Title
MUON SHIELDING: DOOR HARDWARE STRUCTURAL CALCULATIONS

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ENGINEERING NOTE

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PROGRAM – PROJECT – JOB
PEP-4

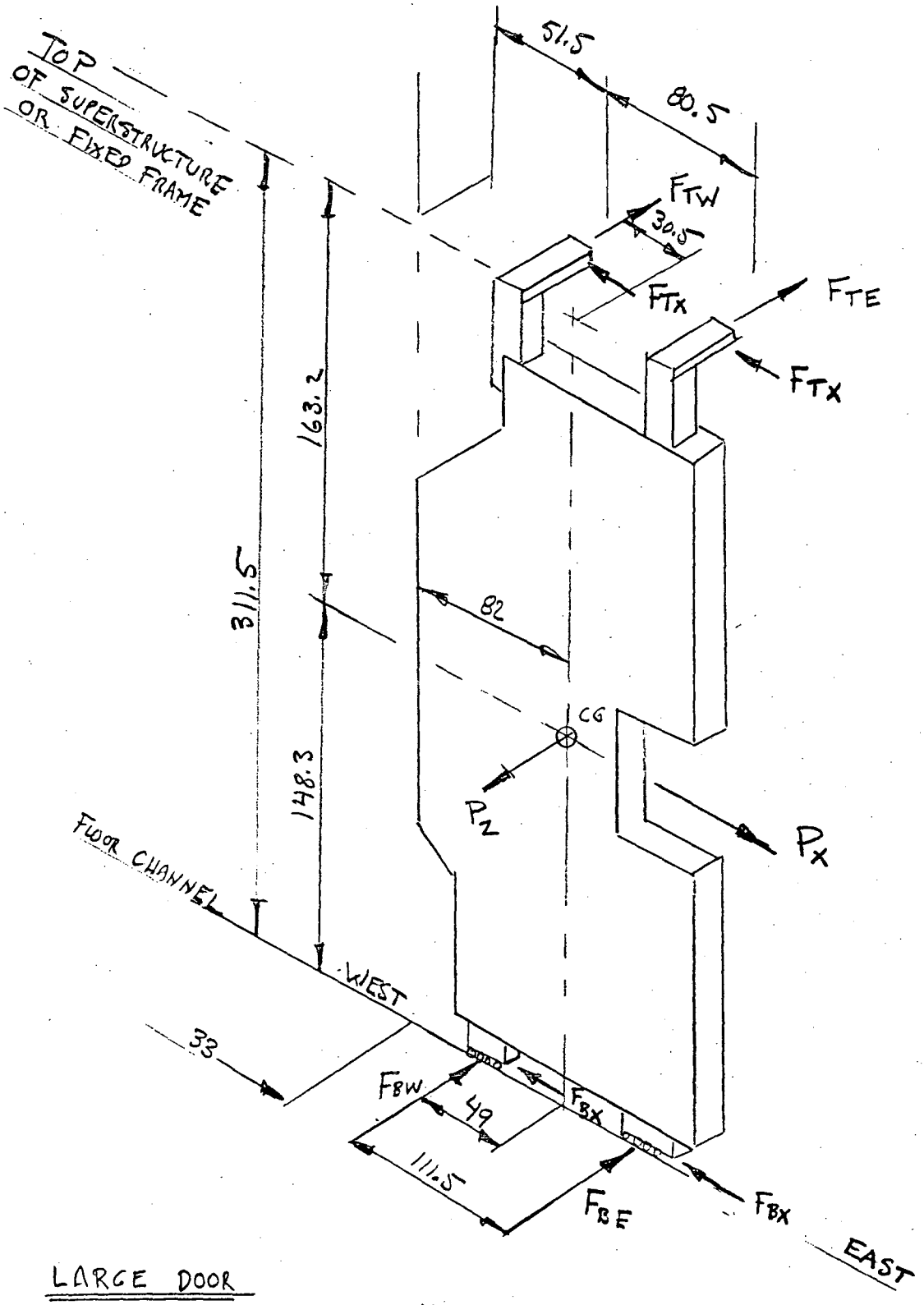
MUON SHIELDING

P.Purcalis
2-26-81

TITLE
DOOR HARDWARE STRUCTURAL CALCULATIONS

THE "DOORS" ARE RESTRAINED AT THE BOTTOM BY THE FLOOR CHANNELS & SEISMIC STOPS AND AT THE TOP BY THE DOOR HANGERS WHICH ATTACH TO THE FIXED FRAME OR SUPERSTRUCTURE

CALCULATIONS SHOW THAT, FOR A .7g EARTHQUAKE, THE STRESSES IN THE ATTACHMENT HARDWARE ARE WITHIN THE ALLOWABLE VALUES SPECIFIED BY AISC.



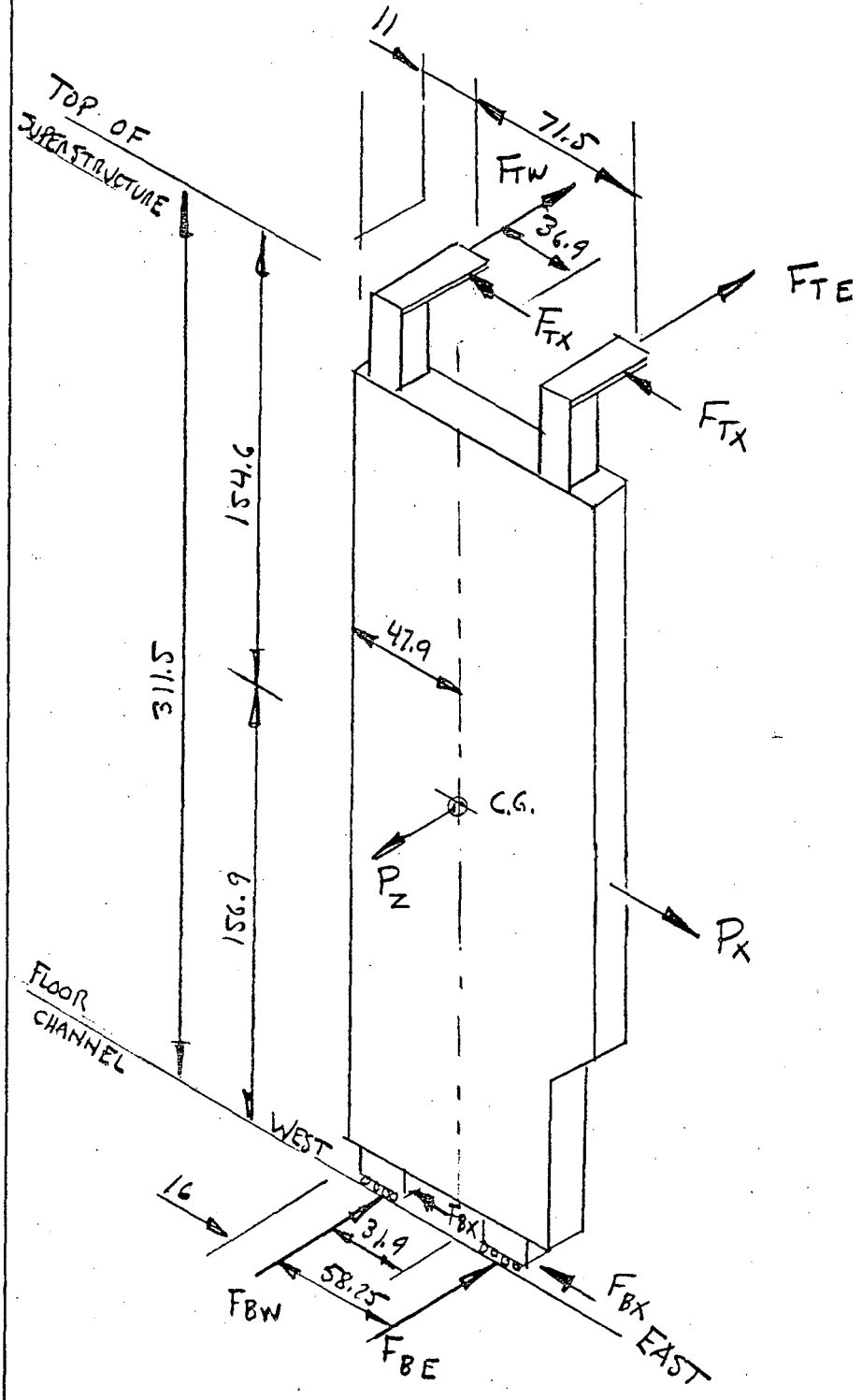
LARGE DOOR

DOOR WEIGHT = 78.5 K

MUON CHAMBERS = 11.1 K @ 10 LB/FT^2

HARDWARE 2.0 K

91.6 ≈ **92 K = W**



SMALL DOOR

DOOR WEIGHT = 54.5^K

MUON CHAMBERS = 7.0^K @ 10 lb/ft^2

HARDWARE = 2.0^K

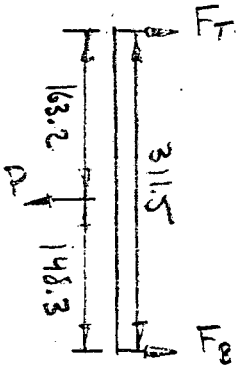
63.5 ≈ **64^K = W**

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

P_z = EARTHQUAKE

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

FORCES AT TOP F_T AND BOTTOM F_B OF DOOR

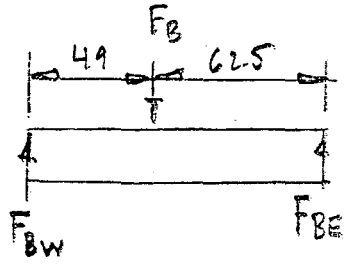


EARTHQUAKE

$F_T = \frac{148.3}{311.5} P = .48P$ $\quad .48(64.4) = \boxed{31^K}$

$F_B = .52P$ $\quad \boxed{33.5^K}$

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

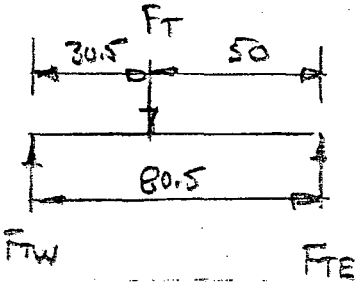


EARTHQUAKE

$F_{BW} = \frac{62.5}{111.5} F_B = .56 F_B$ $\quad .56(33.5^K) = \boxed{18.8^K}$

$F_{BE} = .44 F_B$ $\quad .44(33.5) = \boxed{14.7^K}$

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



EARTHQUAKE

$F_{TW} = \frac{50}{80.5} F_T = .62 F_T$ $\quad .62(31) = \boxed{19.2^K}$

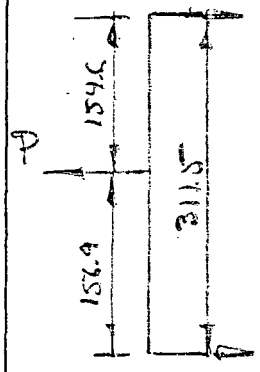
$F_{TE} = .38 F_T$ $\quad .38(31) = \boxed{11.8^K}$

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

P_z = EARTHQUAKE

$= .7(64^K) = 45^K$

FORCES AT TOP F_T AND BOTTOM F_B OF DOOR



$F_T = \frac{156.9(P)}{311.5} = .50P$

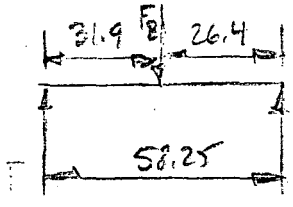
$F_B = .50P$

EARTHQUAKE

$.5(45) = \boxed{22.5^K}$

$\boxed{22.5^K}$

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



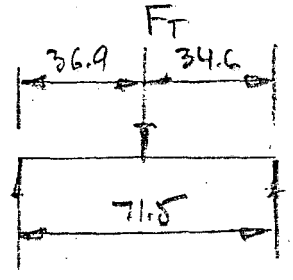
EARTHQUAKE

$F_{BW} = \frac{26.4\,F_B}{58.25}$

$F_{BW} = .45\,F_B$ $\quad .45(22.5) = \boxed{10.1^K}$

$F_{BE} = .55\,F_B$ $\quad .55(22.5) = \boxed{12.4^K}$

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



EARTHQUAKE

$F_{TW} = \frac{34.6\,F_T}{71.5}$

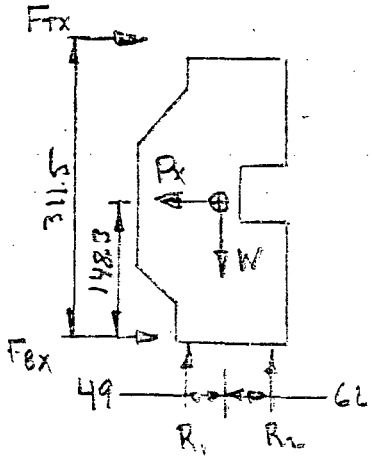
$F_{TW} = .48\,F_T$ $\quad .48(22.5) = \boxed{10.8^K}$

$F_{TE} = .52\,F_T$ $\quad .52(22.5) = \boxed{11.7^K}$

FORCES IN X DIRECTION (PERPENDICULAR TO BEAM)

LARGE DOOR

P_x = EARTHQUAKE = $.7(92^k) = 64.4^k$



FIND FORCE AT TOP F_{TX} FOR $R_2 = 0$ (TO KEEP DOOR FROM LIFTING R_2)

(+ ΣM AROUND R_1

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

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

ΣF_x $\quad F_{TX} + F_{BX} = P_x$

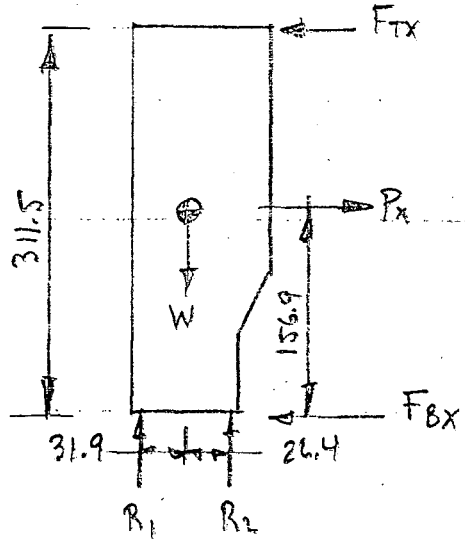
$$F_{BX} = P_x - F_{TX} = 64.4 - 16.2 = 48.2^k$$

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

$R_1 = W = \boxed{92^k}$ ← 0.K → ROLLER HAS 50% CAPACITY

SMALL DOOR

P_x = EARTHQUAKE = $.7(64^k) = 45^k$



FIND F_{TX} SO $R_1 = 0$

(+ ΣM AROUND R_2

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

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

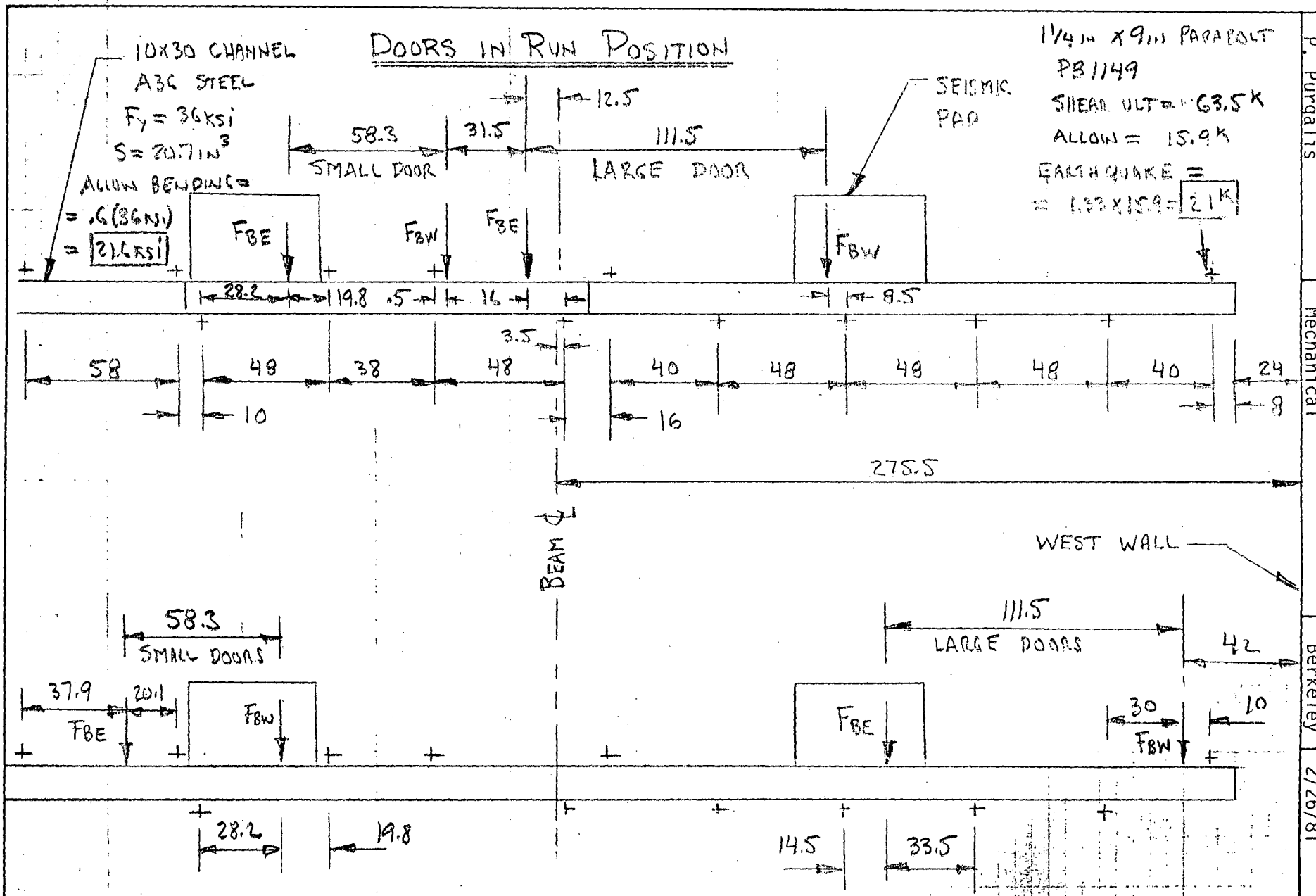
$$= 17.2^k$$

ΣF_x

$$F_{BX} = P_x - F_{TX} = 45 - 17.2 = 27.8^k$$

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

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



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SEE PREVIOUS PAGE FOR 19C5986 CHANNEL LAYOUT

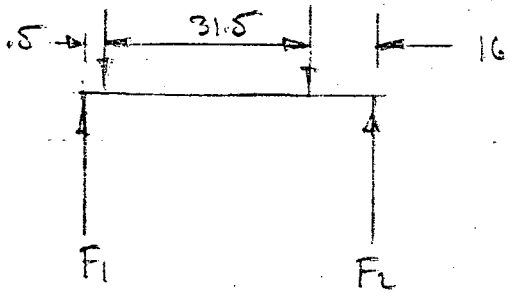
CHECK CHANNEL ATTACHMENT TO FLOOR

CHECK WORST CASE

DOORS CLOSED

SMALL DOOR WEST ROLLER AND LARGE DOOR EAST ROLLER

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



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

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

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

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

0.K

0.K

ALLOWABLE = $\boxed{21\ K}$
FROM PREVIOUS PAGE

CHECK CHANNEL BENDING

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

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

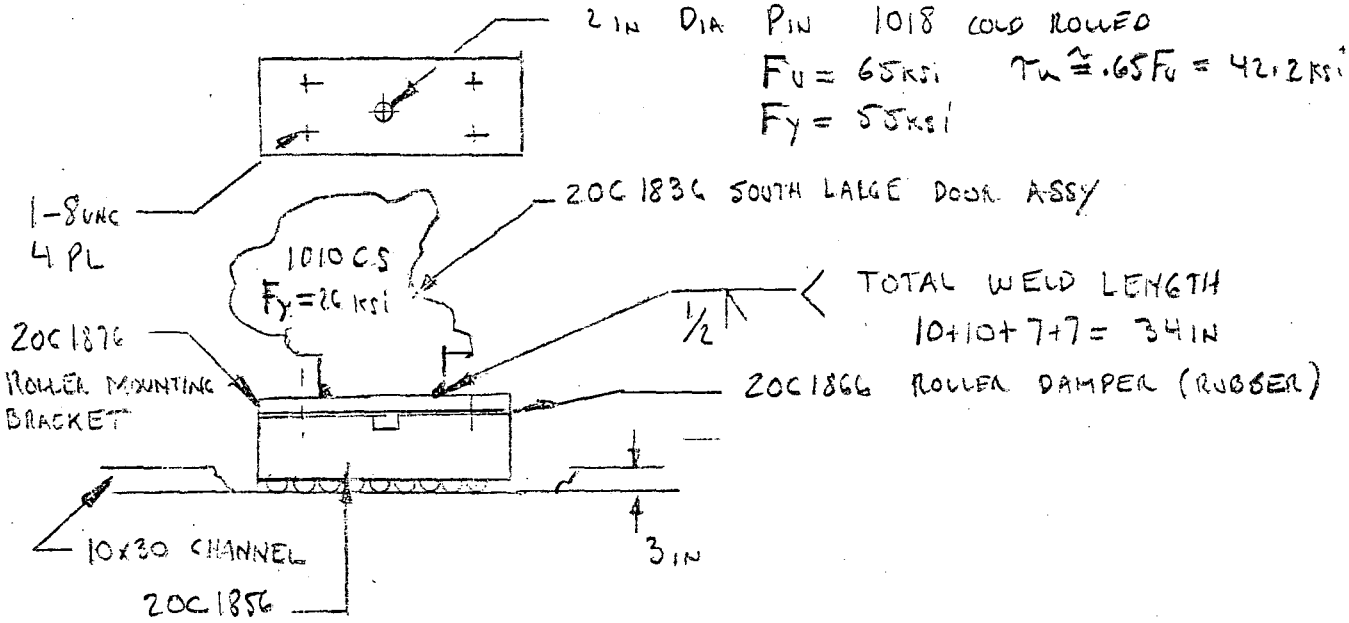
$$\sigma = \frac{M}{S} = \frac{161\ K\text{-}IN}{20.7} = \boxed{7.8\ KSI}$$

ALLOWABLE = $\boxed{21.6\ KSI}$
FROM PREVIOUS PAGE

0.K

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 IN^2

$$\text{SHEAR} = \frac{24.1\ K}{3.14\ IN^2} = 7.6\ KSI$$

FS = 5.6

τ_u = 42.2 KSI

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

$$\text{BEARING} = \frac{24.1\ K}{2\ IN \times .75\ IN} = 16\ KSI$$

FS = 3.8

COMPRESSIVE STRENGTH NEMA G-10 = 60 KSI

WELD SHEAR STRESS ROLLER MOUNTING BRACKET TO "DOOR"

$$\text{SHEAR} = \frac{24.1^{K}}{.5\text{IN} \times 34\text{IN}}$$

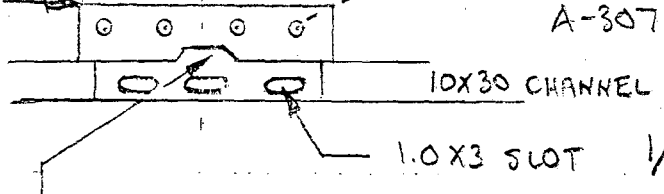
$$= \boxed{1.4\ \text{KSI}}$$

ALLOWABLE = .

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

ROLLER TO CHANNEL SEISMIC STOP — PARALLEL TO CHANNEL

20C2114 DOOR LOWER SEISMIC ASSY



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

BOLT ALLOWABLE

8 BOLTS x 10.3 K/BOLT = $\boxed{83^{K}}$

SHEAR LIP AREA = 1IN x 3IN /SIDE

A36 $F_y = 36\text{KSI}$

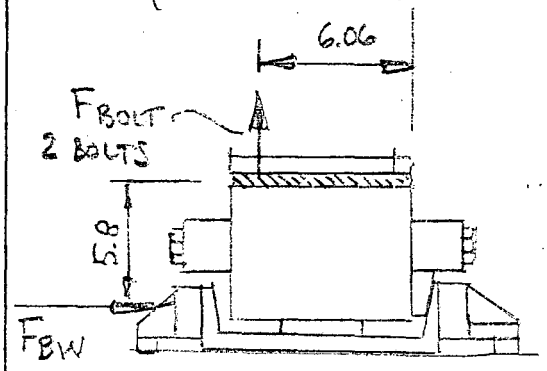
ALLOWABLE = $.4\ F_y \times A = .4(36\text{KSI}) \times (2)(3\text{IN}^2)$

$= \boxed{86.4\ K}$

MAX LOAD = $\boxed{24.1\ K}$ — O.K.

ROLLER AND CHANNEL SEISMIC STOP - PERPENDICULAR TO CHANNEL

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



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

EARTHQUAKE

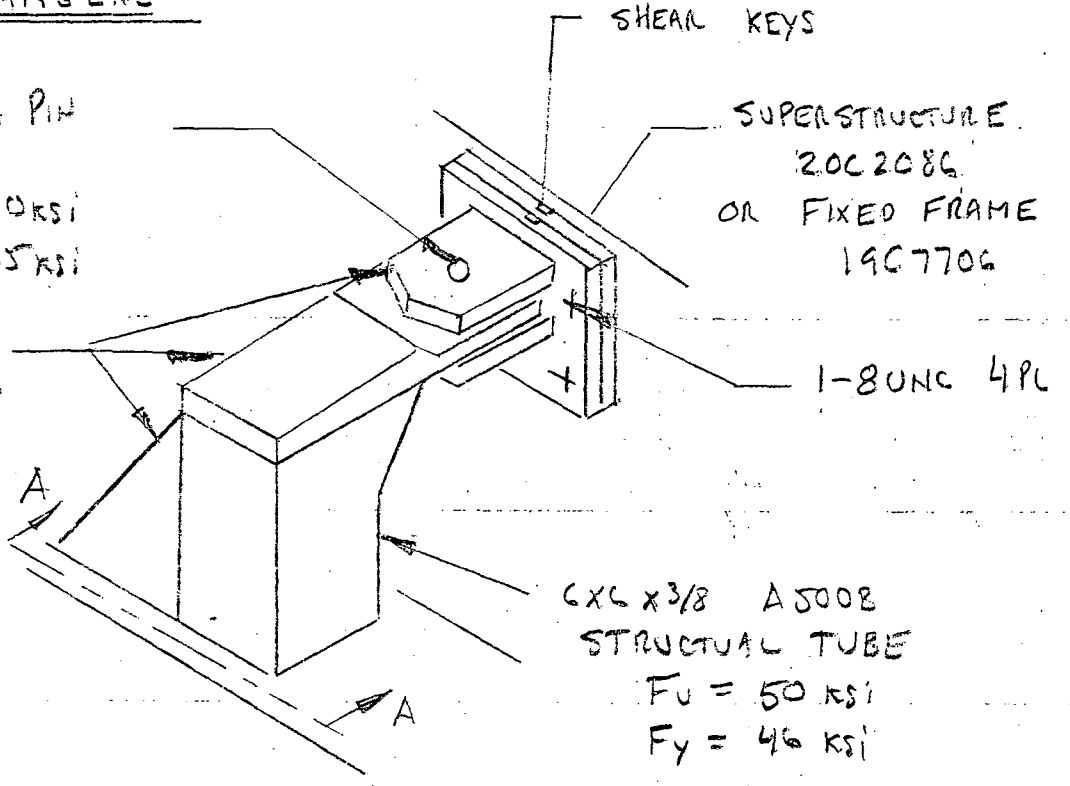
$F_{BOLT} = 18.8^K(.48)$

$= \boxed{9.0^K}$

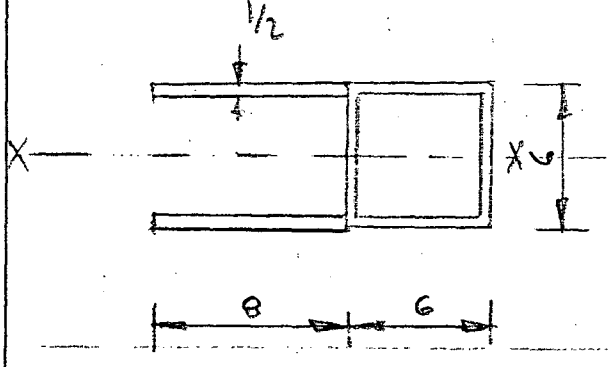
ALLOWABLE

A307 BOLT $= 1.33\ (12.1^K) = \boxed{16^K}$

DOOR HANGERS



SEE DWG 20C2026 DOOR HANGER ASSY



6X6X3/8 TUBE $I = 40.5$

PLATE $I = I_o + Ad^2$

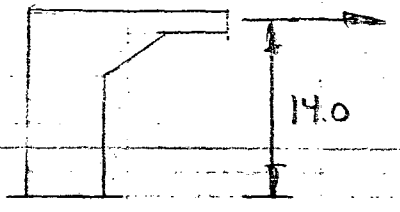
$= 2(.083) + 2(.5)(8)(3)^2$

$= 72$

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

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

CHECK BENDING & SHEAR AT A-A



F = EARTHQUAKE

$= 19.2^K$

BENDING

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

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

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

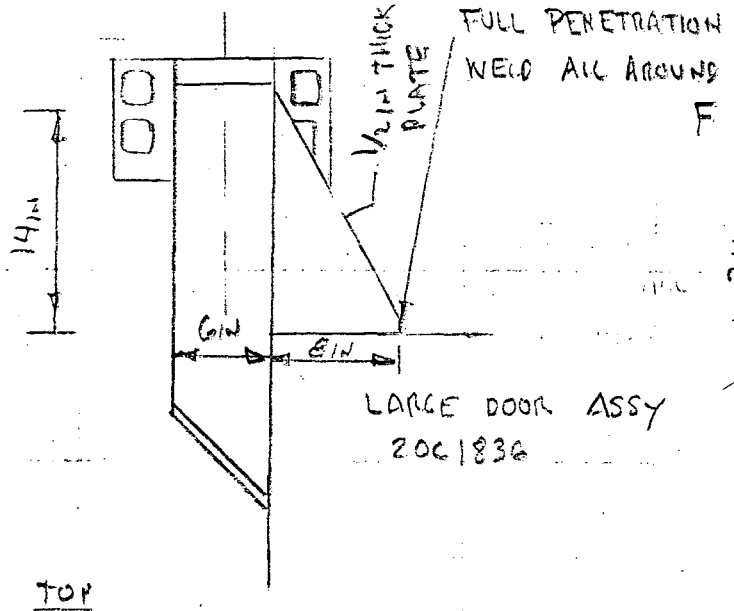
O.K

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

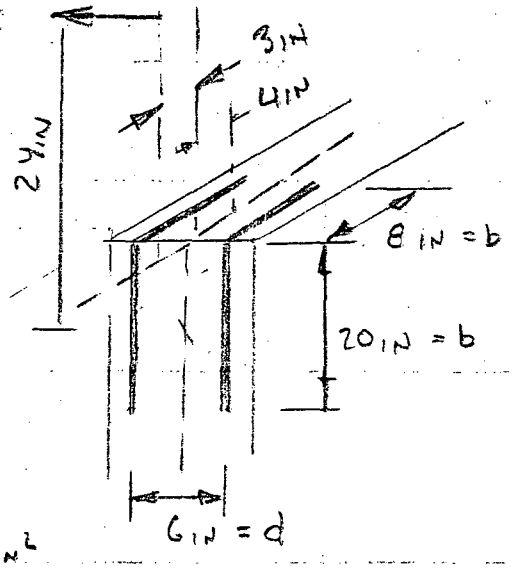
CHECK WELD STRENGTH

WELD IS FULL PENETRATION ALL AROUND

FOR LARGE DOOR WEST HANGER



LARGE DOOR ASSY
20C1836



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

TORSION $J_w = \frac{b}{6}(b^2+3d^2) = 229\,in^3$

SEE BLODGETT "DESIGN OF WELDMENTS"

SIDE BENDING $c = \frac{b+4d^2}{2} = 5\,in$

$S_w = 360\,in^2$

TORSION $J_w = 1693\,in^3$

$c = 10.4\,in$

$F = F_{TW} = 19.2^K$

TOP

$M = 14_{IN} \times 19.2^K = 269\ K\text{-}IN$ $\quad f = \frac{M}{S_W} = \frac{269}{144} = 1.87\ K/IN$

$T = 7_{IN} \times 19.2^K = 134\ K\text{-}IN$ $\quad f = \frac{Tc}{J_W} = \frac{134(5)}{229} = 2.93\ K/IN$

SIDE

$M = 3_{IN} \times 19.2^K = 57.6\ K\text{-}IN$ $\quad f = \frac{M}{S_W} = \frac{57.6}{360} = .16\ K/IN$

$T = 24_{IN} \times 19.2^K = 461\ K\text{-}IN$ $\quad f = \frac{461(10.4)}{1693} = 2.83\ K/IN$

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

SHEAR = $\frac{19.2^K}{56.4} = .34\ K/IN$

TOP

$= (2.93 + .34) = 3.27\ K/IN$

1.87 K/IN

$f_r = \sqrt{3.27^2 + 1.87^2}$

$= 3.77\ K/IN$

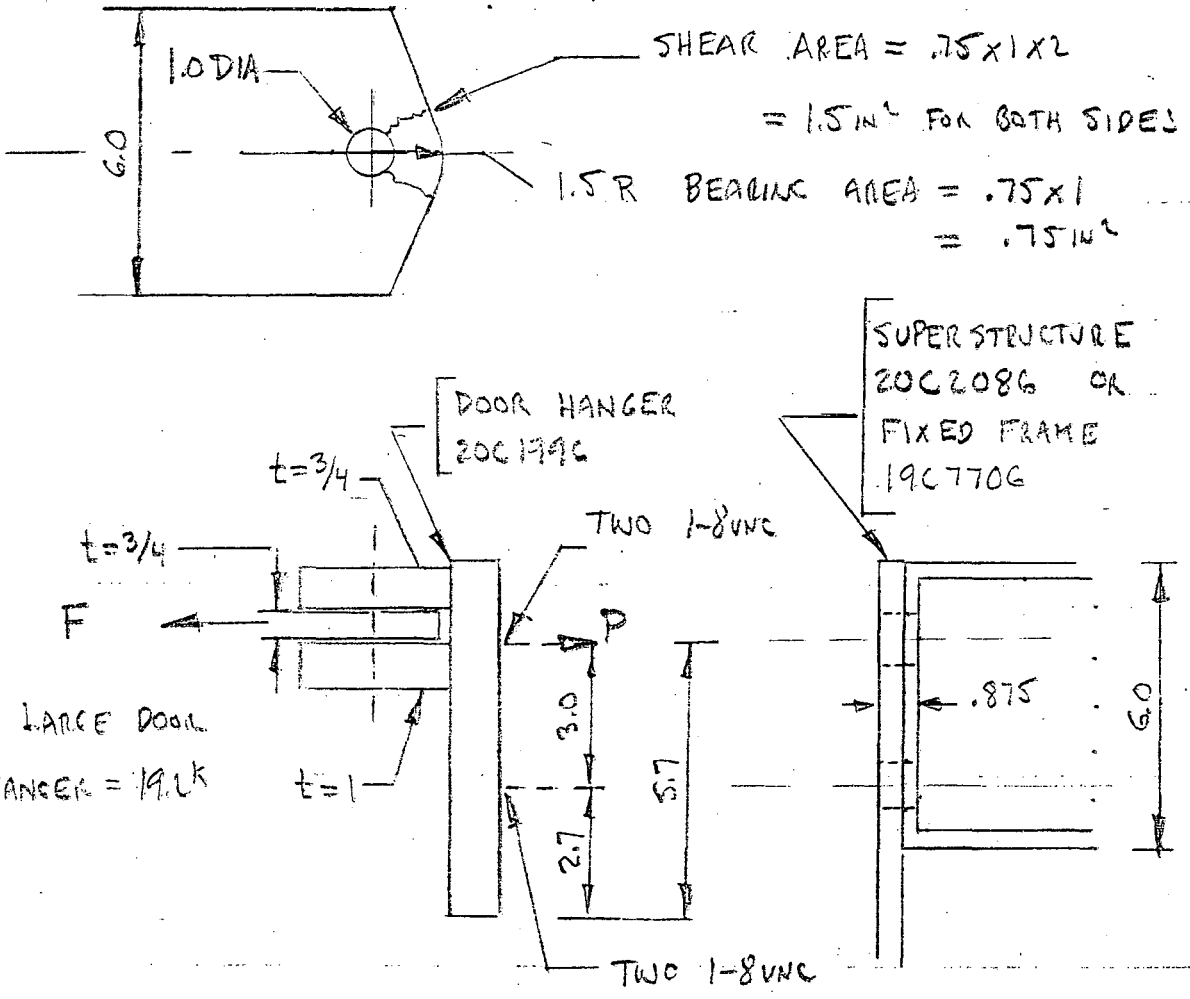
O.K

ALLOWABLE 1/2 FOR 1/2 WELD 5.0 K/IN

SO TOP WELD ALONE IS O.K

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

CHECK ATTACHMENT TO FIXED FRAME ; SUPERSTRUCTURE



CHECK PIN - IN DOUBLE SHEAR $A = \frac{\pi}{4}(1)^2 = .785\ IN^2$

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

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

F.S = 4.8

ULT SHEAR =

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

CHECK TEAROUT

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

$$= \frac{19.2\,K}{1.5\,in^2} = \boxed{12.8\ ksi}$$

FS = 2.9

ULT SHEAR = .65 (Fu)

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

CHECK BEARING STRESS

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

$$= \frac{19.2^K}{.75\,in^2} = \boxed{25.6\ ksi}$$

0.1K

ALLOWABLE =

$= .9\,F_y = .9(36) = \boxed{32.4\ ksi}$

CHECK BOLT STRESS

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

$$= 19.2(1.1) = 21.1$$

$$\sigma = \frac{P}{A} = \frac{21.1K}{2(1.605\,in^2)} = \boxed{17.4\ ksi}$$

FS = 1.9

PROOF STRESS

A307 BOLT = 33 ksi

THREAD ENGAGEMENT

FROM MACHINERY'S HANDBOOK 20TH ED PAGE 1168)

SHEAR AREA INTERNAL THREADS FOR 1-8UNC = $2.34\ in^2/in$

$A = 2.34\,in^2/in \times .875\,in = 2.05\,in^2$

ULT STRENGTH = $.65(58\ ksi) \times 2.05\,in^2 = \boxed{77.3\,K/BOLT}$

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