Fermilab

Particle Physics Division

Mechanical Department Engineering Note

Number: MD-ENG-313 Date: February 17, 2011

Project:

Project Internal Reference:

Title: E906 Beam Dump Shielding Cave Revised Layout

Author(s): R. J. Woods

Reviewer(s):

Key Words: E906, Beam Dump, Shielding Cave

Abstract/Summary:

Two standard "J" shield blocks originally supported two layers of "H" blocks that cantilevered out 54 inches perpendicular to the "J" block's span. This note investigates if these two "J" shield blocks, stacked on top of each other with their 36 inch dimensions horizontally, can support an additional shield block load stacked 48 inches high. This note also checks the "G" blocks for the additional 48 inches of shield block loading, since their clear span of 232.75 inches is greater than the "J" block span of 113 inches.

Applicable Codes:

Building Code Requirements for Structural Concrete (ACI 318-02), American Concrete Institute, Farmington Hills, Michigan.

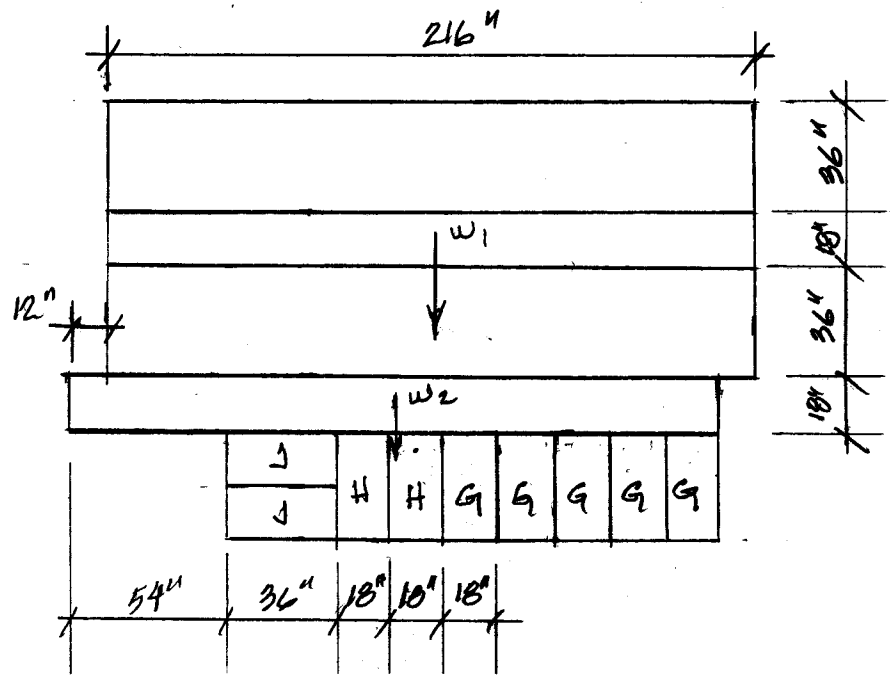
E906 BEAM DUMP

SHIELDING CAVE

R. J. WOODS
FEB. 17, 2011

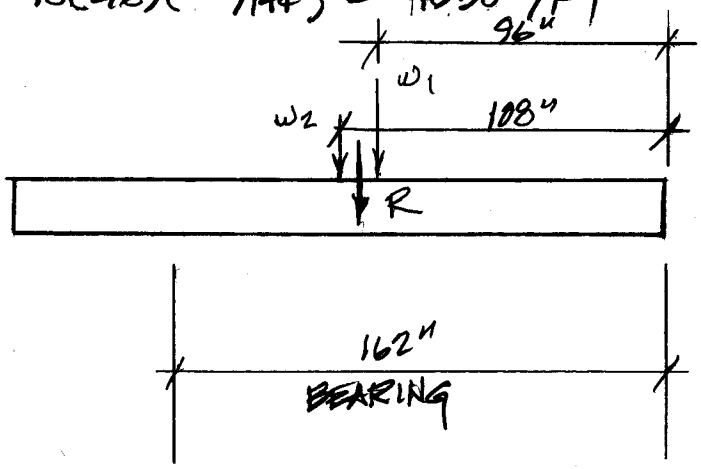
1

℄ BLOCK 288" x 36 x 18



$w_1 = (36+18+36)(216)(150/144) = 20250\ \#/FT$

$w_2 = 18(216)(150/144) = 4050\ \#/FT$



$R = 20250 + 4050 = 24300$

$96(20250) + 108(4050) = 2381400$

$2381400 / 24300 = 98"$ FROM RIGHT END

FIND MAX & MIN. FORCE:

$$A = \frac{d(b+b_1)}{2}$$

$$24300 = \frac{162(b+b_1)}{2}$$

$$300 = b + b_1$$

$$300 - b_1 = b$$

$$c = \frac{d(2b+b_1)}{3(b+b_1)}$$

$$98 = \frac{162(2b+b_1)}{3(300)}$$

$$544.4 = 2(300 - b_1 + b_1)$$

$$544.4 = 600 - b_1$$

$$-55.56 = -b_1$$

$$55.56 = b_1$$

$$244.44 = b$$

CHECK "J" BLOCKS

MAX LOAD = 244.4 #/IN

MIN LOAD = 244.4 - 36(1.17)
= 202.28 #/IN

RATE OF SHEAR DECREASE = $\frac{244.4 - 55.56}{162} = 1.17$ #/IN

LOAD = $\frac{36(244.4 + 202.28)}{2} = 8040.2$ #/FT

J BLOCK LOAD = $\left(\frac{36 \times 18}{144}\right)(150) = 675$ #/FT

TOTAL LOAD = 8040 + 2(675) = 9386 #/F
= 782 #/IN

$R_L = R_R = 782(113)/2 = 44183$ #

$V_u @ d = 44183(1.4) - 782(15.25)(1.4)$
= 45161 psi #

$V_n = V_c$

$\phi V_n \geq V_u$

$V_c = 2\sqrt{f'_c}\, b_w d$
$= 2\sqrt{5000}(36)(15.25$
$= 77640$

$0.75(77640) = 58230 > 45161$ ok

$M_u = 1.4(782)(113)^2/8 = 1747438$ #-IN

$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{1.76(60)}{0.85(5)(36)} = 0.690$

$M_u = \phi A_s f_y (d - a/2)$
$= 0.9(1.76)(60)(15.25 - \frac{0.690}{2}) = 1417$ K-IN
$= 1,417,000$ #-IN

FOR 2 "J" BLOCKS:
CAPACITY $= 2(1,417,000) = 2,834,000$ #-IN $> 1,747,438$ #-IN
ok

BEARING AREA $= 12.75(36)$
$= 459$ IN^2

$44183(1.4) = 61856$ #

ALLOW. BEARING STRESS $= \phi(0.85(f'_c)A_1)$
$= 0.65(0.85)(5000)(459)$
$= 1,267,988$ # > 61856 ok
(ACI 10.17)

CHECK "G" BLOCKS:

LOAD:
DISTANCE FROM LEFT EDGE OF SUPPORT =
$36" + 18" + 18" = 72"$

MAX. LOAD $= 244.4 - 72(1.17)$
$= 160.2$ #/IN

MIN. LOAD $= 160.2 - 18(1.17)$
$= 139.0$ #/IN

LOAD $= \frac{18(160.2 + 139.0)}{2} = 2692.8$ #/FT

"G" BLOCK LOAD $= \frac{(36 \times 18)}{144} \times 150 = 675$ #/FT

TOTAL $= 3367.8$ #/FT
$= 281$ #/IN

BEAM SPAN $= 232.75"$

$M_u = \frac{1.4(281)(232.75)^2}{8}$
$= 2\,663\,936$ #-IN

CAPACITY OF "G" BLOCK:

$f'_c = 5000$ PSI $f_y = 60,000$ PSI
$h = 36"$ $b = 18"$ $A_s = 2$-#8 BARS $= 2(.79) = 1.58$ IN^2
$d = 36 - 2.75 = 33.25"$

$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{1.58(60)}{0.85(5)(18)} = 1.24$

$M_u = \phi A_s f_y (d - a/2) = 0.9(1.58)(60)(33.25 - \frac{1.24}{2})$
$= 2784$ K-IN $= 2,784,000$ #-IN

$2{,}784{,}000\ \#\text{-}IN > 2{,}663{,}936\ \#\text{-}IN$ ok

$R_L = R_R = 281(232.75)/2 = 32701\ \#$

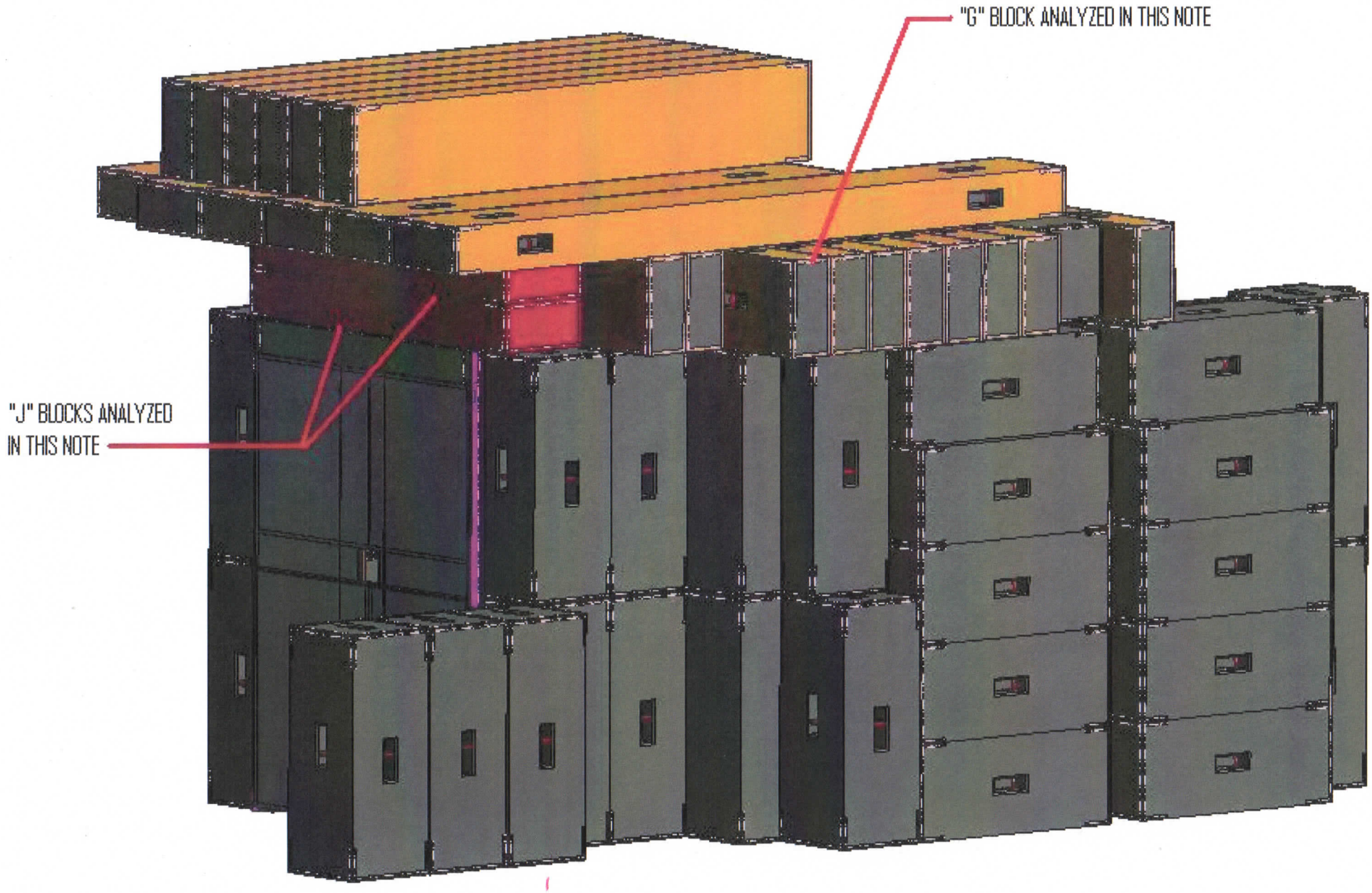
$V_u @ d = 32701(1.4) - 281(33.25)(1.4)$
$= 19621\ \#$

$V_n = V_c$
$\phi V_n \geq V_u$
$V_c = 2\sqrt{f'_c}\ b_w d$
$= 2\sqrt{5000}\,(18)(33.25)$
$= 84641\ \#$

$0.75(84641) = 63{,}481\ \# > 19621\ \#$ ok

BEARING AREA $= 21.5'' \times 18''$
$= 387\ IN^2$

ALLOW. BRG. STRESS $= \phi(0.85(f'_c)A_1)$
$= 0.65(0.85)(5000)(387)$
$= 1{,}069{,}088\ \#$
$R_u = 32701(1.4) = 45781\ \#$
$1{,}069{,}088\ \# > 45781\ \#$ ok


"G" BLOCK ANALYZED IN THIS NOTE
"J" BLOCKS ANALYZED
IN THIS NOTE