Masonry Design
Homework 3
April 11, 2005

1. Check the DPC Gymnasium north wall on Grid Line A as an unreinforced composite wall using 4" nominal face brick and 12" concrete masonry units with a 2" grouted collar joint. If the wall fails, suggest a method to make it pass.

   Properties

   Block: $f'_m = 1{,}500$ psi, $E_m = 2.08(10)^6$ psi, block is ungrouted
   Brick: unit strength= 8 ksi, $E_m = 2.4(10)^6$ psi
   Grout, $f_g = 5{,}100$ psi, $E_g = 2.55(10)^6$ psi

   Bearing plate

   6" x 12" (12" dimension along the wall) positioned so the back edge of the plate is at the interface between the concrete block and grout.

   Loads

   $P_D = 4{,}960$ lb
   $P_{D+L} = 14{,}900$ lb
   Wind load = 20 psf on a 24' high wall (pinned top and bottom)

MASONRY HOMEWORK #3 - PROBLEM #1

CHECK THE DPC GYM NORTH WALL AS UNREINFORCED COMPOSITE WALL W/ 4" NOMINAL BRICK, 12" CMU & 2" GROUTED COLLAR JOINT

CMU $f'_m = 1500$ psi, $E_m = 2.08(10)^6$, BLOCK UNGROUTED

BRICK $E_m = 2.4(10)^6$ psi

GROUT $E_g = 2.55(10)^6$ psi

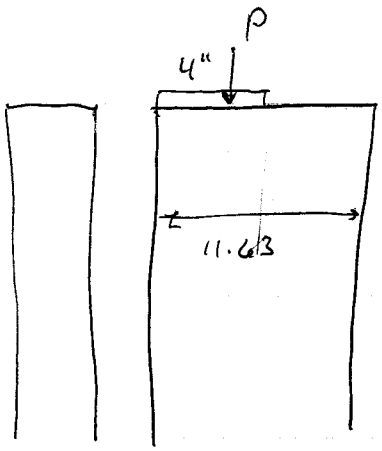
JOIST LOADS = $P_D = 4960$ lb

$P_{DL} = 14900$ lb

$$M_w = \frac{20 \text{ psf}(1' \text{ strip})(24)^2}{8} = 1440 \text{ lb-ft}$$

$$= 17280 \text{ in-lb}$$

INITIAL CHECK - SEE IF THE CMU ALONE CAN CARRY THE LOAD.



$$e = \frac{11.63}{2} - 4 = 1.82"$$

~~A_{eff}~~ = EFFECTIVE SECTION = $12" + 4(11.63)$

$= 58.5"$

$$P_D = \frac{4960 \text{ lb}}{58.5"} = 1020 \text{ lb/ft}$$

$$P_{LL} \quad \frac{14900}{58.5} = 3060 \text{ lb/ft}$$

D+L+W

$$M = 17280 \text{ in-lb} + \frac{3060 \text{ lb}(1.82")}{2} = \cancel{22850} \; 20065 \text{ in-lb}$$

$$f_b = \frac{M}{S} = \cancel{\frac{22850}{160}} \; \frac{20065 \text{ in-lb}}{160 \text{ in}^3} = 125 \text{ psi}$$

(FACE SHELL BED ASSUMED)

$$f_a = \frac{3060\ lb}{36\ in^2} = 85\ psi$$

$$\frac{h}{r} = \frac{24'(12'')}{5.08''} = 56.7 \qquad < 99$$

$$F_a = \frac{1}{4} f'_m \left(\frac{70 r}{h}\right)^2 = \frac{1}{4}(1500\ psi)\left[\frac{70}{56.7}\right]^2 = 571\ psi$$

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} = \frac{85}{571} + \frac{125}{500} = 0.40$$

$$P_e = \frac{\pi^2 E_m I_n}{h^2}\left(1 - .577\frac{e}{r}\right)^3$$

$$= \frac{\pi^2 (2.08)(10)^6 (929)}{(24\times 12)^2}\left(1 - .577\frac{1.82}{5.08}\right)^2 = 144700\ lb$$

$$1/4\ P_e = 36175\ lb > 3060\ lb \quad O.K.$$

ALL COMPRESSION CHECKS ARE O.K.

USE $\underline{D+W}$ TO CHECK TENSILE STRESSES

$$M_{W+D} = 17280\ in\text{-}lb + \frac{1020(1.82)}{2} = 18210\ in\text{-}lb$$

$$f_b = \frac{18210}{160} = 113.8\ psi$$

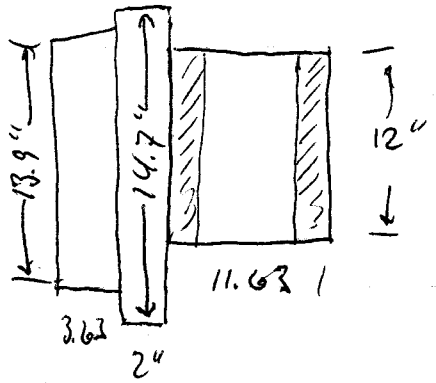
$$f_a = \frac{1020}{36} = 28.3\ psi$$

TENSILE STRESS = $113.8 - 28.3 = 85\ psi$ NO GOOD

QUICK CHECK W/ FULL BENDING ALSO NO GOOD

DESIGNER COULD GROUT THE CMU BUT SHOULD CHECK THE SECTION AS A COMPOSITE FIRST.

TRANSFORMED SECTION



$$b_g = \frac{2.55(10)^6}{2.08(10)^6}(12") = 14.7 \text{ in}$$

$$b_b = \frac{2.4(10)^6}{2.08(10)^6}(12") = 13.9 \text{ in}$$

STILL HAVE FACE SHELL BEDDING ON THE CMU

MEASURING FROM THE CENTER OF THE CMU

$$\bar{Y} = \frac{\Sigma A y}{\Sigma A} = \frac{36 in^2(0) + 2"(14.7)(6.815") + 3.63(13.9)(9.63")}{36 + 2(14.7) + 3.63(13.9)}$$

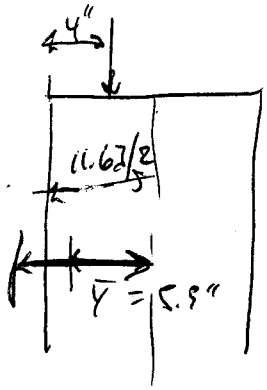
$$\bar{Y} = 5.89" \text{ TO LEFT OF CMU CENTER}$$

$$I = 929 in^4 + 36(5.89)^2 + \frac{14.7(2)^3}{12} + 14.7(2)(6.815 - 5.89)^2$$

$$+ \frac{(3.63)^3(13.9)}{12} + 3.63(13.9)(9.63 - 5.89)^2 = 2960 in^4$$

DO NOT NEED TO PERFORM COMPRESSION CHECKS AGAIN BECAUSE HAVE ALREADY SHOWN THAT THE CMU ALONE WORKS FOR COMPRESSION

CHECK TENSILE STRESS D+W



$e = \frac{11.63}{2} + 4 - 5.9"$

$= 4.085"$

FOR CMU

$M = 17280 - 1020(4.085") = 13113$ in-lb

$f_b = \frac{13113 \quad (5.9 + \frac{11.63}{2})}{2960 \text{ in}^4} = 52$ psi

ACCOUNTING FOR AXIAL COMPRESSION, THIS WILL STILL FAIL TENSION CHECK.

TRY FULL BEDDING FOR THE CMU

$\bar{Y} = 5.36"$ FROM CENTER OF CMU

$I = 1065 + 57.8(5.36)^2 + \frac{14.7(2)^3}{12} + 14.7(2)(6.815 - 5.36)^2$

$+ \frac{(3.63)^3(13.9)}{12} + 3.63(13.9)(9.63 - 5.36)^2 = 3773 \text{ in}^4$

$e = 3.55"$ $\quad M = 17280 - 1020(3.55) = 13660$

$f_b = \frac{13660(5.36 + 11.63/2)}{3773} = 40.5$ psi

STILL TOO BIG

GO TO FULL GROUTED