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### **Title**

MAGNET CORE: POLE TIP ASSEMBLY SEISMIC BRACING

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UNIVERSITY OF CALIFORNIA

## Engineering & Technical Services Division

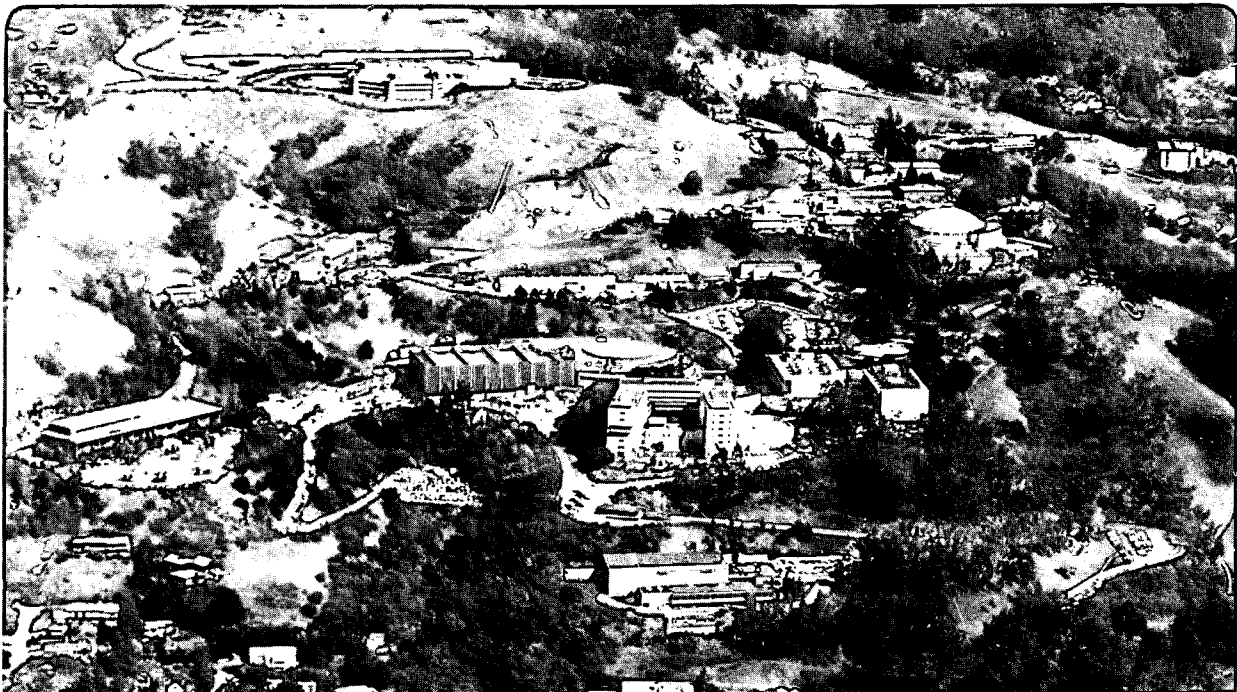
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**ENGINEERING NOTE**

P40200

M5475A

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AUTHOR

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2-26-80

PROGRAM - PROJECT - JOB

PEP-4

MAGNET CORE

TITLE

POLE TIP ASSEMBLY SEISMIC BRACING

THE PURPOSE OF THIS NOTE IS TO DETERMINE STRESSES AND SAFETY FACTORS WITHIN MEMBERS OF THE POLE TIP ASSEMBLY SEISMIC BRACING UNDER EARTHQUAKE LOAD CONDITIONS. THESE BRACES MUST BE ABLE TO WITHSTAND FORCES RESULTING FROM THE HORIZONTAL ACCELERATION OF THE POLE TIP ASSEMBLY. VERTICAL ACCELERATION IS TAKEN CARE OF BY THE POLE TIP POSITIONING MECHANISM.

THREE HORIZONTAL DIRECTIONS OF GROUND ACCELERATION ARE CONSIDERED. FOR EACH CASE, RESULTANT LOADS AND SAFETY FACTORS WITHIN THE MEMBERS ARE DETERMINED. PAGE 4 SHOWS THE THREE CASES OF GROUND ACCELERATION AND THE FORCE DIAGRAM UPON WHICH CALCULATIONS ARE BASED. DETAILED CALCULATIONS FOR ONE CASE ARE SHOWN. CALCULATION RESULTS FOR ALL CASES ARE TABULATED ON PAGE 7.

REV "A" ADDED CHECK ON BRACE ATTACHMENT PAGES  
 P. Peters 8 & 9. FOR JOINT "E" HAVE TO USE SOCKET  
 2-27-81 HEAD SHOULD BE SCREW SEE PAGE 9

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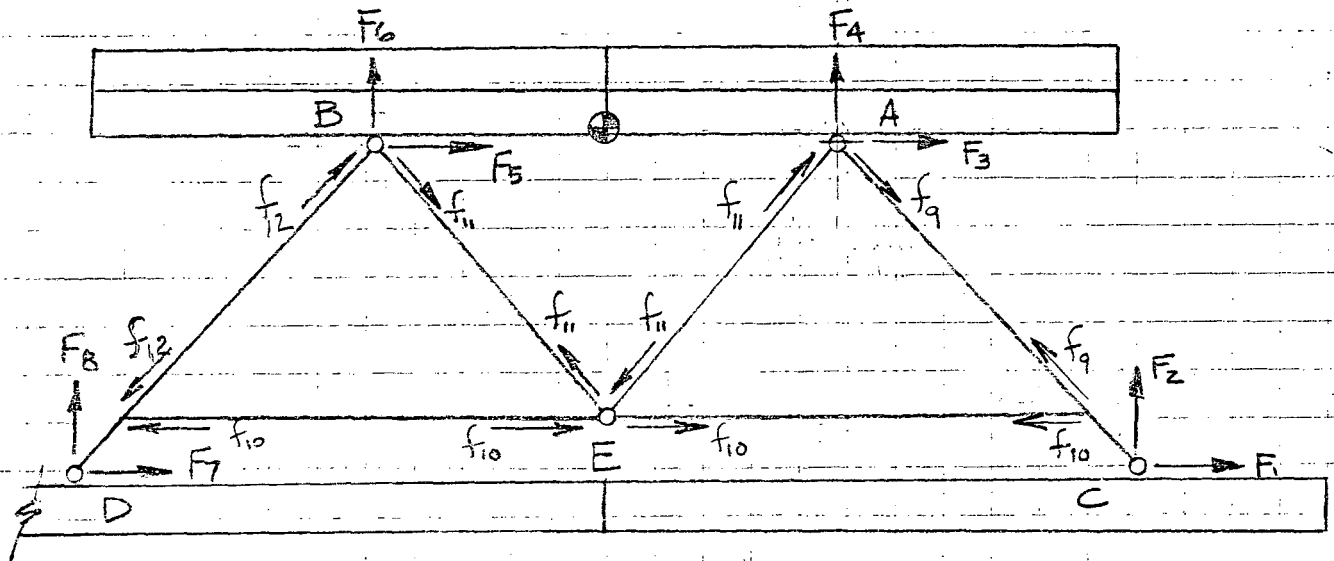
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CASE I  $.7G \rightarrow$ CASE II  $.7G \uparrow$ CASE III  $.7G \swarrow$ 

THREE CASES OF  
GROUND ACCELERATION  
RELATIVE TO STRUCTURE  
ABOVE.

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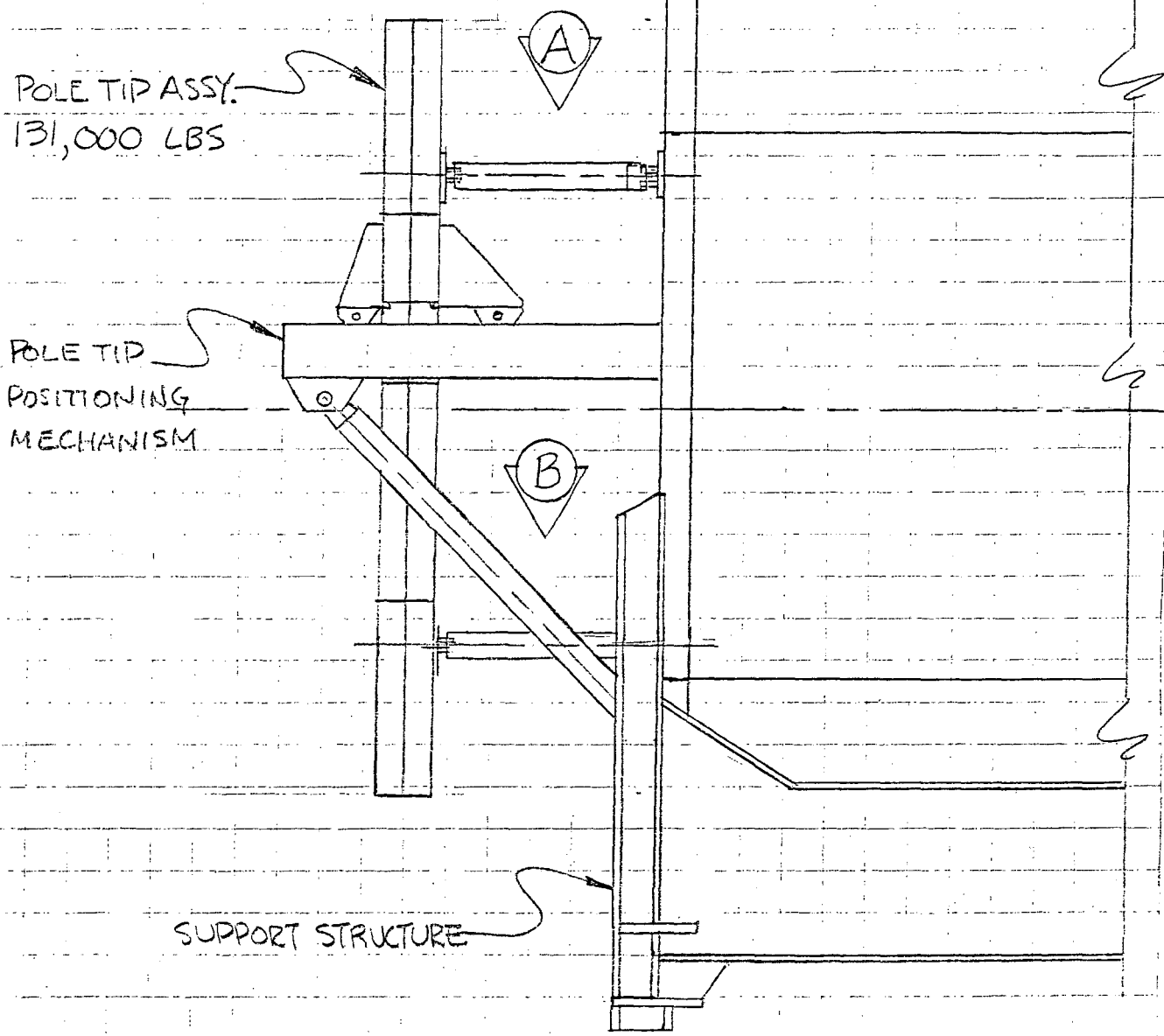
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SUPPORT STRUCTURE AND POLE TIP ASSEMBLY.

SIDE ELEVATION VIEW

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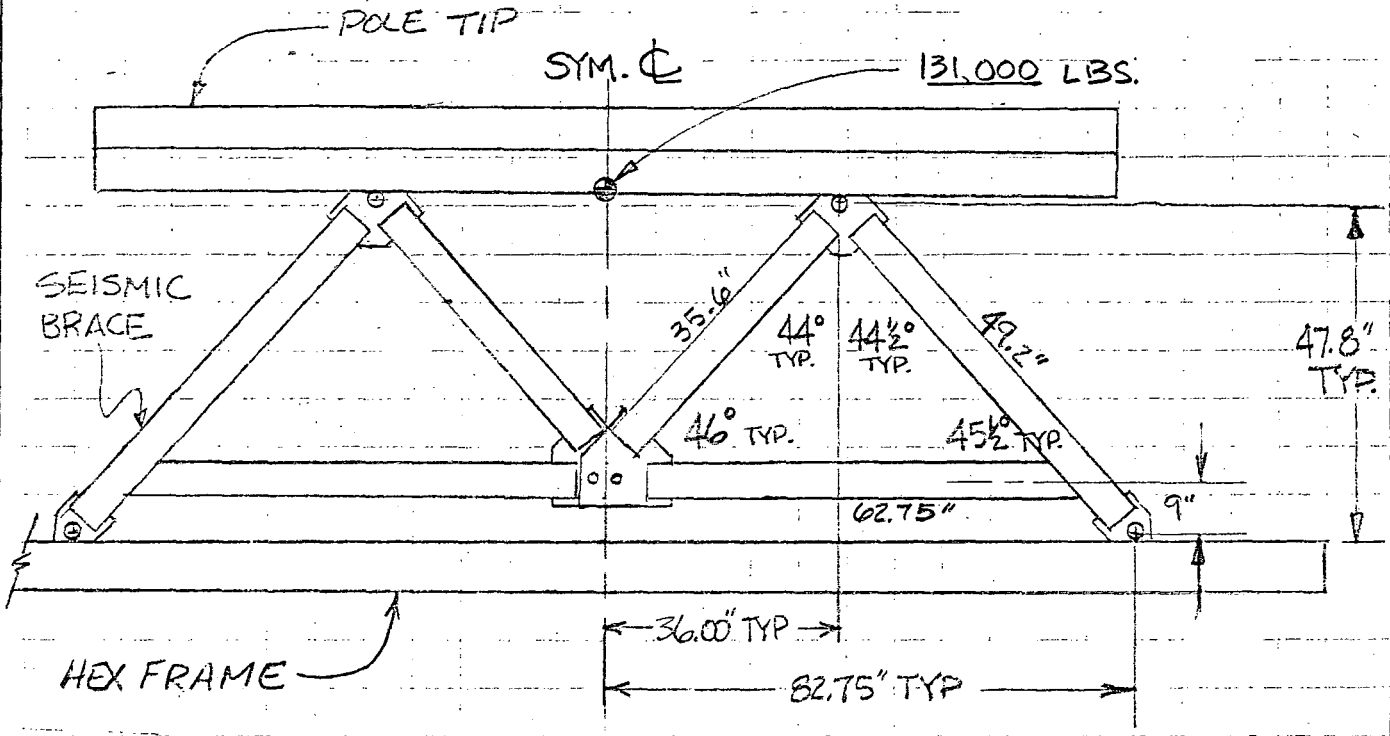
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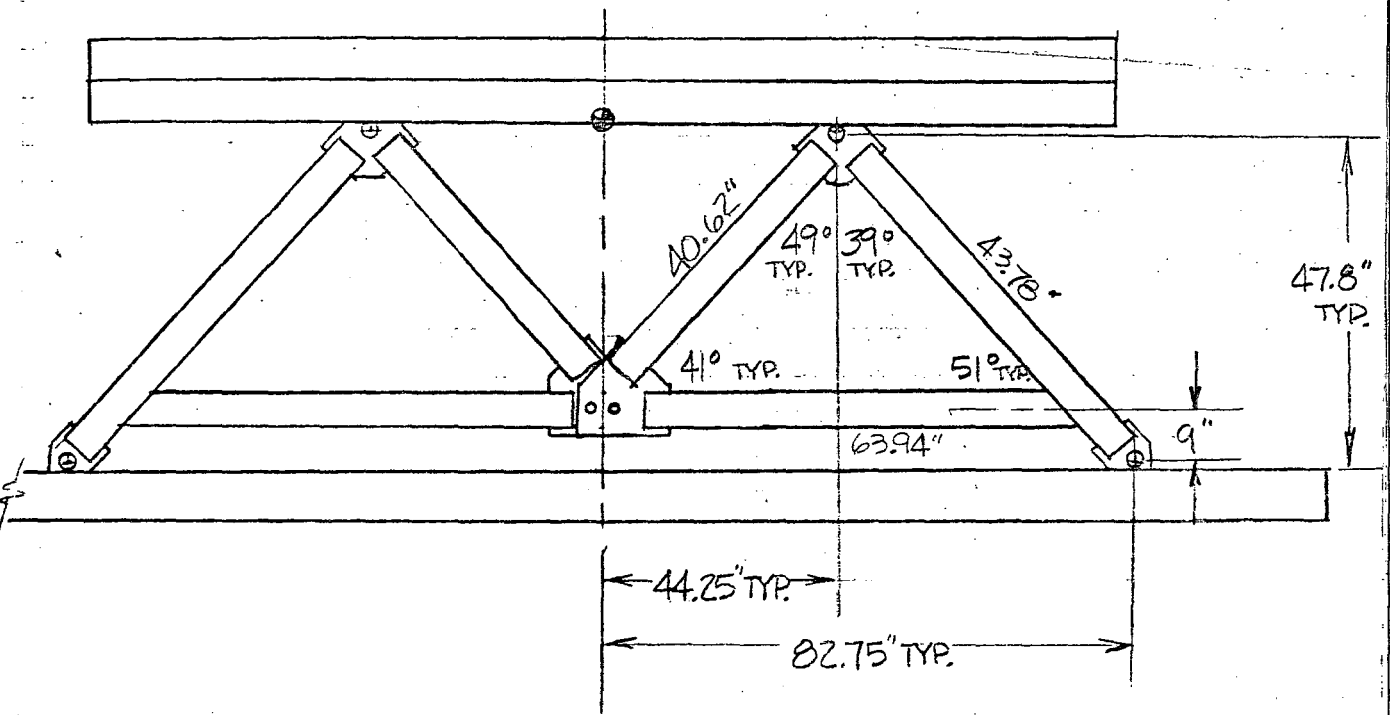
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VIEW A - UPPER SEISMIC BRACE



VIEW B - LOWER SEISMIC BRACE

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CASE I UPPER BRACE

$$\text{ON POLE TIP } \sum F_H = MA = 131,000 \text{ LB} \times .76$$

$$= 88 \text{ K}$$

$$\text{FORCE OF POLE TIP ON BRACE} = \frac{88 \text{ K}}{2} = 44 \text{ KIP.}$$

$$F_3 + F_5 = -44 \text{ K}$$

BY COMPARING FORCES AT JOINT A &amp; B,

$$F_3 = F_5 = -\frac{44}{2} = \boxed{-22 \text{ K}}$$

$$\sum F_V = MA = 0 \quad \therefore F_4 + F_6 = 0$$

$$\sum M_C = 0 \quad \therefore \boxed{F_4 = F_6 = 0}$$

$$\text{ON BRACE } \sum F_H = 0 \quad \therefore F_1 + F_7 + F_3 + F_5 = 0$$

$$F_1 + F_7 = 44 \text{ K}$$

$$\sum F_V = 0 \quad \therefore F_4 + F_6 + F_2 + F_8 = 0$$

$$F_2 + F_8 = 0$$

$$\sum M_D = 0 \quad \therefore F_2 (82.75)(2) = (47.8)(F_3 + F_5)$$

$$\boxed{F_2 = -12.7 \text{ K}}$$

$$\boxed{F_8 = +12.7 \text{ K}}$$

$$\sum f_A = 0 \quad \therefore f_{11} (\cos 44^\circ) + F_4 = (\cos 44\frac{1}{2}^\circ) f_9$$

$$.719 f_{11} = .713 f_9, \quad f_{11} = .992 f_9$$

$$f_{11} (\sin 44^\circ) + f_9 (\sin 44\frac{1}{2}^\circ) + F_3 = 0$$

$$\therefore (.694)(.992 f_9) + f_9 (.701) = 22 \text{ K}$$

$$\boxed{f_9 = 15.83 \text{ K}}$$

$$\therefore f_{11} = .992 (15.83) = \boxed{15.71 \text{ K}}$$

$$\sum f_B = 0 \quad \therefore f_{11} (\cos 44^\circ) = F_6 + f_{12} (\cos 44\frac{1}{2}^\circ)$$

$$f_{11} (.719) = f_{12} (.713), \quad f_{12} = \boxed{15.83 \text{ K}}$$

$$\sum f_E = 0 \quad \therefore f_{10} = (\cos 46^\circ) f_{11} = (.695)(15.71) = \boxed{10.92 \text{ K}}$$



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$$\sum F_c = 0 \therefore F_1 = f_{10} + (\cos 45 \frac{1}{2}^\circ) f_9 = 10.92 + (0.701)(15.83)$$

$$F_1 = 22.01 \text{ K}$$

$$F_7 = 44 - F_1 = 21.99 \text{ K}$$

ALLOWABLE AXIAL LOADING.

MEMBER	MAX. ALLOWABLE (FROM RYERSON DATA BK, P. 198)	SAFETY FACTOR (OVER ALLOWABLE)
AE - 4" SQ. TUBE	136 K	8.7
AC - "	132 K	8.3
EC - "	127 K	11.6

WELD STRESSES - ALL WELDED JOINTS CONSIST OF  
AT LEAST 20" OF  $\frac{3}{8}$ " FILLET WELD.

$$\text{MAX. WELD STRESS} = \frac{\text{MAX. LOAD.}}{\text{AREA}} = \frac{F_1}{\text{AREA}} = \frac{15.83 \text{ K}}{20" \times \frac{3}{8}"}$$

$$= 1,266 \text{ PSI}$$

$$\text{SAFETY FACTOR} = \frac{\text{ALLOWABLE}}{\text{MAX. STRESS}} = \frac{9,200}{1,266} = 7.3$$

BENDING STRESS - MAX OCCURS AT JOINT OF MEMBERS  
AC AND EC.

$$\sigma_b = \frac{MC}{I} \quad M = 9" (F_1 + F_2)$$

$$= 9" (22.0 - 12.7) = 83.7 \text{ K-IN.}$$

$$C = 2", \quad I = 12 \text{ IN}^4$$

$$\sigma = \frac{83.7 (2)}{12} = 13.95 \text{ KSI}$$

$$\text{SAFETY FACTOR} = \frac{55 \text{ KSI U.L.}}{13.95 \text{ KSI}} = 3.9$$

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ITEM	CASE I →		CASE II ↑		CASE III ↘	
	UPPER	LOWER	UPPER	LOWER	UPPER	LOWER
<b>EXTERNAL FORCES (KIPS)</b>						
F <sub>1</sub>	22.0	22.0	-21.6	-17.8	-32.8	-30.2
F <sub>2</sub>	-12.7	-12.7	22.0	22.0	24.5	24.5
F <sub>3</sub>	-22.0	-22.0	21.6	17.8	28.7	26.0
F <sub>4</sub>	0	0	-22.0	-22.0	-15.5	-15.5
F <sub>5</sub>	-22.0	-22.0	-21.6	-17.8	2.4	5.1
F <sub>6</sub>	0	0	-22.0	-22.0	-15.5	-15.5
F <sub>7</sub>	22.0	22.0	21.6	17.8	-1.7	-9
F <sub>8</sub>	12.7	12.7	22.0	22.0	6.6	6.6
<b>INTERNAL FORCES (KIPS)</b>						
f <sub>9</sub>	15.8	14.5	-30.9	-28.3	-34.4	-31.6
f <sub>10</sub>	10.9	12.9	0	0	-8.7	-10.4
f <sub>11</sub>	15.7	17.1	0	0	-12.6	-13.8
f <sub>12</sub>	15.8	14.5	-30.9	-28.3	9.1	8.3
<b>AXIAL LOAD SAFETY FACTOR</b>						
MEMBER AE	8.7	7.7	-	-	10.8	9.6
AC	8.3	9.2	4.3	4.7	3.8	4.2
EC	11.6	9.9	-	-	14.6	12.2
<b>WELD STRESS</b>						
PSI	12,660	13,660	24,000	22,600	27,400	25,250
SAFETY FACTOR	7.3	6.7	3.8	4.1	3.4	3.6
<b>BENDING STRESS</b>						
PSI	13,950	13,950	0	0	12,450	8,565
SAFETY FACTOR	3.9	3.9	-	-	4.4	6.4

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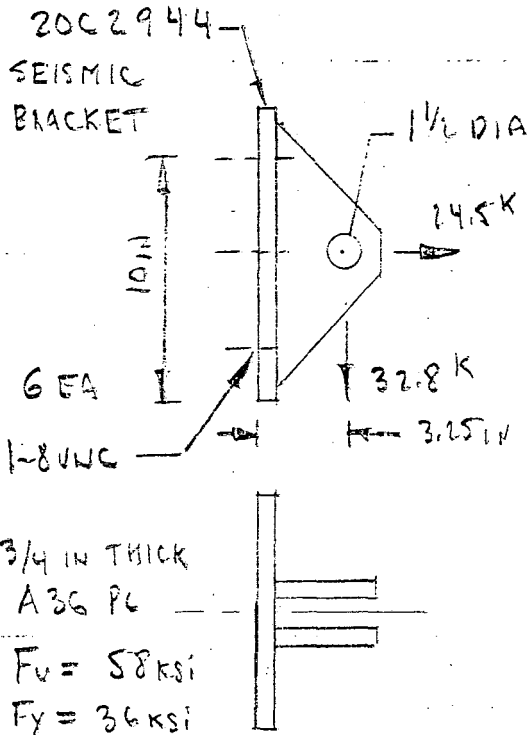
PINS AT A, B, C, D

CHECK PIN SHEAR WORST CASE III UPPER

$$F_1 = 32.8$$

$$F_2 = 24.5$$

$$F = \sqrt{32.8^2 + 24.5^2} = 40.95$$



PIN 1.5 DIA COLD ROLLED 1018

$$F_u = 64 \text{ ksi}$$

$$F_y = 54 \text{ ksi}$$

$$\tau_w = .65 \sigma_w = .65(64) = 41.6 \text{ ksi}$$

$$A = \frac{\pi D^2}{4} = \frac{3.14(1.5)^2}{4} = 1.76 \text{ in}^2$$

DOUBLE SHEAR

$$\tau = \frac{F}{2A} = \frac{40.95}{2(1.76)} = 11.6 \text{ ksi}$$

FS = 3.5

CHECK BOLTS A307 1-8UNC

$$\text{AISC ALLOWABLE TENSION} = 1.33(19.8) = 26.33 \text{ ksi}$$

$$\text{II ALLOWABLE SHEAR} = 1.33(10) = 13.3 \text{ ksi}$$

$$\text{MAX TENSION} = \frac{32.8 \text{ k}(3.25)}{10 (2) \text{ BOLTS}} + \frac{24.5 \text{ k}}{6 \text{ BOLTS}} = 9.3 \text{ k}$$

$$\text{OR } \frac{9.3 \text{ k}}{.606 \text{ in}^2} = 15.3 \text{ ksi} = \sigma_t$$

$$\text{SHEAR} = \frac{32.8 \text{ k}}{6 (.55 \text{ in}^2)} = 10 \text{ ksi} = \tau_v$$

COMBINING

$$\left(\frac{\sigma_t}{F_t}\right)^2 + \left(\frac{\tau_v}{F_v}\right)^2 \leq 1$$

$$\left(\frac{15.3}{26.33}\right)^2 + \left(\frac{10}{13.3}\right)^2 = .34 + .56 = .9 < 1 \text{ O.K.}$$

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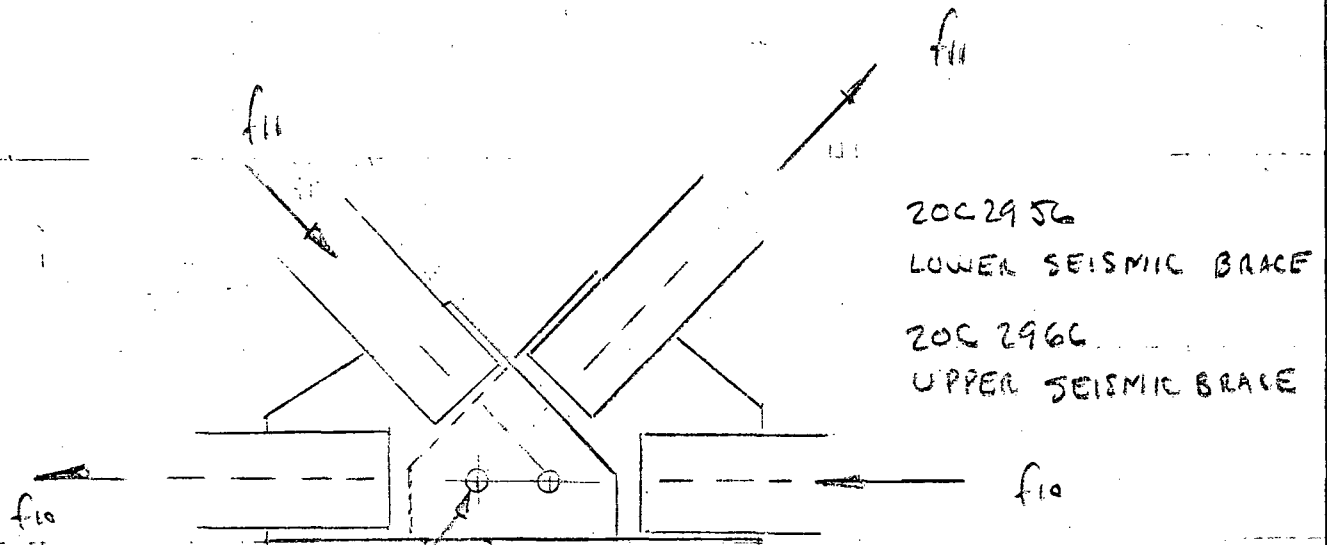
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2-22-81  $\Delta$ CHECK JOINT E

WORST CASE

17.1 K =  $f_{II}$

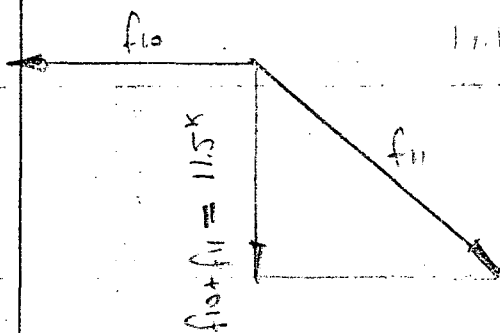
12.9 =  $f_{IO}$



1" DIA 1 IN THICK PLATE A36

$F_u = 58 \text{ ksi}$

$F_y = 36 \text{ ksi}$

FOR 1-8 UNC BOLT  $A = .55 \text{ in}^2$ 

SHEAR STRESS =  $\frac{11.5 \text{ K}}{.55 \text{ in}^2} = 20.9 \text{ ksi}$

ALLOWABLE FOR A307 BOLT = 10 ksi

SOCKET HEAD SHOULDER SCREW

NOM 1" SHOULDER DIA

SHEAR STRENGTH 9.6 ksi

FS = 4.6

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