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

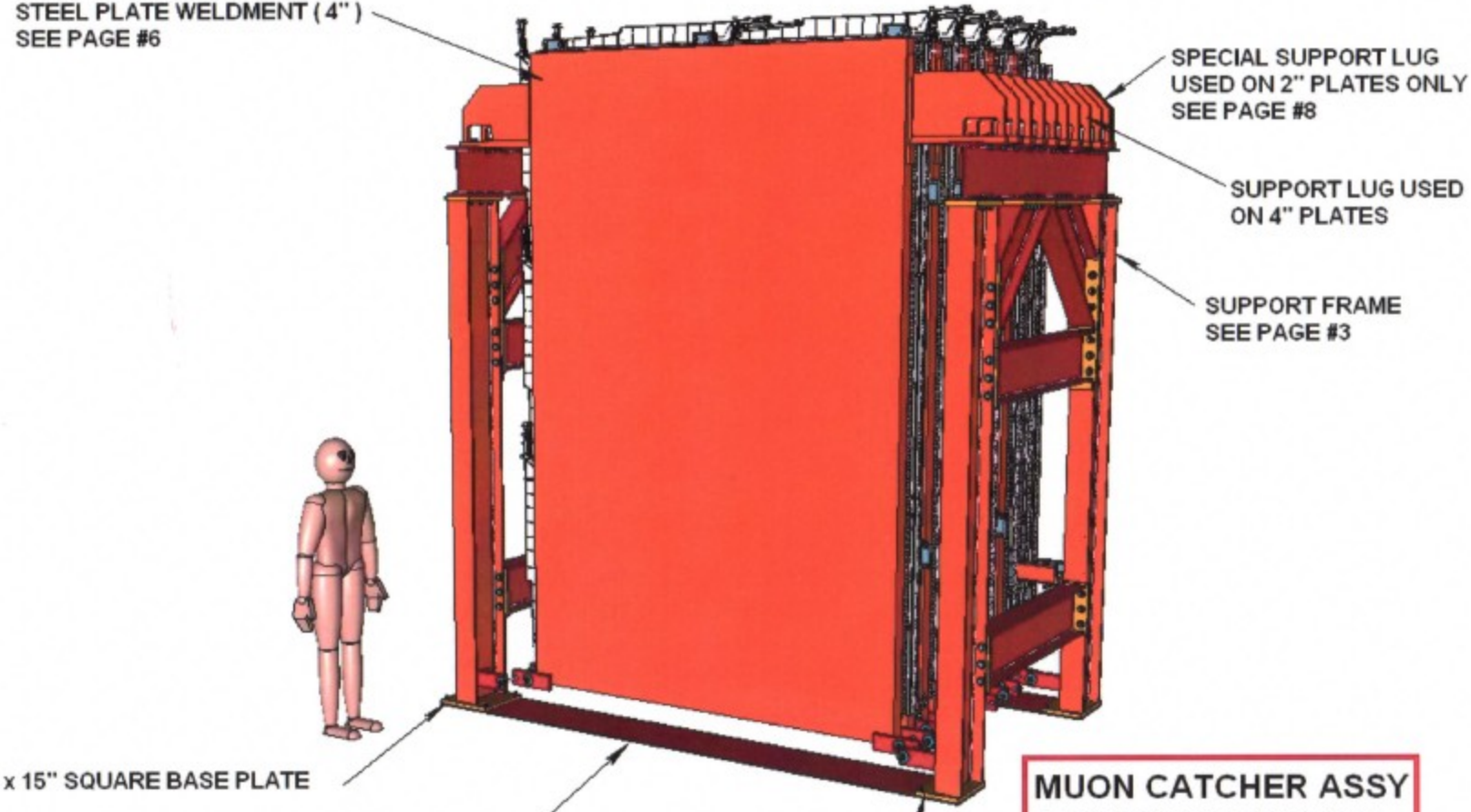
Reviewer(s): Anglee 3-26-2010/AL / 7-17-2011

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

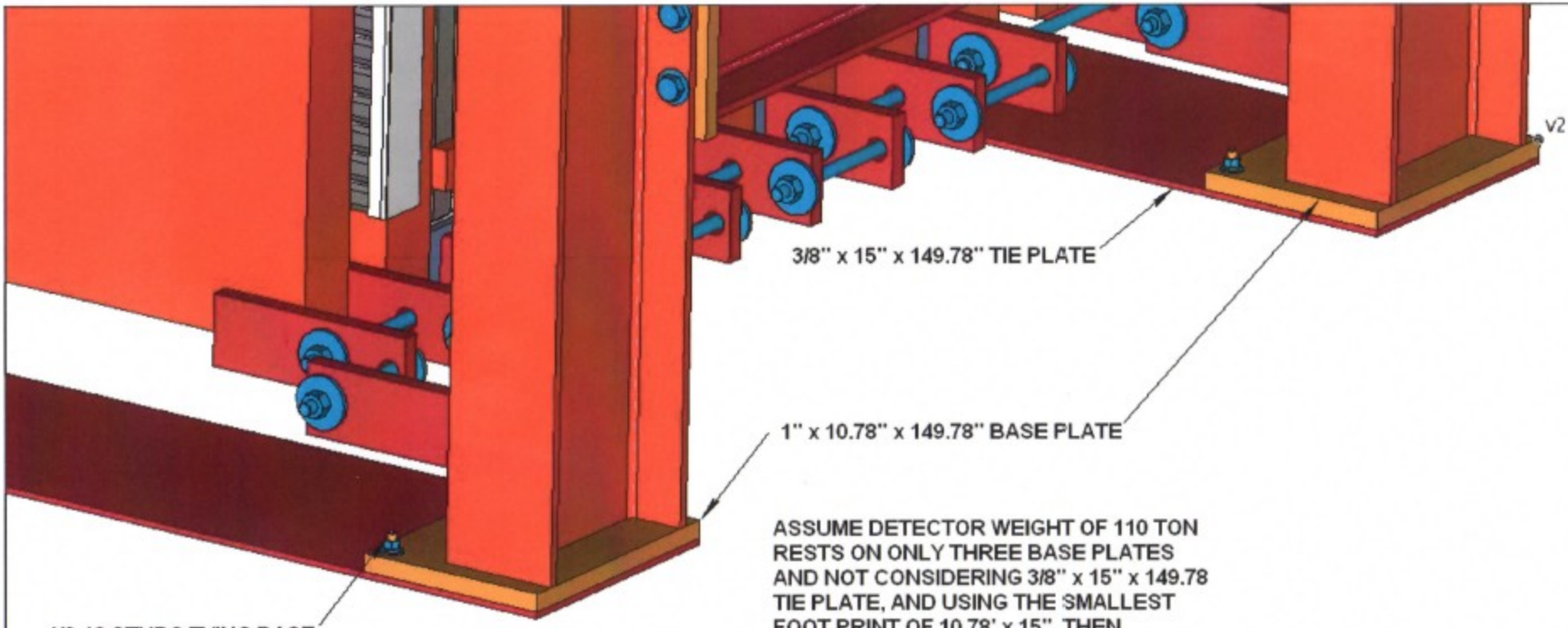
Abstract/Summary:THE DETECTOR IS COMPOSED OF THE FOLOWING:

(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 TO 3/8" x 15" x 150"
(6) THE DETECTOR WEIGHT IS APPROXIMATELY 110 TON

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

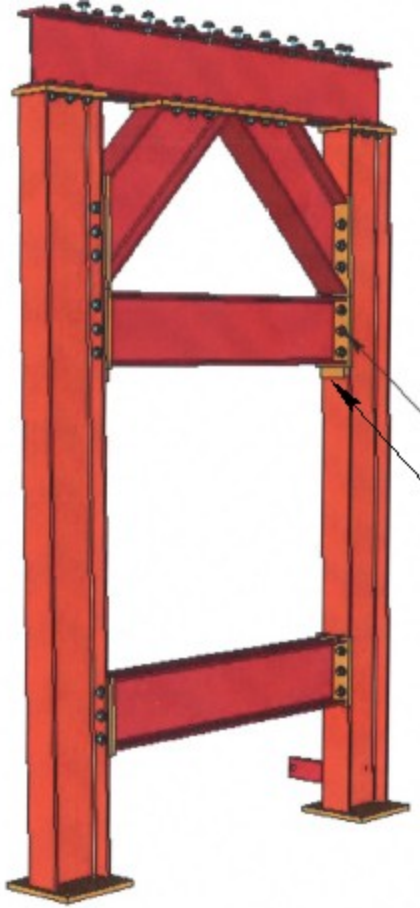


MUON CATCHER ASSY
APPROX WT 110 TON



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.

BASE PLATES AND TIE PLATES



SEE PAGES 4 & 5 FOR ONE-DIMENSIONAL FRAME FEA

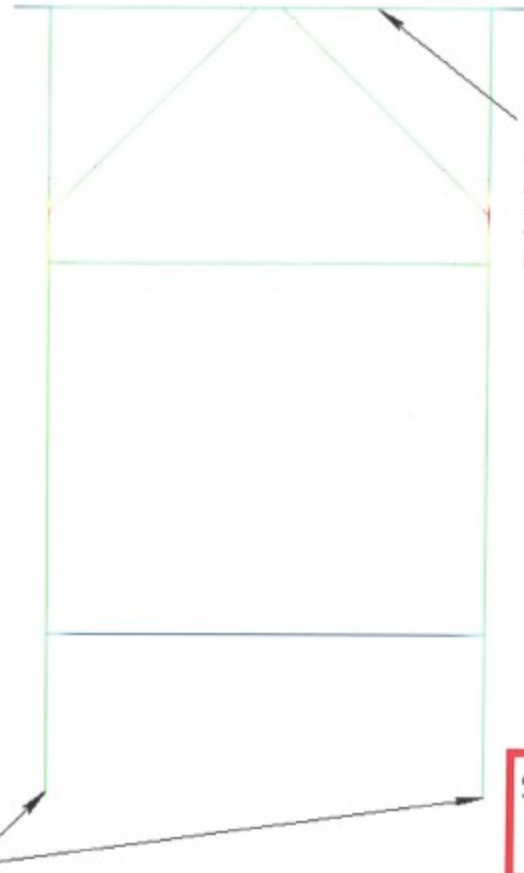
ALL FASTENERS 3/4-10 GRADE 8 BOLTS

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

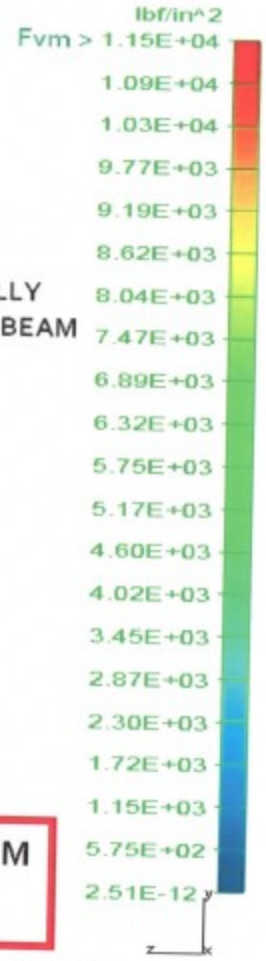
MUON_CATCHER_SUPT_FRAME_FEM
55_TON_LOAD
STRESS Von Mises Averaged Top shell
Beam stress: Von Mises , maximum point
Min: 2.51E-12 lbf/in^2 Max: 1.15E+04 lbf/in^2
B.C. 1,DISPLACEMENT_1,LOAD SET 1
DISPLACEMENT XYZ Magnitude
Min: 0.00E+00 in Max: 0.00E+00 in

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 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

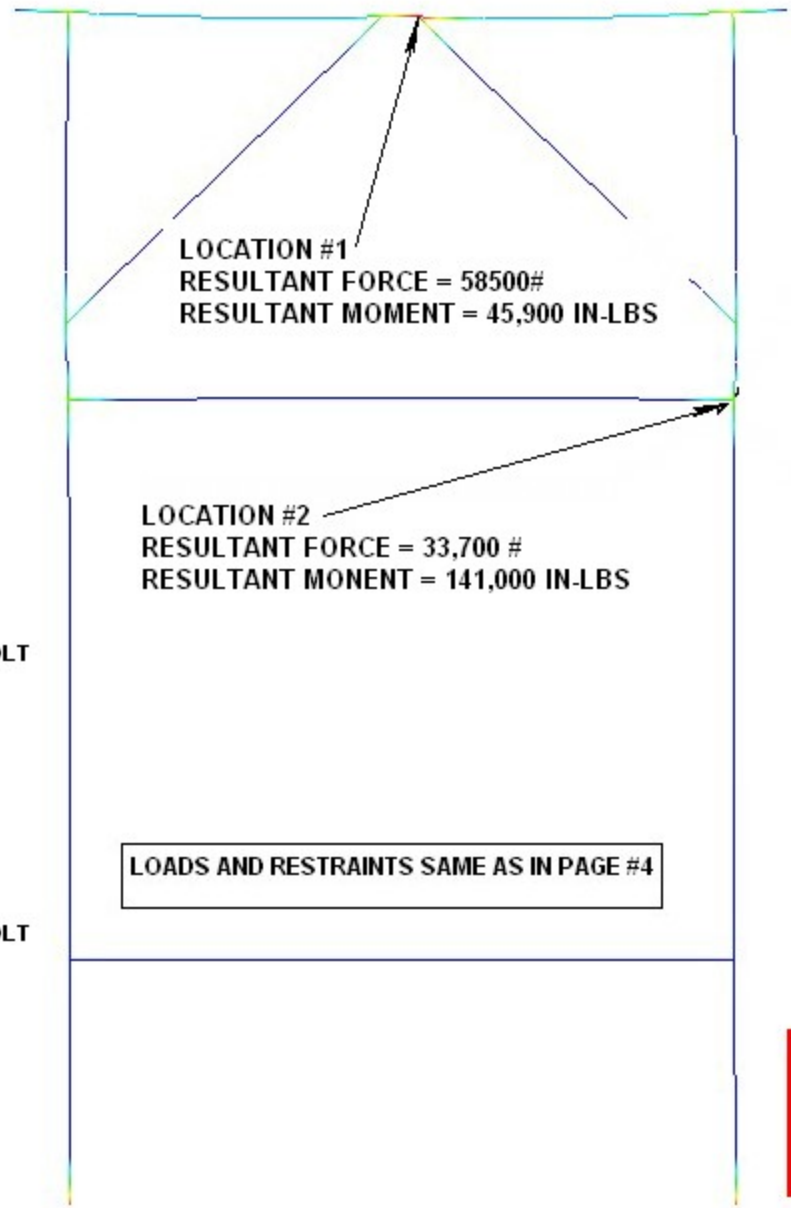
6 BOLTS CARRY 45,900 IN-LBS
fm = 45,900/6 x 1" = 7650#/BOLT

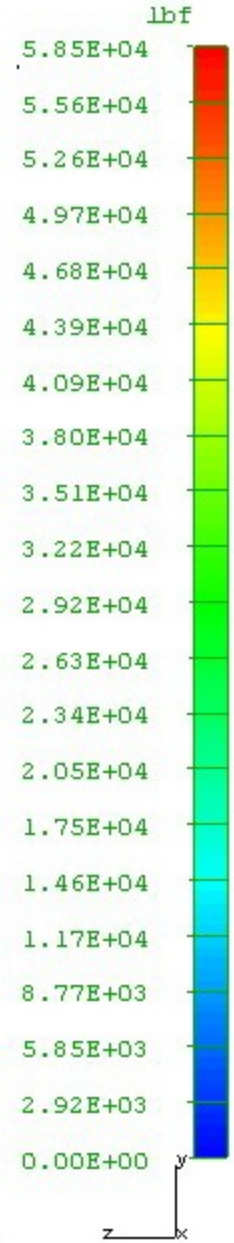
COMBINING FORCES
CLAMP LOAD = SQRT(9750^2 + 7650^2) = 12,393#/BOLT < 30,400#/BOLT

LOCATION # 2
6 BOLTS CARRY 33,700#
f = 33,700/6 = 5617#/BOLT

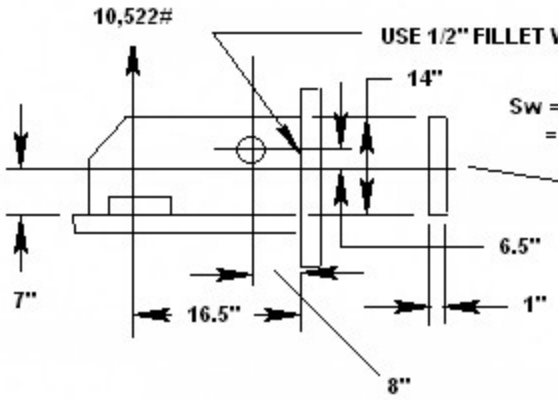
6 BOLTS CARRY 141,000 IN-LBS
fm = 141,000/6 x 1" = 23,500 #/BOLT

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





SUPPORT FRAME FEA FORCES



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

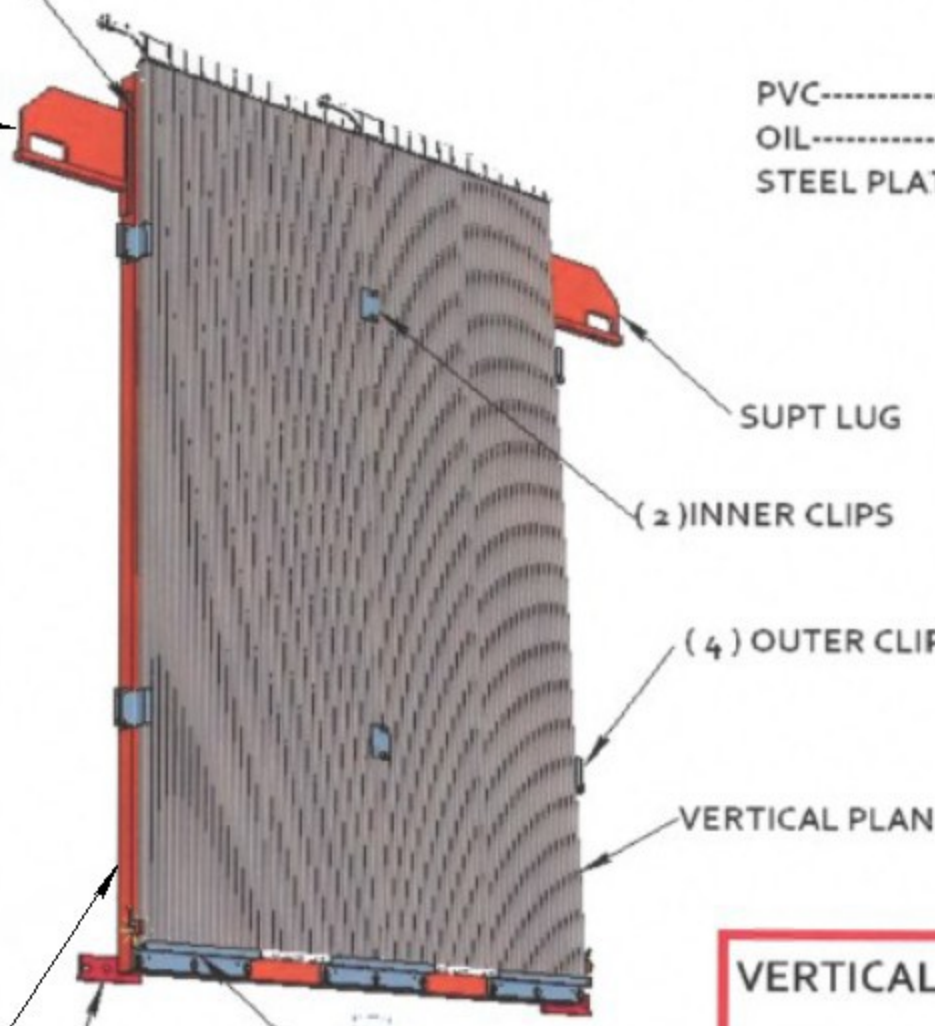
fv = 10522/2X14+2X1" =351#/IN

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

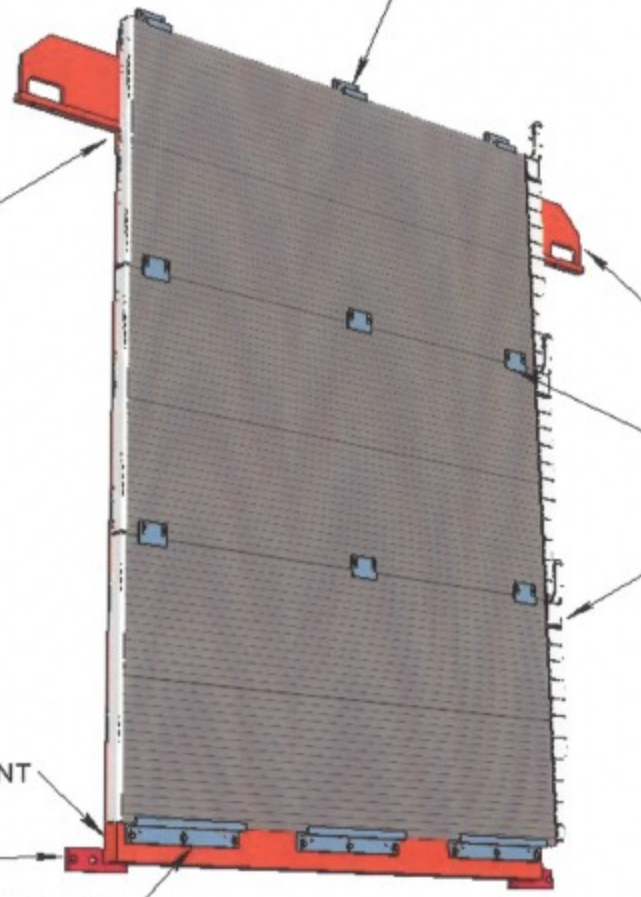


WEIGHT

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

VERTICAL PLANE ASSY

PAGE #6



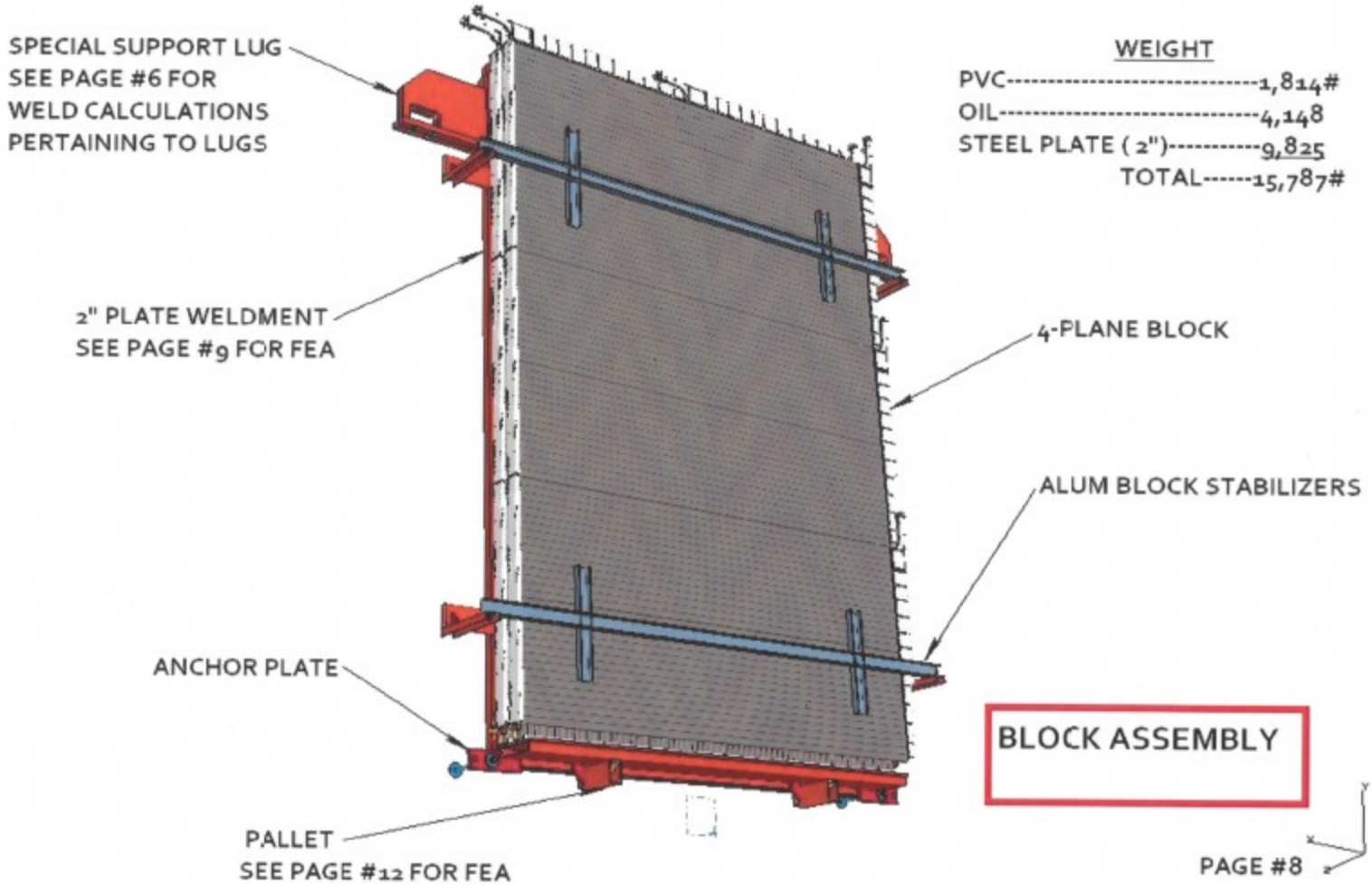
NOTE :
SEE PAGE # 6 FOR WELD CALCULATIONS PERTAINING TO SUPT LUGS

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#

BLOCK ASSEMBLY

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

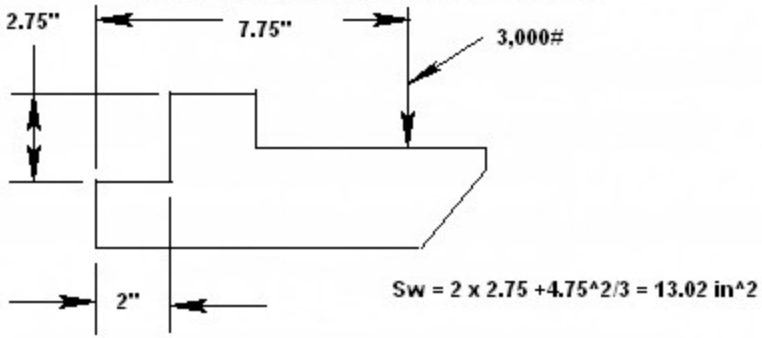
MATERIAL: ASTM A36 STEEL

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



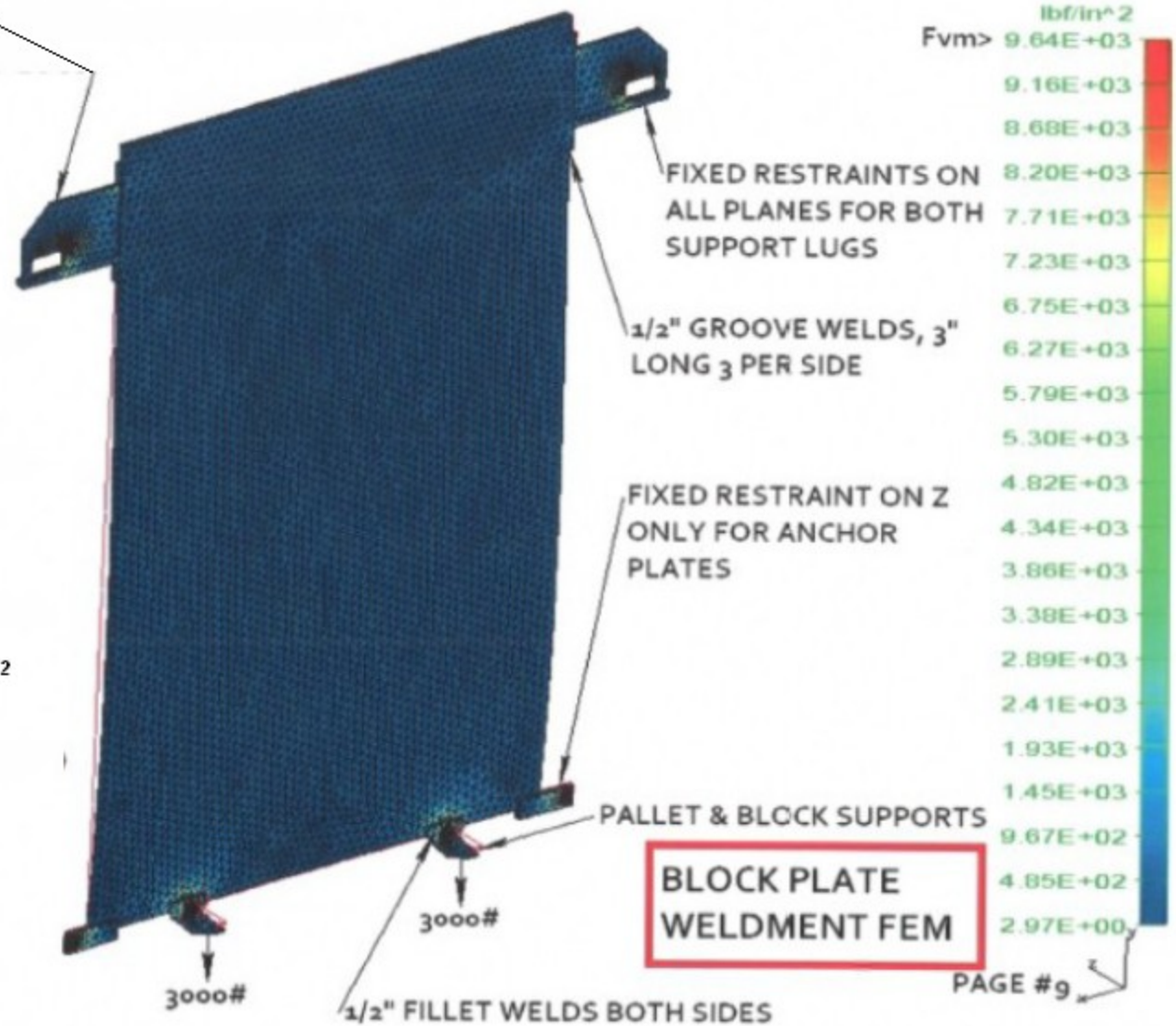
Sw = 2 x 2.75 +4.75^2/3 = 13.02 in^2

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



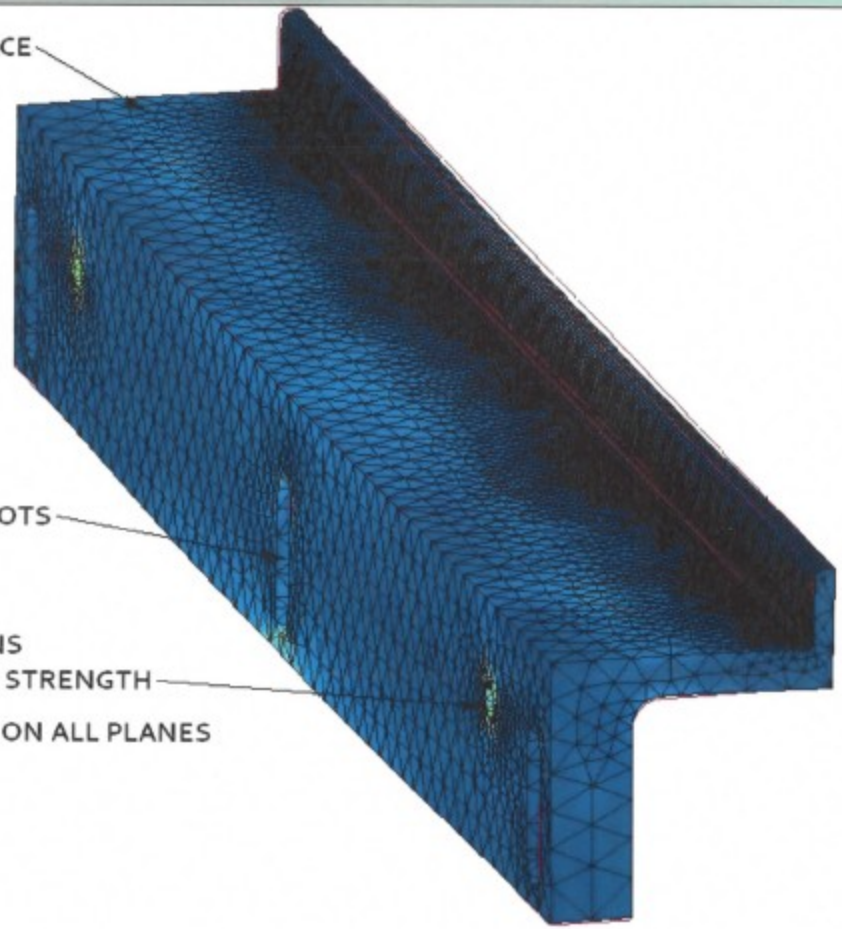
775# LOAD ON SURFACE

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

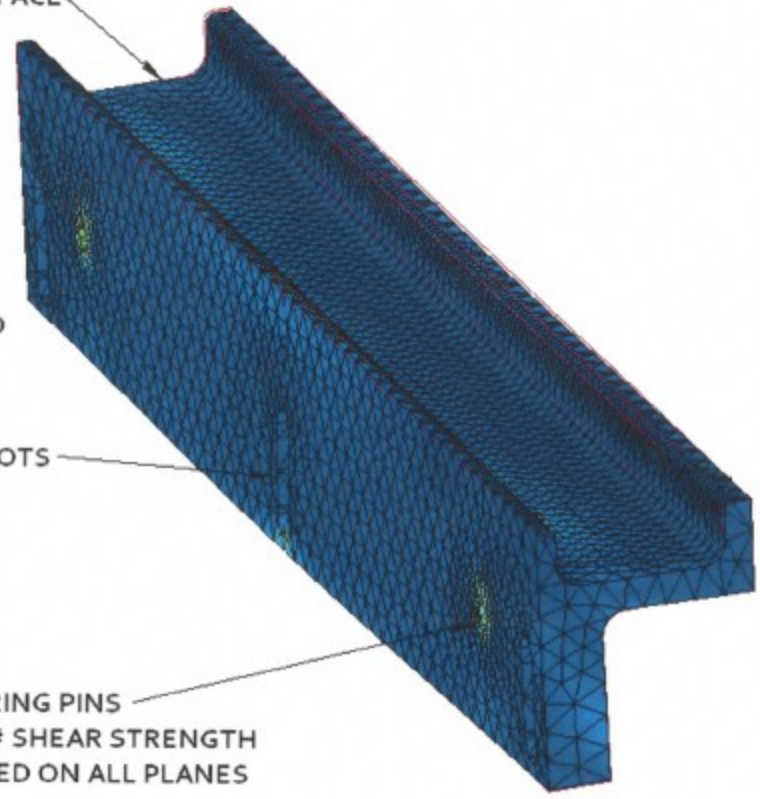
CLIP BOTTOM VERTICAL FEM

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

750# LOAD ON SURFACE

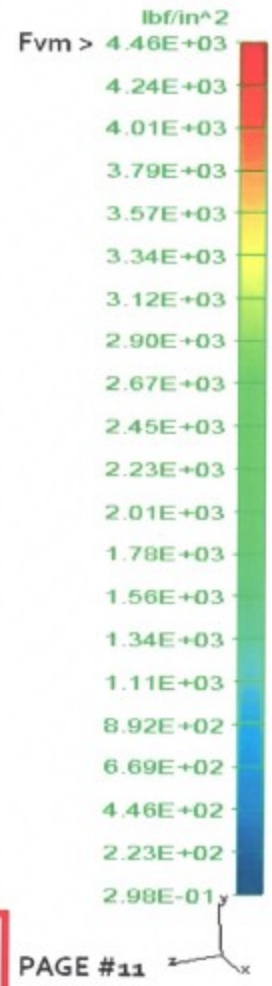
CLIP_BOTT_HORIZ_FEM
750LB_LOAD
STRESS Von Mises Averaged Top shell
Min: 2.98E-01 lbf/in^2 Max: 4.46E+03 lbf/in^2
B.C. 1,DISPLACEMENT_1,LOAD SET 1
DISPLACEMENT XYZ Magnitude
Min: 0.00E+00 in Max: 2.31E-03 in

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

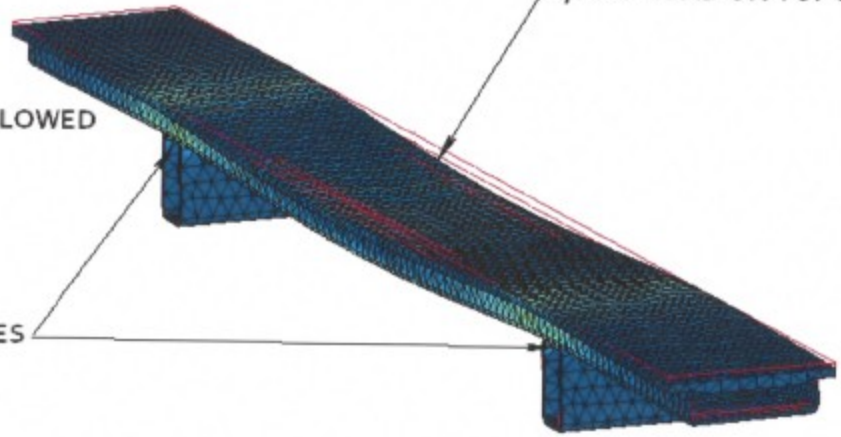
(2) 3/8 SPRING PINS
17,600# SHEAR STRENGTH
RESTRAINED ON ALL PLANES



CLIP BOTTOM HORIZONTAL

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



lbf/in^2
Fvm > 1.17E+04
1.11E+04
1.05E+04
9.91E+03
9.33E+03
8.75E+03
8.16E+03
7.58E+03
7.00E+03
6.42E+03
5.83E+03
5.25E+03
4.67E+03
4.08E+03
3.50E+03
2.92E+03
2.33E+03
1.75E+03
1.17E+03
5.85E+02
1.65E+00

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

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

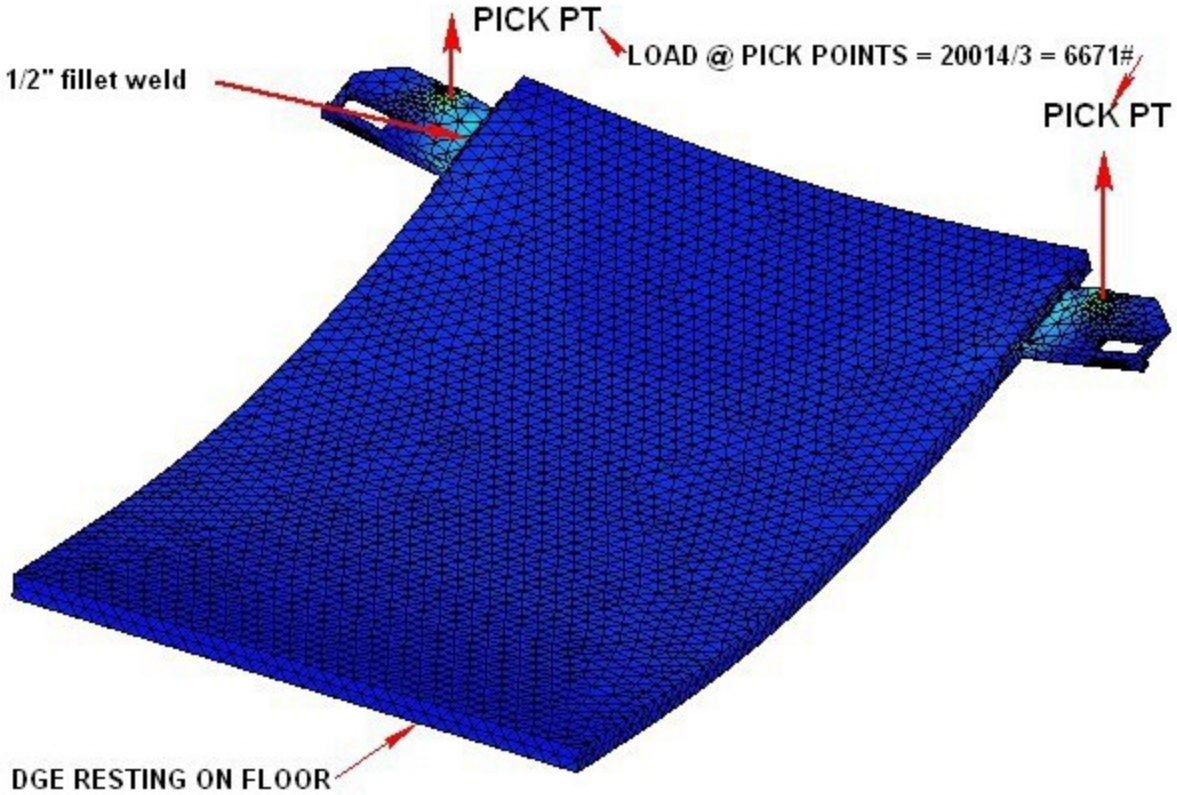
Fm = 53368 / 14.3 = 3723 # / in

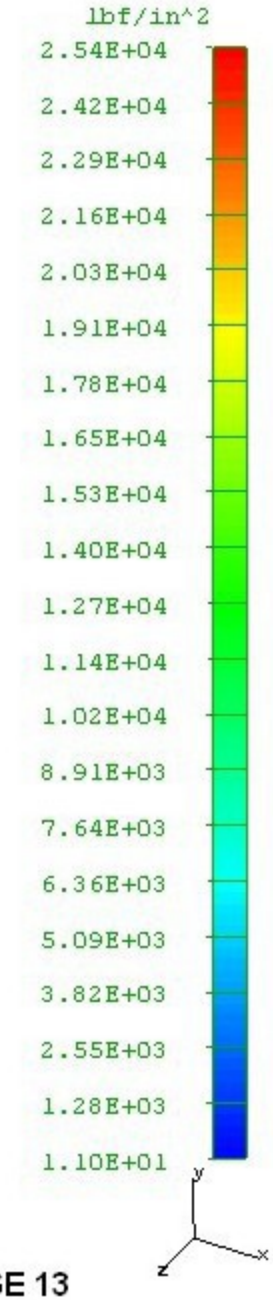
ft = 6.5 x 6671 / 563 = 77 # /in

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

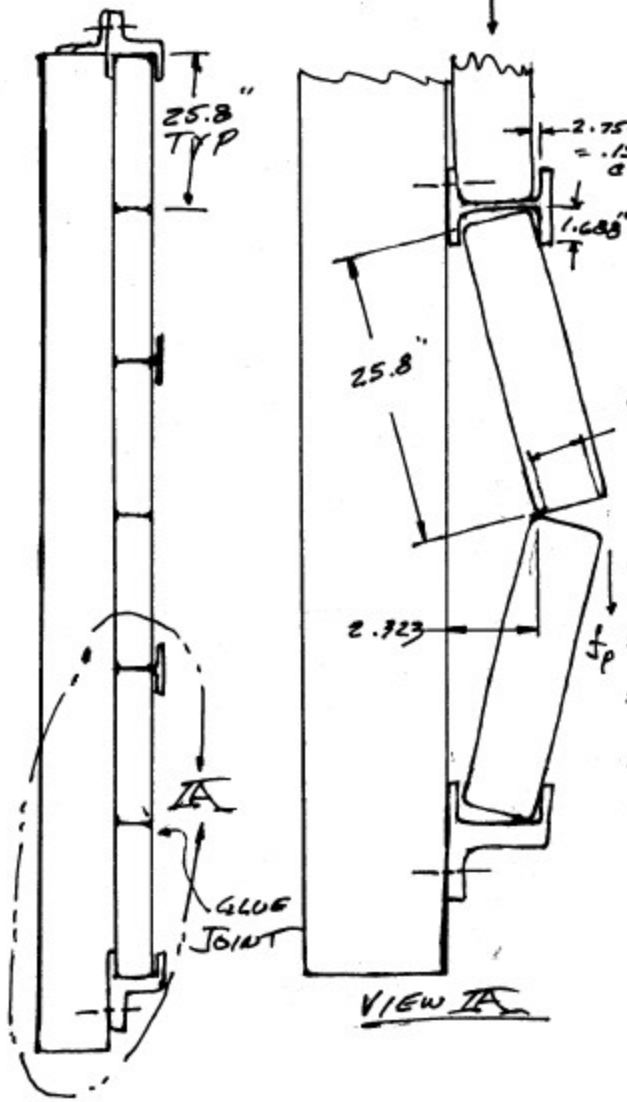
NAME: E M Hollyer

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

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

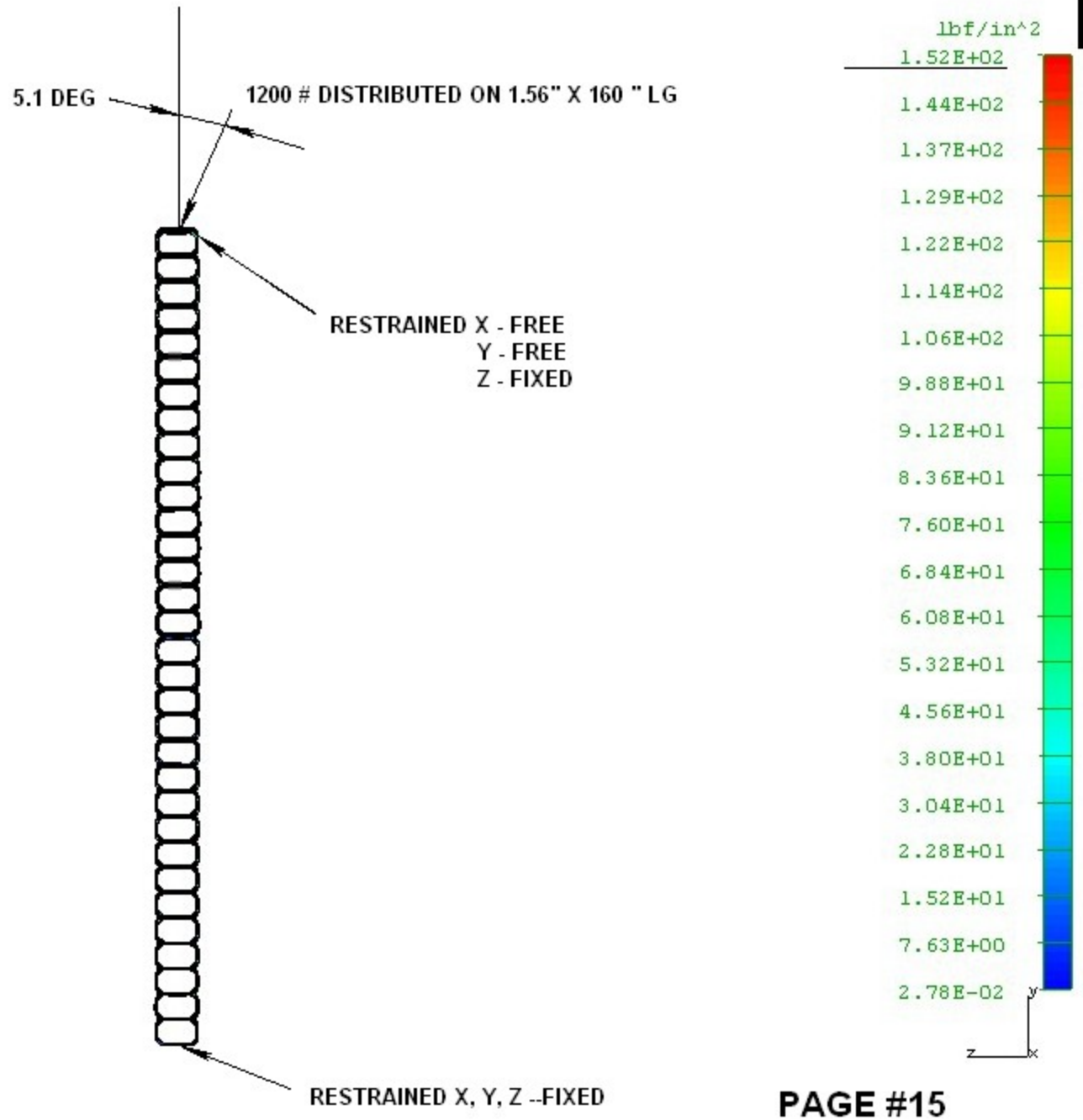
$$= 12.33^{\#/IN} \ll\ll 99.12^{\#/IN}$$

PER ARGONNE TEST

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 2

By Ingrid Fang

February 28, 2011

Figure 1. Meshing

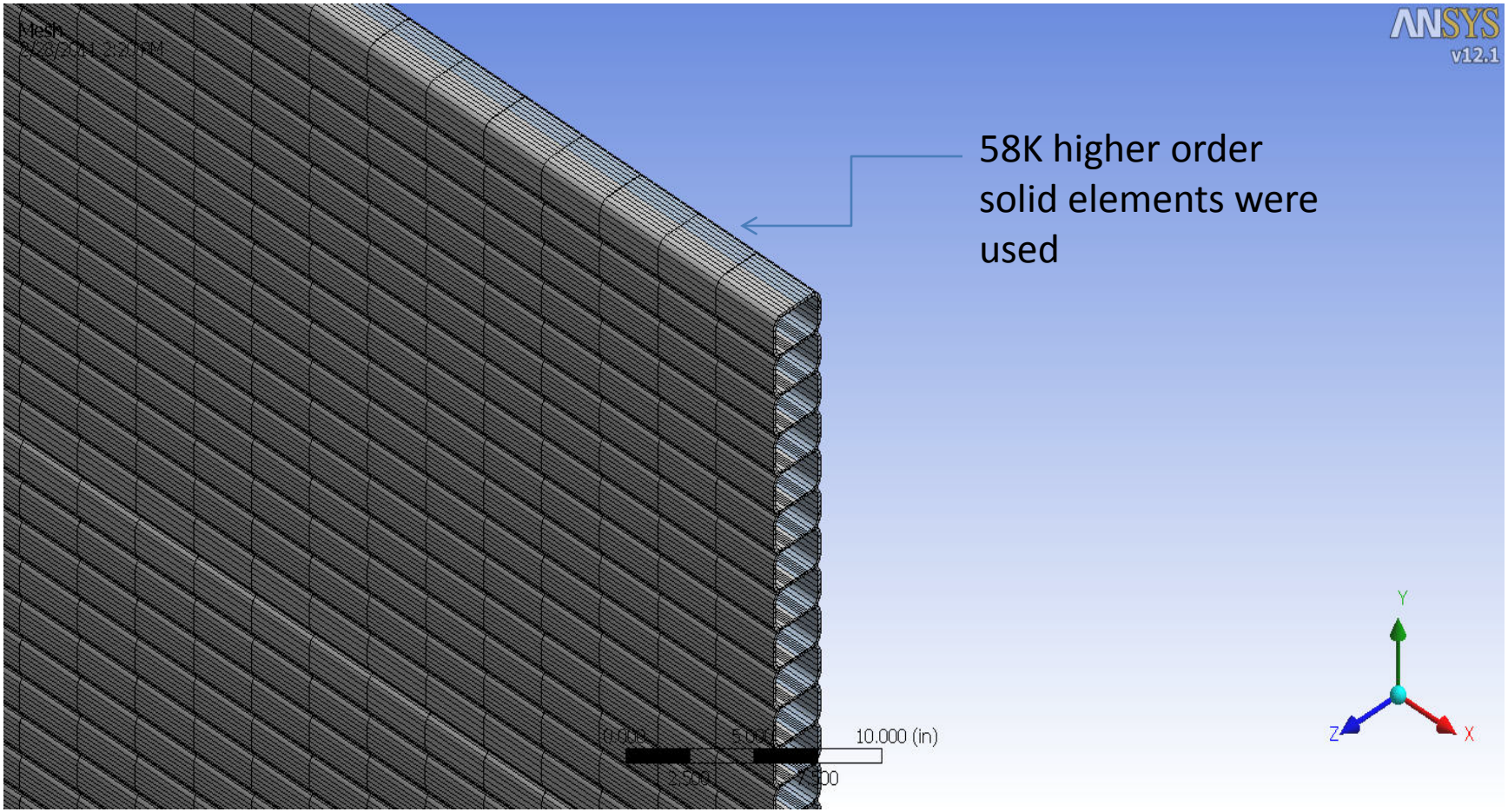


Figure 2. Loading

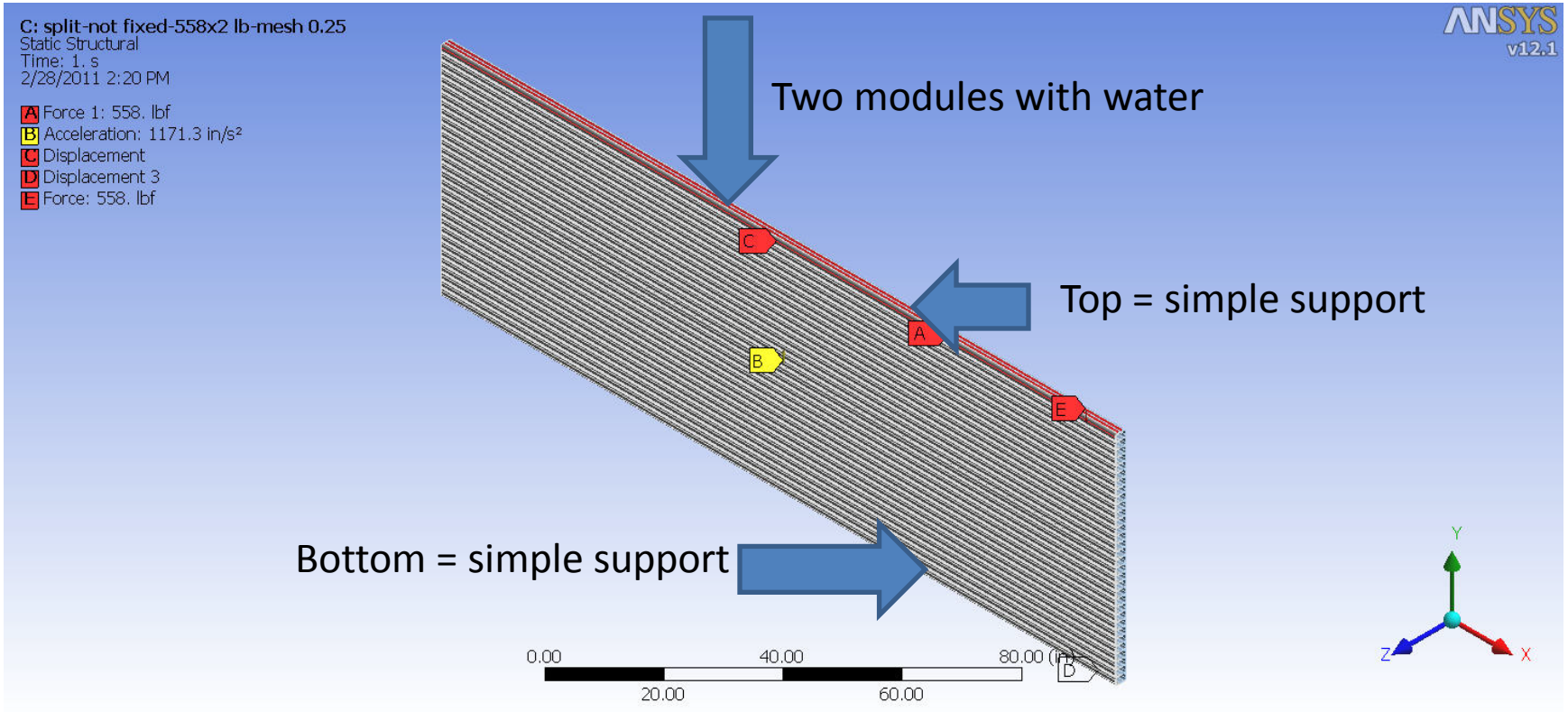
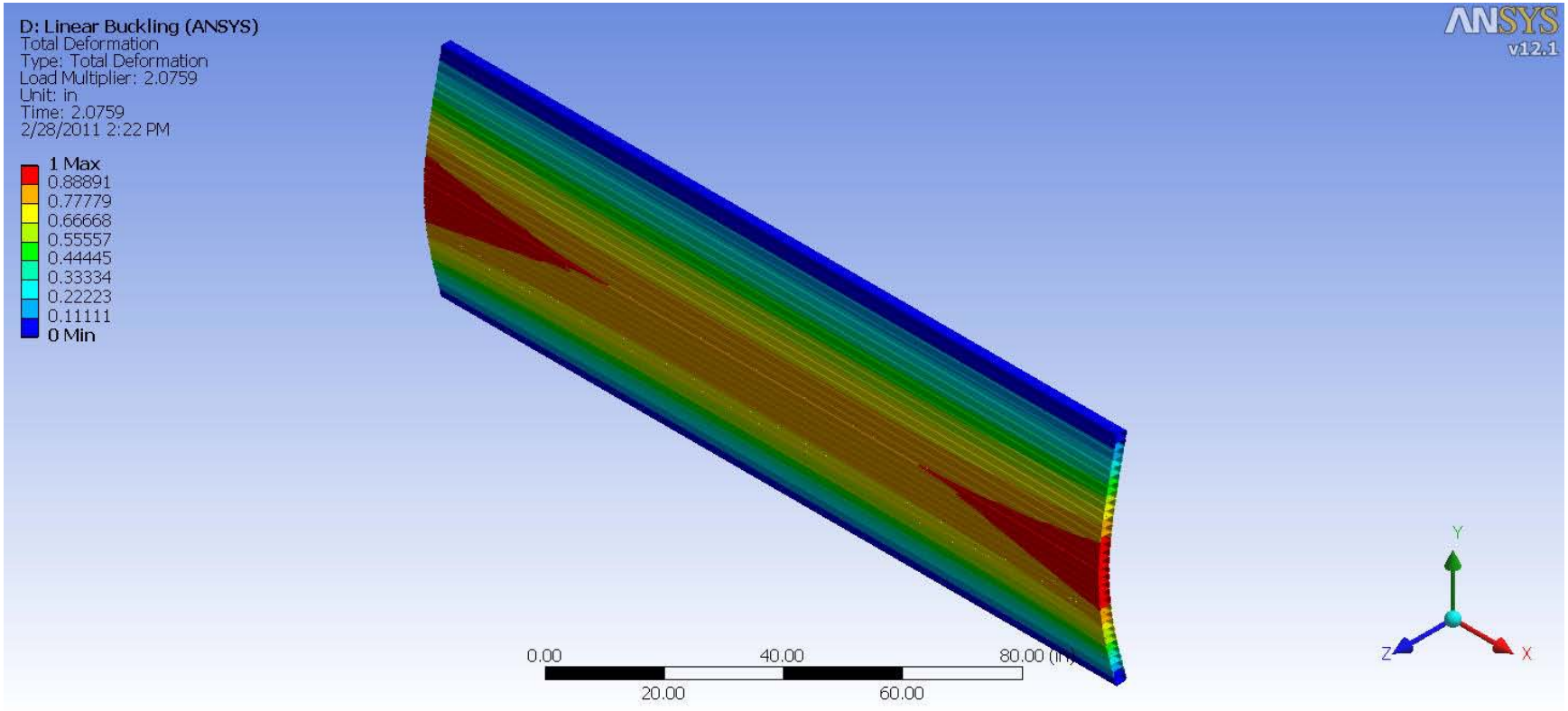


Figure 3. First Buckling Mode



Conclusion

The buckling load factor is about 2. It is smaller than the previous analysis for three reasons:

1. The previous analysis used the weight of only two modules, applied to the top of the bottom module. The new analysis includes the weight of the bottom module (water plus PVC), which tends to reduce the load factor.
2. The previous analysis used a fixed boundary condition at the bottom of the module; the new analysis uses a simply-supported boundary condition. This is another contributor to the load factor reduction
3. Following discussions with Ang Lee, we decided that we should use the 20 year creep modulus of PVC (75000 psi) instead of the short-time modulus.