ENGINEERING NOTE
3823-116-EN-528

C LAYER MDT SUPPORTS
STRUCTURAL ANALYSIS

TONY LEVAND
JUNE 26, 2000

CHECKED BY:

7-6-2000

FERMILAB
ENGINEERING NOTE

SECTION

PROJECT

SERIAL-CATEGORY

PAGE

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SUBJECT

CLAYER MAT SUPPORTS

NAME

Tony Leonard

DATE

6/1/00

REVISION DATE

LOADS

MDT OCTANT WEIGHTS:

$$\text{MDT} = .033 \text{ lb/in}$$

$$\text{OCTANTS } 1,2,0,3: \quad \frac{74 + 237}{2} + 43 \times .033 \times 3 = 350 \text{ lbs}$$

$$\text{OCTANTS } 5,6: \quad \frac{74 + 177}{2} \times 30 \times .033 \times 3 = 419 \text{ lbs}$$

$$\text{OCTANTS } 4,7: \quad 419 + (17 \times 177 \times .033 \times 3) = 762 \text{ lbs}$$

FRAME WEIGHTS:

$$.04 \text{ SKINS} \times 2 \times 1.2 (\text{CORE}) \times 2 \times .102 \text{ lb/in}^3 = .020 \text{ lb/in}^2$$

COVER WEIGHTS:

$$.1 \times 2 \times .102 = .02 \text{ lb/in}^2 \times 1.2 = .024 \text{ lb/in}^2$$

$$\text{Frame} + \text{Cover} = .044 \text{ lb/in}^2$$

$$\text{OCTANTS } 1,2,0,3: .044 \times \frac{237 + 74}{2} \times (237 - 74) = 1115 \text{ lbs}$$

$$5,6 = \frac{177 \times 74}{2} \times (177 - 74) \times .044 = 569 \text{ lbs}$$

$$4,7 = 1115 - \frac{(237 - 177)^2}{2} \times .044 = 1036 \text{ lbs}$$

Totals:

$$\text{C } 0,1,0,3 = 1115 + 350 = 1465 \text{ lbs}$$

$$\text{C } 4,7 = 1036 + 762 = 1798 \text{ lbs}$$

$$\text{C } 5,6 = 569 + 419 = 987 \text{ lbs}$$

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MOUNT LOADS:

OCTANTS 1,2

$$\text{Load A} = 1965 \times \frac{59.23}{59.23 + 56.11} = 1009 \text{ lbs}$$

$$\text{Load B} = 1965 - 1009 = 956 \text{ lbs}$$

$$\text{Load C} = 0$$

OCTANTS 0,3:

$$\text{Load A} = 1965 \times \frac{78.27}{78.27 + 68.43} = 1158 \text{ lbs}$$

$$\text{Load B} = 1965 - 1158 = 807 \text{ lbs}$$

$$\text{Load C} = 0$$

OCTANTS 4,7:

$$\text{Load A} = 1778 \times \frac{74.73}{74.73 + 72} = 989 \text{ lbs}$$

$$\text{Load B} = 1778 - 989 = 809 \text{ lbs}$$

OCTANTS 5,6

$$\text{Load A} = 762 \times \frac{74.82}{74.82 + 41.42} = 495 \text{ lbs}$$

$$\text{Load B} = 762 - 495 = 267 \text{ lbs}$$

$$\text{Load C} = 0$$

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LINKAGE, DWG 386 403ROD END $\frac{1}{4}$ " Master 60645K16 - $\frac{1}{2}$ " MALE ROD END

MAX LOAD = 8338 LBS, ultimate

$$\frac{8338}{1.5 \times 3} = 1853 \text{ lbs, } \frac{\text{limit load}}{3} > 1158 \text{ lbs}$$

NUT, Grade 8 Material,

$$\text{Thread Stripless, } A = .5 \times .5 \pi = .393 \text{ in}^2$$

$$f_s = \frac{1158}{.393} = 2.9 \text{ KSI}$$

WELD ANALYSIS

$$\text{WELD AREA} = \frac{.75 \pi \times .125}{\sqrt{2}} = .208 \text{ in}^2$$

$$f_s = \frac{1158}{.208} = 5.5 \text{ KSI} < 8 \text{ KSI}$$

PIPE: Gross Tension:

$$f_t = \frac{1158}{(1.05^2 - .324^2) \frac{\pi}{2}} = 3.5 \text{ KSI}$$

BASE MATERIAL:

SCH 40 PIPE

ASTM A 53 TYPE F

$$F_T = 25 \text{ KSI} \text{ ①}$$

$$F_A = \frac{2}{3} 25 = 16.7 \text{ KSI}$$

$$F_s = \frac{16}{2} = 8 \text{ KSI}$$

① ASTM B31.3-1993 TABLE A-1 P152

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MOUNT DWG 386391

LOAD, C 4-7 LOCATION B: 809 lbs max

MATERIAL:

1018 CF BAR

$$F_{ty} = 60 \text{ KSI} \quad (35 \text{ KSI})^*$$

$$F_t = \frac{60}{3} = 20 \text{ KSI} \quad (11.6)^*$$

* HOT ROLLED PROPERTIES

SECTION A-A:

$$M = 809 \times .73 = 591 \text{ in lbs}$$

$$f_b = \frac{6M}{bt^2} = \frac{6 \times 591}{2^2 \times .5} = 1.7 \text{ KSI}$$

$$f_s = \frac{809}{2 \times .5} = .809 \text{ KSI}$$

SECTION B-B

$$M = 809 \times 8.5 = 6876 \text{ in lbs}$$

$$f_b = \frac{6 \times 6876}{.5 \times \frac{(5.37 - .46)^2}{2}} = 6.8 \text{ KSI} < 11.6 \text{ KSI}$$

WELD ANALYSIS: (C)

$$M = 809 \times (12 - .31 - 3.5) = 6221 \text{ in lbs}$$

$$\left(\frac{6M}{bt^2} \right)$$

$$f_b = \frac{6 \times 6221}{2 \times \frac{.25}{\sqrt{2}} \times 5.68^2} = 3.3 \text{ KSI} + \frac{809}{5.68 \times \frac{.25}{\sqrt{2}}} = 4.1 \text{ KSI}$$

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MOULT DWG 33631 (cont)

WELD ANALYSIS (CONT)

$$f_b = 3.3 \text{ KSI}$$

$$f_s = \frac{809}{2 \times \frac{.25}{\sqrt{2}} \times 5.69} = .4 \text{ KSI}$$

$$f_a + f_b = 3.7 \text{ KSI}$$

BOLT ANALYSIS

$$\text{Bolt load} = \frac{1309}{2} = 654 \text{ lbs}$$

$$f_t = \frac{654}{.1419} = 4.6 \text{ KSI}$$

$$f_s = \frac{809}{.1419 \times 4} = 1.5 \text{ KSI}$$

THREAD PULL OUT:

$$A = \frac{.5 \pi \times .5}{2} = .392 \text{ in}^2$$

$$f_s = \frac{654}{.392} = 1.7 \text{ KSI} < 8.3 \text{ KSI}$$

PIN BEARING:

$$f_{b,p} = \frac{809}{.5 \times .5} = 309 \text{ PSI}$$

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MOUNT 386392, 467

LOADS:

OCTANT C4-7, A location $P = 989 \text{ lbs} - \text{Max}$ OCTANT C0/3, B location $P = 807 \text{ lbs}$

FREEBODY:

WELD ANALYSIS:

$$M = 989 \times 4.5 = 4451 \text{ in lbs}$$

$$f_b = \frac{6 \times 4451}{2 \times \frac{.25}{\sqrt{2}} \times 6^2} = 2 \text{ KSI}$$

$$f_s = \frac{989}{2 \times 6 \times .25 \sqrt{2}} = .4 \text{ KSI}$$

Bolt Loads:

$$f_t = \frac{1041}{.1417} = 7.3 \text{ KSI}$$

$$f_s = \frac{989}{4 \times .1417} = 1.7 \text{ KSI}$$

Mount + 386393

$$\text{total} = 2.4 \text{ KSI}$$

Mount is used to locate octant in horizontal direction
there are no gravity loads on it.

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Moort 386 421, 469

Octant C 0,3 A Load = 1158 lbs

Freebody:

WELD ANALYSIS:

$$M = 1158 \times 4.64 = 5.4 \text{ Kip in}$$

$$f_b = \frac{6 \times 5.4}{2 \times \frac{.25}{\sqrt{2}} \times 5.9^2} = 2.6 \text{ ksi}$$

$$f_s = \frac{1158}{5.9 \times \frac{.25}{\sqrt{2}}} = .55 \text{ ksi}$$

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MDT FRAME MOUNTING BLOCK

CRITICAL LOAD C 0,3 A = 1158 lbs

1/2" socket hd cap screw, 4 1/2" long

Assume bolt has lost clamp up,
all bending in shank.

$$I = \frac{.5}{64} \pi = .003$$

$$M_{max} = P_1 = \frac{1158 \times (.83}{2} + (\frac{.704 \cdot .625}{2}) + \frac{.625}{4} = 354 \text{ lb} \cdot \text{in}$$

$$f_b = \frac{Mc}{I} = \frac{354 \times .25}{.003} = 29 \text{ KSI} < 57 \text{ KSI}$$

$$\text{Shear: } 1158 < 7450 \times 2$$

BOLT MATERIAL ALLOWANCES: ①

$$F_y = 170 \text{ KSI}$$

$$F_a = \frac{170}{3} = 57 \text{ KSI}$$

$$\text{Shear} = \frac{27,353}{3} = 7450 \text{ lbs}$$

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C-1,2 UPPER MOUNTSKinematic mount C1,2 Y, Z (B)DWG 386401

Load = 1009 lbs

MATERIAL:

1045 CF STEEL

From FEA model:

$$\sigma_{max} = 21.24 \times \frac{1009}{1667} = 12.9 \text{ KSI} < 25 \text{ KSI}$$

$$F_{ty} = 25 \text{ KSI}$$

$$F_y = 25 \text{ KSI}$$

DWG 386339

Load = 1009 lbs

From FEA model:

$$\sigma_{max} = 7.01 \text{ KSI} < 25 \text{ KSI}$$

SID 136

1999 741

DWG 386398

Load = 1009 lbs

Freebody:

$$M = \frac{1009}{2} \times 9.84 = 4964 \text{ in lbs}$$

$$f_b = \frac{M}{S} = \frac{4964}{1.10} = 4.5 \text{ KSI} < 12 \text{ KSI}$$

MATERIAL ALLOWANCES:

ASTM A-36 STEEL

$$F_{ty} = 36 \text{ KSI}$$

$$F_y = \frac{36}{3} = 12 \text{ KSI}$$

SECTION PROPERTIES:

$$< 3 \times 3\frac{1}{2} \times .25$$

$$S = 1.10 \text{ in}^3$$

$$I = 2.33 \text{ in}^4$$

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DRAWING 386400

MATERIAL:

ASTM C-1013 CE
FLAT

$$F_{TY} = 60 \text{ KSI}$$

$$F_1 = \frac{60}{3} = 20 \text{ KSI}$$

Fastener bearing:

$$P_F = \frac{1009}{6} + \frac{1009 \times 6.57}{7.00 \times 2} = 642 \text{ lbs}$$

$$f_{brg} = \frac{642}{5 \times .25} = 5.13 \text{ KSI}$$

Fastener shear:

$$f_s = \frac{642}{.1417} = 4.5 \text{ KSI}$$

Stability:

$$J = \frac{.25^3 \times 5}{12} = 6.5 \times 10^{-3} \text{ in}^4$$

$$\frac{\pi^2 EI}{L^2} = \frac{\pi \times 30 \times 10^6 \times 6.5 \times 10^{-3}}{47^2} = 12.5 \text{ KSI} > 64.1$$

$$\frac{15 \text{ KIP} \times 1 \text{ in}^4}{1 \text{ in}^2} = 15 \text{ KIP}$$

$$12.5 \times .25 \times 5 = 15 \text{ KIP} > 1009 \text{ lbs}$$

RESULTS: 2- B.C. 1,STRESS_2,LOAD SET 1
STRESS - VON MISES MIN: 2.73 MAX: 7013.60
DEFORMATION: 1- B.C. 1,DISPLACEMENT_1,LOAD SET 1
DISPLACEMENT - MAG MIN: 0.00 MAX: 0.00
FRAME OF REF: PART
SCALE: 3

VALUE OPTION:ACTUAL

Stress (KSI)

7.01
6.62
6.23
5.85
5.46
5.07
4.68
4.29
3.90
3.51
3.12
2.73
2.34
1.95
1.56
1.17
0.78
0.39
0.00

C Layer MDT Supports
Octant C 1-2 upper
Kinematic mount
1009 lbs load
Dwg 386339
Tony Levand
June 6, 2000

/cadwhs/server02/ms_levand/C_layer_octant_0161.mfl.Z

RESULTS: 2- B.C. 1, STRESS_2, LOAD SET 1
STRESS - VON MISES MIN: 2.20 MAX: 21666.40
DEFORMATION: 1- B.C. 1, DISPLACEMENT_1, LOAD SET 1
DISPLACEMENT - MAG MIN: 0.00 MAX: 0.00
FRAME OF REF: PART
SCALE: 3

VALUE OPTION: ACTUAL

RESULTS: 2- B.C. 1, STRESS_2, LOAD SET 1
STRESS - VON MISES MIN: 0.78 MAX: 6893.64
DEFORMATION: 1- B.C. 1, DISPLACEMENT_1, LOAD SET 1
DISPLACEMENT - MAG MIN: 0.00 MAX: 0.00
FRAME OF REF: PART
SCALE: 3

VALUE OPTION: ACTUAL

/cadwhs/server02/ms_levand/C_layer_octant_0161.mf1.2

RESULTS: 2- B.C. 1, STRESS_2, LOAD SET 1
STRESS - VON MISES MIN: 2.20 MAX: 21666.40
DEFORMATION: 1- B.C. 1, DISPLACEMENT_1, LOAD SET 1
DISPLACEMENT - MAG MIN: 0.00 MAX: 0.00
FRAME OF REF: PART
SCALE: 3

VALUE OPTION: ACTUAL

RESULTS: 2- B.C. 1, STRESS_2, LOAD SET 1
STRESS - VON MISES MIN: 5.46 MAX: 21237.21
DEFORMATION: 1- B.C. 1, DISPLACEMENT_1, LOAD SET 1
DISPLACEMENT - MAG MIN: 0.00 MAX: 0.00
FRAME OF REF: PART
SCALE: 3

VALUE OPTION: ACTUAL

STRESS (KSI)

C layer MDT support
Octants C1-2
Upper Mount Pivot Pin
Load = 1667 lbs
Tony Levand
June 6, 2000