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### **Title**

MUON SHIELDING: DOOR HARDWARE STRUCTURAL CALCULATIONS

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### **Author**

Purgalis, Peter.

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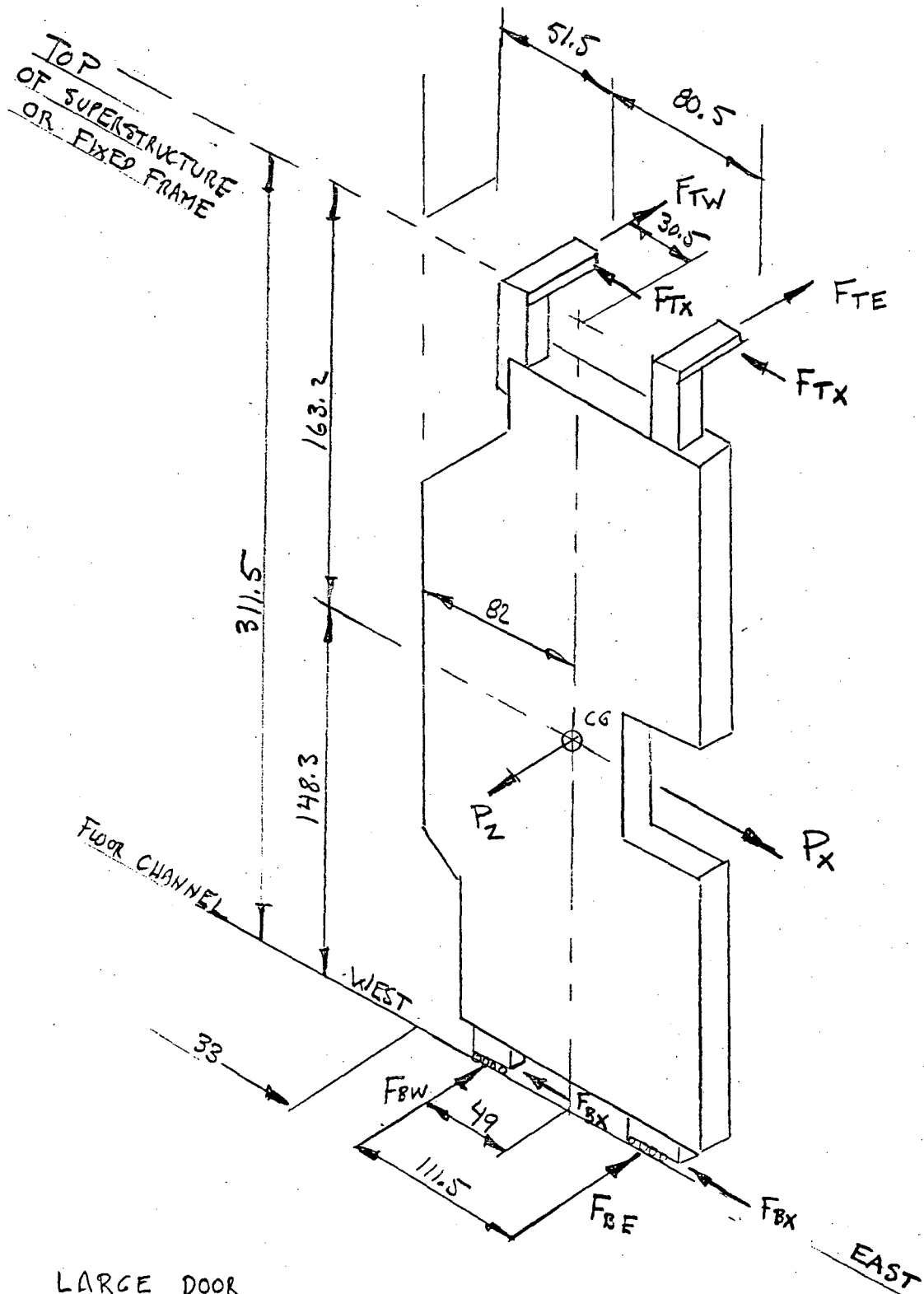
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LAWRENCE BERKELEY LABORATORY - UNIVERSITY OF CALIFORNIA		CODE	SERIAL	PAGE
<b>ENGINEERING NOTE</b>		P40201	M5691	1 OF 16
AUTHOR	DEPARTMENT	LOCATION	DATE	
P. PURCALIS	MECH. ENGR.	BERKELEY	2-26-81	
PROGRAM - PROJECT - JOB				
PEP-4				
MUON SHIELDING				P. Purcalis
TITLE				2-26-81
DOOR HARDWARE STRUCTURAL CALCULATIONS				
<p>THE "DOORS" ARE RESTRAINED AT THE BOTTOM BY THE FLOOR CHANNELS &amp; SEISMIC STOPS AND AT THE TOP BY THE DOOR HANGERS WHICH ATTACH TO THE FIXED FRAME OR SUPERSTRUCTURE</p> <p>CALCULATIONS SHOW THAT, FOR A .7g EARTHQUAKE, THE STRESSES IN THE ATTACHMENT HARDWARE ARE WITHIN THE ALLOWABLE VALUES SPECIFIED BY AISC.</p>				

# ENGINEERING NOTE

AUTHOR	DEPARTMENT	LOCATION	DATE
P. Purgalis	Mechanical	Berkeley	2/26/81



LARGE DOOR

DOOR WEIGHT = 78.5K  
 MUON CHAMBERS = 11.1K @ 10 LB/FT<sup>2</sup>  
 HARDWARE = 2.0K  
 91.6 ≈ 92K = W

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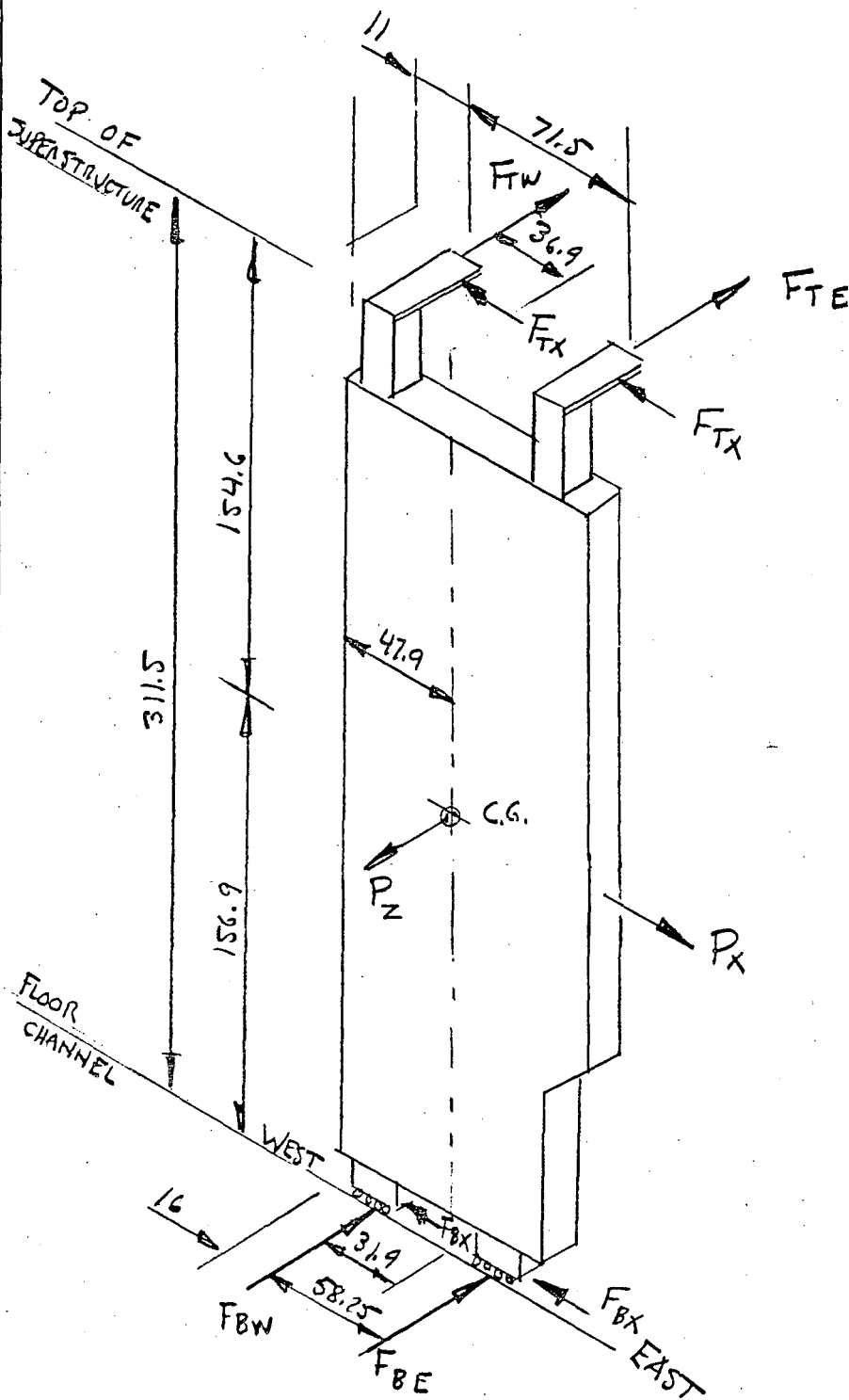
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Mechanical

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SMALL DOOR

DOOR WEIGHT = 54.5 k

MOON CHAMBERS = 7.0 k @ 10 lb/ft<sup>2</sup>

HANDWARE = 2.0 k

$$63.5 \approx \boxed{64 \text{ k} = W}$$

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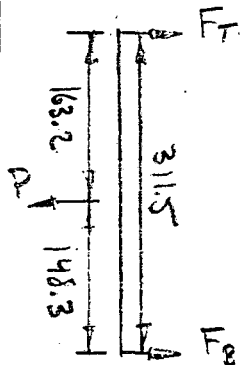
Berkeley

2/25/81

LOAD ACTING ON LARGE DOOR C.G. ALONG BEAM LINE IS DUE TO EARTHQUAKE AND PEP-9 MAGNET

$$P_z = \text{EARTHQUAKE}$$

$$= .7(92K) = 64.4K$$

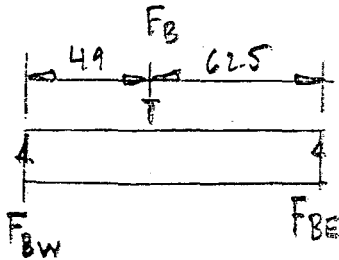
FORCES AT TOP  $F_T$  AND BOTTOM  $F_B$  OF DOOREARTHQUAKE

$$F_T = \frac{148.3}{316.5} P = .48P$$

$$.48(64.4) = \boxed{31K}$$

$$F_B = .52P$$

$$\boxed{33.5K}$$

FORCE ACTING ON WEST ROLLER  $F_{BW}$  & EAST ROLLER  $F_{BE}$ 

$$F_{BW} = \frac{62.5}{111.5} F_B$$

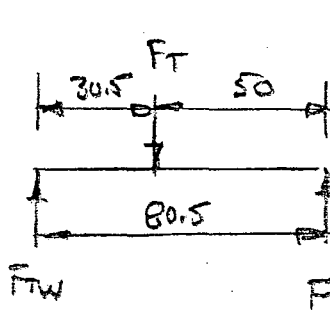
EARTHQUAKE

$$= .56 F_B$$

$$.56(33.5K) = \boxed{18.8K}$$

$$F_{BE} = .44 F_B$$

$$.44(33.5) = \boxed{14.7K}$$

FORCE ACTING ON WEST HANGER  $F_{TW}$  & EAST HANGER  $F_{TE}$ 

$$F_{TW} = \frac{50}{80.5} F_T$$

EARTHQUAKE

$$= .62 F_T$$

$$.62(31) = \boxed{19.2K}$$

$$F_{TE} = .38 F_T$$

$$.38(31) = \boxed{11.8K}$$

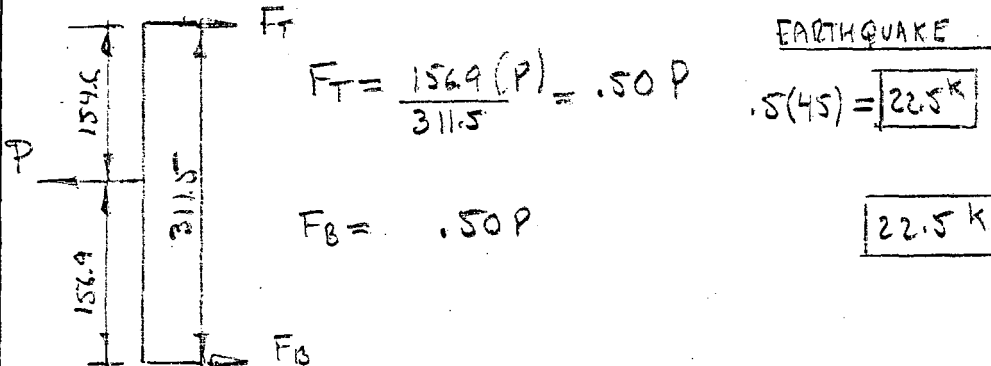
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LOAD ACTING ON SMALL DOOR C.G. ALONG BEAM LINE IS DUE TO EARTHQUAKE AND PEP-9 MAGNET.

$$P_2 = \text{EARTHQUAKE}$$

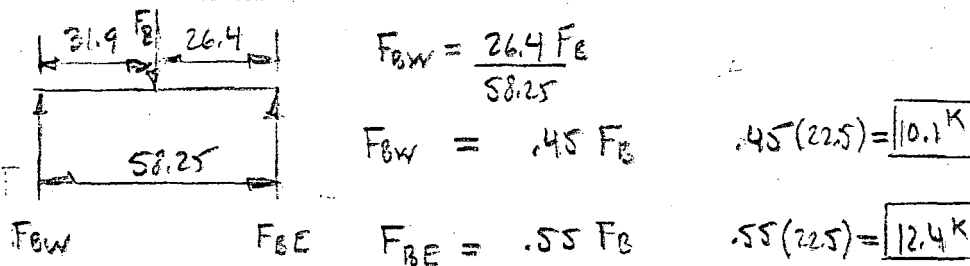
$$= .7 (64k) = 45k$$

FORCES AT TOP  $F_T$  AND BOTTOM  $F_B$  OF DOOR



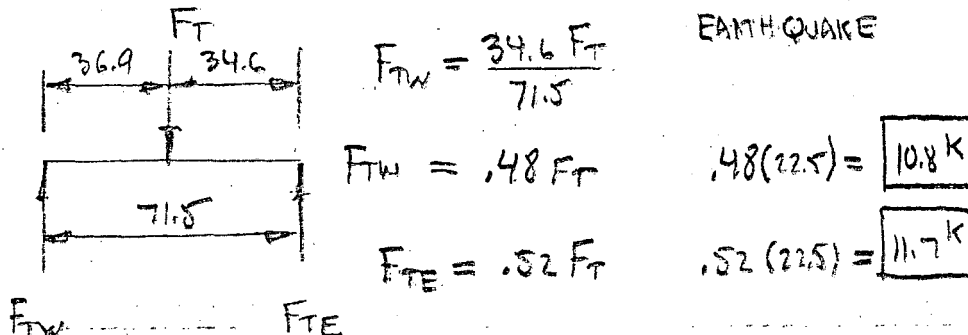
FORCE ACTING ON WEST ROLLER  $F_{BW}$   
← EAST ROLLER  $F_{BE}$

EARTHQUAKE



FORCE ACTING ON WEST HANGER  $F_{TW}$   
← EAST HANGER  $F_{TE}$

EARTHQUAKE





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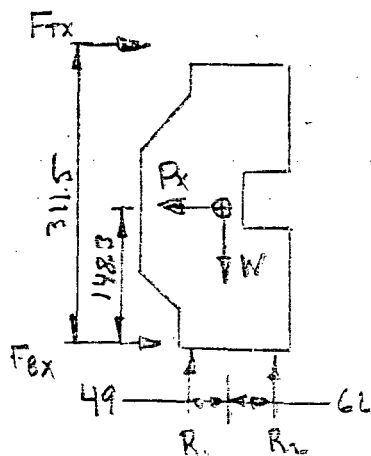
FORCES IN X DIRECTION (PERPENDICULAR TO BEAM)LARGE DOOR

$$P_x = \text{EARTHQUAKE} = .7(92^k) = 64.4^k$$

FIND FORCE AT TOP

 $F_{Tx}$ 

FOR

 $R_2 = 0$ (TO KEEP DOOR FROM LIFTING  $R_2$ ) $\sum M$  AROUND  $R_1$ 

$$-P_x(148.3) + 49(W) + F_{Tx}(311.5) = 0$$

$$F_{Tx} = \frac{64.4^k(148.3) - 49(92^k)}{311.5} = \boxed{16.2^k}$$

 $\sum F_x$ 

$$F_{Tx} + F_{Bx} = P_x$$

$$F_{Bx} = P_x - F_{Tx} = 64.4 - 16.2 = 48.2^k$$

$$\text{OR } \frac{48.2}{2} = \boxed{24.1^k / \text{ROLLER}}$$

$$R_1 = W = \boxed{92^k} \leftarrow 0^k \rightarrow \boxed{\text{ROLLER HAS 50T CAPACITY}}$$

SMALL DOOR

$$P_x = \text{EARTHQUAKE} = .7(64^k) = 45^k$$

FIND  $F_{Tx}$  SO  $R_1 = 0$  $\sum M$  AROUND  $R_2$ 

$$P_x(156.9) - 26.4(W) - F_{Tx}(311.5) = 0$$

$$F_{Tx} = \frac{45^k(156.9) - 64^k(26.4)}{311.5}$$

$$= 17.2^k$$

 $\sum F_x$ 

$$F_{Bx} = P_x - F_{Tx} = 45 - 17.2 = 27.8^k$$

$$\text{OR } \frac{27.8}{2} = \boxed{13.9^k / \text{ROLLER}}$$

$$R_2 = W = \boxed{64^k}$$

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1/4" X 9" PARABOLT  
PB1149  
SHEAR ULT = 63.5 K  
ALLOW = 15.9 K  
EARTHQUAKE =  
= 1.33 X 15.9 = 21 K

SEISMIC  
PAD

DOORS IN RUN POSITION

10X30 CHANNEL

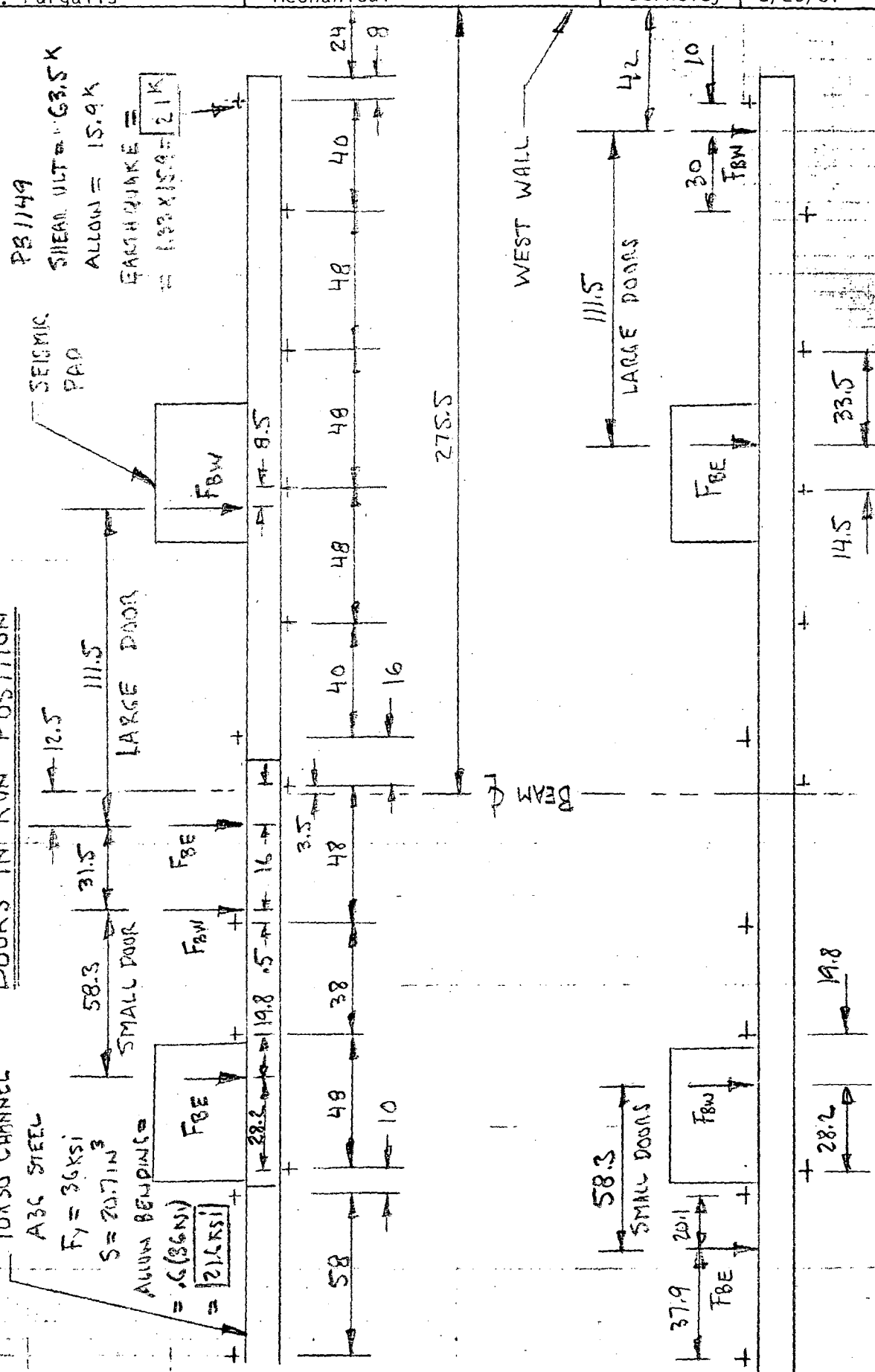
ABC STEEL

$F_y = 36 \text{ ksi}$

$S = 20.7 \text{ in}^3$

ALLOW BENDING =

$= \frac{.6(36 \text{ ksi})}{21(1 \text{ ksi})}$



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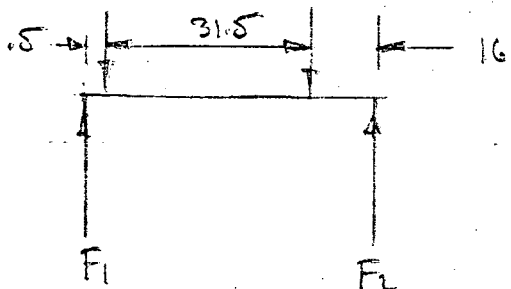
SEE PREVIOUS PAGE 1905986 FOR CHANNEL LAYOUT

CHECK CHANNEL ATTACHMENT TO FLOORCHECK WORST CASE

DOORS CLOSED

SMALL DOOR WEST ROLLER AND LARGE DOOR EAST ROLLER

$$F_{BW} = 10.1 \quad F_{BE} = 14.7$$



$$F_1 = \frac{F_{BE}(16) + F_{BW}(47.5)}{48}$$

$$= .33(14.7) + 1(10.1) = \boxed{15.0 \text{ K}}$$

$$F_2 = F_{BE} + F_{BW} - F_1$$

$$= 14.7 + 10.1 - 15 = \boxed{9.8 \text{ K}}$$

$$\text{ALLOWABLE} = \boxed{21 \text{ K}}$$

FROM PREVIOUS PAGE

CHECK CHANNEL BENDING

$$M = \frac{F_{BW}(a)(b) + F_{BE}(a)(b)}{L} = \frac{10.1(.5)(47.5) + 14.7(16)(32)}{48}$$

$$= 161 \text{ K-IN}$$

$$\sigma = \frac{M}{S} = \frac{161 \text{ K-IN}}{20.7} = \boxed{7.8 \text{ KSI}}$$

$$\text{ALLOWABLE} = \boxed{21.6 \text{ KSI}}$$

FROM PREVIOUS PAGE

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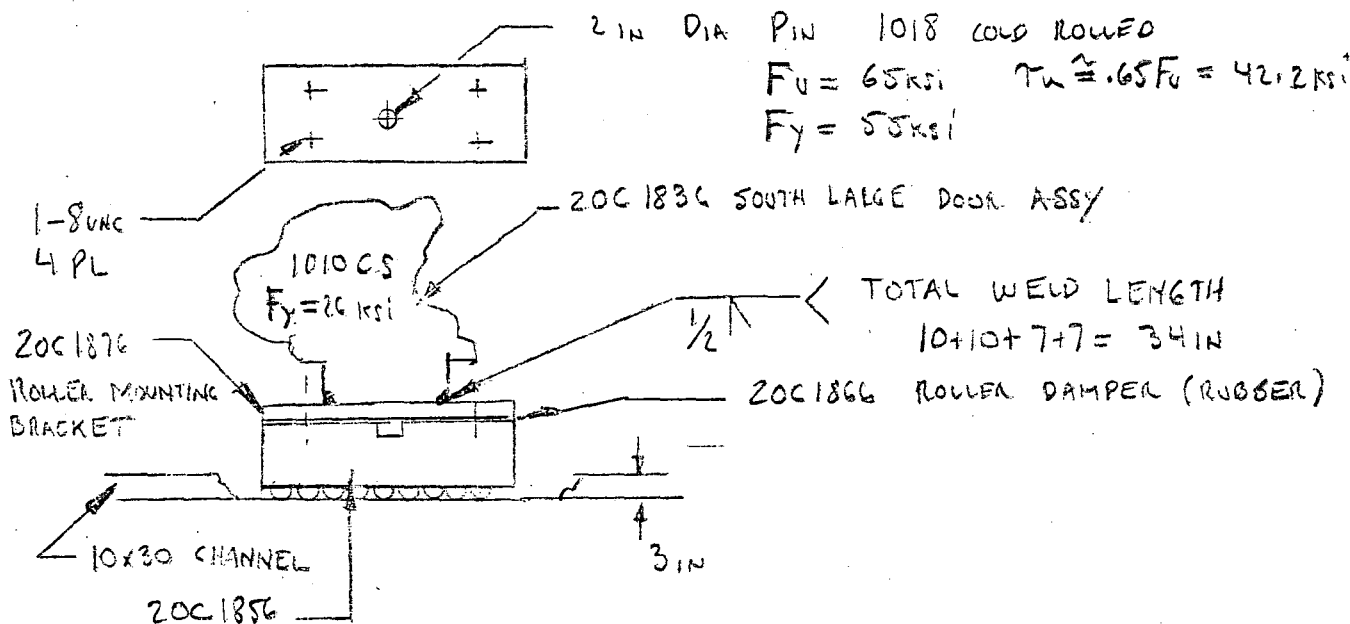
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CHECK ROLLER ATTACHMENT TO DOOR

MAX FORCE = EARTHQUAKE IN X DIRECTION FOR LARGE DOOR (PAGE 6)  
= 24.1 K



100T HILLMAN ROLLER

CHECK SHEAR ON 2 IN DIA PIN

$$A = 3.14 \text{ IN}^2$$

$$\text{SHEAR} = \frac{24.1 \text{ K}}{3.14 \text{ IN}^2}$$

$$7.6 \text{ ksi}$$

$$T_u = 42.2 \text{ ksi} \leftarrow \text{FS} = 5.6$$

2 IN PIN FITS INTO NEMA G-10 INSULATING  
 BUSHING BEARING ON BUSHING

$$\text{BEARING} = \frac{24.1 \text{ K}}{2 \text{ IN} \times 7.5 \text{ IN}}$$

$$= 16 \text{ ksi}$$

$$\text{COMPRESSIVE STRENGTH NEMA G-10} = 60 \text{ ksi} \leftarrow \text{FS} = 3.8$$

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WELD SHEAR STRESS ROLLER MOUNTING BRACKET  
TO " DOOR "

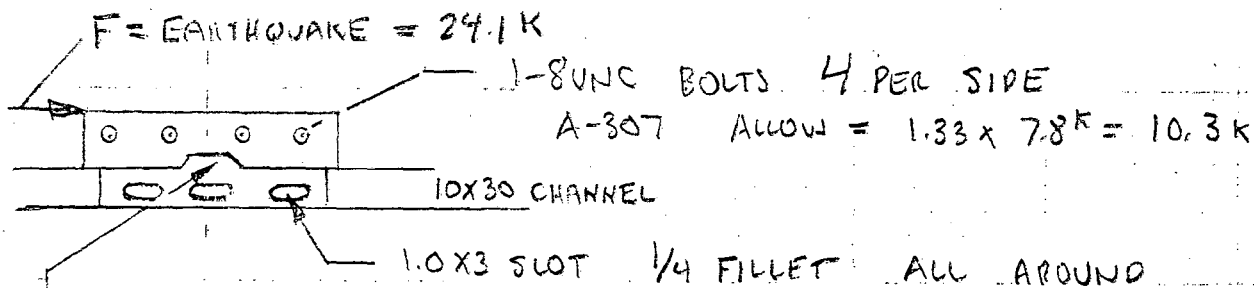
$$\text{SHEAR} = \frac{24.1 \text{ K}}{.5 \text{ IN} \times 3.4 \text{ IN}}$$

$$= \boxed{1.4 \text{ KSI}}$$

ALLOWABLE =

$$= .4 \times F_y = .4 (26 \text{ KSI}) = \boxed{10.4 \text{ KSI}}$$

ROLLER TO CHANNEL SEISMIC STOP - PARALLEL TO CHANNEL  
20C2114 DOOR LOWER SEISMIC ASSY



$$\text{WELD ALLOWABLE} = 2.5 \text{ K/IN} \times 6 \text{ SLOTS} \times 7 \text{ IN/SLOT} = \boxed{105 \text{ K}}$$

BOLT ALLOWABLE

$$8 \text{ BOLTS} \times 10.3 \text{ K/BOLT} = \boxed{83 \text{ K}}$$

SHEAR LIP AREA = 1 IN X 3 IN / SIDE

A36  $F_y = 36 \text{ KSI}$ 

$$\text{ALLOWABLE} = .4 F_y \times A = .4 (36 \text{ KSI}) \times (2)(3 \text{ IN})$$

$$= \boxed{86.4 \text{ K}}$$

$$\text{MAX LOAD} = \boxed{24.1 \text{ K}} \quad \text{O.K.}$$

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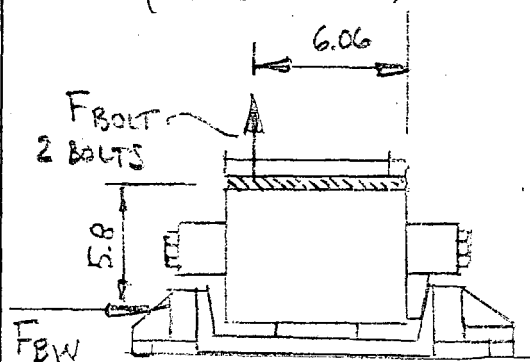
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ROLLER AND CHANNEL SEISMIC STOP - PERPENDICULAR TO CHANNEL

WORST SIDE FORCE  $F_{BW} = 18.8 \text{ K}$   
(LARGE DOOR)



$$F_{BOLT} = \frac{5.8}{6.06} \left( \frac{F_{BW}}{2} \right) = \frac{.96}{2} (F_{BW})$$

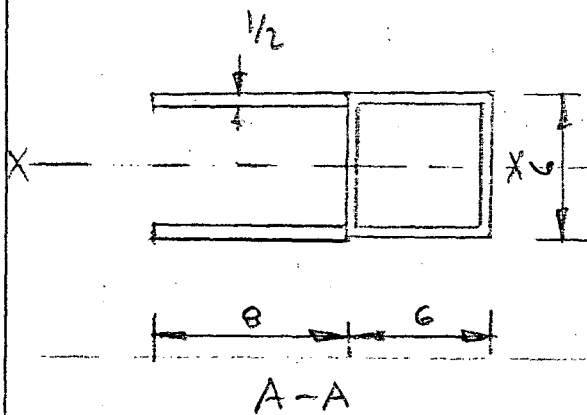
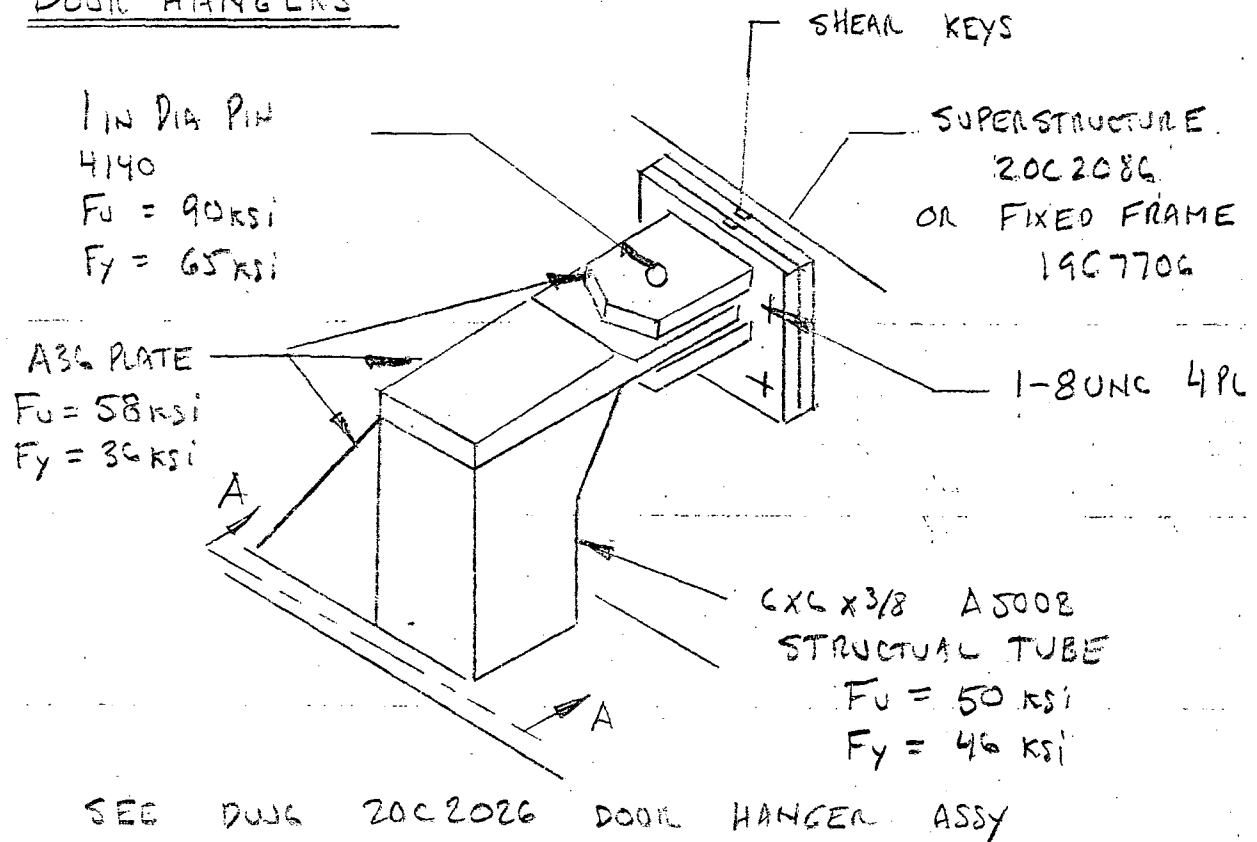
EARTHQUAKE

$$F_{BOLT} = 18.8 \text{ K} (.48)$$

$$= \boxed{9.0 \text{ K}}$$

ALLOWABLE

$$\text{A 307 BOLT} = 1.33 (12.1 \text{ K}) = \boxed{16 \text{ K}}$$

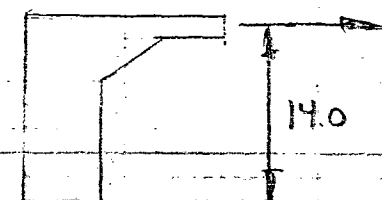
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2/26/81DOOR HANGERS6X6X3/8 TUBE  $I = 40.5$ 

$$\begin{aligned} \text{PLATE } I &= I_0 + Ad^2 \\ &= 2(.083) + 2(.5)(8)(3)^2 \\ &= 72 \end{aligned}$$

$$I_{\text{TOT}} = 40.5 + 72 = 112.5 \text{ IN}^4$$

$$S = \frac{I}{c} = \frac{112.5}{3} = 37.5 \text{ IN}^3$$

CHECK BENDING &amp; SHEAR AT A-A



$$\begin{aligned} F &= \text{EARTHQUAKE} \\ &= 19.2 \text{ K} \end{aligned}$$

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BerkeleyDATE  
2/26/81BENDING

$$\sigma = \frac{M}{S} =$$

$$= \frac{19.2 \text{ k} (14 \text{ in})}{37.5 \text{ in}^3}$$

$$= \boxed{7.2 \text{ ksi}}$$

ALLOWABLE =

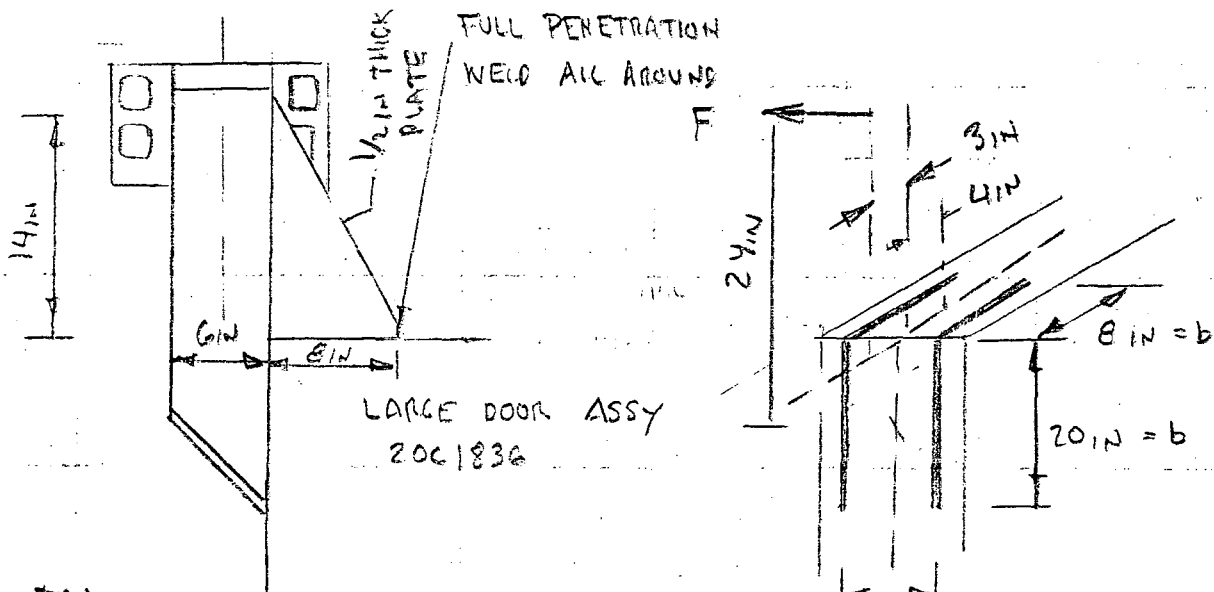
$$= .6 F_y = .6 (36) = \boxed{21.6 \text{ ksi}}$$

O.K.

CHECK WELD STRENGTH.

WELD IS FULL PENETRATION ALL AROUND

FOR LARGE DOOR WEST HANGER

TOP

BENDING

$$S_w = \frac{b d^2}{2} = \frac{8(6)^2}{2} = 144 \text{ in}^2$$

TORSION

$$S_w = \frac{b}{6} (b^2 + 3d^2) = 229 \text{ in}^3$$

SIDE

BENDING

$$S_w = \frac{b d^2}{2} = 5 \text{ in}^2$$

TORSION

$$J_w = 1693 \text{ in}^4$$

$$C = 10.4 \text{ in}$$

SEE BLODGETT "DESIGN  
OF WELDMENTS"



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$$F = F_{TW} = 19.2 \text{ K}$$

TOP

$$M = 14 \text{ IN} \times 19.2 \text{ K} = 269 \text{ K-IN}$$

$$f = \frac{M}{S_w} = \frac{269}{144} = 1.87 \text{ K/IN}$$

$$T = 7 \text{ IN} \times 19.2 \text{ K} = 134 \text{ K-IN}$$

$$f = \frac{T_c}{J_w} = \frac{134(8)}{229} = 2.93 \text{ K/IN}$$

SIDE

$$M = 3 \text{ IN} \times 19.2 \text{ K} = 57.6 \text{ K-IN}$$

$$f = \frac{M}{S_w} = \frac{57.6}{360} = 0.16 \text{ K/IN}$$

$$T = 24 \text{ IN} \times 19.2 \text{ K} = 461 \text{ K-IN}$$

$$f = \frac{461(10.4)}{1693} = 2.83 \text{ K/IN}$$

$$\text{TOTAL WELD LENGTH} = 2(10) + 2(8) = 56 \text{ IN}$$

$$\text{SHEAR} = \frac{19.2 \text{ K}}{56 \text{ IN}} = 0.34 \text{ K/IN}$$

TOP

$$= (2.93 + 0.34) = 3.27 \text{ K/IN}$$

$$f = \sqrt{3.27^2 + 1.87^2} = 3.77 \text{ K/IN}$$

ALLOWABLE

FOR 1/2 WELD

5.0 K/IN

O.K.

SO TOP WELD ALONE IS O.K.

AND ALL OTHER HANGERS ARE O.K. SINCE THEY HAVE MORE WELD LENGTH.

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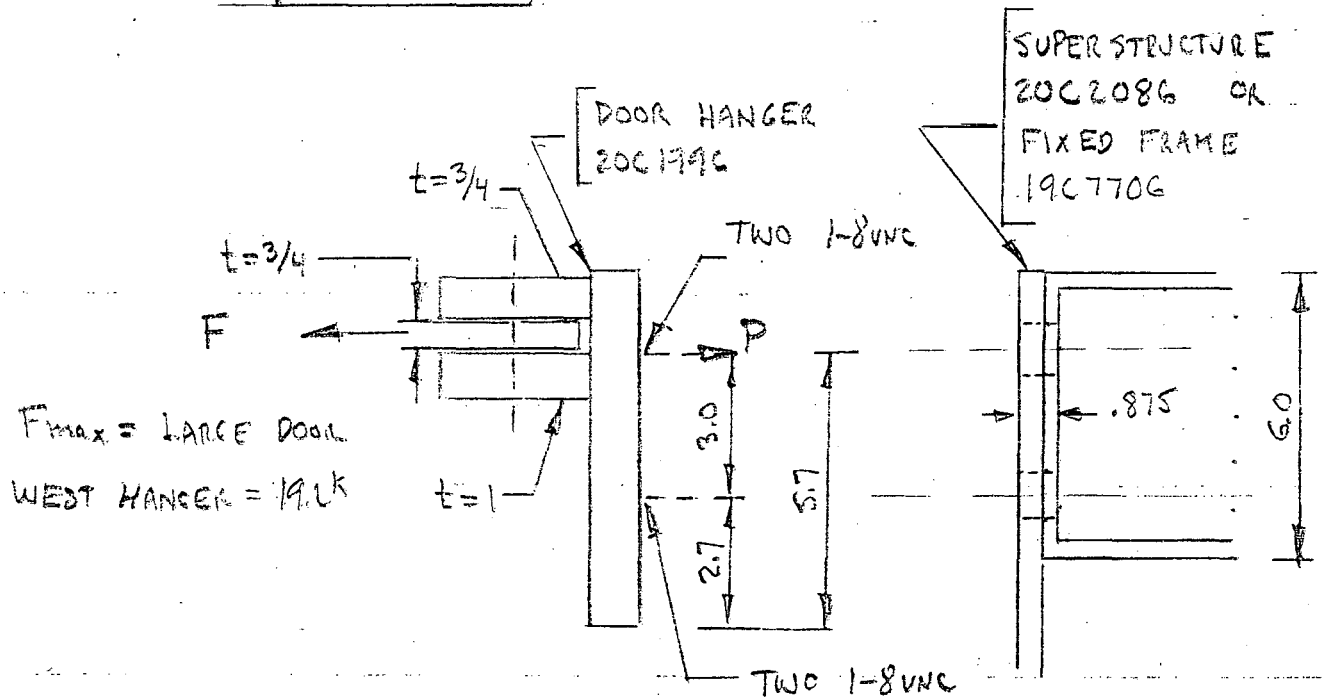
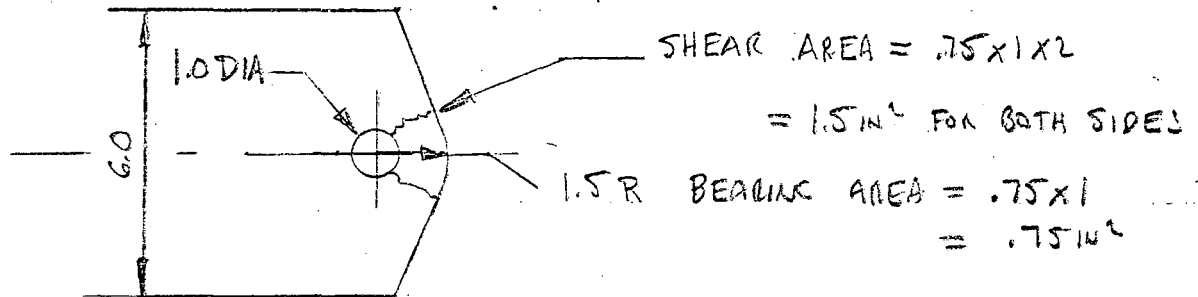
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CHECK ATTACHMENT TO FIXED FRAME ; SUPERSTRUCTURECHECK PIN - IN DOUBLE SHEAR  $A = \frac{\pi}{4} (1)^2 = .785 \text{ IN}^2$ 

$$\tau = \frac{F}{A} =$$

$$= \frac{19.2 \text{ K}}{2(.785)} = \boxed{12.3 \text{ ksi}}$$

ULT SHEAR =

$$.65 F_u = .65 \times 90 = \boxed{58.5 \text{ ksi}}$$

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P. Purgalis

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LOCATION  
BerkeleyDATE  
2/26/81CHECK TEAROUT

$$\tau = \frac{F}{A}$$

$$= \frac{19.2 \text{ K}}{1.5 \text{ IN}^2} = \boxed{12.8 \text{ KSI}}$$

$$\text{ULT SHEAR} = .65(F_u)$$

$$.65(58 \text{ KSI}) = \boxed{37.7 \text{ KSI}}$$

↑ FS = 2.9

CHECK BEARING STRESS

$$\sigma_{BR} = \frac{F}{A}$$

$$= \frac{19.2 \text{ K}}{.75 \text{ IN}^2} = \boxed{25.6 \text{ KSI}}$$

$$\text{ALLOWABLE} =$$

$$.9 F_y = .9(36) = \boxed{32.4 \text{ KSI}}$$

↑ O.K.

CHECK BOLT STRESS

$$P = F \left( \frac{6.2}{5.7} \right) = F(1.1)$$

$$= 19.2(1.1) = 21.1$$

$$\tau = \frac{P}{A} = \frac{21.1 \text{ K}}{2(.605 \text{ IN}^2)} = \boxed{17.4 \text{ KSI}}$$

PROOF STRESS

$$\text{A307 BOLT} = \boxed{33 \text{ KSI}}$$

↑ FS = 1.9

THREAD ENGAGEMENTFROM MACHINERY'S HANDBOOK 20<sup>TH</sup> ED PAGE 1168)SHEAR AREA INTERNAL THREADS FOR 1-8 UNC = 2.34 IN<sup>2</sup>/IN

$$A = 2.34 \text{ IN}^2/\text{IN} \times .875 \text{ IN} = 2.05 \text{ IN}^2$$

$$\text{ULT STRENGTH} = .75(58 \text{ KSI}) \times 2.05 \text{ IN}^2 = \boxed{77.3 \text{ K/BOLT}}$$

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