Fermilab

Particle Physics Division
Mechanical Department Engineering Note

Number: MD-ENG-195 Date: 12 Aug 2009

PPD# 168 Lifting Fixture #

Project Internal Reference:

Project: Minerva

Title: Below the hook lifting fixture

Author(s): Mike Zuckerbrot

Reviewer(s):

Key Words: Below the hook lifting fixture

Applicable Codes: 1.) ASME B30-20 "Below the hook lifting devices"
2.) AISC "manual of steel construction" 9th ed.
3.) AHSI/AWS D14.1 "Specification of welding of industrial and mill cranes and other material handling

Abstract Summary:
The following is a stress analysis of a below the hook lifting fixture designed for a 1000# load, split between the two pins.

BELOW-THE-HOOK LIFTING DEVICE
Engineering Note Cover Page

Lifting Device Numbers: 195

FNAL Site No/ _____ Div. Specific No. 168 Asset No. _____

If applicable — If applicable — If applicable

ASME B30.20 Group: (check one)
- [x] Group I Structural and Mechanical Lifting Devices
- [ ] Group II Vacuum Lifting Devices
- [ ] Group III Magnets, Close Proximity Operated
- [ ] Group IV Magnets, Remote Operated

Device Name or Description: 1 kip spreader

Device was (check all applicable)
- [ ] Purchased from a Commercial Lifting Device Manufacturer. Mfg Name _____
- [X] Designed and Built at Fermilab
- [ ] Designed by Fermilab and Built by a Vendor. Assy drawing number _____
- [ ] Provided by a User or other Laboratory
- [ ] Other: Describe _____

Engineering Note Prepared by: M. Zuckerbrot Date: 8/12/09

Engineering Note Reviewed by: [signature] Date: 8/17/09

Lifting Device Data:

Capacity: 1000#

Fixture Weight: 550 #

Service: [X] normal [ ] heavy [ ] severe (refer to B30.20 for definitions)

Duty Cycle _____ 8, 16 or 24 hour rating (applicable to groups III, and IV)

Inspections Frequency: EVERY USE

Rated Load Test by FNAL (if applicable) Date: 10/19/09 Load: 1500 Lbs

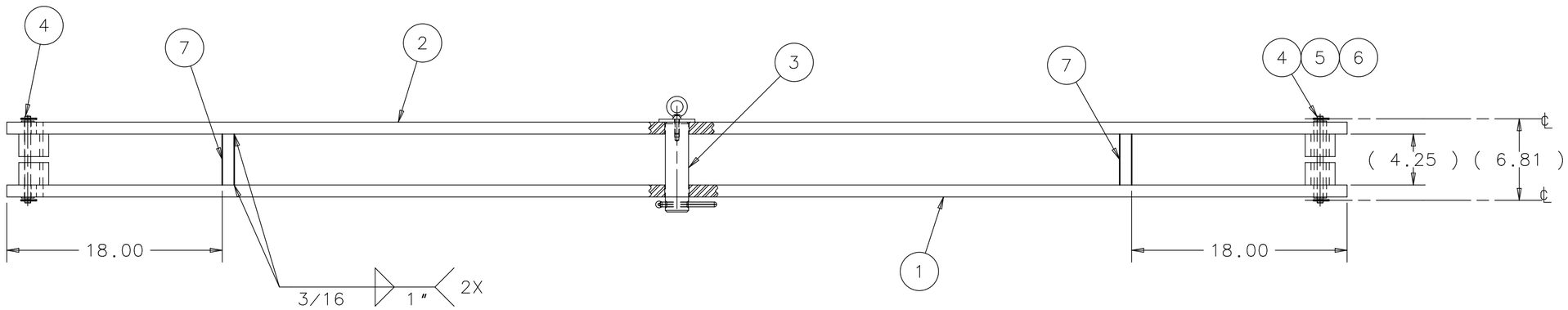
[ ] Check if Load Test was by Vendor and attach the certificate

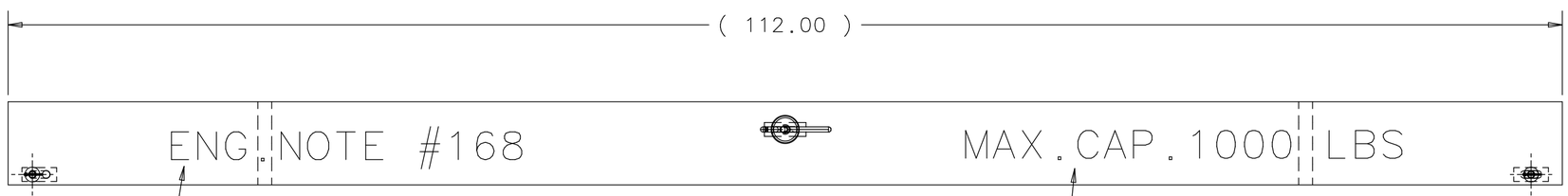
Satisfactory Load Test Witnessed by: John Voirin

Signature (of Load Test Witness): [signature]

Notes or Special Information:

REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE
A	REV.TITLE; ADD HK.PIN WLDMT;	PAT POLL	10/6/09
	ADD SPACER BAR, ENL.DWG.SIZE	DAVE PUSHKA	10/7/09





STENCIL @3" MIN. HEIGHT (BLACK)
ENG. NOTE #168

STENCIL @3" MIN. HEIGHT (BLACK)
"MAX. CAP. 1000 LBS"

ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
7	COML	SPACER BAR, 1x4.25x6.00, ASTM A36	2
6	COML	WASHER, FLAT, 1/2	4
5	COML	PIN, COTTER, ø1/8 X 1.00 LG.	4
4	MB-466532	SPREADER CONNECTOR PIN	2
3	MB-466596	SPREADER HOOK PIN WELDMENT	1
2	MD-466530	SPREADER WELDMENT, RIGHT	1
1	MD-466527	SPREADER WELDMENT, LEFT	1

PARTS LIST

EST. WT. = 400 LBS.

UNLESS OTHERWISE SPECIFIED
.XX
± .03 ± ±

1. BREAK ALL SHARP EDGES MAX.
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON ASME Y14.5M-1994
4. MAX. ALL MACH. SURFACES 250
5. DRAWING UNITS: U.S. INCH

ORIGINATOR	D.PUSHKA	31-JUL-2009
DRAWN	J.MATESKI	31-JUL-2009
CHECKED	J.RAUCH	06-AUG-2009
APPROVED	M.ZUCKERBROT	06-AUG-2009

USED ON

MATERIAL
SEE PARTS LIST ABOVE

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

MINERVA - GENERAL
A-DETECT 1KIP SPREADER BAR ASSY
SPREADER BAR & HOOK PIN ASSEMBLY

SCALE	DRAWING NUMBER	SHEET	REV
1:1	3938.000-MC-466526	1 OF 1	A

CREATED WITH : Ideas12NXSeries | GROUP: PPD/MECHANICAL DEPARTMENT

NOTICE: IMAGE OBTAINED FROM FERMILAB WEB SITE

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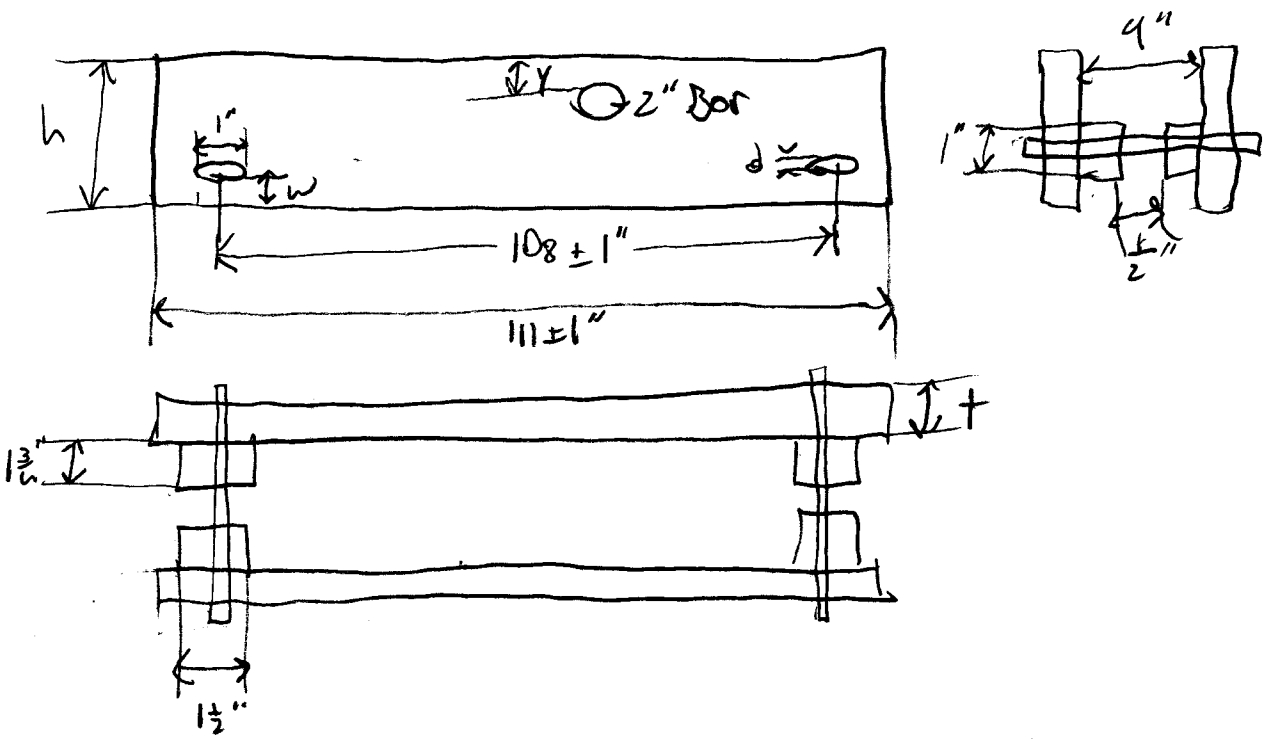
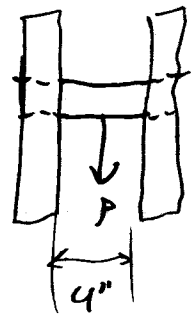


- Carbon Steel $F_y = 36$ ksi
- 1000 # Load

2" Bar

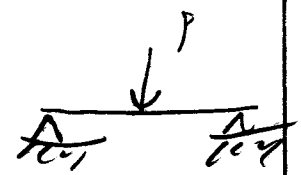


- Shear stress

$P = 1000\#$; $A = \frac{1}{4}\pi(2)^2$

$$f_v = \frac{1000}{\pi} = 318 \text{ psi} < F_{max} = \frac{1}{3}F_y = 12 \text{ ksi} \quad \underline{ok}$$

- Bending stress $\sigma = \frac{Mc}{I}$



$$M = \frac{Pl}{4} = \frac{(1000)4}{4} = 1000 \text{ lb-in} \; ; \; c = 1"$$

$$I = \frac{1}{64}\pi d^4 = \frac{1}{64}\pi(2)^4 = .785 \text{ in}^4$$

$$\sigma_b = \frac{1000(1)}{.785} = 1273.9 \text{ psi} < F_{max} = \frac{1}{3}F_y = 12 \text{ ksi}$$

$\underline{ok}$

Pins

- Shear Stress $F = \frac{P}{A}$; $P = 500\#$; $A = \frac{1}{4}\pi d^2$

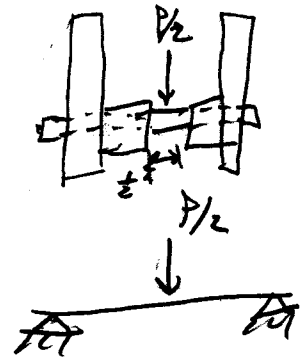
$F_{max} = 12\,ksi$; $d^2 = \frac{4(500)}{12{,}000\pi}$; $d = .23''$

→ set $d = \frac{1}{2}''$

→ $F = \frac{500}{\pi(\frac{1}{4})^2} = 2547\,psi < \frac{1}{3}F_y = 12\,ksi$

ok

- Bending Stress $\sigma = \frac{Mc}{I}$



$M = \frac{Pl}{4} = \frac{500(\frac{1}{2})}{4} = 62.5\,lb\cdot in$

$c = \frac{1}{4}''$

$I = \frac{1}{64}\pi d^4 = \frac{1}{64}\pi(\frac{1}{2})^4 = .003\,in^4$

$\sigma = \frac{62.5(\frac{1}{4})}{.003} = 5093\,psi < F_{max} = 12\,ksi$

ok

Member

- max stress caused by bending
- Assume min. t of $\frac{1}{4}$ to calculate h
- Assume material is unstiffened

- Bending (strong axis) $\sigma = \frac{My}{I}$

$y = \frac{h}{2}$; $I = \frac{1}{12} t h^3$; $\sigma_{max} = \frac{1}{3} F_y = 12$ ksi

$M = 250 \times 54'' = 13{,}500$ lb·in

$h^2 = \frac{13{,}500 \times 48}{2 \times 12000}$; $h = 5.22$

→ set $h = 6''$; $I = \frac{1}{12}(\frac{1}{4})6^3 = 4.5 \text{ in}^4$

$y = 3''$; $\sigma = \frac{13{,}500(3)}{4.5} = 9000$ psi

$\sigma < \frac{1}{3} F_y = 12$ ksi <u>ok</u>

- Bending (Weak axis)
  - max allowable stress $= .6 F_y Q_s$

for $\frac{b}{t} > \frac{95}{\sqrt{F_y}} \rightarrow Q_s = \frac{15{,}500}{F_y (\frac{b}{t})^2}$; for $\frac{b}{t} > \frac{95}{\sqrt{F_y}} \rightarrow$ member is slender

t	slender?	$\frac{b}{t} > \frac{95}{\sqrt{F_y}}$	Q_s	F_{max} (psi)	F_a (psi)	
$\frac{1}{4}''$	Y	Y	.011	119	< 9000	X
$\frac{1}{2}''$	Y	Y	.044	792	< 4500	X
$\frac{3}{4}''$	Y	Y	.1	1800	< 3000	X
$1''$	Y	Y	.18	3240	> 2250	ok

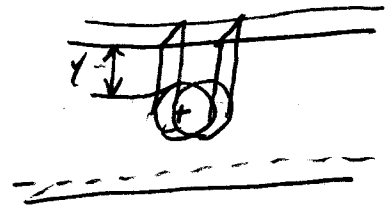
→ set $t = 1''$ to avoid buckling

- Tensile stress $F = \frac{P}{A_{net}}$

$F = 500\#$; $A = (11-2)(1) = 109 in^2$

$F = \frac{500}{109} = 4.58$ psi < 12 ksi <u>ok</u>

- shear stress (from 2" bar)



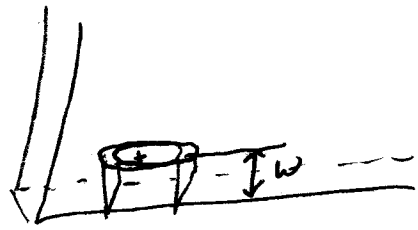
$F = \frac{P}{A}$; $P = 500\#$; $A = 2y(1)$

$F_{max} = 12 ksi = \frac{500}{2y} = .041$

→ set $y = \frac{1}{2}"$

$F = \frac{500}{2(1+\frac{1}{2})(1)} = 166.7$ psi < 12 ksi <u>ok</u>

- shear stress (from pins)



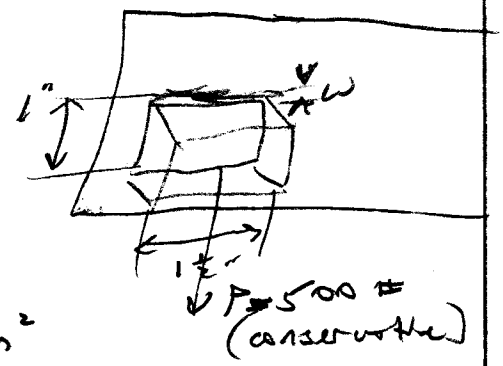
$F = \frac{P}{A}$; $P = 250\#$

$A = 2w(1)$ $F_{max} = 12 ksi = \frac{250}{2w}$ → $w = .0125$

→ set $w = \frac{1}{2}"$

$F = \frac{250}{2(\frac{1}{2}+\frac{1}{4})(1)} = 166.7$ psi < 12 ksi <u>ok</u>

Welds (for Blocks)



- minimum filet weld size $= \frac{5}{16}''$

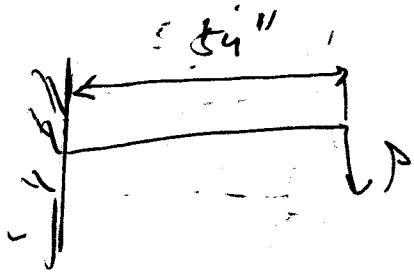
  throat $= (.707)(\frac{5}{16})(1'') = .22\ in^2$

- w/ E60xx fillers rod $18\ ksi \times .22\ in^2 = 3.98\ \frac{k}{in}$ allowable

  use 2" of 5/16 welds, (1" on each side)

  ok

Max deflection (cantilever)



$$\delta = \frac{PL^3}{3EI} \quad ; \quad P = 250\#$$

$$E_{steel} = 29 \times 10^6\ psi \quad ; \quad I = \tfrac{1}{12}(1)6^3 = 18\ in^4$$

$$\delta = \frac{250(54)^3}{3(29\times10^6)18} = .025'' \qquad (\text{Fea} \rightarrow .0256'')$$

Recommendations

$d = \frac{1}{2}''$

$t = 1''$

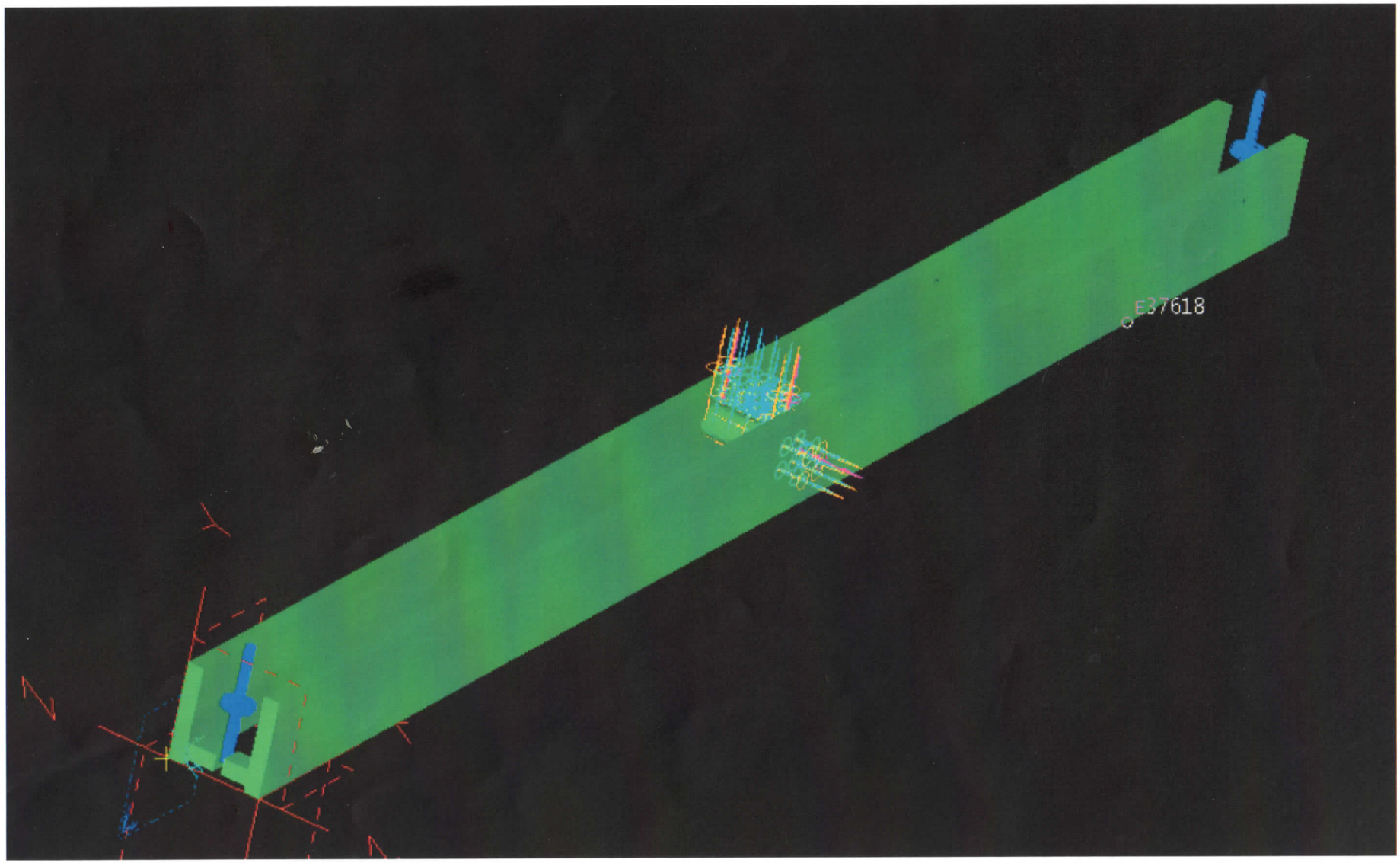
$y = \frac{d}{2}''$

$w = \frac{1}{2}''$

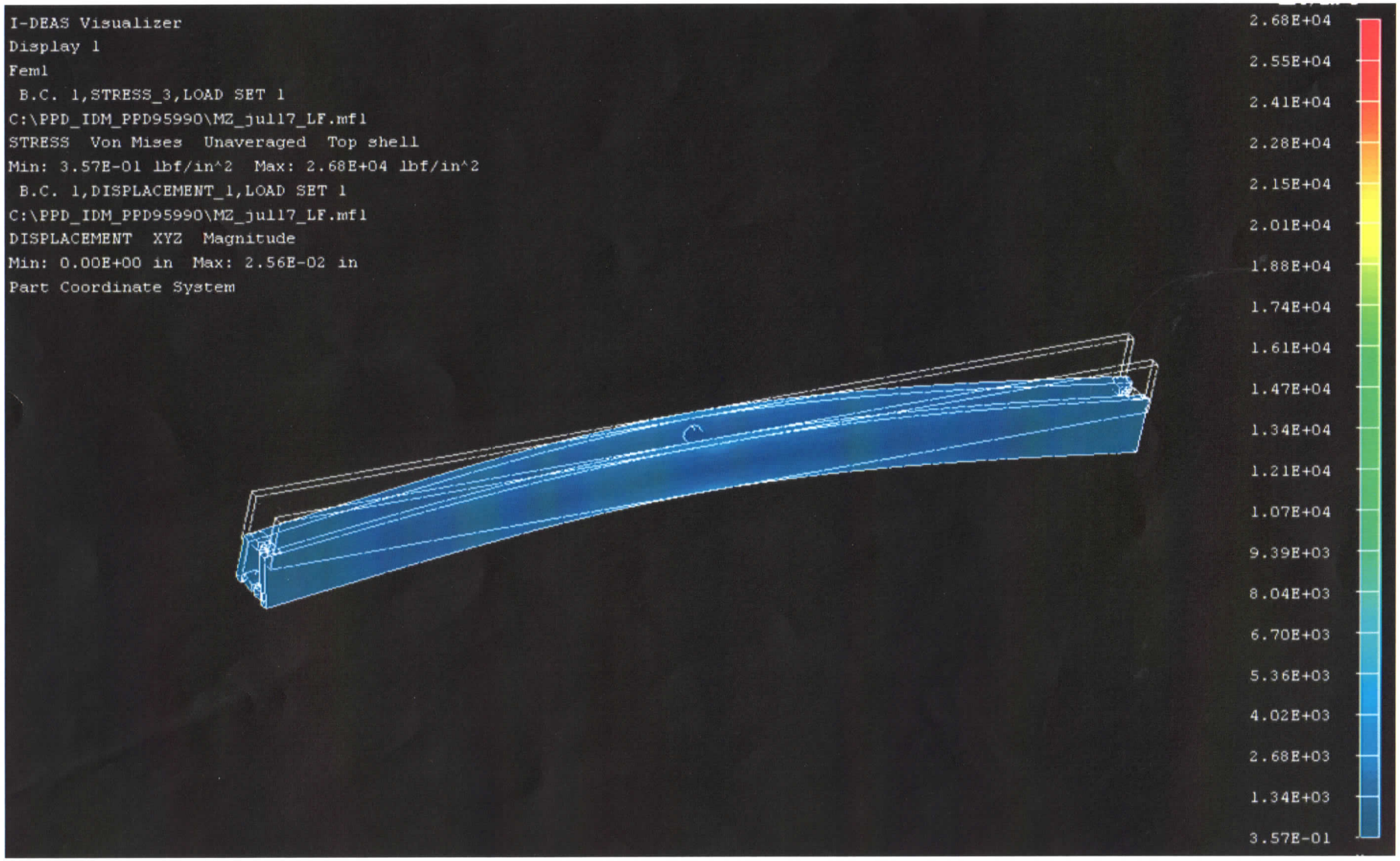
$h = 6''$

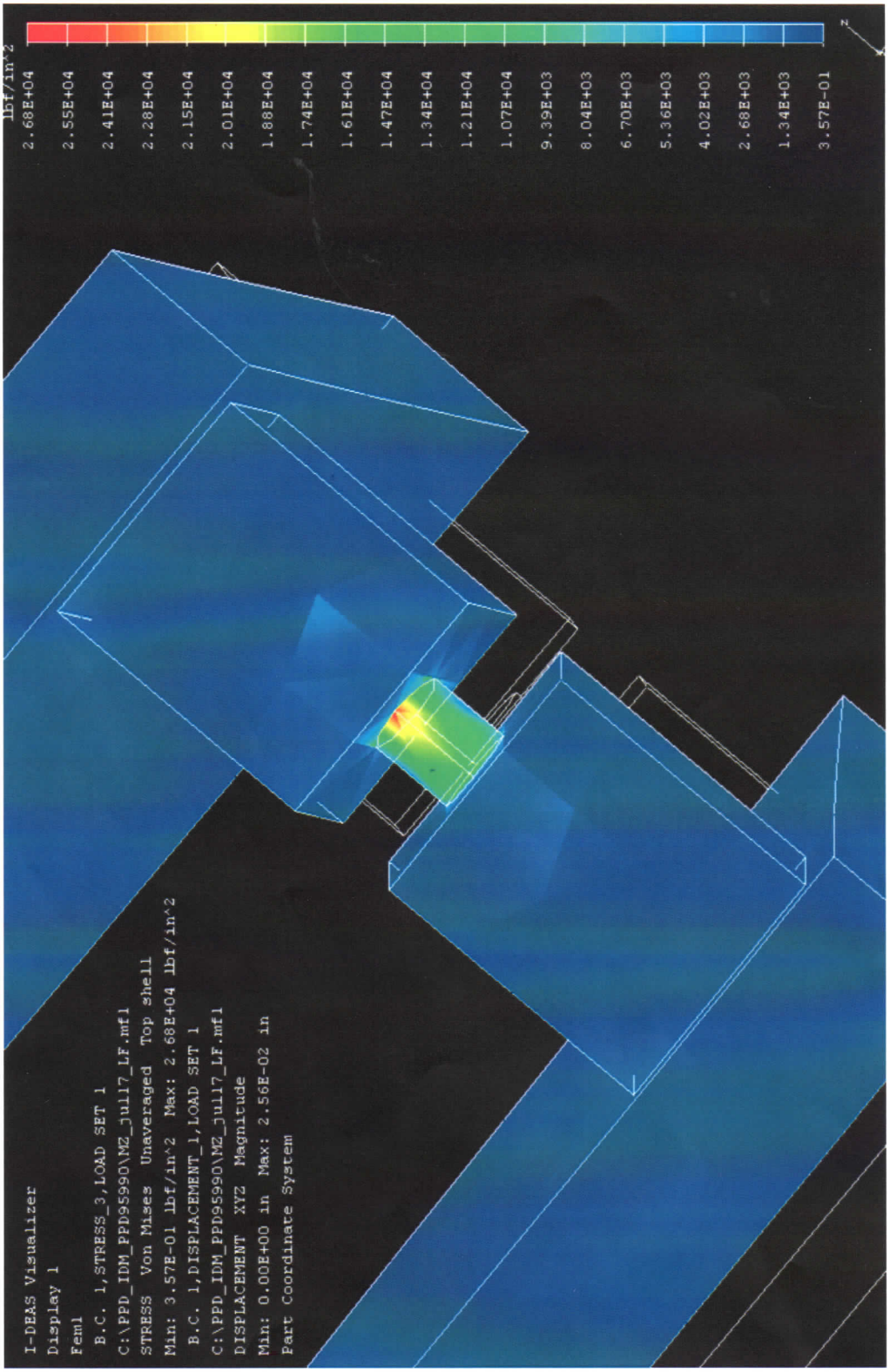
$W = \frac{5}{16}''$

Part w/ constraints + forces



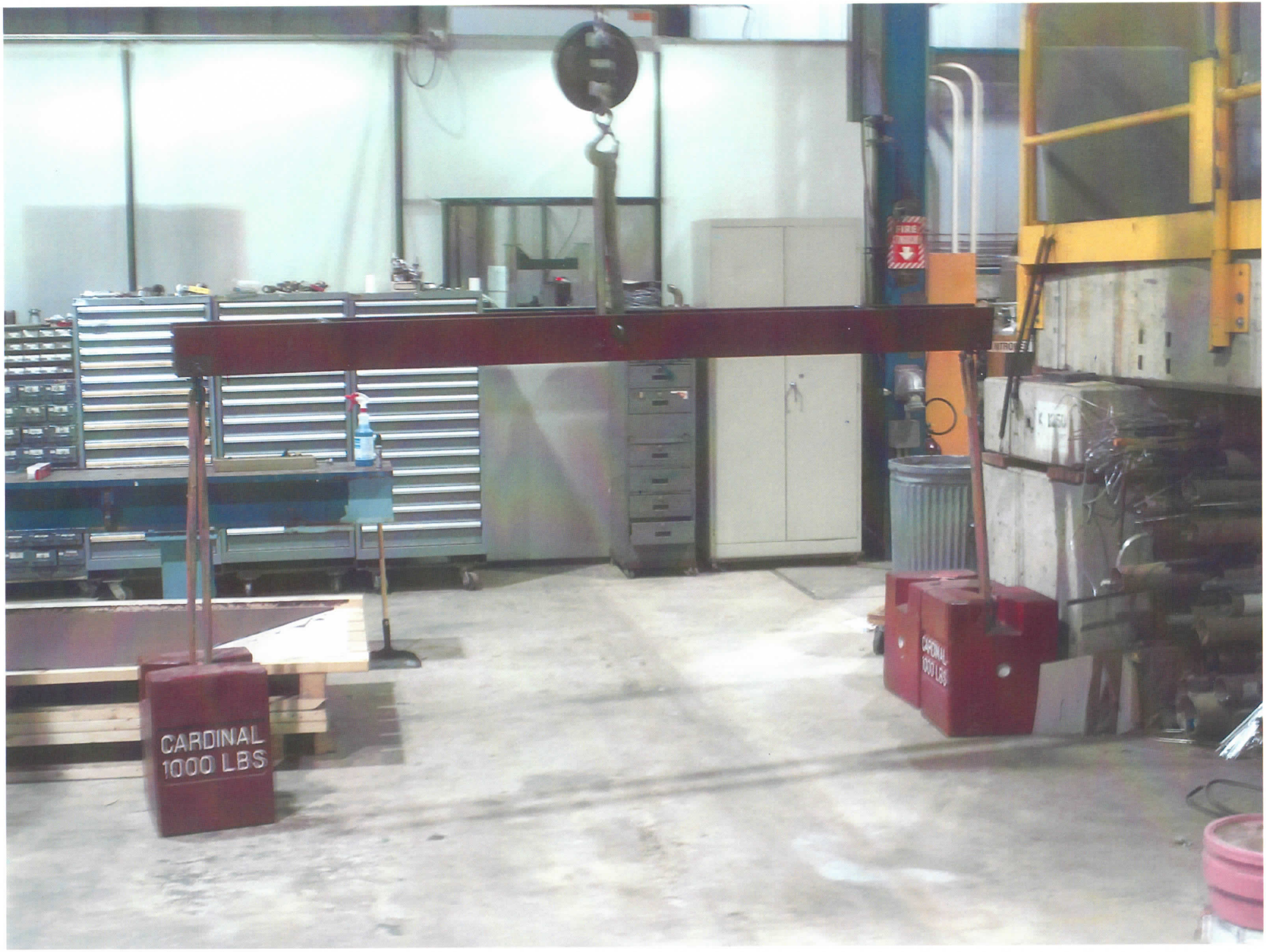
undeformed / deformed





Fea finds localized maximum stress present on the bottom of both pins due to the 500# downward force as well as the weak axis bending causing some buckling and amplifying the stress on the pins.

Chatillon


CARDINAL
1000 LBS
CARDINAL
1000 LBS