 = 0$$

$$R_B = -\frac{21000(.7) + 5910}{119} = \frac{8790\ \text{K-IN}}{119\ \text{IN}} = 74\ \text{K}$$

HOLD DOWN FORCE EACH CORNER $= \frac{74}{2} = \boxed{37\ \text{K}} = P$

SHEAR AT EACH CORNER $S = \left(\frac{130+8}{4}\right).7 = \frac{96.6\ \text{K}}{4} = \boxed{24.1^K}$

CHECK OVERTURNING IN OTHER DIRECTIONS



NO CONCRETE BLOCK

← FORCE TOWARDS BACK

+↻ Σ M AROUND R_B

$$g = \frac{130(77.2) + 8(59.5)}{130(158) + 8(57.5)} = \frac{10512}{21000}$$

$$= \boxed{.50}$$

FORCE SIDE WAYS →

$$g = \frac{(130+8)(70.75)}{21000}$$

$$= \boxed{.46}$$

WITH EX2 BLOCK W=11.6K 3'x4'x6'

→ F TOWARDS FRONT

+↻ Σ M AROUND R_A

$$g = \frac{130(41.8) + 8(59.5) + 11.6(89)}{130(158) + 8(57.5) + 11.6(48)} = \frac{6940}{21560}$$

$$= \boxed{.32}$$

→ FORCE SIDE WAYS

$$g = \frac{(130+8+11.6)70.75}{21560}$$

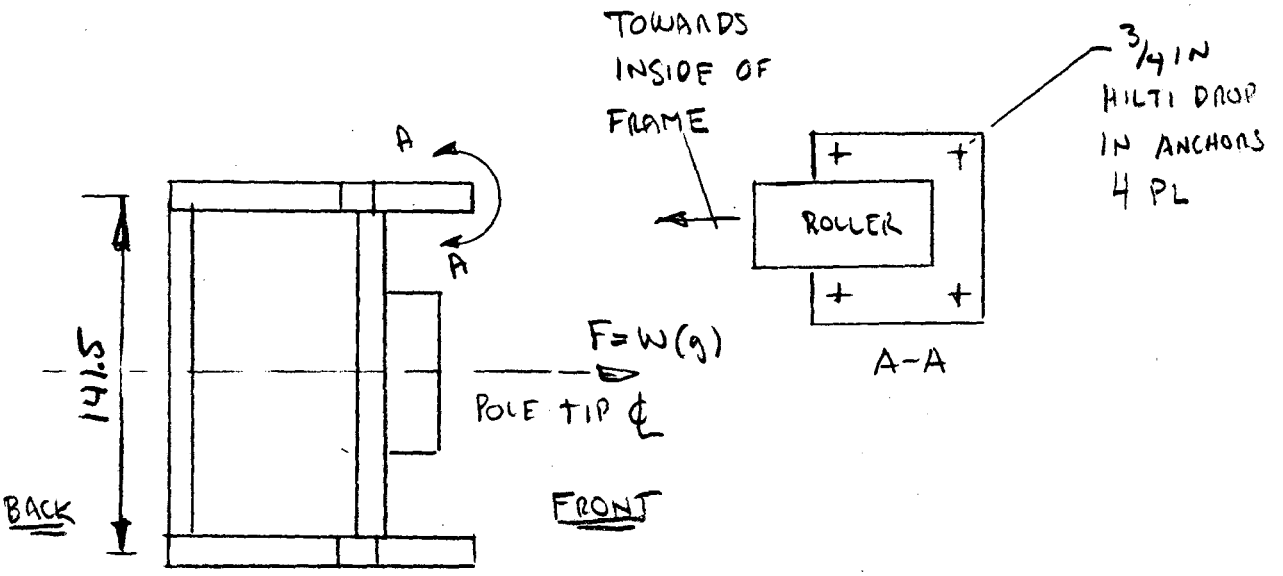
$$= \boxed{.49}$$

← FORCE TOWARDS BACK

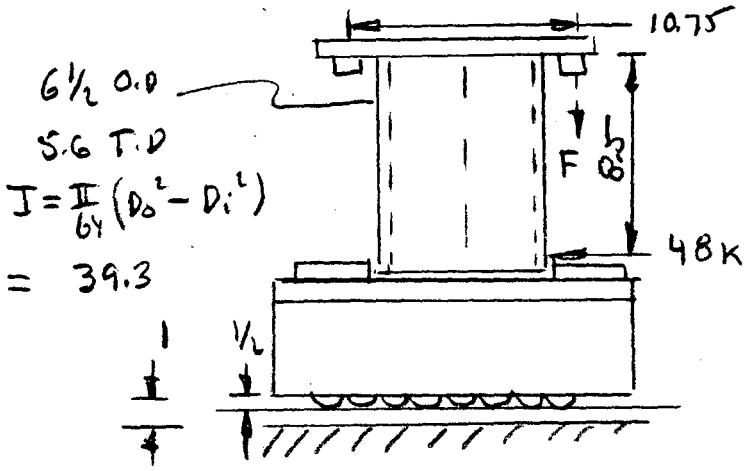
+↻ Σ M AROUND R_B

$$g = \frac{130(77.2) + 8(59.5) + 11.6(30)}{21560} = \frac{10860}{21560}$$

$$= \boxed{.50}$$



WORST CASE FORCE ALONG POLE TIP ℄
FRONT STOPS TAKE ALL SHEAR FORCE
BACK STOPS TAKE UPLIFT



$M = 48^K \times 8.5 = 408$ K-IN

$S = \frac{I}{c} = \frac{39.3}{3.25} = 12.09$

$\sigma = \frac{M}{S} = \frac{408 \text{ K-IN}}{12.11 \text{ IN}^3} = 33.7$ KSI

F.S = 2.2

$\sigma_{YIELD} = 75$ KSI
D.O.M TUBE

CHECK ATTACHMENT BOLTS

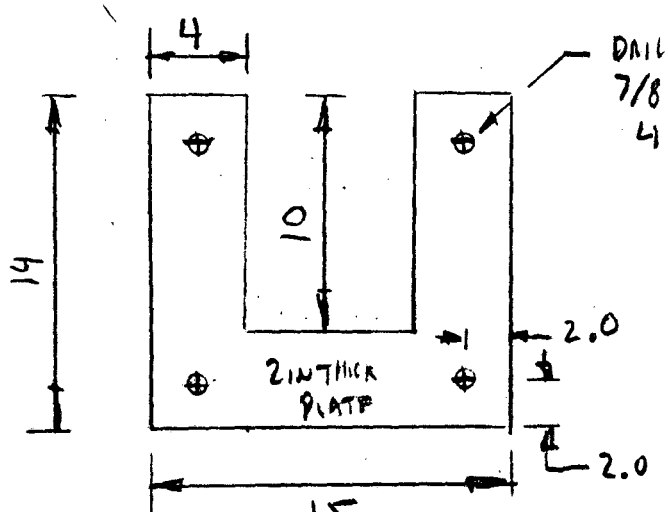
$F = \frac{48^K (8.5)}{10.75} = 38^K$

$\sigma = \frac{38^K}{.606} = 62$ KSI

F.S = 1.25

Gr 5 1-8UNC BOLT

PROOF LOAD = 78 KSI



HILTI DROP IN ANCHORS HDI 3/4 3/4 IN BOLT

ULTIMATE CAPACITY IN 4000 PSI CONCRETE

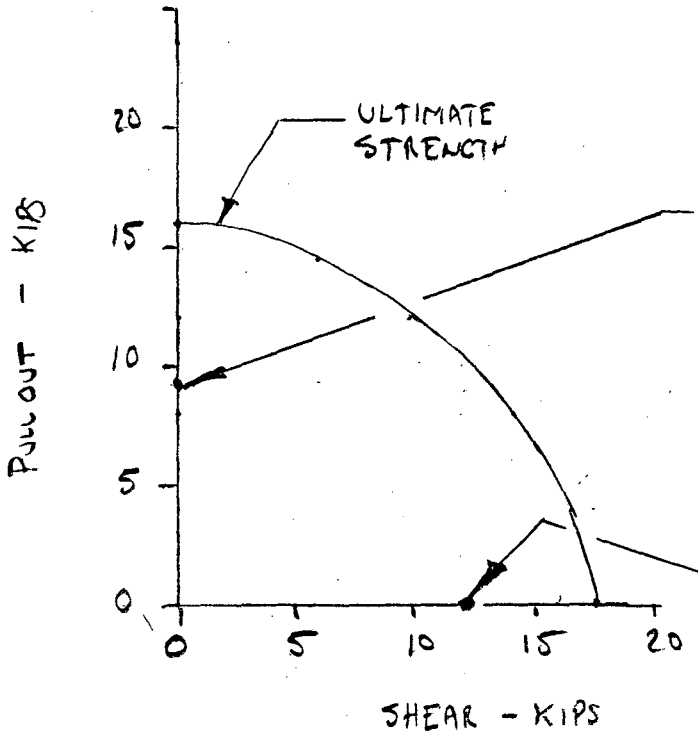
PULLOUT = P_u = 16.03 K
SHEAR = S_u = 17.6 K

} HILTI CATALOG H-390B 4/77

FROM McMACKIN P.J "HEADED STEEL ANCHORS UNDER COMBINED LOADING" AISC ENG JOURNAL 2ND QUARTER 1973

FOR COMBINED LOADING

$$\left(\frac{P}{P_u}\right)^{5/3} + \left(\frac{S}{S_u}\right)^{5/3} \leq 1$$



UPLIFT ON REAR STOP

$\frac{37^K}{4 \text{ BOLTS}} = 9.25^K$

SHEAR ON FRONT STOPS

$\frac{96.6^K}{2} = 48.3^K$/STOP

$\frac{48.3^K}{4 \text{ BOLTS}} = 12^K$

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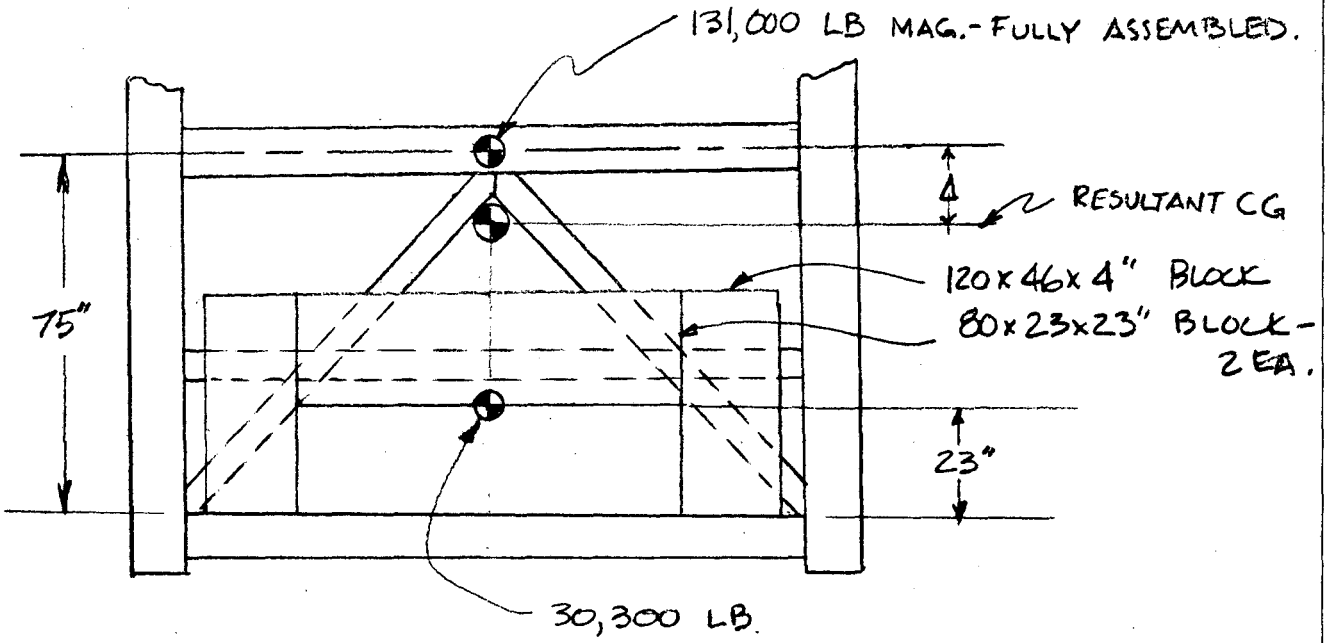
PEP- 40 GeV

MAGNET CORE

TITLE
POLE TIP CARRIAGE

POLE TIP CARRIAGE TIP-OVER STABILITY IS TO BE UPGRADE BY ADDITION OF THREE STEEL BLOCKS.



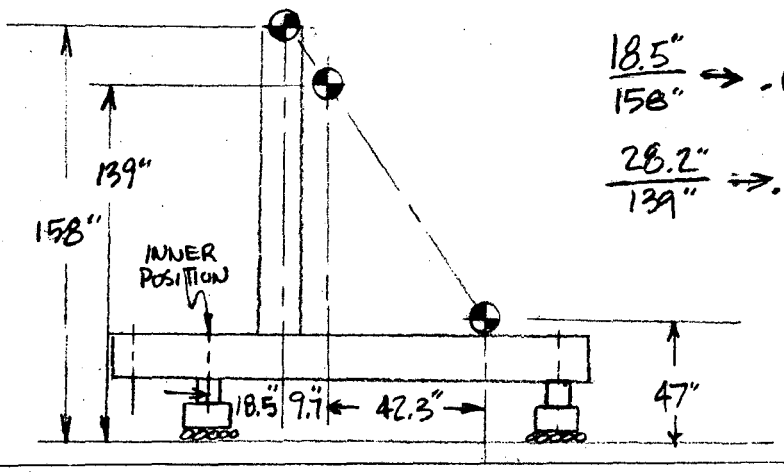
DETEMINE C.G. Δ:

ΣM: $\Delta \times 131{,}000\ LB = (75" - 23" - \Delta) \times 30{,}300\ LB$

$\Delta(131{,}000 + 30{,}300) = 52 \times 30{,}300$

$\Delta = 9.7"$

WITH ROLLERS IN INNER POSITION, RESULTS IN:



$\frac{18.5"}{158"} \rightarrow .11\ G$ OLD EARTHQUAKE TIP OVER STABIL.

$\frac{28.2"}{139"} \rightarrow .20\ G$ NEW. " "

80% INCREASE IN TIP-OVER STABILITY.

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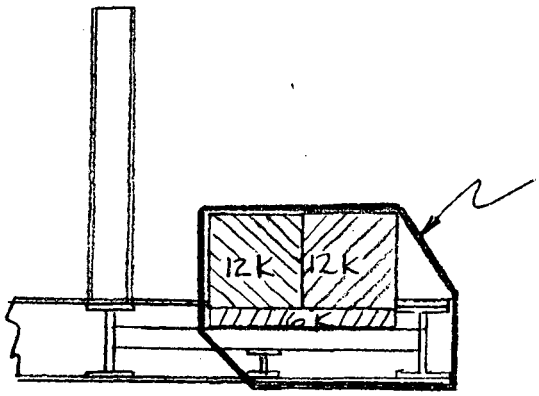
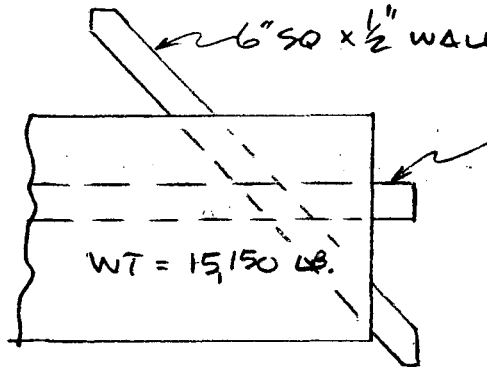
SECURE COUNTER WEIGHTS AS FOLLOWS:



SECURED WITH 2 EACH 3/4" CHAINS. (11,000 LB. WORKING LOAD RATING)

CHECK BENDING σ IN STRUCTURE DUE TO ADDED WT:



TYPICAL SUPPORT FOR COUNTER WT.

ASSUME EACH MEMBER HAS FIXED ENDS (WELDED) MAX. -M OCCURS WHEN LOAD IS AT $\ell/3$ WHICH IS APPROX. CONDITION FOR EACH MEMBER.

$$\text{MAX } -M = -.148\, w\ell \qquad \text{(ROARK V ED. P.97)}$$

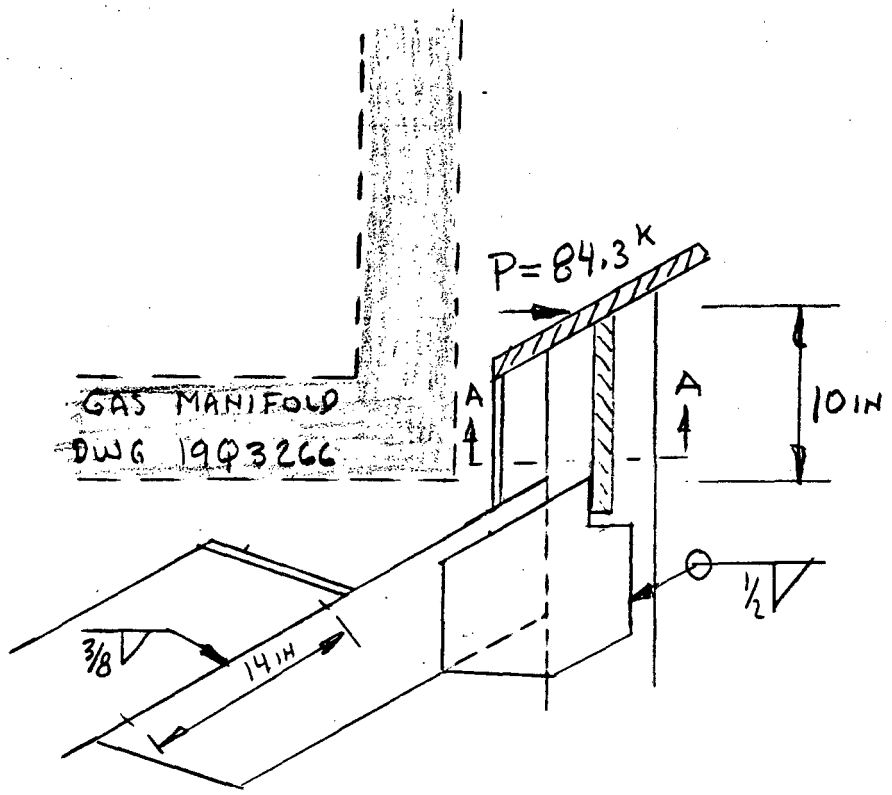
□ : $-M = -.148 \times 15{,}150 \times 110 = -246{,}642$ IN-LB.

$$\sigma = \frac{MC}{I} = \frac{-246{,}642 \times 3''}{55.9\,in^4} = -13{,}237 \text{ psi}$$

I : $-M = -.148 \times 15{,}150 \times 140 = -313{,}908$ IN-LB

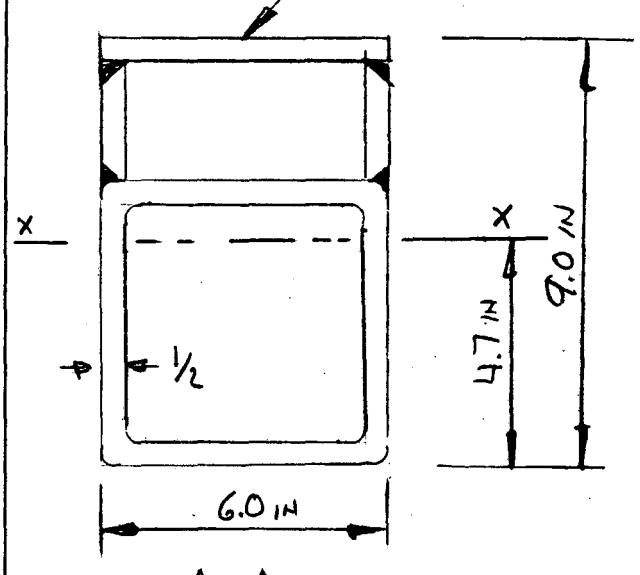
$$\sigma = \frac{MC}{I} = \frac{-313{,}908 \times 3}{30\,in^4} = -31{,}390 \text{ psi}$$

$\therefore$ MAX $\sigma \cong 70\% \times 13$ KSI $=$ **9 KSI**



PROPOSED MODIFICATION TO CLEAR GAS MANIFOLD.

CHECK BENDING AT A-A



$M = 84.3^{K} \times 10\,IN = 843\ K\text{-}IN$

$I = 155\ IN^4$

$S = 155/4.7 = 33\ IN^3$

$\sigma = \frac{M}{S} = \frac{843\ K\text{-}IN}{33\ IN^3} = 25.5\ KSI$

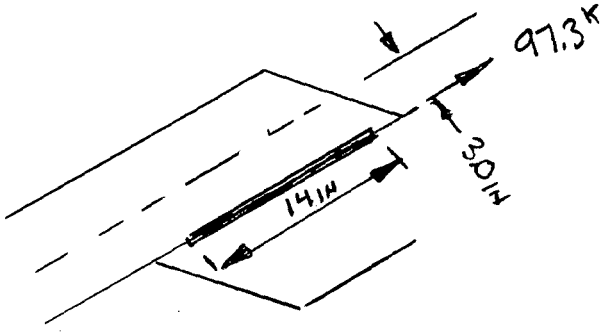
AISC ALLOWABLE

$= \sigma_y \times .6 \times 1.33 = 36 \times .6 \times 1.33$

$= 28.7\ KSI$

CHECK BENDING DUE TO ECCENTRIC LOAD

6 x 6 x 1/2 IN TUBE
$I = 48.6\ IN^4$
$S = 16.2\ IN^3$



$M = 97.3^K \times 3.0\ IN$
$= 292\ K\text{-}IN$

$\sigma = \frac{M}{S} = \frac{292}{16.2} =$ 18.0 KSI

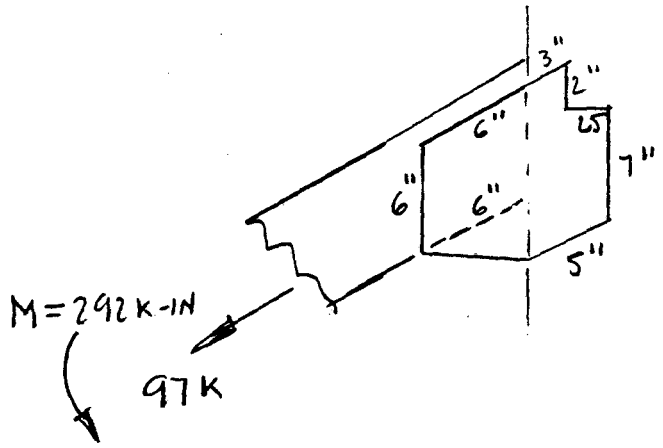
AISC ALLOWABLE 28.7 KSI — 0.K

CHECK WELD BETWEEN TUBES

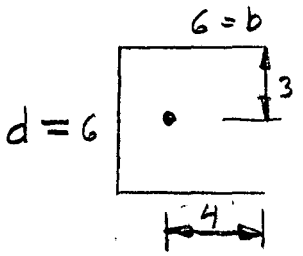
LOAD = 97.3K — 0.K

3/8 FILLET ALLOW 3750 LB/IN x 2 x 14 IN = 105K

CHECK WELD ATTACHMENT TO VERTICAL COLUMN



CHECK WELD PLATE TO TUBE



$$\bar{y} = \frac{b^2}{2b+d} = \frac{36}{12+6} = 2.0$$

$$J_w = \frac{(2b+d)^3}{12} - \frac{b^2(b+d)^2}{(2b+d)}$$

$$= 486 - 288 = 198 \text{ in}^3$$

TWO PLATES USED M PER PLATE = $\frac{292}{2} = 146$ K-IN

TORSION

$$f_{th} = \frac{Mc}{J} = \frac{146(3)}{198} = 2.21 \text{ K/IN}$$

$$f_{tv} = \frac{146(4)}{198} = 2.95 \text{ K/IN}$$

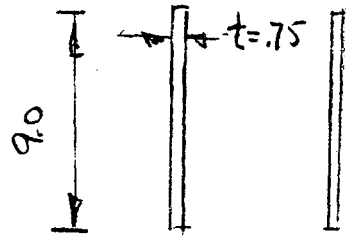
SHEAR $f_s = \frac{P}{L} = \frac{97}{2}\frac{1}{18 \text{ IN}} = 2.7 \text{ K/IN}$

COMBINING $f = \sqrt{(2.21+2.7)^2 + 2.7^2} = \boxed{5.6 \text{ K/IN}}$

0.1K

1/2 IN FILLET ALLOWABLE = $\boxed{5.0 \text{ K/IN}}$

CHECK PLATES



$$I = 2\frac{bh^3}{12} = \frac{2(.75)(9)^3}{12} = 91.1$$

$$S = \frac{91.1}{4.5} = 20.2$$

BENDING

$$\sigma_B = \frac{M}{S} = \frac{292}{20.2} = 14.5 \text{ KSI}$$

TENSION

$$\sigma_t = \frac{P}{A} = \frac{97 \text{ K}}{2(9)(.75)} = 7.19 \text{ KSI}$$

F = ALLOWABLE = .6(36)(1.33) = 28.7 KSI

$$\frac{\sigma_B}{F} + \frac{\sigma_t}{F} \boxed{\leq 1.0} \quad \frac{14.5}{28.7} + \frac{7.19}{28.7} = .51 + .25 = \boxed{.76}$$

O.K

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