PRELIMINARY DESIGN:

SHIELD BLOCK CONC. = 5000 PSI
REINF. = 60,000 PSI
} FROM SHIELD BLOCK DWG. #2961 ME-30369

ALLOWABLE BEARING = $\phi(0.85 f'c A_1)$ ACI 10.15.1
$= 0.70(0.85)(5000)$
$= 2975$ PSI (ULTIMATE)

MAXIMUM LOAD FOR "G" BLOCK: (24.0 x 3.0 x 1.5)
USE MIN. 1'-0 SUPPORT @ EA. END. (SPAN = 22.0')

A) BLOCK IN UPRIGHT POSITION:

1) BENDING

REINF. = 2 - #8 $A_s = 2(0.79) = 1.58$ IN$^2$

$$a = \frac{A_s f_y}{0.85(f'c)b} = \frac{1.58(60)}{0.85(5)(18)} = 1.239$$

$d = 36 - 2.75 = 33.25$ IN.

$$M_{u\ ALLOW.} = \phi A_s f_y (d - a/2)$$
$$= 0.9(1.58)(60)(33.25 - 1.239/2)$$
$$= 2784\ ^{K\text{-}IN} = 232\ ^{K\text{-}FT}$$

$$M = wl^2/8$$

$$232 = w(22.0)^2/8$$

$3.83^{KLF} = w_{ALLOW}$

DEAD LOAD $= 1.4(.150)(3.0)(1.5)$
$= 0.95$ KLF SAY 1.0 KLF

ALLOW. LIVE LOAD $= 3.83 - 1.0$
$= 2.83$ KLF (ULTIMATE)
$= 2.83/1.7$
$= 1.67$ KLF (SERVICE)
$1.67/1.5 = 1.11$ KSF SERVICE

2) SHEAR

$$V_{u\ ALLOW} = \phi 2\sqrt{f'c}\ b_w d$$
$$= 0.85(2)(\sqrt{5000})(18)(33.25)$$
$= 71945^{\#}$ (ULTIMATE) @ "d"/2

$$R_{DL} = 1.5(3.0)(1.4)(22.0/2)(150) = 10,395^{\#}$$

$$R_{LL} = 71,945 - 10,395$$
$= 61555^{\#}$ (ULTIMATE)

$61555/1.7 = 36,206$ # (SERVICE)

$R = wl/2$

$36206 = w(22.0)/2$

$3291$ #/FT $= w$

$3291/1.5 = 2194$ #/FT$^2$ (SERVICE)

3) DEFLECTION:

$\Delta = \frac{5wl^4}{384EI}$ FOR $l/240$ $\Delta_{MAX} = 12(22)/240 = 1.1''$

$I = 18(33.25)^3/12 = 55,140$ IN$^4$ $E_c = 57000\sqrt{5000} = 4,030,509$ PSI

$1.1 = 5w(22)^4(1728)/384(4,030)(55,140)$

$46.4$ KLF $= w$

$46.4 - (.15(1.5)(3.0)) = 45.73$ KLF

$45.73(1000)/1.5 = 30,483$ #/FT$^2$

B) BLOCK LAYING FLAT

1) BENDING:

REINF. = 6 - #8 $A_s = 6(0.79) = 4.74$

$a = \frac{A_s f_y}{0.85(f_c)b} = \frac{4.74(60)}{0.85(5)(36)} = 1.86$

$d = 18 - 2.75 = 15.25$

$M_{u\,ALLOW} = \phi A_s f_y (d - a/2)$
$= 0.9(4.74)(60)(15.25 - 1.86/2)$
$= 3665$ K-IN $= 305$ K-FT

$M = wl^2/8$

$305 = w(22)^2/8$

$5.04$ KLF $= w_{ALLOW}$

ALLOW. LIVE LOAD $= 5.04 - 1.0 = 4.04$ KLF (ULTIMATE)

$4.04/1.7 = 2.38$ KLF (SERVICE)

$2.38/3.0 = 0.792$ KSF (SERVICE)

2) SHEAR

$V_{u\,ALLOW} = \phi 2\sqrt{f'c}\ bwd$
$= 0.85(2)(\sqrt{5000})(36)(15.25)$
$= 65,994^{\#}$ (ULTIMATE)

$R_u = 65,994 - 10395$
$= 55,599^{\#}$

$55,599/1.7 = 32705^{\#}$ (SERVICE)

$R = wl/2$
$32705 = w(22.0)/2$
$2973^{PLF} = w$

$2973/3.0 = 991^{\#}/FT^2$ (SERVICE)

3) DEFLECTION:

$I = 36(15.25)^3/12 = 10639\ IN^4$

$1.1 = \dfrac{5(w)(22.0)^4(1728)}{384(4,030)(10,639)}$

$8.95^{KLF} = w$

$8.95 - (.15(3.0)(1.5) = 8.27^{KLF}$
$8.27/3.0 = 2.75^{KSF}$

MAXIMUM LOAD FOR "H" BLOCK (18.0 × 3.0 × 1.5)
USE MIN. 1'-0 SUPPORT @ EA. END (SPAN = 16'-0)

A) BLOCK IN UPRIGHT POSITION:

1) BENDING

REINF. = 2-#6 $A_s = 2(0.44) = 0.88\ IN^2$

$a = \dfrac{A_s f_y}{0.85(f'c)b} = \dfrac{0.88(60)}{0.85(5)(18)}$
$= 0.69$

$d = 36 - 2.75 = 33.25$

$M_{u\,ALLOW} = \phi A_s f_y (d - a/2)$
$= 0.9(0.88)(60)(33.25 - 0.69/2)$
$= 1564^{K\text{-}IN} = 130^{K\text{-}FT}$

$M = wl^2/8$
$130 = w(16.0)^2/8$
$4.07^{KLF} = w_{ALLOW}$

ALLOW L.L. = 4.07 - 1.0
= 3.07 KLF (ULTIMATE)

3.07/1.7 = 1.81 KLF (SERVICE)

1.81/1.5 = 1.2 KSF (SERVICE)

2) SHEAR

$V_{u\,ALLOW} = \phi 2\sqrt{f'_c}\, b_w d$
$= 0.85(2)(\sqrt{5000})(18)(33.25)$

$= 71,945^{\#}$ (ULTIMATE)

$R_u = 71,945 - 10,395$
$= 61,555$ (ULTIMATE)

$61,555/1.7 = 36\,202^{\#}$ (SERVICE)

$R = wl/2$

$36,202 = w(16.0)/2$

$4525^{PLF} = w$

$4525/1.5 = 3017$ PSF (SERVICE)

3) DEFLECTION

$\Delta = \frac{5wl^4}{384EI}$ FOR $l/240$ $\Delta_{MAX} = 16(12)/240$
$= 0.80''$

$0.80 = 5(w)(16)^4(1728)/384(4030)(55,140)$

$121^{KLF} = w$

$121 - (.15)(1.5)(3.0) = 120$ KLF

$120(1000)/1.5 = 80,217$ PSF

B) BLOCK LAYING FLAT

1) BENDING:

REINF. = 6-#6 $A_s = 6(.44) = 2.64$ IN²

$a = \frac{A_s f_y}{0.85(f'_c)b} = \frac{2.64(60)}{0.85(5)(36)}$

$= 1.035$

$d = 18 - 2.75 = 15.25$

$M_{u\,ALLOW} = \phi A_s f_y (d - a/2)$
$= 0.9(2.64)(60)(15.25 - 1.035/2)$
$= 2100$ K-IN $= 175$ K-FT

$M = w\ell^2/8$

$175 = w(16.0)^2/8$

$5.47 = w_{ALLOW}$

ALLOW. LL = 5.47 − 1.0

= 4.47 KLF (ULTIMATE)

4.47/1.7 = 2.63 KLF (SERVICE)

2.63/3.0 = 0.876 KSF (SERVICE)

2) SHEAR

$V_{u\,ALLOW} = \phi\, 2\sqrt{f'c}\; b_w d$

$0.85(2)(\sqrt{5000})(36)(15.25)$

= 65,994# (ULTIMATE)

$R_u$ = 65,994 − 10395

= 55,599#

55,599/1.7 = 32705# (SERVICE)

$R = w\ell/2$

$32705 = w(16.0)/2$

4088 PLF = w

4088/3.0 = 1362 PSF (SERVICE)

3) DEFLECTION FOR $\ell/240$ = 12(16)/240 = 0.80"

$I = 36(15.25)^3/12 = 10639\ IN^4$

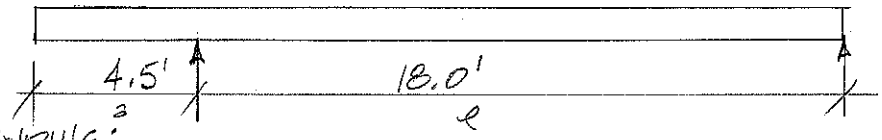
$0.8 = \dfrac{5(w)(16.0)^4(1728)}{384(4{,}030)(10{,}639)}$

22.7 KLF = w

22.7 − (.15 (3.0)(1.5) = 22.0 KLF

22.0/3 = 7.34 KSF

CHECK CANTILEVER SUPPORT IN MAC6
CASE #I FULL LOAD




BENDING:

POS MOMENT:

$$M = \frac{W}{8l^2}(l+a)^2(l-a)^2$$

$$232 = \frac{W}{8(18)^2}(18+4.5)^2(18-4.5)^2$$

$$6.52^{KLF} = W \quad \text{(ULTIMATE)}$$

NEG. MOMENT:

$$M = Wa^2/2$$

$$232 = W(4.5)^2/2$$

$$22.9^{KLF} = W \quad \text{(ULTIMATE)}$$

SHEAR:

$$R = W/2l(l+a)^2$$

$$36206 = (W/2(18))(18+4.5)^2$$

$$2575^{\#}/FT = W$$

$$2575/1.5 = 1716 \text{ PSF (SERVICE)}$$

CASE II LOAD ON CANTILEVER ONLY:
BENDING:

NEG. MOMENT:

$$M = Wa^2/2$$

$$232 = W(4.5)^2/2$$

$$22.9^{KLF} = W \quad \text{(ULTIMATE)}$$

CASE III LOAD BETWEEN SUPPORTS ONLY:

POS. MOMENT:

$$M = Wl^2/8$$

$$232 = W(18.0)^2/8$$

$$5.7^{KLF} = W \quad \text{(ULTIMATE)}$$

SUMMARY:
FOR N WEST AND MP
MAX SPAN = 16'-0

$232 = W(16.0)^2/8$
$7.25^{KLF} = W$

$7.25 - 1.0 = 6.25^{KLF}$ (ULTIMATE)

$6.25/1.7 = 3.68$ KLF (SERVICE)

$3.68/1.5 = 2.45$ KSF (SERVICE)

SHEAR:
$36.2 = W(16.0)/2$ (SERVICE)
$4.53^{KLF} = W$

$4.53/(1.5) = 3.02^{KSF}$ (SERVICE)

DEFLECTION:
$\ell/240 = 16(12)/240 = 0.80''$

$$0.80 = \frac{5(W)(16)^4(1728)}{384(4030)(55140)}$$

$120^{KLF} = W$

$120/1.7 = 70.9^{KLF}$

$70.9/1.5 = 47.3^{KSF}$ (SERVICE)

SLAB ON GRADE MAX. LOAD = 5000 PSF

WALL BLOCK = .15(7.5) = 1.125 KSF
BEAM WT:
2 @ .15(3.0) 16.0/2 = 7.2 KLF
1 @ .15(1.5) 16.0/2 = 1.8 KLF
9.0 KLF

9.0/3 = 3.0 KSF
+ 1.125 KSF
4.125 KSF

5.0 − 4.125 = .875 KSF

$(16.0/2(W))/3.0 = .875$

W = 2.33 KSF (SERVICE)

∴ MAXIMUM LIVE LOAD = 2.45 KSF SAY 2.0 KSF

FOR MC

MAXIMUM LOAD LIMITED BY CANTILEVER BLOCKS.

= 1.7 KLF

Fermilab

July 7, 1992

To: Bob Woods

From: Bob Wands BW

Subject: Shield Block Loading Calculations

I have reviewed the calculations of allowable loads on the shield blocks in the Meson Detector Building, and found no errors in the approach or numerical results. If I can be of any further assistance, please let me know.