4

THESIS ON

THE DESIGN OF A FIVE-STORY
REINFORCED CONCRETE
APARTMENT HOUSE

UNDER A.C.I. BUILDING CODE

SUBMITED IN PARTIAL FULFILMENT
OF THE REQUIRMENTS FOR THE
DEGREE OF BACHELOR OF SCIENCE
IN CIVIL ENGINEERING FROM
ROBERT ENGINEERING SCHOOL

ISTANBUL, TURKEY
1939

Submitted by Saraylıoğlu Yani

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LETTER OF TRANSMITTAL

209 Kuyulu bagi sokagi
Kurtulus, Istanbul
May 10, 1939

Prof. E. R. Wiseman
Robert College
Bebek Post Box 8

Dear Sir:

I submit "a thesis on the design of a five-story reiforced concrete apartment house " in partial fulfilment of the requirments for the degree of Bachelor of Science in C.E. from Robert Engineering School.

Yours very truly,

Saraylioglu Yani

Saraylioglu Yani

INTRODUCTION

The purpose of this thesis is to design a reinforced concrete building under the A.C.I. Building code. In designing the building I had in mind to satisfy also completly the municipal laws of Istanbul.

In designing this building I combined both architectural and design requirments in order to get an economical,safe,useful and beautiful apartment house.

ARCHITECTURAL REQUIRMENTS

To get best utility,confort,and beauty of each story, the building is divided in the following way;

Every storyis divided in two separate apartments with two main doors for eachone, the smallest of the doors being used by the servants.

The bedrooms are located at the rear side of each story in order to be away from any noise.

The requirements of the municipality

of Istanbulfor the constraction of a building are:

The max. height of a building cannot be greater than the width of the street.

The max. width of the vaious parts of the building which are projecting outside of the property of the building(for example a balcony) hasto be equal or smaller than 75cm (=29½")

The elevation of the first floor has to be smaller than 2meters(=6.58ft) orgreater than half a meter from the surface elevation of the street.

The cross sectional area of skylights has to be equal to 6sq.meters.

The opening of the doors must have a width greater than 90cm and a height of 2meters(=6.58ft)

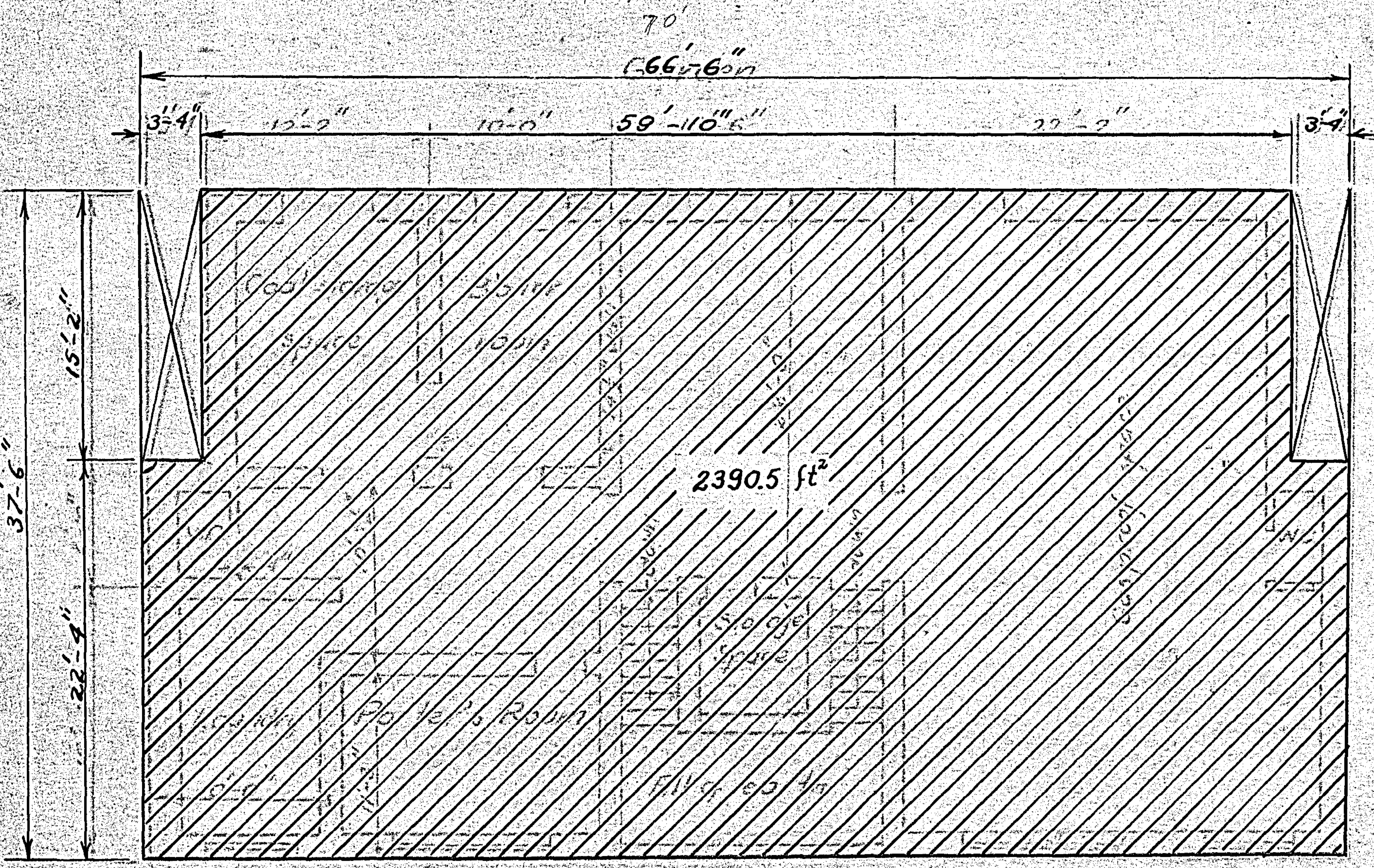
Thewidth of stairs must be 150sm(=4.92ft)

The height of each story has to be greater than 2.85meters (=9.34ft.).

FRONT ELEVATION

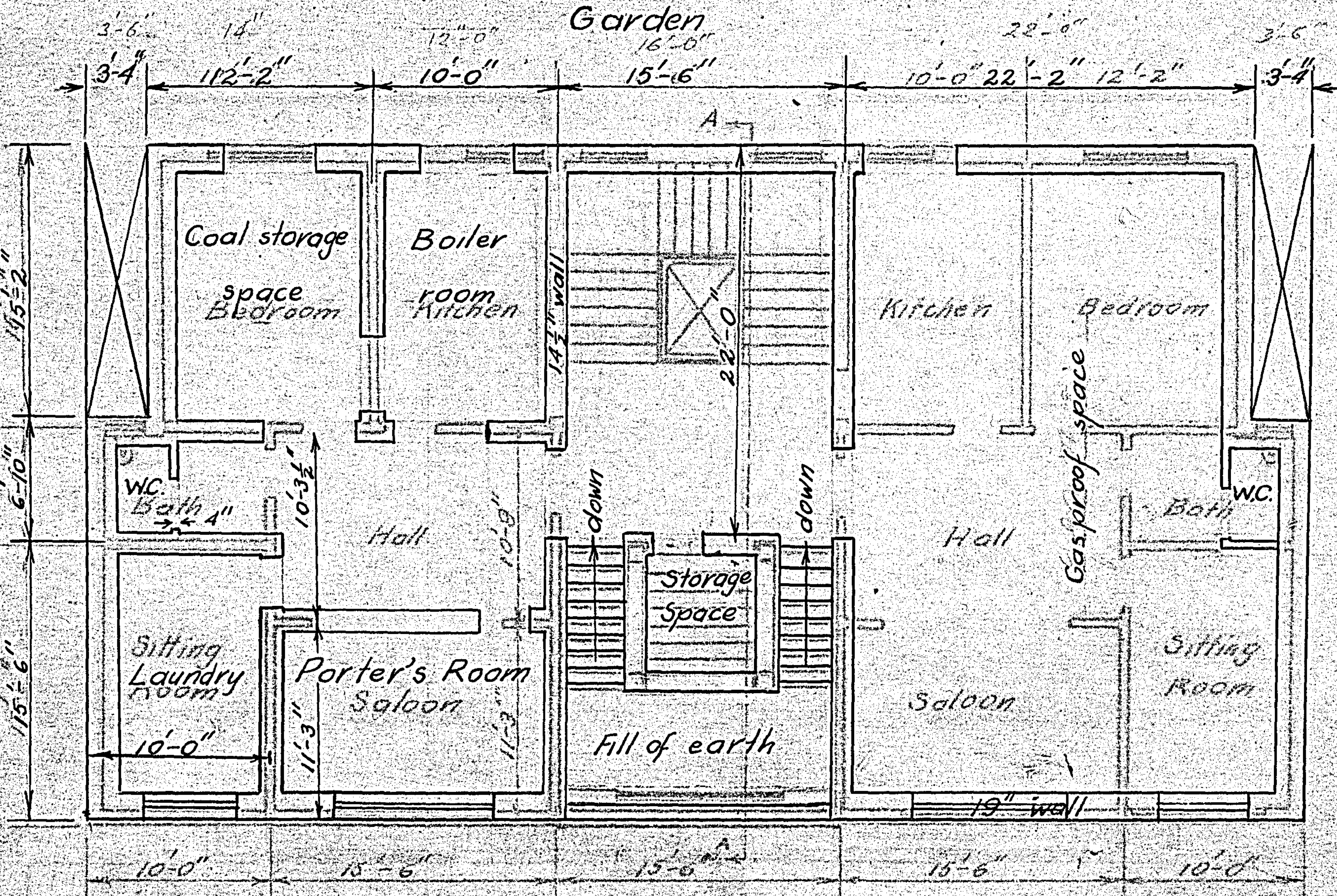
Scale: 1' = 1/8"

Sarayhoglu Yani '39



BASEMENT FLOOR
PLAN OF PROPERTY

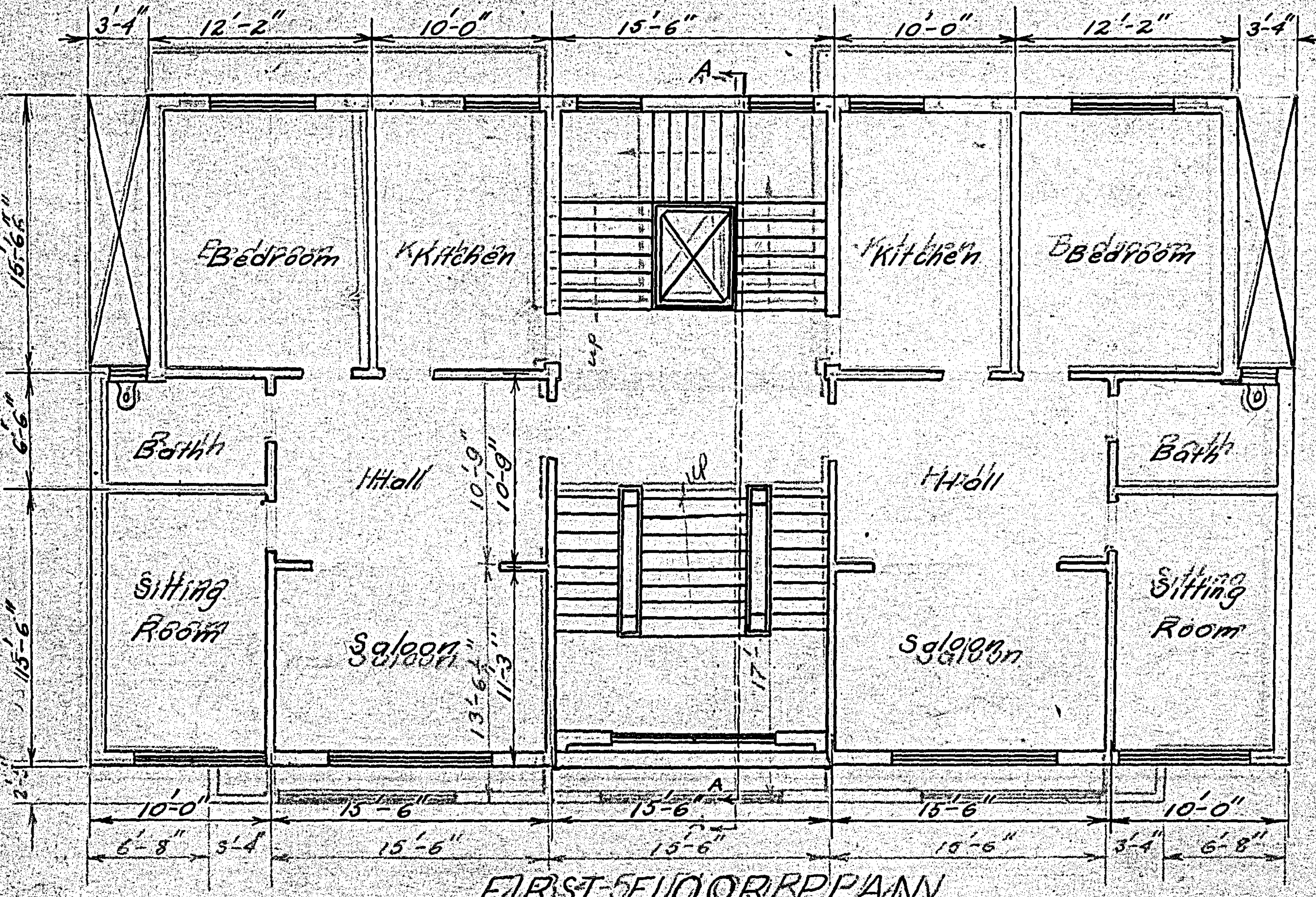
Scale: 1/8" = 1'



FIIBASEMENT FLOOR

Scale: 1' = 1/8"

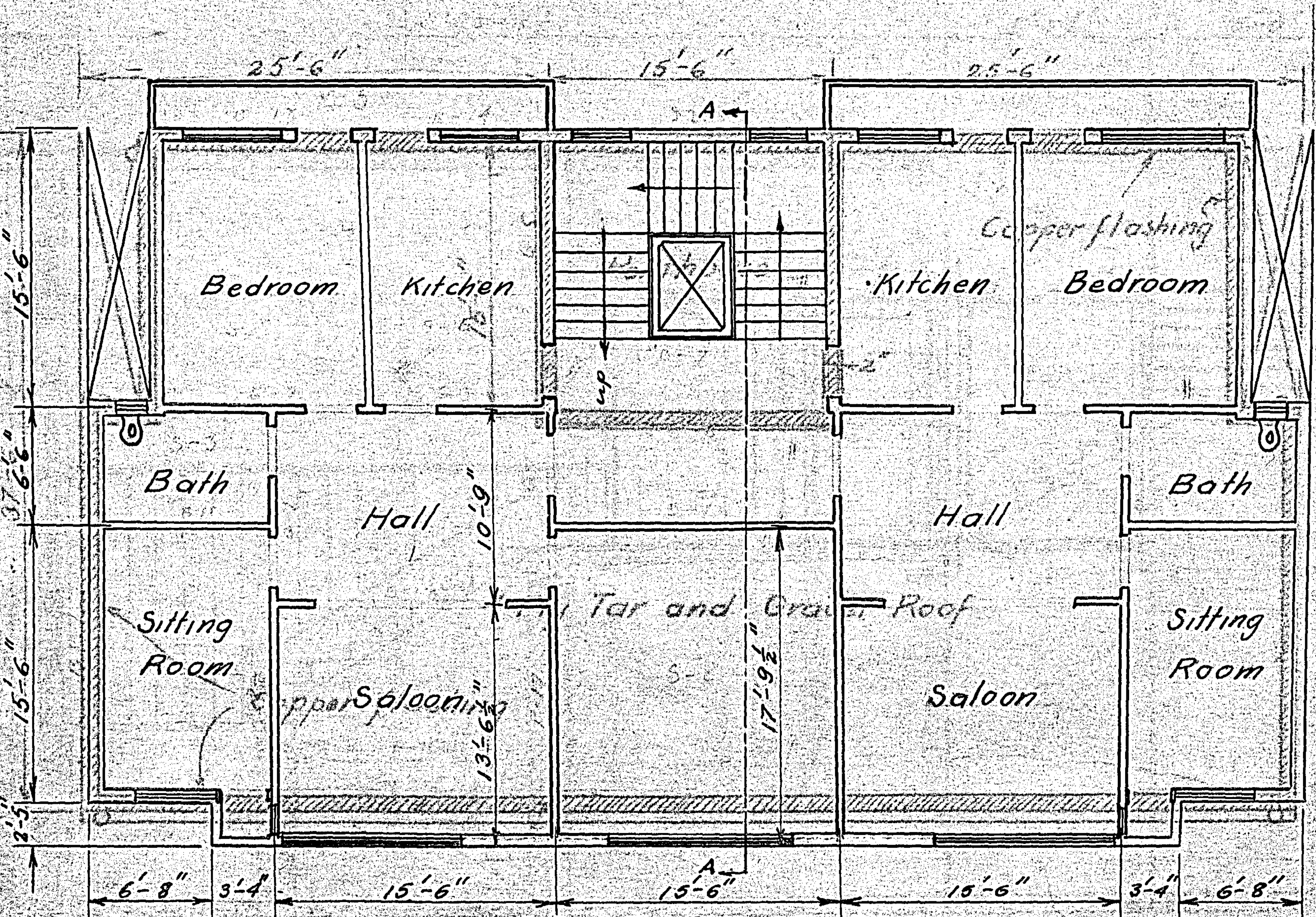
Drawn by



FIRST FLOOR PLAN

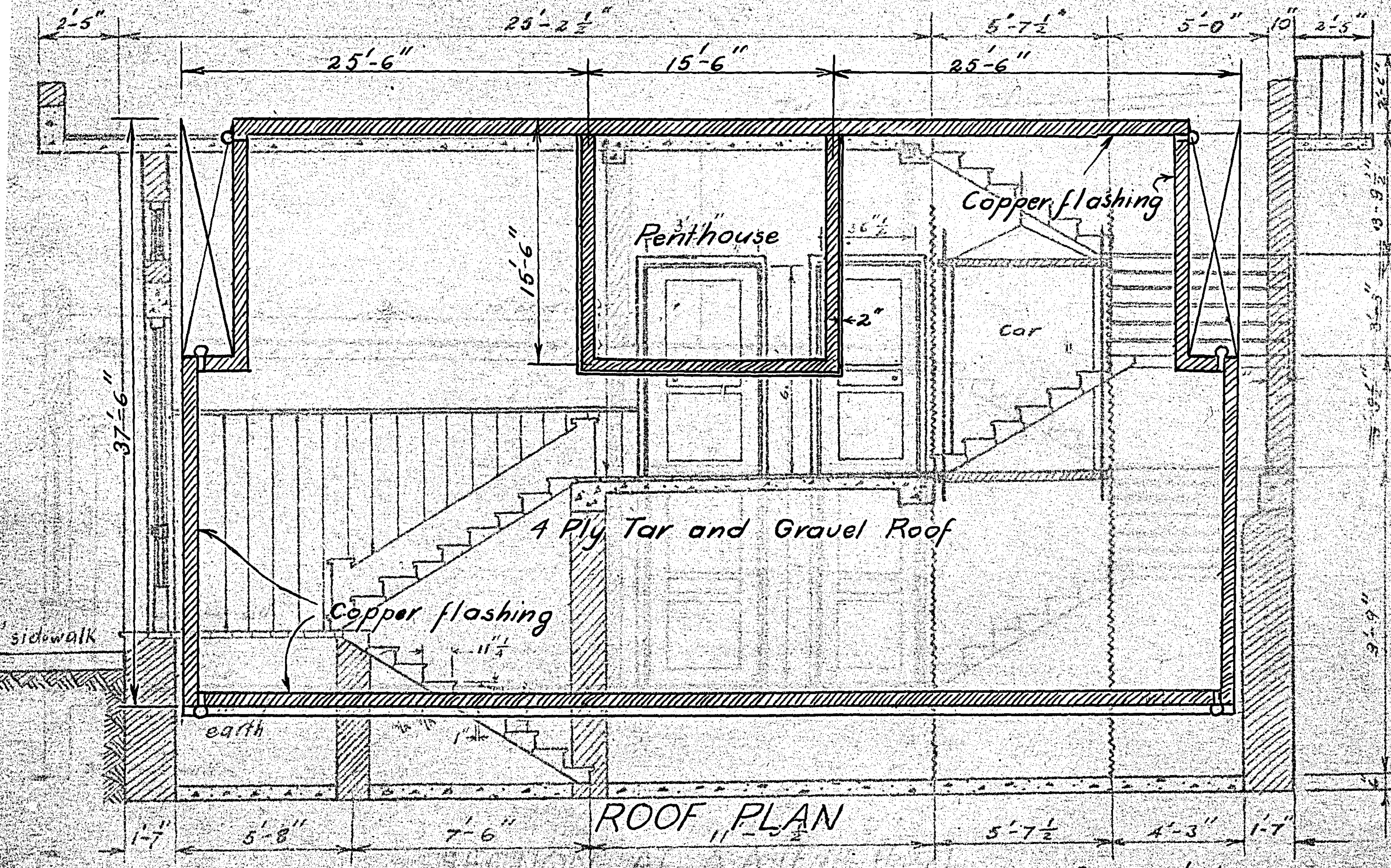
Scale: 1' = 1/8"

Drawn by: Saraylıoğlu Yarı



2-3-4-5 FLOOR PLAN

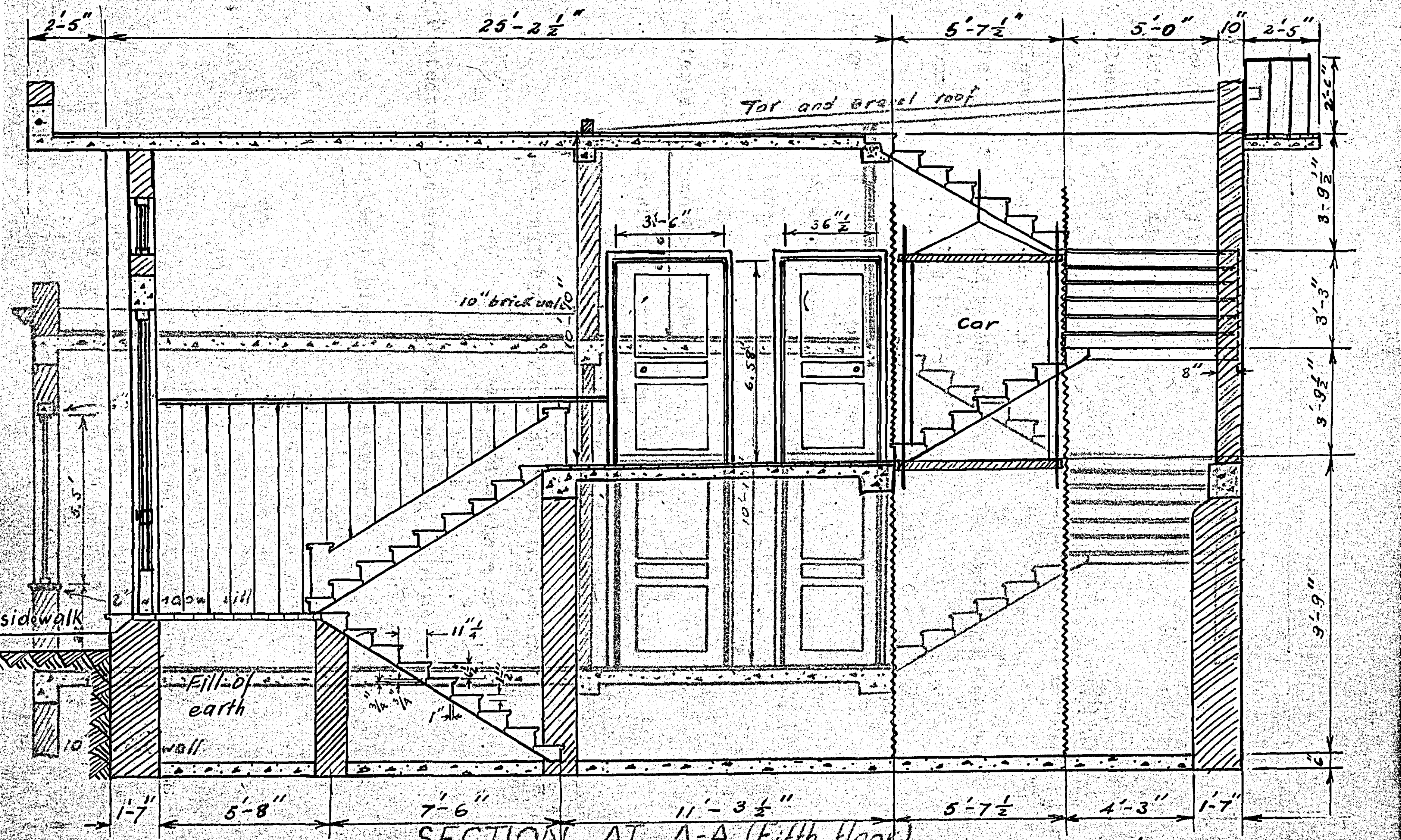
Scale: 1' = 1/8"



ROOF PLAN

Scale: 1' = 1/4

Drawn by: Saraylioglu Yani '2



SECTION AT A-A (Fifth floor)

SECTION AT A-A

Scale: 1'=1/4

Scale: Drawn by: Saraylioglu Yani '39

Structural Design Requirements

Length of building = 88ft-8"

Width of building = 37ft-6"

Clearance of basement floor = 9ft.-[illegible]

Clearance of 1st, 2nd, 3rd, 4th and [illegible] 10 ft.-4 in.

Elevation of ground is 50

The soil is composed of medium stiff clay and [illegible] a bearing copacity of 3 tons/ft²

Live Load: For floor = [illegible] p.s.f.

For footings [illegible] live Load is used.

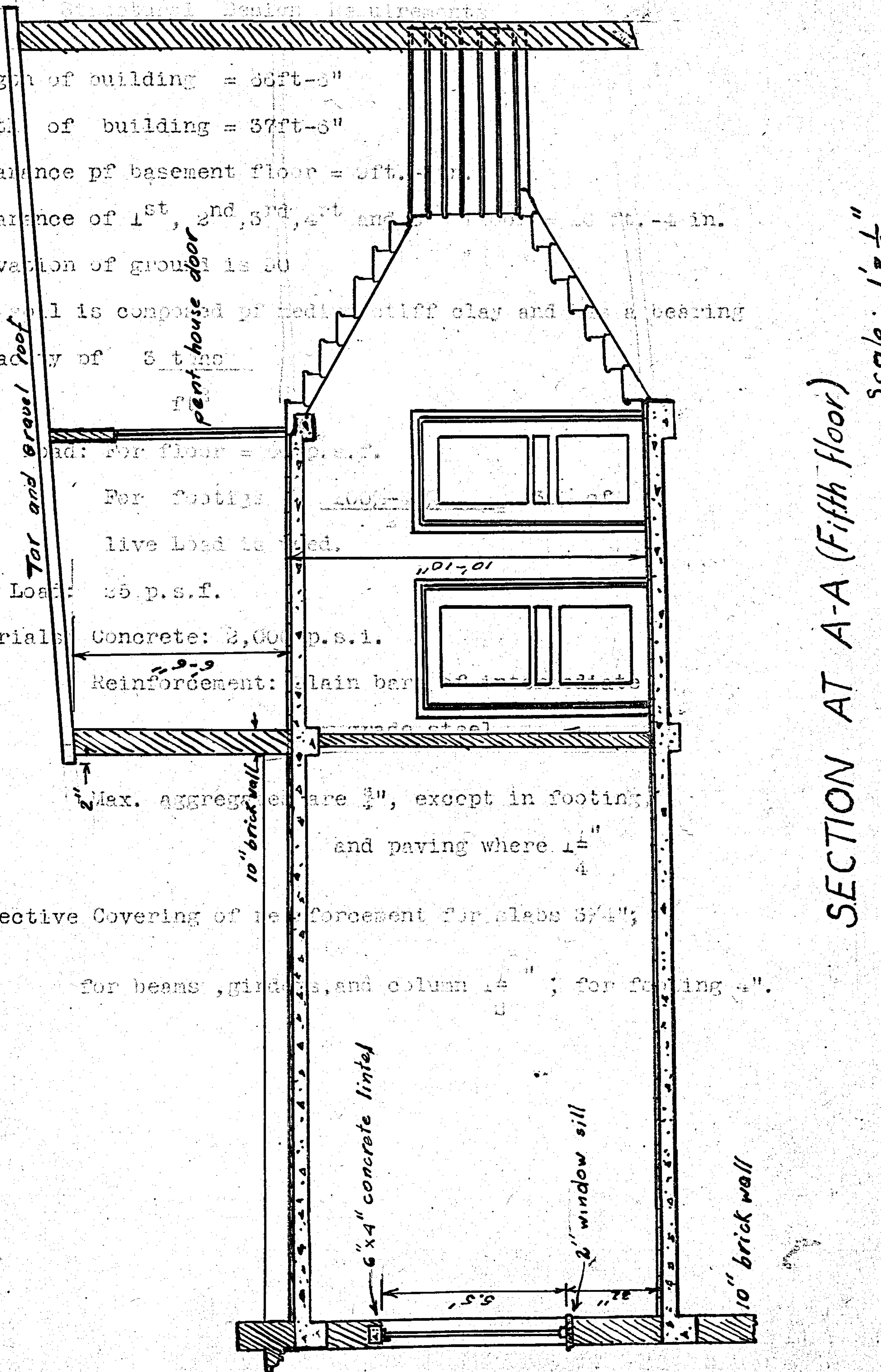
Snow Load: 25 p.s.f.

Materials: Concrete: 2,000 p.s.i.

Reinforcement: plain bars [illegible] grade steel

Max. aggregates are 3/4", except in footing and paving where 1 1/4"

Protective Covering of reinforcement for slabs 3/4"; for beams, girders, and column 1 1/2"; for footing 4".



Structural Design Requirements

Length of building = 66ft-6"

Width of building = 37ft-6"

Clearance pf basement floor = 9ft.-3in.

Clearance of 1^{st}, 2^{nd}, 3^{rd}, 4^{rt} and 5^{th} floor = 10 ft.-4 in.

Elevation of ground is 90

The soil is composed pf medium stiff clay and has a bearing copacity pf $3\ \frac{tons}{ft^2}$

Live Load: For floor = 40 p.s.f.

For footings $\frac{100\%-40\%}{2}$ = 30% of live Load is used.

Snow Load: 25 p.s.f.

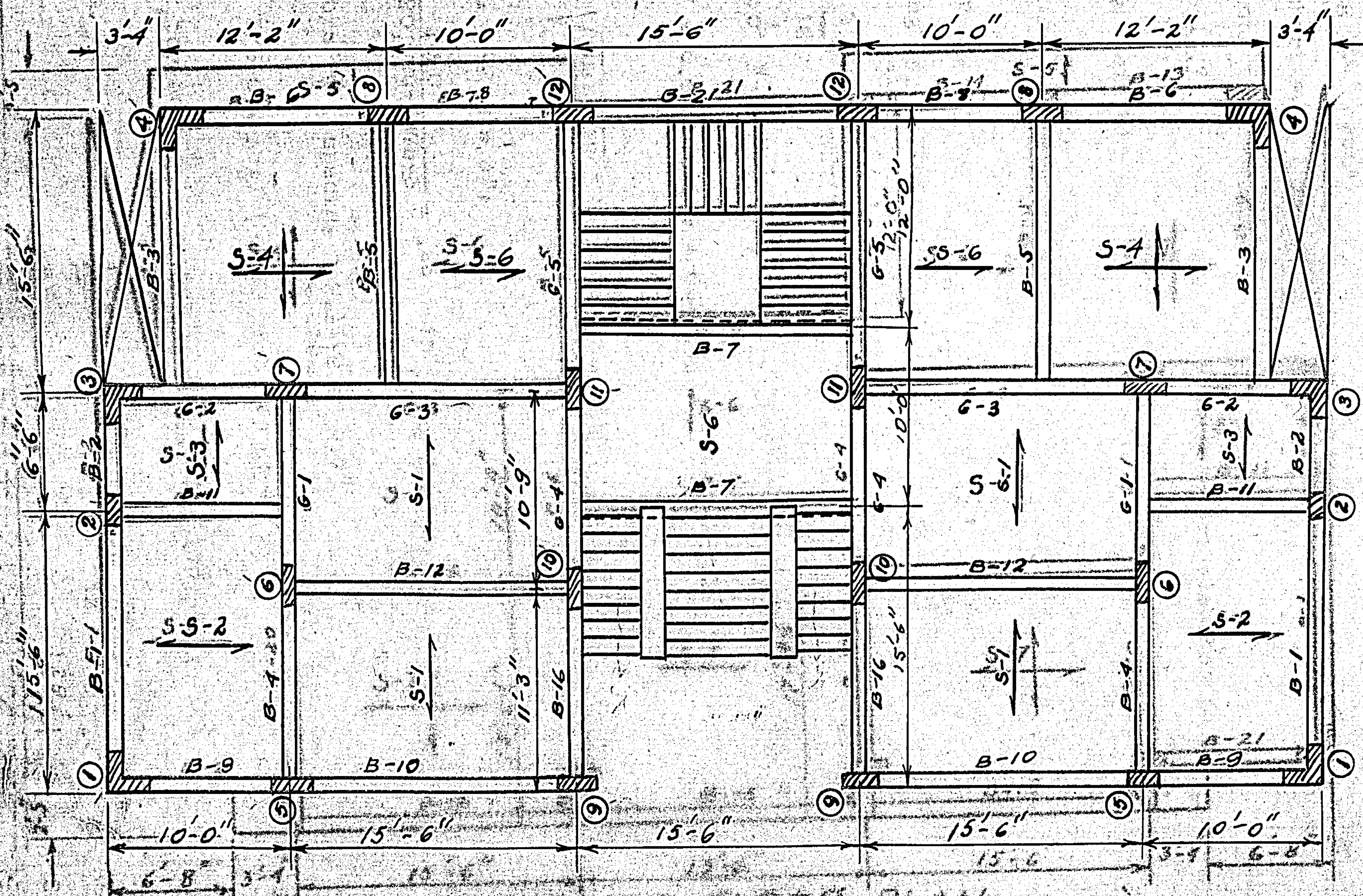
Materials: Concrete: 2,000 p.s.i.

Reinforcement: Olain bars of intermediate grade steel

Max. aggregates are $\frac{3}{4}$", except in footing, and paving where $1\frac{1}{4}$"

Protective Covering of reinforcement for slabs 3/4";

for beams ,girders,and column $1\frac{1}{2}$" ; for footing 4".



FIRST FLOOR FRAMING PLAN

Saraylioglu Yani

Scale: 1" = 1/8"

Saraylioglu Yani 139

Assuming 10" beams:

Clear short span : [illegible]

Clear long span [illegible]

Since $\frac{14.7}{[illegible]}$ = 1.49 about 1.5 therefore the slab has to be

one way reinforced.

L.L. = [illegible] p.s.i.

D.L.

Plaster =

Flooring =

w =1[illegible]

$-M = \frac{1}{12} w l^2$ [illegible]

$+M = \frac{1}{10} wl^2 = \frac{1}{10}$ [illegible] $(9.9)^2$ = 1020 ft.-lb is the max. M

Max. V = 0.5 [illegible] 104 [illegible] 9 = 609 lbs.

$d_m = \sqrt{\frac{1020 \times 12}{1[illegible]1 \times [illegible]}}$ = 2.75" [illegible] = 609 [illegible] 1.5"

Use t= 4" (d = 3")

$As = \frac{1020 \times 12}{20,000 \times .875 \times 3}$ = .23 in²/ft = 0.[illegible] in

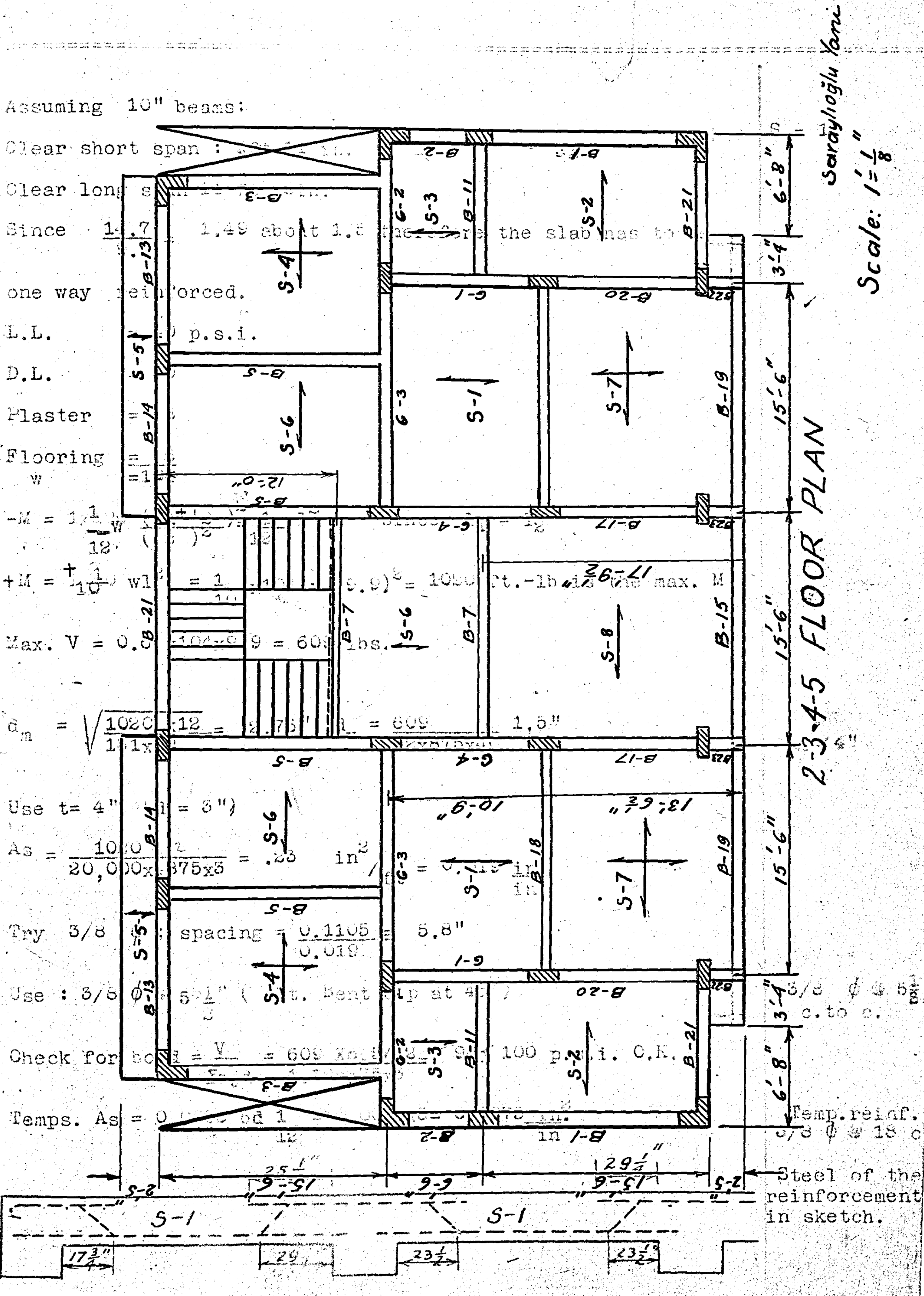
Try 3/8 ; spacing = $\frac{0.1105}{0.019}$ = 5.8"

Use : 3/8 φ @ 5½" ([illegible] Bent up at 4[illegible])

Check for bond = V/[illegible] = 609 [illegible] = [illegible] 100 p.s.i. O.K.

Temps. As = 0.[illegible] bd 1 [illegible] in

Steel of the reinforcement in sketch.



DESIGN OF SLABS

S. - 1

Assuming 10" beams:

Clear short span : 9ft-11 in.

Clear long span 14 ft -8in.

Since $\frac{14.7}{9.9} = 1.49$ about 1.5 therefore the slab has to be one way reinforced.

L.L. = 40 p.s.f.

D.L. = 50

Plaster = 8

Flooring = 6

w = 104

$-M = \frac{1}{12} w \frac{(l_1+l_2)^2}{(2)^2} = \frac{1}{12} wl^2$ since $l_1 = l_2$

$+M = \frac{1}{10} wl^2 = \frac{1}{10} x104 \times (9.9)^2 = 1020$ ft.-lb is the max. M

Max. V = 0.6 x104x9.9 = 609 lbs.

$d_m = \sqrt{\frac{1020 \times 12}{131 \times 12}} = 2.76"$ $d_v = \frac{609}{12 \times 875 \times 40} = 1,5"$

t= 4"

Use t= 4" (d = 3")

$As = \frac{1020 \times 12}{20,000 \times .875 \times 3} = .23$ $in^2/ft = 0.019 \frac{in^2}{in.}$

Try 3/8 ϕ ; spacing = $\frac{0.1105}{0.019} = 5.8"$

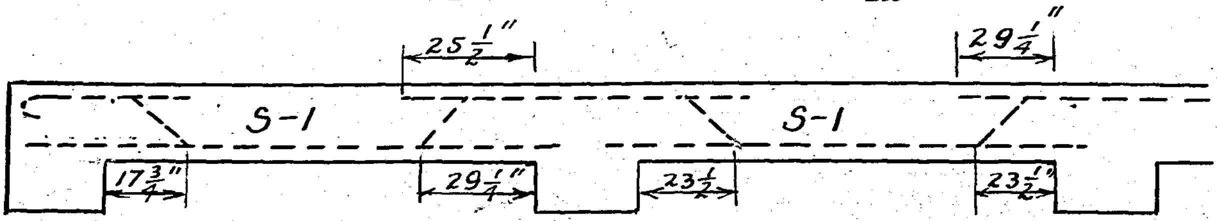
Use : 3/8 ϕ;@ $5\frac{1}{2}"$ (Alt. Bent up at 45^0)

3/8 ϕ @ $5\frac{1}{2}"$ c.to c.

Check for bond = $\frac{V}{\Sigma o jd} = \frac{609 \times 5.5/12}{1.18 \times 875 \times 3}$ 90 < 100 p.s.i. O.K.

Temps. As = 0.0025 bd $\frac{1}{12}$ = 0.0025x3= 0.0075 $\frac{in^2}{in}$

Temp.reinf. 3/8 ϕ @ 18 c.t



Steel of the m reinforcement a in sketch.

Assuming 10" beams

Clear span of S-2 =8ft-8"

L.L.	= 40 p.s.f.
D.L.	= 62
Plaster	= 8
Flooring	= 6
w	= 116 p.s.f.

$+M = 1/10 wl^2 = \frac{116}{10} x (8.7)^2 = 880$ ft-lbs.

$-M = 1/8 w \frac{(l_1+l_2)^2}{(2)^2} = \frac{1}{8} x116 \, x \frac{(8.7+14.6)^2}{(2)^2} = 1,960$ ft-lbs.

Max V= 0.6x116x8.7 =lbs

$d_m = \sqrt{\frac{M}{Rb}} = \sqrt{\frac{1960x12}{157 \, x12}} = 3.6$ in.

$d_v = \frac{V}{bjd} = \frac{600}{12x0.875 \, x40} = 1.5$ in.

Use t= 5 in. (d=4 in.)

$+As = \frac{M}{f_s jd} = \frac{880 \, x \, 12}{20,000 \, x \, 0.875 \, x \, 4} = 0.15 \frac{in^2}{ft} = 0.013 \frac{in^2}{in.}$

Use 3/8 in. Ø with spacing $\frac{0.11}{0.013} = 8.5$ use 8"

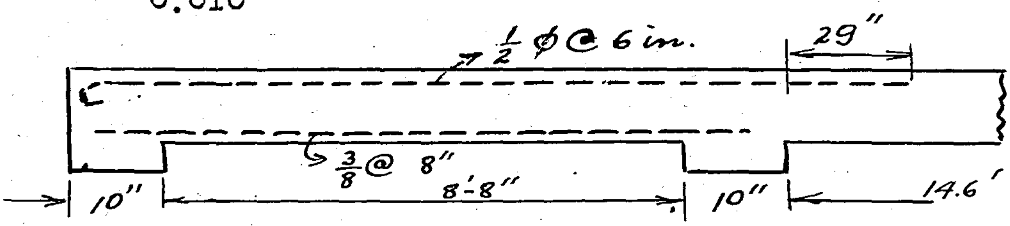
$- As = \frac{1960 \, x \, 12}{20,000 \, x \, 0.875x4} = 0.34 \frac{in^2}{ft} = 0.028 \frac{in^2}{in.}$

Use 1/2 in. Ø with spacing = $\frac{0.19}{0.028} = 6.5$ use 6 in.

Check for bond $u = \frac{V}{\Sigma o jd} = \frac{540 \, x6/12}{1.57x0.875x4} = 49 < 100$ p.s.i. O.K.

Temp. As = $0.0025 \, bdx1/2 = 0.0025x4 = 0.01 \frac{in^2}{in.}$

with $s = \frac{0.1105}{0.010}$ ∴ use s=11



S-2

t = 5 in.

As: 3/8 Ø at 8 in. c to c.
-As: ½ Ø at 6 in c.to.c.

Temp reinf. 3/8 Ø at 11" c.t.c. Steel of the main reinforcement as in the sketch.

Assume 10" beams

Clear span of S-3 = 5ft6"

L.L. = 40 p.s.i.

D.L. = 50

Plaster = 8

Flooring = 18

w = 116 p.s.i.

$$-M = 1/10 \times 116 \times \left(\frac{5.5+14.5}{2}\right)^2 = 1160 \text{ ft-lbs is the max M}$$

$$\max V = 0.6 \times 116 \times 5.5 = 384 \text{ lbs.}$$

$$d_m = \sqrt{\frac{M}{Rb}} = \sqrt{\frac{1160 \times 12}{157 \times 12}} = 2.7$$

$$d_v = \frac{384}{12 \times 0.875 \times 40} = 0.9$$

Use t= 4" slab (d= 3")

$$A_s = \frac{1160}{20{,}000 \times 0.866 \times 3} = 0.213 \frac{in^2}{ft} = 0.018 \frac{in^2}{in}$$

Try 3/8 , spacing = $\frac{0.1105}{0.018} = 6.1"$

Use: 3/8 ⌀ @ 6" (Alt. Bent)

$$u = \frac{V}{\Sigma o jd} = \frac{384 \times 6/12}{1.18 \times 0.875 \times 3} = 62 < 100 \text{ p.s.i. O.K.}$$

Temp. As = $0.0025 \times 3 = 0.0075 \frac{in^2}{in}$

S-3

t = 4"

3/8 ⌀ @ 6" c.c

Temp. reinf.:
3/8 ⌀ @ 18" c.c

Clear long span : 14ft-4"

Clear short span : 11ft-1"

Since $\frac{14.3}{11.1} < 1.5$ the slab has to betwo way reinforced

S-4

L.L. = 40 p.s.f.
D.L. = 50
Plaster = 8
flooring= 6
w = 104 p.s.f.

$$W_s = \left(\frac{14.3}{11.1} - 0;5\right)104 = 0.8 \times 104 = 84.2 \text{ p.s.f.}$$

$$W_l = 104.0 - 84.2 = 19.8 \text{ p.s.f.}$$

Short span
==========

Center Half.

$$-M = \frac{1}{8} \times 84.2 \times \left(\frac{11.1+9.2}{2}\right)^2 \; 1070 \text{ ft-lbs.}$$

$$+M = \frac{1}{10} 84.2 \times (11;1)^2 = 1040 \text{ ft-lbs.}$$

for f_c =0.40x2000 =800 p.s.i. and f_s = 20,000 p.s.i.

R = 131 and j= 0.875

for f_c = 0.45x2000=900 p.s.i. and f =20,000 p.s.i.

R= 157 and j= .866

$$d = \sqrt{\frac{1040 \times 12}{131 \times 12}} = 2.8 \text{ in.}$$

$$d = \sqrt{\frac{10700 \times 12}{157 \times 12}} = 2.7 \text{ in.}$$

t= 4" (d=3")

$$A_s = \frac{M}{f_s jd} = \frac{1070 \times 12}{20{,}000 \times .866 \times 3} = 0.25 \; \frac{\square''}{ft}$$

Use 1/2" ϕ spaced 8" c.to. c.

End Quarters

Here the M is reduced 50%

$M = 545$ ft -lbs

$R = \frac{M}{bd^2} = \frac{545x12}{12 \times 9} = 61$ $f_s = 20000$ p.s.i.

$f_c = 500$ p.s.i. p= 0.0034 and j=.91

$As = \frac{510 \times 12}{20,000x0.91x3} = 0.11$ sq in

Use 1/2" O , spaced 3xthicknessoof slab = 3x4=12"

becausethe actual spacing that was needed for A_s=0.11 was greater than the allowable 12"

Long Span
=========

Center Half
===========

max $M \frac{1}{10} x 19.2x \; 14.3^2 = 393$ ft

Assuming 1/4 Ø steel we have:

Five proofing 0.75

Short steel diameter = 0.50

To center of gravity of long steel =0.12

t -d= 1.37

∴ 4 - 1.37 = 2.63

$R = \frac{M}{bd^2} = \frac{393 \times 12}{12x\,(2.63)^2} = 57$ $f_s = 20,000$ p.s.i.

$f_c = 485$ j=.915

$As = \frac{393 \times 12}{20,000x.915x2.63} = 098$

Use Ø1/4 rounds, spaced 6" c.to.c.

End Quarters

The moment = $\frac{393}{2}$ = 196ft i.e. one half as much bending moment as the mid-sections, and the distance center to center of the 1/4" reinforcing bars may be increased to 7,8, and 9 inches.

S - 4
continued

t"4

Steel :
Short span:
===========
Center half
1/2" O @ 8"

End Quarters
1/2" Ø @ 12"

Steel:

Long span:
==========
Center half
1/4 rounds @

End Quarters
1/4 rounds @
7", 8",9".

Clear span 2ft-5"

S -5

L.L. = 40

D.L. = 50

Plaster = 8

Flooring = 18

w = 116 p.s.f.

$-M = 116 \times \frac{(2.5)^2}{2} = 363$ ft -lbs

v= 116 x2.5 = 290 lbs

$d_m = \sqrt{\frac{363 \times 12}{12 \times 157}} = 1.6 \angle 4"$

$d_v = \frac{290}{12 \times 0.9 \times 40} \angle 4"$

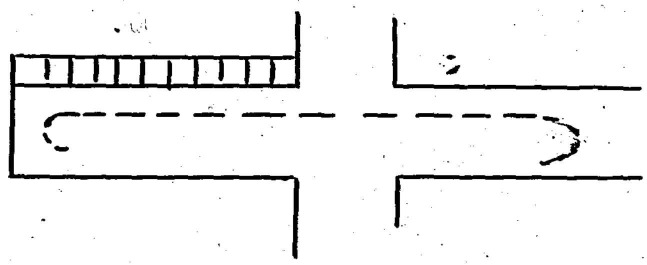
t=4

Therefore use t =4" with

$As = \frac{363 \times 12}{20,000 \times 0.9 \times 3} = .08 \text{ in}^2$ $u = \frac{290}{1.18 \times 0.9 \times 3} = 66 \angle 100$ O.K.

Use 3/8 in ϕ with s= 10 in.c.to c.

3/8" ϕ @ 10"



S -6

Assume 12" beams

Clear span of s-6=9ft-2 in.

L.L.= 40 p.s.i.
D.L.= 50
Plaster= 8
Flooring 18
116

$+M = \frac{1}{10} \times 116 \times 9.2^2 = 980$ ft- lbs

$-M = \frac{1}{10}\ 116\ \frac{(9.2\ 10.67)^2}{(2)^2} = 1200$ ft- lbs

Max V = 0.6x116x9.2= 640 lbs

$dm = \sqrt{\frac{M}{Rb}} = \sqrt{\frac{980x12}{131x12}} = 2.8$

$dm = \sqrt{\frac{1200x12}{157x12}} = 2.7$

$dv = \frac{V}{bjv} = \frac{640}{12x.875x40} = = 1.5$

Use t= 4" (d= 3")

t= 4"

$As = \frac{1200}{20,000x0.860x3} = .22 \frac{in^2}{ft} = 0.018 \frac{in^2}{in.}$

Try $\frac{3}{8}$ ø , spacing = $\frac{0.1105}{0.918}$ = 6.1"

Use: 3/8 9 @ 6" (Alt. Bent)

Check for bond $u = \frac{V}{\Sigma Ojd} = \frac{640x6/12}{1.18x.875x3} = 104 > 100$

Therefore. use special anchorage

Temp. A_s = 0.0025 bd 1/12 =0;0025x3 = 0.0075 $\frac{in^2}{in.}$

Temp. reinf.

with $s = \frac{0;1105}{0.0075}$. use s= 18"

=3/8 ø @ 18"

S- 7

Clear long span : 14.5ft

Clear short span :11.8ft

Since $\frac{14.5}{11.8} = 1.5$ the slab has to be two way

reinforced.

L.L. = 40
D.L. = 50
Plaster = 8
Flooring = 6
w= 104 p.s.i.

$w_s = \frac{(14.5 - 0.5)}{(11.8)} x\ 104 = 76$ p.s.f.

$w_1 = 104 - 76 = 28$ p.s.f.

<u>Short span</u>

<u>Center Half</u>

$-M = 1/8 x 76 \ x \left(\frac{11.8 \ 9.75}{(2)}\right)^2 = 1{,}100$

$tM = 1/10 \ x \ 76 x \ (11.8)^2 = 1{,}060$

for fc = 0.40x2000 =800 p.s.i. and f_s = 20,000 p.s.i.

R = 131 and j= 0.875

for fc = 0.45x20000=9000 p.s.i. and fs = 20,000 p.s.i.

R= 157 and j=0.866

$d = \sqrt{\frac{1100x12}{157x12}} = 2.6$

$d = \sqrt{\frac{1{,}060x12}{131x12}} = 2.9$

t=4" (d= 3") t=4"

$A_s = \frac{M}{fsj.d} = \frac{1100x12}{20{,}000x866x3} = 0.25$

Use 1/2" ø spaced 8" c.to c.

S - 7
continued

Steel:

Short span

Center Half
1/2"ϕ@ 8"c.to c

End quarters
1/2"ϕ@ 12"c.to c

End Quarters

Here the Mis reduced 50%

Therefore M = 550 ft.-lbs

$R = \frac{M}{bd^2} = \frac{550x12}{12x9} = 61$ fs = 20,000p.s.i.

fc = 499 p.s.i.   j=.91

$As = \frac{550x12}{20,000x0.91x3} = 0.12$ sq. in.

Use 1/2" ϕ spaced 3xt = 3x4=12 because the actual spacing that was needed for As=12 was greater than the allowable 12"

Long Span

Center Half

max M =1/10 x28x(14.5)^2=588 ft-lbs

Assuming 1/4 ϕ steel we have :

Fire proofing	= 0.75
Short steel diameter	= 0.50
To center of gravity of long steel	= 0.12
t -d	= 1.37

Therefore d= 4-1.37= 2.63

$R = \frac{M}{bd^2} = \frac{588x12}{12x(2.63)^2} = 85$ fs = 20,000 p.s.i.

fc = 610 p.s.i.   j =.897

$As = \frac{588x12}{20,000x.897x2.63} = 0.15$

Use 1/4 rounds , spaced 4" c.to c.

<u>End Quarters</u>

The moment = [illegible]x$\frac{588}{2}$ =294 ft-lb i.e one half as much bending moment as the mid section , and the distance center to center of the 1/4" reinforcing bars may be increased to 5,6 and 7 inches.

S - 7
continuedd

Steel:
======

Long span
=========
<u>Center half</u>
1/4ϕ@ 4" c. to c
End quorters
1/4 ϕ @ 5",6,7,in

S - 8

Clear long span : 19-0"

Clear short span: 14ft-7"

Since 19ft-0" is equal about 1.5x14.6, the slab may be one way reinforced

L.L. = 40 p.s.f.

D.L. = 62

Flooring 6

Plaster 8

116 p.s.i.

$\pm M = wl^2/12 = \frac{1}{12} 116 \times (14.6)^2 = 2,050$ ft-lbs

V= 0.5x116x14.6 = 850 lbs

$d_m = \sqrt{\frac{2050 \times 12}{131 \times 12}} = 3.96$ in

$d_v = \frac{850}{12 \times 0.875 \times 40} = 2.1$ in

Use t= 5 in (d=4)

t= 5 in.

$\pm As = \frac{M}{fsjd} = \frac{2050 \times 12}{10,000 \times 0.875 \times 4} = 0.34 \frac{in^2}{ft} = 0.028 \frac{in^2}{in.}$

Use 1/2 inØ with spacing = $\frac{0.19}{0.028}$ = 6.5 use 6 in

Steel:

1/2 Ø @ 6 in.

check for bond $u = \frac{850 \times \frac{6}{12}}{1.57 \times 0.875 \times 4} = 77 < 100$ p.s.i. O.k

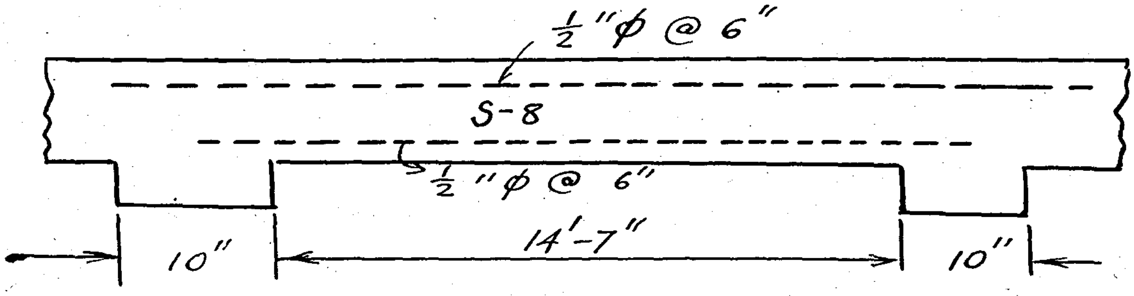
Temp. $As = 0.0025 bd \times \frac{1}{12} = 0.0025 \times 4 = .001 \frac{in^2}{in.}$

Temp As:

3/8"Ø@ 18" c.to

with s= $\frac{0.11}{0.01}$ Therefore s= 18"

1/2" Ø with s=6in.



DESIGN OF BEAMS

Design of beam B1

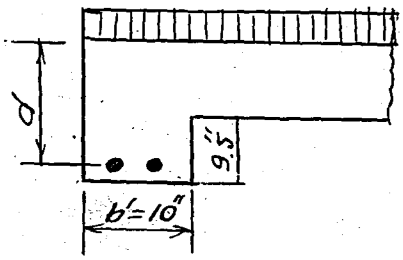
Assume columns 24"

Clear span of B1 = 12ft - 6 in.

L.L.+ Slab = 5.25x116 = 610

Assume stem = 10x9.5 = 99

9.5 ft 8" brick wall = 762



1461

$-M = \frac{1461}{80} \times \frac{(12.5\ 3.8)^2}{(2)^2} = 12300$ ft.-lbs

$+M = \frac{1461}{10} \times (12.5)^2 = 22900$ ft.-lbs

$-M$ (ext.end) $= \frac{1}{12} \times 1407 \times (12.5)^2 = 19000$ ft. lbs

Max. V = 0.6 x 1461x12.5 =11000 lbs

(ext.) V 0.4 x 1461 x12.5= 7,300 lbs

b=6xt = 24 b' = 10"

$d_{+m} = \sqrt{\frac{22900 \times 12}{131 \times 24}} = 9.3$

$d_{-m} = \sqrt{\frac{19000 \times 12}{157 \times 10}} = 12.0"$

$d_v = \frac{V}{bjd} = \frac{10600}{10 \times 0.9 \times 120} = 9.8"$

10" x 13.5"

Use 10"x14" (d=12")

$-A_s$ (1st Int sup.) $= \frac{12300 \times 12}{20,000 \times 0.9 \times 12} = 0.6$

$A_s = \frac{22900 \times 12}{20,000 \times 0.9 \times 12} = 1.2$

$- A_s$ (ext.end) $= \frac{19000 \times 12}{20,000 \times 0.9 \times 12} = 1.0$

max. $u = \frac{V}{\Sigma O jd} = \frac{11000}{7.85 \times 0.9 \times 12} = 130$ p.s.i.

Therefore use 4 - 5/8" ϕ with special anchorage

$v = \frac{V}{bjd} = \frac{11000}{10 \times 0.0 \times 12}$ 1100 p.s.i. > 40 weneed stirrups

Detailing of B1 .

Design of stirrups

Using 3/8 O U $S = 2A_s f_s = 2x.1105x20,000=4420$

Max $s= 0.6d = 0.6x12 = 7.2$ use 7"

Interior End: $s= \frac{S}{vb} = \frac{4420}{(100-40)x10} = 7.4$ " use 7"

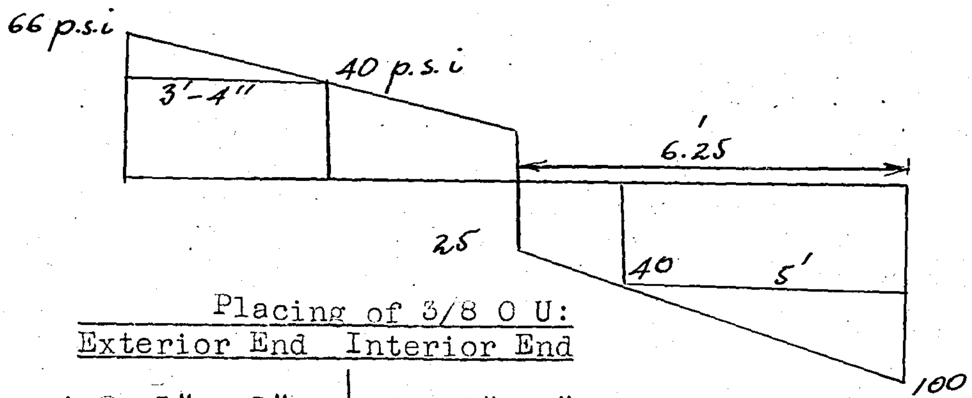
To find the point where we don't need stirrups:

$x=6.25x \frac{60}{100-25} = 5ft$

Exterior End: $s= \frac{4420}{(66-40)x10} =17.3$ use the max. 7.

To find the point where we don't need stirrups:

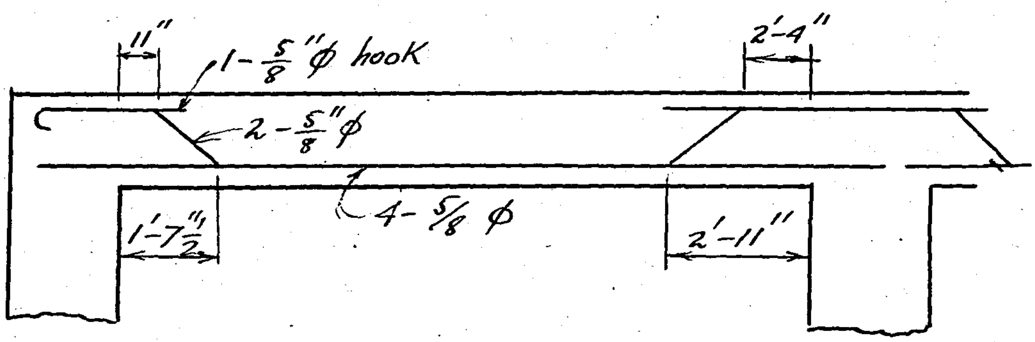
$x= 6.25x \frac{26}{66-16.5} =3.25$ = 3ft-4"



Placing of 3/8 O U:

Exterior End	Interior End
1 @ 3" = 3"	1 @ 3" =3"
5/6 @ 7" 35"	8/9 @ 7" = 56"
38"	59"

Location of the points at which steel may be bent:



Assume columns = 24"

Clear span of B2 =3.8ft | B 2

L.L. ≑ slab =5.25x116= 610

Assume stem = 7.5"x10" = 78

10ft of 8" brick wall = 800

w = 1488

$$-M = \frac{1}{8} \times 1488 \times \left(\frac{12.5\ 3.8}{2}\right)^2 = 12300 \text{ ft-lbs}$$

$$M = x\ 1488 \times (3\text{ft}\ .8)^2 = 2,130 \text{ ft-lbs}$$

Max V =0;6 x 1488 x3.8 = 2370 lbs

$$dm = \sqrt{\frac{12,300 \times 12}{157 \times 10}} = 9.7"$$

$$d_m = \sqrt{\frac{0.6 \times 1488 \times 3.8}{10x.9 \times 120}} = 3.12"$$

Use 10"x 12" (d=10") | 10"x12"

$$-A_s \text{ (1st. Inter. sup.) } = \frac{12300x12}{20,000x0.9x10.} = 0.82$$

$$As = \frac{2,130 \times 12}{20,000 \times 0.9 \times 10} = 0.142 \qquad 2 - \frac{3}{8}\ \phi = 0.22$$

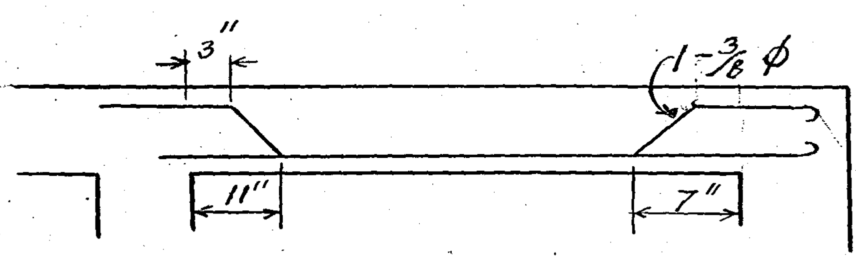
$$u = \frac{V}{\sum 0jd} = \frac{2370}{6.29x0.9x\ 10} = 41.8$$

$$u = \frac{0.4 \times 1488 \times 3.8}{2.36 \times 0.9 \times 10.} = 106 < 150 \text{ p.s.i.}$$

Use $2-\frac{3}{8}"\ \phi$ with special anchorage

Steel : $2-\frac{3}{8}"\ \phi$ with special anchorage

$$v = \frac{V}{bjd} = \frac{2370}{10.0.9 \times 10} = 26.3 < 40 \text{ p.s.i.}$$ ∴we don't need stirrups



Assume column = 24"

Clear span of B 3= 12.5ft

L.L. Slab = 3x104 = 312

Assume stem = 10x7 = 73

9.5.ft of 8" brick wall = 762

w 1047

$-M = \frac{1}{16} \times 1047 \times (12.5)^2 = 10{,}200$ ft- lbs

$+M = \frac{1}{8} \times 1047 \times (12.5)^2 = 20{,}400$ ft-lbs

$V = 0.5 \times 1047 \times 12.5 = 6{,}550$ lbs

$d\ m = \sqrt{\frac{20400 \times 12}{24 \times 131}} = 8.8$ in.

d

$d-m = \sqrt{\frac{10200 \times 12}{10 \times 157}} = 8.8$ in.

$d_v = \frac{6{,}550}{10 \times .9 \times 120} = 6.1$ in.

Use 10"x11" (d= 9")

$-A_s = \frac{102000 \times 12}{20{,}000 \times 0.9 \times 9} = 0.75$ sq in.

$+A_s = \frac{20400 \times 12}{20{,}000 \times 0.9 \times 9} = 1.51$ sq. in.

$\max u = \frac{6650}{5.5 \times 0.9 \times 9} = 147$

Therefore use 4-$\frac{7}{8}$" ϕ with special anchorage

$v = \frac{V}{bjd} = \frac{6550}{10 \times 0.9 \times 9} = 81$ p.s.i. > 40 ∴ we need stirrups

B 3

Steel:

4-$\frac{7}{8}$" ϕ with special anchorage

Detailing of B-3

Design of stirrups

Using 3/8 ∅ U S= $2Asf_s$=2x0.1105x20,000= 4420

Max. s = 0.6xd = 0.6x9= 5.4 use 5"

End s = $\frac{4420}{(81-40)10}$ =10.6 therefore use the max 5=s"

To find the point where we don't need stirrups:

$$x=6.25 \times \frac{41}{81-20.25} = 4.22$$ use 4ft-3"

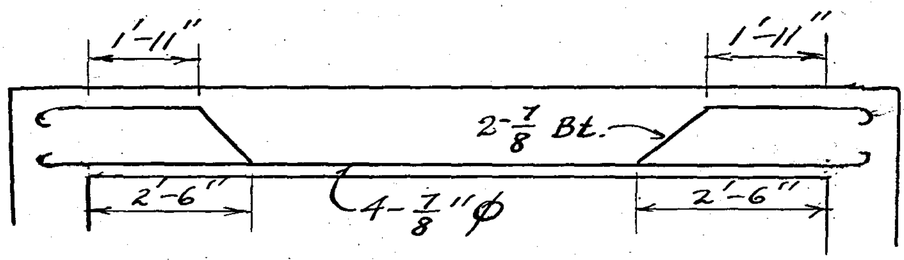
Placing of 3/8 ∅ U

1 @ 2" = 2"

10 @ 5" = 50

11   52"

Location of points where the steel may be bent:



Assume columns = 10"x24"

Clear span of B4 = 9ft-5"

L.L. Slab = 10.2x104=1060

Assume stem = 10"x11" =115

8ft of 8" brick wall = 640
w =1815

$-M = 1/8 \times 1815 \times \left(\frac{9.42 + 10.1}{2}\right)^2 = 21,500$ ft-lbs.

$+M = 1/10 \times 1815 \times (9.42)^2 = 16,100$ ft-lbs

$-M$ ext. end $= 1/24 \times 1815 \times (9.42)^2 = 5,960$ ft-lbs

Max V = 0.6x1815x9.42 = 10,200 lbs

V = 0.4x 1815x9.42= 6,830 lbs

Assume b= 10"

$$d_{-m} = \sqrt{\frac{21500 \times 12}{157 \times 10}} = 12.8"$$

$$d_v = \frac{10200}{10 \times 0.9 \times 120} = 11.0"$$

Use 10 x 15 (d=13")

$$-A_s \text{ (1st inter. sup)} = \frac{21,500}{20,000 \times 0.9 \times 13} = 1.10$$

$$+A_s = \frac{16,100 \times 12}{20,000 \times 0.9 \times 13} = 0.83$$

$$-A_s \text{ (ext. end)} = \frac{5,960 \times 12}{20,000 \times 0.9 \times 13} = 0.31$$

$$\max u = \frac{V}{\Sigma o\, jd} = \frac{0.4 \times 1815 \times 9.42}{5.5 \times 0.9 \times 13} = 106 \not< 150 \text{ p.s.i.}$$

Therefore, use 2-$\frac{7}{8}$" ø , with special anchorage

$$v = \frac{10,200}{10 \times 0.9 \times 13} = 87 \text{ p.s.i.}$$ ∴ we need stirrups

$$v = \frac{6,830}{10 \times 0.9 \times 13} = 58 \text{ p.s.i.}$$

B-4

B - 16, B - 17 and B - 20

10"x15"

Steel: 2-$\frac{7}{8}$" ø with special anchorage

Detailing of B4

Desing of stirrups
=================

Using 3/8 O U S= 2x0.1105x20,000==4420

Max s=0.6d= 0.6x13=7.8 use 7"

Interior end : $s=\frac{S}{vb}=\frac{4420}{(87-22)}$ =9.4 use 7"

To find the point where we don't need stirrups:

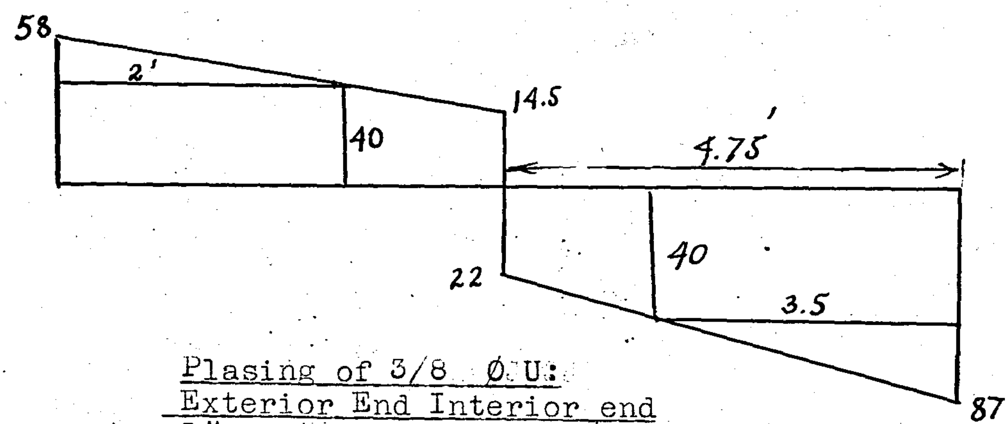
$$x=\frac{4.75x(87-40)}{(87-22)} = 3.4 \text{ ft.}$$

Exterior end :

$$s=\frac{4420}{(58-40)x10} = 24 \text{ use} 7"$$

To find the point where we don't need stirrups:

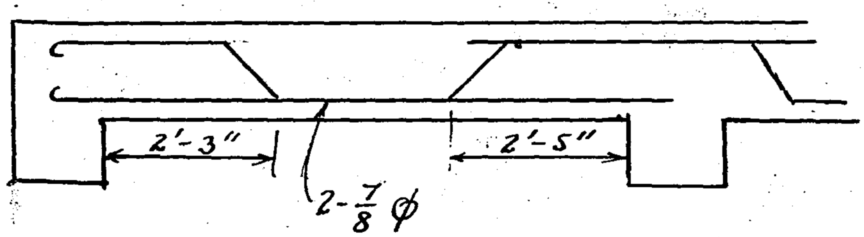
$$x= 4.75 \; x \frac{(58-40)}{58-14.5} = 2 \text{ ft}$$



Plasing of 3/8 Ø U:

Exterior End	Interior end
1 @ 3" = 3"	1 @ 3" = 3"
$\frac{3}{4}$ @ 7" $\frac{=21}{24"}$	$\frac{5}{6}$ @ 7" $\frac{=35}{38"}$

Location of the points where we have to bent the steel:



Assume columns 24"x10"

Clear span of FB 5 = 14.5ft

L.L. + Slab =104x6 116 x5 =1204

Assume stem = 10x12 =1.25

9ft. pf 8" brick wall = 762

2091

$-M = \frac{2091}{16} x(14.5)^2 = 27,500$ ft-lbs

$+M = \frac{2101}{8} x(14.5)^2 = 55,000$ ft-lbs

$V = 0.5x\ 2091x14.5 = 15,200$ lbs

$d_{-m} = \sqrt{\frac{27,500x12}{157\ x\ 10}} = 14.5$ in.

$d_{+m} = \sqrt{\frac{55,000x12}{131x(4x8)}} = 12.5$ in.

$d_v = \frac{15200}{10x0.9x120} = 14.1$ in.

Use 10"x16" (d= 14.5")

$-As = \frac{27,500x12}{20,000x0.9x14.5} = 1.27$ in.^{2}

$As = \frac{55,000\ x12}{20,000\ x0.9x14.5} = 2.54$ in.^{2}

$\max u = \frac{15200}{8x0.9x14.5} = \angle\angle\ 150$ O.K.

Therefore use 4 - 1" □ with special anchrage

$v = \frac{15200}{10x0.9x14.5} = 116 > 40$ ∴ we need stirrups

B 5

10" x 16"

Steel:

4-1" □ with

special anchor

Detailing of B5

Design of stirrups:

Max. $s=0.6d=0.6x14.5=8.7$ use 8"

End $s=\frac{4420}{(116-40)x10}=5.8$ use 5"

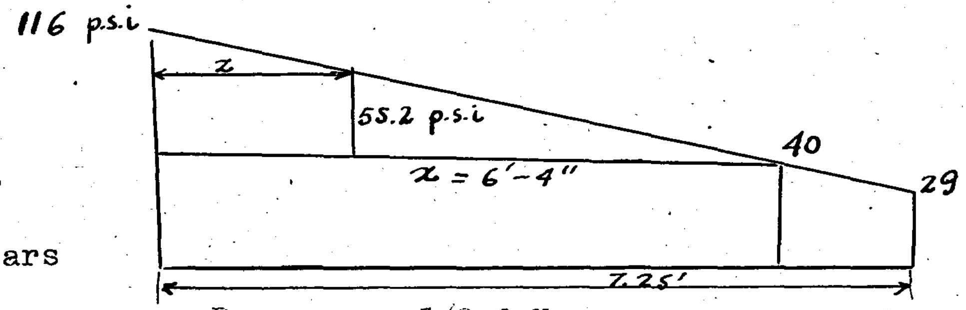
To find the point where we don't need stirrups:

$x=7.25\frac{76}{116-29}=6.33$ use 6ft -4" TO find the point where the max s=8 may be used ,at first we find the v corresponding to s=8:

$v=\frac{4420}{8x10}=55.2$ p.s.i.

then $z=6.33x\frac{(76-55.2)}{76}1.7=1-8\frac{1}{2}$

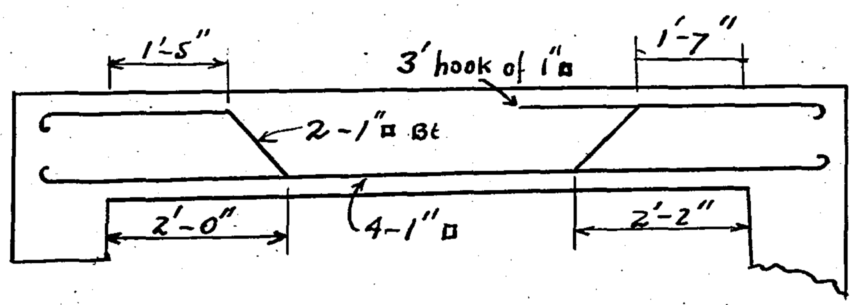
Curve of Max. Shears



Placing of 3/8 O U

1 @ 2" = 2"
2 @ 5" = 10"
8 @ 8" = 64"
11 76"

Location of points where the steel may be bent:



B - 7

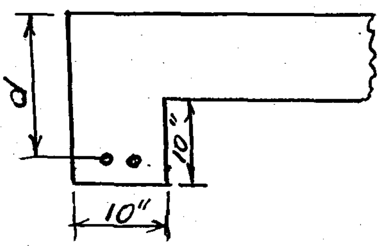
Clear span = 14.7

L.L. + Slab = 116 × 5.4 = 625

Assume stem=10x10 = 104

9.5ft of 8" brick wall = 762

w = 1491



$$-M = \frac{1491 \times (14.7)^2}{24} = 13{,}300 \text{ ft-lbs}$$

$$+M = \frac{1491}{8} \times (14.7)^2 = 40{,}000 \text{ ft-lbs}$$

V = 0.5x1491x14.7 = 11,000 lbd

$$d_{-m} = \sqrt{\frac{13300 \times 12}{157 \times 10}} = 10.1 \text{ in.}$$

$$d_m = \sqrt{\frac{40{,}000 \times 12}{131 \times 4 \times 6}} = 12.3 \text{ in.}$$

$$d_v = \frac{11{,}000}{10 \times 0.9 \times 120} = 10.2 \text{ in.}$$

Use 10"x14" (d = 12.5")

10" x 14"

$$-A_s = \frac{13{,}300 \times 12}{20{,}000 \times 0.9 \times 12.5} = 0.71$$

$$A_s = \frac{40{,}000 \times 12}{20{,}000 \times 0.9 \times 12.5} = 2.1$$

$$\max u = \frac{11{,}000}{6.3 \times 0.9 \times 12.5} = \text{about } 150 \text{ O.K.}$$

Steel:

4-1" ∅ with special anchorage

Therefore use 4-1" ∅ bars with special anchorage

$$v = \frac{11000}{10 \times 0.9 \times 12.5} = 98 > 40 \text{ p.s.i.}$$

Therefore we need stirrups.

Detailing of B-7

Desing of stirrups:

Using 3/8 ∅ U S= $zAsf_s$ = 2x9.1105=4420

Max s= 0.6d = 0.6x12.5 =8.1 use 8"

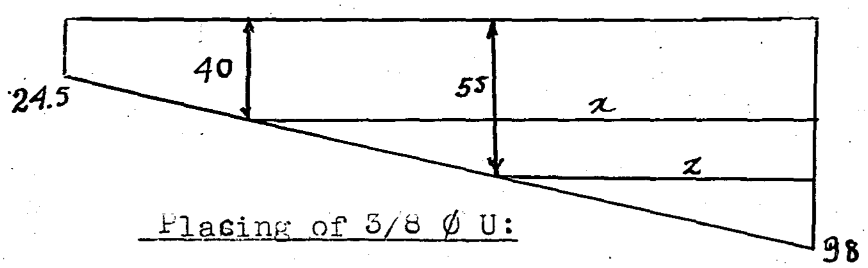
End s= $\frac{4420}{(98-40)x10}$=7.5 use 7"

To find the point where weedon'tneed stirrups

$$x= \frac{7.35x(98-40)}{(98-24.5)x10}= 5 \text{ ft}$$

To find the point where the max s may be used ,at first we find the v corresponding to s=8

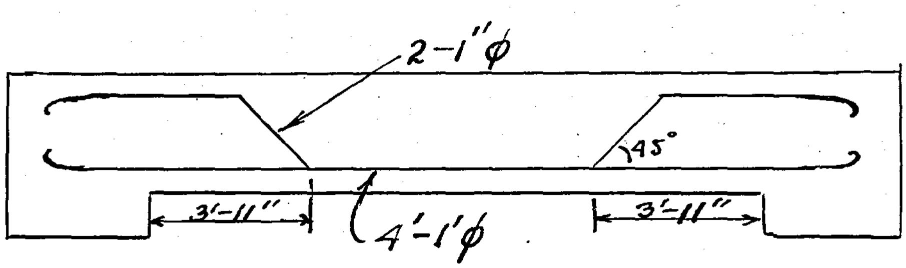
v= $\frac{4420}{8x10}$ 55   then x = $\frac{43x7.35}{73.5}$ = 4.3 ft



Placing of 3/8 ∅ U:

1	@ 3"	= 3"
7	@ 7"	=49"
1	@ 8"	= 8"
9		60

Location of points where the steel may be bent



Assume columns 24"

Clear span = 8ft-0in.

4ft of 8" Brick wall=320

5.5 of window = 55

Ass. 8x8 beam = 67 lbs per foot

w = 442

$-M = \frac{442 \times (8\ 9.2)^2}{10\ (2)^2} = 3{,}300$ ft-lbs

$+M = \frac{442 \times 8^2}{12} = 2{,}260$ ft-lbs

$V = 0.5 \times 442 \times 8 = 1770$ lbs

$d_m = \sqrt{\frac{3300 \times 12}{8 \times 157}} = 5.7$ in.

$d_v = \frac{1770}{8 \times 0.9 \times 120} = 2.1$ in.

Use 8" x 8" (d"=$6\frac{1}{2}$")

$-A_s = \frac{3300}{20{,}000 \times 0.875 \times 6.5} = 0.3.$

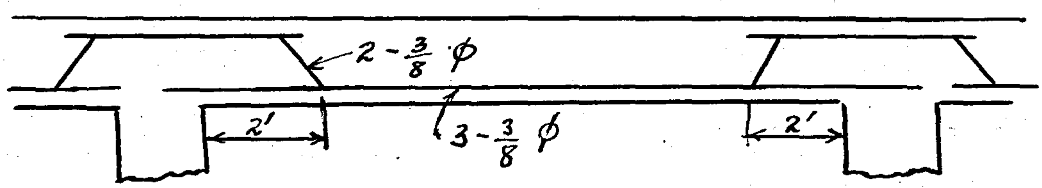
$A_s = \frac{2260}{20{,}000 \times 0.875 \times 6.5} = .2$

$\text{Max } u = \frac{1770}{2.36 \times 0.875 \times 6.5} = 132 \angle 150$ p.s.i.

Therefore use 3 # 3/8 ϕ with special anchorage

$v = \frac{1770}{8 \times 0.875 \times 6.5} = 39 \angle 40$ p.s.i.

Therefore we don't need stirrups



and B - 8

Columns 24"

Clear span of B-9=7ft-0" | B 9

B-21

4 ft of 8" brick wall = 320

5ft5 of window = 55

Ass. 8" x 9" beams = 75
w 450 lbs per foot

$-M\ (1^{st}\ \text{int.sup}) = \frac{450}{8}\left(\frac{7+13.5}{2}\right)^2 = 5{,}900$ ft-lbs

$+M = \frac{450}{10} \times \left(\frac{7+13.5}{2}\right)^2 = 2{,}210$ ft-lbs

$-M(\text{ext. end}) = \frac{450}{16} \times 7^2 = 1{,}380$ ft-lbs. V=0.4x450x7=1260

Max V = 0.6x450x7 = 1,890

$d_{-m} = \sqrt{\frac{5900 \times 12}{157 \times 8}} = 7.49$

$d_v = \frac{1890}{8 \times 0.875 \times 120} = 2.25$

7se 8" x 9" (d=7 $\frac{1}{2}$)

$-As\ (\text{1st. Int.sup.}) = \frac{5900 \times 12}{20{,}000 \times 0.875 \times 7.5} = 0.54$

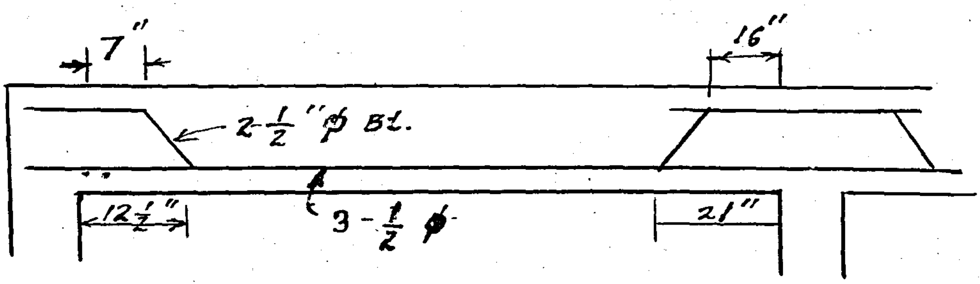
$As = \frac{2210 \times 12}{20{,}000 \times 0.875 \times 7.5} = 0.21$ 3-$\frac{1}{2}$" O As =0.59

$-As\ (\text{ext. end}) = \frac{1380 \times 12}{20{,}000 \times 0.875 \times 7.5} = 0.13$

$\max u = \frac{1260}{3.14 \times 0.875 \times 7.5} = 613 \angle 100$ O.K.

Therefore use 3 - $\frac{1}{2}$" ϕ

$v = \frac{V}{bjd} = \frac{1260}{8 \times 0.875 \times 7.5} = 24 \angle 40$ p.s.i., we don't need stirrups.



Clear span = 13 -6" B10

L.L.+ slab = 5.8x104 =603

Assume stem=10"x11 115

9.5 of 8" wall 762

1480

$-M = -\frac{1480}{8} \times \frac{(13.3)^2}{(2)^2} = 19400$ ft-lbs

$+M = \frac{1480}{10} \times (13.5)^2 = 26,900$ ft-lbs

$-M = \frac{1480}{12} \times (13.5)^2 = 22,400$ ft-lbs

Max V = 0.6 x 1480 x 13.5 = 12,000 lbs

V = 0.4 x 1480 x 13.5 = 8,000

bx t= 24" b = 10

$d_m = \sqrt{\frac{26,900 \times 12}{131 \times 24}} = 11.4"$

$d_m = \sqrt{\frac{22,400 \times 12}{157 \times 10}} = 13.1"$

$d_v = \frac{12,000}{10 \times 0.9 \times 120} = 11.1"$

Use 10"x15" (d= 13.5") 10" x 15"

-As (1 st Int. sup.) = $\frac{19400 \times 12}{20,000 \times 0.9 \times 13.5} = 9.96$

As = $= \frac{26900 \times 12}{20,000 \times 0.9 \times 13.5} = 1.33$

- As (ext. end) = $\frac{22400 \times 12}{20,000 \times 0.9 \times 13.5} = 1.11$

end u = $\frac{8,000}{7.06 \times 0.9 \times 13.5}$ = 93 . u= $\frac{12000}{7.85 \times 0.9 \times 13.5}$ = 126 p.s.i. ∠ 150

Therefore use 4 - $\frac{3}{4}$" ∅ with special anchorage

$v = \frac{12,000}{10 \times 0.9 \times 13.5} = 99$ p.s.i.

∴ we need stirrups in the whole beam

$v = \frac{8000}{10 \times 0.9 \times 13.5} = 66$ p.s.i.

Desing of stirrumps

Using 3/8 ϕ U $S = 2As f_s$ =2x.1105x20,000=4420

Max s = 0.6d = 0.6x13.5=8.1 use 8"

Interior End: $s = \frac{S}{vb} = \frac{4420}{(99-40)10}$ = 4=9.03

To find the point where we don't need stirrups:

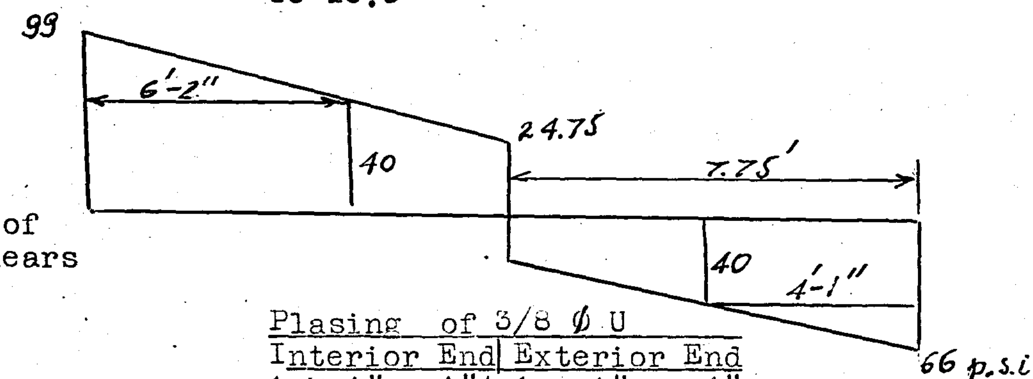
$x = 7.75 \times \frac{59}{99-24.75} = 6.16$ 6'-2"

Exterior End: $s = \frac{4420}{22x10} = 20$ use the max. s=8"

To find the point where we don't need stirrups:

$x = 7.75 \times \frac{26}{66-16.5} = 4.07$ 4ft-1"

Curve of max shears

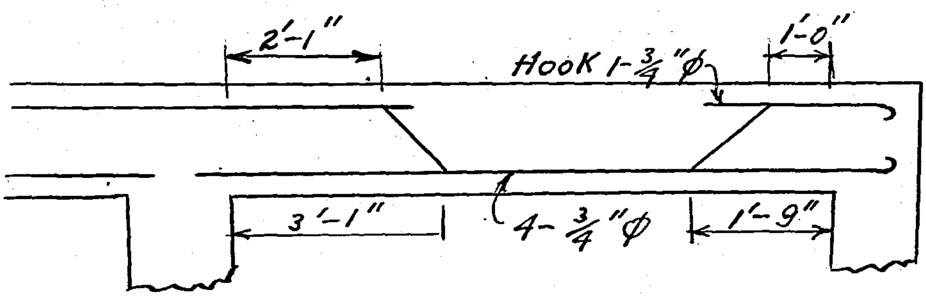


Plasing of 3/8 ϕ U

Interior End		Exterior End	
1 @ 4"	= 4"	1 @ 4" =	4"
9 @ 8"	=72"	6 @ 8" =	48"
10	76"	7	52"

Detailing of B 10

Location of points where the steel may be bent:



B-11

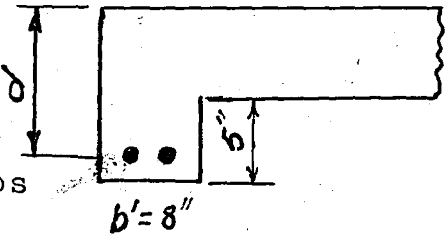
Clear span = 8ft-9"

L.L.+ Slab =116x3.25= 377

Assume stem =5"x8" = 42

9.5ft of 8" brick wall 762

w = 1181



$-M = \frac{1181}{16} x (8.75)^2 = 5,650$ ft-lbs

$+M = \frac{1181}{8} x (8.75)^2 = 11,300$ ft-lbs

V = 0.5x1181x8.75 =5,170 lbs

$d_{+m} = \sqrt{\frac{11300 x 12}{(4x6) x 131}} = 6.6"$

$d_{-m} = \sqrt{\frac{5,650 x 12}{8 x 187}} = 7.4"$

$V = \frac{5170}{8 x 0.9 x 120} = 6.0"$

Use 8" x 9" (d = 7.5)

8"x 9"

$-As = \frac{5650 x 12}{20,000 x 0.9 x 7.5} = 0.5$

$As = \frac{11300 x 12}{20,000 x 0.9 x 7.5} = 1.0$

$u = \frac{5170}{55 x 5.5 x 0.9 x 7.5} = 150$ p.s.i. O.K.

Therefore use 3 - $\frac{7}{8}"$ ø with special anch.

$v = \frac{V}{bjd} = \frac{5170}{8 x 0.9 x 7.5} = 96$ p.s.i. > 40

Therefore we need stirrups

Steel:
3 - $\frac{7}{8}"$ ø
with spec.an

Detailing of B # 11

Design of stirrups:

Using 3/8 Ø U S= 2x0.01105x20,000=4420

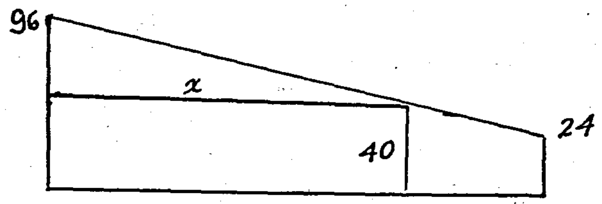
Max s= 0.6x7.5 =4.5= 4.5 use 4"

$$\text{End } s= \frac{4420}{(96-24) \times 8} = 10 \quad \text{use } 4"$$

To find the point where we don't need stirrups.

$$x= \frac{4.38 \times (96-40)}{(96-24)} = 3.4$$

Curve of max shears:



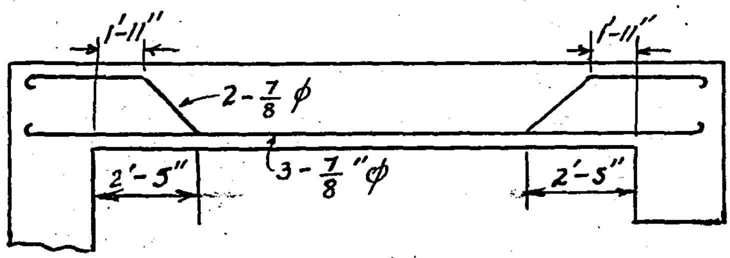
Placing of 3/8 Ø U

1 @ 2" = 2"

9 @ 4" =36"

10 38"

Location of points where the steel may be bent:



Assume columns 24"x10"

Clear span of B-12 = 14 ft -8"

L.L.+ Slab = 104x10.75 = 1120

Assume stem = 10x15 = 156

9ft of 8" brick wall = 762

2,038

B-12
B-15
B-18
B-19
B-21

$$\pm M = \frac{2038}{12} \times (14.7)^2 = 36,700 \text{ ft-lbs}$$

$$V = 0.5 \times 2038 \times 14.7 = 14,950 \text{ lbs}$$

$$d_m = \sqrt{\frac{36,700 \times 12}{10 \times 0.9 \times 120}} = 16.8 \text{ in.}$$

$$d_v = \frac{14950}{10x0.9x120} = 13.9 \text{ in.}$$

Use 10" x 19" (d=17.") 10"x19"

$$As = \frac{36,700 \times 12}{20,000x0.9x17} = 1.44 \text{ in}^2$$

$$u = \frac{14950}{6.28x0.9x17} = 155$$

Therefore use 4 - 1" Ø (alt. bent) with special anch.

$$v = \frac{14,950}{10x0.9x17} = 98 \text{ p.s.i.} > 40$$

Therefore we need stirrups

Design of stirrups

Using 3/8 ∅ U $S = Asf_s$ = 2x0.1105x20,000=4,420

Max. s = 0.6d = 0.6x17 =10.2 use 10 in.

End s= $\frac{S}{vfb}$ = $\frac{4420}{(98-40)x10}$ 7.46 use 7"

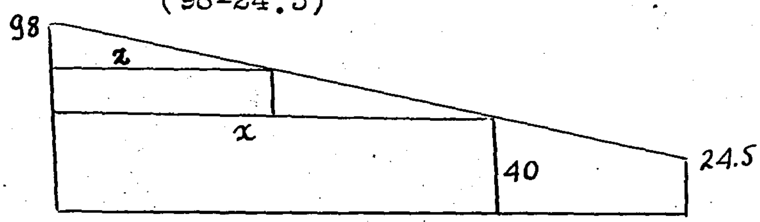
To find the point where we don't need stirrups:

$$x=7\frac{.4x58}{98-24.5}\ 5.85$$ use 5ft-11"

Now to find the point where the max s may be used, at first we find the v corresponding to s=10"

$$v= \frac{4420}{10x10} = 44.2\ p.s.i.$$

$$z= 7.4x\ \frac{(98-44)}{(98-24.5)} = 5.5$$



Placing of 3/8 ∅ U

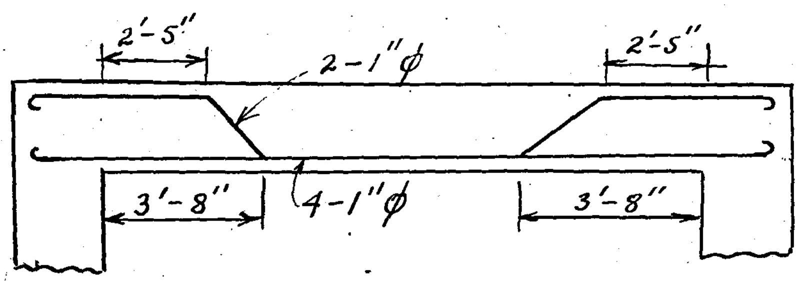
1 @ 3" = 3"

9 @ 7" =63"

1 @ 10 =10"

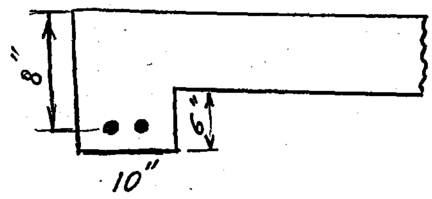
11 76

Detailing of B - 12



Assume columns 24"

Clear span = of B-13= 9ft-2"



B - 13

B - 6

L.L.+ Slab = 416.
4ft of 8" Brick wall=320
5.5 of window = 55
Assume 10 x 6 stem = 63
w = 854

$-M = \frac{854}{8} \times \frac{(9.2 \quad 8)^2}{(2)^2}$ 7,900 ft-lbs

$+M = \frac{874}{10} \times (9.2)^2 = 7,400$ ft-lbs

v= 0.4x9.2x854 = 3,800 lbs.

Max V = 0.6x9.2x854 = 5,700 in. lbs.

$d_{-m} = \sqrt{\frac{7900 \times 12}{10 \times 157}} = 7.8$ in.

$d_v = \frac{5700}{10 \times 0.9 \times 120} = 5.3$ in.

Use 10"x10" (d=8")

10"x10"

$-A_s = \frac{7,900 \times 12}{20,000 \times 0.9 \times 8} = 0.66$ sq.in.

$A_s = \frac{7,400 \times 12}{20,000 \times 0.9 \times 8} = 0.62$ sq in.

$\max u = \frac{3800}{4 \times 0.9 \times 8} = 132$

Therefore use 4-1/2" squares with special anchprage

Steel

4-1/2" squares

with special an

anchorage

$v = \frac{V}{bjd} = \frac{5700}{10 \times 0.9 \times 8} = 80$ p.s.i. > 40

$v = \frac{3800}{10 \times 0.9 \times 8} = 53$ p.s.i. > 40

Therefore we need stirrups in both sides.

Design of stirrups

Using 3/8 Ø U s= 2x0.1105x20,000=4420

Max s= 0.6x8 = 4.8 use 4

Interior end : $s = \frac{4420}{(80-40)x10} = 11''$ use 4"

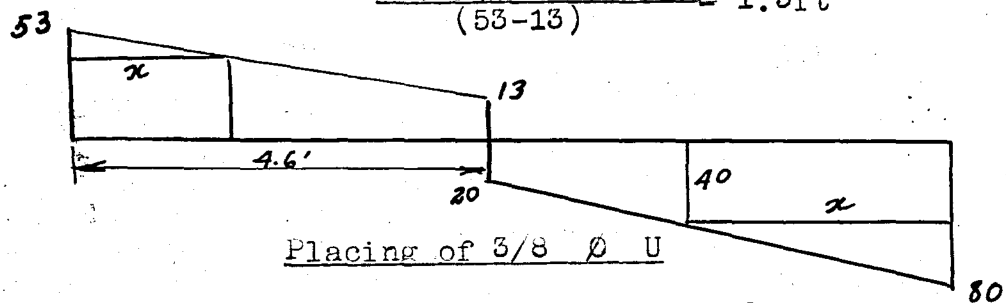
To find the point where we don't need stirrups:

$$x = \frac{4.6x(80-40)}{60} = 3ft\text{-}9''$$

Exterior end: $s = \frac{4420}{(53-40)x10} = 34''$ use 4"

To find the point where we don't need stirrups:

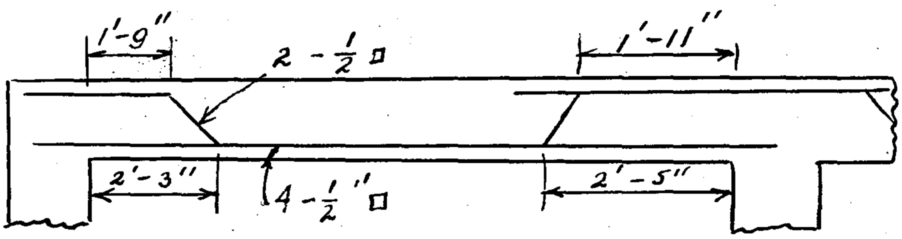
$$x = \frac{4.6x(53-40)}{(53-13)} = 1.5ft$$



Placing of 3/8 Ø U

Exterio end			Interior end		
1 @ 2	=	2"	1 @ 2	=	2"
4 @ 4	=	18	11 @ 4	=	44
55		18"	12		46"

Detailing of B-13



B-14

Clear span = 8ft-0 in.

4ft of 8" Brick wall	=320
5.5ft of window	= 55
From slab S-5	=290
Assume 9"x9"	= 85
	750

$-M = \frac{750}{10} x \frac{(8\ \ 9.2)^2}{(\ 2\ )^2} = 5600$ ft-lbs

$M = \frac{750}{12} x 8^2 = 4,000$ ft-lbs

V = 0.5x 750 x 8 = 3,000 lbs

$d_m = \sqrt{\frac{5600 \times 12}{9 \times 157}} = 6.9$ in.

$d_v = \frac{3000}{9 \times 0.9 \times 120} = 3.2$ in.

Use 9"x9" (d=7") 9"x9"

$-As = \frac{5600 \times 12}{20,000 \times 0.9 \times 7} = 0.53$ in^2

$As = \frac{4000 \times 12}{20,000 \times 0.9 \times 7} = 0.37$ in^2

use 2-5/8" Ø

$v = \frac{3000}{9 \times 0.9 \times 7}$ ~~=53~~ p.s.i. $\not>$ 40 use stirrups

Detailing

B-14

Design of stirrups

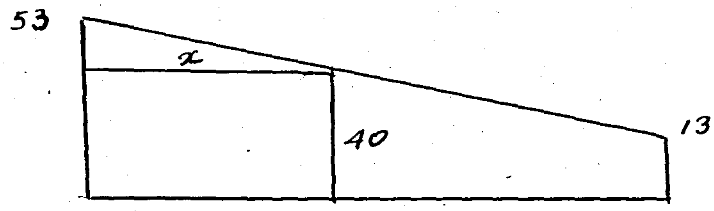
Using 3/8 Ø U   S=44 20 lbs.

Max s= 0.6x7 = 4.2 use 4"

end s= $\frac{4420}{13 \times 10}$ 34"   use 4"

To fimd the point where we don't need stirrups.

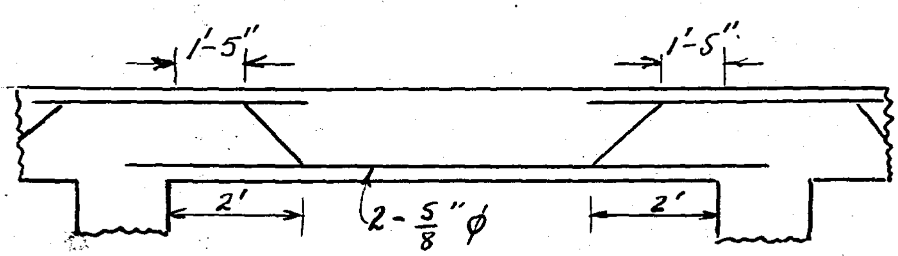
$$x = \frac{4 \times (53-40)}{53-13} = 1.3$$



Plasing of stirrups:

1 @ 2 = 2"

$\frac{4}{5}$ @ 4 = $\frac{16}{18}$"



Span 2.4ft

9.5ft of 8" brick wall = 762

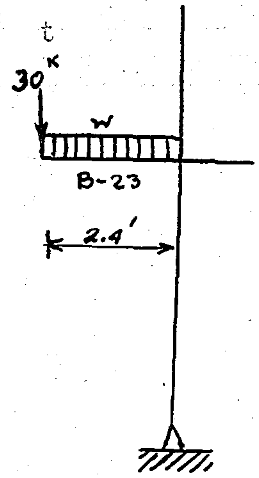
12x27" beam = 338

$w = 1100$

B-23 and B-22

$-M = 30000 \times 2.4 + 1100 \times \frac{(2.4)^2}{(2)} = 75000$ ft-lbs

$V = 30,000 + 1100 \times 2.4 = 32,640$ lbs



$d_m = \sqrt{\frac{75000 \times 12}{157 \times 12}} = 21.9$

$d_v = \frac{32,640}{12 \times 0.9 \times 120} = 25.2$

Use 12x27" (d=25.5 in.)

12x27"

$A_s = \frac{75,000}{20,000 \times 0.9 \times 25.5} = 1.96$

$u = \frac{32640}{11 \cdot 0.9 \times 25.5} = 130 \angle 150$ p.s.i.

Therefore , use 4-7/8"Ø and use special anchorage i.e. extend the 2 bars (which are not used by the next beam as reinforcement) 50 diameters (44 inches) beyond the section of max shear.

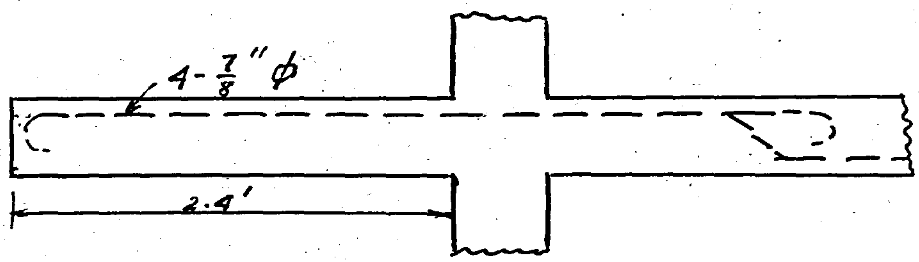
$v = \frac{32640}{12 \times 0.9 \times 25.5} = 118 \not< 40$ p.s.i. ∴ use stirrups

Design of stirrups

Using 3/8 Ø U $s = 2Asf_s = 2 \times 0.1105 \times 20,000 = 4420$

Max $s = 0.6d = 0.6 \times 25.5 = 15.3$

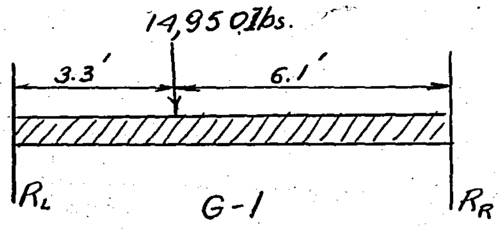
End $s = \frac{4420}{(118-40) \times 10} = 4.7$ ∴ use 4" as spacing of stirrups



DESIGN OF GIRDERS

G-1 and G-4

Clear span of 6-1 = 9.4 ft.



Assume beam =208 =208
9.5ft pf 8" brick wall =762
w = 970

$$R1= \frac{970 \times 9.4}{2} + \frac{14.950 \times 6.1}{9.4} = 14,260 \text{ lbs}$$

Rr = 9,790 lbs

$$M_{(\frac{1}{8})} = 14260 \times 3.3 - \frac{970 \times 3.3^2}{2} = 41,720 \text{ ft-lbs}$$

$$-M(\text{ext.end}) = \frac{8}{16} \times 41,720 = 20,900 \text{ ft-lbs}$$

$$M = \frac{8}{10} \times 41,720 = 33,400 \text{ ft-lbs}$$

$$V(\text{inter.end}) = \frac{6}{5} \times 14,260 = 17,200 \text{ lbs.}$$

$$V(\text{ext.end}) = \frac{4 \times 9,790}{5} \quad 7,850 \text{ lbs}$$

$$d_m = \sqrt{\frac{33400 \times 12}{131 \times 10}} = 17.6 \text{ in.}$$

$$d_v \quad \frac{17200}{10 \times .875 \times 120} = 16.4 \text{ in.}$$

Use 10" x 20" (d = 18") 10" x 20"

$$As = \frac{33,400 \times 12}{20,000 \times 0.875 \times 18} \quad 1.3 \text{ in}^2$$

$$-As(\text{ext.end}) = \frac{20,900 \times 12}{20,000 \times 0.875 \times 18} \quad 0.8 \text{ in}^2$$

$$\text{Max } u = \frac{17200}{8.71 \times 0.875 \times 18} = 125 \angle 150$$

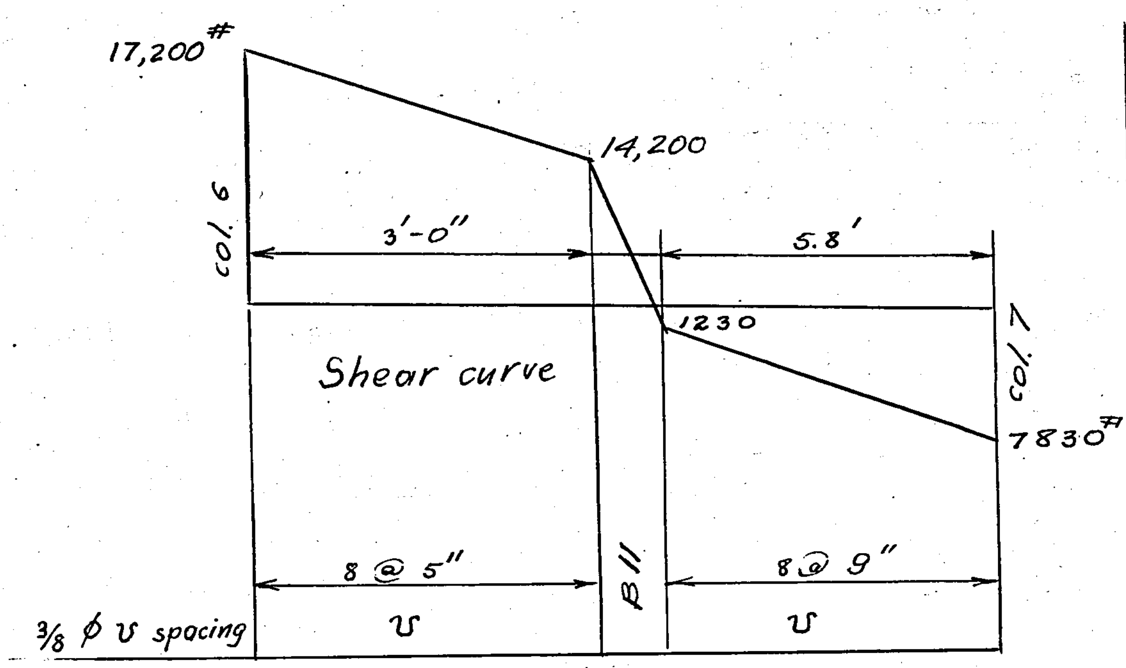
Use 4-3/4" Ø with special anchorage

$$v = \frac{17200}{10 \times 0.875 \times 18.5} = 106 \not< 40 \text{ p.s,i.}$$

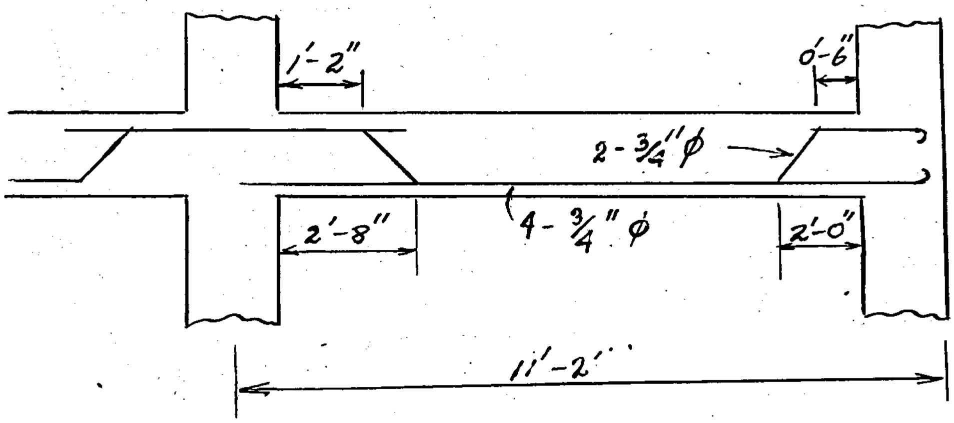
Therefore we need stirrups

Stirrups:

Stirrups Design for G-1



Steel of G-1 as in the sketch



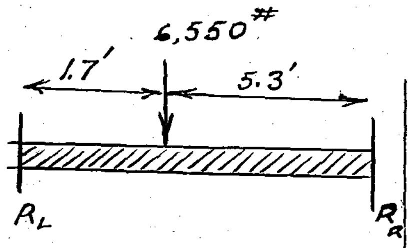
Clear span of G-2 =7ft-0"

L.L. slab =116 x 3.3+104x3.6=756

Assume stem = 10"x9" = 93

9.5ff of 8" brick wall= 762

1611



G-2

$$R_l = \frac{1611x7}{2} + \frac{6550x5.3}{7} = 10,590 \text{ lbs}$$

R_R = 7,220 lbs

$$M = 10,590x1.7 - 1611x\frac{(1.7)^2}{2} = 15,650 \text{ ft-lbs}$$

$$-M = \frac{8}{8}x15,670 = 15.670 \text{ ft-lbs}$$

$$M = \frac{8}{10} \times 15,670 = 12,500 \text{ ft-lbs}$$

$$-M = \frac{8 \times 15,670}{16} = 7,840 \text{ ft-lbs}$$

$$V(\text{int.end}) = \frac{6 \times 7,220}{5} = 8,660 \text{ lbs}$$

$$V(\text{ext.end}) = \frac{4x10,590}{5} = 8,450 \text{ lbs.}$$

$$d_m = \sqrt{\frac{15,670}{157 \times 10}} = 11 \text{ in.}$$

10"x13"

$$d_v = \frac{8660}{10x0.9x120} = 8.2 \text{ in.}$$

Use 10"x13" (d=11")

$$As = \frac{12,500}{20,000x0.875x11} = 0.82 \text{ sq. in.}$$

$$-As \text{ (ext.end)} = \frac{7,840}{20,000x0.875x11} = 0.5 \text{ sq. in.}$$

$$\text{Max } u = \frac{8450}{6.3x0.875x11} = \text{about 150 p.s.i.}$$

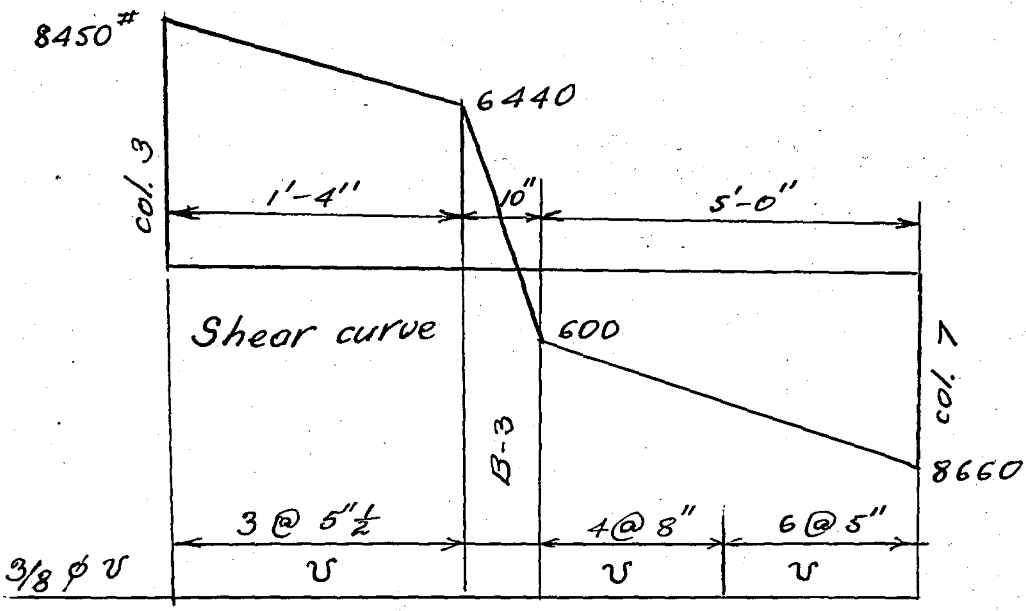
Use 4-1" ∅ with special anchorage

$$v = \frac{8660}{10 \times 0.875 \times 11} = 90 > 40 \text{ p.s.i.}$$

$$v = \frac{8450}{10x0.875x11} = 87 > 40 \text{ p.s.i.}$$

Therefore use stirrups in both sides

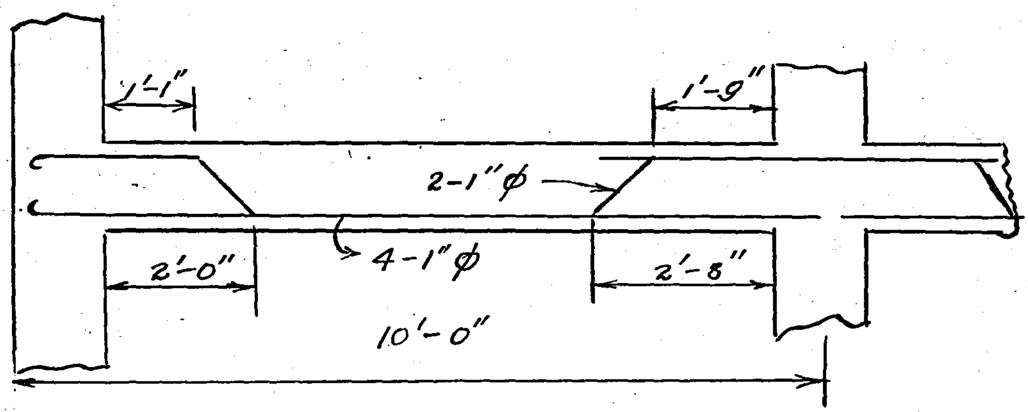
Stirrups:



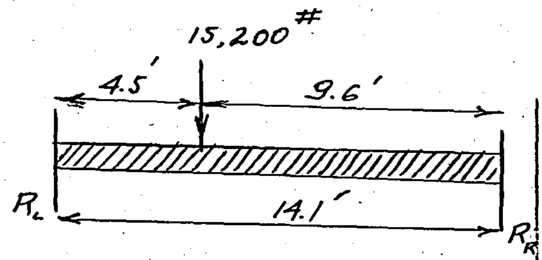
Design of stirrups

G-2

G-2
Steel:
(see sketch)



Clear span of G-3 = 14.1



G-3

Assume stem $10'' 23'' \times \frac{150}{144} = 240$

9.5ft of 8" brick wall = 762

L.L. + slab $=104 \times 6.7 = 696$

$w = 1698$

$R_L = \frac{1698 \times 14.1}{2} + \frac{15200 \times 9.6}{14.1} = 22,300$ lbs

$R_R = 16850$ lbs.

$M = 22,300 \times 4.5 - 1,698 \times \frac{(4.5)^2}{2} = 82,700$ ft-lbs

$-M = \frac{8}{8} \times 82,700 = 82,700$ ft-lbs

$M = \frac{8 \times 82,700}{10} = 66,000$ ft-lbs

$-M = \frac{8 \times 82,700}{16} = 41,400$ ft-lbs

$V(\text{int-end}) = \frac{6 \times 22,300}{5} = 26,800$ lbs.

$V(\text{ext.end}) = \frac{4 \times 16,850}{5} = 13,500$ lbs. 10"x27"

$d_m = \sqrt{\frac{82,700 \times 12}{10 \times 157}} = 25.0$ in

$d_v = \frac{26800}{10 \times 0.9 \times 120} = 24.8$ in.

Use 10"x27" (d=25") 10"x27"

$As = \frac{66000 \times 12}{20,000 \times 0.9 \times 25} = 1.76$ sq. in.

$-As\ (\text{ext.end}) = \frac{41,400 \times 12}{20,000 \times 0.9 \times 25} = 1.11$ sq in.

$\text{Max } u = \frac{13500}{5.5 \times 0.9 \times 25} = 109 \angle 150$

Use $4-\frac{7}{8}$ Ø with special anchorage

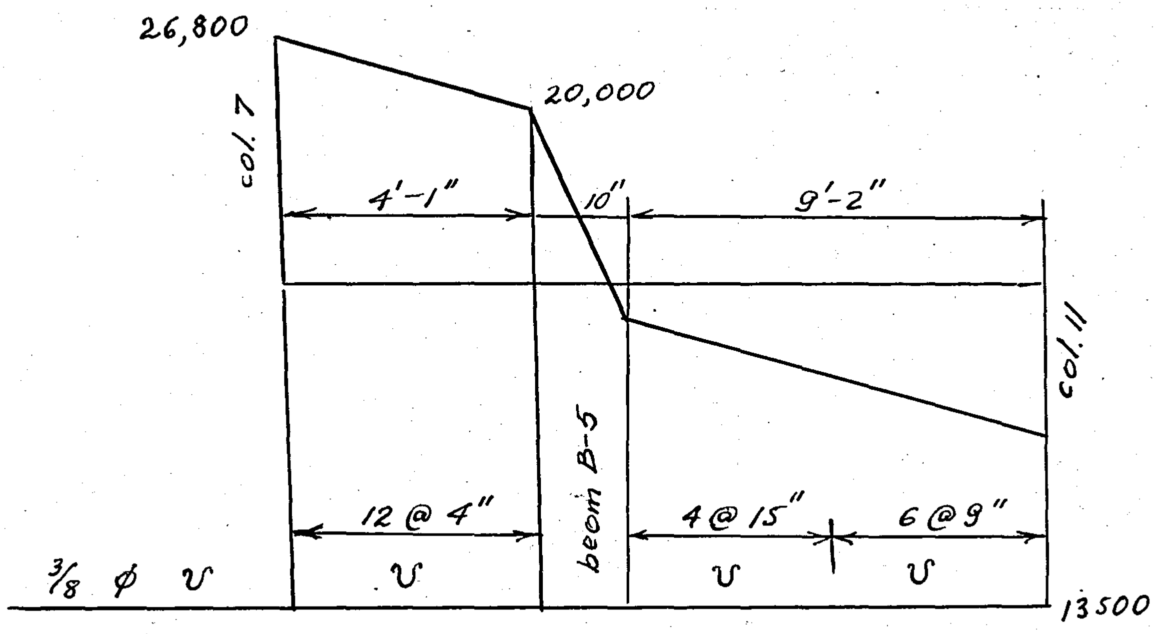
$v = \frac{26800}{10 \times 0.9 \times 25} = 119 \not> 140$ p.s.i.

. Therefore, we need stirrups

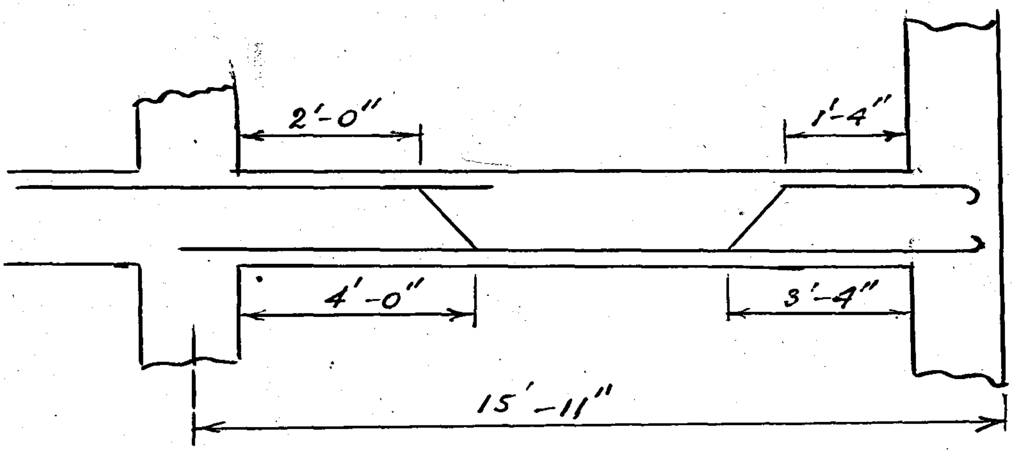
$v = \frac{13500}{10 \times 0.9 \times 25} = 60 \not> 40$ p.s.i.

Stirrups:

Design of stirrups G-3



G-3 steel (see sketch



Clear span of G-5 =13.7ft

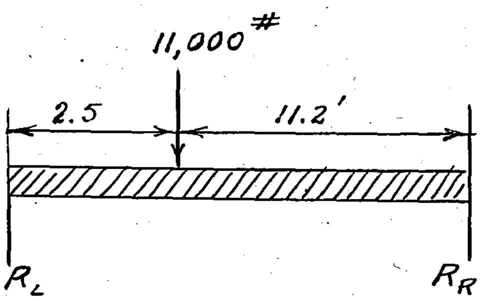
L.L.+ slab = 116x4.6 = 533

Stairs 2.5x160 = 400

9ft of 8" brick wall = 720

Assume stem 10"x32" = 229

1882



$$R_L = \frac{1882x13.7}{2} + \frac{11000x11.2}{13.7} = 21,800 \text{ lbs}.$$

R_R = 14,800 lbs

$$M = 21,800x2.5 - 1882x\frac{(2.5)^2}{2} = 48,700 \text{ ft-lbs}$$

$$-Mext = \frac{8x48700}{16} = 24,400$$

$$\pm M = \frac{8x48,700}{10} = 39,000 \text{ ft-lbs}$$

$$V(ext.) = \frac{4x21800}{5} = 17,500 \text{ lbs}$$

$$V(int.end) = \frac{6x21,800}{5} = 26,200 \text{ lbs}$$

$$d_m = \sqrt{\frac{39000x12}{157x10}} = 17.3 \text{ in.}$$

$$d_v = \frac{26200}{10.0.9x120} = 24.2 \text{ in.}$$

Use 10"x26" (d=24".5)

$$As = \frac{39000x12}{20,000 \times 0.9 \times 24.5} = 1.06 \text{ sq in.}$$

$$\text{Max } u = \frac{26200}{7.85x0.9x25} = 146 \angle 150$$ Use special anchorage

Therefore use 4-5/8 Ø and a hook of 5/8 Ø

$$v = \frac{26,200}{10x0.9x24.5} = 120 \angle 40 \text{ p.s.i.}$$

$$v = \frac{17,500}{10x0.9x24.5} = 80 \angle 40 \text{ p.s.i.}$$

Therefore we need stirrups.

G-5

Use 10"x26"

Steel:

4-5/8" Ø alt B

and a hook

of 5/8 Ø at

ext. end

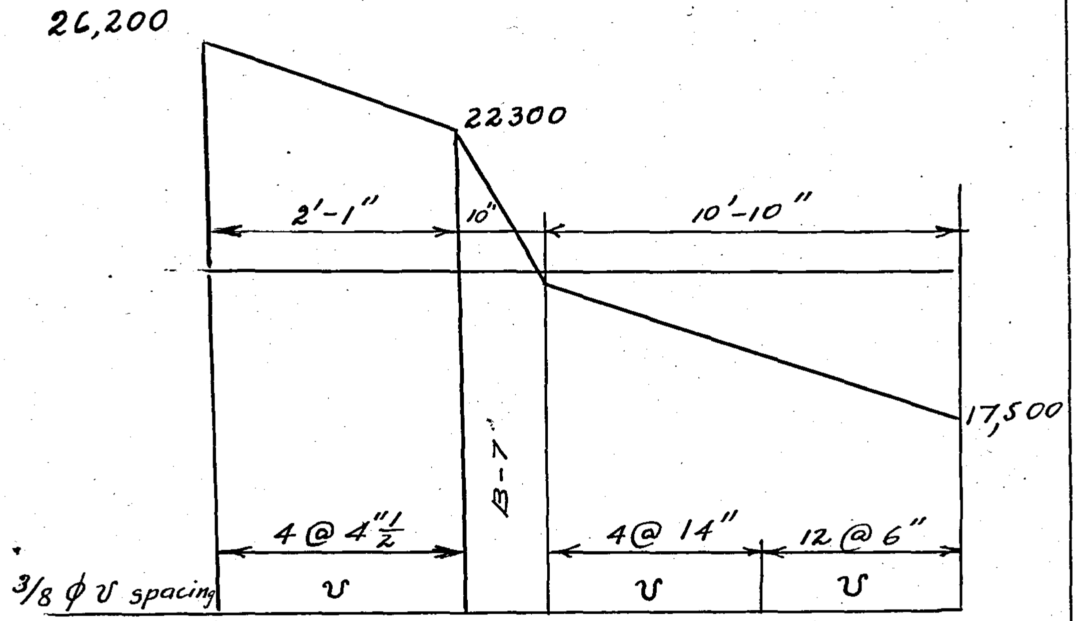
Use special ar

Use stirrups

Stirrups:

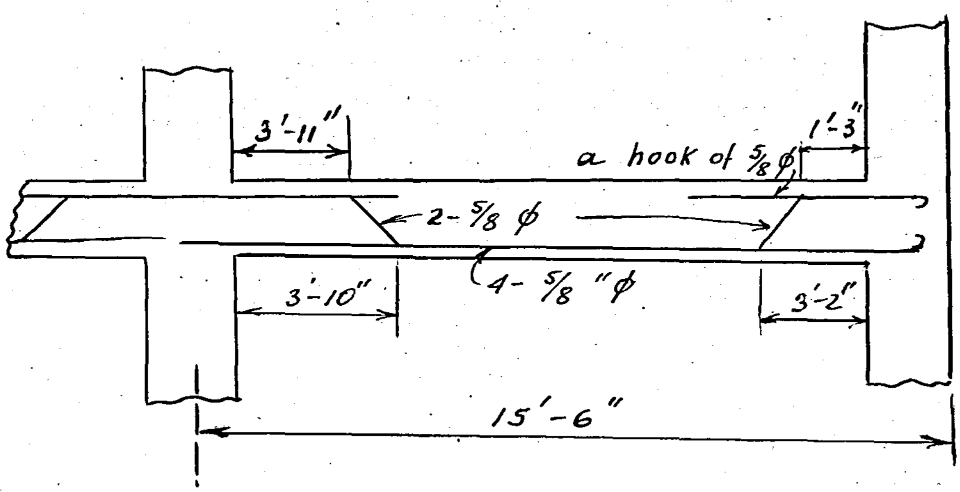
Stirrups Desig

for G-5



Steel of G-5

(See sketch)



DESIGN OF COLUMNS

Axial loads on column 9 from:

B-19 = 14950 = $\frac{14'-8''}{2}$ x 2038#
B-16 = 6830
B-15 = 14950
36730

D.L. = $\frac{15x24}{144}$ x9.75 x150 = 3670 lbs.

Worst condition of loading: M=53,250 ft-lbs
P=3670x2+36730 =44070

Assume 3,000 lb concrete

$e = \frac{53250}{44070} = 12.1$ Try 15"x24"

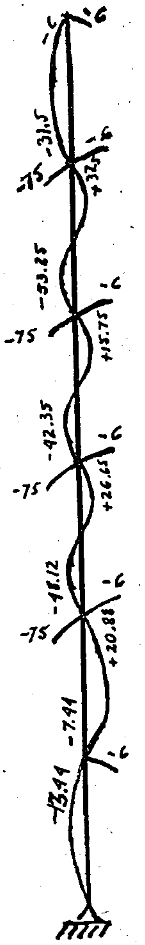
0.2x width = 0.2x15 =3

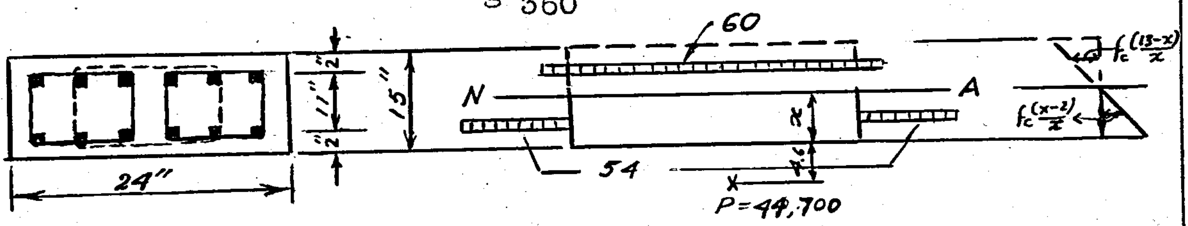
Since 3/ 12.1 that means that in this column the bending moment is large enough to cause tensile stress on part of the cross section, i.e. the neutral axis falls within the section.

Max As =0.4x360=14.4

Try : 12-1"square bars $p_g = \frac{12}{360} = 0.033$

Distribution of moment to Column No.9





$1/2\ f_c\ 24x(4.6\ \frac{x}{3})\quad 54f_c\ \frac{(x-2)}{x}\ 6.6-60\frac{(13-x)}{x}\quad 17.6=0$

$12x^2(13.8\quad x)\quad 162(x-2)6.6-180(13-x)17.6=0$

Design of f
Column 9
10,11,12
6,7

3,000 lb
cpncrete.

Section:
15"x24"
with
12-1" square
bars
with
4-3/8 Ø tie
@ 12"
Alt. with
1-3/8 @ 12

Design of col. 9 continued

$x^3 + 13.8x^2 + 354x - 3600 = 0 \qquad x = 7.0$

$\frac{1}{2} f_c \times 24x7 + 54f_c \frac{5}{7} - 60f_c \times \frac{3}{7} - 44070 = 0$

$\text{actual } f_c = \frac{44070}{96.9} = 455$

$f_c = 10x455x \frac{6}{7} = 3900 \text{ p.s.i.}$

$24x15 = 360 \text{ in}^2 \quad \frac{x1}{12}x(15)^2 = 6740$

$12x9 = 108 \quad x5.5^2 \qquad = 3280$

$At = 468 \text{ in}^2 \qquad I = 10,0z0 \text{ in}^4$

$R^2 = \frac{I}{A} = \frac{10.020}{468} = 21.4$

$\frac{ec}{R^2} = \frac{12.1x7.5}{21.4} = 4.24$

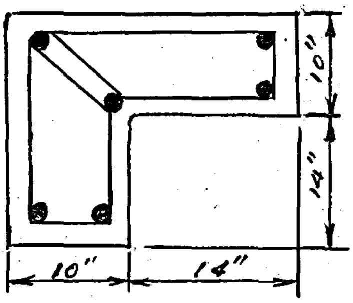
$\text{allowable } f_c = \frac{0.154x3000 + 0.7x20,000x0.033}{1+9 \; x0.033} \quad x \frac{(1+4.24)}{1+0.8x4424}$

all. $f_c = 850 \;/\; 418$ O.K. although we have a very small increase of moment due to the loads of B-19 and B-16 which are eccentric by $\frac{2\frac{1}{1}}{2}$"

Axial loads pn column 4 from:

B-13 3800

B- 3 $\underline{6550}$
10,350



Use 2000 lb. concrete

Min. As = 0.01x319 =3.19

Use 6- $\frac{7}{8}$ Ø

$P_g = \frac{3.61}{319} \doteq 0.0113$

P= 319 (0.22x2,000 20,000x0.0113)

P= 180,000 #all.

The worst axial loading is on the column of basement floor for which we have a permissible reduction of 40% of load according to the Building Code.

$6 \times 10350 \times \frac{60}{100} = 37200 \angle 180{,}000$ O.K.

Since it is more than 4 times as strong as required for direct load it is unnecessary to investigate for B.M.

Column 4

3,1

2,000 lb concrete

6-1" Ø with twin ties

$\frac{1}{4}$ Ø @ 12"

Axial loads on column 8 from:

B-14 = 3,000 Column 8

B-13 or B-6 = 5,700 5 ,2

B-5 =15,200

23,900 lbs

Dead load = $\frac{10x24}{144}$ x10 x150 = 2500 lbs

P = 23900 + 2500 = 26,400 lbs

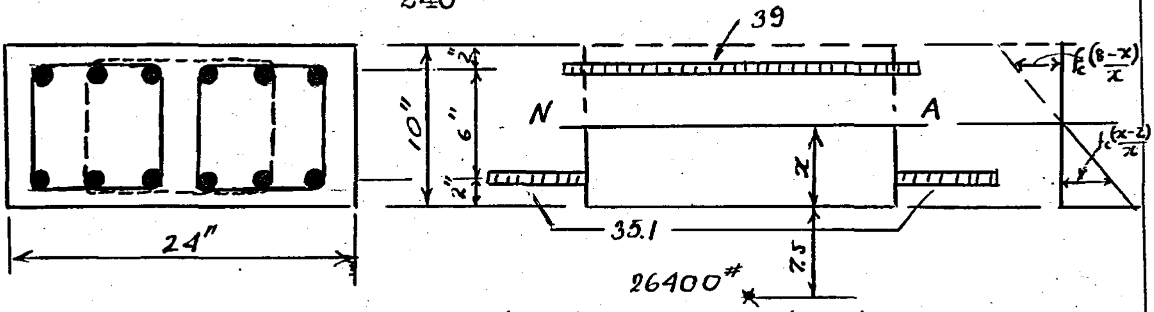
M = 27,500 ft-lbs

$e = \frac{27,500x12}{26,400} = 12.5''$

Try: 10" x24" column; 3000 lb concrete 10"x24"

Max. As = .04x240 = 9.6

12-1" Ø Bars . $p_g = \frac{12x0.78}{240}$ = 0.039 12-1" Ø



$$1/2\ f_c 24x(7.5 + \frac{x}{3}) + 35.1 f_c \frac{(x-2)}{x} 9.5 - 39 f_c \frac{(8-x)}{x} 15.5 = 0$$

Design of Column 8 continued

$24x^2(22.5+x)+2000\times(x-2)-3630(8-x)=0$

$x^3+22.5x^2+235x-1380=0 \qquad x=4.05''$

$\frac{1}{2} f_c \times 24 \times 6.05+35.1\, f_c \frac{2.05}{4.05} - 39 f_c \frac{3.95}{4.05} - 26{,}400 = 0$

$$f_c = \frac{26{,}400}{52.1} = 507 \text{ p.s.i.}$$

$$f_s = 10 \times 507 \times \frac{3.95}{4.05} = 4.950 \text{ p.s.i.}$$

At	Io
240 in^2	$\times \frac{1}{12} \times 10^2 = 2000$
$9 \times 12 \times 0.78 = 84.3$	$\times 3^2 = 760$
324.3	2760

$R^2 = \frac{Io}{A} = \frac{2{,}760}{324.3} = 8.5 \qquad \frac{ec}{R^2} = \frac{16.3}{8.5}\ 9.6$

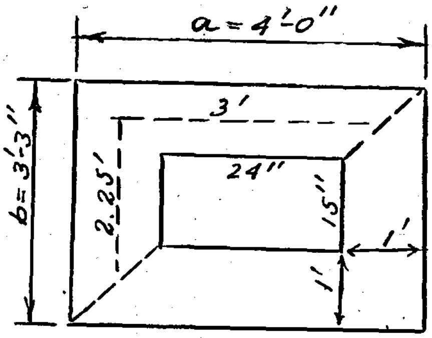
all. $f_c = \frac{0.154 \times 3000+0.7 \times 20{,}000 \times 0.039 \times (1+9.6)}{(1+9\times0.039) \times (1+0.8 \times 9.6)}$

all. $f_c = \frac{624.2}{11.7} = 534 \text{ p.s.i.} > 507$ P.K.

DESIGN OF FOOTINGS

Footing 9, 10,11,12, 6,7.

Footing Base

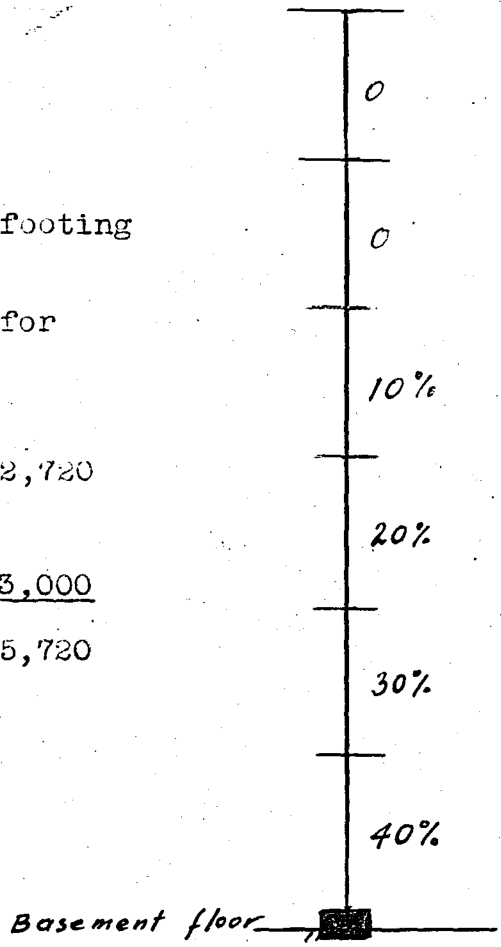


A rectangular footing will be used with the rectangular column since we have thecheapest proportion if the rect. base projects the same distance beyond each column fase, because these proportions require the minimum amount of material.

Live Load 100%

reduction for 5 floors = 40%

60%
30
30% for footing



Therefore design the footings for

D.L. 30% L.L.

Column Load =6x40 400 x $\frac{30}{100}$ = 72,720

Assume weight of footing = 3,000

Total Load =75,720

Design of Footing 9 continued

Area of base $= \frac{75,720}{6,000} = 12.6$

a= 4ft-0" b= 3ft-3"

$A = 4x3.25 = 13 \ ft^2$

Net soil pressure

$w = \frac{72720}{13} = 5,600$ lbs / sq ft.

Depth by bending moment

2000 lb concrete

$M = w \frac{c}{2} \frac{(a-c)^2}{2^2} + w0.6 \frac{(a-c)^3}{2^3}$

Ma = 5600x0.62(1+ 0.6) = 5,550 ft-lbs

Mb = 5600(1+ 0.6) = 8,950 ft-lbs

$\min d = \sqrt{\frac{M}{Rb}} = \sqrt{\frac{8,950x12}{131x24}} = 5.85"$

use $d_{av} = 6"$ t = 10"

Diagonal tension

$v = \frac{V}{bjd} = \frac{5600(13-3x2.25)}{2x(36+27)x0.875x6}$ 53 p.s.i. ∠ 60 O.K.

Actial weight

Weight = 13x $\frac{10}{12}$ x 150 = 1630 ∠ 3000 O.K.

Steel

For steel in long direction d= 5.75"

Design of footing 9 continued

$As = \frac{5,550 \times 12}{20,000 \times 0.87 \times 5.75}$ 0.7

V bond = 5600x1x(1+1.25) = 14,900

$\Sigma O = \frac{14,900}{112.5x\ 0.875x5.75} = 26.4"$

Use 14 - 1/2" squares @ 33/1/2" c.c. (hooked)

Forsteel in short direction d= 6.25"

$$As = \frac{8,950 \times 12}{20,000 \times 0.87 \times 6.25} = 1.0$$

$$V\ bond = 5600\ (2+1) = 16800$$

$$\Sigma 0 = \frac{16800}{112.5 \times 0.875 \times 6.25} = 27.3$$

Use 14" squares @ 4" c.c.

Dowels

Same size and number as main column reinforcement. Dowels are placed at the column-footing junction extending 24 diam. into each member. Since extent in footing is less than 24 bar diam. we have to hook dowels.

Design of footing 9 continued

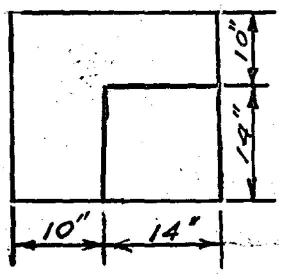
Steel

Long bars
14- $\frac{1}{2}$" squares @ 3 $\frac{1}{2}$" c.c. hooked
Short bars
14-1/2" squares @ 4
Long bars on top of short bars.

Column load = 6x10350x $\frac{30}{100}$ = 18600 lbs

Assume weight of footing = 2,000

Total load = 20600 lbs



Area of base = $\frac{20600}{6000}$ = 3.5 s.f.

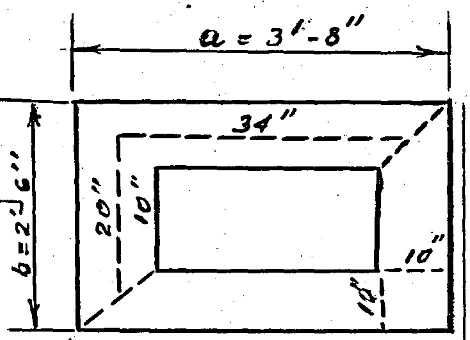
Use 2ft- square

t=10" (d=6") O.K. by inspection

Footing 4, 3,1

2ftsquare

Column load = $26400 \times 6 \times \dfrac{30}{100} = 47{,}500$



Design of footing 8, 5 , 2

Assume weight of footing = 2,500

Total Load = 50,000

$A = \dfrac{50{,}000}{6{,}000} = 8.33$

a = 3ft-8in. b= 2ft-6" A = 9.2 ft^2

Net soil pressure $w = \dfrac{47500}{9.2} = 5{,}160$ p.s.f.

Ma = 5160 x(0.69 0.6x0.57) = 5300 ft-lbs

Mb = 5160 x 0.417(0.69 0.6 x 0.57) = 2220 ft-lbs

3ft-8" x2ft-(

$d_m = \sqrt{\dfrac{5300 \times 12}{131 \times 24}} = 4.6$

t = 9" (d_{av} = 5)

t = 9"

$v = \dfrac{Vd.t}{bjd} = \dfrac{5160(9.2 - \frac{20x34}{144})}{2(34 \;\; 20)x0.875x5} = \dfrac{23{,}200}{473} = 49 \angle 60$ O.K.

Actual weight = $9.2 \times \dfrac{9}{12} \times 150 = 1030 \angle 2500$ O.K

Short bars:
7-1" Ø @ 4"
Long bars
5-1" Ø @ 8"

Steel in short direction: d = 5.25"

$As = \dfrac{5300 \times 12}{20{,}000 \times 0.87 \times 5.5} = 0.7$

$\Sigma 0 = \dfrac{5160 \times 10(10 \;\; 24)/144}{112.5x0.87x5.5} = 23.$ use 7-1" Ø @ 4"

Short bars
on botton
of long bars

Steel in long direction : d = 4.75

$As = \dfrac{2220 \times 12}{20{,}000x0.87x4.5} = 0.4$

$\Sigma 0 = \dfrac{5160x10x20/144}{112.5x0.87x4.5}$ 14.2

Use 5-1" Ø @ 8"