Fermilab

Particle Physics Division

Mechanical Department Engineering Note

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Project: CDF Decommissioning

Project Internal Reference:

Title: MUON Wall Deconstruction

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Abstract/Summary:

As part of the CDF decommissioning, two large twenty one feet long by two feet wide steel shielding walls, one twenty nine feet tall and the other twenty seven feet tall, have to be disassembled and removed. In order to perform this task, ten levels of blocks will need to be removed from each wall, one layer at a time. First, two prefabricated steel lifting lugs must be welded to the top surface of the uppermost block layer. These lugs will then be load tested with 125% of the lifted load to insure that they will not fail during the actual lift. The existing welds between block layers must be cut and the block layer can then be moved to the designated storage area.

This calculation contains the design for the lifting lugs and calculates the size and length of the weld between the lugs and the [illegible]

Applicable Codes:

Design of Below-the-Hook Lifting Devices, ASME BTH -1-2005, The American Society of Mechanical Engineers, 2006.

Manual of Steel Construction, ASD, Ninth Edition, American Institute of Steel Construction, Inc. 1989

LIFTING LUG:
MATERIAL = ASTM A36 STEEL 2" THICK

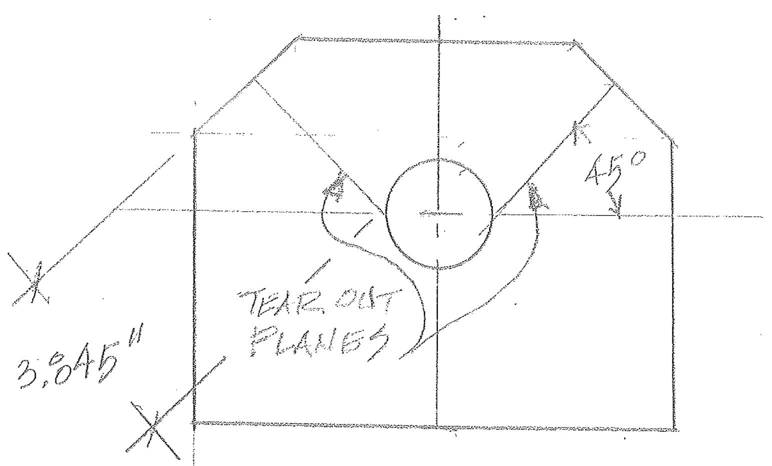
LOADS:
LARGEST SINGLE BLOCK = 11.5 TONS = 23,000 #
LARGEST MULTIPLE BLOCK = 37.3 TONS = 74,600 # =
37,300 #/LUG USING
2 LUGS

DESIGN LUGS FOR 38,000 # LIFTED LOAD

TENSION:
USE 35 TON CAP. SHACKLES
SHACKLE BOLT = $2\frac{1}{4}$"ϕ ; HOLE = $2\frac{3}{8}$"ϕ

TENSION AREA = (10" − 2.375")(2") = 15.25 IN^2
F_T = 1/3 (36,000)(15.25 IN^2) = 183,000 #
183,000 # > 38,000 # <u>OK</u>

SHEAR AREA:



(3.845" × 2") 2 = 15.38 IN^2
15.38 (12,000) = 184,560 # > 38,000 # <u>OK</u>

BEARING, SHACKLE BOLT:
BOLT ϕ = $2\frac{1}{4}$"

BEARING AREA = d_{BOLT} × PLATE THICKNESS (AISC J3.3
= 2.25 (2) = 4.50 IN^2 P. 5-72)

$F_p = L_e F_u / 2d < 1.2\ F_u$ (AISC J3.7 p 5-74)

$= 3.625\,(58{,}000) / 2(2.25)$

$= 46{,}720$ PSI

F_u = SPEC. MIN. TENSILE STRENGTH

L_e = DIST. BETWEEN CENTER OF HOLE AND EDGE OF PL

d = NOMINAL BOLT DIAMETER

BEARING AREA = $2.0\,(2.25) = 4.50\ IN^2$

$46{,}720\,(4.50) = 210\,240$ #

$2.4\,(2.25)(2.0)(58{,}000) =$

$626{,}400$ # $> R_n$

$R_a = 38{,}000$ # $< 210\,240$ # $/ 2.0 = 105\,120$ #

R_n / Ω... $R_n = 339{,}370$ #

BEARING OK

WELDS:

MINIMUM SIZE FILLET FROM TAB. J2.4 (p. 5-67 AISC)

$= 5/16''$ (THICKER PART $> 3/4''$)

MAXIMUM SIZE FILLET = $2'' - 1/16'' = 1\ 15/16''$

(J2.2.b p. 5-67 AISC)

MINIMUM WELD FOR BLOCKS > 28 T

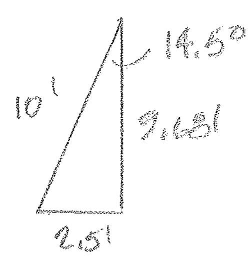
LARGEST = PLATE #7 @ 37.3 T = 74,600 #

74,600 / 2 = 37300 # / LUG VERT. USE 38,000 #

i) FOR 5'-6 BETWEEN LUGS & 20'-0 SLING:

SLING LOAD = 38 / COS 14.5 = 39.25^K

HORIZ LOAD = 38 (TAN 14.5) = 9.83^K



TILT ANGLE FOR LUG 1" OFF CENTER

= 2.2°

VERT LOAD = 38^K (SIN 2.2) = 1.46^K

MOMENT = 1.46 (4.375) = $6.39^{K\text{-}IN}$

VERT. LOAD = ± 6.39 / 2" = 3.2^K = 3200 #

MAX. VERT LOAD = 38 000 # / 2 + 3200 # = 22 200 #

F_T ALLOW. WELD = 36,000 / 3 = 12 000 psi

WELD STRENGTH = 0.707 (12 000) (1/16)

= 530 # / IN PER 1/16" WELD THICKNESS

FOR 3/8" WELD, 530 (6) = 3180 # / IN

22200 / 3180 = 7.0" PER SIDE

TRY 8" WELD PER SIDE, $f_T = 19000/8 + 22200/8$
$= 2375 \#/IN + 2775 \#/IN$

HORIZONTAL LOAD = $38^K (TAN\ 14.50°) = 9.83^K$

F_V ALLOW. $= \frac{0.60(70)}{1.20(2)}$
= 17,500 PSI

FOR 8" OF 3/8" WELD / SIDE:
$.707(17,500)(3/8) = 4640 \#/IN$

$f_V = (9.83/2)/8 = 0.614\ ^K/IN$
$= 614 \#/IN$

COMBINED LOADS

f_t MAX $= 2775 / (.707)(3/8) = 10467$ PSI

$F_T = 12,000$ PSI

$f_V = 614/0.707(3/8) = 2316$ PSI

$f_t/F_T + f_V/F_V \overset{?}{\leq} 1.0 = \frac{10467}{12000} + \frac{2316}{17500}$
$= 1.005 > 1.0$ N.G.

TRY 7/16" WELD

f_t MAX $= 2775/.707(7/16) = 8972$ PSI

$f_V = 614/.707(7/16) = 1985$ PSI

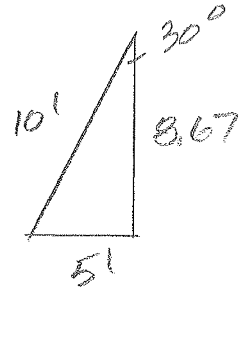
$\frac{8972}{12000} + \frac{1985}{17500} = 0.861$ OK

USE 7/16" WELD

2) FOR 10'-0 BETWEEN LUGS & 20'-0 SLING

SLING LOAD = $38/\cos 30° = 43.9^K$
HORIZ LOAD = $38(TAN\ 30) = 22^K$

MAX. VERT. LOAD SAME AS 5'-0 SPACING = 38270#



HORIZ LOAD = 38(TAN 30)
= 22^K

FOR 8" OF 3/8" WELD / SIDE

$f_V = (22/2)/8 = 1.375^K/IN$
$= 1375\#/IN$

$f_V = 1375/.707(3/8) = 5186$ psi

$f_t/F_T + f_v/F_V = \frac{10467}{12000} + \frac{5186}{17500}$

$= 1.169 > 1.0$ N.G.

TRY 7/16" WELD

$f_{t\,MAX} = 2775/.707(7/16) = 8972$ psi

$f_v = 1375/.707(7/16) = 4445$ psi

$\frac{8972}{12000} + \frac{4445}{17500} = 1.002$ OK (WITHIN 10%)

USE 8" OF 7/16" WELD BA SIDE OF LUG.

MINIMUM WELD FOR BLOCKS 428 T
LARGEST = SOUTH WALL 31" HIGH = 26.5 T
DESIGN FOR 28 T = 56000#
56000/2 = 28000#/LUG

1) FOR 5'-0 BETWEEN LUGS & 20'-0 SLING

SLING LOAD = 28/COS 14.5 = 28.9 K
HORIZ LOAD = 28(TAN 14.5) = 7.2 K

TILT ANGLE FOR LUG 1" OFF CENTER
= 3.30°

VERT. LOAD = 28K (SIN 3.3) = 1.61 K
MOMENT = 1.61(4.375) = 7.05 K-IN
VERT LOAD = ± 7.05/2" = 3.53 K = 3530#

MAX. VERT LOAD = 28000/2 + 3530
= 17530#

TRY 3/8" WELD:
.707(12000)(1/16) = 530#/IN
FOR 3/8, 530(6) = 3180#/IN

17530/3180 = 5.5 IN REQ'D/SIDE

TRY 7" WELD/SIDE
$f_T = 28000/2 = \frac{14000}{7}$ OR $\frac{17530}{7}$
= 2000 OR 2504 #/IN²

HORIZ. LOAD $f_V = 28^K (\tan 14.5) = 7.24^K$

$f_{t\,max} = 2504/.707\,(3/8) = 9445$ psi

$f_V = (7.24/2)/7 = 0.517^K = 517^\#$

$= 517/0.707\,(3/8) = 1951$ psi

$f_t/F_t + f_v/F_v = 9445/12000 + 1951/17500$

$= 0.899 < 1.0$ ok

SINCE WELD REQUIRE MENTS ARE SIMILAR, USE LARGER WELD FOR BOTH 5'-0" SPAN CASES, 8" OF 7/16" WELD EA. SIDE MINIMUM.