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INTERNAL TECHNICAL REPORT

Title: STRESS ANALYSIS OF THE
MODIFIED PULSED NEUTRON ACTIVATION
SYSTEM DOWNSTREAM SHIELD
SUPPORT STRUCTURE

Organization: Applied Mechanics Branch

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NRC Research and Technical
Assistance Report

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LOFT TECHNICAL REPORT

Title: STRESS ANALYSIS OF THE MODIFIED PULSED NEUTRON ACTIVATION SYSTEM DOWNSTREAM SHIELD SUPPORT STRUCTURE	LTR No. LO-87-80-134 RE-A-80-047
Author: W. R. Mosby	Released By LOFT CDCS
Performing Organization: Applied Mechanics Branch R. C. Guenzler 4/24/80	Date May 28, 1980
LOFT Review and Approval: 4-30-80	Project System Engineer: R. T. Ford 4/30/80

PSB Mgr. LMD Mgr.

ABSTRACT

The modified LOFT Pulsed Neutron Activation (PNA) System downstream shielding support structure was stress analyzed for deadweight and worst-case LOCE loads. No deficiencies were found in the structure. This stress analysis was performed for the PNA Shielding Configuration that has been used on Test L3-2 and that is to be used on Test L3-7.

DISPOSITION OF RECOMMENDATIONS

Reference No. 6, LTR LO-87-79-127, will be issued at a later date. No other disposition is required. RCG/SD per telecon 5-29-80

NRC Research and Technical Assistance Report

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1. INTRODUCTION

The purpose of this investigation was to determine the adequacy of the modified Pulsed Neutron Activation system structure to support the PNA sources, detectors, and lead shielding during the most severe design loading. The loading consisted of deadweight plus acceleration due to an 8-inch, hot-leg, 0.001 second opening time LOCE. Stresses in the modified downstream detector shielding support structure and the most highly stressed portions of the existing PNA structure were calculated and compared to AISC[1] and ASME[2] Code allowables. This stress analysis was performed for the PNA shielding configuration that has been used on Test L3-2 and that is to be used on Test L3-7.

2. METHOD OF ANALYSIS

Affected portions of the existing PNA structure along with the modified downstream shielding support structure[3] were modelled using the SAP IV finite element computer program.[4]

Deadweight and three response spectrum runs (one for each of x, y, and z directions) were made. The response spectra were obtained from a computer analysis of the MTA.[5] Ten percent damping was used in generating the response spectra to account for the damping effects of the lead brick shielding.

Beam element and plate element stresses from the SAP IV runs were calculated and combined, using the absolute sum of all force components, and compared to AISC and ASME Code allowables, respectively.

Some portions of the existing PNA structure were analyzed by multiplying the results of the previous PNA stress analysis[6] by the ratio of the present shielding mass to the original shielding mass, while other parts were analyzed using the static-equivalent load method.[7]

The SAP IV computer output is not included in this report, but is available for inspection at the Applied Mechanics branch.

A listing of the SAP IV version used is included in Appendix B.

3. RESULTS

All components of the PNA shielding support structure analyzed in this investigation were found to be adequate.

Components not analyzed in this report include the actual methods of attachment of the lead shielding to the PNA source support structure, as mentioned in the previous PNA stress analysis.

4. REFERENCES

1. Manual of Steel Construction, American Institute of Steel Construction, 7th edition, 1970.

2. "Nuclear Power Plant Components," ASME Boiler and Pressure Vessel Code, American Society of Mechanical Engineers, Section III, Division 1, 1977.

3. EG&G Idaho, Inc., "LOFT Pulse Neutron Activation System," Drawing No. 210358, August 24, 1979.

4. R. C. Guenzler, IBM 360/75 and CDC7600 Versions of SAP IV, a Structural Analysis Program for Static and Dynamic Analysis of Linear Systems, TR-775, January 1976.

5. R. G. Rahl, "Stress Analysis of the LOFT Mobile Test Assembly," LTR 1110-20, February 20, 1974.

6. W. R. Mosby, "Stress Analysis of the Pulsed Neutron Activation System Support Structure," LTR LO-87-79-127, to be published.

7. RDT Standard F9-2T, Division of Reactor Research and Development, United States Atomic Energy Commission, January 1974.

APPENDIX A

PNA DOWNSTREAM SHIELDING SUPPORT STRESS ANALYSIS

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CALCULATION WORK SHEET

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I. Mateials

A. Beams, channels, plate

material - A-36 steel

S_y = 36,000 psi = yield stress

S_u = 58,000 psi = ultimate stress

ρ = .286 lb/in^3

AISC code (Ref. 1) allowable stresses were used for all structural members except plates. For plates, the stress intensities for membrane stress alone and for membrane plus bending were compared to ASME (Ref. 2) allowable stress intensities of $\frac{2}{3} S_y$ and S_y, respectively.

For structural members other than plate, the following allowable stresses were used:

F_t = allowable axial stress in tension = $.6 S_y$

F_b = allowable normal stress in bending = $.6 S_y$

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F_v = allowable shear stress = .4 S_y

$F_t = F_b$ = 21,600 psi

F_v = 14,400 psi

B. Welds

Weld metal: E7018 electrode

S_y = 60,000 psi

S_u = 72,000 psi

Allowable stress on effective area is the least of

.3(72,000) or .4(36,000) = 14,400 psi

where the weld stress is computed as

$$\sigma_w = \frac{\text{total (vector) force on weld}}{\text{(weld length)(weld throat)}}$$

C. Bolts ($\frac{1}{2}$-13 UNC, A307 steel)

F_t = allowable tensile stress based on area of .1419 in^2

F_t = 20,000 psi

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II. Arrangement of structure

Figures 1 and 2 show the physical arrangement of the structure considered in this analysis.

Figures 3, 4, and 5 show the SAP IV model of the structure used in this analysis.

III. Loading considered

The same loading used in the original PNA LOCE analysis (Ref. 6) was used in this analysis.

A plot of the spectra was shown in ref. 6 and will not be repeated here.

Static equivalent loads the same as in ref. 6 were used here:

A_x = acceleration in x-direction = 1.5 (spectrum peak) = 4.46g

A_y = 2.81g

A_z = +1.46g, −3.46g

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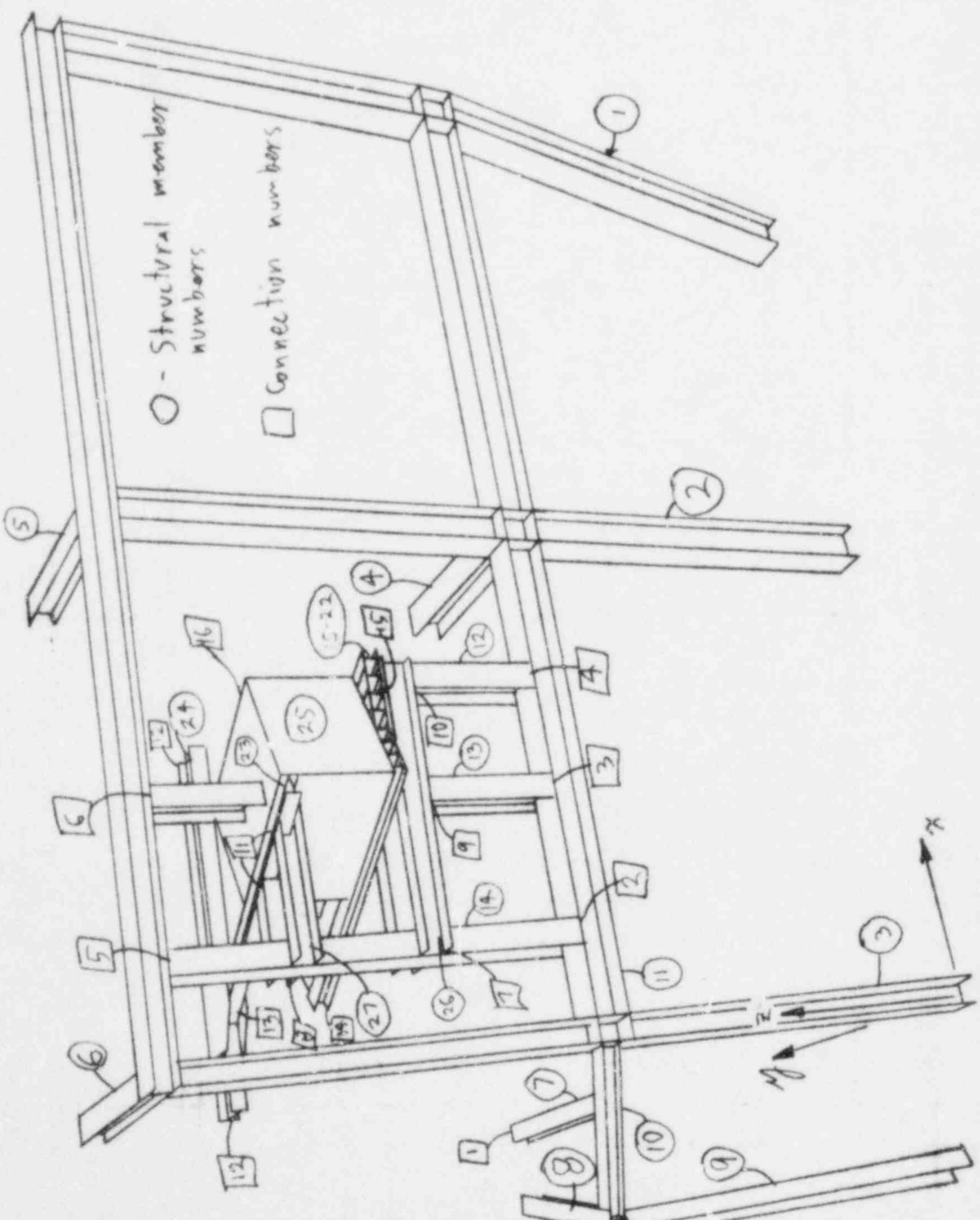

Figure 1: Overall view of shielding support structure looking toward MTA

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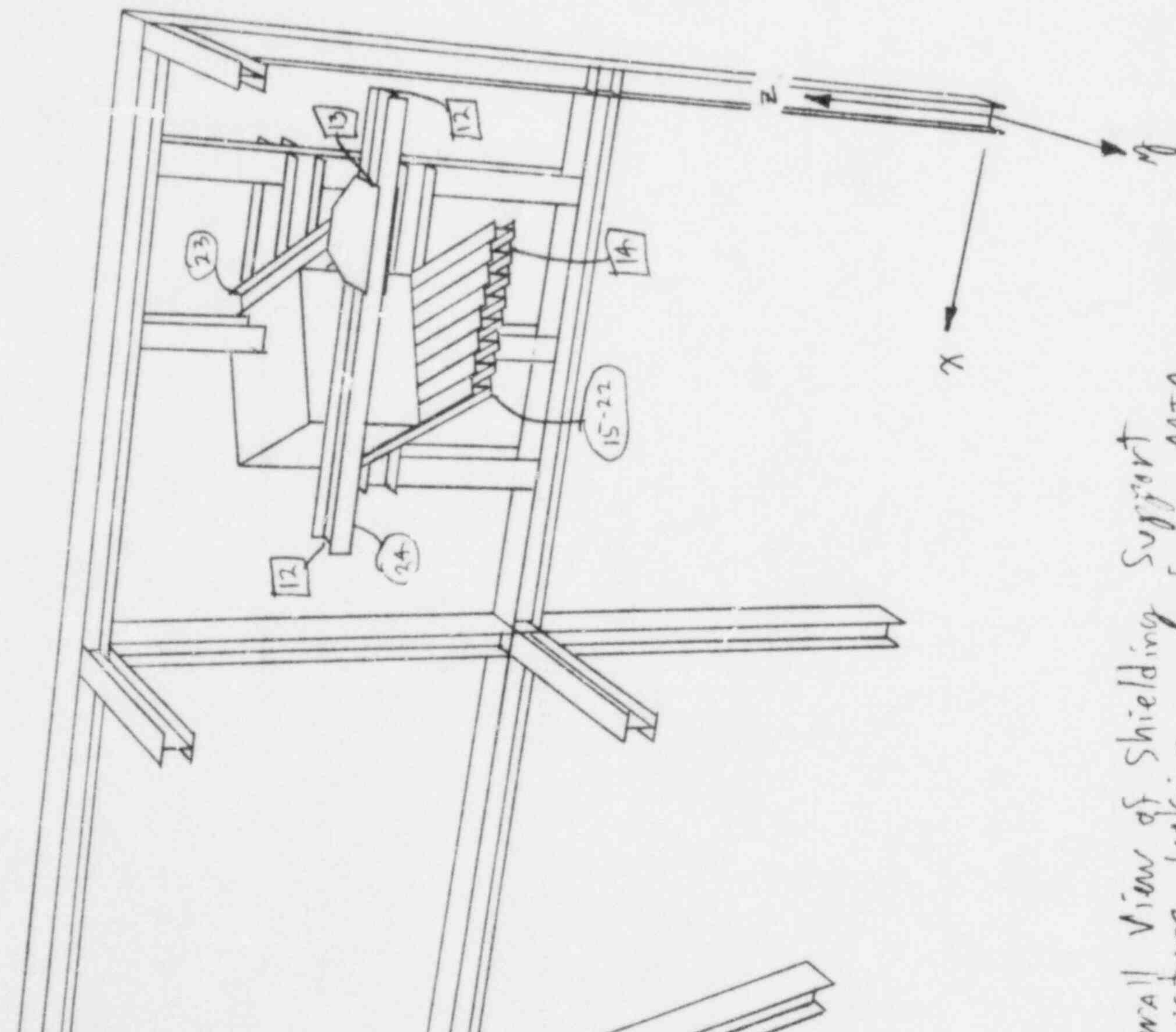

Figure 2: Overall View of Shielding Support structure, looking away from MTA

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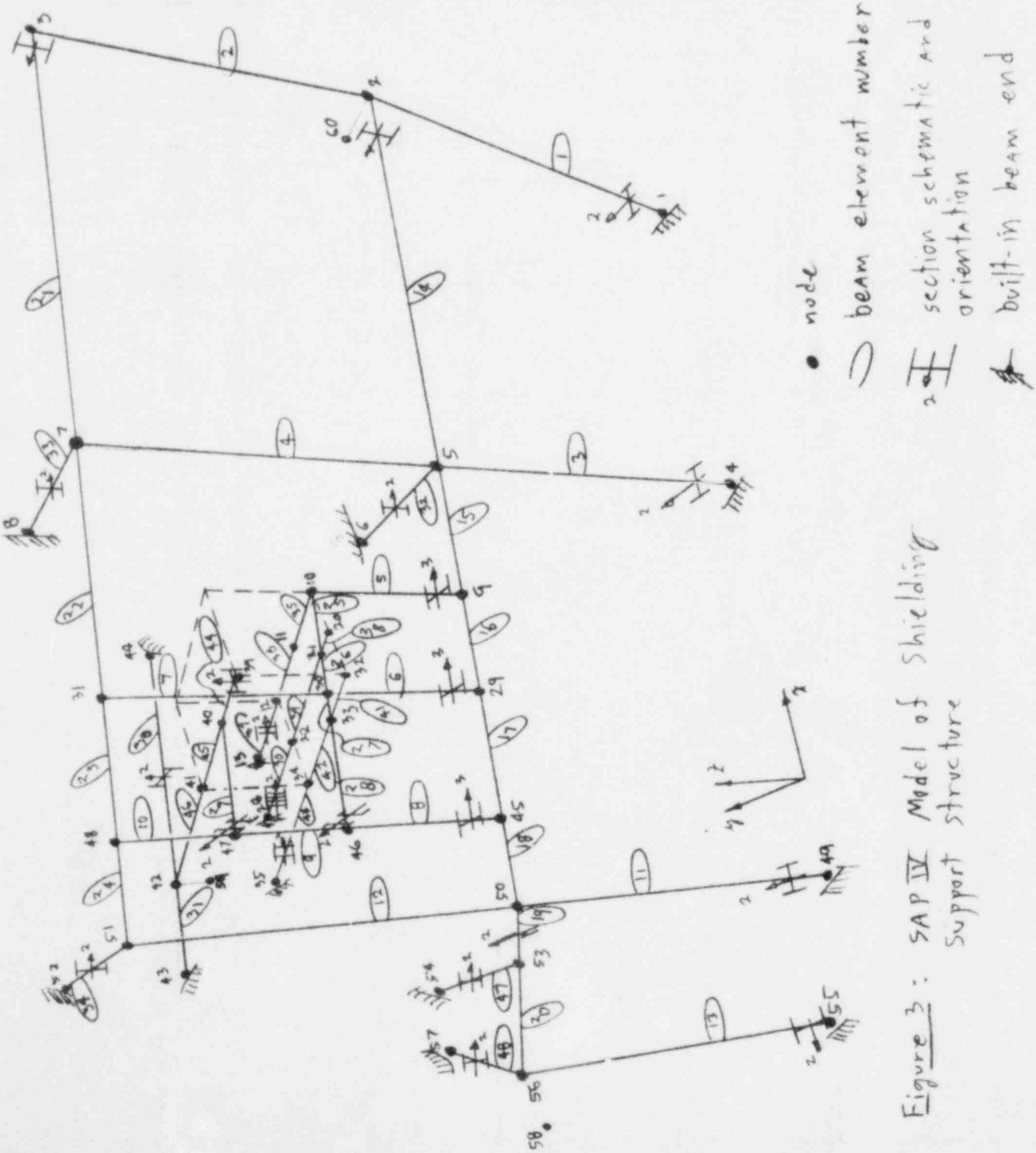

Figure 3: SAP IV Model of Shielding Support structure

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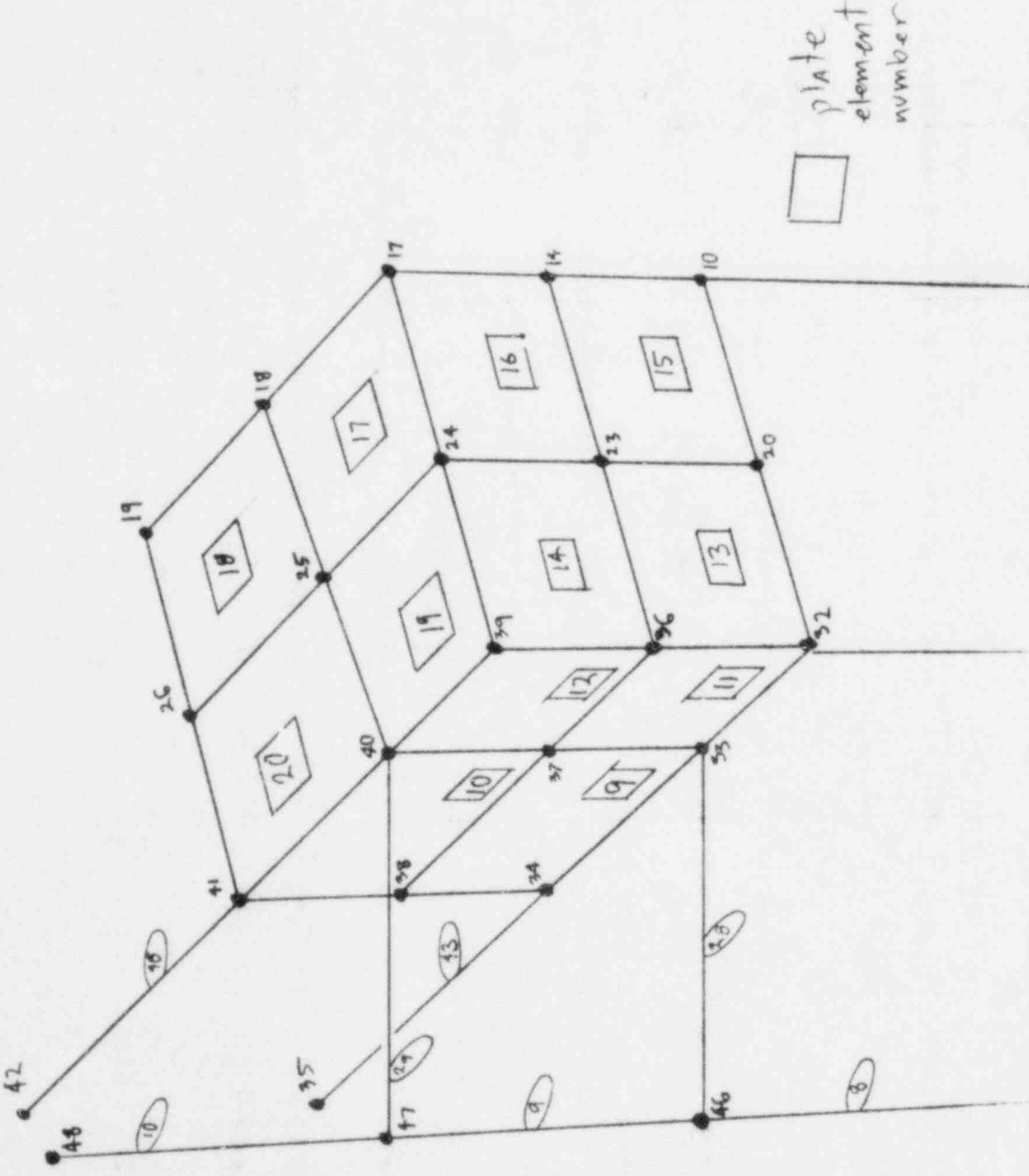

Figure 4: Detail of SAP IV Model of Shielding support structure showing Plate Elements representing Front of Shielding Box

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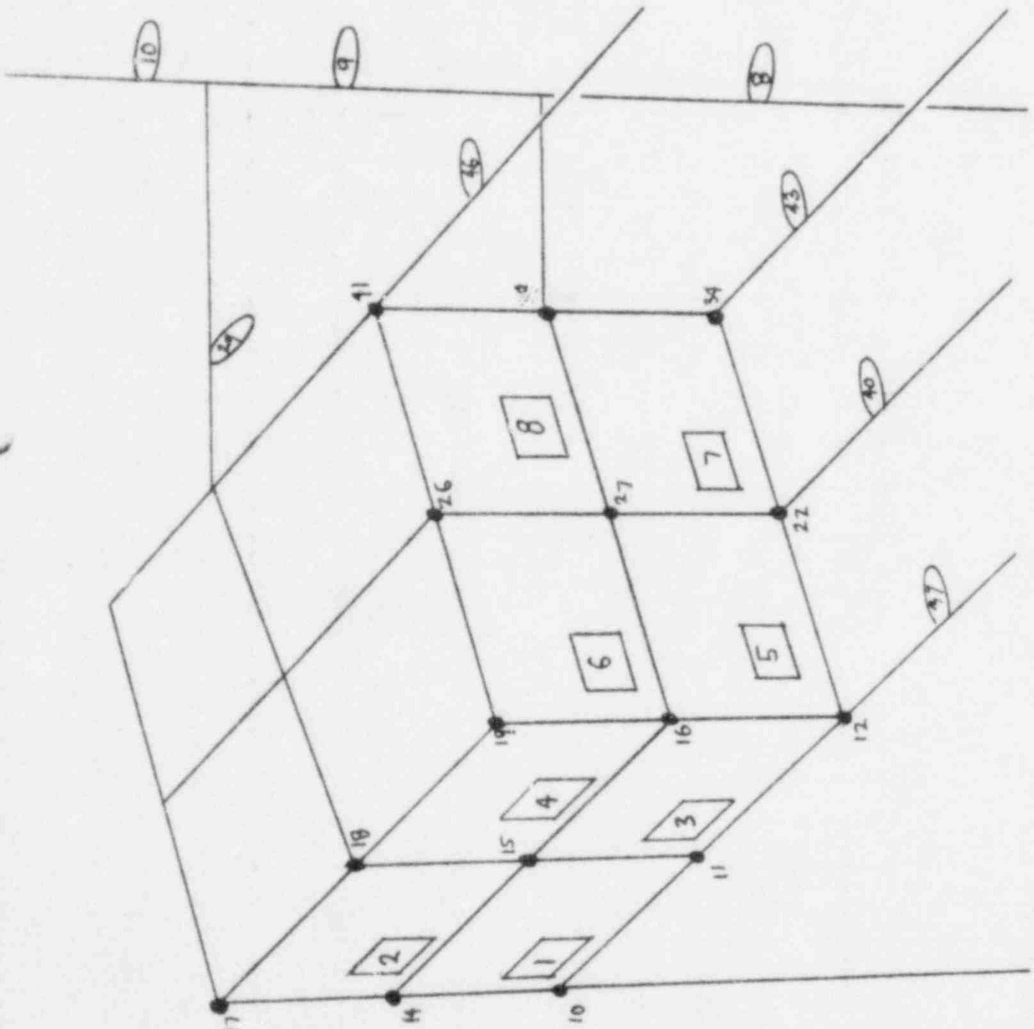

Figure 5: Detail of SAP IV Model of Shielding Support Structure showing plate Elements Representing Rear of Shielding Box

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IV. Existing structure affected by downstream shielding modifications

A. Structural members 1-10 (fig. 1)

These members were analyzed previously (Ref. 6). The results of this analysis are in the form of

$$R = \frac{\text{combined stress}}{\text{allowable stress}},$$

from Ref. 1, part 5, section 1.6, equations 1.6-1a, 1.6-1b, and 1.6-2 as applicable. These members will be more severely stressed in the present case due to an (next page)

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increased shielding weight. Therefore new values of R can be conservatively calculated by multiplying R by

$$\frac{\text{weight of new downstream + source shielding}}{\text{weight of source shielding}}.$$

This is conservative because it neglects the weight of the old downstream shielding which would appear in the denominator.

Weight of new downstream shielding

$$= .42 \frac{\text{lb}}{\text{in}^3} \times 28\text{ in} \times 24\text{ in} \times 34.75\text{ in} = 9807\text{ lb}$$

weight of source shielding (Ref. 8) = 7903

$$R' = R \frac{(9807 + 7903)}{7903} = \underline{\underline{2.24\,R}}$$

Table I shows the results of this procedure.

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Table I: Stress/Allowable for Existing Structure

Structural Member	Element #'s (Ref. 1)	R (Ref. 1)	Eqn. # (Ref. 1)	R'	Passes?	Element #'s (present)
1	1	.140	1.6-2	.314	yes	1
2	3	.130	1.6-2	.291	yes	3
3	5	.340	1.6-1a	.762	yes	11
	164	.310	1.6-1a	.695	yes	
4	17	.110	1.6-1b	.247	yes	32
5	18	.120	1.6-1b	.269	yes	33
6	19	.120	1.6-1b,-2	.269	yes	34
7	158	.690	1.6-2	1.546	no	47
	159	.360	1.6-2	.807	yes	
	160	.250	1.6-2	.560	yes	
	161	.260	1.6-2	.583	yes	
	162	.460	1.6-2	1.031	no	
	163	.630	1.6-2	1.412	no	
8	140	.180	1.6-2	.403	yes	48
	141	.130	1.6-2	.291	yes	
	142	.160	1.6-1b,-2	.359	yes	
	143	.330	1.6-1b,-2	.74	yes	
	144	.530	1.6-2	1.188	no	
9	315	.170	1.6-2	.381	yes	13
	316	.150	1.6-2	.336	yes	
	317	.210	1.6-2	.471	yes	
10	136	.460	1.6-2	1.031	no	19
	137	.410	1.6-1b	.919	yes	20
	138	.230	1.6-1b	.515	yes	
	139	.340	1.6-1b,-2	.762	yes	

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The members shown to fail in Table I will be analyzed somewhat less conservatively by adding the maximum force components caused by x-direction accelerations applied to the downstream shielding in the beams in question (shear force V_2 and moment M_3, along with axial force R_1 and torsion T_1) to the maximum force components calculated for these beams in Ref. 6. X-direction accelerations are the only ones which cause the downstream shielding to load these beams.

Forces

$R_1 = 4{,}185 + 1{,}094 = 5{,}279\ lb;\quad T_1 = 392 + 22 = 414\ in\text{-}lb$

$V_2 = 1{,}068 + 568 = 1{,}636\ lb;\quad M_2 = 45{,}890\ in\text{-}lb$

$V_3 = 6{,}931\ lb \qquad M_3 = 7{,}710 + 11{,}544 = 19{,}254\ in\text{-}lb$

Stresses (W4x13 section)

$f_a = \frac{5279}{3.82} = 1{,}382\ psi \qquad f_{b_2} = \frac{45\,890}{5.45} = 8{,}420\ psi$

$f_v \le \frac{2961}{2.8} + \frac{6931}{1.17} + \frac{414\,(.28)}{.154} \qquad f_{b_3} = \frac{19{,}254}{1.85} = 10{,}408\ psi$

$= 7{,}734\ psi$

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Allowable stresses (Ref. 1)

$$C_c = \sqrt{\frac{2\pi^2 (29 \times 10^6)}{36,000}} = 126.1$$

$$\frac{Kl}{r} \le \frac{2(44.6)}{.991} = 90 < C_c \; ; \quad \frac{Kl/r}{C_c} = .71$$

$$F_a = \frac{[1 - \frac{1}{2}(.71)^2](36,000)}{\frac{5}{3} + \frac{3}{8}(.71) - \frac{1}{8}(.71)^3} = 14,260 \text{ psi}$$

$$\frac{f_a}{F_a} = \frac{1382}{14,260} = .10 \quad \text{so use eqn. 1.6-2:}$$

$$F_b = .6(36,000) = 21,600$$

$$.10 + \frac{8,420 + 10,108}{21,600} = .97 < 1$$

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B. Existing W6x25 beam, member 11 (fig. 1)

Almost all the loading on this beam is due to deadweight and LOCE Z-accelerations. (fig 6).

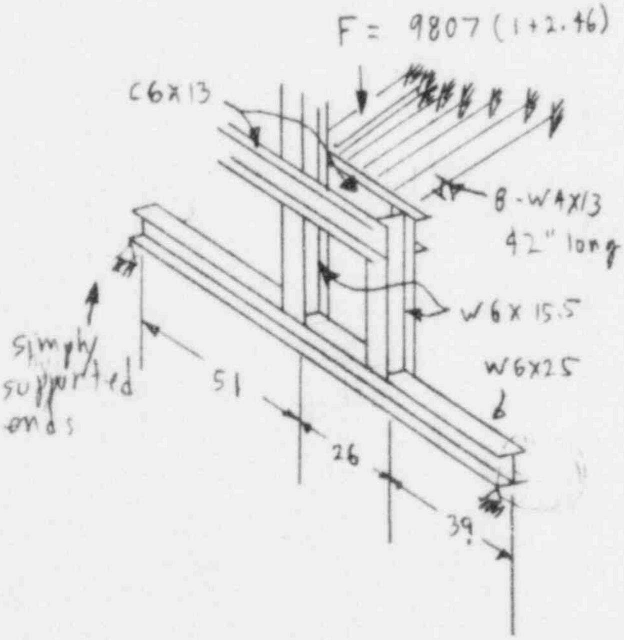

Figure 6 : Existing W6x25 beam : arrangement

The total force acts on both the W6x25 beam and on 8-W4x13 beams of average length 42 inches.

The stiffness of the 8 W4x13's together is

$$K_1 = \frac{2EI}{l_1^3} = \frac{2(29\times10^6)(11.3)}{42^3}$$

$$K_1 = 7.077\times10^4 \text{ lb/in}$$

The stiffness of the W6x25 beam will be calculated by assuming that half the load is applied by each vertical W6x15.5 and using the average

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of the deflections calculated at both points (fig. 7)

From Ref. 1,

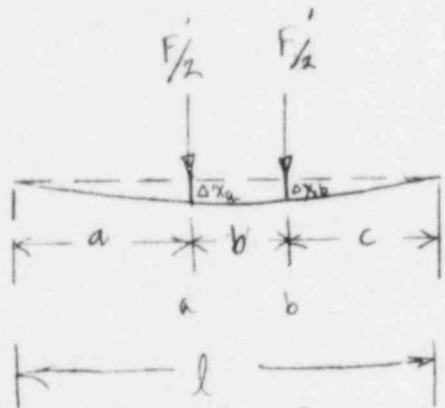

Figure 7: W6x25 beam (#11, fig. 1)

Δx_a = deflection at a

$$= \frac{Fa}{12EIl}\left[(l^2 - a^2)(b+2c) - (b+c)^3 - c^3\right]$$

$$\Delta x_b = \frac{Fc}{12EIl}\left[(l^2 - c^2)(b+2a) - (a+b)^3 - a^3\right]$$

with $l = 116$, $a = 51$, $b = 26$, $c = 39$, $E = 29 \times 10^6$, $I = 53.3$

$$\Delta x = \frac{1}{2}(\Delta x_a + \Delta x_b) = 1.793 \times 10^{-5} F'$$

$$K = K_2 = \frac{F'}{\Delta x} = \underline{5.578 \times 10^4 \text{ lb/in}}$$

The total force applied to the W6x25 beam is

$$F' = \frac{5.578 \times 10^4}{7.077 \times 10^4 + 5.578 \times 10^4}(9807)(3.46) = \underline{14,956 \text{ lb}}$$

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Bending moment at a & b:

$$M_a = \tfrac{1}{2}F'\left\{\frac{(b+c)(a)}{l} + \frac{(c)(a)}{l}\right\} = 22.86\,F'$$

$$M_b = \tfrac{1}{2}F'\left\{\frac{(b+2c)a}{l}\right\} = 21.52\,F'$$

MAX moment $= M_a = 341{,}894$ in-lb

$S = 16.7$ for W6X25, so

$$f_b = \frac{341{,}894}{16.7} = 20{,}473 \text{ psi} < .6\,\text{yield} = 21{,}600 \text{ psi}$$

C. W6X15.5 beams, members 12-14, Fig. 1

Loads (maximum)

$R_1 = 8108$ lb $\qquad T_1 = 95$ in-lb

$V_2 = 2606$ lb $\qquad M_2 = 17\,410$ in-lb

$V_3 = 461$ lb $\qquad M_3 = 58{,}504$ in-lb

$$f_a = \frac{8{,}108}{4.57} = 1{,}774 \text{ psi} \qquad f_{b_2} = \frac{17{,}410}{10} = 1{,}741 \text{ psi}$$

$$f_v \le \frac{2{,}606}{3.23} + \frac{461}{1.41} + \frac{95\,(.235)}{.111} \qquad f_{b_3} = \frac{58{,}504}{3.23} = 18{,}113 \text{ psi}$$

$$= 1{,}335 \text{ psi}$$

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shear

$$\frac{f_v}{F_v} = \frac{1335}{14,400} = .09 < 1$$

combined

$$\frac{Kl}{r} \leq \frac{(1)(92)}{1.46} = 63 < C_c$$

$$C_c = 126.1 \quad , \quad \frac{Kl/r}{C_c} = .5$$

$$F_a = \frac{\left[1 - \frac{1}{2}(.5)^2\right] 36,000}{\frac{5}{3} + \frac{3}{8}(.5) - \frac{1}{8}(.5)^3} = 17,133 \text{ psi}$$

$$F_e' \leq \frac{12(\pi^2)(29 \times 10^6)}{23(63)^2} = 37,624$$

$C_m = .85$, $F_b = .6(36,000) = 21,600$; eqns. 1.6-1a & -1b

are then:

1.6-1a

$$\frac{1774}{17133} + \frac{.85(1741)}{\left(1 - \frac{1774}{37624}\right) 21,600} + \frac{.85(18,133)}{\left(1 - \frac{1774}{37,624}\right) 21,600} = \underline{.92 < 1}$$

1.6-1b

$$\frac{1774}{21,600} + \frac{1741 + 18133}{21,600} = \underline{1.00} \text{ , so o.k.}$$

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V. New downstream shield structure
A. W4 x 13 beams, members 15 - 24

Loads (maximum) -

$R_1 = 3271$ lbs $\quad T_1 = 935$ lbs

$V_2 = 1243$ lbs $\quad M_2 = 45190$ in-lbs

$V_3 = 3235$ lbs $\quad M_3 = 19,776$ in-lbs

stresses -

$$f_a = \frac{3271}{3.82} = 856 \text{ psi} \qquad f_{b_2} = \frac{45,190}{5.45} = 8292 \text{ psi}$$

$$f_v \leq \frac{1243}{2.8} + \frac{3235}{1.17} + \frac{935(.28)}{.154} \qquad f_{b_3} = \frac{19,776}{1.85} = 10,690 \text{ psi}$$

$$= 4909 \text{ psi}$$

Allowable stresses (Ref. 1)

$$C_c = 126.1 \quad , \quad \frac{Kl}{r} \cong \frac{1(80)}{.991} = 80.73 \quad , \quad \frac{Kl/r}{C_c} = .64$$

$$F_a = \frac{\left[1 - \frac{1}{2}(.64)^2\right](36,000)}{\frac{5}{3} + \frac{3}{8}(.64) - \frac{1}{8}(.64)^3} = 15,277 \text{ psi}$$

$$\frac{f_a}{F_a} = \frac{856}{15,277} = .06 \quad , \text{ so eqn. 1.6-2 applies}$$

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$$.06 + \frac{8292 + 10,690}{21,600} = .94 < 1$$

$$\frac{f_v}{F_v} = \frac{4909}{14,400} = .34 < 1$$

B. C 6 × 13 channels, members 26 + 27, fig. 1

Loads (MAX)

$R_1 = 6828$ $T_1 = 882$

$V_2 = 1229$ $M_2 = 57,618$

$V_3 = 4083$ $M_3 = 11,310$

section properties

$A_1 = 7.66\ in^2$ $J_1 = .482,\ t_1 = .343$ $r = .525$

$A_2 = 2.959\ in^2$ $S_2 = 11.6$

$A_3 = 5.244\ in^2$ $S_3 = 1.28$

Stresses

$f_a = \frac{6828}{7.66} = 891$ psi $f_{b_2} = \frac{57,618}{11.6} = 4967$ psi

$f_v = \frac{1229}{2.959} + \frac{4083}{5.244} + \frac{882(.343)}{.482} = 1822$ psi; $f_{b_3} = \frac{11,310}{1.28} = 8836$ psi

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$$\frac{Kl}{r} = \frac{2(32)}{.525} = 122 \; ; \; C_c = 126.1 \; ; \; \frac{Kl/r}{C_c} = .9675$$

$$F_a = \frac{\left[1 - (.9675)^2\right] 36{,}000}{\frac{5}{3} + \frac{3}{8}(.9675) - \frac{1}{8}(.9675)^3} = 9{,}994 \text{ psi}$$

$$\frac{f_a}{F_a} = .089 < .15 \text{, so 1.6-2 applies -}$$

$$.089 + \frac{4967 + 8836}{21{,}600} = \underline{\underline{.73 < 1}}$$

$$\frac{f_v}{F_v} = \frac{1822}{14{,}400} = \underline{\underline{.13 < 1}}$$

C. Plates used in downstream shielding box (#25, fig. 1)

plate thickness = .25 in

Maximum loads -

membrane stresses

$\sigma_x = 742$ psi
$\sigma_y = 1079$ psi
$\tau_{xy} = 2296$ psi

$\} \; 2\tau_{max\,membrane} = 4940$ psi

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bending stresses + membrane stresses

$\sigma_x = 6496 + 742 = 7238$

$\sigma_y = 8270 + 1079 = 9349$

$\tau_{xy} = 12237 + 2296 = 14533$

$\Big\}\ 2\tau_{MAX_{memb+bend}} = 29{,}371$ psi

Allowable stresses - the ASME code (Ref. 7) will be used as a guide here, since the AISC code (Ref. 1) does not address plate structures -

allowable membrane stress intensity $= \frac{2}{3}(36{,}000) = \underline{24{,}000}$ psi

allowable memb. + bending stress intens. $= \underline{36{,}000}$

so $\dfrac{2\tau_{MAX\,memb}}{24{,}000} = \underline{\underline{.21 < 1}}$

$\dfrac{2\tau_{MAX\,memb+bend}}{36{,}000} = \underline{\underline{.82 < 1}}$

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VI. Connections

A. Connections in existing structure

The method of IV. A. (p. 10) will be used

1. Connection of angled W4X13 beam to MTA built-up beam (fig. 1, connection # 1)

see ref. 6, p. 69: this is the most highly stressed major connection in the source structure, so re-analyze:

$R_1 = 2988$ $T_1 = 123$ (See fig. 3, node 54)

$V_2 = 1953(2.24) = 4375$; $M_2 = 8031$

$V_3 = 1162$ $M_3 = 16,960(2.24) = 37,990$

at ①

$\tau_{12} = \frac{2988}{2.683} + \frac{2(37,990)}{2.683(4.06)} = 8,089$ psi

$\sigma_2 = \frac{4375}{2.683} = 1631$ psi

$\tau_{32} = 3699$ psi

$\sigma_{MAX} = 8946$ psi $< 14,400$

at ②

$\tau_{13} = 8089$

$\tau_{23} = 1631$

$\sigma_3 = 3699$

$\sigma_{MAX} = 10,111$ psi $< 14,400$ psi

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2. Connections between W6X15.5 uprights and existing W6X25 beams (fig. 1, # 2-6)
see ref. 6 p. 47-51:

$$\sigma_{MAX} = 2.24(5383) = \underline{\underline{12,058 \text{ psi} < 14,400 \text{ psi}}}$$

B. Connections in new shielding support structure

1. Connections between C6x13 channel and W6X15.5 upright beams (#7-10, fig. 1)

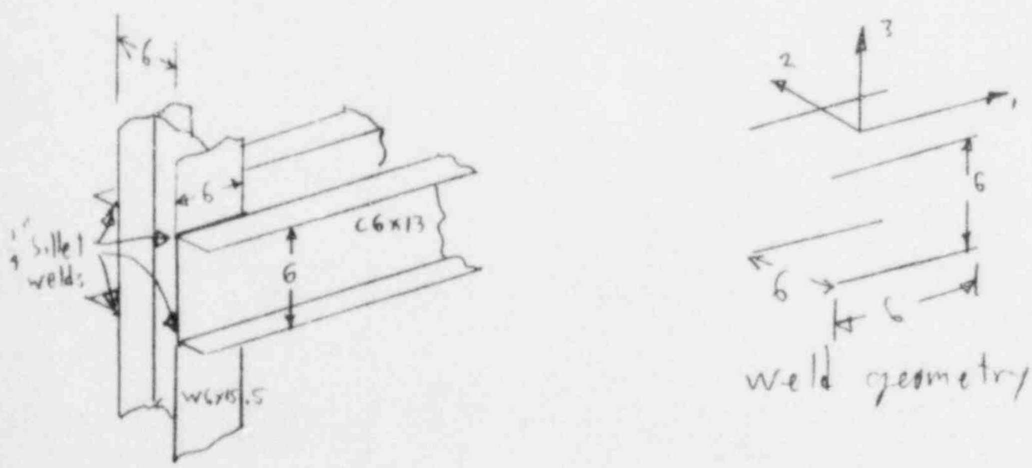

Figure 8: Connection between C6x13's and W6X15.5's

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Loads

$R_1 = 6828$ lb $T_1 = 882$ in-lb

$V_2 = 1229$ lb $M_2 = 57,618$ in-lb

$V_3 = 4083$ lb $M_3 = 11,310$ in-lb

Forces parallell to weld

due to R_1 $F'_{R_1} = \frac{6828}{4(6)} = \underline{285 \text{ lb/in}}$

due to M_2 :

$$\frac{1}{4}(57,618) = F'_{m_2}(3)(6) \Rightarrow F'_{m_2} = \underline{800 \text{ lb/in}}$$

Forces perpendicular to weld

due to V_2

$$F'_{V_2} = \frac{1229}{4(6)} = \underline{51 \text{ lb/in}}$$

due to V_3

$$F'_{V_3} = \frac{4083}{4(6)} = \underline{170 \text{ lb/in}}$$

due to T_1 : $F'_{T_1} = \frac{882}{6(2)(6)} = \underline{12 \text{ lb/in}}$

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due to M_3

$$2\left\{2\left(\tfrac{1}{2}F'_{m_3}\right)(3)\right\} = \frac{1}{4}(11,310)$$

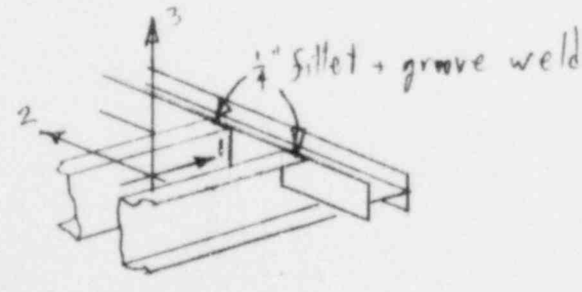
$$F'_{m_3} = 471.25 \text{ lb/in}$$

$$\text{total force/in} = \sqrt{(285+800)^2 + (51+12+471.25)^2 + 170^2}$$

$$= 1221 \text{ lb/in}$$

$$\sigma_{weld} = \frac{1221}{(.707)(.25)} = 6910 \text{ psi} < 14,400 \text{ psi}$$

2. Connections between C6X13 channels and W4X13 beam (fig. 1, # 11)



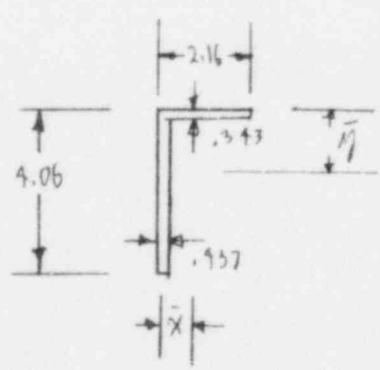


Figure 9: Connections between C6X13 channels and W4X13 beam

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weld section properties -

$$Area = 2\left(.343(2.16 - .437) + .437(4.06)\right) = 4.73 \text{ in}^2$$

$$\bar{x} = \frac{\frac{.437}{2}(1.624) + \frac{2.16}{2}(.741)}{1.624 + .741} = .488 \text{ in}$$

$I_{xx} = .692 \text{ in}^4$

$$\bar{y} = \frac{\frac{4.06}{2}(1.774) + \frac{.343}{2}(.591)}{.591 + 1.774} = 1.566 \text{ in}$$

$I_{yy} = 3.974 \text{ in}^4$

Loads

$R_1 = 1952$ lb $T_1 = 298$ in-lb

$V_2 = 308$ lb $M_2 = 7497$ in-lb

$V_3 = 1322$ lb $M_3 = 7771$ in-lb

forces

parallell to weld

due to V_2 : $\frac{308}{4.32} = 71.3$ lb/in.

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due to V_3 : $\frac{1322}{8.12} = 163$ lb/in

due to T_1 : $\frac{298}{6(4.06)} = 12.2$ lb/in

normal to weld

due to M_2

$$\frac{7497(4.06-1.566)}{2(3.974)}(.437) = 1028 \text{ lb/in}$$

due to M_3

$$\frac{7771(2.16-.988)}{2(.692)}(.343) = 3220 \text{ lb/in}$$

due to R_1

$$\frac{1952}{2(4.06+2.16)} = 157 \text{ lb/in}$$

$$\text{max force/in} \le \sqrt{(3220+157)^2 + (163+12.2)^2}$$

$$= 3382 \text{ lb/in}$$

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so weld stress $\approx \frac{3382}{.343} = 9959$ psi $< 14,400$

3. Connection between W4X13 beam and MTA built-up beams (fig. 1, #12; fig. 10)

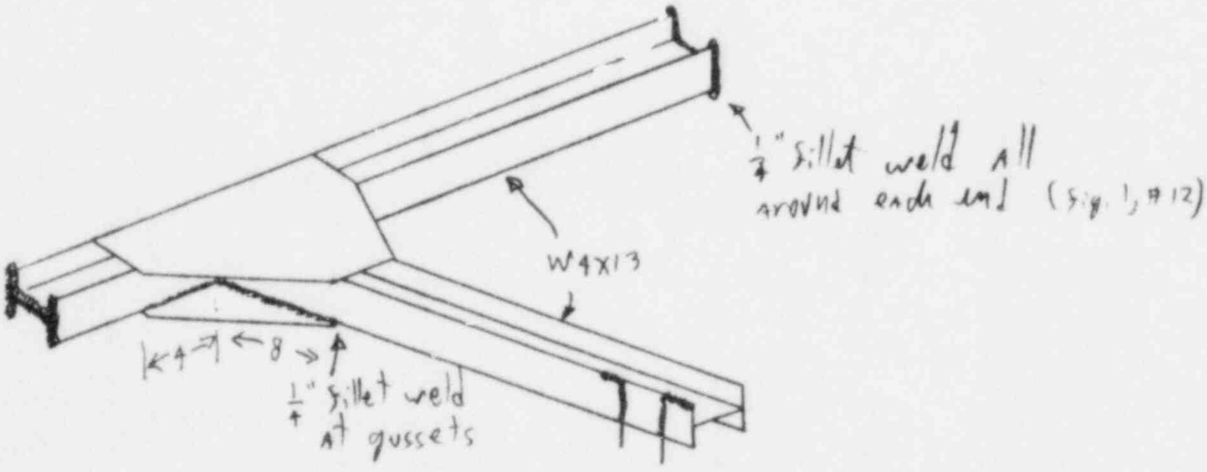
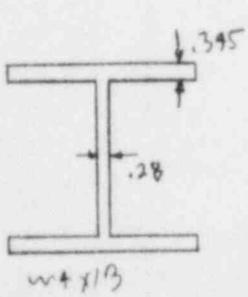


Figure 10: W4X13 beam structure

strength of connection –



Effective weld leg – thicknesses of section are greater than 1/4 inch, so Ref. 1, sec. 1.17.6 applies –

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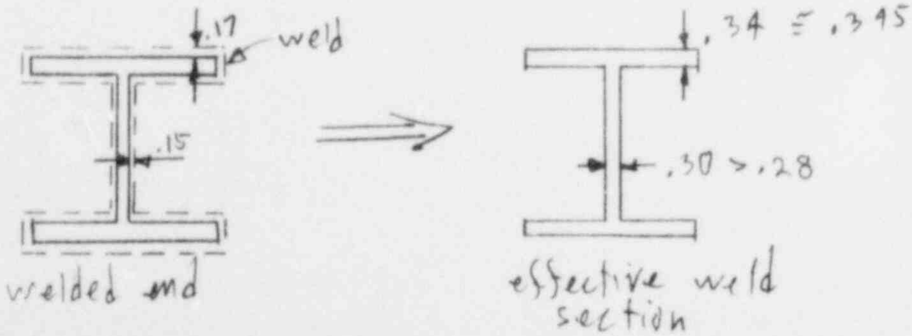
and maximum weld size is $\frac{1}{16}$ inch less than material thickness

flanges : $.345 - \frac{1}{16} = .2825 \Rightarrow .25$ inch leg, a

web : $.28 - \frac{1}{16} = .2175$ inch leg, a

$a < 3/8$ in each case, so the weld throat is equal to the weld leg, .25 and .22 inches, respectively. The weld allowable stress is 14,400 psi vs. 21,600 psi for the base metal. To allow for this, reduce the effective weld throats by $\frac{14,400}{21,600} = .67$ to .17 in and .15 in., respectively. The weld pattern is then:



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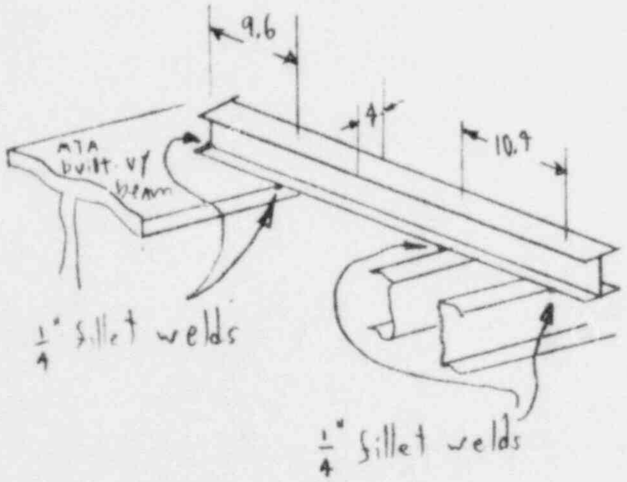
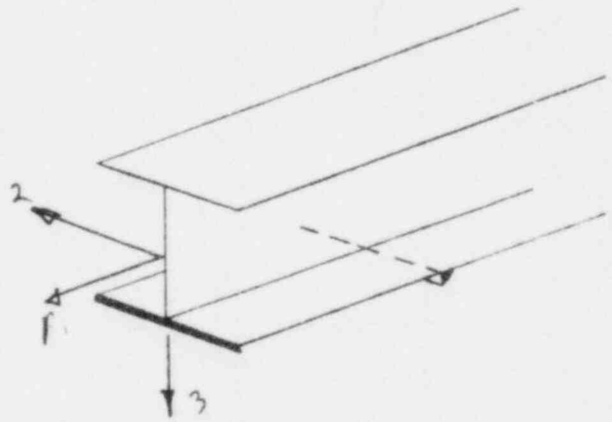
The effective weld section is as strong as the beam itself, so no further analysis is required.

By inspection, the gusset welds (fig. 1, # 13; fig. 10) are stronger than the end welds just considered.

4. Connections between 8 W4X13 beams and MTA built-up beam and C6X13 channels (fig. 1, # 14&15)





The weld at the built-up beam end is the weaker, so analyze it with the worst loads.

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Loads

$R_1 = 1297$ lb $T_1 = 25$ in-lb $\cong 0$

$V_2 = 306$ lb $M_2 = 51465$ in-lb

$V_3 = 777$ lb $M_3 = 13,312$ in-lb

Forces parallell to weld

due to V2

$$F'_{V_2} = \frac{306}{8} = 38.25 \text{ lb/in}$$

due to M3

$$F'_{m_3} = \frac{13,312}{9.6(4)} = 347 \text{ lb/in}$$

Forces perpendicular to weld

-1 direction

due to R_1

$$F'_{R_1} = \frac{1297}{8} = 162 \text{ lb/in}$$

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in -3 direction

due to M_2

$$F'_{m_2} = \frac{51965}{9.6(4)} = 1390 \text{ lb/in}$$

$$\text{Total weld force/in} = \sqrt{(347+38.25)^2 + 162^2 + 1390^2}$$

$$= 1404 \text{ lb/in}$$

$$\text{weld stress} = \frac{1404}{(.707)(.25)} = 7942 \text{ psi} < 14{,}400 \text{ psi}$$

5. Connections between plates in welded box structure

The plates are nearly simply-supported, so the welds are only subject to the membrane stresses in the plates

Loads max normal stress in plate = 3141 psi

max shear stress in plate = 2296 psi

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weld forces/inch

parallel - 2296 (.25) = 574 lb/in

normal - 3141 (.25) = 785 lb/in

total = 973 lb/in

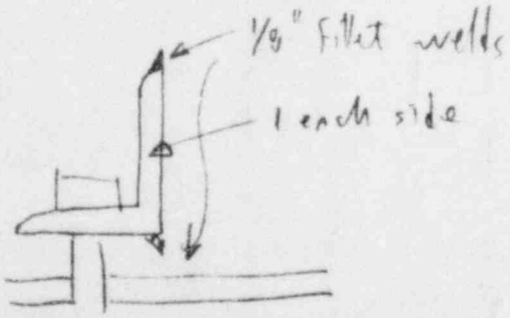
weld stress = $\frac{973}{.707(.25)}$ = 5505 psi < 14,400 psi

6. Bolted connection in shield box structure (fig 1, #17)

18 bolts, ½ inch - 13 UNC

stress ≐ $\frac{9807 \text{ lb } (4.46)}{18(.1419)}$ = 17,124 psi < 20,000 psi

the bolts attach the cover plate to the box through a welded angle 20 inches long (See sketch),



weld stress = $\frac{9807 (4.46)}{80(.125)(.707)}$

= 6187 psi < 14,400 psi

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APPENDIX B
SAP IV SOURCE LISTING

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