Fermilab

Particle Physics Division

12-01-01

Mechanical Department Engineering Note

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Project: MuCool

Project Internal Reference:

Title: MuCool Transfer Line and Bayonet Box

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Reviewer(s):

Key Words: MuCool, Transfer Line, Bayonet Box, Bayonet Box Support Structure

Abstract/Summary:

This report contains calculations for:

A) The maximum length between vertical supports for a He/Ln_2 Transfer Line.
B) Design of the Bayonet Can
C) Cool down calculations for contraction of the one inch tubing within the Bayonet Box
D) Cool down calculations for contraction of the one inch tubing within the Transfer Line
E) Heat transfer calculations for the Bayonet Box Shield

PART A

MAXIMUM LENGTH BETWEEN VERTICAL SUPPORTS FOR THE He / LN_2 TRANSFER LINE

F) Design of a structure to support the Bayonet Box

Applicable Codes:

1. *AISC Manual of Steel Construction*, Allowable Stress Design, Ninth Edition
2. *ASME BOILER AND PRESSURE VESSEL CODE,* Section VIII, Division 1
3. *ANSI/ASCE Minimum Design Loads for Buildings and Other Structures 7-88* Approved November 27, 1990
4. *BROOKHAVEN NATIONAL LABORATORY SELECTED CRYOGENIC DATA NOTEBOOK* Volume 1, Sections I-IX, Revised August 1980
5. *Flexible Metal Hose and Fittings,* Senior Flexonics Inc., February 1993
6. *Hilti North American Product Technical Guide 2001 edition.*

MuCOOL TRANSFER LINE

R.J. WOODS
OCT. 28 2004

ASME CODE B31.9 WORKING PRESSURE FOR NON-FLAMMABLE LIQUIDS = 350 PSIG (2300 KPA)

TRANSFER LINE WT. :

1" OD LINES: 4 @ 0.50 #/F = 2.0 #/F
3½" SCH 10: = 4.97 #/FT
4" SCH 10: = 5.61 #/FT
6" SCH 5: = 7.59 #/FT
20.17 #/FT

HELIUM WT = 7.8 #/FT³

AREA OF HELIUM IN 1" OD PIPE:

1.0 - (2(0.049)) = 0.902 IN

AREA = $\pi d^2/4$ = 3.1415 (0.902)²/4 = 0.639 IN²

= 0.0044 FT²

WT OF HELIUM = 0.0044(7.8)

= 0.04 #/FT

NITROGEN WT = 50.5 #/FT³

AREA OF NITROGEN = $\frac{\pi(4.260)^2}{4} - \frac{\pi(4.000)^2}{4}$

= 14.253 - 12.566

= 1.687 IN²

= 0.012 FT²

WT OF NITROGEN = 50.5 (0.012)

= 0.59 #/FT

TOTAL WEIGHT PER FOOT = 20.17 + 0.04 + 0.59

= 20.80 #/F

SAY 21 #/FT

OR 1.75 #/IN

6" SCH 5 PIPE CARRIES TOTAL WEIGHT

I = 11.85 IN⁴ S = 3.576 IN³

FOR MIN. 2 SPAN CONDITION, $M_{MAX} = -\frac{1}{8} w l^2$ FOR UNIFORM LOAD ON BOTH SPANS

FROM TABLE 1-A 1995 SECTION II @ PAGE 104:
ALLOW. STRESS = 18.8 KSI FOR -20° TO 100° F

BENDING: $f_b = M/S$

$M = S(f_b)$
$= 3.576(18,800)$
$= 67229$ #-IN

$67,229 = -w\ell^2/8$
$= -1.75(\ell^2)/8$
$\ell^2 = 307,332$ IN^2
$\ell = 554''$ = MAX. SPACING OF SUPPORTS DUE TO BENDING

SHEAR:

$R_{MAX} = 1.25 w \ell$
$= 1.25(1.75)(554)$
$= 1,212$#

SHEAR $= 1212/A_{PIPE}$
$= 1212/2.231$
$= 543$ psi < 18800 psi ok

DEFLECTION:

$\Delta_{MAX} = 0.00541 \frac{w\ell^4}{EI}$
$= 0.00541\left(\frac{1.75(554)^4}{29,000,000(11.85)}\right)$
$= 2.6''$ TOO LARGE N.G.

MAX SPAN FOR 0.5" Δ

$0.5 = 0.00541\left(\frac{1.75(\ell)^4}{29,000,000(11.85)}\right)$

$\ell = 367'' = 30'-6''$

MUCOOL TRANSFER LINE — TRANSFER LINE BUCKLING — R. J. HOOPS, OCT. 8, 2008

1

1" STAINLESS LINE:

PROPERTIES:

O.D. = 1" WALL THICKNESS = 0.049" WT = 0.50 #/FT

I.D. = 0.902"

$$I = \pi(d_o^4 - d_i^4)/64 = \frac{\pi(1^4 - 0.902^4)}{64}$$

$$= 0.0166 \text{ IN}^4$$

$$Z = \frac{\pi(d_o^4 - d_i^4)}{32 d_o} = \frac{\pi(1^4 - 0.902^4)}{32(1.0)}$$

$$= 0.0332 \text{ IN}^3$$

$$A = \frac{\pi(d_o^2 - d_i^2)}{4} = \frac{\pi(1^2 - 0.902^2)}{4}$$

$$= 0.1464 \text{ IN}^2$$

$$r = \sqrt{I/A} = \sqrt{\frac{0.0166}{0.1464}}$$

$$= 0.3367$$

$$E = 29{,}000{,}000 \text{ PSI}$$

$$l = 5.0'(12) = 60''$$

(LENGTH BETWEEN SPACERS)

CRITICAL SLENDERNESS RATIO:

$$S_{CR} = \sqrt{\frac{2\pi^2 E}{\sigma_y}} = \sqrt{\frac{2(\pi)^2(29\,000\,000)}{35{,}000}}$$

$$= 128$$

$$S_{ACT} = l/r = 60/0.3367$$

$$= 178 > 128 \therefore \text{EULER EQUATION APPLIES}$$

$$P_{CR} = \pi^2 EI/L^2 = \frac{\pi^2(29000000)(0.0166)}{(60)^2}$$

$$= 1320^{\#}$$

3½" + 4" LINE

	3½"	4"
OD	4.00	4.50
I.D.	3.76	4.26

$$I = \frac{\pi(4^4 - 3.76^4)}{64} \qquad \frac{\pi(4.5^4 - 4.26^4)}{64}$$

$$= 2.76 \text{ IN}^4 \qquad = 3.96 \text{ IN}^4$$

$$Z = \frac{\pi(4^4 - 3.76^4)}{32(4.0)} \qquad = \frac{\pi(4.5^4 - 4.26^4)}{32(4.5)}$$

$$= 1.38 \text{ IN}^3 \qquad = 1.76 \text{ IN}^3$$

$$A = \frac{\pi(4^2 - 3.76^2)}{4} \qquad = \frac{\pi(4.5^2 - 4.26^2)}{4}$$

$$= 1.46 \text{ IN}^2 \qquad = 1.65 \text{ IN}^2$$

$$r = \sqrt{\frac{2.76}{1.46}} = 1.38$$

$$P_{CR} = \frac{\pi^2(29{,}000{,}000)(2.76)}{((40(12))^2} = 3429^{\#}$$

$$r = \sqrt{\frac{3.96}{1.65}} = 1.55$$

$$= \frac{\pi^2(29{,}000{,}000)(3.96)}{((40(12))^2} = 4913^{\#}$$

FOR 1" LINE:

$$\Delta L = (304 \times 10^{-5})L$$
$$= 304 \times 10^{-5}(40 \times 12)$$
$$= 1.46''$$

PART D

COOL DOWN CALCULATIONS FOR CONTRACTION OF THE ONE INCH TUBING WITHIN THE TRANSFER LINE

THERMAL CONTRACTION:
FOR 5K LINE:

$T_{ROOM} = 68^\circ F = 293^\circ K$

FROM "BUBBLE CHAMBER GROUP SELECTED CRYOGENIC DATA" HANDBOOK:
TABLE IX-W-1.2 FOR 304 STAINLESS

$$\frac{L_{293} - L_T}{L_{293}} = 300 \times 10^{-5}$$

$$\frac{30' - L_T}{30'} = 300 \times 10^{-5}$$

$$L_T = 29.91'$$

$$L_{293} - L_T = 30.0 - 29.91$$
$$= 0.09'$$
$$= \underline{\underline{1.08''}}$$

FROM SENIOR FLEXONICS INC. "FLEXIBLE METAL HOSE AND FITTINGS" p. 17, FOR 1" I.D. HOSE AND "Y" OFFSET = 1¼" O.A. LENGTH = FROM 10¾" TO 8¾".

<u>USE 18" LONG FLEX HOSE</u>

PART E

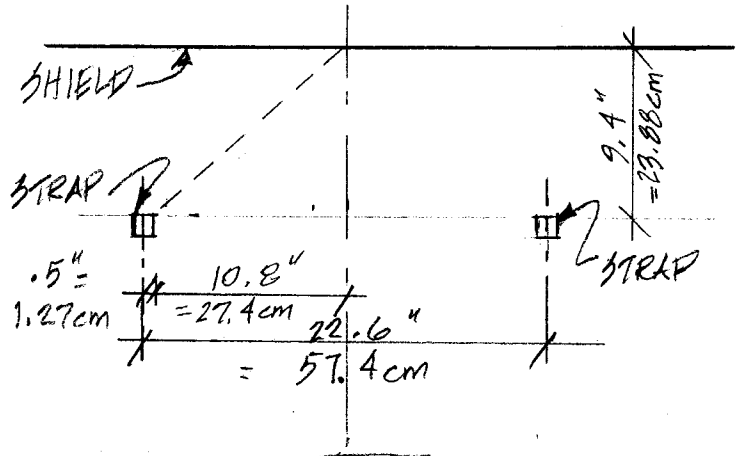
HEAT TRANSFER CALCULATIONS FOR BAYONET BOX SHIELD

CHECK TEMPERATURE DIFFERENCE BETWEEN COOLING TUBE & SHIELD

COPPER SHIELD = 1/8" O.F.H.C. COPPER
FROM BROOKHAVEN DATA BOOK, CONDUCTIVITY @ 80°K = 4.9 W/cm °K

C TO C SPACING OF STRAP = 22.6" = 57.4 cm
DISTANCE FROM TOP/STRAP TO T/SHIELD = 9.4" = 23.88 cm
STRAP WIDTH = 2.5 CM

STRAP LENGTH = $\sqrt{3.3^2 + 1.5^2}$ = 3.625" = 9.21 CM



FIN LENGTH = $\sqrt{27.4^2 + 9.4^2}$ = 28.97 cm
FIN THICKNESS = 1/8" = 0.3175 cm

$$T_0 - T_L = \frac{C \times L^2}{2 \times k \times t_h}$$

WHERE T_0 = TEMP @ COOLING TUBE
T_L = TEMP @ LENGTH L

C = UNIFORM HEAT LOAD
= 3.3 W/m² = 0.00023 W/cm²

L = FIN LENGTH
k = THERMAL CONDUCTIVITY OF FIN
t_h = FIN THICKNESS

LN2 = 80°K = T_0

$$80^\circ - T_L = \frac{0.00023(28.97)^2}{2(4.9)(.3175)}$$

$80^\circ - T_L = 0.062$
$T_L = 79.94^\circ K$

HEAT GAIN @ TUBE THROUGH STRAP.

AREA PER STRAP FROM SKETCH ABOVE:
WIDTH = 22.6" = 57.4 cm
HEIGHT = 24.75" = 62.87 cm

A = 57.4(62.87) = 3609 cm²

$$T_0 - T_L = \frac{0.00023(3609)}{2(4.9)(0.3175)} = 0.270^\circ K \quad < 5^\circ K \text{ ok}$$

CHECK STRAP @ SMALL END OF BAYONET BOX

END DIMENSIONS

WIDTH = 21.75" = 55.25 cm

HEIGHT = 24.75" = 62.87 cm

$$A = 55.25(62.87) = 3474 \text{ cm}^2$$

$$T_0 - T_L = \frac{0.00023(3474)}{2(4.9)(0.3175)} = 0.25^\circ K < 5^\circ K \quad \underline{\underline{OK}}$$

THERMAL CONDUCTIVITY INTEGRALS

for COPPERS

Comments: The six curves were extrapolated to 300°K. The curve for O.F.H.C. was extrapolated to 4°K and the curve for (Pb)Cu was extrapolated to 6°K. It is estimated that the extrapolated values do not deviate more than 10% from the probable values.

$$Q = \frac{A}{L} \int_{T_o}^{T_L} \lambda \, dT; \qquad Q \frac{L}{A} = \int_{T_o}^{T_L} \lambda \, dT$$

Where:

- Q = heat flow in watts
- A = cross sectional area in cm^2
- L = length in cm
- λ = thermal conductivity in watts/cm-°K
- T = temperature in °K
- T_o = initial temperature (6°K for [Pb]Cu and [Te]Cu; 4°K for all other Coppers)

Thermal Conductivity Integrals are on following page.

Temp. °K	Thermal Conductivity watts/cm-°K					
	Hi-Purity Annealed	Coalesced	Elect. T.P.	O.F.H.C.	(Pb) Cu	(Te) Cu
4	70	6.2	3.2	2.4*		
6	96	10.	4.8	3.7*	2.7*	2.2
8	120	14.	6.3	4.7*	3.6*	2.8
10	134	17.5	7.8	6.0*	4.5*	3.4
15	120	23	11	8.5*	6.3*	5.0
20	88	24	13	11 *	8 *	6.5
25	60	23	14	12	9.2	7.3
30	40	22	14	12	9.6	7.8
35	28	18.5	13	11	9.5	7.9
40	20	15	11.5	10	9	7.7
50	12	10	8.8	7.7	6.9	6.8
60	8.0	7.8	7.0	6.2	5.5	5.8
70	6.2	6.5	5.9	5.5	4.7	5.2
76	5.7	6.0	5.5	5.2	4.5	4.9
80	5.2	5.7	5.2	4.9	4.3	4.6
90	4.7	5.1	4.7	4.7	4.0*	4.3
100	4.5	4.8	4.5	4.5	3.8*	4.2
120	4.3	4.5	4.3	4.3	3.7*	4.0
140	4.2	4.3	4.2	4.2	3.6*	3.8
160	4.1	4.2	4.1	4.1	3.6*	3.8
180	4.0	4.2	4.0	4.0	3.6*	3.8
200	4.0	4.2	4.0	4.0	3.6*	3.8
250	4.0	4.2*	4.0	4.0	3.6*	3.8*
300	4.0*	4.2*	4.0*	4.0*	3.6*	3.8*

* Extrapolated Values

THERMAL CONDUCTIVITY INTEGRALS

for COPPERS (cont.)

Temp. °K	$\int_{T_o}^{T_L} \lambda \, dT$ watts/cm					
	Hi-Purity Annealed	Coalesced	Elect. T.P.	O.F.H.C.	(Pb) Cu	(Te) Cu
6	166	16.2	8.00	6.1		
8	382	40.2	19.1	14.5	6.3	5
10	636	71.7	33.2	25.2	14.4	11.2
15	1270	173	80.2	61.4	41.4	32.2
20	1790	290	140	110	77.2	60.9
25	2160	408	208	168	120	95.4
30	2410	520	278	228	167	133
35	2580	622	345	285	215	172
40	2700	705	406	338	261	211
50	2860	830	508	426	341	284
60	2960	919	587	496	403	347
70	3030	991	651	554	454	402
76	3070	1030	686	586	481	432
80	3090	1050	707	606	499	451
90	3140	1100	756	654	540	496
100	3180	1160	802	700	579	538
120	3270	1250	891	788	654	620
140	3360	1340	976	874	727	698
160	3440	1420	1060	956	799	774
180	3520	1510	1140	1040	871	850
200	3600	1590	1220	1120	943	926
250	3800	1800	1420	1320	1120	1120
300	4000	2000	1620	1520	1300	1310

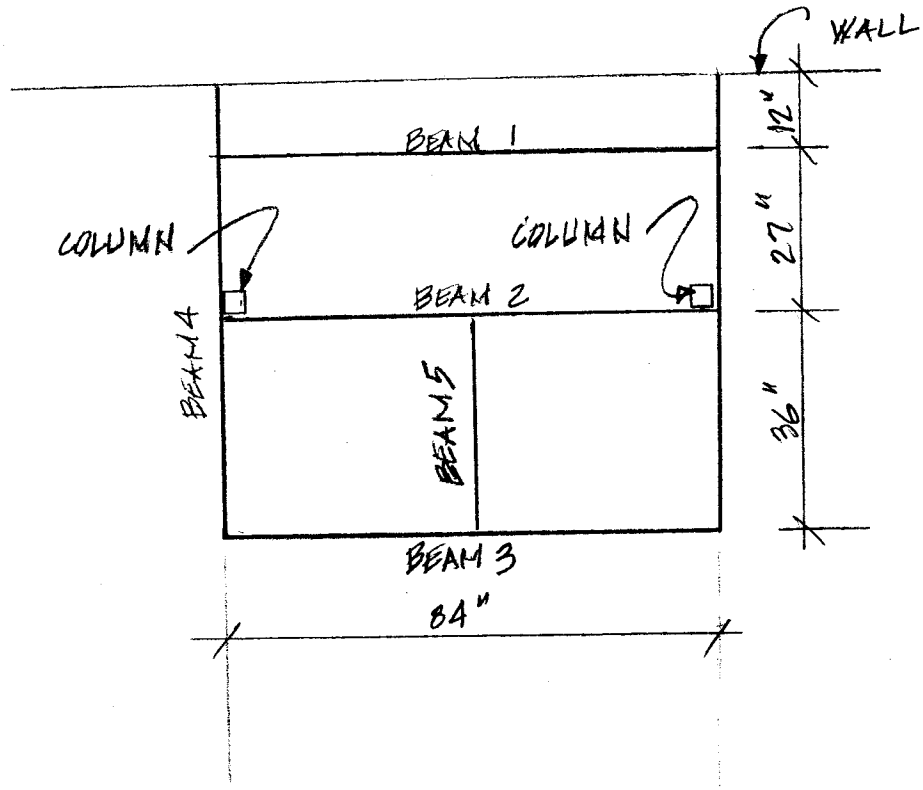
Reprinted from WADD Tech.Report 60-56

PART F

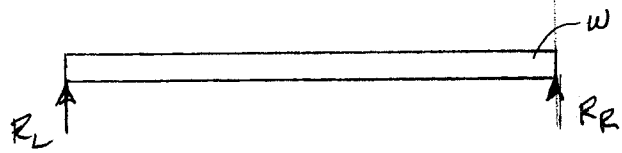
DESIGN OF A STRUCTURE TO SUPPORT THE BAYONET BOX

BAYONET CAN WT. = 2055# + 7(15+50)
= 2510#

PLATFORM LOADS:
FRAMING = 5.0 #/FT²
LIVE LOAD = 100 #/FT² (ABCE MIN. DESIGN LOADS)
105#/FT² = 0.73#/IN²



BEAM 1

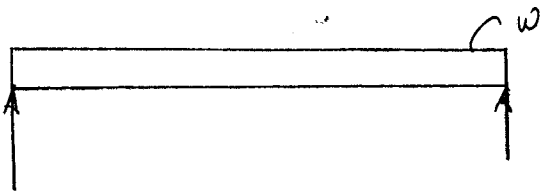


$w = 27/2(0.73) = 9.9$ #/IN

$R_L = R_R = \frac{9.9(84)}{2}$
$= \underline{\underline{416\#}}$

$M = wl^2/8 = \frac{9.9(84)^2}{8}$
$= 8732$ #-IN

BEAM 2

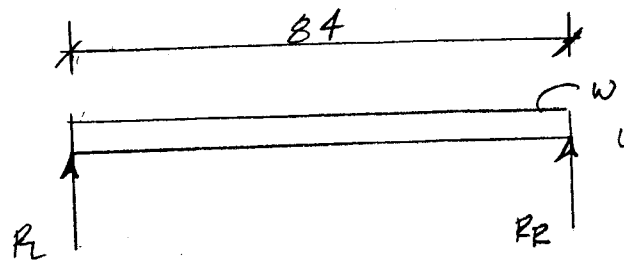


$w = 27/2(0.73) + (2510/2)/84$
$= 24.8$ #/IN

$R_L = R_R = \frac{24.8(84)}{2}$
$= \underline{\underline{1042\#}}$

$M = 24.8(84)^2/8$
$= 21874$ #-IN

BEAM 3



$w = (2510/2)/84$
$= 14.9$ #/IN

$R_L = R_R = 14.9(84)/2$
$= \underline{\underline{626\#}}$

$M = 14.9(84)^2/8$
$= 13,142$ #-IN

DESIGN ALL 3 BEAMS FOR LOADS OF BEAM 2:

$R = 1042\#$, $M = 21,874$ #-IN

TRY C4×5.4 $S_x = 1.93$ $A = 1.59$ $I_x = 3.85$

$b/t = 1.584/0.296 = 5.35$ $65\sqrt{36} = 390$

$390 > 5.35 \therefore$ COMPACT SECTION

$76bf/\sqrt{3x} = 76(1.584)/\sqrt{36} = 20.06'' < 84$

$\therefore F_b = \dfrac{12\times10^3 C_b}{ld/A_f} \leq .60 F_y$

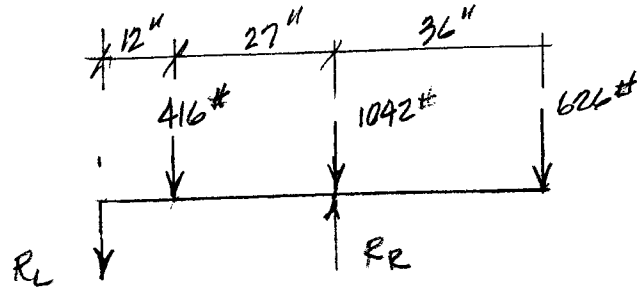
$= \dfrac{12\times10^3(1)}{84(8.52)} = 16.8$ KSI $= 16,800$ psi

$f_b = 21874/1.93 = 11,334$ psi $< 16,800$ psi $\underline{\underline{ok}}$

$F_v = 0.40(36) = 14.4$ KSI $= 14,400$ psi

$f_v = 1042/1.59 = 655$ psi $< 14,400$ $\underline{\underline{ok}}$

BEAM 4

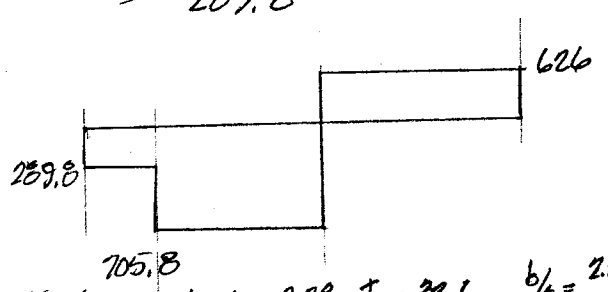


$$R_R = \frac{75(626) + 39(1042) + 12(416)}{39}$$

$$= 2373.8\#$$

$$R_L = \frac{27(416) + 36(626)}{39}$$

$$= 289.8\#$$



$M = 289.8(12) + 705.8(27) = 22,534$ #-IN

TRY C8×11.5 $S_x = 8.14$ $A = 3.38$ $I_x = 32.6$ $b/t = 2.26/0.390 = 5.795 < 390$ (SEE BEAM #4) ∴ COMPACT SECTION

$L_c = 76\,bf/\sqrt{36} = 76(2.26)/\sqrt{36} = 28.63 < 36$

$\therefore F_b = \frac{12\times10^3 C_b}{ld/A_f} \le .60F_y = \frac{12\times10^3(1)}{36(9.08)} = 36.7$ USE $0.6(36) = 21.6$

$f_b = 22,534/8.14 = 2768$ psi $< 21,600$ psi OK

$F_v = 0.40(36) = 14.4$ KSI $f_v = 2373.8/3.38 = 702$ psi $< 14,400$ psi OK

$\Delta_{MAX} = 0.626(36)^3/3(29,000)(32.6)$ 0.01" OK

COLUMN

$P = 2373.8\#$ SAY $2500\#$ COLUMN LENGTH ≈ 80"

TRY 4×4×5/16 TUBE $r = 1.54$ $A = 4.36$ IN²

$Kl/r = 2(80)/1.54 = 104 < 200$ OK

$f_a = 2500/4.36 = 573$ psi

ASSUME 10% HORIZ. LOAD @ TOP OF COLUMN

$M = 2500(0.10)(80) = 20,000$ #-IN

$f_b = 20,000/4.79 = 4,175$ psi

$$L_c = \left(1950 + 1200\frac{M_1}{M_2}\right) b/F_y = 1950\,(4)/46 = 170'' > 80'' \text{ ok}$$

$$F_b = 0.66\,F_y = 0.66(46) = 30.4\text{ ksi} = 30{,}400\text{ psi}$$

$$F_a = \frac{\left[1 - \frac{(Kl/r)^2}{2C_c^2}\right]46}{5/3 + \frac{3(Kl/r)}{8C_c} - \frac{(Kl/r)^3}{8C_c^3}} \qquad C_c = 111.6 \text{ (p. 5-120 AISC)}$$

$$= \frac{\left[1 - \frac{(104)^2}{2(111.6)^2}\right]46}{5/3 + \frac{3(104)}{8(111.6)} - \frac{(104)^3}{8(111.6)^3}} = \frac{26.03}{1.915} = 13.59\text{ psi}$$

$$f_a/F_a + f_b/F_b \le 1.0$$

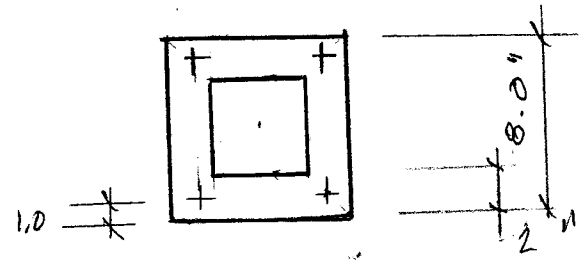
$$573/13{,}590 + \frac{4175}{30{,}400} = 0.180 < 1.0 \text{ ok}$$

USE TS $4 \times 4 \times 5/16$

COLUMN BASE PL:

$$F_p = 0.35\,f'_c \quad \text{(AISC p 3-107)}$$
$$= 0.35(3000)$$
$$= 1050\text{ psi}$$

FOR 7.5" × 7.5" PL, $P = 1050(7.5)^2 = 59{,}000\# > 2500\#$ ok



$$m = \frac{(8.0 - .95d)}{2} = \frac{(8.0 - .95(4))}{2} = 2.10''$$

$$t_p = 2(2.10)\sqrt{f_b/F_y} \quad \text{(AISC p. 3-106)}$$
$$= 2(2.10)\left(\sqrt{1050/36{,}000}\right)$$
$$= 0.72'' \text{ USE } 3/4'' \text{ THICK PL}$$

TENSION ON ANCHOR BOLTS $= \left(20{,}000\#\text{-IN}/6''\right)/2\text{ BOLTS} = 1{,}667\#$

FOR 3/4" ϕ HILTI DROP-IN ANCHORS $T = 4065 \times$ SPACING ADJ. FACTOR $= 4065\,(0.5) = 2033\# > 1667\#$ ok

USE 3/4" ϕ DROP INS

FLOOR GRATING:

FOR WELDED STEEL GRATING:

LIVE LOAD = $100^{\#}/FT^2$

SPAN = $84/2$ = 42"

SELECT 3/4" × 3/16" 19-W-4 GRATING

$w_{ALLOW} = 174^{\#}/FT^2$

MAX. CONCENTRATED LOAD = $305^{\#}$

BEAM 5

SPAN = 36" $w = (84/2\,(0.73))/2 = 15.3^{\#}/IN$

$R_L = R_R = 36(15.3)/2 = 276^{\#}$

$M = 15.3(36)^2/8 = 2479$ #-IN

TRY W4×13 $S_x = 5.46$ $A = 3.83$ $I_x = 11.3$

$76 b_f/\sqrt{36} = 76(4.06)/\sqrt{36} = 51.4$

$20{,}000/(d/A_f)F_y = 20{,}000/2.97(36) = 187$

36" < 51.4 IF BEAM IS COMPACT, $F_b = 0.66F_y$

$b/t = 4.06/0.345 = 11.8$

$65/\sqrt{36} = 10.83 < 11.8$ BEAM IS NOT COMPACT

$\therefore F_b = F_y\left[0.79 - 0.002\, b_f/2t_f\sqrt{36}\right]$

$= 36\left[0.79 - 0.002(4.06/2(0.345)(6)\right]$

$= 25.9^{KSI}$

$f_b = 2479/5.46 = 454$ psi < 25,900 psi OK

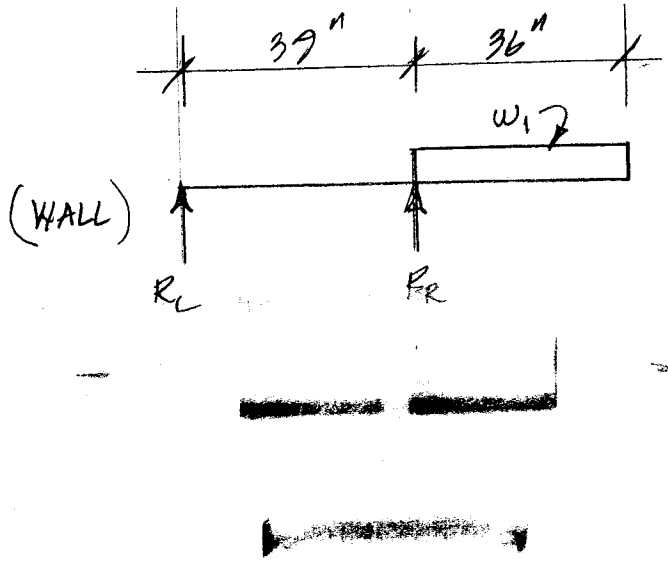
$F_v = 14.4^{KSI}$

$f_v = 276/3.83 = 72.0$ psi < 14,400 PSI OK

USE W4×13

WALL CONNECTION FOR BEAM 4 (SIDE CHANNELS)

FIND MAXIMUM REACTION @ WALL:
A) FULL LIVE LOAD & DEAD LOAD ON PLATFORM



$w_1 = 0.73(84/2)$
$= 30.7\#/IN$

$R_R = \frac{57(30.7(36))}{39}$
$= 1{,}615\#$

$R_L = \frac{36(30.7)(\frac{36}{2})}{39}$
$= 510\#$

USING 4 "HILTI DROP-IN ANCHORS":
CONCRETE STRENGTH = 4000 PSI
FOR 3/4" ϕ BOLTS, ALLOW. SHEAR = 5,000# EA.

MINIMUM SPACING = 7"
REDUCTION FACTOR FROM "HILTI" CAT. P 136 = 0.57
$5000(0.57) = 2850\#$

MINIMUM EDGE DISTANCE = 9.75"
REDUCTION FACTOR FROM "HILTI" CAT. P 136 = 0.83
$2850(0.83) = 2366\#$ ← USE

SHEAR CAPACITY OF "HILTI DROP-INS"
$= 2366$ (4 BOLTS) $= 9464\# > 510\#$ OK

USE 4 - 3/4" ϕ "HILTI" DROP-IN ANCHORS

CONNECTION OF ANGLE TO PLATE:
DEVELOP FULL STRENGTH OF "HILTI" ANCHORS = 9464#:
ANGLE THICKNESS = 3/8"
PLATE THICKNESS = 1/2"
MAX WELD SIZE = 3/8" - 1/16" = 5/16"

STRENGTH OF 1" LENGTH OF 5/16" WELD:
$0.3(.707)(5/16)(70) = 4.64\ K/IN = 4640\#/IN$

STRENGTH OF 1" LENGTH OF 1/4" WELD:

$0.3(.707)(1/4)(70) = 3.71^K/IN = 3710^\#/IN$

USING 3" WELD EA. SIDE OF ANGLE:

$2(3")(3710) = 22{,}260^\# > 9464^\#$ OK

USE 3" OF 1/4" WELD EA. SIDE OF ANGLE

CHECK BOLTS BETWEEN CHANNEL AND ANGLE:

SHEAR CAPACITY OF 3/4"ϕ GR 5 BOLTS IN SINGLE SHEAR: $7.51^K = 7510^\#$ EA.

FOR 2 BOLTS, ALLOW. LOAD $= 2(7510)$

$= 15020^\# > 510^\#$

OK

USE 2- 3/4"ϕ GR. 5 BOLTS

PLATFORM RAILING DESIGN

FROM OSHA CODE:
TOP SURFACE OF RAIL 42" ABOVE PLATFORM
HORIZONTAL LOAD OF 200#

LENGTH FROM TOP OF TOP RAIL TO TOP/SUPPORT
= 43"

$M = 200^{\#}(43) = 8600^{\#-IN}$

STANDARD PIPE, 1½" NOMINAL, $S_x = 0.326 IN^3$

$f_b = 8600/0.326$
$= 26,380$ psi

FOR ASTM A500 GRADE C $F_y = 46,000$ psi

$F_b = 46,000(0.60)$
$= 27,600$ psi $> 26,300$ psi ok

USE 1½" ϕ ASTM A500 GRADE C PIPE

BENDING ON CONNECTOR PLATE
TRY ½" PLATE 6" LONG

$S = 0.5(6)^2/6$
$= 3 IN^3$

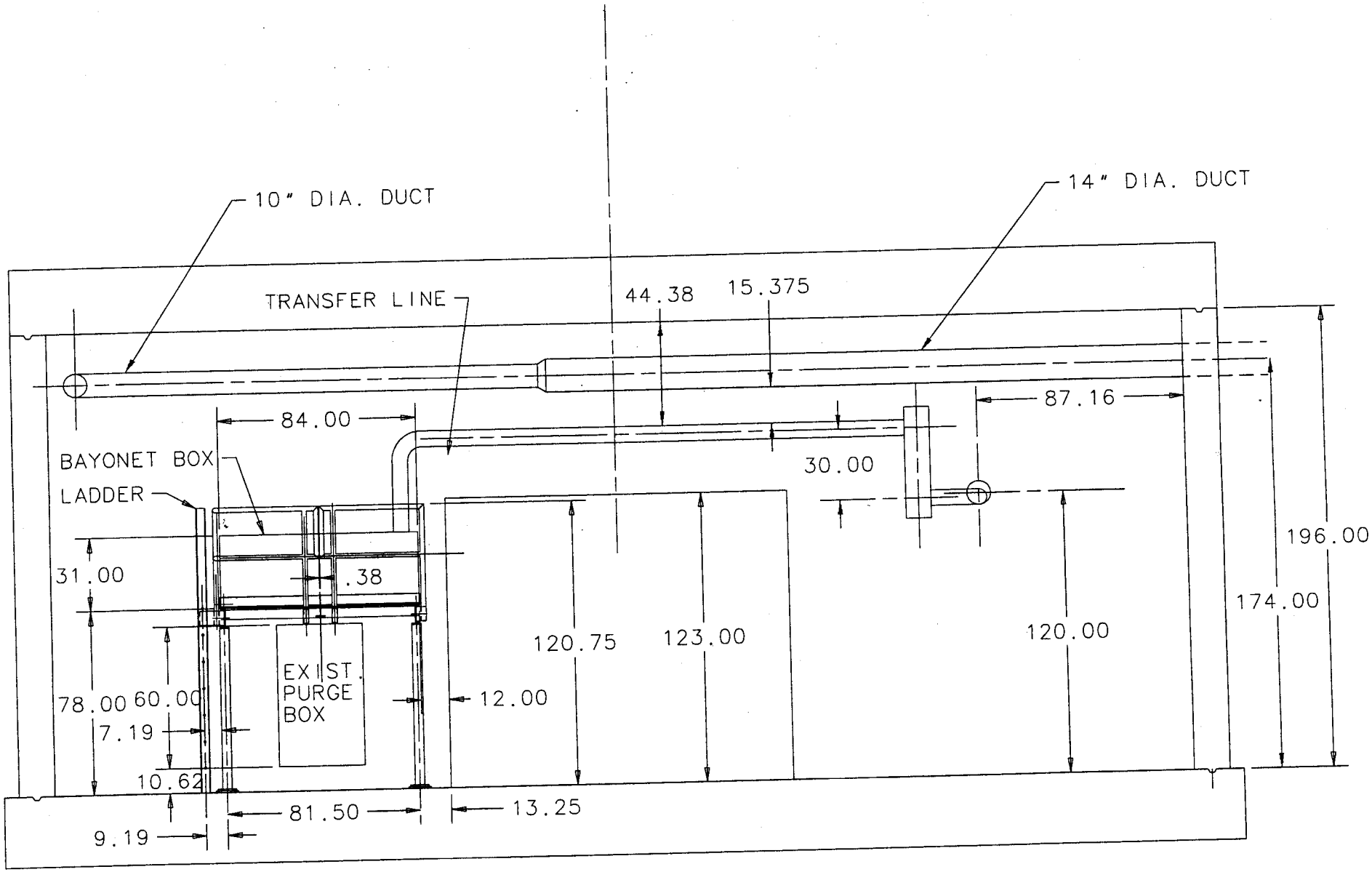
$f_b = 8600/3$
$= 2867$ psi

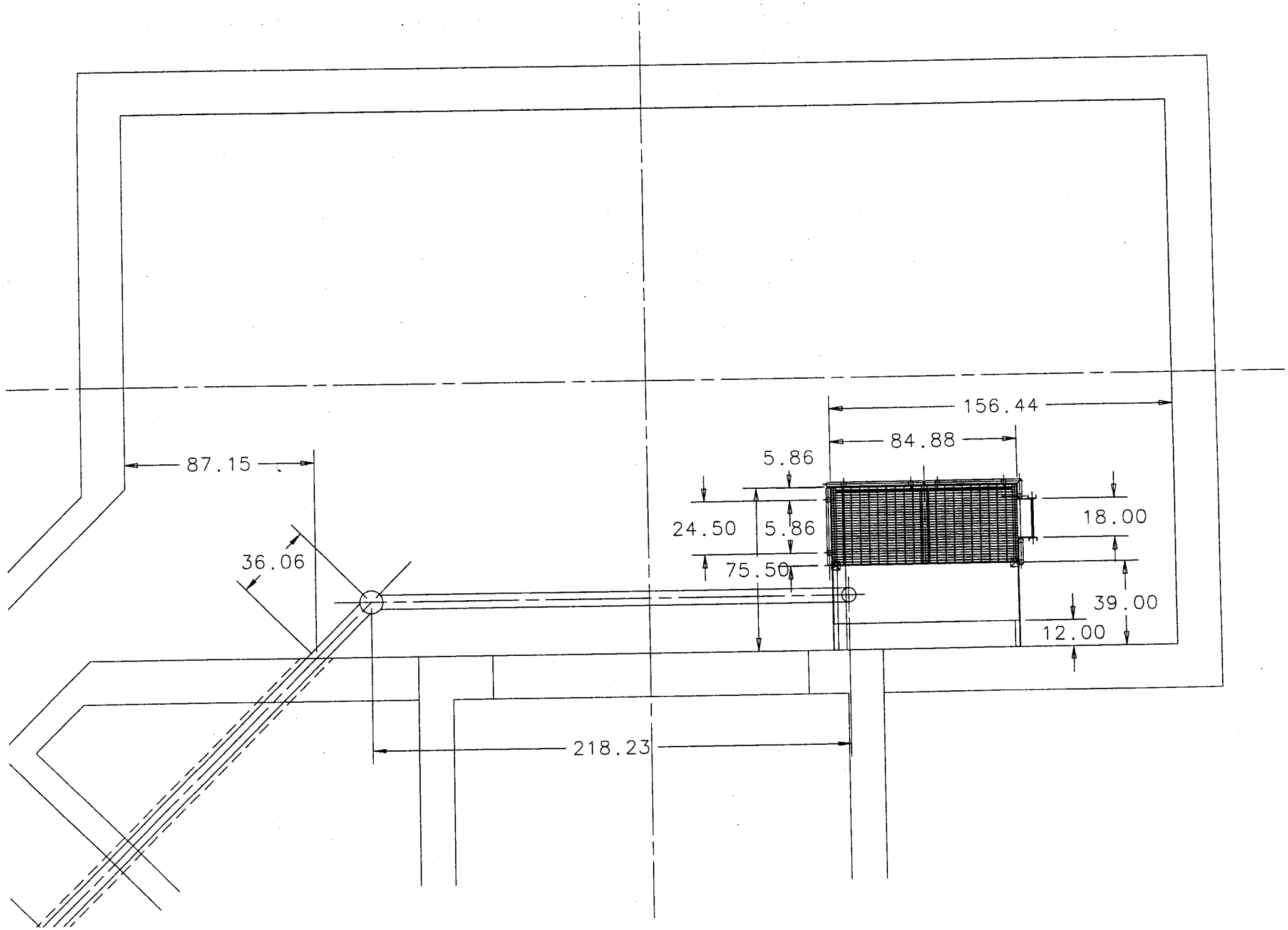
$F_b = 0.60(36)$
$= 21.6$ KSI $= 21,600$ psi > 2867 psi ok

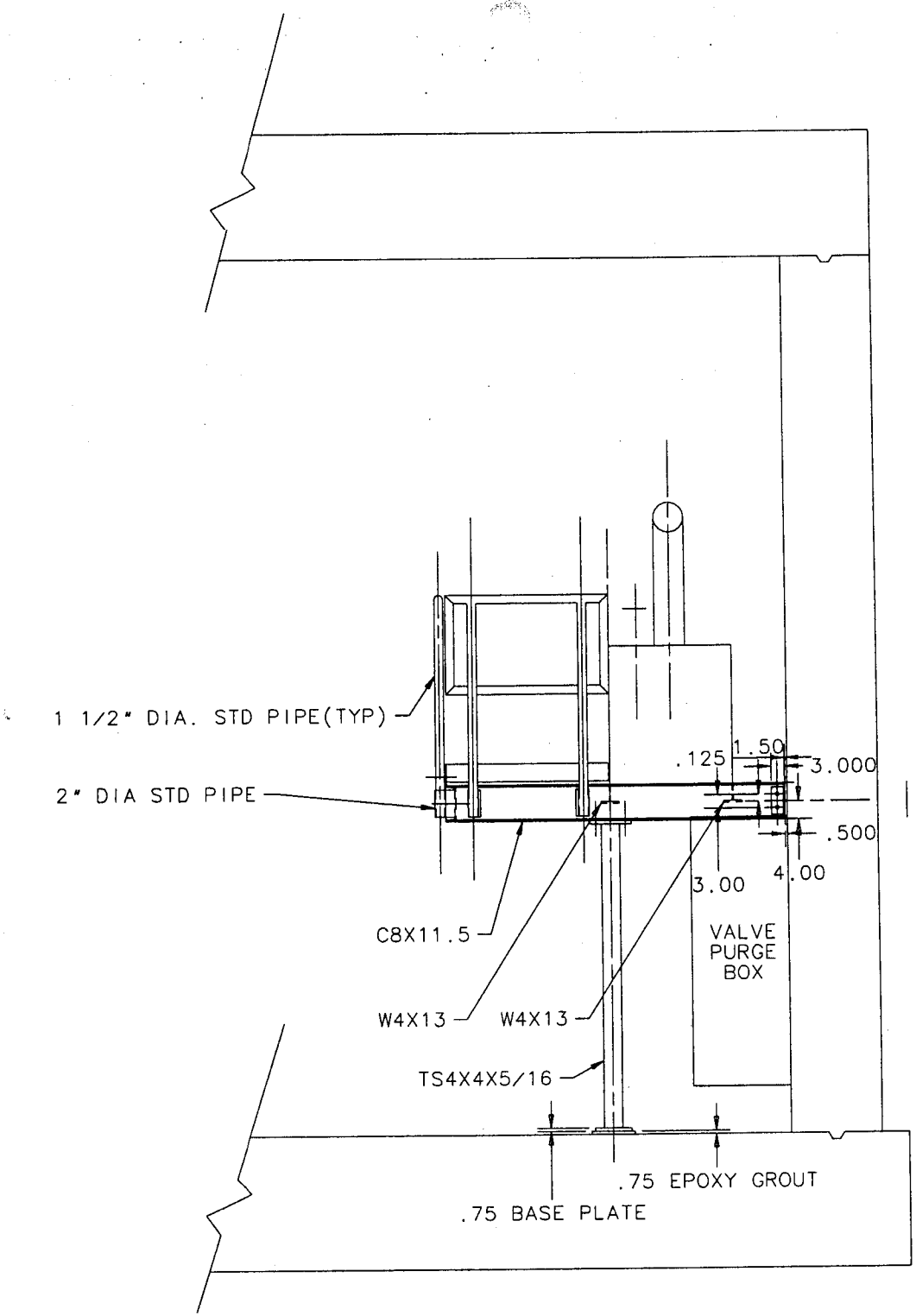
WELDS:
$P = 8600/6"$
$= 1433^{\#}$ TOP & BOTTOM
1" OF ¼" WELD $= 0.3(.707)(70)(1/4)$
$= 3.7^K = 3700^{\#}$

ACTUAL LOAD $= 1433/2$ (WELD EA. SIDE OF ϕ)
$= 717^{\#} < 3700^{\#}$ ok

USE ¼" WELD EA. SIDE
OF ½" x 6" PLATE


10" DIA. DUCT
14" DIA. DUCT
TRANSFER LINE
44.38
15.375
87.16
84.00
BAYONET BOX
LADDER
30.00
196.00
31.00
.38
174.00
120.75
123.00
120.00
EXIST.
PURGE
BOX
78.00
60.00
12.00
7.19
10.62
81.50
13.25
9.19


156.44
84.88
5.86
87.15
24.50
5.86
18.00
36.06
75.50
39.00
12.00
218.23


1 1/2" DIA. STD PIPE(TYP)
2" DIA STD PIPE
.125
1.50
3.000
.500
3.00
4.00
C8X11.5
VALVE
PURGE
BOX
W4X13
W4X13
TS4X4X5/16
.75 EPOXY GROUT
.75 BASE PLATE

MuCool TRANSFER LINE

R.J. Woods
DEC. 12, 2008

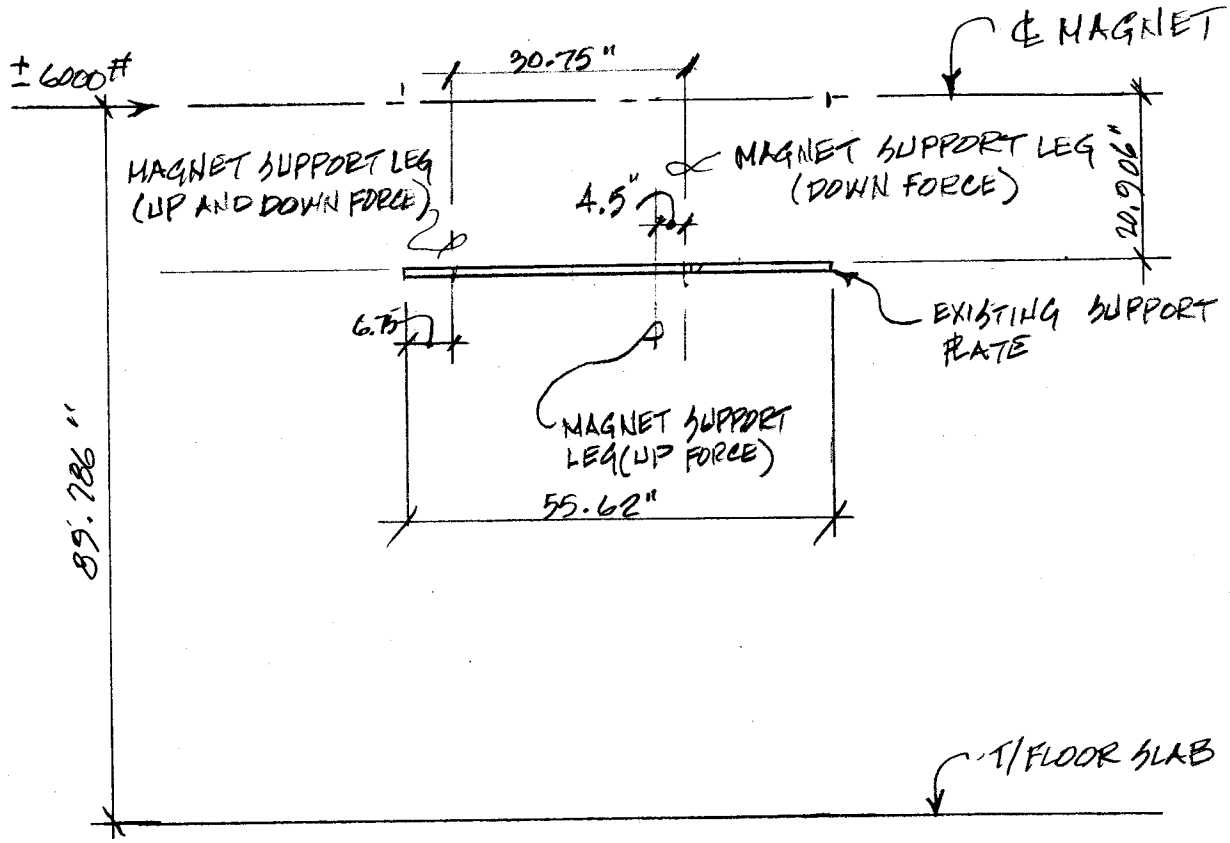
PART 9
MAGNET SUPPORT

NEW MAGNET SUPPORT ± 36" HIGHER THAN EXISTING:

EXISTING HEIGHT FROM ℄ MAGNET TO FLOOR = 32.88 + 20.906
= 53.786"

NEW HEIGHT = 53.786 + 36.0 = 89.786"

FROM ENGINEERING NOTE 078: HORIZ LOAD = 6000# (P. 3)



A) FOR HORIZONTAL FORCE FROM UPSTREAM TO DOWNSTREAM:
EXISTING SUPPORT PLATE:
M. = 6,000 × 20.906
= 125,436 #-IN

DISTANCE BETWEEN MAGNET SUPPORT LEGS = 30.75"

VERTICAL FORCE = ± 125436 / 30.75
= 4080#

OR 4080 / 2 = 2040 # PER LEG

DEAD WEIGHT OF CRYOSTAT W/ 150 LITERS OF LIQUID HELIUM = 2600#

2600/2 = 1300# PER SIDE
1300/2 = 650# PER LEG FOR 2 SUPPORTS
1300/3 = 433# PER LEG FOR 3 SUPPORTS

MAXIMUM DOWN FORCE = 2040 + 650
= 2690#

FROM REID CATALOG, ALLOWABLE LOAD ON LEVELING PAD = 5000# > 2690# OK

4 - 1/2" ϕ BOLTS, 2 PER SIDE, TO TAKE SHEAR & TENSION

VERT. TENSION LOAD = 2040# - 433#
= 1670# PER SIDE

1670#/2 = 803.5# BOLT

SHEAR LOAD = (6000/2)/2 BOLTS
= 1500#/BOLT

ASSUME GRADE 18-8 SS BOLTS 1/2" ϕ:
YIELD = 80,000 PSI TENSILE = 100,000 PSI

$F_t = 0.33 F_U$
$= 0.33(100{,}000)$
$= 33{,}000$ PSI

$F_V = 0.17 F_U$
$= 0.17(100{,}000)$
$= 17{,}000$ PSI

AREA OF 1/2" ϕ BOLT = $\pi(1/2)^2/4$
$= 0.1964 \text{ IN}^2$

TENSION/BOLT = 0.1964(33,000)
= 6480#

SHEAR/BOLT = 0.1964(17,000)
= 3339#

$f_t = 1670/0.1964 = 8503$ PSI
$f_V = 1500/0.1964 = 7638$ PSI

$8503/33{,}000 + 7638/17{,}000 = 0.707 < 1.0$ OK

B) FOR HORIZONTAL FORCE FROM DOWNSTREAM TO UPSTREAM:

DISTANCE BETWEEN MAGNET SUPPORT LEGS AND VERTICAL BRACING CHANNEL = 30.75 - 4.5
= 26.25"

VERTICAL FORCE = 125436/26.25
= 4779#

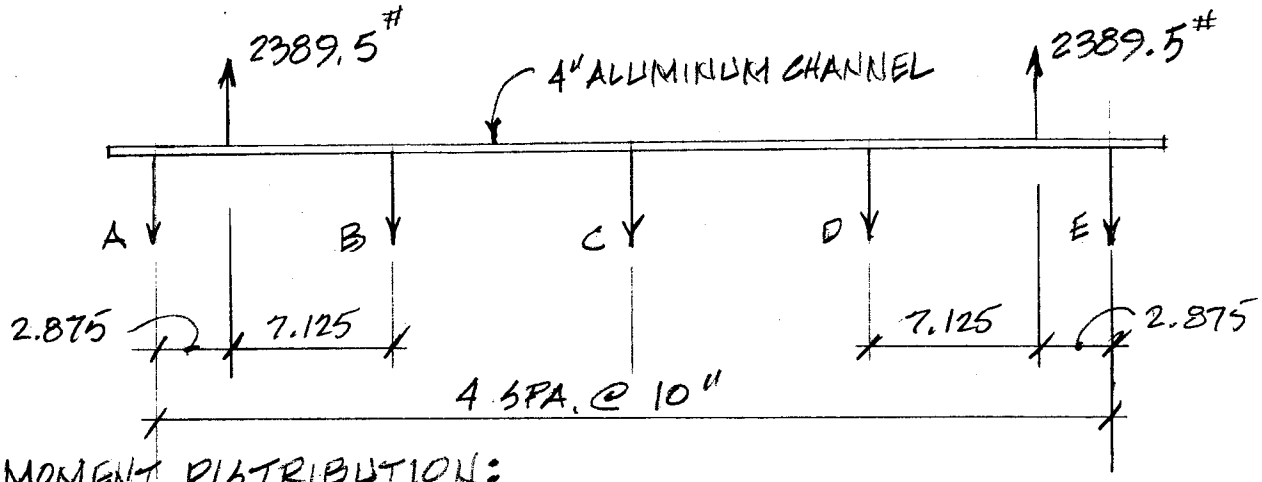
MAX DOWN FORCE = 4779 + 650
= 5429.0#/LEG

DOWARD LOAD CARRIED ON UPSTREAM LEG W/ 4" x 6" PLATE:

5429/(4 x 6) = 226 PSI ok

UPWARD LOAD CARRIED BY 5, ½"ϕ 13 THREADE RODS.

NAX. UP FORCE = 4779#
CHANNEL PICKS UP FORCE IN 2 PLACES
= 4779/2 = 2389.5# EA.



MOMENT DISTRIBUTION:

FEM A→B & E→D $= \frac{Pab^2}{l^2} = \frac{2389.5(2.875)(7.125)^2}{10^2} = 3487.5$ #-IN

FEM B→A & D→E $= \frac{Pa^2b}{l^2} = \frac{2389.5(2.875)^2(7.125)}{10^2} = 1407.2$ #-IN

DF	1.0	0.5	0.5	0.5	0.5	0.5	0.5	1.0
FEM	-3487.5	+1407.2	0.0	0.0	0.0	0.0	-1407.2	+3487.5
DIST	+3487.5	-703.6	-703.6	0.0	0.0	+703.6	+703.6	-3487.5
CO	-351.8	+1743.8	0.0	-351.8	+351.8	0.0	-1743.8	+351.8
DIST	+351.8	-871.9	-871.9	0.0	0.0	+871.9	+871.9	-351.8
CO	-436.0	+175.9	0.0	-175.9	+175.9	0.0	-175.9	+436.0
DIST	+436.0	-88.	-88.0	0.0	0.0	+88.0	+88.0	-436.0
CO	-44.0	+218.0	0.0	-44	+44.0	0.0	-218.0	+44.0
DIST	+44.0	-109.0	-109.0	0.0	0.0	+109.0	+109.0	-44.0
M	0.0	+1772.4	-1772.5	-571.7	+571.8	+1772.5	-1772.4	0.0

REACTION @ A & E $= \frac{Pb^2}{\ell^3}(3a+b) = \frac{2389.5(7.125)^2}{10^3}(3(2.875)+7.125)$

$= 1910.5^{\#}$

REACTION @ B & D $= \frac{Pa^2}{\ell^3}(3b+a) = \frac{2389.5(2.875)^2}{10^3}(3(7.125)+2.875)$

$= 479.0^{\#}$

R	1910.5	479.0	0.0	0.0	0.0	0.0	479.0	1910.5
P_M	177.2	177.2 + 120.1	−120.1	−120.1	+120.1	177.2	177.2
	1733.3	656.2 + 120.1	−120.1	−120.1	+120.1	+656.2	1733.3
TOTAL R	1733.3#	776.3#	−240.2#			776.3#	1733.3#

THREADED ROD = 1/2" ϕ 316 STAINLESS

$F_y = 35$ KSI $F_u = 85$ KSI

$F_t = 0.33 F_u$
$= 0.33(85)$
$= 28.05$ KSI

$A = \frac{\pi d^2}{4}$
$= 3.14159(0.5)^2/4$
$= 0.1963 \text{ IN}^2$

ALLOWABLE TENSION $= 0.1963(28.05)$
$= 5.5^{K}$
$= 5500^{\#} > 1733.3^{\#}$ ok

SHEAR CARRIED BY 4 BOLTS ON UPSTREAM LEGS.

NEW MAGNET STAND:

PRELIMINARY HEIGHT OF MAGNET = 90" ABOVE FLOOR

OVERTURNING MOMENT = 90"(6000)#
= 540,000 "-#

IF LEGS ARE 44.375" APART, VERTICAL REACTION =
540,000/44.375 = 12,169 # TENSION OR COMPRESSION
12,169/2 = 6085 #/LEG T OR C

STAND LEGS:

VERTICAL HEIGHT OF LEG = 90" − (20.906 + 0.625)
= 68.469"

SAY ℓ = 68.5"

TRY 4 × 4 × 1/4" TUBE
6063-T5

$A = d_1^2 - d_2^2 = 4.0^2 - 3.5^2$
$= 3.75 \text{ IN}^2$

$r = \sqrt{\frac{d_1^2 + d_2^2}{12}}$
$= \sqrt{\frac{4.0^2 + 3.5^2}{12}}$
$= 1.53$

$I = \frac{d_1^4 - d_2^4}{12} = \frac{4.0^4 - 3.5^4}{12}$
$= 8.83 \text{ IN}^4$

$S = \frac{d_1^4 - d_2^4}{6 d_1} = \frac{4.0^4 - 3.5^4}{6(4.0)}$
$= 4.41 \text{ IN}^3$

$\ell/r = 68.5/1.53$
$= 45$

SLENDERNESS LIMITS FROM ALUMINUM ASSOC "SPECIFICATIONS FOR ALUMINUM STRUCTURES" P. 41 FOR 6063-T5

$S_1 = 11$ $S_2 = 99$ OR $S_1 = 65$ < 1" FROM WELD

$S_1 < \ell/r < S_2$ ∴ $F_c = 8.9 - 0.037\,\ell/r$ OR 6.5 KSI 1" FROM WELD
$= 8.9 - 0.037(45)$
$= 7.235$ KSI

COMPRESSION:
ALLOWABLE LOAD = 7.235 (3.75)
= 27.13 K = 27,130# > 6085 # ok

TENSION:
FOR SECTION WITHIN 1" OF WELD F_t = 6.5 KSI

ALLOWABLE LOAD = 6.5 (3.75)
= 24.4 K = 24,400# > 6085# ok

DIAGONAL BRACE:

$$\text{LENGTH} = \sqrt{44.375^2 + 68.5^2}$$
$$= 81.6''$$

$$l/r = 81.6/1.53$$
$$= 53$$

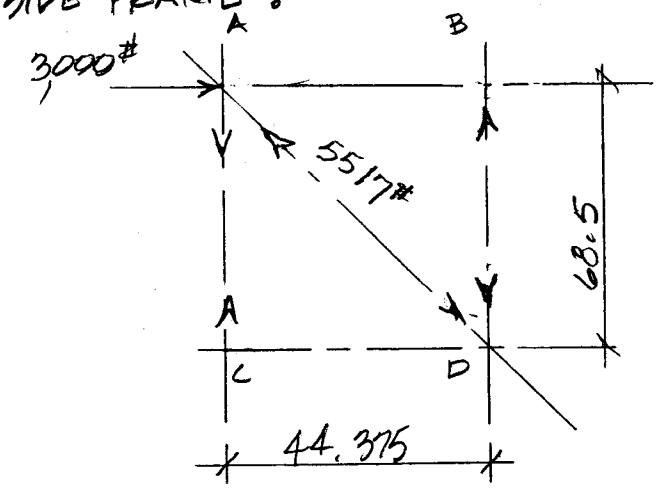
$$S_1 < l/r < S_2 \therefore F_c = 20.2 - 0.126\, l/r$$
$$= 20.2 - 0.126(55)$$
$$= 13.27 \text{ KSI}$$

COMPRESSION:
ALLOWABLE LOAD $= 13.27(3.75)$
$= 49.8^K = 49{,}800^\#$

TENSION:
FOR SECTION WITHIN 1" OF WELD $F_t = 11.0$ KSI

ALLOWABLE LOAD $= 11.0(3.75)$
$= 41.25 = 41{,}250^\#$

ONE SIDE FRAME:



$$\text{TAN } \angle ADC = 44.375/68.5$$
$$\angle ADC = 32.94^\circ$$

MEMBER A-D $= 3000/\sin 32.94$
$= 5517^\#$ (DIAGONAL BRACE)

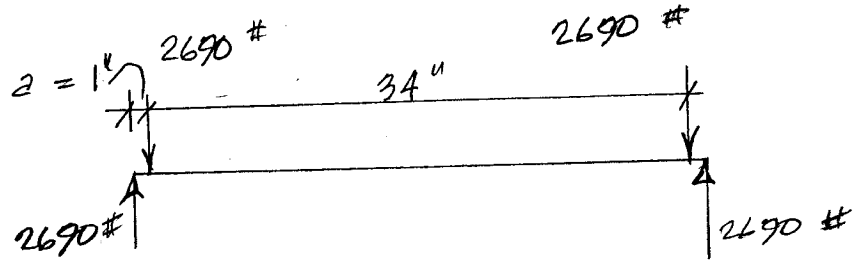
MEMBER B-D $= 5517(\cos 32.94)$
$= 4630^\#$ (VERT. COMP)

MEMBER A-C $= 3000/\tan 32.94$
$= 4630^\#$ (VERT. TENSION)

ALL

MAXIMUM DOWNFORCE ON MAGNET DOWNSTREAM SUPPORT LEGS = 2040 # + 650# MAGNET DEAD LOAD
= 2690 #

BEAM UNDER REAR MAGNET SUPPORTS:
SPAN = 36"



$M = Pa = 2690(1.0)$
$= 2690$ #-IN

FOR 4×4×1/4 SQUARE TUBE:
$L_b = 36"$
$S_c = bd^3 - b_1d_1^3/6d = 4(4)^3 - 3.5(3.5)^3/6(4)$
$= 4.41 \text{ IN}^3$

$I_y = bd^3 - b_1d_1^3/12 = 4(4)^3 - 3.5(3.5)^3/12$
$= 8.83 \text{ IN}^4$

SLENDERNESS (P. 40) FOR 6061-T6:
$S_1 = \frac{L_b S_c}{I_y} = = 36(4.41)/8.83 = 18.0 < 146$
$\therefore F_b = 21.0$ KSI

S_x REQ'D $= 2690/21{,}000$
$= 0.13 \text{ IN}^3 < 4.41$ ok

USE 4×4×1/4 TUBE

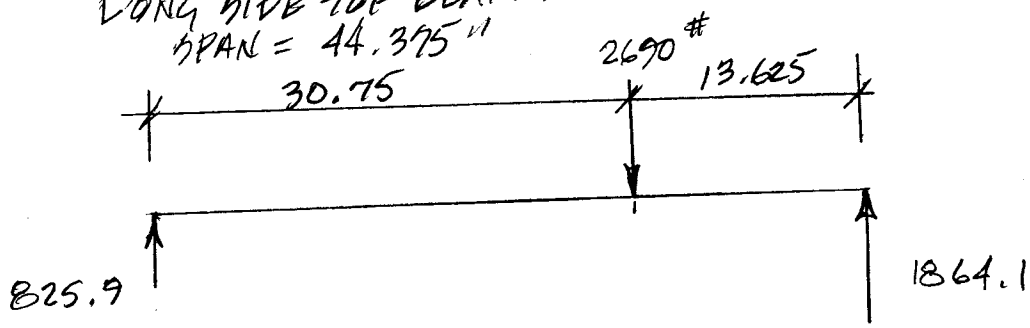
FOR CONNECTION TO SIDE SUPPORT BEAM;
FROM P 56 TABLE 7.1.3.1
USE 4043 ELECTRODE

FROM P. 56 TABLE 7.1.3.2
ALLOWABLE SHEAR STRESS = 5.0 KSI

FOR 3/16" WELD, ALLOW. LOAD = 3/16(5.0)(.707)
= 663 #/IN

LENGTH OF WELD REQ'D = 2690/663
= 4.1"
USE 3/16" FILET EA. SIDE OF TUBE = 8" > 4.1" ok

LONG SIDE TOP BEAM:
SPAN = 44.375"



$M = 30.75(13.625)(2690)/44.375$
$= 25,398$ #-IN

SLENDERNESS:
$S = L_b S_c / I_y = \frac{44.375(4.41)}{8.83} = 22 < 146$
$\therefore F_b = 21.0$ KSI

$S_{x\,REQ'D} = 25398/21000$
$= 1.21\ IN^3 < 4.41\ IN^3$ ok

CHECK COMBINED LOADING:

BENDING $f_b = 25398/4.41$
$= 5759$ psi

COMPRESSION $= 3000/((4)(4) - 3.5(3.5))$
$= 800$ psi

$r = \sqrt{I/A} = \sqrt{8.83/3.75} = 1.53$

$L/r = 44.375/1.53 = 28.9$

$9.5 < L/r < 66$

$\therefore F_a = 20.2 - 0.126\, L/r$
$= 20.2 - 0.126(28.9)$
$= 16.6$ KSI

$f_a/F_a + f_b/F_b = 800/16,600 + 5759/21,000$
$= 0.322 < 1.0$ ok

USE TUBE 4 x 4 x 1/4

WELD REQ'D:
FOR 3/16" FILLET: $3/16(5)(.707) = 663$ #/IN
$1864/663 = 2.8$" WELD BOTH SIDES = 8" ok

STAND LEGS:

REAR (DOWNSTREAM) LEGS:

VERTICAL LOAD FROM MAGNET = 1864.1#
VERTICAL LOAD DUE TO 6000# HORIZONTAL LOAD = 4630.0#
6494.1#

DESIGN FOR 6500# VERT + 3000# HORIZ. LOAD

LEG LENGTH = 89.786" − 20.906"
= 68.88"

TRY 4×4×¼ TUBE

$A = 4(4) - 3.5(3.5) = 3.75 \text{ IN}^2$

$S = 4(4)^3 - 3.5(3.5)^3 / 6(4) = 4.41 \text{ IN}^3$

$I = 4(4)^3 - 3.5(3.5)^3 / 12 = 8.83 \text{ IN}^4$

$r = \sqrt{I/A} = \sqrt{8.83/3.75} = 1.53$

$L/r = 68.88/1.53 = 45$

$S_1 < L/r < S_2$

$\therefore F_a = 20.2 - 0.126\, L/r$ p.40 TAB 3.3.27
$= 14.53$ KSI

$f_v = 6500/3.75 = 1734$ psi

SHEAR:
$h/t = 4/0.25 = 16$

$h/t < S_1$
$\therefore F_v = 7.5$ KSI p.40 TAB 3.3.27

$f_v = 3000/3.75 = 800$ psi

COMBINED LOADING:
$f_a/F_a + f_v/F_v = 1734/14530 + 800/7500$
$= 0.226 < 1.0$ ok

USE TUBE 4×4×¼

LEG BASE PLATE:
LOADS: 6500 COMPRESSION
6085 TENSION

TRY 8X8 PLATE:
CONCRETE STRENGTH = f'c = 4000 PSI

FROM AISC P 3-107

$A_{PL} = P/0.7f'_c$

$= 6500/0.7(4000)$

$= 2.32 IN^2 < (8)^2 = 64 IN^2$ OK

$f_p = 6500/64 = 101.6 PSI$

$0.95d = 0.95(4)$
$= 3.8$

$m = (8 - 3.8)/2$
$= 2.1''$

$F_b = 16 KSI$ WEAK AXIS WITHIN 1" WELD
P40 TAB 3.3.27

$t_{PL} = 2m\sqrt{f_p/F_y}$

$= 2(2.1)\sqrt{102/16000} =$
$= \underline{0.33''}$

FOR UPLIFT:
$6085/4 = 1521\#/BOLT$

FOR 1/2" ϕ HILTI DROP-IN ANCHORS:
ALLOW. TENSION = 1840#
BOLT SPACING = 6", USE LOAD ADJUSTMENT FACTOR OF 0.85
$1840(0.85) = 1564\#/BOLT$

SHEAR = $3000/4 = 750\#/BOLT$

ALLOW. SHEAR = 2760×0.85
$= 2346\#/BOLT$

FOR COMBINED LOAD:

$1521/1564 + 750/2346 = 1.29 > 1.0$ NG.

TRY 5/8" ϕ DROP-IN ANCHORS:
ALLOW. TENSION = 2630#/BOLT
ALLOW SHEAR = 4510#

LOAD ADJUSTMENT FACTOR FOR 6" SPACING
= 0.61
ALLOW. TENSION = 0.61(2630) = 1578#
ALLOW. SHEAR = 0.6(4510) = 2751#

1521/1578 + 750/2751 = 1.24 > 1.0 NG.

TRY 3/4" ϕ DROP-IN ANCHORS
ALLOW. TENSION = 3830#
ALLOW. SHEAR = 5580#

LOAD ADJUSTMENT FACTOR FOR 6" SPACING
= 0.50
ALLOW. TENSION = 3830(0.50) = 1915#
ALLOW. SHEAR = 5580(0.50) = 2790

1521/1915 + 750/2790 = 1.06 WITHIN 10%
OK

USE 3/4" ϕ STAINLESS HILTI DROP-IN ANCHORS

WELD BETWEEN LEG & BASE PL:
FROM P56, TABLE 7.1.3.2, ALLOW. SHEAR STRESS = 5.0 KSI

FOR 3/16" WELD, ALLOW LOAD = 3/16(5.0)(.707) = 663#/IN

MAX. ALLOW. LOAD PER SIDE OF TUBE = 4(663)
= 2652#

2652 × 2 SIDES = 5304" < 6085# - NG.

FOR 1/4" WELD, ALLOW LOAD = 1/4(5.0)(.707) = 0.884 K/IN
MAX. ALLOW LOAD PER SIDE OF TUBE = 4(0.884)(1000)
= 3535#

3535 × 2 SIDES = 7070# > 6085# ok

∴ 2 SIDES OF TUBE CARRY VERT. LOAD = 6085#
& 2 SIDES OF TUBE CARRY HORIZ. LOAD = 3000#

USE 1/4" FILLET ALL AROUND OK

BOLTS CONNECTING TOP PLATE TO FRAME

USE ASTM A193 GRADE B8 OR B8M
$F_y = 30,000$ PSI $F_T = 75,000$

BOLTS HOLDING UPSTREAM LEGS:

DESIGN LOADS:
TENSION = 6085/4 BOLTS = 1521#/BOLT
SHEAR = 3000/4 BOLTS = 750#/BOLT

FOR 18-8 OR 316 STAINLESS FASTENERS

TENSILE STRENGTH = 100 000 PSI
YIELD STRENGTH = 65000 PSI

A307 STEEL $F_T = 60,000$ PSI ∴ USE
ALLOWABLES FOR A307 BOLTS

$F_T = 20$ KSI $F_S = 10.0$ KSI

FOR 3/4"ϕ BOLTS

$\pi(0.75)^2/4 = 0.4418$

$F_T = 20,000(0.4418) = 8836$#
$F_S = 10,000(0.4418) = 4418$#

$f_t = 1521/0.4418 = 3443$ PSI
$f_s = 750/0.4418 = 1698$ PSI

$3443/20,000 + 1698/10,000 = 0.342 < 1.0$ OK

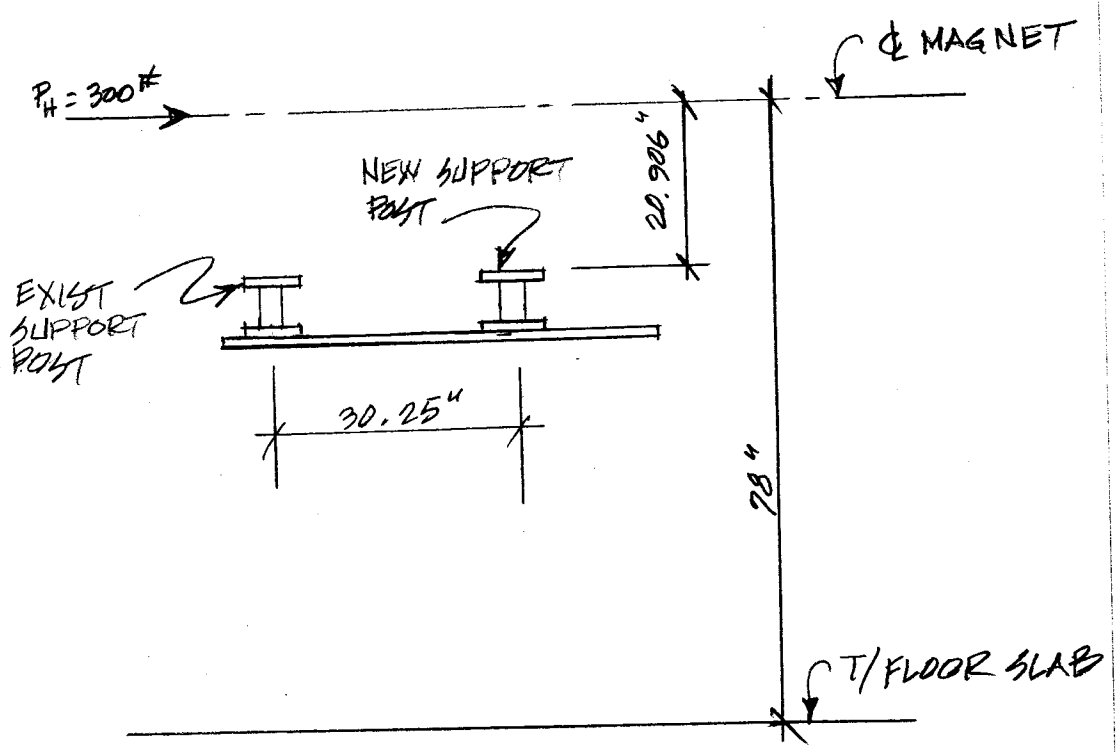
USE 3/4"ϕ BOLTS

MuCool | MAGNET SUPPORT STAND MODIFICATION | R.J. WOODS OCT. 16, 2008 | 1

℄ MAGNET RAISED TO 78" ABOVE EXIST. FLOOR
NEW HORIZONTAL LOAD = 256# (FROM Z. TANG ANALYSIS)
USE 300#

REMOVE EXIST. MAGNET LEVELER AND USE 2 NEW REAR SUPPORTS SIMILAR TO FRONT SUPPORTS.

CHECK NEW REAR SUPPORTS:



NEW SUPPORT POST:

COMPARE STAINLESS STEEL TO ALUMINUM

STAINLESS

3" SCH 40 SS
OD = 3.5
ID = 3.068

$$A = \frac{\pi(3.5^2 - 3.068^2)}{4}$$
$$= 2.23 \text{ IN}^2$$

L = 5.75"
E = 29,000,000 PSI

$$r = \frac{\sqrt{d_1^2 + d_2^2}}{4}$$
$$= \frac{\sqrt{3.5^2 + 3.068^2}}{4}$$
$$= 1.16$$

ALUMINUM

3" SCH 40 AL
OD = 3.5
ID = 3.068

$$A = \frac{\pi(3.5^2 - 3.068^2)}{4}$$
$$= 2.23 \text{ IN}^2$$

L = 5.75"
E = 10,000,000 PSI

$$r = \frac{\sqrt{d_1^2 + d_2^2}}{4}$$
$$= \frac{\sqrt{3.5^2 + 3.068^2}}{4}$$
$$= 1.16$$

DEAD WEIGHT OF CRYOSTAT W/150 LITERS OF LIQUID HELIUM
= 2600#

IF 3 OF 4 SUPPORTS TAKE LOAD:
2600#/3 = 867#

HORIZONTAL LOAD = 300#
MOMENT ARM = 20.906"
M = 300(20.906)
= 6272#-IN

VERTICAL LOAD FROM HORIZ. LOAD:
= 6272/30.25
= 207#

TOTAL VERT. LOAD = 867 + 207
= 1074# USE 1075#

3" SCH 40 SS

$\Delta = PL/AE$
$= \frac{1075(5.75)}{2.23(29{,}000{,}000)}$
$= 0.0001"$

3" SCH 40 AL

$\Delta = PL/AE$
$= \frac{1075(5.75)}{2.23(10{,}000{,}000)}$
$= 0.0003"$

AXIAL LOAD = 1075#

$Kl/r = \frac{2.0(5.75)}{1.16}$
$= 9.91 < 200$ OK

$L/r = 5.75/1.16$
$= 4.96 < 9.5$
$\therefore F_c = 12.0$ KSI TAB. 3.3.27 P. 40 ALUMINUM SPECF.

$C_c = \sqrt{\frac{2\pi^2 E}{F_y}} = \sqrt{\frac{2\pi^2(29{,}000000)}{35{,}000}}$
$= 128$

$f_c = P/A = 1075/2.23$
$= 482$ psi $< 12{,}000$ psi
OK

$$F_a = \frac{\left[1 - \frac{(Kl/r)^2}{2C_c^2}\right]F_y}{5/3 + \frac{3(Kl/r)}{8C_c} - \frac{(Kl/r)^3}{8C_c^3}}$$

$$= \frac{\left[1 - \frac{(1.16)^2}{2(128)^2}\right]35}{5/3 + \frac{3(1.16)}{8(128)} - \frac{(1.16)^3}{8(128)^3}}$$

$= 21.0$ KSI > 482 psi OK

HORIZ. LOAD = 300#
USE 3 LEGS
P_H / SUPPORT = 300/3
= 100#

$M = 100(5.75)$
$= 575$ #-IN

$f_b = M/S = 575/1.72$
$= 334$ psi

$S = \frac{\pi(d_1^4 - d_2^4)}{32 d_1}$

$= \frac{\pi(3.5^4 - 3.068^4)}{32(3.5)}$

$= 1.72 \text{ IN}^3$

$D/t = 3.5/.216$
$= 16.2$

FROM TAB. B5.1 p 5-36 AISC:
$3300/36 = 91.7 > 16.2$

∴ PIPE IS COMPACT

$F_b = 0.66 F_y$ F3.1 P. 5-48
$= 0.66(35)$
$= 23.1$ KSI > 334 psi ok

$R = \frac{3.5}{2} - \frac{.216}{2}$
$= 1.64$

$R/t = 1.64/0.216$
$= 7.59 < 9.0$

∴ $F_b = 12.0$ KSI
TAB. 3.3.27 p40
ALUM. SPEC.

$f_b < F_b$
$334 < 12{,}000$ ok

USE 3" ϕ SCHED 40 PIPE, EITHER STAINLESS STEEL OR ALUMINUM.

CHECK POST MOUNTING PLATES:

LENGTH FROM TOP OF TOP PLATE TO BOTTOM OF BOTTOM PLATE:
$= 0.75 + 5.75 + 0.75$
$= 7.25"$

$M = 7.25(300)$
$= 2175$ #-IN

SPACING OF BOLT HOLES = 5"

VERTICAL LOAD = 2175/5
= 435#

MOMENT ON PLATE = 435(2.5")
= 1088 #-IN

$S_y = 5(0.75)^2/6$
$= 0.469 \text{ IN}^3$

MOMENT ON PLATE DUE TO VERT. LOAD:

$P = 867\#$

PLATE SIZE $= 7'' \times 5''$

$w = 867/7 \times 5$

$= 25\ \#/IN^2$

$P = 25(3.5 \times 5)$ (FOR 1 SIDE OF PLATE)

$= 438\#$

MOMENT ARM $= 3.5/2$

$= 1.75''$

$M = 438(1.75)$

$= 767\ \#\text{-}IN$

COMBINED MOMENT $= 1088 + 767$

$= 1855\ \#\text{-}IN$

$f_b = 1855/0.469$

$= 3955\ psi$

FIND ALLOWABLE LOAD FOR 6061-T6 ALUMINUM
USE "SPECIFICATIONS FOR ALUMINUM STRUCTURES" p 40

$t = 5''$ $d = 0.75''$ $L_b = 7.0/2$

$= 3.5''$

$d/t = 0.75/5$

$= 0.15$

$\sqrt{L_b/d} = \sqrt{3.5/0.75}$

$= 2.16$

$d/t\sqrt{b/d} = 0.15(2.16)$

$= 0.32 < 26 \therefore F_b = 16^{KSI}$ (FOR 1" FROM WELD)

SINCE $f_b = 3955$ WHICH IS $< 16{,}000$

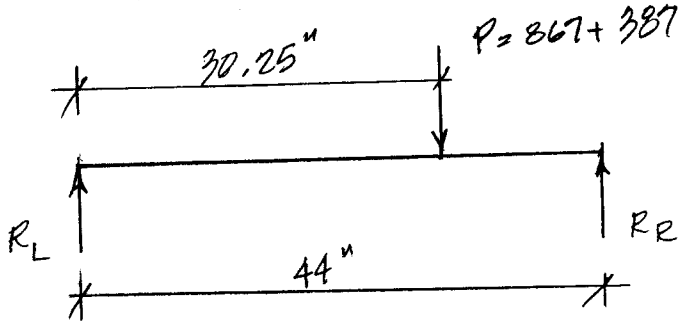
PLATE IS OK FOR BENDING → USE 3/4" THICK PLATE

STAND REDESIGN

TOP HORIZONTAL TUBES - LONG SIDE
SPAN = 44" TRY TS 4 x 4 x 1/4 6061-T6 ALUMINUM

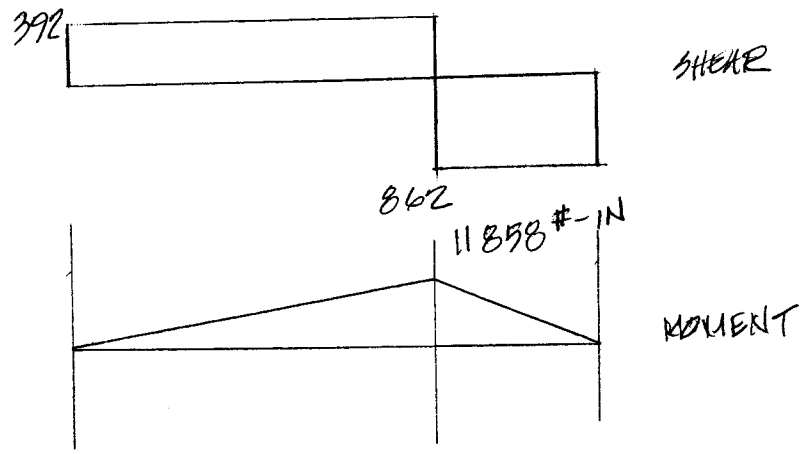
LOADS:
VERT. = 867#
VERT. LOAD DUE TO MAGNET QUENCH = (300# x 78"/30.25")/2
= 387#

P = 867 + 387 = 1254#



R_L = 1254(44 - 30.25)/44
= 392#

R_R = 1254(30.25)/44
= 862#



S = 4.41 IN³ (P. VI-36 ALUM. MANUAL)

f_b = 11858/4.41
= 2689 psi

SLENDERNESS:
L_b = 44 S_c = 4.41 I_y = 8.83

$L_b S_c / I_y = 44(4.41)/8.83$

$= 22 < 146 \therefore F_b = 12^{KSI}$ (p. 40) (WITHIN 1" OF WELD)

$f_b < F_b$

$2689 < 16{,}000$ ok

SHEAR AREA $= 2(0.25 \times 4.0)$
$= 2.0 \text{ IN}^2$

SHEAR STRESS $= 1254/2.0$
$= 627$ PSI

$h = 4 \quad t = 0.25 \quad h/t = 4/0.25$
$= 16 < 32 \therefore F_V = 7.5^{KSI}$

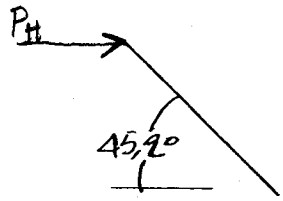
$627 < 7{,}500$ ok USE TS 4x4x0.25

DIAGONAL BRACE – LONG
LENGTH = 57" ANGLE = 45.2°
$r = 1.53$
$L/r = 57/1.53$
$= 37$

ALLOW. STRESS
TENSION = 11.0 KSI
COMPRESSION = 12.0 KSI

ALUM. MANUAL SPEC. NO.
1
7

SINCE BRACE CAN BE IN TENSION OR COMPRESSION, USE SMALLER TENSION VALUE OF 11.0 KSI



HORIZ LOAD = 300#
$P_H = 300/2$ (1/2 EA. SIDE)
$= 150$#

AXIAL LOAD:
$P_A = 150/\cos 45.2°$
$= 213$#

$f_A = 213/3.75$
$= 56.8$ psi $< 11{,}000$ psi
ok

USE TS 4x4x0.25

LOAD ON SHORT BRACE = 10% VERT. LOAD
= 10% 2600#
= 260#

SINCE BRACE IS SHORTER AND LOAD IS SMALLER, USE SAME SIZE TUBE FOR SHORT BRACE.

STAND LEGS:

MAXIMUM LEG LOAD = 867# + 387#
= 1254#

$f_A = P/A$
= 1254/3.75
= 334 psi

LEG LENGTH = 42"
L/r = 42/1.53
= 28

FROM ALUMINUM MANUAL P. 40 SPEC. NO 7
WITHIN 1" WELD F_A = 12 KSI

334 < 12,000 psi ok
USE TS 4x4x0.25

ANCHOR BOLTS:

HORIZONTAL LOADS:
IN LONG DIRECTION 300#
IN SHORT DIRECTION 10% 2600# = 260#
RESULTANT LOAD:
$\sqrt{300^2+260^2}$ = 397#

VERTICAL LOAD
MAXIMUM UPLIFT LOAD:
300 (78)/44 = 532#
FOR EA. FRONT LEG, LOAD = 532/2
= 266#

WT. OF MAGNET PER LEG = 2600/4
= 650#

650 - 266 = 384# DOWN FORCE
∴ NO UPLIFT & NO TENSION IN ANCHOR BOLTS

IF TOTAL HORIZONTAL LOAD IS CARRIED BY ONE LEG, LOAD PER BOLT = 397/4
= 99#/BOLT

FOR 3/4" ø HILTI DROP-IN:
ANCHOR SPACING = 7 3/4" c TOC

FROM HILTI TECH GUIDE P. 136

$f_A = 0.33 \frac{s}{h_{nom}} - 0.17$
= 0.33((7.75)/3.1875) - 0.17
= 0.63

ALLOWABLE SHEAR = 5000(0.63)
= 3162# > 99# ok USE 3/4" ø HILTI

CONNECTION BETWEEN MAGNET LEGS AND STAND PEDISTALS:

OF BOLTS @ EA. LEG = 2
BOLT SIZE = 1/2" ϕ

VERTICAL LOAD FROM PAGE 2, THIS CALCULATION = 207# TENSION

HORIZONTAL LOAD FROM PAGE 2, THIS CALCULATION = 300# TOTAL

CONSERVATIVELY USE LOAD APPLIED TO ONE LEG

$f_t = 207/2\text{ BOLTS} \times 0.1963\text{ IN}^2$
$= 527\text{ PSI}$

F_T FOR GRADE 5 BOLTS $= 26 - 1.8 f_v \leq 20$ KSI (AISC P. 5-74 TAB. J3-3)
$f_v = 300/2\text{ BOLTS} \times 0.50\text{ IN}^2$
$= 300\text{ PSI}$

$F_T = 26 - 1.8(0.527) \leq 20$
$= 25.1 \rightarrow$ USE 20 KSI MAX

$F_V = 10.0$ KSI (AISC P. 5-73 TAB J3.2)

$f_v/F_V + f_t/F_T \leq 1.0$

$300/10000 + 207/20{,}000 = 0.040 < 1.0$ OK

USE 1/2" ϕ GRADE 5 BOLTS

CONNECTION BETWEEN MAGNET MOUNTING PLATE AND STAND:

OF BOLTS = 8 FRONT AN 2 REAR
BOLT SIZE = 3/4" ϕ

VERTICAL REACTION FROM QUENCH LOAD OF 300#:
$M = 300 \times (20.906 + 8.25)$
$= 8747\text{ \#-IN}$

DISTANCE BETWEEN FRONT & REAR LEGS = 30.69"
$P_V = 8747/30.69$
$= 285\#$

HORIZONTAL LOAD PER BOLT = 300/10
= 30#/BOLT

VERTICAL LOAD PER BOLT = 285/2X2 (REAR LEGS IN TENSION)
= 71.25#

f_v = 30/0.4418
= 68 psi

f_t = 71.25/0.4418
= 161 psi

F_T = 26 − 1.8(0.068)
= 25.9 KSI → USE MAX 20 KSI

F_V = 10 KSI (AISC P. 5-73 TAB. J3.2)

$.068/10 + .161/20 \overset{?}{\leq} 1$

= 0.015 < 1.0 ok USE ¾"ϕ GRADE 5 BOLTS

LEG WELDS:
TOP MEMBERS
END WELD TO LEG
BUT WELD
THROAT AREA = s(L − 2s) s = TUBE THICKNESS
= 0.25(4 − 2(0.25)) L = LENGTH OF WELD
= 0.875 IN² EA. SIDE

MAX LOAD = 862#
f_v = 862/2(0.875)
= 493 psi
F_V = 7.0 KSI (TAB. 7.1.3.2 ALUM. MANUAL)
7,000 psi > 493 psi ok

DIAGONAL BRACE
END WELD TO LEG
BUTT WELD
LENGTH OF WELD
TOP HORIZONTAL = 3.26"
TOP VERTICAL = 2.39"
HORIZONTAL THROAT AREA = 0.25(3.26 − 2(0.25))
= 0.69 IN² EA. SIDE

HORIZ. LOAD = 300#
f_v = 300/2(0.69)
= 22 psi < 7000 psi ok

VERTICAL LEGS @ BASE
FILLET WELD ALL AROUND
MAX HORIZ. LOAD = 300#
MAX VERT. LOAD = 862# (UPLIFT)

$a_{WELD} = 0.707(3/16)$
$= 0.133 \text{ IN}^2/\text{IN}$

THROAT AREA $= a_{WELD}\, 2(H+B)$
$= 0.133 \times 2 \times (4+4)$
$= 2.13 \text{ IN}^2$

$f_H = 300/2.13$
$= 141 \text{ PSI}$

$f_T = 862/2.13$
$= 405 \text{ PSI}$

$f_H/F_H + f_T/F_T = 141/7000 + 405/7000$
$= 0.020 + 0.058$
$= 0.078 < 1.0$ OK

NO COOL TRANSFER LINE

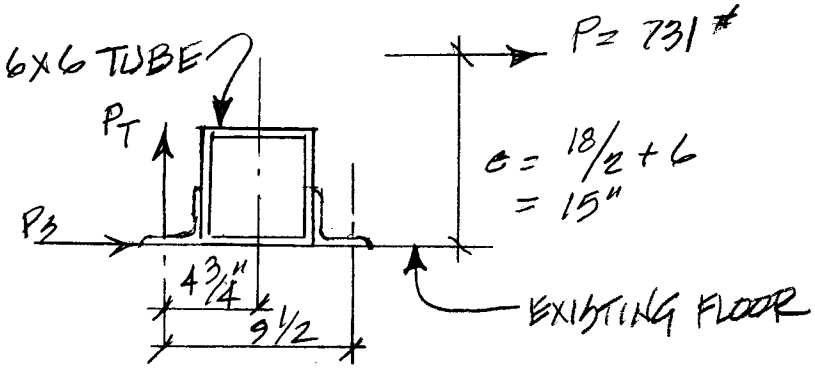
R.J. HOODS
DEC 12, 2008

PART H
SHEILD BLOCK FLOOR

CHECK SHIELD BLOCK SUPPORT TUBE:

"A" BLOCK WT. = 1.5(3.0)(7.5)(150) = 5063 #
LIVE LOAD = 3.0(7.5)(100 #/FT²) = 2250 #
FOR HORIZONTAL LOAD = 10% VERT:

10%(5063 + 2250) = 731 # PER "A" BLOCK



HORIZONTAL MOMENT = 731(15") = 10,965 #-IN

RESISTING ARM OF TUBE = 4 3/4"

P_T = 10965/4.75 = 2308 #

P_S = 731/2 = 366 #

FROM "HILTI NORTH AMERICA PRODUCT TECHNICAL GUIDE."

RECOMMENDED WORKING LOAD: TENSION:

$N_{REC} = N_{ALL} \times f_A \times f_{RN}$

RECOMMENDED WORKING LOAD: SHEAR:

$V_{REC} = V_{ALL} \times f_A \times f_{RV}$.

COMBINED LOADING:

$$\left(\frac{N_d}{N_{REC}}\right)^{5/3} + \left(\frac{V_d}{V_{REC}}\right)^{5/3} \leq 1.0$$

N_d = ACTUAL TENSION LOAD
V_d = ACTUAL SHEAR LOAD

FOR 5/8"φ STAINLESS DROP-IN ANCHORS:

$$f_A = 0.33\left(S/h_{nom}\right) - 0.17 = 0.33\left(\frac{9.5}{2.5625}\right) - 0.17$$
$$= 1.05 \rightarrow \text{USE } 1.0$$

FROM TABLE ON PAGE 135 N_{ALL} = 2630
V_{ALL} = 4510

SINCE ANCHORS INSTALLED IN FLOOR, f_{RN} & f_{RV} = 1.0

$N_{REC} = N_{ALL} \times f_A \times f_{RN} = 2630 \times 1.0 \times 1.0$
$= 2630\#$

$V_{REC} = V_{ALL} \times f_A \times f_{RV} = 4510 \times 1.0 \times 1.0$
$= 4510\#$

COMBINED LOADING:

$$\left(\frac{2308}{2630}\right)^{5/3} + \left(\frac{366}{4510}\right)^{5/3} \leq 1.0$$

$$(0.878)^{5/3} + (0.081)^{5/3} \leq 1.0$$

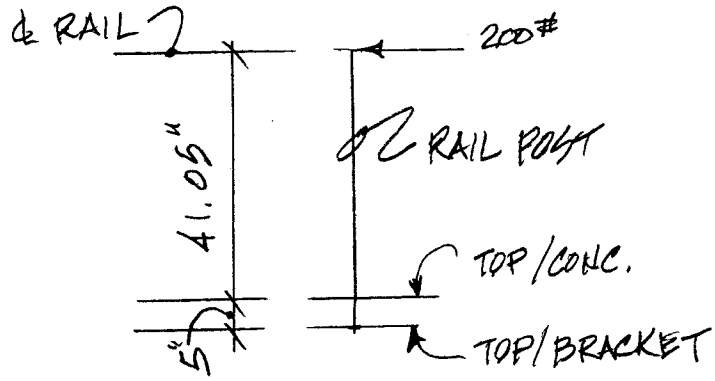
$$0.805 + 0.015 = 0.820 < 1.0 \quad \underline{ok}$$

SINCE THERE ARE 3 - 6X6 TUBE SUPPORTS AND ONE TUBE SUPPORT CAN CARRY THE HORIZONTAL FORCE, THERE IS A MINIMUM 3 TO 1 SAFETY FACTOR <u>ok</u>

NOT USED (2/9/07)

RAILING:

RAIL HT. = 42" TO TOP SURFACE



$M = (41.05 + 5)(200\#)$
$= 9210\#\text{-IN}$

FOR SCHEDULE 80 1½ϕ ALUMINUM PIPE, $S_x = 0.412 \text{ IN}^3$
$I_x = 0.391 \text{ IN}^4$
$A = 1.068 \text{ IN}^2$

$f_b = 9210/0.412$
$= 22{,}354 \text{ PSI}$

FOR 6061-T6 ALUMINUM PIPE F_T ALLOW = 24,000 psi > 22,354 <u>ok</u>

∴ USE 1½" ϕ SCHED 80 PIPE

NOT USED (2/9/07)

SUPPORT BRACKET:

LOAD ON BOLTS:

$28252/6'' = 4709^{\#}$ T OR C

FOR 2 BOLTS:
LOAD PER BOLT $= 4709/2$
$= 2355^{\#}$

FOR 5/8" ϕ SS DROP-IN ANCHORS:

$P_T = 2630^{\#}$
SPACING FACTOR FOR 6" = 0.61
EDGE DIST. FACTOR FOR 6" = 0.87

$P_{ALLOW} = 2630(0.61)(0.87)$
$= 1396^{\#}$/BOLT < 2355 N.G.

FOR 3/4" ϕ SS DROP-IN ANCHORS:
$P_T = 3830^{\#}$
SPACING FACTOR FOR 6" = 0.50

$P_{ALLOW} = 3830(0.50)$
$= 1915^{\#}$/BOLT < 2355 N.G.

TRY 8" SPACING:
SPACING FACTOR FOR 8" = 0.67
$P_{ALLOW} = 3830(0.67) = 2566^{\#} > 2355^{\#}$ ok

USE 3/4" ϕ SS DROP IN ANCHORS W/ 8" MIN. SPACING

DETERMINE PLATE THICKNESS:
$P = 4709^{\#}$, SPAN = 8" BETWEEN BOLTS

MAX. STRESS WILL OCCUR WITHIN 1" OF WELD
$\therefore f_b = 16$ KSI $= 16{,}000$ PSI

$M = Pl/4 = 4709(8)/4$
$= 9418$ #-IN

$S_{YREQ'D} = 9418/16{,}000$
$= 0.589\ IN^3$

$0.589 = 8(t)^2/6$
$0.665'' = t$

USE 3/4" THICK PLATE

NOT USED (2/9/07)

HORIZONTAL RAILS:

MAX SPAN FOR 1½" SCHED 40 ALUM. PIPE:

$F_b = 24$ KSI $= 24{,}000$ PSI (OVER 1" AWAY FROM WELD)

$S = 0.326$

$24{,}000 = M_{MAX}/0.326$

$7824 = M_{MAX}$

$P \cdot l/4 = 200(l)/4 = 7824$

$l = 156" \approx 13.0$ FEET

MAX. SPACING PER OSHA = 8'-0"

TRY 1/2" ϕ SS DROP-IN ANCHORS

ALLOWABLE WORKING LOADS: (4000 PSI CONC.) P. 135

TENSION = 1840#
SHEAR = 2760#

SPACING ADJUSTMENT FACTOR:

$$f_A = 0.33\, s/h_{nom} - 0.17$$
$$= 0.33\,(9.5/2) - 0.17$$
$$= 1.40 \text{ USE } 1.0$$

EDGE DISTANCE ADJUSTMENT FACTOR = 1.0
SINCE ANCHOR IS IN FLOOR SLAB.

TENSION:

$$N_{rec} = N_{all} \times f_A \times f_{rn}$$
$$= 1840 \times 1.0 \times 1.0$$
$$= 1840\#$$

SHEAR:

$$V_{rec} = V_{all} \times f_A \times f_{RV}$$
$$= 2760 \times 1.0 \times 1.0$$
$$= 2760\#$$

FOR 3 ROWS OF TUBE SUPPORTS:

$$N_d = 2308/3$$
$$= 769\#$$
$$V_d = 366/3$$
$$= 122\#$$

COMBINED LOADING:

$$\left(\frac{769}{1840}\right)^{5/3} + \left(\frac{122}{2760}\right)^{5/3} \leq 1.0$$

$$0.234 + 0.006$$

$0.240 < 1.0$ OK USE 1/2" ϕ ANCHORS

CHECK BLOCK SUPPORT TUBE:

"A" BLOCK WT.:

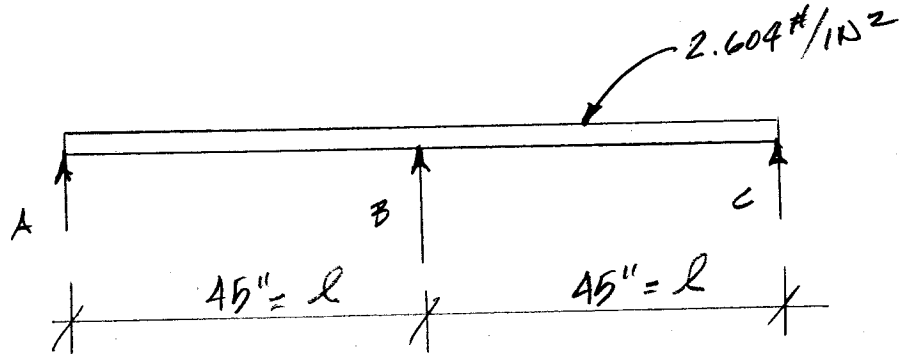
$150\ \#/FT^3 \times 7.5 \times 3.0 \times 1.5 = 5063\#$

PER SQUARE FOOT LOAD $= 150(1.5) = 225\ \#/FT^2$

LIVE LOAD $= 150\ \#/FT^2$

$375\ \#/FT^2$

$= 2.604\ \#/IN^2$



$R_A = R_C = 3/8\ wl$
$= 3/8(2.604)(45)$
$= 43.94\ \#/IN$

$R_B = 1.25\ wl$
$= 1.25(2.604)(45)$
$= 146.475\ \#/IN$

ULTIMATE LOADS:

$225(1.4) + 150(1.7) = 570\ \#/FT^2 = 3.958\ \#/IN^2$

BENDING:

$M_{ULT\ MAX} = -1/8\ wl^2$ OVER CENTER SUPPORT
$= -1/8(3.958)(45)^2$
$= 1001.9\ \#\text{-}IN/IN$

FOR 36" BLOCK WIDTH $M_{ULT\ MAX} = 36(1001.9)$
$= 36068\ \#\text{-}IN$

REINF. STEEL @ TOP BLOCK = 3 - #7 BARS
$A_s = 3(0.60) = 1.8\ IN^2$

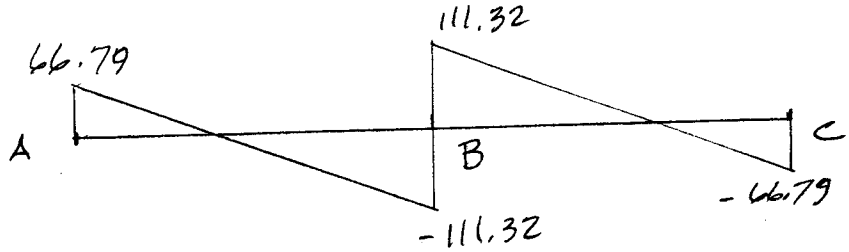
$d = 18" - (2.75) = 15.25"$

$a = A_s f_y / 0.85(f'c)(b) = \dfrac{1.8(60{,}000)}{0.85(5000)(36)}$
$= 0.706"$

$\phi M_u = \phi A_s f_y (d - a/2) = 0.9(1.8)(60{,}000)(15.25 - \frac{0.706}{2})$
$= 1{,}447{,}988\ \#\text{-}IN$

$M_u = 36(1001.9) = 36{,}068\ \#\text{-}IN < 1{,}447{,}988$ OK

SHEAR:



ULTIMATE LOADS:

$R_A = R_C = 3/8\, w l = 3/8\, 3.958(45)$
$= 66.79\ \#/IN$

$R_B = 1.25\, w l = 1.25(3.958)(45)$
$= 222.64\ \#/IN$

TOTAL MAXIMUM ULTIMATE SHEAR $= 36(111.32)$
$= 4007.5\#$

$V_u \leq \phi V_n$ (ACI 11.1.1)

$\phi = 0.85$ (ACI 9.3.2.3)

$V_u = 4007.5\# = 4007.5/36(15.25)$
$= 7.3$ PSI

$V_n = V_c + V_s$

$V_c = 2\sqrt{f'c}\ b_w d = 2(\sqrt{5000})(36)(15.25)$
$= 77640\#$

$V_{c\,max} = 3.5\sqrt{f'c}\ b_w d = 3.5\sqrt{5000}\,(36)(15.25)$
$= 135,871\# > 77640\#$

USE 77,640#

11.5.6.2:

$V_s = \dfrac{A_v f_y d}{s} = \dfrac{2(0.20)(60000)(15.25)}{15}$
$= 24\,400\#$

11.5.6.8:

$V_{s\,max} = 8\sqrt{f'c}\ b_w d = 8\sqrt{5000}\,(36)(15.25)$
$= 310\,561\# > 24\,400\#$

USE 24,400#

$\phi V_n = 0.85(77\,640 + 24\,400) = 86\,734\# > 4008\#$ ok

6X6 ALUMINUM TUBES:

MAXIMUM LOAD ON CENTER TUBE = 146.5 #/IN

AREA OF VERTICAL SIDES = 2(6)(0.5)
= 6 IN²

COMPRESSIVE STRESS = 146.5/6
= 24.4 psi

ALLOW. LOAD:

$L = 6''$ $r = \sqrt{\frac{d_1^2 - d_2^2}{12}} = \sqrt{\frac{6^2 - 5^2}{12}} =$
$= 0.957$

$L/r = 6/0.957 = 6.27 < 9.5$

$\therefore$ F_a allow. = 19 KSI = 19000 psi (P. 40)

19000 psi < 24.4 psi ok

TRY 6×6×1/4 TUBE

$r = \sqrt{\frac{6^2 - 5.5^2}{12}} = 0.692$

$L/r = 6/0.692 = 8.67 < 9.5$

$\therefore$ F_a allow = 19 KSI

AREA OF VERT. SIDES = 2(6)(0.25)
= 3.00 IN²

146.5/3 = 48.8 psi
< 19000 psi ok

HORIZONTAL BENDING ABOUT WEAK PLATE AXIS:
USE 10% VERT. LOAD:
10% 146.5 = 14.65 #/IN

M = 14.65 × 6" = 87.9 #-IN

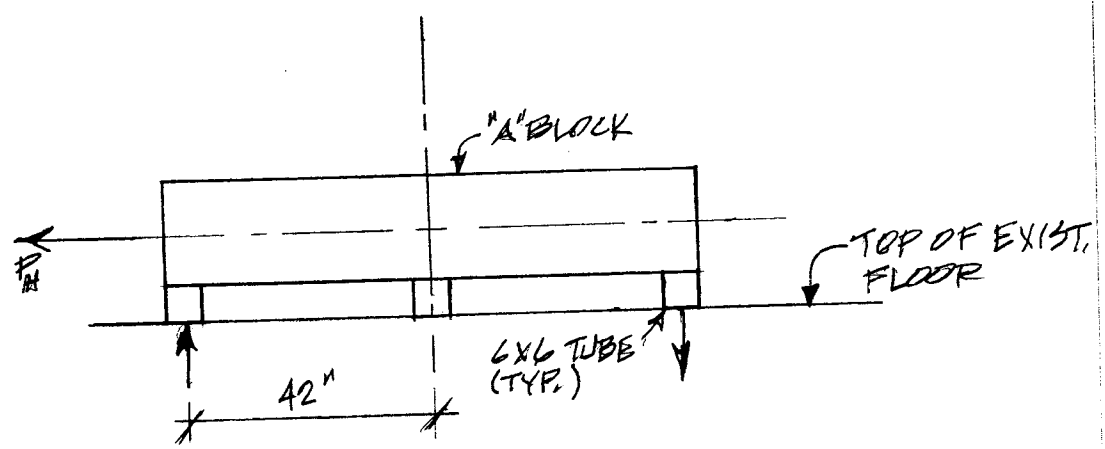
$S_y = 1(0.25)^2/6 = 0.010$ IN³

$f_b = 87.9/0.010 = 8438$ psi

ALLOW. = 28 KSI = 28,000 PSI > 8438 psi
ok

USE 6×6×1/4 TUBE

REDESIGN OF SHIELD BLOCK FLOOR SUPPORTS:



"A" BLOCK WT. = 1.5(3.0)(7.5)(150) = 5063#
LIVE LOAD = 3.0(7.5)(100#/FT²) = 2250# (NOTE REDUCED LIVE LOAD FROM 150#/FT²)

USE HORIZ. LOAD, P_H, = 10% VERT. LOAD:

10% (5063 + 2250) = 731# PER "A" BLOCK

HORIZ. MOMENT = (18"/2 + 6")·731
= 10 965 #-N

RESISTING MOMENT ARM = 7.5'(12) − 6"
= 84"

VERT. LOAD CAUSED BY HORIZ LOAD =
± 10,965/84 = ±131#

SHIELD BLOCK DEAD LOAD = 5063#
BEAM LOAD = 5063#/90"
= 56 #/IN

END REACTION = 3/8 w ℓ = 3/8 (56)(45)
= 949 # > 131 # ∴
HORIZONTAL LOAD DOES NOT CAUSE UPLIFT

HORIZONTAL LOAD IN PERPENDICULAR DIRECTION:
CENTER TUBE WILL NOT CARRY LOAD

3 (5063 + 2250)/90" = 244 #/IN

244 (90/2) = 10 980#

10% HORIZ LOAD = 0.10(10980) = 1098# PER SIDE

USE 2 BOLTS PER BLOCK EACH SIDE

EXPANSION ANCHORS IN FLOOR:

SHEAR LOAD PER ANCHOR:

SHORT SIDE = 731/(2 SIDES × 2 BOLTS)
= 183#/BOLT

LONG SIDE = 1098/6 BOLTS
= 183#/BOLT

TRY 1/2"ϕ STEEL "HILTI" DROP-IN ANCHORS:

ALLOWABLE SHEAR IN 4000 psi CONC. = 2125#/BOLT
SPACING > 7" ∴ NO REDUCTION
NO EDGE DISTANCE ∴ NO REDUCTION

RESULTANT LOAD = $\sqrt{183^2 + 183^2}$
= 259# < 2125# ok

EXPANSION ANCHORS IN SHIELD BLOCK

LONG SIDE SHEAR = 1098/6
= 183#/BOLT

TENSION SHORT SIDE = 731/2 BOLTS
= 366#/BOLT
SPACING > 7" ∴ NO REDUCTION

EDGE DISTANCE = 4.625 < 7"
∴ REDUCTION REQ'D

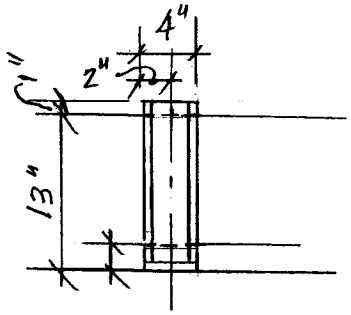
SHEAR = 0.74 ALLOW = 0.74(2125) = 1573#
TENSION = 0.85 ALLOW. = 0.85(1785) = 1517#

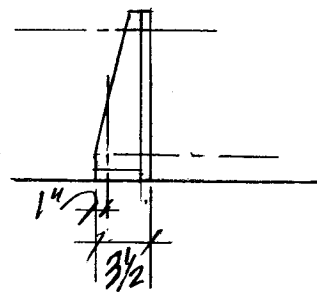
$183/1575 + 366/1517 \overset{?}{\leq} 1.0$
0.358 < 1.0 ok

USE 1/2"ϕ DROP-IN ANCHORS

ANCHOR MOUNTING BRACKET

ALL PLATES 1/2" 6061 T6
ALL HOLES 9/16" ϕ





$P_H = 366''$

$M = 366(13)$
$= 4758$ #-IN

$S_{PL} = 0.5(3.5)^2/6$
$= 1.02 \text{ IN}^3$

$f_b = 4758/1.02$
$= 4665$ psi

CHECK GUSSET
$t = 1/2''$ $d = 3.5''$ $d/t = 3.5/1/2 = 7$

FROM ALUMINUM HANDBOOK, P 40 FOR 6061-T6 ALUMINUM:

$\sqrt{L_b/d} = \sqrt{13/3.5}$
$= 1.93$

$d/t\sqrt{L_b/d} = 7(1.93)$
$= 13.49 < S_1 = 26 \therefore F_b = 16{,}000$ psi

4665 psi < 16,000 psi <u>ok</u>

CHECK BACK PLATE
$t = 1/2''$ $d = 3''$ $d/t = 3/1/2 = 6$

$\sqrt{L_b/d} = \sqrt{13/3}$
$= 2.08$

$d/t = 3/0.5$
$= 6$

$d/t\sqrt{L_b/d} = 6(2.08)$
$= 12.48 < S_1 = 26 \therefore F_b = 16000$ psi

$M = 183(13) = 2379$ #-IN

$S_{PL} = 0.5(3)^2/6$
$= 0.75 \text{ IN}^3$

$f_b = 2379/0.75 = 3{,}172$ psi < 16,000 psi <u>ok</u>

ANCHOR MOUNTING BRACKET (CONT.)

WELDS:

FROM TABLE 7.2-2 p. 1-A-66 ALUM. DESIGN MANUAL
ALLOW. SHEAR STRESS IN FILET WELDS = 7.0 KSI

FOR 1/16" WELD:

$$F_W = 7.0(.707)(1/16)$$
$$= 0.31 \text{ K/IN}$$

FOR 3/16" WELD:

$$F_W = 7.0(.707)(3/16)$$
$$= 0.928 \text{ K/IN}$$

BOTTOM PLATE TO BACK PLATE

WELD LENGTH = 3"
$P_H = 3(0.928)$
$= 2.8^K = 2{,}800^\# > 366^\#$ OK

BOTTOM PLATE TO GUSSETS

WELD LENGTH = 2(3")
= 6"
$P_H = 6(0.928)$
$= 5.6^K = 5{,}600^\# > 366^\#$ OK

USE 3/16" WELDS