

BELOW-THE-HOOK LIFTING DEVICE
Engineering Note Cover Page

Lifting Device Numbers: 111FNAL Site No.: _____
if applicableDiv. Specific No.: 111
if applicableAsset No. _____
if applicableASME B30.20 Group:
(check one)

- 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: CLAYER MDT OCTANT ORIENTATION FIXTURE

- Device was: Purchased from a Commercial Lifting Device Manufacturer
 mfg. name: _____
- (check all applicable) 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: Tony Levand Date: 7/7/00Engineering Note Reviewed by: [Signature] Date: 8/11/00

Lifting Device Data:

Capacity: 2200 lbsFixture Weight: 3000 lbsService: normal heavy severe (refer to B30.20 for definitions)Duty Cycle: NA 8, 16 or 24 hour rating (applicable to groups III, and IV)

Inspections Frequency: _____

Rated Load Test by FNAL (if applicable): Date: 8/23/00 Load: 3000 lbs Check if Load Test was by Vendor and attach the certificate.Satisfactory Load Test Witnessed by: Tony LevandSignature (of Load Test Witness): Anthony Levand

Notes or Special Information:



FERMILAB
ENGINEERING NOTE

SECTION

PROJECT

SERIAL-CATEGORY

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SUBJECT

INSTALLATION FIXTURE
C LAYER MDT OCTANT

NAME

TONY LEVANO

DATE

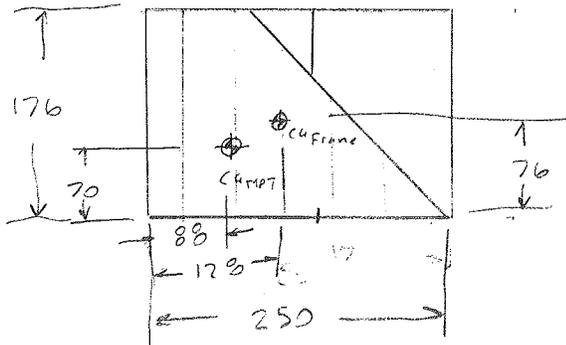
7/6/00

REVISION DATE

DWG 330749

FIXTURE WEIGHT = 3000 LBS

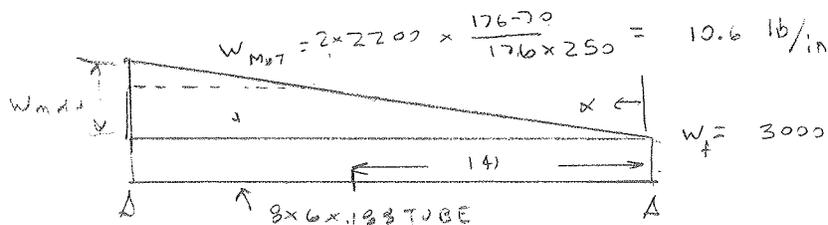
LOADING WEIGHT = 2200 LBS



MATERIAL: ASTM A-500 TUBE

$$F_y = 42 \text{ KSI}$$

$$F_1 = \frac{42}{3} = 14 \text{ KSI}$$



$$W_f = 3000 \times \frac{176-70}{176 \times 250} = 6.81 \text{ lb/in}$$

TUBE STRESS:

$$M_{msy} = \frac{W_f L^2}{8} + .06415 W_{MDT} L^2$$

$$M_{msy} = \frac{6.81 \times 250^2}{8} + .06415 \times 10.6 \times 250^2 = 95.7 \text{ kip}\cdot\text{in}$$

$$fb = \frac{95.7}{11.7} = 8.1 \text{ KSI} < \frac{42}{3} < 14 \text{ KSI}$$

FLANGE MOMENT:

$$x = 141$$

$$M_y = \frac{W_f x}{2} (L-x) + \frac{W_{MDT} x}{6L} (L^2 - x^2)$$

$$M_y = \frac{6.81 \times 141}{2} (250-141) + \frac{10.6 \times 141}{6 \times 250} (250^2 - 141^2) = 94.8 \text{ in}\cdot\text{kip}$$



SUBJECT

Installation structure
C LAYER MAT

NAME

Tony Leonard

DATE

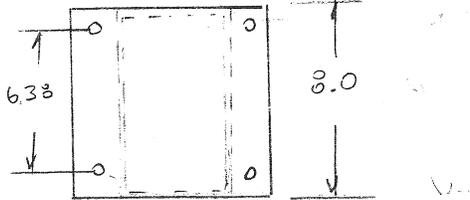
7/7/00

REVISION DATE

FLANGE MOMENT (in-lb)

DWG 335749

$$M_x = 94.8 \text{ kip-in}$$



FASTENER TENSION:

$$P = \frac{94.8}{\frac{6.38 - 3.0}{2}} = 7.19 \text{ kIP}$$

$$f_t = \frac{7.19}{.1419 \times 2} = 25.3 \text{ KSI} < 30 \text{ KSI}$$

SAE GRADE 5 BOLT

$$\sigma_{proof} = 105 \text{ KSI}$$

$$\sigma_y = 90 \text{ KSI} \quad f_t = 30 \text{ KSI}$$

WELD STRESS $\propto \sqrt{2}$ TUBE STRESS $f_w = 9.1 \sqrt{2} = 11.5 \text{ KSI} < \frac{70}{3} < 23 \text{ KSI}$

TUBE DEFLECTION:

$$\delta = .00652 \frac{W_{max} L^4}{EI} + \frac{5 W_f L^4}{384 EI} = \left[.00652 \times 10.6 + \frac{5 \times 6.91}{384} \right] \frac{250^4}{30 \times 10^6 \times 46.8} = .439 \text{ in}$$



FERMILAB
ENGINEERING NOTE

SECTION

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SERIAL-CATEGORY

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SUBJECT

INSTALLATION FIXTURE
C LAYER MOT

NAME

Tony Leonard

DATE

7.7.00

REVISION DATE

Vertical Pick
DWG 3807001

3/4 x 6 BAR

Bending:

$$M = 3028 \times 1.06 = 3237 \text{ in lbs}$$

$$f_b = \frac{6M}{bt^2} = \frac{6 \times 3237}{6 \times .75^2} = 6 \text{ KSI} < \frac{36}{3} < 12 \text{ KSI}$$

Thread pull through:

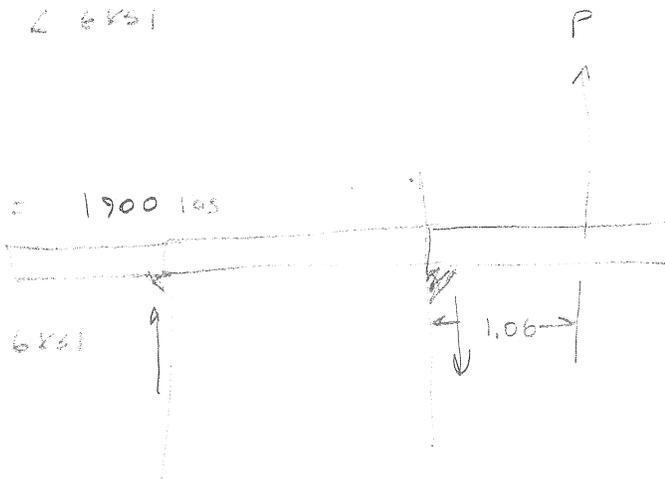
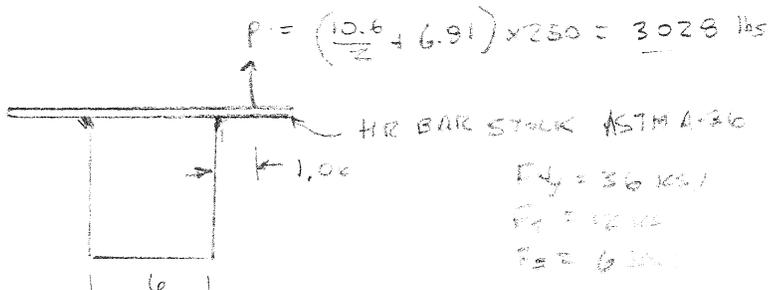
$$A_{\text{thread}} = .75\pi \times .75 = 1.7 \text{ in}^2$$

$$f_s = \frac{3028}{1.7} = 1.7 \text{ KSI} < 6 \text{ KSI}$$

WFLD STRESS:

$$P_w = \frac{3028}{2} + \frac{3028 \times 1.06}{8} = 1900 \text{ lbs}$$

$$f_s = \frac{1900}{8 \times \frac{.133}{12}} = 2.4 \text{ KSI} < 6 \text{ KSI}$$





SUBJECT

INSTALLATION FIXTURE
C LAYER NOT

NAME

Tony Levand

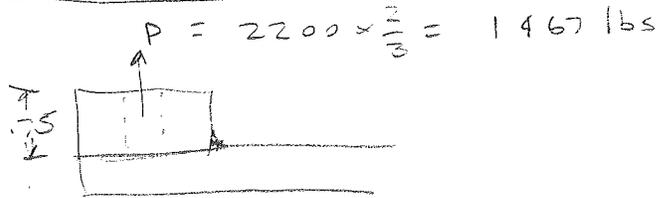
DATE

7/18/00

REVISION DATE

DWG 386372 MODIFICATION

ADD BLOCK AND TAPPED HOLE.

THREAD PULL OUT:

$$f_s = \frac{1467}{.5\pi \times .5} = \underline{467 \text{ PSI}} \quad \text{Thread stripping}$$

$$\underline{B_oH} = \frac{1467}{.1417} = 10 \text{ KSI} < \frac{90 \text{ KSI}}{3}$$

WELD: $A = (2.5 \times 2 + 1.75 \times 2) \times \frac{.25}{\sqrt{2}} = 1.5 \text{ in}^2$

$$f_s = \frac{1467}{1.5} \approx 1 \text{ KSI} < 6 \text{ KSI}$$

DWG 386761:

LOADS AND MOMENT SAME AS 386372



SUBJECT

MDT OCTANT LIFTING/TURNING FIXTURE

NAME

Tony Leonard

DATE

3/30/00

REVISION DATE

THIS FIXTURE IS USED TO TRANSPORT MDT OCTANTS IN THE HORIZONTAL AND VERTICAL POSITIONS. IT IS ALSO USED TO TURN THE OCTANTS FROM VERTICAL TO HORIZONTAL AND BACK, AND ALSO AS A TABLE.

DURING INSTALLATION IT WILL BE USED TO ORIENT OCTANTS TO MOUNTING POSITION. THE FIXTURE MAY ALSO BE MODIFIED FOR PIXEL OCTANT TRANSPORT.

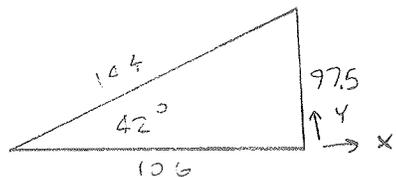
$$\text{FIXTURE WEIGHT} = 1730 \text{ lbs}$$

$$\text{MDT OCTANT WEIGHT (C 0.3)} = 2500 \text{ lbs}$$

$$\text{TOTAL} = 4230 \text{ lbs}$$

SLING LOADS:

THE SHORTEST SLING TO BE USED IS 12 FEET



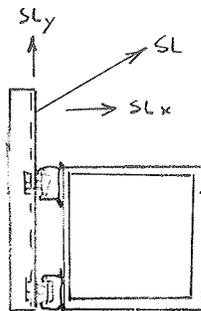
1/2 WEIGHT ON ONE SLING:

$$\text{SLING LOAD} = \frac{4230}{2 \sin(42)} = 3200 \text{ lbs}$$

$$S_L X = \frac{4230}{\tan(42)} = 2377$$

$$S_L Y = \frac{4230}{2} = 2115$$

LIFTING POINT:





SUBJECT

MOT. OCTANT LIFTING/TURNING FEATURE

NAME

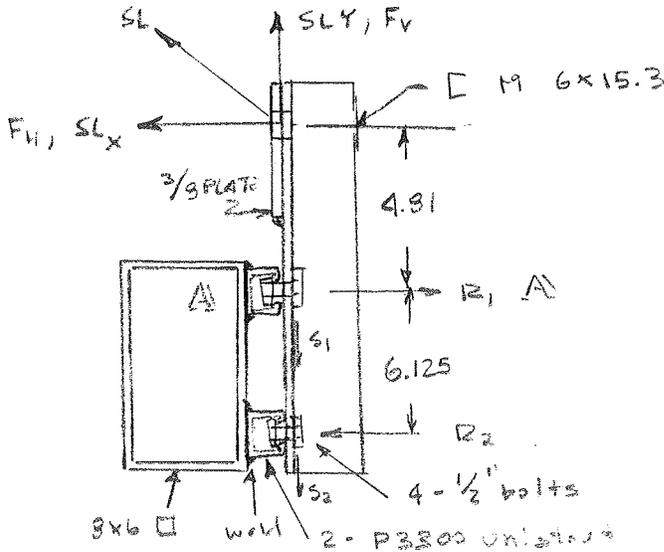
Tony Leonard

DATE

3/30/00

REVISION DATE

LIFTING POINTS:



MATERIAL ALLOWABLES:

ASTM A-36 STEEL

$$F_y = 36 \text{ KSI}$$

$$F_a = \frac{F_y}{3} = 12 \text{ KSI}$$

$$F_b = \frac{F_a}{2} = 6 \text{ KSI}$$

$$F_{br} = \frac{F_y}{3} = \frac{58}{3} = 19 \text{ KSI}$$

SECTION PROPERTIES:

M 6x15.3 I

$$I_{yy} = 4.97$$

$$S_{xy} = 2.03$$

$$W_{FB} = .340$$

FASTENER:

4-1/2" bolts

$$f_h = \frac{4244}{2 \times 147} = 15 \text{ KSI} < 30 \text{ KSI}$$

$$f_b = \frac{1070}{2 \times 167} = 3.3 \text{ KSI} < 15 \text{ KSI}$$

$$f_{br} = \frac{1070}{.5 \times 34 \times 2} = 3.1 \text{ KSI} < 19 \text{ KSI}$$

BENDING: A-A

$$M = 2377 \times 4.81 = 11.4 \text{ kip-in}$$

$$f_b = \frac{11.4}{2.03} = 5.7 \text{ KSI} < 12 \text{ KSI}$$

LOADS:

$$S_{LX} = 2377 \text{ L}$$

$$S_{LY} = 2140$$

$$F_H = \frac{4280}{3} = 1427$$

$$F_v = \frac{4280}{2} = 2140$$

$$R_1 = 4244$$

$$R_2 = 1867$$

$$s_1 = s_2 = 1070 \text{ lbs}$$

FASTENER ALLOWABLES: C

GRADE 5 (A 325)

$$F_y = 92 \text{ KSI}$$

$$F_a = \frac{92}{3} = 30.6 \text{ KSI}$$

$$F_b = \frac{30.6}{2} = 15.3 \text{ KSI}$$



SUBJECT

MDT OCTANT LIFTING/TORNING FIXTURE

NAME

Tony Levand

DATE

3/30/00

REVISION DATE

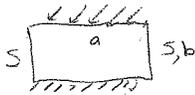
LIFTING POINT (cont)

PIN BEARING:

$$\frac{2140}{.75 \times .340} = 8.4 \text{ KSI} < 23 \text{ KSI}$$

WEB BENDING:

Rectangular plate fixed one edge, SS O



$a = 5.5, b = 3.38 \quad \frac{1}{b} = 1.627, B_1 = .47$

$$\sigma_{max} = \frac{-B_1 q b^2}{t^2} = \frac{-.47 \times \frac{2377}{5.5} \times 5.5^2}{(.375 \times 34)^2} = 12 \text{ KSI} = 12 \text{ KSI allowable}$$

Torsion on tube:

$$T = 2377 \left(4.91 + \frac{6.125}{2} \right) + 2140 (3 + .875) = 27 \text{ kip in}$$

$$f_s = \frac{T}{2abt} = \frac{27}{2 \times 6 \times 8 \times .158} = 1.5 \text{ KSI} < 7.6 \text{ KSI}$$



SUBJECT

MDT LIFTING / TWINING MIXTURE

NAME

Tony Leonard

DATE

3/30/00

REVISION DATE

UNISTRUT CONNECTION

$$\frac{R_1}{2} = \frac{4244}{2} = 2122 < 4000 \text{ lbs}$$

$$\frac{R_2}{2} = \frac{1867}{2} = 933 \text{ lbs} < 1500$$

$$\frac{S_1}{2} = \frac{1070}{2} = 535 < 1500$$

COMBINED LOADS SHEAR/TENSION

$$\frac{2122}{4000} + \frac{535}{1500} = .89 < 1$$

$$\frac{933}{1500} + \frac{535}{1500} = .98 < 1$$

UNISTRUT ALLOWABLES: ②

P3300 channel

P_T = 1500 lbs pulled

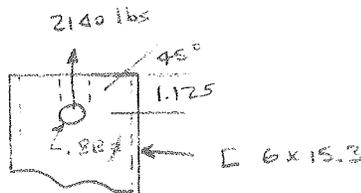
P_S = 1500 lbs slip

P_C = 4000 lbs crushing

CHANNEL SHEAR/TENSILE

$$A = \left[1.125 - \frac{.813}{2\sqrt{2}} \right] .34 \times 2$$

$$= .569 \text{ in}^2$$



$$f_s = \frac{2140}{.569} = 3.7 \text{ KSI} < 6 \text{ KSI}$$

WELD ANALYSIS:

1/8 x 1.5" fillet welds

WELD ALLOWABLES:

$$F_u = \frac{70}{3} = 23 \text{ KSI}$$

$$F_u = \frac{23}{2} = 11.6 \text{ KSI}$$

tension: $f_t = \frac{R_2}{A} = \frac{1867 \cdot \sqrt{2}}{.125 \times 1.5 \times 4} = 3.5 \text{ KSI}$

shear: $f_s = \frac{S_2}{A} = \frac{1070}{.125 \times 1.5 \times 4} = 1.4 \text{ KSI}$

combine shear + tension.

$$\frac{3.5}{23} + \frac{1.4}{11.6} < 1$$

BASE MATERIAL:

$$\frac{3.5}{12} + \frac{1.4}{6} < 1$$



SUBJECT

MOT OCTANT LIFTING TURBINE ENCORE

NAME

Tony Lewis

DATE

4/4/00

REVISION DATE

I- BEAM ANALYSIS

SPAN = 170.26 inches

$$M = \frac{WL^2}{8} = \frac{3.64 \times 170.26^2}{8} = 13.2 \text{ kip-in}$$

$$f_b = \frac{13.2}{4.62} = 2.8 \text{ ksi} < 12 \text{ ksi}$$

STABILITY OF FLANGE:

THE AISC CODE CAN BE APPLIED WITHOUT ADDITIONAL SAFETY FACTORS.

$$F_b = \frac{12 \times 10^3 \text{ cb}}{L_d / A_f}, \text{ cb} = 1$$

$$F_b = \frac{12 \times 10^3 \times 1}{170 \times 13.6} = 3.78 \text{ ksi}$$

$$2.8 \text{ ksi} < 3.78 \text{ ksi}$$

THIRD DIST:

$$F_b = \frac{12 \times 10^3 \times 1}{137 \times 13.6} = 4.7 \text{ ksi}$$

$$f_b = \frac{9.5}{4.62} = 1.9 \text{ ksi} < 4.7 \text{ ksi}$$

SECTION PROPERTIES:

11.8 x 6.5 I

$I_{xx} = 18.5 \text{ in}^4$

$S_{xx} = 4.62 \text{ in}^3$

$\frac{I_f}{Z_{ff}} = 6.0$

$\frac{d}{A_f} = 18.6, r_f = .63$

OCTANT WEIGHT = 2500 lbs
= .103 lb/in²

UNIFORM LOAD:

$$\frac{6.5}{12} \times .103 \times 30.12 = 3.64 \text{ lb/in}$$



SUBJECT

MDT OCTANT LIFTING/TURNING FIXTURE

NAME

Tony Leonard

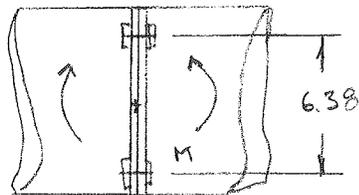
DATE

4/4/00

REVISION DATE

FLANGED CONNECTIONS

UPPER END TUBE



LOADS: ③

$$M_2 = 16 \text{ kip-in}$$

FASTENER LOADS:

$$P_f = \frac{16}{6.38 \times 2} = 1.2 \text{ kip}$$

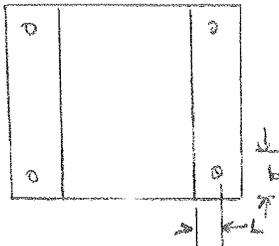
$$P_s = \frac{84}{4} = 21 \text{ lbs}$$

FASTENERS:

$$f_t = \frac{1.2}{.1419} = 8.4 \text{ ksi} < 32.6 \text{ ksi}$$

$$f_s = \text{small}$$

BENDING OF FLANGES:



$$M = PL = 1.2 \times \frac{(7.38 - 6)}{2} = 825 \text{ in-lbs}$$

$$f_b = \frac{GM}{Et^3} = \frac{6 \times 825}{1.5 \times .5^3} = 13.25 < 16.7 \text{ ksi}$$

MATERIAL ALLOWABLES:

ASTM A572 PLATE Grade 50

$$F_y = 50 \text{ ksi}$$

$$F_a = \frac{F_y}{2} = 16.7 \text{ ksi}$$

WELD:

3/16" WELD 5 inches long

$$f_t = \frac{16 \sqrt{2}}{8 \times .188 \times 5} = 3 \text{ ksi} < 23 \text{ ksi}$$

③ from Idem's FEA results



SUBJECT

MDT OCTANT LIFTING / TURNING PICTURE

NAME

Tony Leonard

DATE

4/4/00

REVISION DATE

FLANGED CONNECTIONS, CONT.

CONNECTION FOR 8x4 TUBE

FASTENERS - not critical

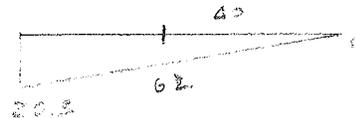
Flange bending - not critical

WELDS:

$$f_t = \frac{1311 \sqrt{2}}{8 \times 11.9 \text{ ksi}} = 4 \text{ ksi}$$

LOADS: (3)

$$M = 20.3 \times \frac{40}{62} = 13.1 \text{ kip-in}$$



WELD ANALYSIS

MAXIMUM MOMENT = 20333 in-lb

4x 8x4 tubing S = 8.83

$$f_b = \frac{20333}{8.83} = 2.4 \text{ ksi} < 15.3 \text{ ksi}$$

WELDS: 3/16 fillet weld

$$f_t = \frac{20333}{8.83} \frac{1}{\sqrt{2}} = 3.2 \text{ ksi}$$

MATERIAL ALLOWABLE

ASTM 500 UTK

$$F_{ty} = 46 \text{ ksi}$$

$$F_t = \frac{46}{3} = 15.3 \text{ ksi}$$

$$F_b = \frac{15.3}{2} = 7.6 \text{ ksi}$$



M=20 kip-in
critical location



SUBJECT

MOT LIFTING / TURNING FIXTURE

NAME

Tony Levinski

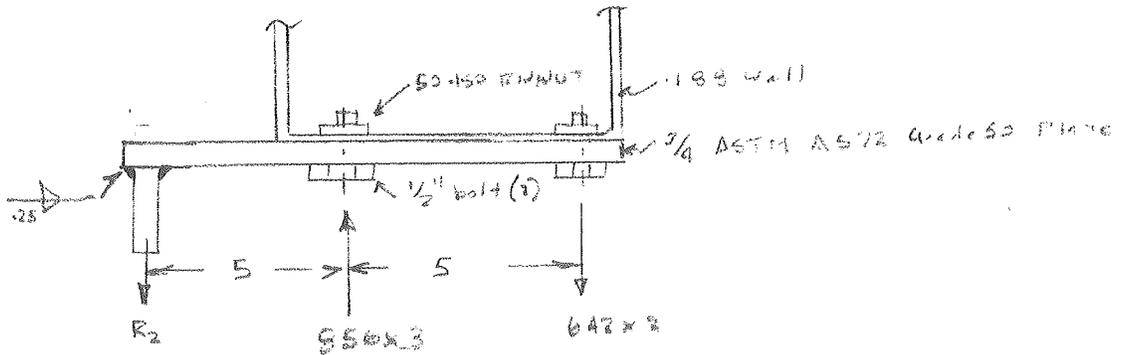
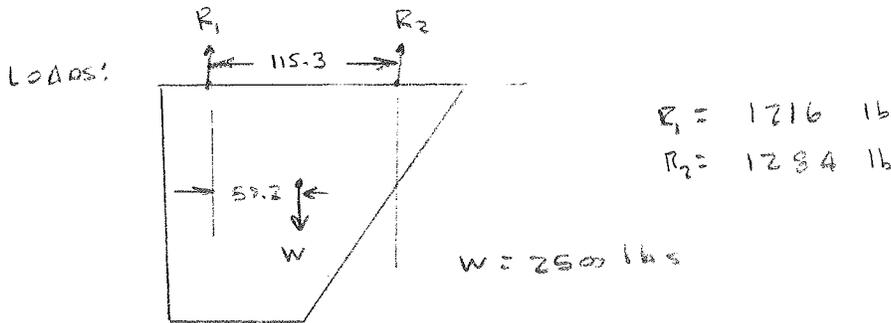
DATE

4/5/00

REVISION DATE

OCTANT COLLECTION BRACKETS:

THESE BRACKETS SUPPORT THE WEIGHT OF THE OCTANT WHEN VERTICAL. 2 BRACKETS TAKE THE WEIGHT.



Fasteners:

$$f_t = - \frac{1856}{.1419} = 13080 \text{ ksi} < 30 \text{ ksi}$$

Rivnut:

Allowable tension:

$$\frac{5800}{1.3 \times 1.5} = 1289 \text{ lbs}$$

$$856 < 1289$$

material:

C-1010 STEEL

upset load = (A)

5800 lbs



SUBJECT

Octant lifting/turning fixture

NAME

Tony Levand

DATE

4/5/00

REVISION DATE

Octant Connection brackets (cont):

Shear/Pull through of rivets:

SHEAR:

$$A = .625\pi \times .183 = .369 \text{ in}^2$$

$$f_s = \frac{856}{.369} = 2.3 \text{ ksi} < 7.6 \text{ ksi}$$

PULL THROUGH:

Ultimate tension = 4900 lbs [ⓔ]

$$\text{Allowable} = \frac{4900}{3 \times 1.5} = 1057 \text{ lbs} > 856 \text{ lbs}$$

Consider the pull-through area a circular disk with $\frac{b}{a} = .5$, outer edge fixed, inner edge loaded:

$$K_r b = .2121$$

$$M = .2121 \sqrt{\frac{856}{.625\pi}} \times .625 = 58.1 \text{ lbs}$$

$$f_b = \frac{6 \times 58}{.183^2} = 9.9 \text{ ksi} < 15.3 \text{ ksi}$$

ⓔ Rank 6th ed p 402 case 1f

ⓕ Rivet engineering Data p 14 fig 4



SUBJECT

MOT OCTANT CIFTING/TORINIA FUTURE

NAME

Tony Lewand

DATE

4/5/00

REVISION DATE

OCTANT CONNECTION (cont)

BRACKET BENDING:

$$M = 1234 \times 5 = 6470 \text{ in. lbs}$$

$$f_b = \frac{6M}{b^3} = \frac{6 \times 6470}{4.5 \times .75^3} = 15.2 \text{ KSI} < 16.7 \text{ KSI}$$

PIN SHEAR: 1/2" PIN

$$f_s = \frac{1234}{.1419} = 9 \text{ KSI} < 15.3 \text{ KSI}$$

TEAROUT:

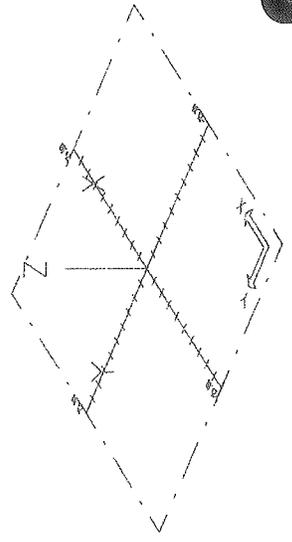
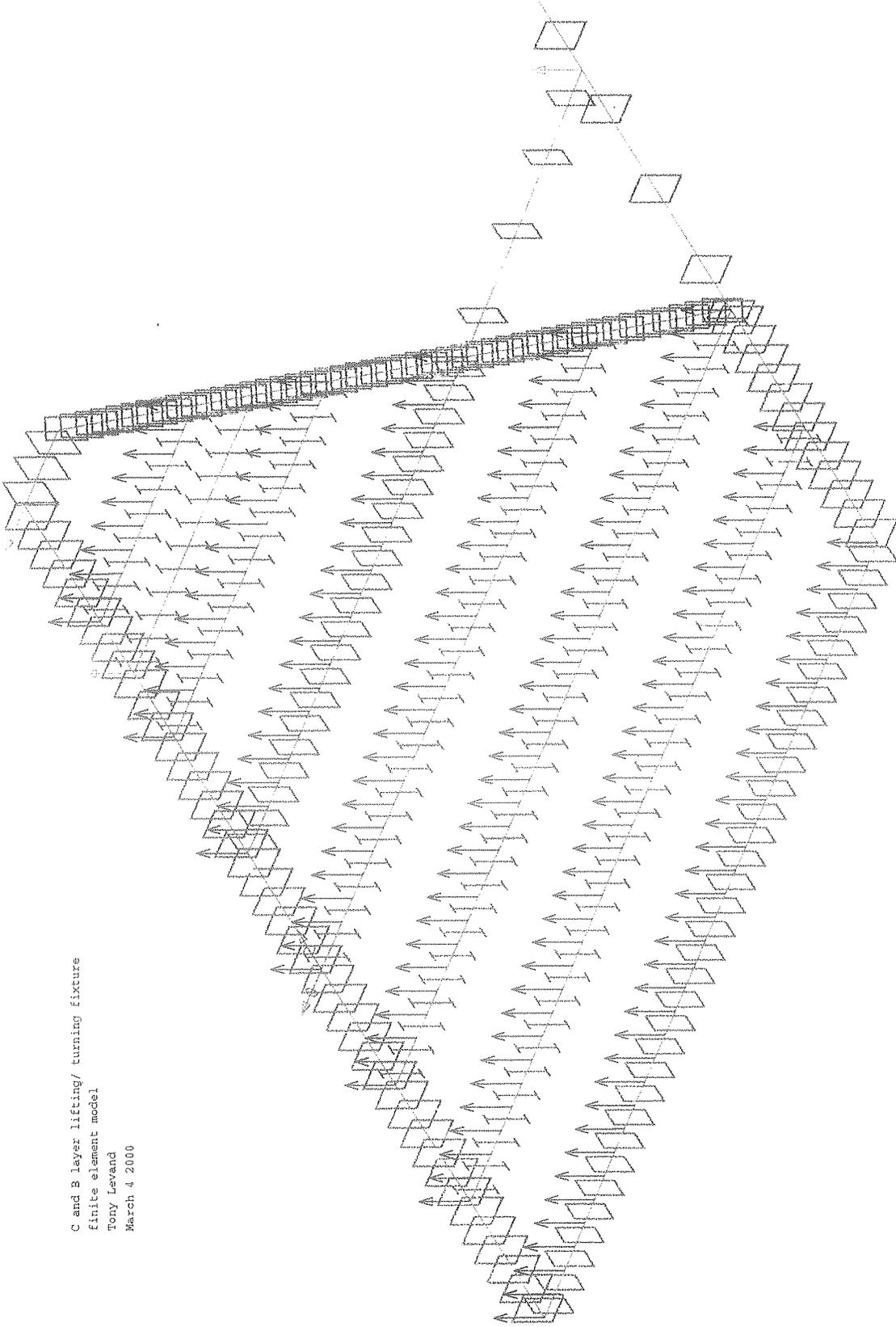
$$A = \left[.75 - \frac{.5}{2\sqrt{2}} \right] \times 2 \times .5 = .57 \text{ in}^2$$

$$f_s = \frac{1234}{.57} = 2.2 \text{ KSI}$$

WELD:

$$f_s = \frac{1234}{\frac{.25}{\sqrt{2}} \times 2 \times 2} = 1.8 \text{ KSI}$$

C and B layer lifting/turning fixture
finite element model
Tony Levand
March 4 2000

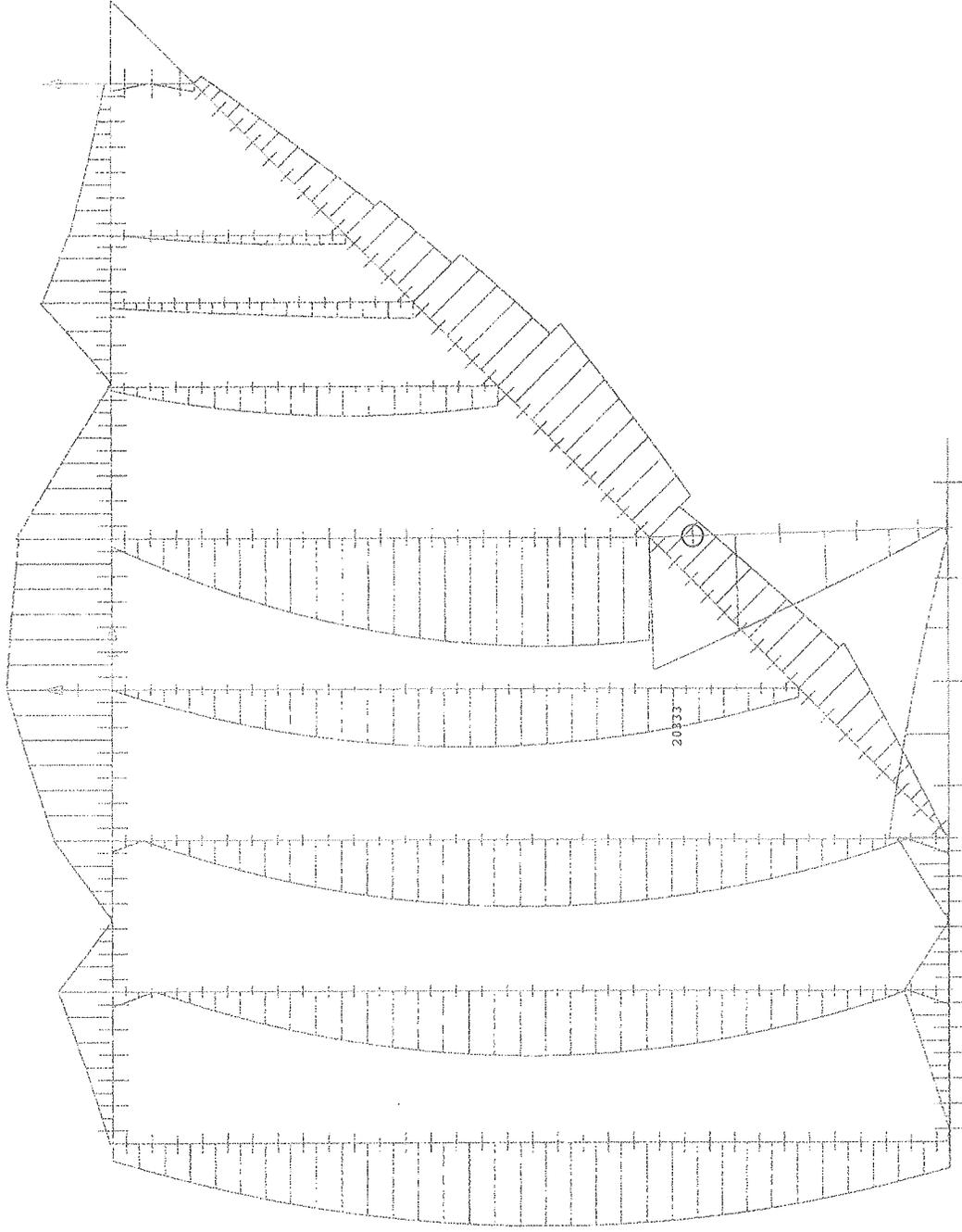


/cadwhs/server02/ms_levand/CB_Lifting_turning.mfl

RESULTS: 5- B.C. 1,ELEMENT FORCE_5,LOAD SET 1

Data component: SRSS BENDING MOMENT

Maximum amplitude = 20333.44

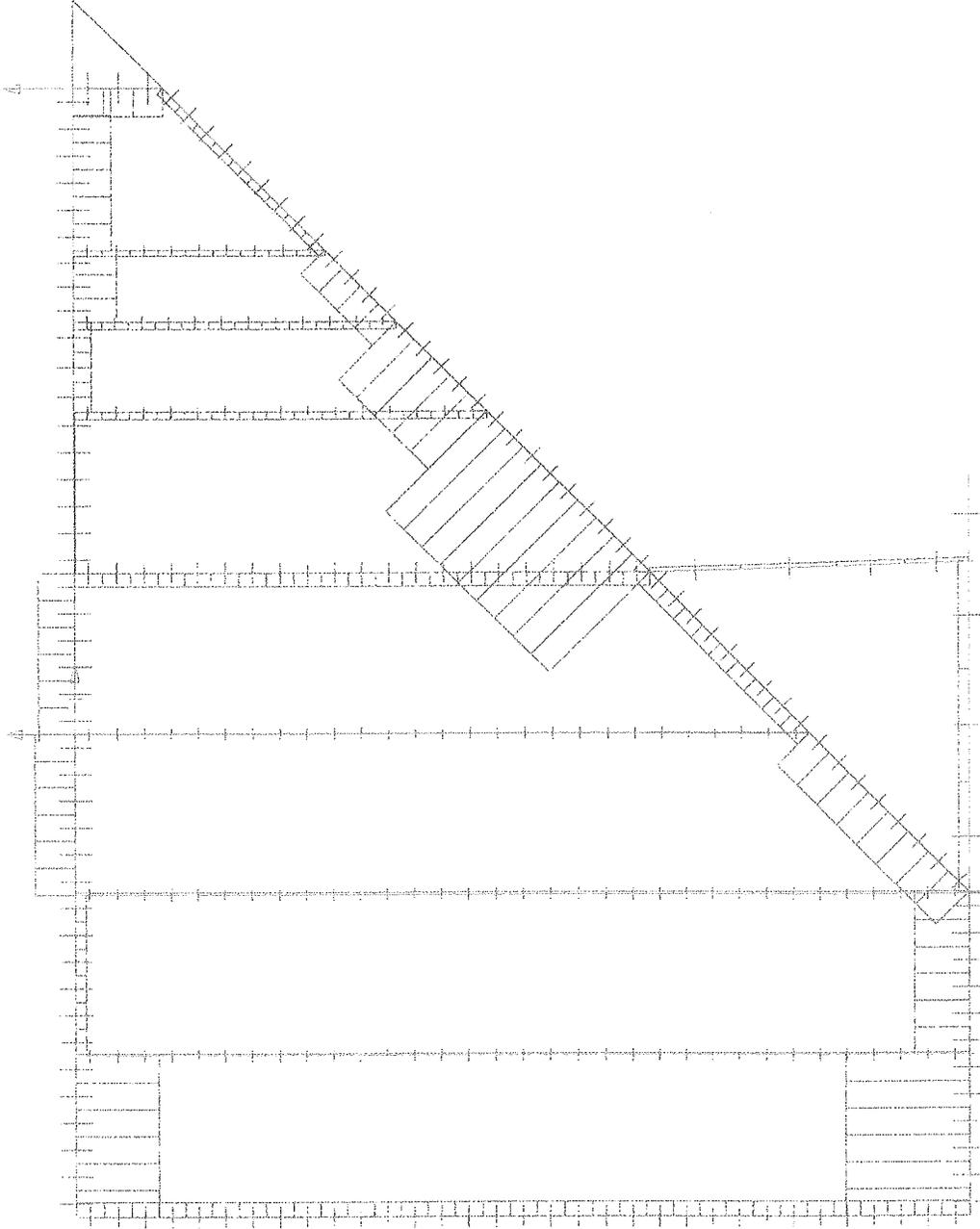


/cadwhs/server02/ms_levand/CB_Lifting_turning.mfl

RESULTS: 5- B.C. 1,ELEMENT FORCE_5,LOAD SET 1

Data component: TORQUE

Maximum amplitude = -4617.972

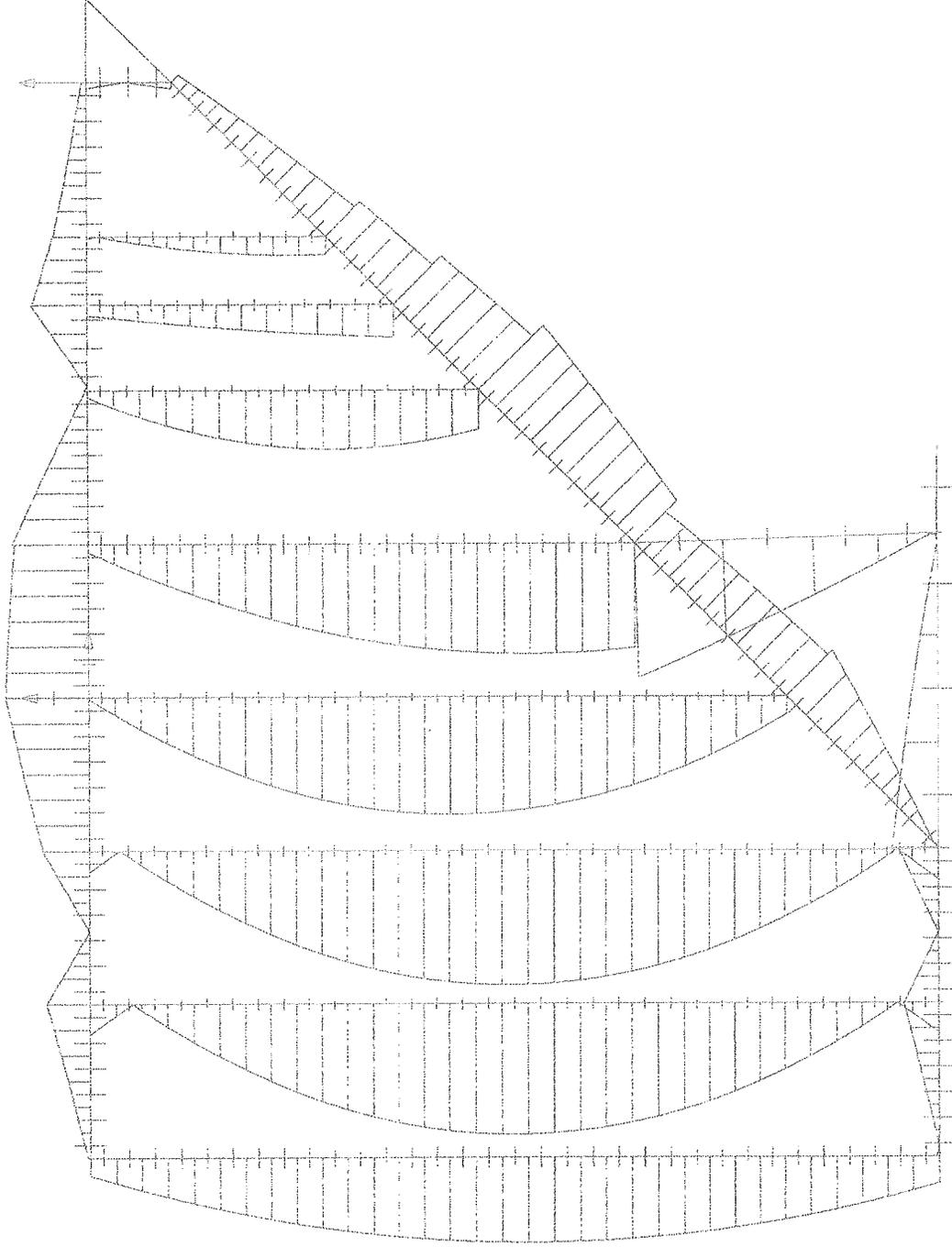


/cadwhs/server02/ms_levand/CB_Lifting_turning.mfl

RESULTS: 5- B.C. 1, ELEMENT FORCE_5, LOAD SET 1

Data component: SRSS BENDING STRESS at maximum point

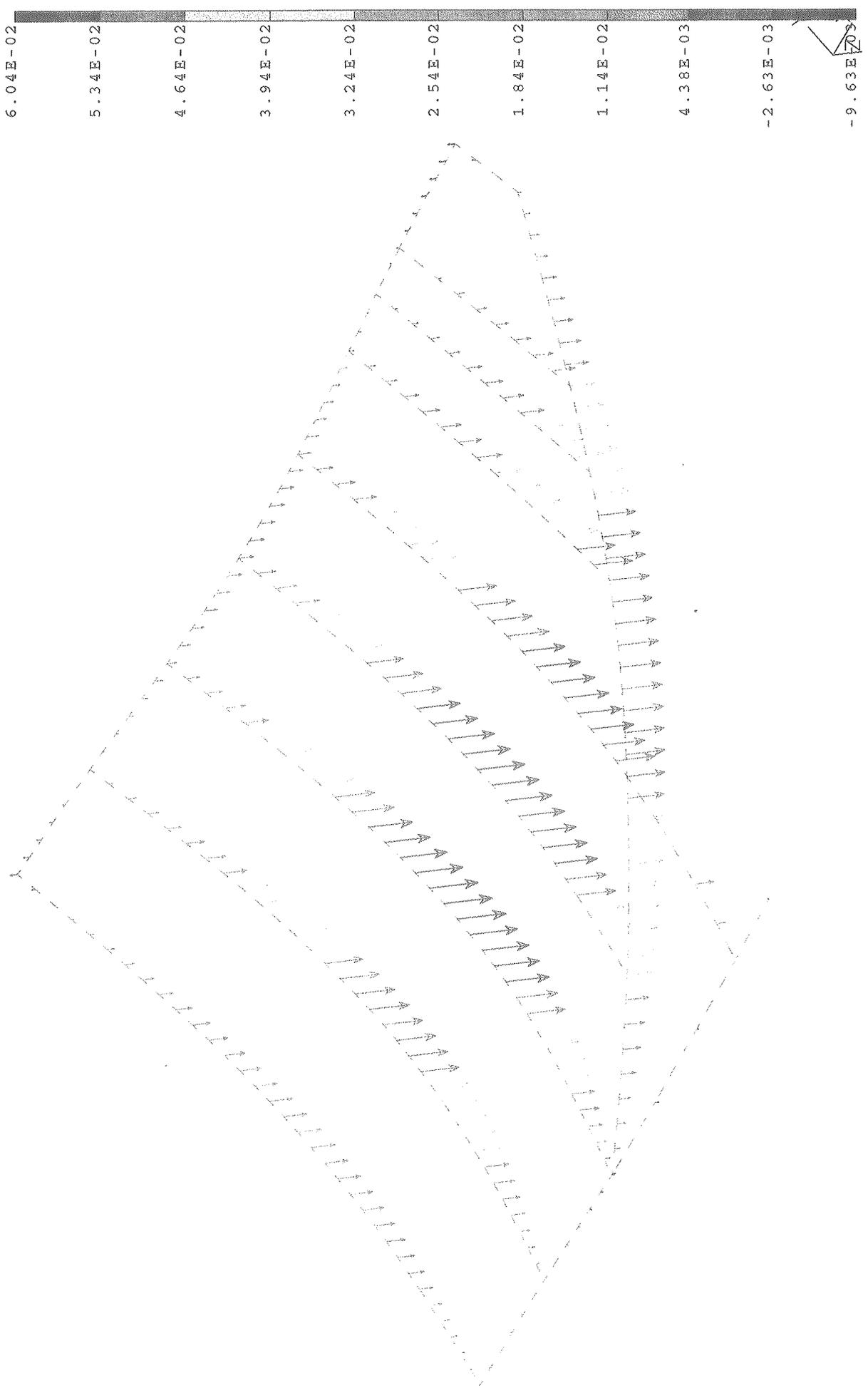
Maximum amplitude = 2214.202



/cadwhs/server02/ms_levand/CB_Lifting_turning.mfl

RESULTS: 1- B.C. 1, DISPLACEMENT_1, LOAD SET 1
DISPLACEMENT - Z MIN: -9.63E-03 MAX: 6.04E-02
RESULTS: 1- B.C. 1, DISPLACEMENT_1, LOAD SET 1
DISPLACEMENT - MAG MIN: 1.65E-11 MAX: 6.04E-02
FRAME OF REF: PART

VALUE OPTION: ACTUAL



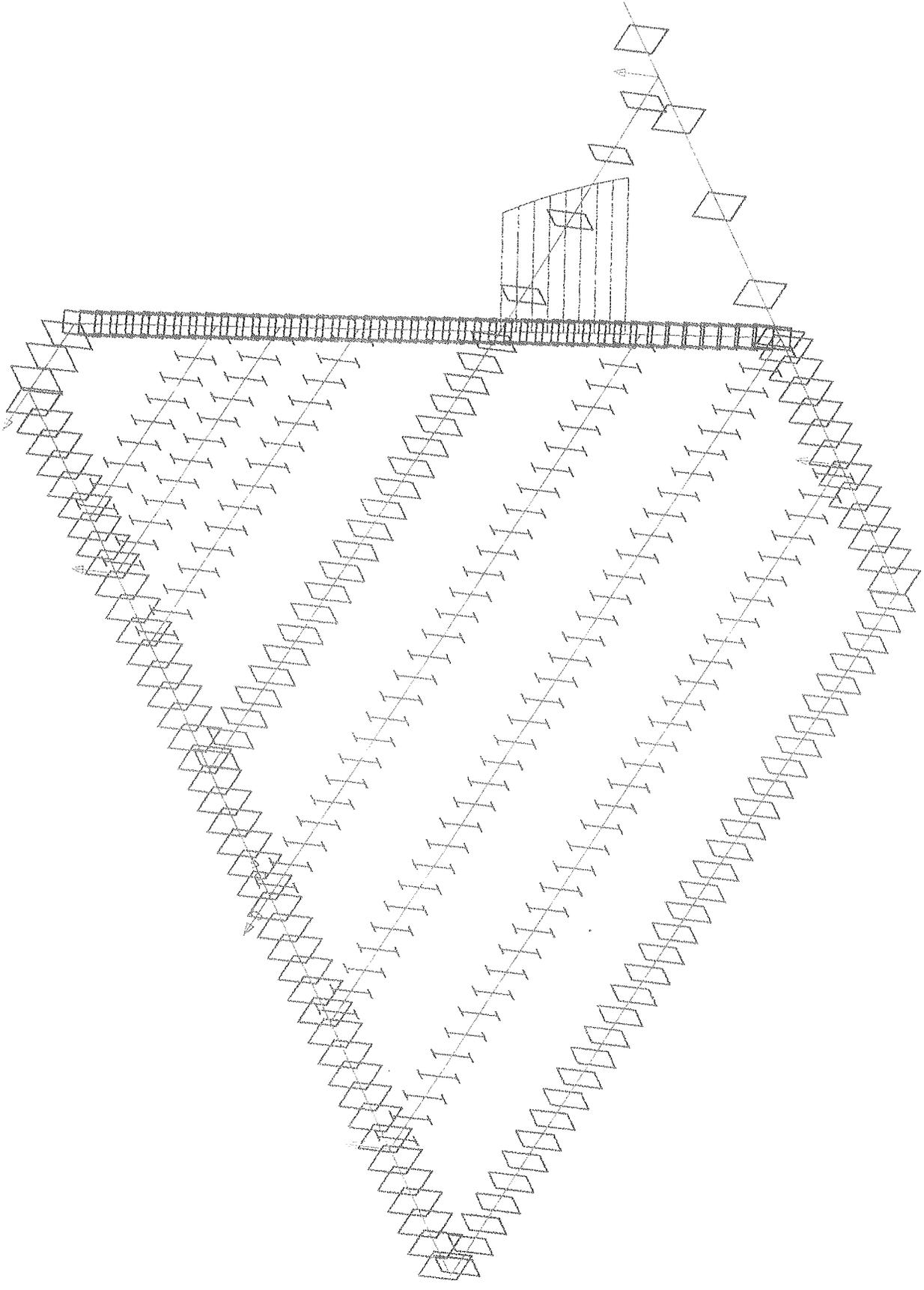
/cadwhs/server02/ms_levand/CB_Lifting_turning.mfl

RESULTS: 4- B.C. 1, ELEMENT FORCE_4, LOAD SET 1
ELEMENT FORCE - MAG MIN: 1.02E-13 MAX: 1.17E+03
RESULTS: 1- B.C. 1, DISPLACEMENT_1, LOAD SET 1
DISPLACEMENT - MAG MIN: 1.65E-11 MAX: 6.04E-02
FRAME OF REF: PART

VALUE OPTION: ACTUAL



/cadwhs/server02/ms_levand/CB_Lifting_turning.mf1
RESULTS: 5- B.C. 1, ELEMENT FORCE_5, LOAD SET 1
Data component: SRSS BENDING MOMENT
Maximum amplitude = 8689.011

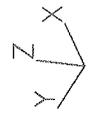
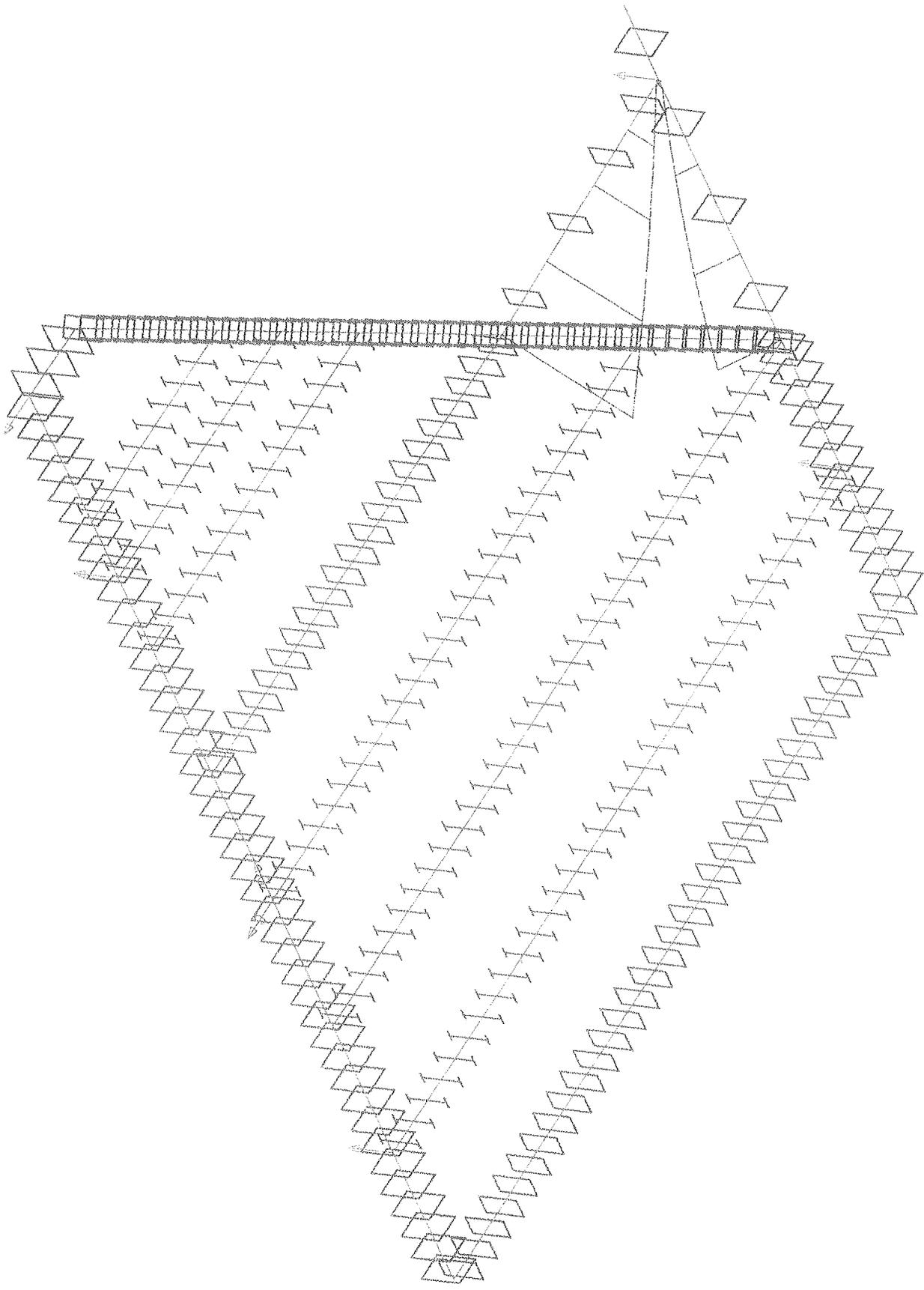


/cadwhs/server02/ms_levand/CB_Lifting_turning.mfl

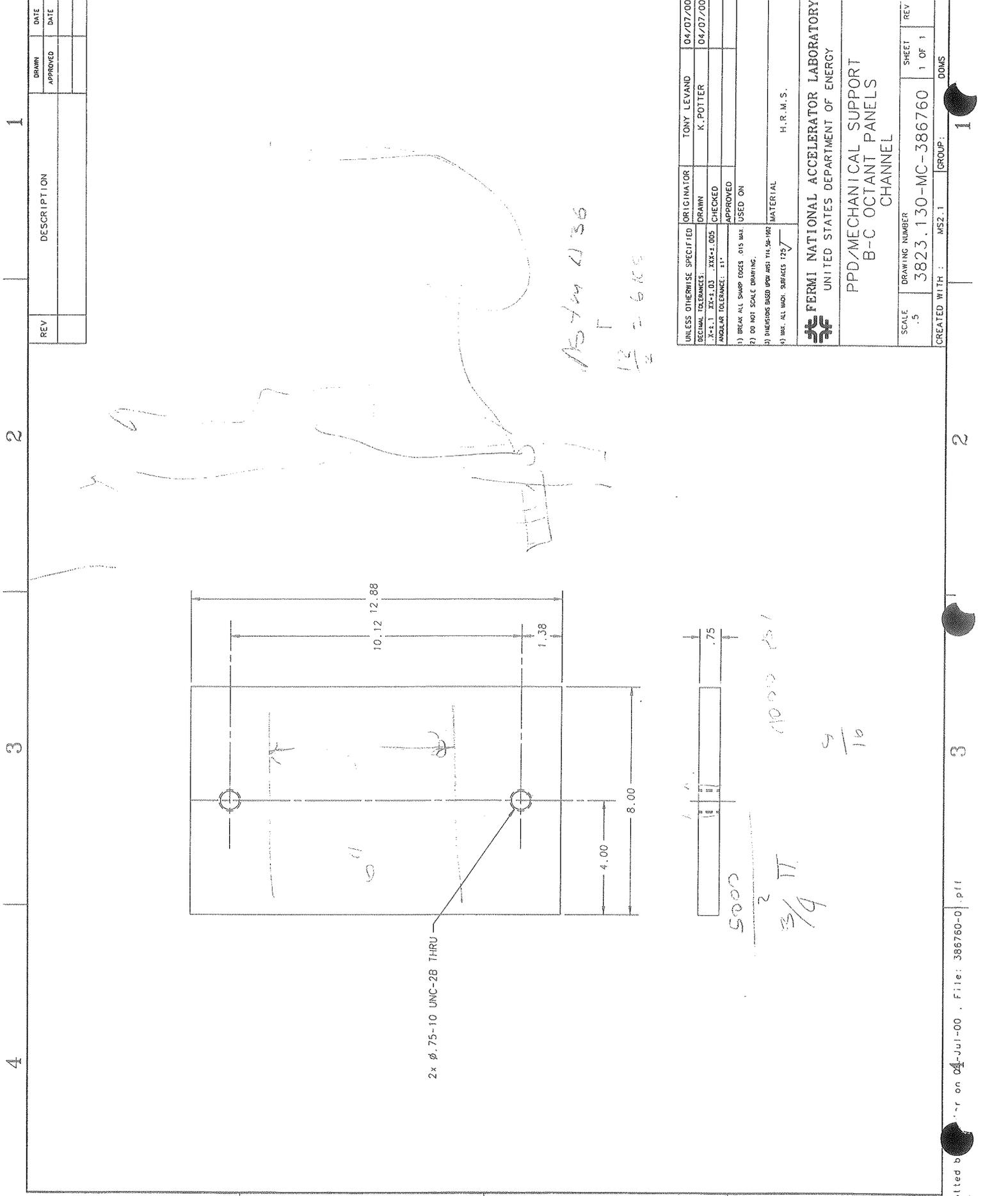
RESULTS: 5- B.C. 1, ELEMENT FORCE_5, LOAD SET 1

Data component: SRSS BENDING MOMENT

Maximum amplitude = 20333.44



1 2 3 4



REV	DESCRIPTION	DRAWN	DATE

UNLESS OTHERWISE SPECIFIED	ORIGINATOR	TONY LEVAND	04/07/00
DECIMAL TOLERANCES:	DRAWN	K. POTTER	04/07/00
.XX-1.1 XX-1.03 .XXX±.005	CHECKED		
ANGULAR TOLERANCES: ±1°	APPROVED		
1) BREAK ALL SHARP EDGES .015 MAX.	USED ON		
2) DO NOT SCALE DRAWING.			
3) DIMENSIONS BASED ON 90° AND 114.94°			
4) MAX. ALL MOD. SURFACES 125	MATERIAL		
		H. R. M. S.	

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

PPD/MECHANICAL SUPPORT
B-C OCTANT PANELS
CHANNEL

SCALE	DRAWING NUMBER	SHEET	REV
.5	3823.130-MC-386760	1 OF 1	

CREATED WITH: MS2.1 GROUP: D0MS