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FEASIBILITY OF USING CARBON FIBER REINFORCED POLYMER SHEETS ON CRACKED RESIDENTIAL FOUNDATION WALLS

PREPARED FOR STABL-WALL INCORPORATED
365 HIGHLAND ROAD EAST
MACEDONIA, OHIO 44056

COMMON PROBLEMS ENCOUNTERED

1. Many foundations are leaking moisture from the earth against the exterior of the walls.

2. The earth pressure has caused the concrete block (or clay tile in older foundations) to crack and bow inward. These cracks may be classed as "stair-step", vertical, or horizontal.

3. The pressure from the ground freezing adds to the normal earth pressures and tends to cause horizontal cracks in the mortar joints usually in the area between 16 inches and 40 inches below the exterior grade of the earth. The magnitude of the pressure from freezing cannot be easily determined, but combined with the earth pressure clearly exceeds the ability of an unreinforced masonry wall to resist these forces.

CORRECTIVE MEASURES

Through the years, there have been several methods developed to stabilize these cracked walls. The more common methods are:

1. Install vertical steel beams or channels to transfer a part of the horizontal earth load to the basement floor slab and the floor system above.

2. Cut out a vertical chase (12 inches-16 inches wide) and create a reinforced concrete or masonry pilaster.

3. Cut out only a portion of the wall and place vertical reinforcing rods in the block cells. These are then grouted in another attempt to create a pilaster.

4. Core horizontal holes in the wall and install earth anchors horizontally to provide a tie-back system for resisting the earth pressure against the wall.

5. Remove and replace the entire damaged portions of the wall.

All of the above corrective measures are costly, messy and only partially successful at restraining a wall from further movement and cracking.

Also, none of these corrective measures address the basic engineering reason for the cracking, lack of tensile strength in masonry.

A NEW SOLUTION

This analysis will estimate the usual loads on three typical foundation walls and show by conventional engineering analysis that the Carbon Fiber Reinforced Polymer sheets can provide the required tensile strength for masonry walls needed to resist the earth loads.

The use of this material will not, nor is it intended to straighten walls, which are presently bowed.

This material is not intended to be used on walls, which have deflected inward more than 1.5-2.0 inches for a 12 course high wall. Walls with deflections greater than 2.0 inches must be evaluated for stability or replacement.

Kenneth W. Jensen, P.E., P.S.

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BASIS FOR DESIGN

Earth-Average Weight 100 P.C.F.
Angle of Repose ϕ =35°00'

$$P = \frac{1 - \sin\phi}{1 + \sin\phi} = 0.2710$$

Concrete Block Masonry
F'c = 2000 P.S.I.
Ec = 2,000,000 P.S.I.

Carbon Fiber Reinforced Polymer
F't = 500,000 P.S.I.
Ec = 30,000,000 P.S.I.
Width 24 Inches
Thickness (2mm) = 0.0787 Inches

Adhesive—See Attached Sheet

TYPICAL 11 COURSE WALL

SEE P. 2

$P_{MAX} = 0.2710(100)(6.33)$

$= 172$ PPF

$P_H = 0.5(172)(6.33)$

$= 543$ #/FT

$R_T = 543(2.11)/7$

$= 164$ PPF

$R_B = 543 - 164 = 379$ PPF

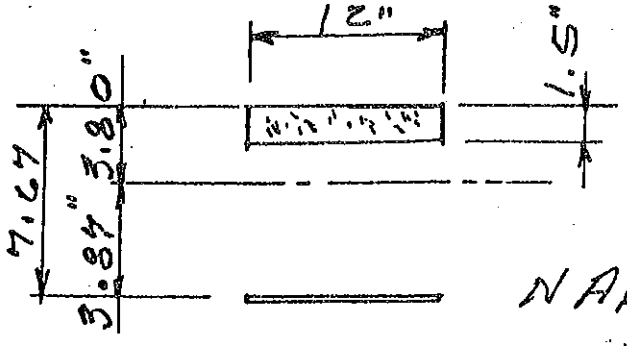
MAXIMUM BENDING

$X = 3.47 + 0.67 = 4.14'$

$M = 164(4.14) - 0.5(27.17)(3.47)^2/2$

$= 625.14$ '#/FT.

SECTION



$A_C = 18.01 IN^2$

$NA_F = 12(0.08)(15)$

$= 14.17 IN^2$

N. A.

$18(0.75) = 13.50$

$14.17(7.67) = 108.68$

$32.17(3.30) = 122.18$

CONCRETE MASONRY STRESS

$C = T = 625(12)/6.92$

$= 1084$ #/FT

$f_c = 1084/18 = 60.2$ PSI

$f_F = 1084/12(0.0787) = 1148$ PSI

ALLOWABLE $F_F = 500\,000/3.5 = 142\,800$ PSI

(SAFETY FACTOR = 3.5)

TYPICAL 12 COURSE WALL

SEE P. 9

$P_{MAX} = 0.2710(100)(7.00)$

$= 190$ PPF

$P_H = 0.5(190)(7) = 665$ #/FT

$P_T = 665(2.33)/7.67$

$= 202$ PPF

$P_B = 463$ PPF

MAXIMUM BENDING

$X = 3.86 + 0.67 = 4.53'$

$M = 202(4.53) - 0.5(27.14)(3.86)^2/2$

$= 814$ '#/FT

$C = T = 814(12)/6.92 = 1412$ #/FT

$f_c \cong 1412 / 18 = 78.4$ PSI

$f_f = 1412 / 0.94 = 1502$ PSI

TYPICAL 13 COURSE WALL

SEE P. 10

$P_{MAX} = 0.2710(100)(7.67)$

$= 208$ PPF

$P_H = 0.5(208)(7.67) = 797$ #/FT

$P_T = 797(2.56)/8.33 = 245$ PPF

$P_{13} = 552$ PPF

MAXIMUM BENDING

$X = 4.25 + 0.67 = 4.92'$

$M = 208(4.92) - 0.5(27.12)4.25^2/2$

$= 901$ '#/FT.

$C = T = 901(12)/6.92 = 1562$ #/FT

$f_c \cong 1562/18 = 86.8$ PSI.

$f_f = 1562/0.94 = 1662$ PSI

RECOMMEND VERTICAL LENGTH:

USE 24" ABOVE AND BELOW

PENINSULA BLOCK.

TYPICAL PANEL 24" WIDE

48" HIGH

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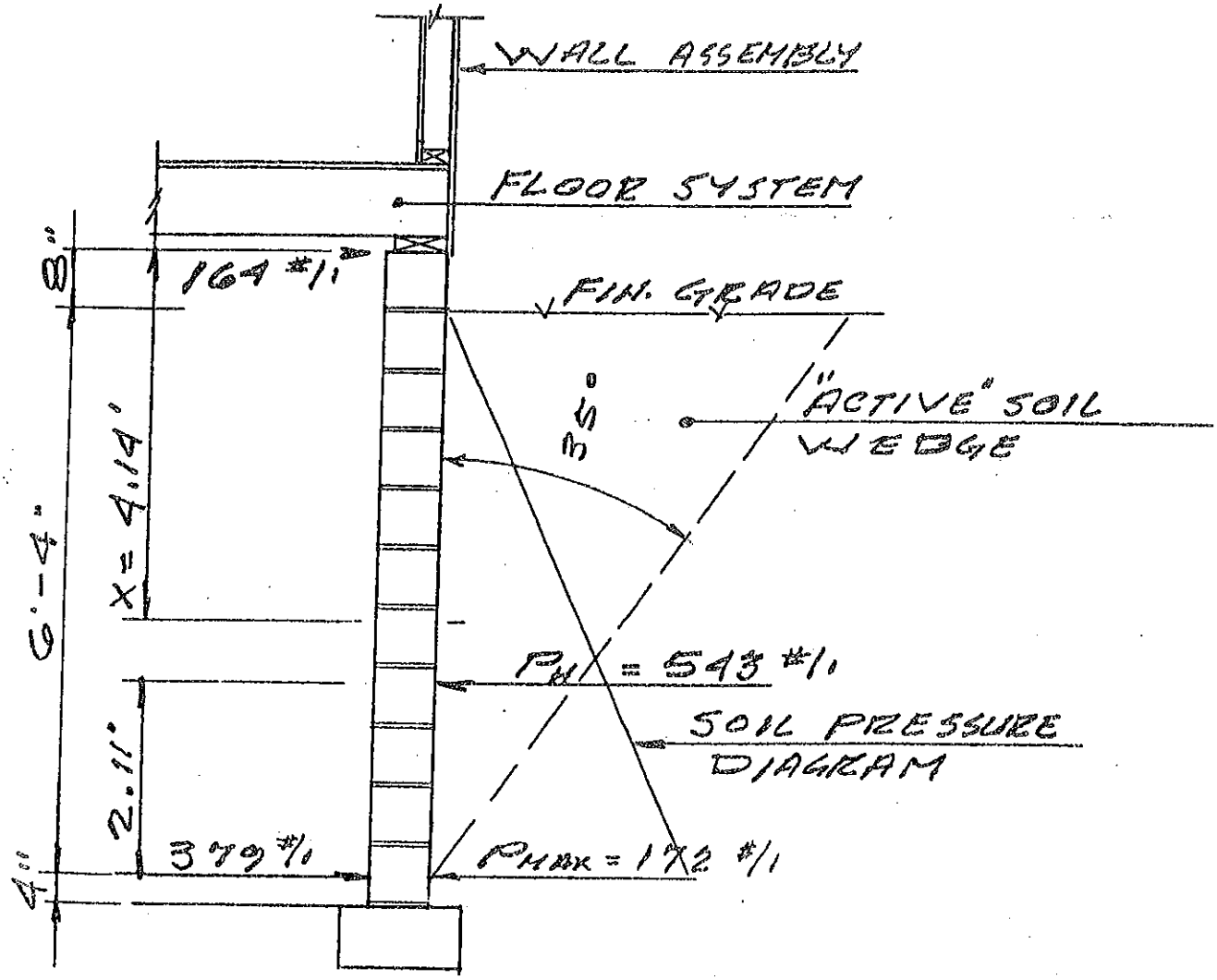
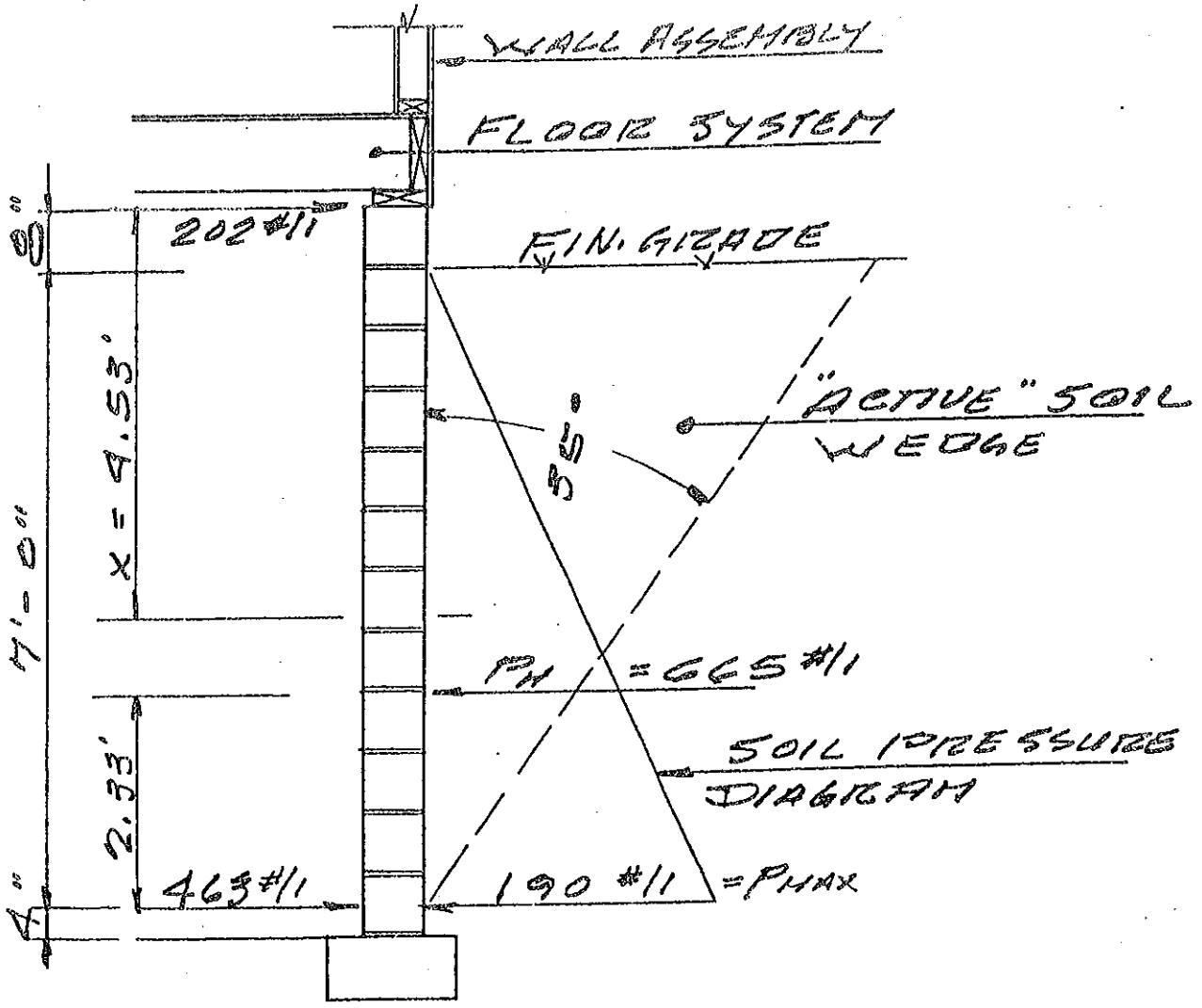
Horizontal Strong Back Wall

1. Center of first panel at each end of horizontal crack.
2. Space panels equally between end panels, not to exceed 6 feet center to center of panels.



TYPICAL 11 CONCRETE WALL - 8"

1/2" = 1'-0



TYPICAL 12 COURSE WALL - 8"

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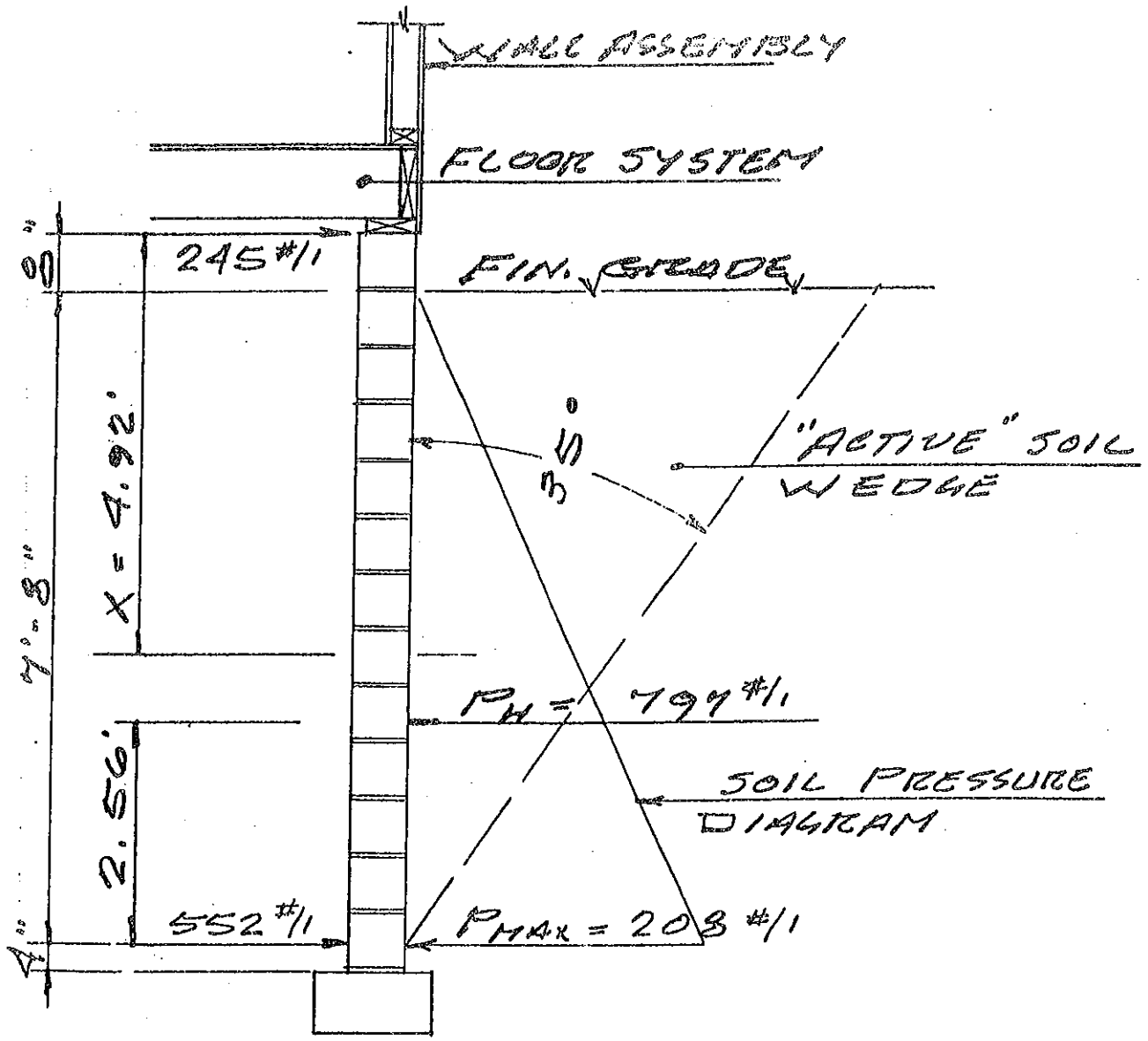


TYPICAL 13 COURSE WALL - 8"

1/2" = 1'-0

TYPICAL 8" PLAIN CONCRETE WALL

SEE P. 5

$P_{MAX} = 0.2710(100)(7.0) = 190$ PPF

$P_H = 0.5(190)(7) = 665$ PPF

$P_T = 665(2.33)/7.67 = 202$ PPF

$P_B = 665 - 202 = 463$ PPF

MAXIMUM BENDING MOMENT

$X = 3.86 + 0.67 = 4.53'$

$M = 202(4.53) - 202(3.86/3$

$= 2855$ #'

CHECK FOR TENSION

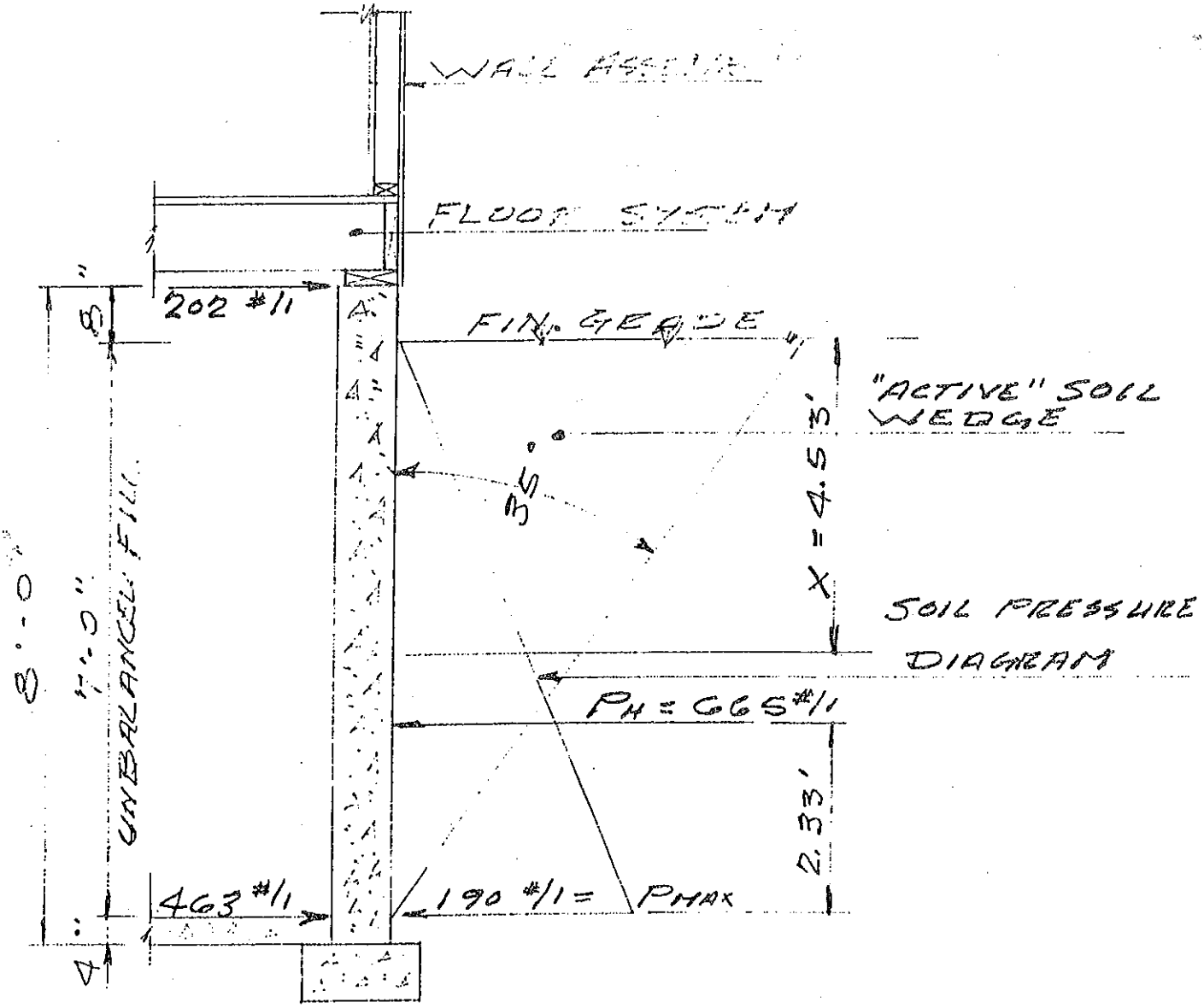
$f_T = 655(12)(4)/512 = 61.4$ PSI

$f_{CR} = 7.5(3000)^{1/2} = 411$ PSI

COMMENT

TENSILE STRESS IS LESS THAN 100PSI, THEREFORE CRACKING DUE TO EARTH LOADS ALONE SHOULD NOT OCCUR.

AFTER A CRACK HAS FORMED, THE CONCRETE CAN NO LONGER PROVIDE TENSION. THEREFORE THE USE OF [illegible] FIBER REINFORCED POLY[illegible]



TYPICAL 8" PLAIN CONCRETE WALL

$\frac{1}{2}$" = 1'-0

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SHEETS CAN BE APPLIED TO PROVIDE THE REQUIRED TENSILE FORCE.

REQUIRED REINFORCEMENT

$M = 655(12) = 7860$ IN. #

$C = T = 7860/8 = 982.5$ #

AREA OF CARBON FIBER REINFORCED POLYMER PER FOOT OF WALL

$A = 982.5/200000 = 0.0049$ IN^2

$L = 0.0049/0.08 = 0.06$ "/FT.

RECOMMENDED USE

HORIZONTAL CRACKS

1. 2'-0" SQUARE PANELS CENTERED 12" ABOVE & BELOW THE CRACK
2. SPACE PANELS AT 6'-0" CENTER CENTER ALONG LENGTH OF WALL

VERTICAL CRACKS

1. 2'-0" SQUARE PANELS CENTERED 12" ON EITHER SIDE OF THE CRACK.
2. SPACE PANELS AT 4'-0" CENTER TO CENTER VERTICALLY.

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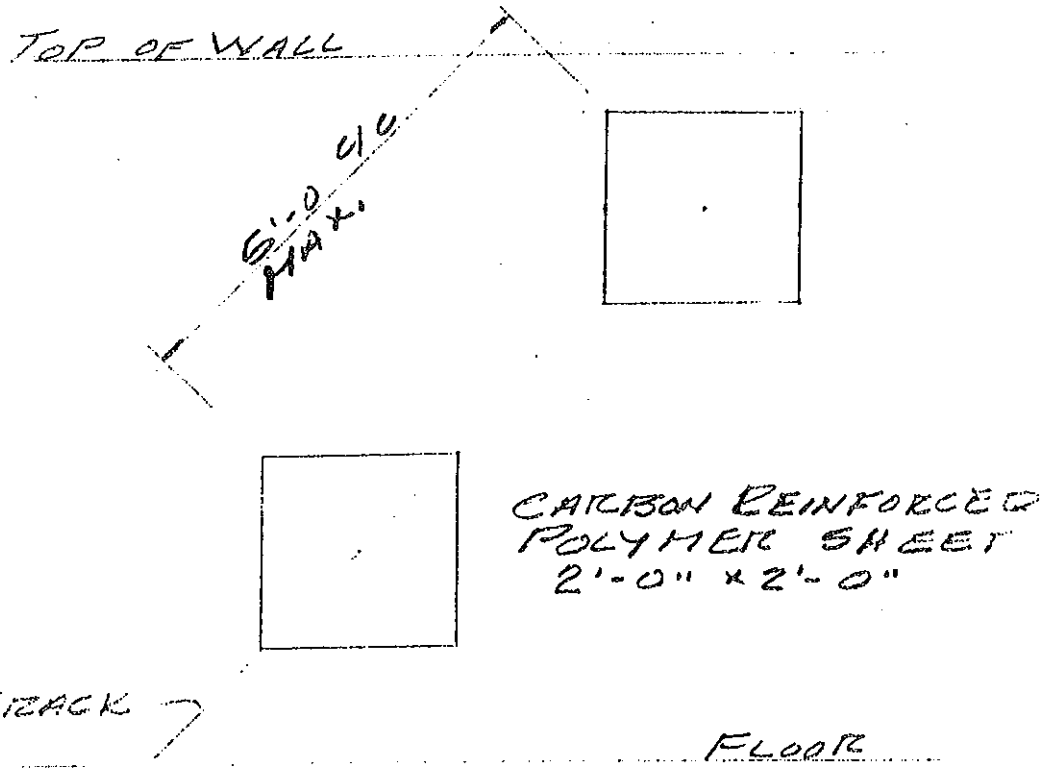
DIAGONAL CRACKS.

1. 2'-0" SQUARE PANELS. SET TOP OF PANEL PARALLEL TO TOP OF WALL AND CENTER LINE OF PANEL AT CENTER OF CRACK.
2. SPACE PANELS AT 5'-0" CENTER TO CENTER ALONG THE CRACK.



TYPICAL SPACING FOR DIAGONAL CRACK