Fermilab

Particle Physics Division

Mechanical Department Engineering Note

Number: MD-ENG-231 Date: 03/12/2010

Project:----------NOvA

Proj Intern Ref:

Title:----------MUON CATCHER FRAME

Author(s):----------VILLEGAS / FANG

Reviewer(s): Anglee 3-26-2010 / AL / 7-17-2011

Key Words:---------BASE PLATES,SUPPORT FRAME,SUPPORT LUGS, CLIPS

Abstract/Summary:THE DETECTOR IS COMPOSED OF THE FOLOWING:

(1) FIVE HORIZ PLANES MOUNTED ON 4" THICK PLATES

(2) FOUR VERT. PLANES MOUNTED ON 4" THICK PLATES

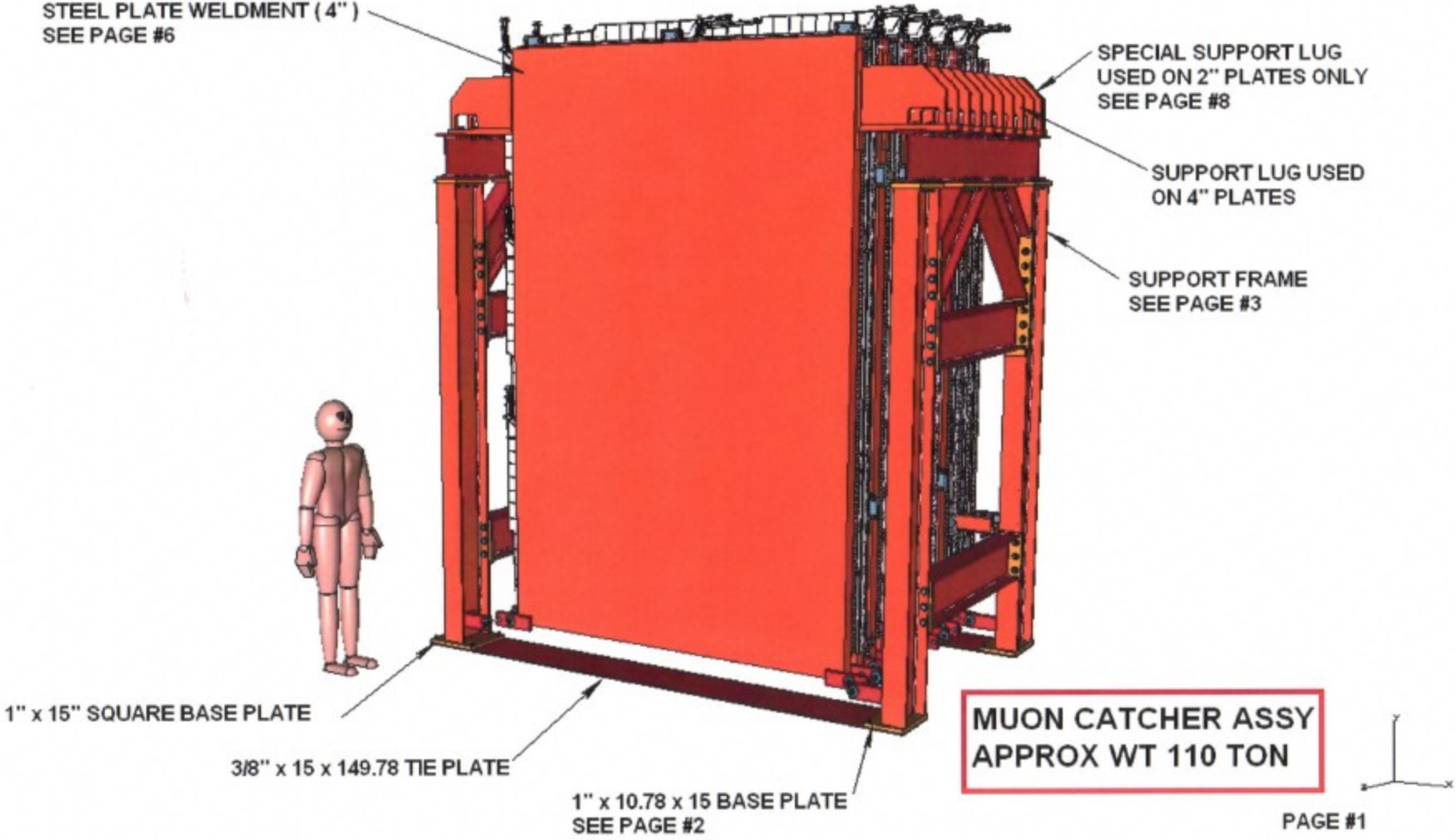
(3) ONE 4-PLANE BLOCK MOUNTED ON 2" THICK PLATE

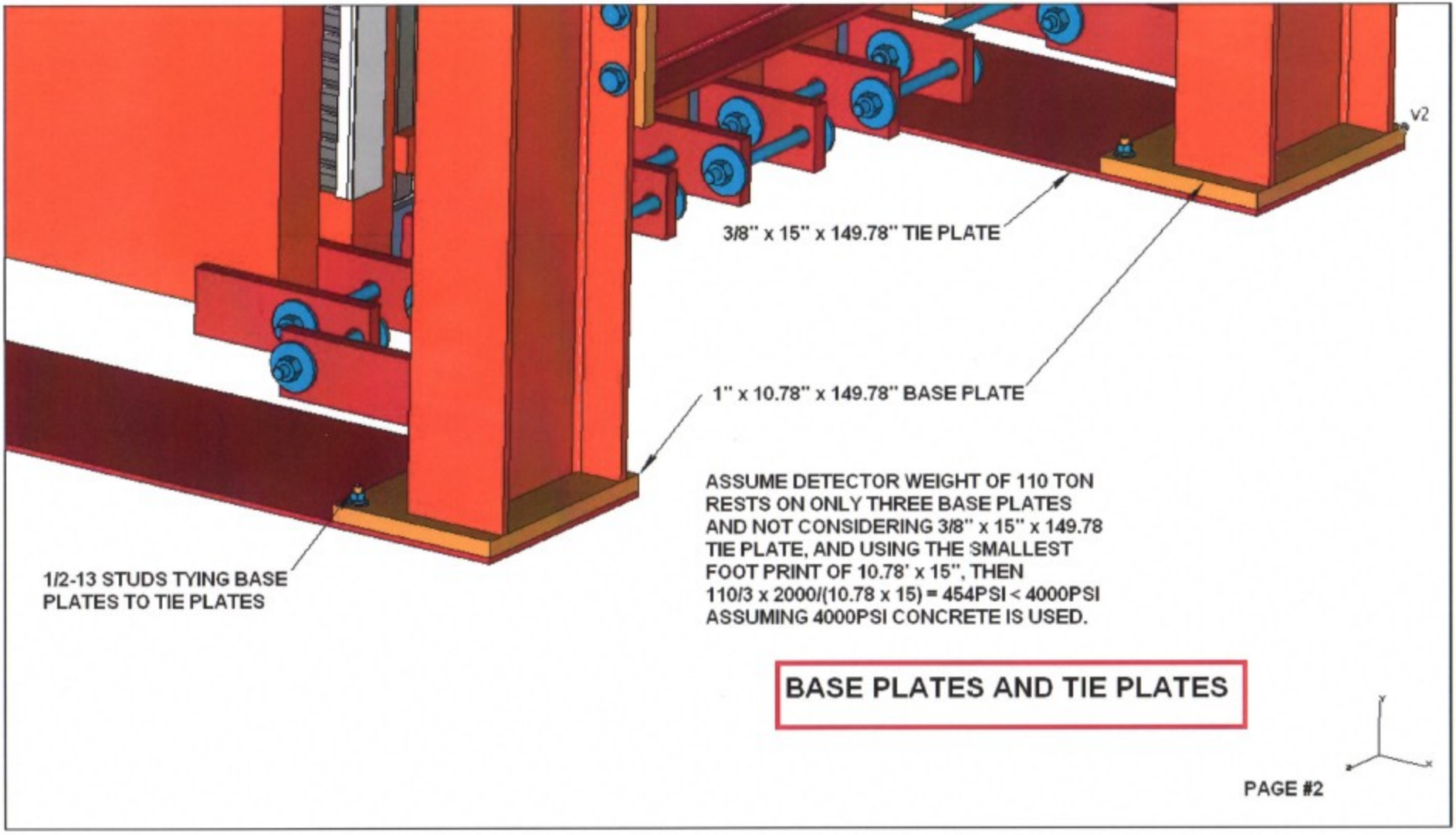
(4) A 2" NAKED PLATE IS MOUNTED JUST UPSTEAM OF ITEM #3

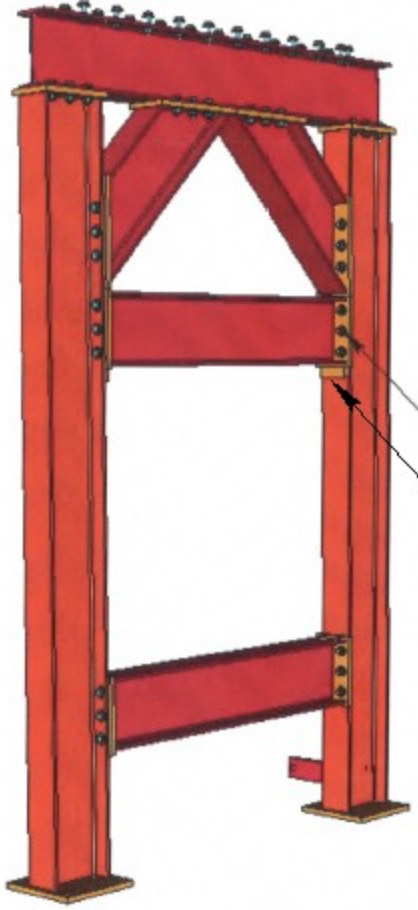
(5) EACH PLATE IS MOUNTED BY MEANS OF SUPPORT LUGS TO A FRAME WHICH IS BOLTED T0 3/8" x 15" x 150"

(6) THE DETECTOR WEIGHT IS APPROXIMATELY 110 TON

Applicable Codes:--AISC " MANUAL OF STEEL CONSTRUCTION "


STEEL PLATE WELDMENT (4")
SEE PAGE #6
SPECIAL SUPPORT LUG
USED ON 2" PLATES ONLY
SEE PAGE #8
SUPPORT LUG USED
ON 4" PLATES
SUPPORT FRAME
SEE PAGE #3
1" x 15" SQUARE BASE PLATE
3/8" x 15 x 149.78 TIE PLATE
1" x 10.78 x 15 BASE PLATE
SEE PAGE #2
MUON CATCHER ASSY
APPROX WT 110 TON


V2
3/8" x 15" x 149.78" TIE PLATE
1" x 10.78" x 149.78" BASE PLATE
ASSUME DETECTOR WEIGHT OF 110 TON
RESTS ON ONLY THREE BASE PLATES
AND NOT CONSIDERING 3/8" x 15" x 149.78
TIE PLATE, AND USING THE SMALLEST
FOOT PRINT OF 10.78' x 15", THEN
110/3 x 2000/(10.78 x 15) = 454PSI < 4000PSI
ASSUMING 4000PSI CONCRETE IS USED.
1/2-13 STUDS TYING BASE
PLATES TO TIE PLATES
BASE PLATES AND TIE PLATES
Y
X
PAGE #2



SEE PAGES 4 & 5 FOR ONE-DIMENSIONAL FRAME FEA

ALL FASTENERS 3/4-10 GRADE 8 BOLTS

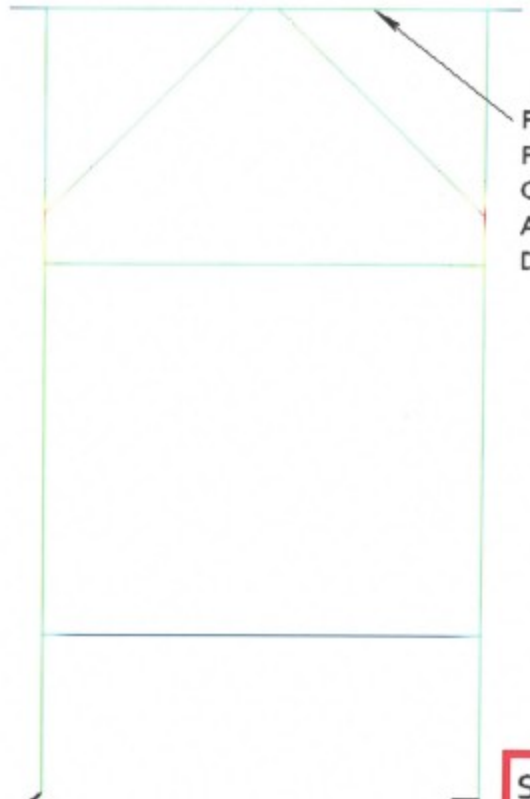
1" X 2" X 6" PLATE WELDED WITH 1/2" FILLET WELD.
ASSUMED WELD HELPS RESIST FORCES ACTING AT THIS JOINT IN ADDITION TO HELP IN ASSY.

SUPPORT EAST FRAME

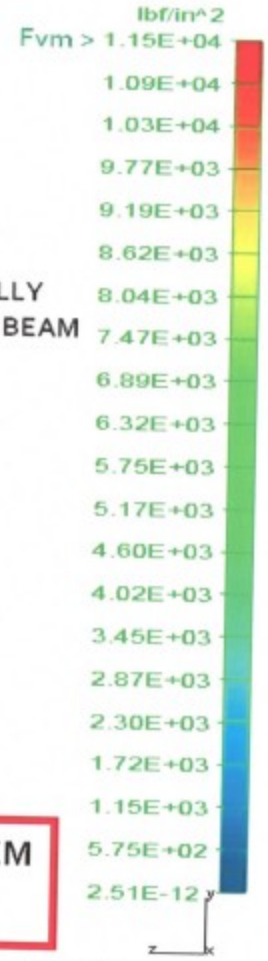
I-DEAS 12 NX Series m2: I-DEAS Visualizer

MUON_CATCHER_SUPT_FRAME_FEM
55_TON_LOAD
STRESS Von Mises Averaged Top shell
Beam stress: Von Mises , maximum point
Min: 2.51E-12 lbf/in^2 Max: 1.15E+04 lbf/in^2
B.C. 1,DISPLACEMENT_1,LOAD SET 1
DISPLACEMENT XYZ Magnitude
Min: 0.00E+00 in Max: 0.00E+00 in

MATERIAL: ASTM A36 STEEL
Fvm = 0.6 X 36,000 = 21,600 PSI (ALLOWED)



FOUR LOADS OF 10522#
FIVE LOADS OF 10,468#
ONE LOAD OF 12806#
ALL LOADS ACT VERTICALLY
DOWNWARD ON W12X35 BEAM



ATTACHED TO 1/2" X 15" X 150" PLATE

SUPPORT FRAME FEM STRESSES

I-DEAS 12 NX Series m4: I-DEAS Visualizer

I-DEAS Visualizer
MUON_CATCHER_SUPT_FRAME_FEM
55_TON_LOAD
ELEMENT FORCE Magnitude Averaged Top shell
Min: 0.00E+00 lbf Max: 5.85E+04 lbf
DISPLACEMENT XYZ Magnitude
Min: 0.00E+00 in Max: 4.04E-02 in

BOLTS USED 3/4-10 GR 8

TORQUE TO 380 FT-LBS
CLAMP LOAD = 380 x 12 / 0.2 x 0.75
= 30,400 #/BOLT

LOCATION # 1

6 BOLTS CARRY 58,500#
f = 58500/6 = 9750#/BOLT

6 BOLTS CARRY 45,900 IN-LBS
fm = 45,900/6 x 1" = 7650#/BOLT

COMBINING FORCES

CLAMP LOAD = SQRT(9750^2 + 7650^2) = 12,393#/BOLT < 30,400#/BOLT

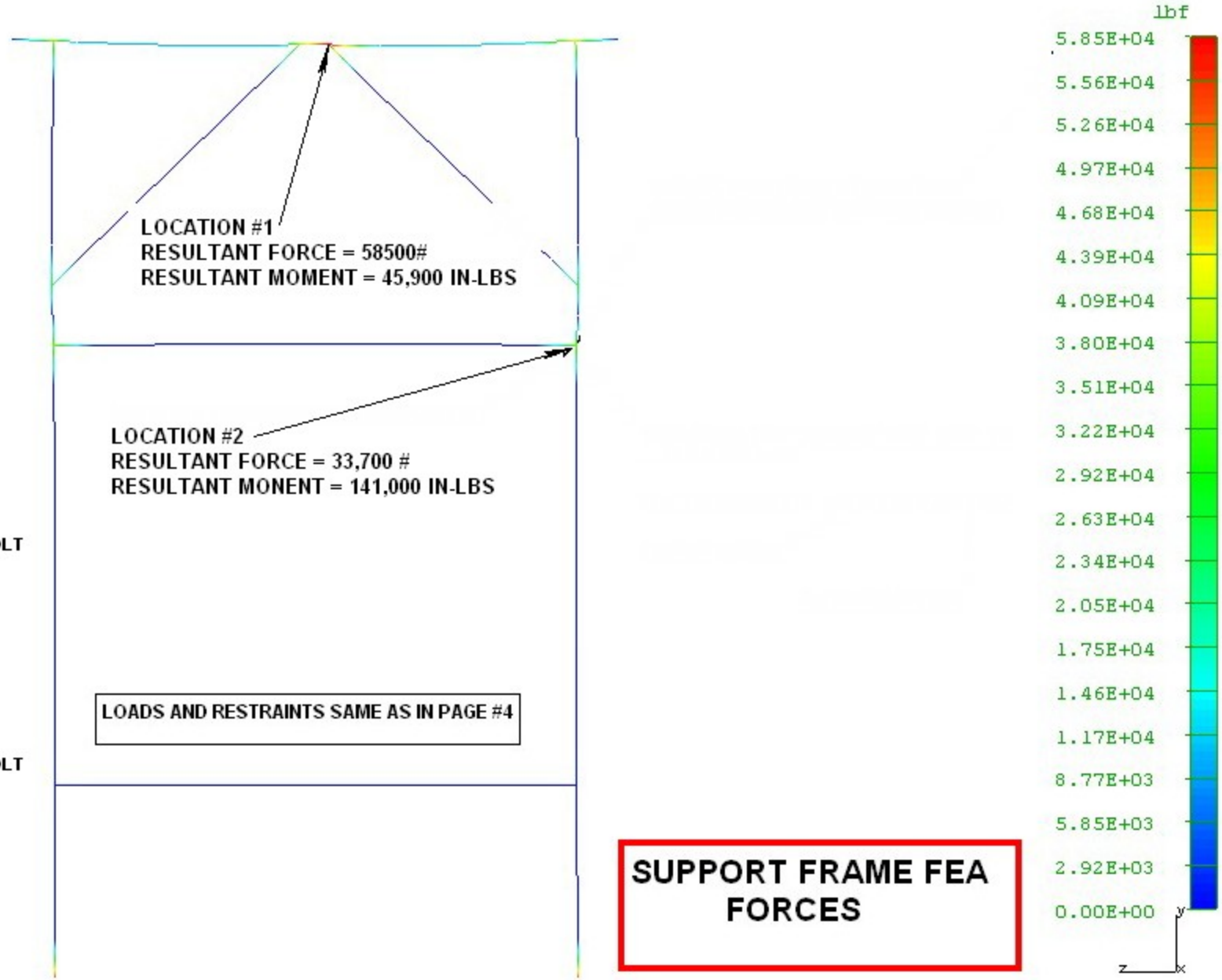
LOCATION # 2

6 BOLTS CARRY 33,700#
f = 33,700/6 = 5617#/BOLT

6 BOLTS CARRY 141,000 IN-LBS
fm = 141,000/6 x 1" = 23,500 #/BOLT

COMBINING FORCES

CLAMP LOAD = SQRT(5617^2 + 23,500^2) = 24,162#/BOLT < 30,400#/BOLT



SUPPORT FRAME FEA FORCES

231PG6~1.JPG

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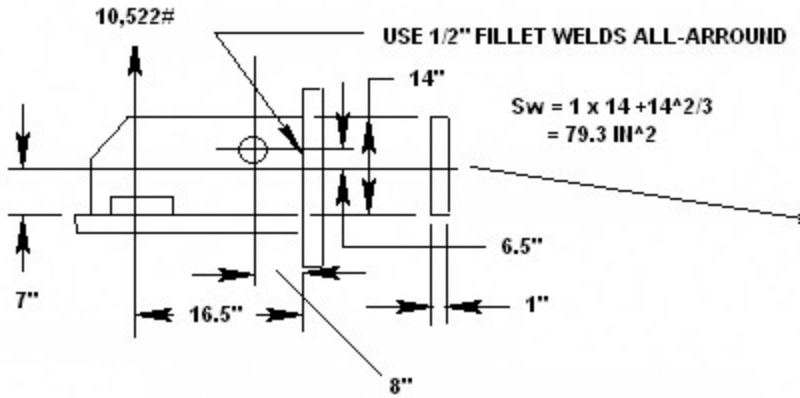


NOTE: ONLY THE WELD ON THE 1" x 14" PLATE WAS CONSIDERED SINCE IT IS OBVOUS THAT THE 2" x 24" IN PLATE WELDED ALL AROUND IS MUCH STRONGER THAN THE 1" X 14 PLATE.

MATERIAL : ASTM A36 STEEL
F = 0.6 x 36,000 = 21,600 PSI ALLOWED

USING WELD ELECTRODES E60XX
Fv = 0.3 x 62,000 = 18,600 PSI ALLOWED
Fw = sin45 X 0.5 x 18,600 = 6576 #/IN ALLOWED

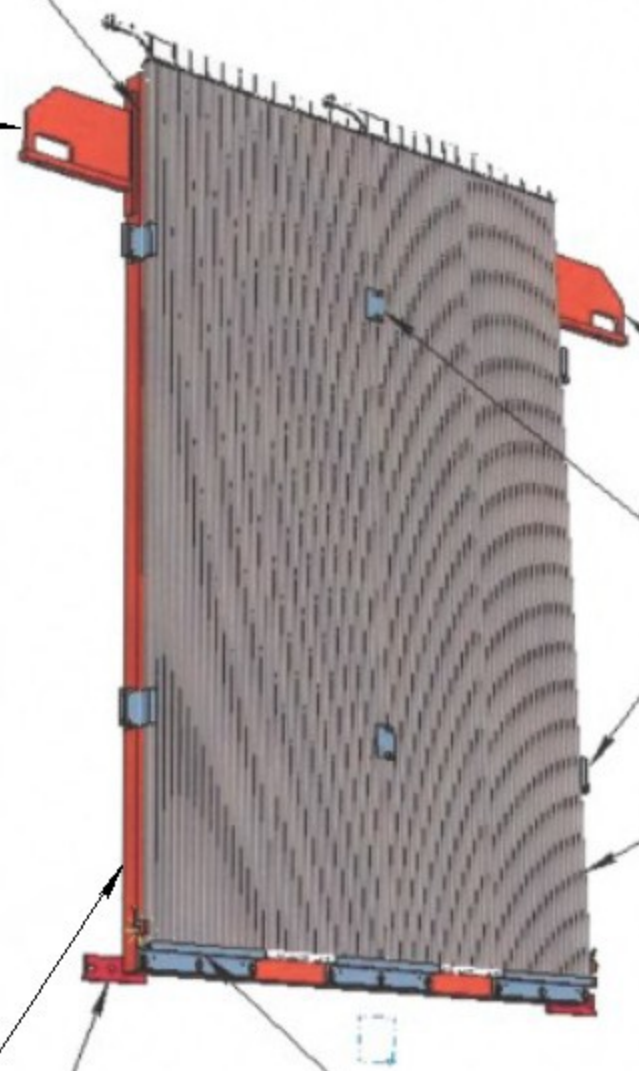
fv = 10522/2X14+2X1" =351#/IN

M = 16.5 X 10,522 = 173,613

fm = 173,613/79.3 = 2189#/IN

COMBINING FORCES

f = SQRT(351^2 + 2189^2) =2,217#/IN < 6576#/IN

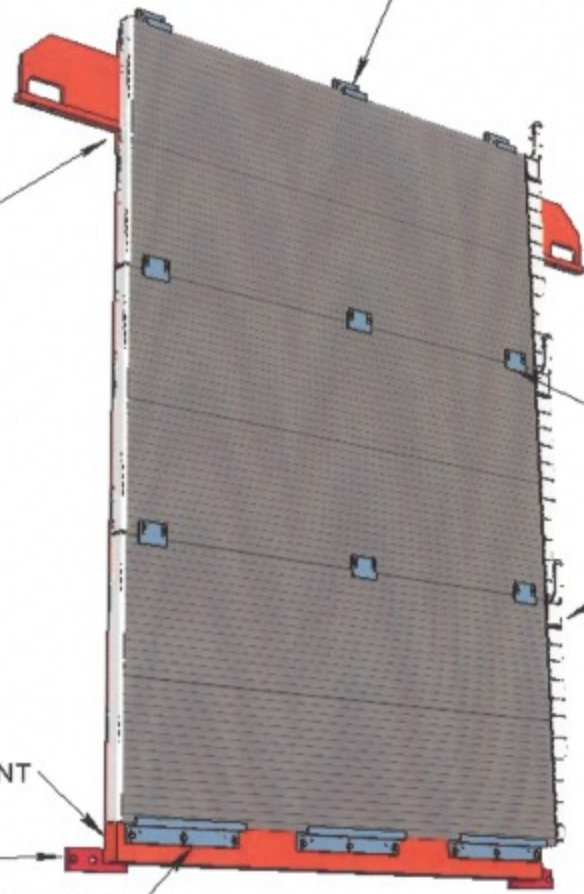


WEIGHT

PVC----------514#
OIL----------1030
STEEL PLATE 4"----------19500
TOTAL-----21,044#

VERTICAL PLANE ASSY

PAGE #6

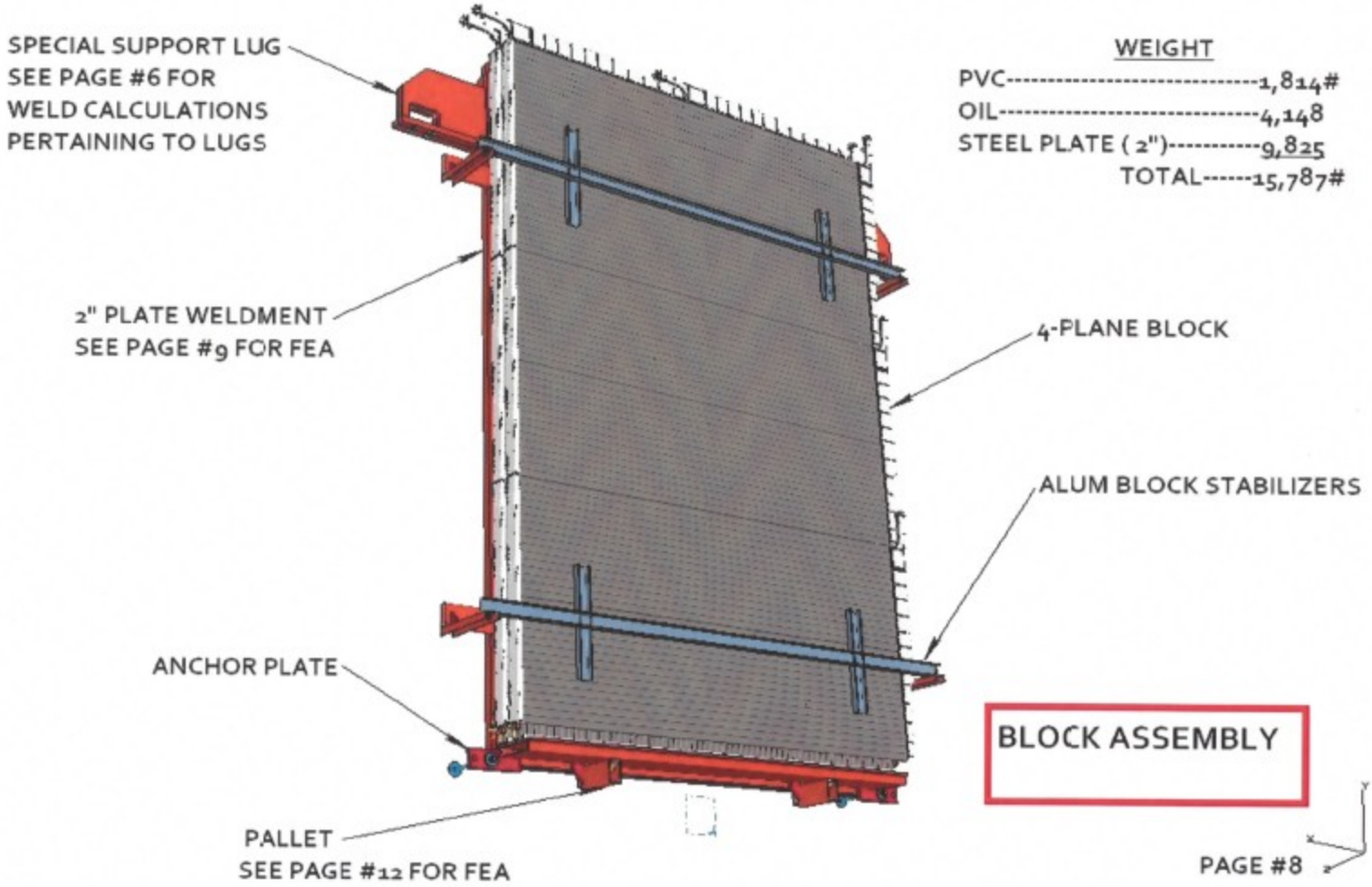


WEIGHT

PVC----------393#
OIL----------1,044
STEEL PLATE (4")-----19,500
TOTAL-- 20,937#

HORIZONTAL PLANE ASSY

PAGE #7



WEIGHT

PVC	1,814#
OIL	4,148
STEEL PLATE (2")	9,825
TOTAL	15,787#

231PG9~1.JPG

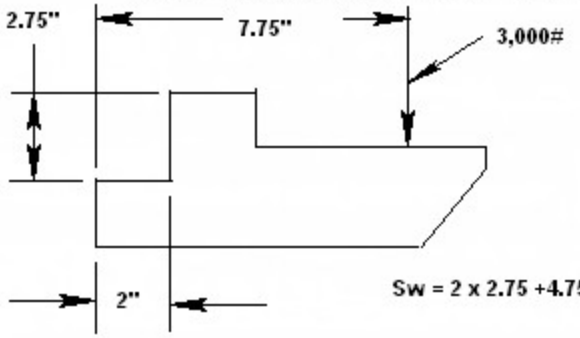
File Edit Image Help

I-DEAS 12 NX Series m2: I-DEAS Visualizer

SUPPORT LUGS, SEE PAGES #6 AND #9 FOR WELD CALCULATIONS

BLOCK_PLATE_WELDMENT_FEM
12K_LOAD_PLUS_GRAVITY
STRESS Von Mises Averaged Top shell
Min: 2.97E+00 lbf/in^2 Max: 9.64E+03 lbf/in^2
B.C. 1,DISPLACEMENT_1,LOAD SET 1
DISPLACEMENT XYZ Magnitude
Min: 0.00E+00 in Max: 2.25E-02 in

MATERIAL: ASTM A36 STEEL
Fvm = 0.6 x 36,000 = 21,600 PSI ALLOWED
WELD ELECTRODES E60XX
Fv = 0.3 x 62,000 = 18,600 PSI
Fw = sin45 X 0.5 X 18,600 = 6576 #/in allowed



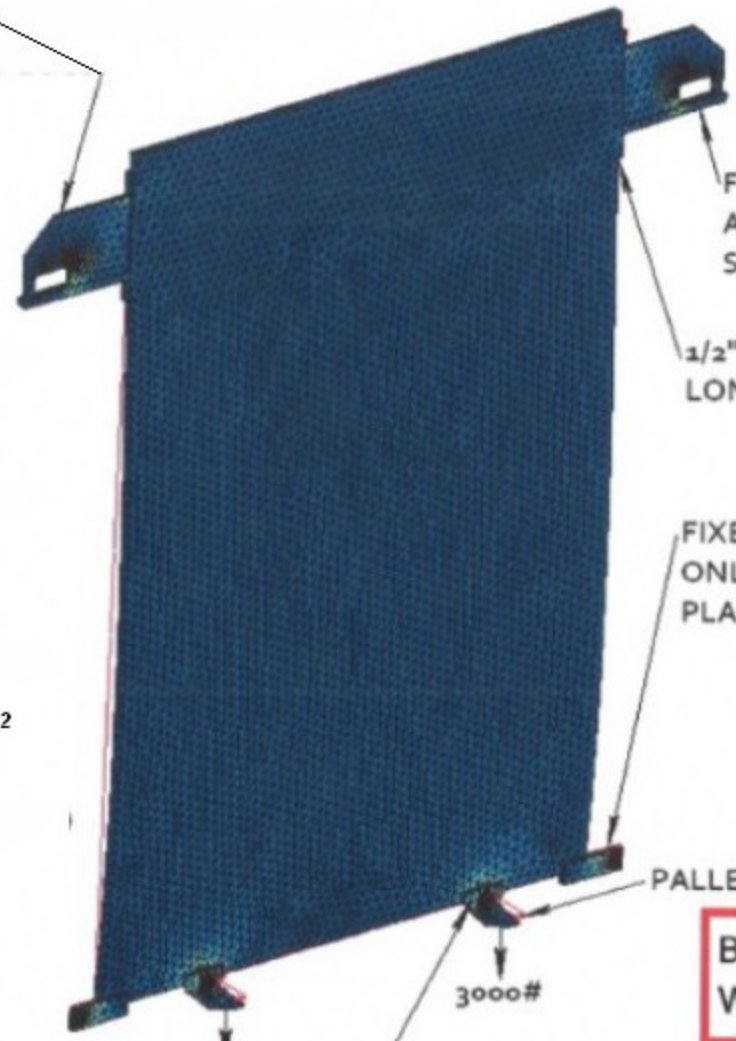
Sw = 2 x 2.75 +4.75^2/3 = 13.02 in^2

fv = 3,000/ 2 (2.75 + 2) = 316 #/in

fm = 7.75 x 3000 / 13.02 = 1786#/in

COMBINING FORCES

f = SQRT(316^2 + 1786^2) = 1814#/in < 6576#/in



FIXED RESTRAINTS ON ALL PLANES FOR BOTH SUPPORT LUGS

1/2" GROOVE WELDS, 3" LONG 3 PER SIDE

FIXED RESTRAINT ON Z ONLY FOR ANCHOR PLATES

PALLET & BLOCK SUPPORTS

3000#

3000#

1/2" FILLET WELDS BOTH SIDES

BLOCK PLATE WELDMENT FEM

PAGE #9

I-DEAS 12 NX Series m2: I-DEAS Visualizer

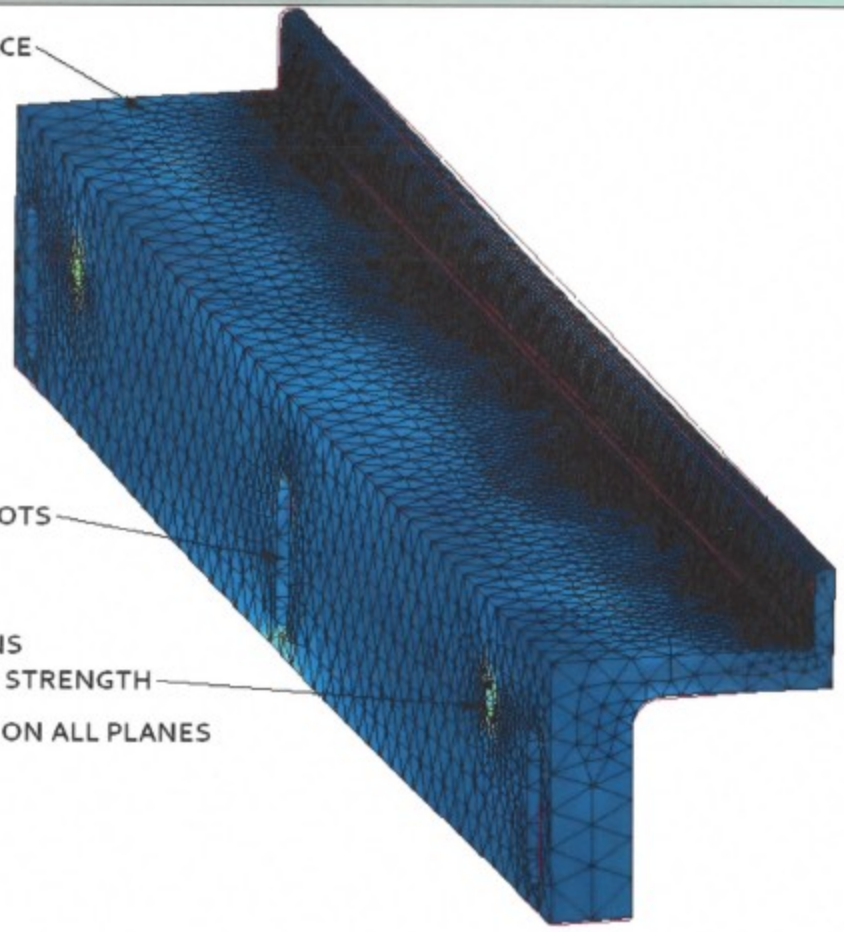
775# LOAD ON SURFACE

CLIP_BOTT_VERT_FEM
775LB_LOAD
STRESS Von Mises Averaged Top shell
Min: 1.95E-01 lbf/in^2 Max: 4.11E+03 lbf/in^2
B.C. 1,DISPLACEMENT_1,LOAD SET 1
DISPLACEMENT XYZ Magnitude
Min: 0.00E+00 in Max: 2.19E-03 in

MATERIAL : ALUMINUM 6061-T6
Fvm = .06 X 35,000 = 21,000 PSI
ALLOWED

(3) 1/2 -13 SCREWS THROUGH SLOTS
RESTRAINTS ON ' Z ' ONLY

(2) 3/8 SPRING PINS
17,600# SHEAR STRENGTH
RESTRAINED ON ALL PLANES



lbf/in^2
Fvm > 4.11E+03
3.90E+03
3.69E+03
3.49E+03
3.28E+03
3.08E+03
2.87E+03
2.67E+03
2.46E+03
2.26E+03
2.05E+03
1.85E+03
1.64E+03
1.44E+03
1.23E+03
1.03E+03
8.21E+02
6.16E+02
4.11E+02
2.05E+02
1.95E-01

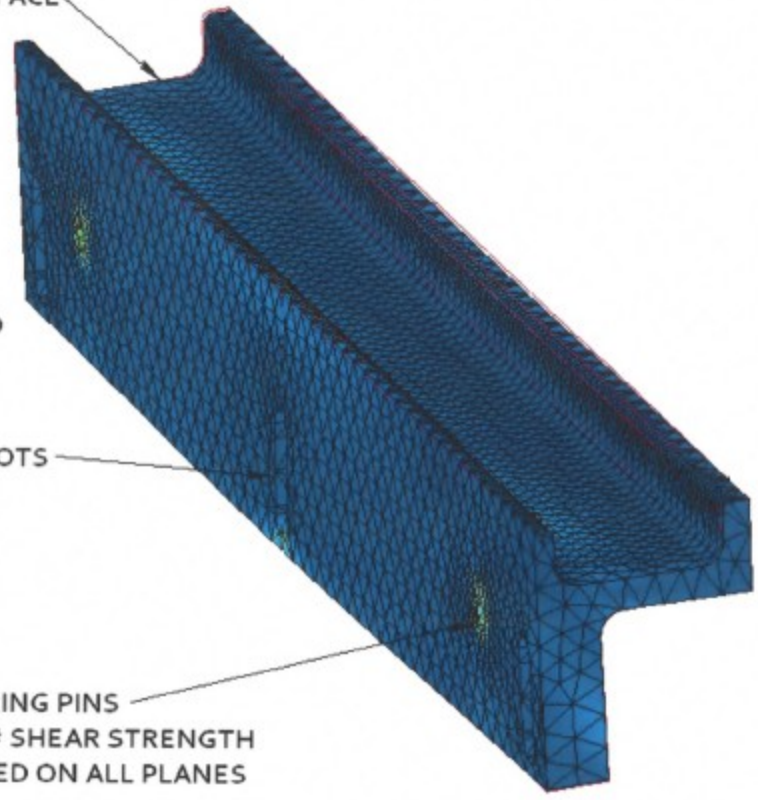
CLIP BOTTOM VERTICAL FEM

I-DEAS 12 NX Series m2: I-DEAS Visualizer

750# LOAD ON SURFACE

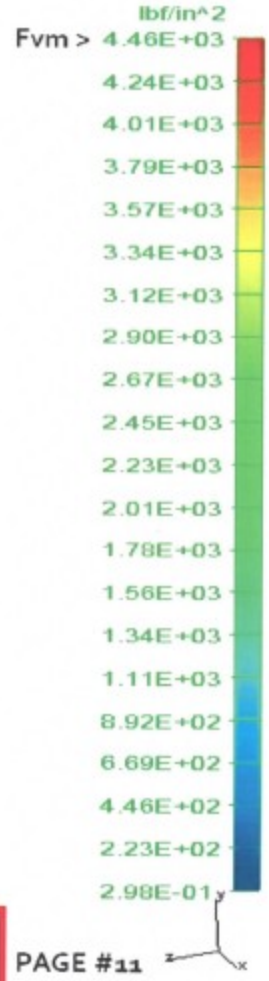
CLIP_BOTT_HORIZ_FEM
750LB_LOAD
STRESS Von Mises Averaged Top shell
Min: 2.98E-01 lbf/in^2 Max: 4.46E+03 lbf/in^2
B.C. 1,DISPLACEMENT_1,LOAD SET 1
DISPLACEMENT XYZ Magnitude
Min: 0.00E+00 in Max: 2.31E-03 in

MATERIAL : ALUMINUM 6061-T6
Fvm = 0.6 X 35,000 = 21,000 PSI ALLOWED



(3) 1/2-13 SCREWS THOUGH SLOTS
RESTRAINED ON " Z " ONLY

(2) 3/8 SPRING PINS
17,600# SHEAR STRENGTH
RESTRAINED ON ALL PLANES



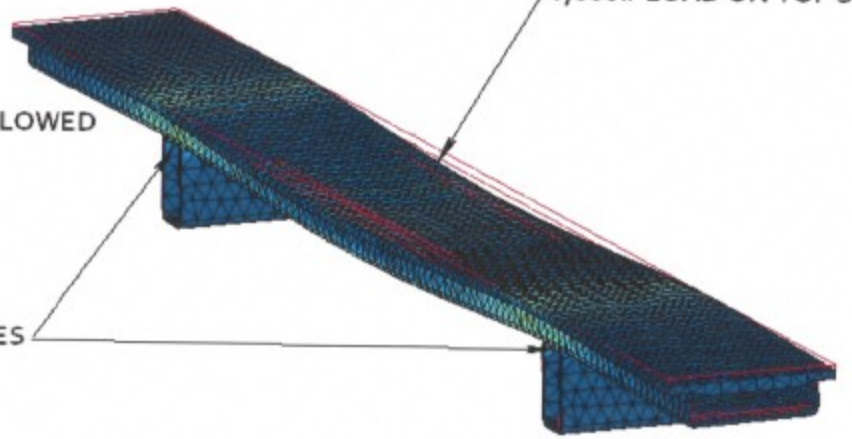
CLIP BOTTOM HORIZONTAL

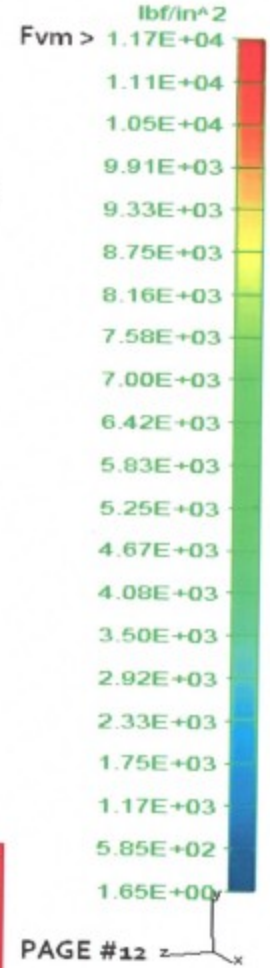
PAGE #11

I-DEAS 12 NX Series m2: I-DEAS Visualizer

MUON_CATCHER_BLOCK_PALLET_FEM
6000LB_LOAD_2-RESTRAINTS
STRESS Von Mises Averaged Top shell
Min: 1.65E+00 lbf/in^2 Max: 1.17E+04 lbf/in^2
B.C. 1,DISPLACEMENT_1,LOAD SET 1
DISPLACEMENT XYZ Magnitude
Min: 0.00E+00 in Max: 1.78E-02 in

MATERIAL : ASTM A36 STEEL
Fvm = 0.6 X 36,000 = 21,600 PSI ALLOWED





MUON CATCHER BLOCK PALLET

ATTACHED TO 2" STEEL PLATE AND
BLOCK IS FILLED WITH OIL

I-DEAS 12 NX Series m4: I-DEAS Visualizer

I-DEAS Visualizer
MUON_CATCHER_VERT_SUPT_WLDNT_FEM
GRAVITY_PLUS_PVC_HORIZ_PICK
STRESS Von Mises Averaged Top shell
Min: 1.47E+01 lbf/in^2 Max: 2.54E+04 lbf/in^2
DISPLACEMENT XYZ Magnitude
Min: 0.00E+00 in Max: 5.52E-02 in

USE ELETRODE E60XX
Fv = 0.3 x 62,000 = 18,600 psi allowed
Fw = sine45 x .5 18600 = 6576 #/in allowed

USING SKETCH SHOWN IN PAGE #6
Sw = 1" x 14 + 1^2/3 = 14.3 in^2
Jw = (1" + 14)^3 / 6 = 563

M = 8 x 6671 = 53,368 in-lbs

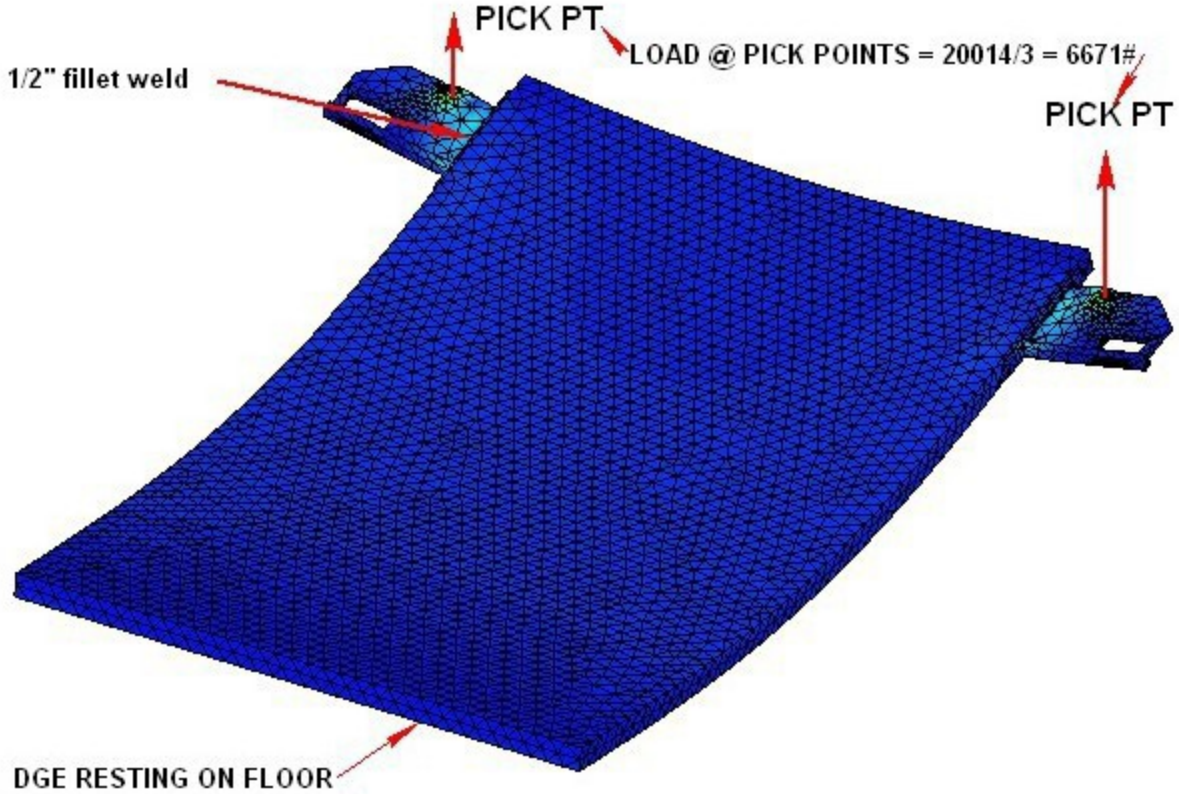
Fm = 53368 / 14.3 = 3723 # / in

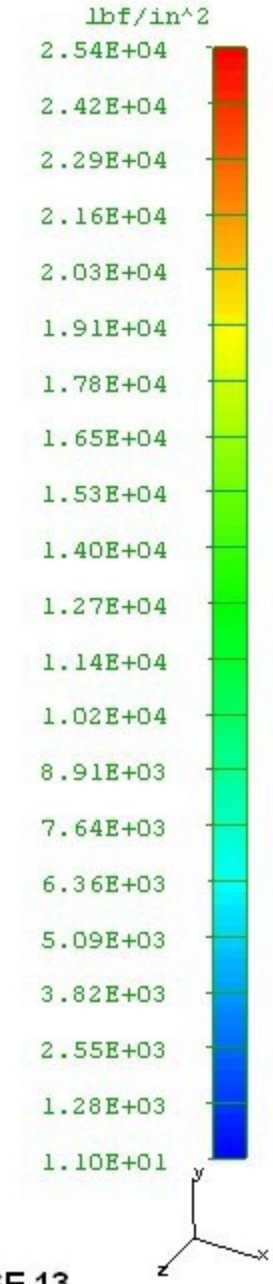
ft = 6.5 x 6671 / 563 = 77 # /in

fv = 6671 / 14+ 2 = 417

COMBINING FORCES

f = sqrt (3723^2 + 77^2 + 417^2) = 3747 # / in < 6576 # / in





WEIGHT

PVC----------514#
STEEL PLATE 4"-----19500
TOTAL------20014#

VERTICAL PLANE ASSY
HORIZ PICK

FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			14

SUBJECT: GLUE PEAL STRENGTH OF BOTTOM EXRUSION PANEL

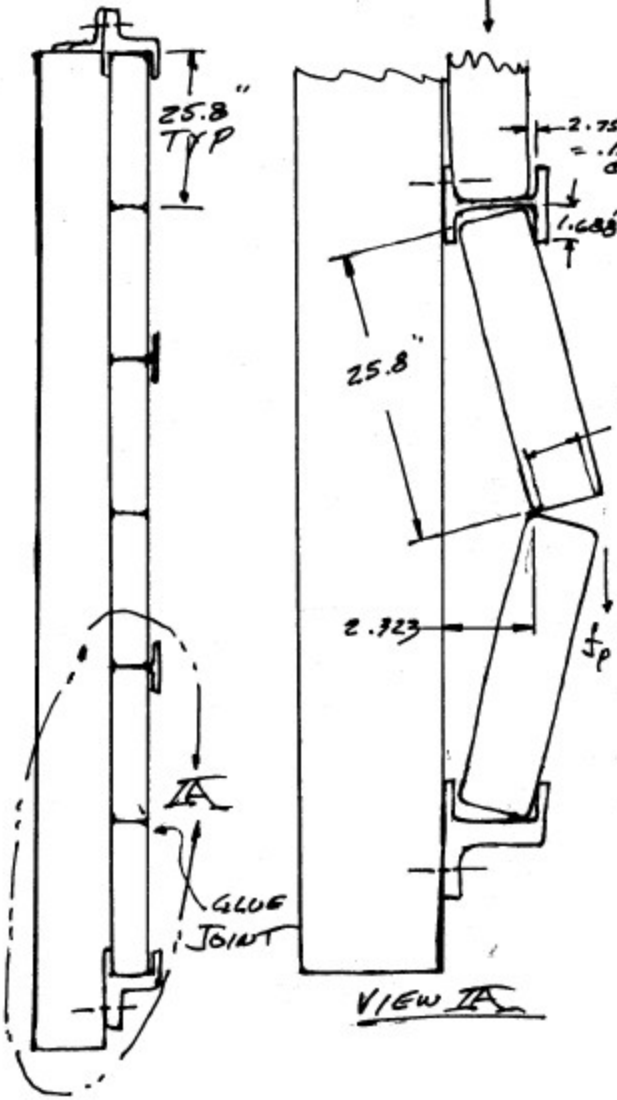
NAME: [illegible]

DATE: 01/25/2010

REVISION DATE:

16 CELL EXTRUSION
DIMENSIONS = 25.8 x 108 lg.

$$w = \left(\frac{393^{\#} + 1049^{\#}}{6}\right) 5$$
$$= 1200^{\#}$$



$$\frac{.152 \times 25.8}{1.688} = 2.323''$$

$$M = 2.323 \times 1200^{\#}$$
$$= 2,788 \text{ IN-LB}$$

f_p = PEAL STRENGTH

$$= \frac{2788}{2.094'' \times 108''}$$

$$= \underline{12.33^{\#}/\text{IN}} <<< \underline{99.12^{\#}/\text{IN}}$$

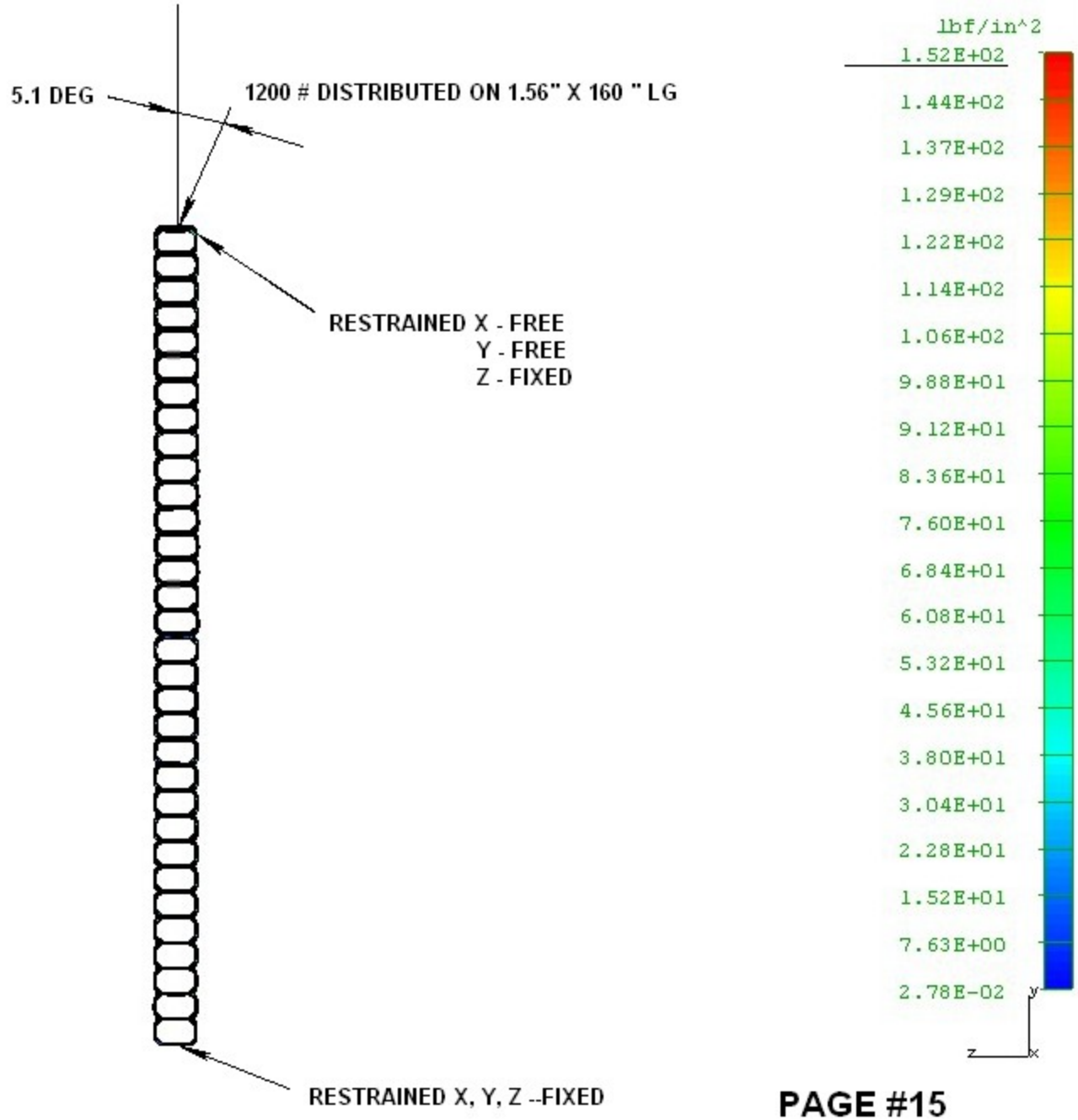
PER ARGONNE TEST

I-DEAS 12 NX Series m4: I-DEAS Visualizer

I-DEAS Visualizer
IPND_16_CELL_HORIZ_GLUED_EXTRUSION_FEM
1200_LB_LOAD
STRESS Von Mises Averaged Top shell
Min: 2.78E-02 lbf/in^2 Max: 1.52E+02 lbf/in^2
DISPLACEMENT XYZ Magnitude
Min: 0.00E+00 in Max: 6.24E-03 in

MATERIAL: POLYVINYL CHLORIDE

YIELD STRENGTH ----------8350 PSI



IPND_16 Cell Horizontal Glued Extrusion Buckling Analysis

By Ingrid Fang

February 17, 2011

Figure 1. Meshing

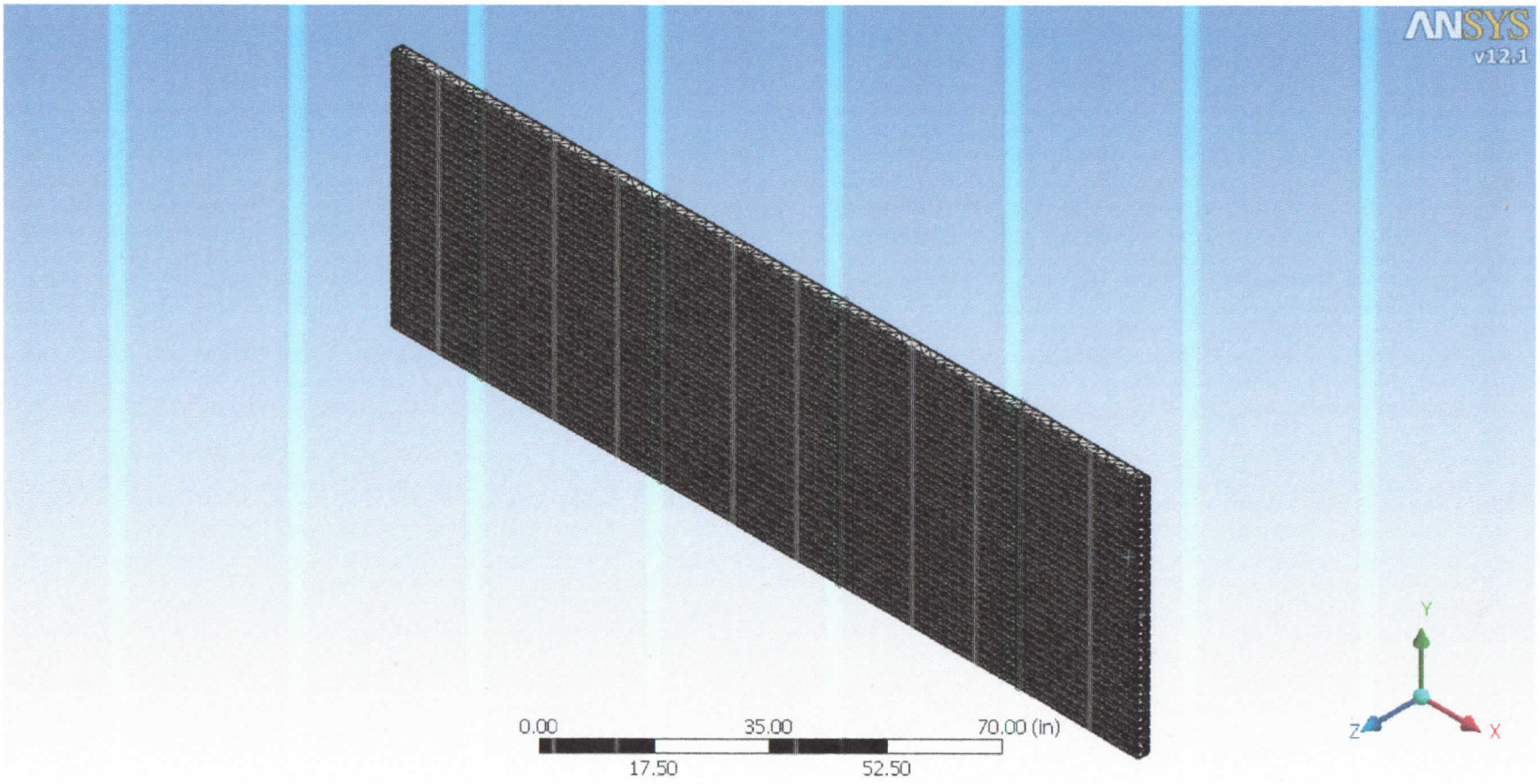


Figure 2. Loading

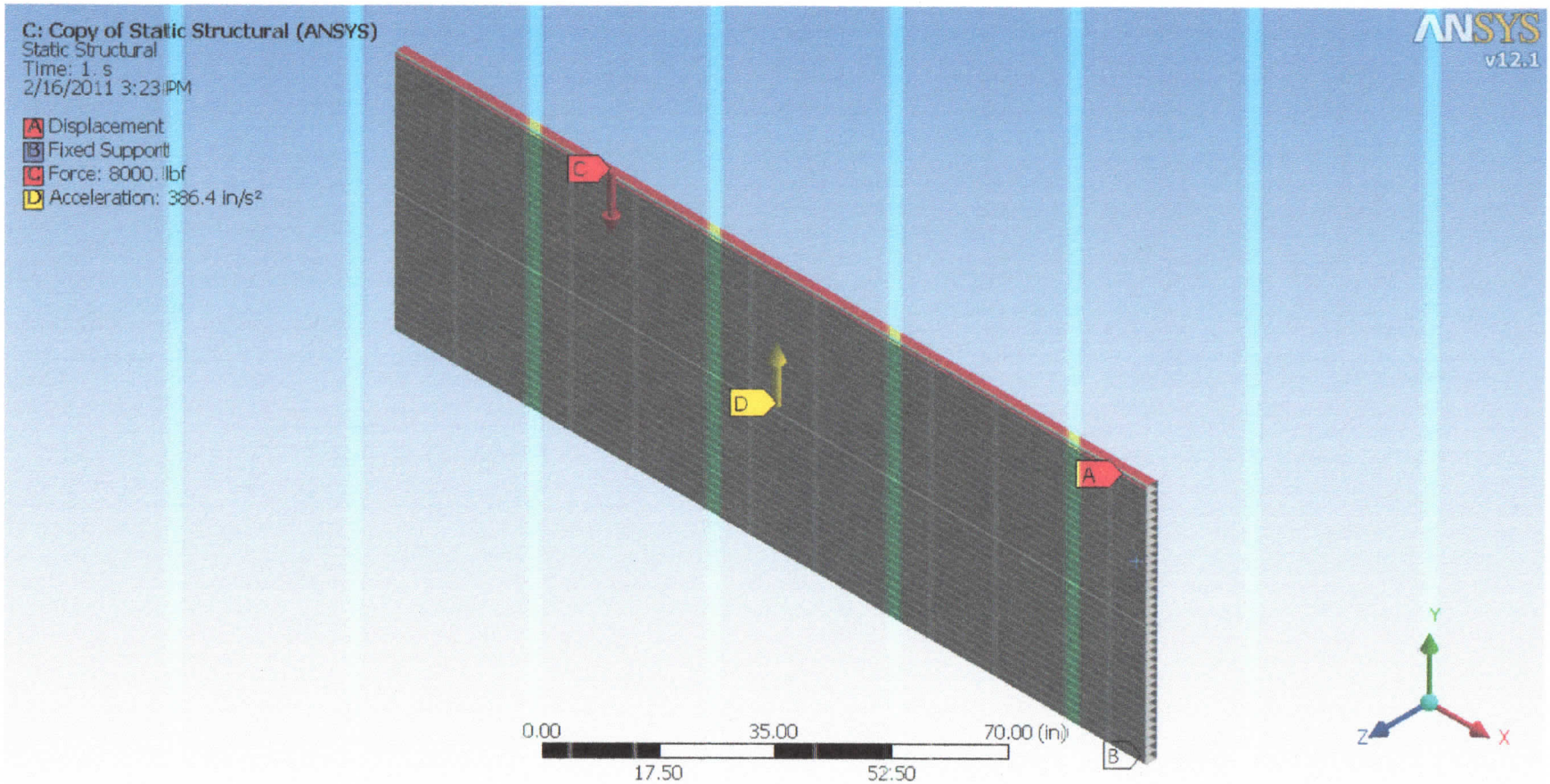
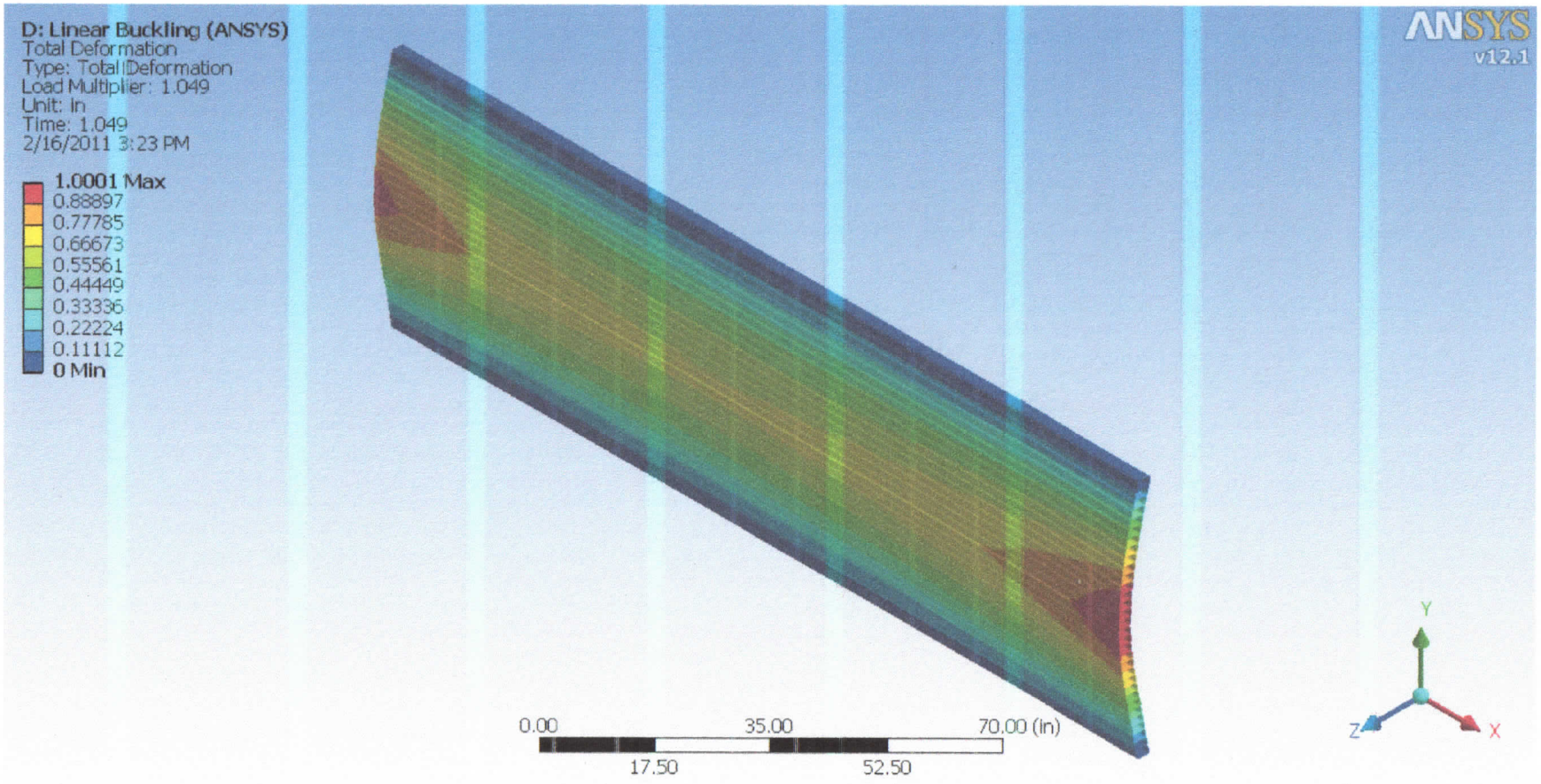


Figure 3. First Buckling Mode



Conclusion

- The results show that the first buckling mode occurs at 8000 lbs. In the actual load of 1200 lbs, a safety factor of 6.6 is obtained.