DESIGN OF A REINFORCED CONCRETE APARTMENT HOUSE

Thesis for the Degree of B. S.

J. Edward Bechtold

1937

THESIS

Cop. 2

Design of a Reinforced

Concrete Apartment

House

A THESIS

Submitted to the Faculty of

THE MICHIGAN AGRICULTURAL COLLEGE

By

J. Edward Bechtold

Candidate for the

Degree of Bachelor of Science

June 1937

The author desires to acknowledge his indebtedness to Associate Prof. C. A. Miller for his many helpful suggestions.

TABLE OF SYMBOLS USED

f_s -- tensile unit stress in longitudinal reinforcement.

f_c -- compressive unit stress in extreme fiber of concrete in flexure.

E_s -- modulus of elasticity of steel in tension or compression (= 30,000,000 p.s.i.)

E_c -- modulus of elasticity of concrete in compression.

n -- E_s/E_c

M -- bending moment or moment of resistance in general.

A_s -- effective area of reinforcement in tension in beams and slabs.

b -- width of rectangular beam or width of flange of T-beam.

d -- depth from compression surface of beam or slab to center of longitudinal tensile reinforcement.

d' -- depth from compressive surface of beam to center of longitudinal compressive reinforcement.

b' -- width of web in T-beams.

k -- ratio of depth of neutral axis to depth d.

j -- ratio of lever arm of resisting couple to depth d.

p -- ratio of effective area of tensile reinforcement to effective area of concrete in beams or slabs = A_s/bd .

p' -- ratio of effective area of compressive reinforcement to effective area of beam.

V -- total shear.

v -- shearing unit stress.

Σ_o -- sum of perimeters of a group of bars.

u -- bond unit stress.

l -- clear span length of beam or slab.

SYMBOLS (continued)

w -- uniformly distributed load per unit of length of beam or slab.

P -- concentrated load.

K -- I/l or I/h

I -- moment of inertia.

h -- height of beam.

Preface

The purpose of this thesis is to design a reinforced concrete structure from a floor plan and front elevation such as might be given an engineer by an architect.

The floor plan was drawn up more from an architect's point of view than from an engineer's, that is why there is so little symmetry between the various members.

The building is of three stories, outside stair type which lends itself admirably to group or block organizations, which may be developed either parallel to, or at an angle with, the surrounding street lines. The apartments are of four and five rooms.

The live roof load was so near the live floor load, that the same slab beams and girders were used throughout.

It was found that no steel was needed for diagonal bracing in the short beams of 14ft. - 6in. These beams being made the same size as the large span beams.

It would be interesting to re-design this building using bearing walls and cantilever floor sections. The building being only three stories in height makes bearing walls possible, as the basement wall would not, in the authors mind, be so large as to be out of consideration.

The floor slabs were figured with a total depth of 5in. and an effective depth of 4in. In this way the forms would be of a uniform thickness while the steel required in the different slabs would vary with the length of slab in question.

The beams and girders were kept at a maximum width of 12in. The purpose in so doing was to conceal as many beams and girders as possible in the partitions.

The columns offered quite another problem, and this is the strongest reason for wanting to try a design of bearing walls. It was found that the columns would not remain hidden in the partitions but would in some cases protrude into the rooms giving same an unsightlyappearance. In using bearing walls not only would an unbroken wall surface be presented to the prospective tenant, but the building expenses would be cut down.

I regret to say that time did not permit me to make what I think would have been a very interesting investigation. I have little doubt in my own mind but that the bearing wall constructed type of house would prove more economical than the beam and girder type for three and four story houses of this type where appearances play a most important part.

Computation for Slab, Beam and Girder Floor

Slab-Beam-Girder Floor

Live load 40#/sq.ft.

Floors Oak

Materials:

Steel: Intermediate grade: deformed bars

Concrete: Maximum size of aggregate 3/4in.

Ultimate strength @ 28 days: 2000#/sq.in.

Specifications: Lansing Building Code 1937

Stresses:

f_s = 20,000#/sq.in.

f_c = 750#/sq.in. bending

= 850 " @ supports

u = 120 "

v = 40 " no web reinforcement

= 120 " with " "

Constants: 20,000 750 n = 15

R or K = $f_s pj$ - 113.8

P = 0.0068

k = 0.3600

j = 0.8800

Computation for Floor Slab using $M = \frac{WL}{12}$

Slab D

Allowable $f_c = 750$ $f_s = 20{,}000$ $n = 15$ $v = 120$ $u = 120$

Clear Span 12ft. - 00in.	Live load		40
Bearing Span 13ft. - 00in.	Slab 5in.		63
Assume 12in. beam	Plaster	metal lath	10
	Flooring		5
	Partitions		16
			134#/sq.ft.

$M = \frac{WL}{12} = \frac{134 \times 12^2}{12} = 1608$ ft.#/ft. strip. Interior Span

$V = \frac{WL}{2} = \frac{134 \times 12}{2} = 804\#$

Thickness:

$$d = \sqrt{\frac{M}{bR}} = \sqrt{\frac{1608 \times 12}{12 \times 118.8}} = \sqrt{13.5} = 3.68 \text{ say } 4.00\text{in.}$$

$$D = \frac{1.00''}{5.00''}$$

Use 5in. Slab

$d = 4$in.

Floor Slab Steel

Interior Span:

$$A_s = \frac{M}{f_s j d} = \frac{1608}{20{,}000 \times .88 \times 4} = .02285 \text{ sq.in./in. or } .274 \text{ sq. in./lin.ft.}$$

1/2 in.ϕ @ 8 1/2 o.c. = 28 sq. in./lin.ft.

Bond Stress @ Supports:

$$v = \frac{V}{f j d} = \frac{804}{12 \times .88 \times 4} = 19.1\#/\text{sq.in.}$$

For 1/2 in.ϕ :

$$u = \frac{vb}{\Sigma o} = \frac{19.1 \times 8.5}{3.142 \times 1/2} = 103\#/\text{sq. in.}$$

Using Depth of Interior Slab Figure Steel Needed in Slab (E)

18ft. - 00in. Clear Span on the Exterior

Find Moment as the Interior Span

$$M = \frac{wL^2}{12} = \frac{134 \times 18^2}{12} = 3618\text{ft.}^{\#}/\text{ft. strip (Int.)} \qquad W = 134^{\#}$$

$$V = \frac{wL}{2} = \frac{2412}{2} = 1206^{\#}$$

Exterior Span:

$$R = \frac{M}{bd^2} = \frac{3618 \times 1.2}{4^2} = 271$$

$$K = pf_s j$$

$$271 = 20{,}000 \times .88 \times p$$

$$p = \frac{271}{20{,}000 \times .88} = .0154$$

Therefore:

$$A_s = .0154 \times 4 = .0616\text{sq.in./in. or } .74\text{sq.in./lin.ft.}$$

$5/8\text{in.}\phi$ @ 5in.o.c. for Ext'r.

Bond Stress @ Supports:

$$v = \frac{V}{bjd} = \frac{1206}{12 \times .88 \times 4} = 28.5^{\#}/\text{sq.in.}$$

For $5/8\text{in.}\phi$:

$$u = \frac{vb}{\Sigma_o} = \frac{28.5 \times 5}{3.142 \times 5/8} = 72.5^{\#}/\text{sq.in.}$$

Computation for Steel in Steel in Interior Spans

Slab (A)

$D = 5in. \quad d = 4in. \quad W = 134^{\#}$

Clear Span 8ft. - 6in.

Bearing Span 9ft. - 6in.

$M = \frac{WL^2}{12} = \frac{134x8.5^2}{12} = 806ft.^{\#}/ft.$ strip

$V = \frac{WL}{2} = \frac{134x8.5}{2} = 1139 \div 569.5^{\#}$

$R = \frac{M}{bd^2} = \frac{806x12}{12x4^2} = 50.4$

$R = f_s pj$

$50.4 = 20,000x.88xp$

$p = \frac{50.4}{20,000x.88} = .0029$

Therefore:

$A_s = .0029x4 = .0116sq.in./in.$ or $.1392sq.in./lin.ft.$

$3/8in. \not{o}$ @ 8 1/2in. o.c. = .15sq.in./lin.ft.

Bond Stress @ Supports:

$v = \frac{V}{bjd} = \frac{569.5}{12x.88x4} = 13.45^{\#}/sq.in.$

For 3/8in. @ 8 1/2 in. o.c.:

$u = \frac{vb}{o} = \frac{13.45x8.5}{3.142x3/8} = 97.3^{\#}/sq.in.$

Computation for Steel in Interior Spans

Slab (B)

$D = 5in.$ $d = 4in.$ $W = 134^{\#}$

Clear Span 11ft. - 6in.

Bearing Span 12ft. - 6in.

$M = \frac{WL^2}{12} = \frac{134 \times 11.5^2}{12} = 1475 ft.^{\#}/ft.$ strip

$V = \frac{WL}{2} = \frac{134 \times 11.5}{2} = \frac{1540}{2} = 770^{\#}$

$R = \frac{M}{bd^2} = \frac{1475 \times 12}{12 \times 16} = 92.3$

$R = f_s jp$

$92.3 = 20,000 \times .88 \times p$

$p = \frac{92.3}{20,000 \times .88} = .00523$

Therefore:

$A_s = .00523 \times 4 = .02092 sq.in./in.$ or $.25104 sq.in./lin.ft/$

3/8in. ϕ @ 5in. o.c. = .26sq.in./lin.ft.

Bond Stress @ Supports

$v = \frac{V}{bjd} = \frac{770}{12 \times .88 \times 4} = 18.2^{\#}/sq.in.$

For 3/8in. ϕ @ 5in. o.c.:

$u = \frac{vb}{\Sigma_o} = \frac{18.2 \times 5}{3.142 \times 3/8} = 77.3^{\#}/sq.in.$

Computation for Steel in Interior Spans

Slab (C)

$D = 5in.\quad d = 4in.\quad W = 134^{\#}$

Clear Span 11ft. - 00in.

Bearing Span 12ft. -00in.

$$M = \frac{WL^2}{12} = \frac{134 \times 11^2}{12} = 1352 ft.^{\#}/ft.\ strip$$

$$V = \frac{WL}{2} = \frac{134 \times 11}{2} = \frac{1475}{2} = 737.5^{\#}$$

$$R = \frac{M}{bd^2} = \frac{1352.12}{12 \times 16} = 84.6$$

$R = f_s jp$

$84.6 = 20,000 \times .88 \times p$

$$p = \frac{84.6}{20,000 \times .88} = .00483$$

Therefore:

$A_s = .00483 \times 4 = .01932$sq.in./in. or .232sq.in./lin.ft.

3/8in.ϕ @ 5 1/2in. o.c. = .24sq.in./lin.ft.

Bond Stress @ Supports:

$$v = \frac{V}{bjd} = \frac{737.5}{12 \times .88 \times 4} = 17.5^{\#}/sq.in.$$

For 3/8in. ϕ @ 5 1/2 in. o.c.:

$$u = \frac{vb}{\Sigma_o} = \frac{17.5 \times 5.5}{3.142 \times 3/8} = 81.5^{\#}/sq.in.$$

Computation of Steel in Floor Slabs with:

$$D = 5\text{in.} \quad d = 4\text{in.} \quad W = 134^{\#}$$

Slabs (F), (G), (H), (F)

Clear Span 13ft. -00in.

Bearing Span 14ft. - 00in.

$$M = \frac{WL^2}{10} = \frac{134 \times 13^2}{10} = 2266\text{ft.}^{\#}/\text{ft. strip}$$

$$V = \frac{WL}{2} = \frac{134 \times 13}{2} = 1741 = 870.5^{\#}$$

$$R = \frac{M}{bd^2} = \frac{2266 \times 12}{12 \times 4^2} = 141.6$$

$$R = f_s p j$$

$$141.6 = 20{,}000 \times .88 \times p$$

$$p = \frac{141.6}{20{,}000 \times .88} = .00805$$

Therefore:

$$A_s = .0081 \times 4 = .0324\text{sq.in./in. or } .388\text{sq/in./lin.ft.}$$

$$1/2\text{in.}\,\phi \text{ @ } 6\text{in. o.c.} = .40\text{sq.in./lin.ft.}$$

Bond Stress @ Supports:

$$v = \frac{V}{bjd} = \frac{870.5}{12 \times .88 \times 4} = 20.6^{\#}/\text{sq.in.}$$

For 1/2in. ϕ :

$$u = \frac{vb}{\Sigma_o} = \frac{20.6 \times 6}{3.142 \times 1/2} = 78.7^{\#}/\text{sq.in.}$$

Stair Slab

From table #23 "Simplified Design of Concrete Floor systems" by the Portland Cement Association.

Horizontal Span of stairs in feet 18ft. - 00in.

Total thickness of slab in inches 10 1/2

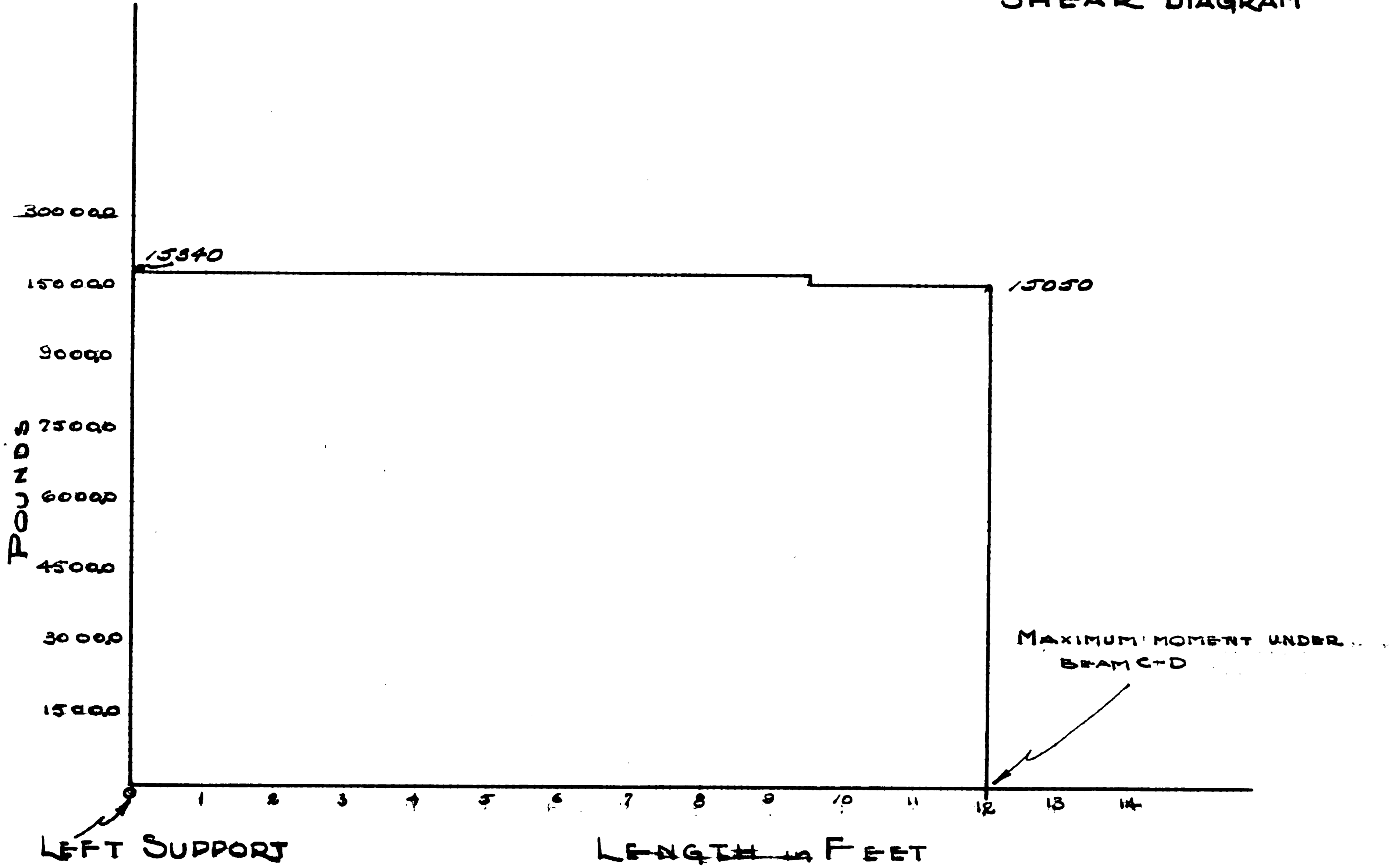
Reinforcing steel 3/4in. 6in. o.c.

For temperature reinforcement place a single 3/8in. round bar under each tread.

(treads add 45#/horizontal square foot.)

The original floor system lay out called for two beams, 2 ft. - 6 in. apart and running into the girder from opposite sides. One of the beams was a floor beam and the other was part of the stair well framing. In order to figure the maximum moment it was necessary to find the point where the shear was zero, this gave the location of the maximum moment. After a preliminary investigation it was found that it would be better to inlarge thestair well, running the beams together over a column. This was done in the final design.

SHEAR DIAGRAM



Computation for Floor Beams (1-10) (5-5)

Allowable 750#/sq.in. $f_s = 20,000$#/sq.in. $n = 15$

$v = 120$#/sq.in. $u = 120$#/sq.in.

850#/sq.in. @ supports

Clear Span 28ft. - 00in.		Live load	40
Bearing Span 29ft. - 00in.		Dead "	94
			134#

Panel width 19ft. - 6in.

Assume 12in. girders

Loads: Live + dead

$134 \times \frac{19.5}{2} = 1305$

Stem = $\underline{250}$

$M = \frac{WL}{10} = \frac{1555 \times 29.5^2}{10} = 135,500$ ft.#/ft. strip

$V = \frac{WL}{2} = \frac{1555 \times 29.5}{2} = 22,950$#

Assume $j = .88$ @ supports .92 @ center of span

$v = 120$ with web reinforcement

Determination of beam section to care for shear

$b^1b = \frac{V}{jv} = \frac{22950}{.88 \times 120} = 217$

$b = 12$in. $d = 18.1$in. say 18.5in.

Total depth 20.5in.

Check wt. of stem

$\frac{(20.5-2)\ (12)\ (150)}{144} = 231$#

Steel area Assume $j = .92$

$A_s = \frac{135,500 \times 12}{20,000 \times .92 \times 18.5} = 4.77$sq.in.

Use 4-1 1/8 in.sq. bars - 5.08sq.ft.

Spaced 2 1/2 d. o.c.

Check Shear

$$v = \frac{22950}{12x.88x18.5} = 117.4^{\#}/sq.in.$$

Bond

$$u = \frac{22950}{4x4.5x.88x18.5} = 48^{\#}/sq.in.$$

At supports

$$\frac{d^1}{d} = \frac{2}{13.5} = .193 \qquad p' = p \frac{4.77}{12x13.5} = .0215$$

From Diagram 10 Vol. 1 "Reinforced Concrete Construction"

by Hool

$$k = .415 \qquad j = .833$$

$$f_s = \frac{135,500x12}{5.08x.833x18.5} = 19,500^{\#}/sq.in.$$

$$f_c = \frac{19,500x.42}{15(1-.42)} = 943^{\#}/sq.in.$$

Stirrup Spacing

From Fig. 17 "Simplified Design of Concrete Floor Systems"

by the Portland Cement Association

$$v = 117^{\#}/sq.in.$$

$$v - v_c = v^1$$

$$\underline{117 - 40 - 77}$$

$$v^1b = (77)(12) = 925$$

$$a = \frac{1}{2} \left(\frac{v^1}{v}\right)$$

$$= 29.5 \left(\frac{77}{117}\right)$$

$$= 9.7ft.$$

Maximum allowable spacing $\frac{1}{2} d = .5)(13.5) = 9.7$

Use 1/2in. v stirrups

12 @ 9in.

# of stirrups in each end of beam = 12

This beam is run through building for construction. The stirrups were fig. for thelongest span.

Computation for Floor Beam (2-9)

Allowable $750^{\#}$/sq.in. $f_s = 20,000^{\#}$/sq.in. $n = 15$

$v - 120^{\#}$/sq.in. $u - 120^{\#}$/sq.in.

$850^{\#}$/sq.in. supports

Live load 40

Dead " $\underline{94}$ 134

Clear Span 28ft. -00in.

Bearing Span 29ft. - 00in.

Panel widths 1 9ft. - 6in. 9ft. - 6in.

Assume 12in. girders

Loads: Live+dead

$$134 \times \left(\frac{19.5}{2} + \frac{9.5}{2}\right) = 1941$$

Stem $= \underline{350}$

$$M = \frac{WL}{10} = \frac{2291 \times 29.5}{10} = 199{,}500 \text{ft.}^{\#}\text{/ft. strip}$$

$$V = \frac{WL}{2} = \frac{2291 \times 29.5}{2} = 33{,}800^{\#}$$

Assume $j = .83$ @ support .92 @ center of span

$v = 120^{\#}$/ sq.in. with web reinforcement

<u>Determination</u> of beam section to care for shear

$$b^1 d = \frac{V}{jv} = \frac{33300}{.83 \times 120} = 320.0$$

$b = 12$in. $d = 26.7$in. say 27in.

Total depth 29.0in.

Check wt. of stem

$$\frac{(29-2)(12)(150)}{144} = 337.5^{\#}$$

Steel area Assume $j = .92$

$$A_s = \frac{19{,}9500 \times 12}{20{,}000 \times .92 \times 27} = 4.83 \text{sq.in.}$$

Use 4 - 1 1/8in. sq. bars = 5.08sq.in.

Spaced 2 1/2 d o.c.

Check Shear

$$v = \frac{33,800}{12x.88x27} = 118.5^{\#}/sq.in.$$

Bond

$$u = \frac{33,800}{4x4.5x27x.88} = 43.0^{\#}/sq.in.$$

At Supports

$$\frac{d^1}{d} = \frac{2}{27} = .0742 \qquad p = p^1 = \frac{5.08}{12x27} = .0157$$

From diagram 10, Vol. 1 "Reinforced Concrete Construction"

by Hool

$$k = .39 \qquad j = .87$$

$$f_s = \frac{192,500x12}{5.08x.87x27} = 20,050^{\#}/sq.in.$$

$$f_c = \frac{20,050x.39}{15(1-.39)} = 855^{\#}/sq.in.$$

Stirrup Spacing

From Fig. 17 "Simplified Design of Concrete Floor Systems"

by the Portland Cement Association

$$v = 119^{\#}/sq.in.$$

$$v - v_c = v^1$$

$$119 - 40 = 79$$

$$v^1b = (79)(12) = 948$$

$$a = \frac{l}{2}\left(\frac{v^1}{v}\right)$$

$$= \frac{29.5}{2}\left(\frac{79}{119}\right)$$

$$= 9.8ft.$$

Maximum allowable spacing 1/2d = (.5)(27) = 13.5in.

Use 1/2in. ϕ U Stirrups 2 @ 9in. 8 @ 12in.

# of Stirrups in each end of beam = 10

This beam is run through the building for construction economy.

Computation for Floor Beam (A-B)

Allowable $f_c = 750^{\#}/sq.in.$ $f_s = 20,000^{\#}/sq.in.$ $n = 15$

$v - 120^{\#}/sq.in.$ $u - 120^{\#}/sq.in.$

$850^{\#}/sq.in.$ @ supports

Clear Span 28ft.-00in.		Live Load	40
Bearing Span 29ft.-6in.		Slab 5in.	63
Panel Widths 9ft.-6in.	12ft.-6in.	Plaster metal lath	10
Assume 12in. girders		Flooring	5
		Partitions	16
			$134^{\#}$

Loads: Live+dead

$$134x(\frac{9.5}{2}+\frac{12.5}{2}) = 1474$$

$$Stem = \underline{200}$$

$$M = \frac{WL^2}{10} = \frac{1674x29.5^2}{10} = 145,700 ft.^{\#}/ft. \text{ strip}$$

$$V = \frac{WL}{2} = \frac{1674x29.5}{2} = 24,700^{\#}$$

Assume $j = .88$ @ support $.92$ @ center of span

$v - 120^{\#}/sq.in.$ with web reinforcement

Determination of beam section to care for shear:

$$b^1 d = \frac{V}{jv} = \frac{24,700}{.88x120} = 233.7 sq.in.$$

$b^1 = 12in.$ $d = 19.5in.$ say $d - 19.5in.$

Total depth 21.5in.

Check Wt. of Stem

$$\frac{(21.5-2)(12)(150)}{144} = 239^{\#}$$

Wt. assumed to far off re-check

Live + dead load	1474
New stem wt.	250
	$1724^{\#}$

$$M = \frac{wL^2}{10} = \frac{1724 \times \overline{20.5}^2}{10} = 150,000 \text{ft.}^{\#}/\text{ft.strip}$$

$$V = \frac{wL}{2} = \frac{1724 \times 20.5}{2} = 25,400^{\#}$$

$$b^1 d = \frac{25,400}{.88 \times 120} = 241 \text{ sq.in.}$$

$b^1 = 12$ in. $d = 20.5$in.

Total depth 22.5in.

Check new wt. of stem

$$\frac{(22.5-2)(12)(150)}{144} = 251^{\#}$$

New wt. of stem assumed

Steel area Assume $j = .92$

$$A_s = \frac{150,000 \times 12}{20,000 \times .92 \times 20.5} = 4.91 \text{ sq.in.}$$

Use 4 - 1 1/8 in. sq. bars 5.03 sq.in.

Spaced 3 in. o.c. 1 in. in the clear on sides

Check Shear

$$v = \frac{V}{bjd} = \frac{25,400}{12 \times (.88)(20.5)} = 117.3^{\#}/\text{sq.in.}$$

Bond

$$u = \frac{25,400}{4 \times 4.5 \times .88 \times 20.5} = 78.2^{\#}/\text{sq.in.}$$

At supports

$$\frac{d^1}{d} = \frac{2}{20.5} = .0976 \qquad p = p^1 - \frac{A_s}{bd} = \frac{5.03}{12 \times 20.5} = .0206$$

From diagram 10, Vol. 1 "Reinforced Concrete Construction"

by Hool

$k = 0.38$ $j = 0.885$

$$f_s = \frac{M}{A_s jd} = \frac{150,000 \times 12}{5.03 \times .885 \times 20.5} = 19,500^{\#}/\text{sq.in.}$$

$$f_c = \frac{f_s k}{n(1-k)} = \frac{19,500)(.38)}{15(1-.38)} = 798^{\#}/\text{sq.in.}$$

Stirrup Spacing

From Fig. 17 "Simplified Design of Concrete Floor Systems"

by the Portland Cement Association

$v = 117^{\#}/\text{sq.in.}$

$v - v_c = v^1$

$117 - 40 = 77$

$v^1 b = (77)(12) = 925$

$a = \frac{\ell}{2} \left(\frac{v^1}{v}\right)$

$= \frac{29.5}{2} \left(\frac{77}{117}\right)$

$= \underline{2.7}\text{ft.}$

Maximum allowable spacing

$1/2d = .5((20.5) = 10.25\text{in.}$

Use 1/2in. ϕ U stirrups

13 @ 9in.

# of stirrups in each end of beam = 13

Computation for Floor Beam (7-8)

Allowable $f_c = 750^{\#}$/sq.in. $f_s = 20,000^{\#}$/sq.in. $n = 15$

$v = 120^{\#}$/sq.in. $u = 120^{\#}$/sq.in.

$850^{\#}$/sq.in. @ supports

Clear Span 28ft. - 00in. Live load 40

Bearing Span 29ft. -00in. Dead load $\frac{94}{134^{\#}}$

Panel widths 12ft. - 6in. 12ft. -00in.

Assume 12in. girders

Loads: Live dead

$$134 \times \left(\frac{12.5}{2} + \frac{12.0}{2}\right) = 1640$$

$$\text{Stem} = \underline{300}$$

$$M = \frac{WL^2}{10} = \frac{1940 \times 29.5^2}{10} = 169,000 \text{ft.}^{\#}/\text{ft.strip}$$

$$V = \frac{WL}{2} = \frac{1940 \times 29.5}{2} = 28650^{\#}$$

Assume $j = .88$ @ support $.92$ @ center of span

$v = 120^{\#}$/sq.in. with web reinforcement

<u>Determination</u> of beam section to care for shear

$$b^1 d = \frac{V}{jv} = \frac{28650}{.88 \times 120} = 271.0 \text{ sq.in.}$$

$b^1 = 12$in. $d = 22.6$in. say 23in.

Total depth 25in.

Check wt. of stem

$$\frac{(25-2)(12)(150)}{144} - 287.5^{\#}$$

Steel area Assume $j = .92$

$$A_s = \frac{169,000 \times 12}{20,000 \times .92 \times 23} = 4.79 \text{sq.in.}$$

Use 4 - 1 1/8" sq. bars = 5.08sq.in.

Spaced 2 1/2 d o.c.

Check Shear

$$v = \frac{23650}{2.75x8x.88x23} = 64.4^{\#}/sq.in.$$

At supports

$$\frac{d^1}{d} = \frac{2}{23} = .087 \qquad p = p^1 = \frac{5.08}{12x23} = .0184$$

From diagram 10. Vol. 1 "Reinforced Concrete Construction"

by Hool

$k = .40 \qquad j = .884$

$$f_s = \frac{169,000x12}{5.08x.884x.23} = 19,650^{\#}/sq.in.$$

$$f_c = \frac{19650x.40}{15(1-40)} = 874^{\#}/sq.in.$$

Stirrup Spacing

From Fig. 17 "Simplified Design of Concrete Floor Systems"

by the Portland Cement Association

$v = 118^{\#}/sq.in.$

$v - v_c = v^1$

$118 - 40 = 78$

$v^1b = (78)(12) = 936$

$$a = \frac{\ell}{2}\left(\frac{v^1}{v}\right)$$

$$= \frac{29.5}{2}\left(\frac{78}{118}\right)$$

$$= 9.75ft.$$

Maximum allowable spacing

$1/2d = .5)(23) = 11.5in.$

Use 1/2in.ϕ U stirrups

12 @ 9in.

\# of stirrups in each end of beam = 12

This beam is run through building for construction economy.

Computation for Floor Beam (C-D)

Allowable $f_c = 750^{\#}/sq.in.$ $f_s = 20,000^{\#}/sq.in.$ $n = 15$

$v - 120 /sq.in.$ $u - 120^{\#}/sq.in.$

$350^{\#}/sq.in.$ @ supports

Clear Span 23ft. - 00in. Live load 40

Bearing Span 29ft. - 00in. Dead " $\frac{94}{134^{\#}}$

Panel widths 12ft. - 00in. & 13ft. - 00in.

Assume 12in. girders

Loads: Live + dead

$$134\left(\frac{12}{2}+\frac{13}{2}\right) = 1675$$

$$\text{Stem} = \underline{300}$$

$$M = \frac{WL}{10} = \frac{1975 \times 29.5^2}{10} = 172,000 ft.^{\#}/ft. strip$$

$$V = \frac{WL}{2} = \frac{1975 \times 29.5}{2} = 29,100^{\#}$$

Assume $j = .88$ @ support .92 @ center of span

$v = 120^{\#}/sq.in.$ with web reinforcement

<u>Determination</u> of beam section to care for shear

$$b^1 d = \frac{V}{jv} = \frac{29,100}{.88 \times 120} = 276.2 \text{ sq.in.}$$

b - 12in. d - 23.0in.

Total depth 25in.

Check wt. of stem

$$\frac{(25-2)(12)(150)}{144} = 288^{\#}$$

Steel area Assume $j = .92$

$$A_s = \frac{172,000 \times 12}{20,000 \times .92 \times 23} = 4.88 sq.in.$$

Use 4 - 1 1/8in. sq. bars = 5.08sq.in.

Spaced 2 1/2 d c.c.

Check Shear

$$v = \frac{29,100}{12x.88x23} = 119.9\#/sq.in.$$

Bond

$$u = \frac{29,100}{4x4.5x.88x23} = 50\ /sq.in.$$

At supports

$$\frac{d^1}{d} = \frac{2}{23} = .0369 \qquad p = p^1 = \frac{52.3}{12x23} = .0134$$

From diagram 10 Vol. 1 "Reinforced Concrete Construction" by Hool

$$k = .40 \qquad j = .884$$

$$f_s = \frac{172,000x12}{5.08x.884x23} = 19,980\#/sq.in.$$

$$f_c = \frac{19,980x.40}{15(1-.40)} = 888\#/sq.in.$$

Stirrup Spacing

From Fig. 17 "Simplified Design of Concrete Floor Systems" by the Portland Cement Association

$$v = 120\#/sq.in.$$

$$v - v_c = v^1$$

$$120 - 40 = 80$$

$$v^1 b = (80)(12) = 960$$

$$a = \frac{l}{2}\left(\frac{v^1}{v}\right)$$

$$= \frac{29.5}{2}\left(\frac{80}{120}\right)$$

$$= 9.85$$

Maximum allowable spacing $1/2d = (.5)(23) = 11.5in.$

Use 1/2in. ∅ U stirrups 13 @ 9in.

# of stirrups in each end of beam = 13

This beam is to be run through the building for construction economy.

Computation for Floor Beam (4-7)

Allowable $f_c = 750^{\#}$/sq.in. $f_s = 20,000^{\#}$/sq.in. $n = 15$

$v = 120^{\#}$/sq.in. $u = 120^{\#}$/sq.in.

$800^{\#}$/sq.in. @ supports

Clear Span 28ft. - 00in. Live load 40

Bearing Span 29ft. - 6in. Dead " $\underline{94}$ $134^{\#}$

Panel widths 19ft. - 6in. 13ft. -00in.

Assume 12in. girders

Loads: Live + dead

$$134\times\left(\frac{19.5}{2}+\frac{13.0}{2}\right) = 2177.5$$

$$\text{stem} = \underline{400}$$

$$M = \frac{wL}{10} = \frac{2577.5\times29.5}{10} = 224,500\text{ft.}^{\#}/\text{ft.strip}$$

$$V = \frac{wL}{2} = \frac{2577.5\times29.5}{2} = 38,000^{\#}$$

Assume $j = .88$ @ supports .92 @ center of span

$v = 120^{\#}$/sq.in. with web reinforcement

<u>Determination</u> of beam to care for shear

$$b'd = \frac{V}{jv} = \frac{38,000}{.88\times120} = 360$$

$b = 12$in. $d = 30$in.

Total depth = 32in.

Check wt. of stem

$$\frac{(32-2)(12)(150)}{144} = 375^{\#}$$

Steel area Assume $j = .92$

$$A_s = \frac{224,500\times12}{20,000\times.92\times30} = 4.88\text{sq.in.}$$

Use 4 - 1 1/8in. sq. bars = 5.06 sq.in.

Spaced 2 1/2d c.c.

Check Shear

$$v = \frac{33,[illegible]}{12x.[illegible]x30} = 120^{\#}/\text{sq.in.}$$

Bond

$$u = \frac{3[illegible]}{4x[illegible].5x.[illegible]x30} = [illegible]^{\#}/\text{sq.in.}$$

At supports

$$\frac{d'}{d} = \frac{2}{30} = .0[illegible] \qquad p = p' = \frac{[illegible]}{12x30} = .0[illegible]$$

From diagram 10 Vol. 1 "Reinforced Concrete Construction" by Hool

$$k = .378 \qquad j = .[illegible]86$$

$$f_s = \frac{22[illegible],[illegible]x12}{[illegible]x30} = 19,900^{\#}/\text{sq.in.}$$

$$f_c = \frac{19,900x.378}{15(1-.378)} = 806^{\#}/\text{sq.in.}$$

Stirrup Spacing

From Fig. 17 "Simplified Design of Concrete Floor Systems"

by the Portland Cement Association

$$v = 120^{\#}/\text{sq.in.}$$

$$v - v_c = v'$$

$$120 - 40 = 80$$
$$v'b = (80)(12) = 960$$

$$a = \frac{L}{2}\left(\frac{v'}{v}\right)$$

$$= \frac{29.5}{2}\left(\frac{80}{120}\right)$$

$$= 9.85\text{ft.}$$

Maximum allowable spacing

$$1/2d = .5(30) = 15\text{in.}$$

Use 1/2in. ϕ U stirrups

2 @ 9in. 1 @ 12in. 5 @ 15in.

\# of stirrups in each end of beam = 8

This beam is to be run through the building for construction economy.

Computation for Floor Girder (6-7-8-9-10)

These girder dimensions are to be used for floor girders:

(1-2-3-4-5-) (11-12-13-14-15-16)

Allowable $f_c = 750^{\#}$/sq.in. $f_s = 20,000^{\#}$/sq.in. $n = 15$

$v = 120^{\#}$/sq.in. $u = 120^{\#}$/sq.in.

$850^{\#}$/sq.in. supports

Clear Span 21ft. - 00in.

Bearing Span 22ft. - 00in.

Panel widths 9ft. - 6in. 12ft. - 6in.

Loads: V from beam (AB) 25,400

Stem = 400

Floor Slab (H) W $= 134 \times \frac{14.5}{2} = \underline{971}$

$\frac{1371 \times 22}{2} = \underline{15081}$

Total V = $40,481^{\#}$

Maximum bending moment

$$M = \frac{Pab}{} - \frac{(25,400)(9.5)(12.5)}{22} \times \frac{8}{10} = 109,900 ft.^{\#}$$

$$1371 \times \overline{22}^2 \times \frac{1}{10} = 66,400 ft.^{\#}$$

Total M = $176,300 ft.^{\#}$

Stem shear

$$b'd = \frac{40,481}{.88 \times 120} = 383 sq.in.$$

$b' = 12in.$ $d = 32in.$

Total depth 34in.

Check wt. of stem

$$\frac{(34-2)(12)(150)}{144} = 401^{\#}$$

Steel area assumed $j = .92$

$$A_s = \frac{176,300 \times 12}{20,000 \times .93 \times 32} = 3.5[illegible] \text{ sq.in.}$$

Use 4 - 1 in. sq. bars = 4.00 sq.in.

Spaced 2 1/2" o.c.

Check Shear

$$v = \frac{40,401}{12 \times .93 \times 32} = 113.9^{\#}/\text{sq.in.}$$

Bond

$$u = \frac{40,401}{4 \times 4 \times .93 \times 32} = 89.3^{\#}/\text{sq.in.}$$

At supports

$$\frac{d'}{d} = \frac{2}{32} = .0625 \qquad p = p' = \frac{4.00}{12 \times 32} = .0104$$

From diagram 19, Vol. 1 "Reinforced Concrete Construction"

by Hool

$$k = .35 \qquad j = .89$$

$$f_s = \frac{176,300}{3.16 \times .[illegible] \times 32} = 19,610^{\#}/\text{sq.in.}$$

$$f_c = \frac{19,610 \times .35}{15(1-.35)} = 7[illegible]3^{\#}/\text{sq.in.}$$

Typical Column Design

by using Table 13 page 4[illegible] in "Reinforced Concrete Design" by Sutherland and Clifford

Column #9 $n = 15$

Third Floor

Load: live dead = 39,048#

Size of column = 14in.

A_s = .98sq.in. Use 4 - 1/2in.sq. A_s = 1.00sq.in.

Second Floor

Load: live dead = 178,096#

Size of column = 20in.

A_s = 2.00sq.in. Use 4 - 3/4in.sq. A_s = 2.25sq.in.

First floor

Load: live dead = 267,144#

Size of column = 24in.

A_s = 2.88sq.in. Use 4 - 7/8in.sq. A_s = 3.06sq.in.

Basement

Load: live dead = 356,192#

Size of column = [illegible]in.

A_s = 3.92sq.in. Use 4 - 1 in. sq. A_s = 4.00sq.in.

For lateral ties use 1/4in. round bars. Spaced 7.5in. apart.

Design of a Footing for an Interior Column

Use 2,000#/sq.in. concrete and 20,000#/sq.in. steel

Column load 356,192#

Soil pressure - 2,000#/sq.ft. (Sandy Clay)

Select twO-way reinforcement

Assume wt. of footing = 33,000#

Footing base area required
$$\frac{\begin{array}{r}356,192\\ 33,000\\ \hline 389,192\end{array}}{2,000} = 194.5\text{sq.ft.}$$

Base of footing 14ft. sq.

$W = 2,000^{\#}/\text{sq.ft.}$

$a = 28\text{in.} = 2.4\text{ft.}$

$c = 1/2(14-2.4) = 5.8\text{ft.}$

$M = \frac{W}{2}(a\ 1.2c)c^2 - \frac{2,000}{2}(2.4\ (1.2)(5.8)33.6$

$= 314,100\text{ft.}^{\#} = 3,769,200\text{in.}^{\#}$

Try $d = 40$in. a total depth - 44in.

Shear

$V = W\ L^2-(a\ 2d)^2 = 2,000\ \overline{14} -(2.4\ 6.67)^2$

$= \qquad 2,000\ 196-82.2$

$= 227,600^{\#}$

$d = 12 \qquad j = .87$

$v = \frac{227,600^{\#}}{4(2.4\ 6.67)(12)(.88)(13)} = 45.7^{\#}\text{sq.in.}$

Allowable shear $v = .06\quad f_c = 120^{\#}$/sq.ft. with ordinary anchorage.

$A_s = \frac{M}{f_s jd} = \frac{3,769,200}{20,000(.88)(40)} = 5.35\text{sq.in.}$

Use 14- 5/8in.sq. bars for each band, giving a steel areaof 5.47sq.in.

Effective width of footing

$$= a \ 2d \ 1/2(L-a-2d) = 2.4 \ 6.67 \ 1/2(14-2.4-6.67)$$

$$= 11.53\text{ft.} = 138.3\text{in.}$$

Space the 14 bars equally over 138in. about 9,86in. c.c.

Two ways

Bond

$$u = \frac{w(ac+c^2)}{\Sigma_o jd} = \frac{2,000(13.92+33.65)}{(14)(2,5)(.88)(40)} = 76.5^{\#}/\text{sq.in.}$$

The following computations were made of the original lay out but as there was a change made in the continuity they had to be discarded.

J. E. B.

Computation for Floor Slab: (A) using $M = \frac{wL^2}{10}$

Allowable $f_c = 750$ $f_s = 20{,}000$ $n = 15$ $v = 120$ $u = 120$

Clear Span 8ft. - 6in.	Live load		40
Bearing Span 9ft. - 6in.	Slab 4in.		50
Assume 12in. beams	Plaster	metal lath	10
	Flooring		5
	Partitions		16
			121#/sq.ft.

$$M = \frac{wL^2}{10} = \frac{121 \times 8.6^2}{10} = 894.92^{\#} \text{ ft./ft. strip.}$$ Interior Span

$$V = \frac{wL}{2} = \frac{121 \times 8.6}{2} = 520.3^{\#}$$

Thickness:

$$d = \sqrt{\frac{M}{bR}} = \sqrt{\frac{894.92 \times 12}{12 \times 113.8}} = \sqrt{7.54} = 2.65 \text{ say } 3.00$$

$$D = \frac{1.00\text{in.}}{4.00\text{in.}}$$

Use 4in. Slab

$d = 3$in.

Floor Slab: Steel

Interior Span: $A_s = pbd = .0068 \times 12 \times 3 = .2348$ sq. in.

3/8in. ϕ @ 5 1/2in. o.c. for Interior

Bond Stress @ Supports:

$$v = \frac{V}{bjd} = \frac{520.3}{12 \times .88 \times 3} = 16.42^{\#}/\text{sq.in.}$$

For 3/8 in. ϕ :

$$u = \frac{vb}{\Sigma o} = \frac{16.42 \times 5.5}{3.142 \times 3/8} = 76.7^{\#}/\text{sq.in.}$$

Computation for Floor Slab (B) using $M = \frac{WL^2}{10}$

Allowable $f_c = 750$ $f_s = 20{,}000$ $n = 15$ $v = 120$ $u = 120$

Clear Span 11ft. - 6in.	Live load	40
Bearing Span 12ft. - 6in.	Slab 5in.	63
Assume 12in. beams	Plaster metal lath	10
	Flooring	5
	Partitions	16
		134#/sq.ft.

$M = \frac{WL^2}{10} = \frac{134\times\overline{11.5}^2}{10} = 177.\text{ft.}^{\#}/\text{ft. strip.}$ Interior Span

$V = \frac{WL}{2} = \frac{134\times 11.5}{2} = 770.5^{\#}$

Thickness:

$d = \sqrt{\frac{M}{bR}} = \sqrt{\frac{1771\times 12}{12\times 118.8}} = \sqrt{14.92} = 3.86$ say 4.00

$$\begin{aligned} &\ \underline{1.00\text{in.}} \\ D &= 5.00\text{in.} \end{aligned}$$

Use 5in. Slab

$d = 4\text{in.}$

Floor Slab: Steel

Interior Span:

$A_s = pdb = .0068\times 12\times 4 = .326$

3/8 in.ϕ @ 4in. o.c. for Intr.

Bond Stress @ Supports:

$v = \frac{V}{bjd} = \frac{770.5}{12\times .88\times 4} = 18.28^{\#}/\text{sq. in.}$

For 3/8 in.ϕ :

$u = \frac{vb}{\sum o} = \frac{18.28\times 4}{3.142\times 3/8} = 62.0^{\#}/\text{sq. in.}$

Computation for Floor Slab (C) using $M = \frac{WL^2}{10}$

Allowable $f_c = 750$ $f_s = 20,000$ $n = 15$ $v = 120$ $u = 120$

Clear Span 11ft. - 00in.	Live load		40
Bearing Span 12ft. - 00in.	Slab 5in.		50
Assume 12in. beams	Plaster	metal lath	10
	Flooring		5
	Partitions		16
			134#/sq.ft.

$M = \frac{WL^2}{10} = \frac{134 \times 3.142}{10} = 1621$#/ft. strip. Interior span

$V = \frac{WL}{2} = \frac{134 \times 11}{2} = 737.5$#

Thickness:

$d = \sqrt{\frac{M}{bR}} = \sqrt{\frac{1621 \times 12}{12 \times 118.8}} = \sqrt{13.68} - 3.7$ say 4.o

$D = \frac{1.0in.}{5.0in.}$

Use 5in. Slab

$d = 4in.$

Floor Slab: Steel

Interior Span:

$A_s = pdb = .0068 \times 12 \times 4 = .326$ sq.in.

3/8 ft. ϕ @ 4in. o.c. for Int.

Bond Stress @ Supports:

$v = \frac{V}{bjd} = \frac{737.5}{12 \times .88 \times 4} = 17.47$#/sq.in.

For 3/8 in. ϕ :

$u = \frac{vb}{\Sigma o} = \frac{17.47 \times 4}{3.142 \times 3/8} = 55.9$#/sq.in.

Computation for Floor Slab (D) using $M = \frac{WL^2}{10}$

Allowable $f_c = 750$ $f_s = 20{,}000$ $n = 15$ $v = 120$ $u = 120$

Clear Span 12 ft. - 00in.	Live load	40
Bearing Span 13ft. - 00in.	Slab 5in.	63
Assume 12in. beam.	Plaster metal lath	10
	Flooring	5
	Partitions	16
		134#/sq.ft.

$M = \frac{WL}{10} = \frac{134 \times 12}{10} = 1930^{\#}$/ft. strip. Interior span

$V = \frac{WL}{2} = \frac{134 \times 12}{2} = 804^{\#}$

Thickness:

$$d = \sqrt{\frac{M}{bR}} = \sqrt{\frac{1930 \times 12}{12 \times 118.8}} = \sqrt{16.23} = 4.03 \text{ say } 4.00$$

$$D = \frac{1.00\text{in.}}{4.00\text{in.}}$$

Use 5in. Slab

$d = 4$in.

Floor Slab: Steel

Interior Span:

$$A_s = pdb = .0068 \times 12 \times 4 = .326$$

3/8 in. ϕ @ 4in. o.c. for Int.

Bond Stress @ Supports:

$$v = \frac{V}{bjd} = \frac{804}{12 \times .88 \times 4} = 19.1^{\#}/\text{sq.in.}$$

For 3/8 in. ϕ :

$$u = \frac{vb}{\Sigma o} = \frac{19.1 \times 4}{3.142 \times 3/8} = 64.5^{\#}/\text{sq.in.}$$

Computation for Floor Slab (A) using $M = \frac{wL^2}{8}$

Allowable $f_c = 750$ $f_s = 20{,}000$ $n = 15$ $v = 120$ $u = 120$

Clear Span 8 ft. - 6in.	Live load	40
Bearing Span 9ft. - 6in.	Slab 4in.	50
Assume 12in. beams	Plaster metal lath	10
	Flooring	5
	Partitions	16 "
		121 "/sq.ft.

$M = \frac{WL^2}{8} = \frac{121 \times 9.5^2}{8} = 1119$ ft."/ft. strip. Interior Span

$V = \frac{WL}{2} = \frac{121 \times 9.5}{2} = 520.3$"

Thickness:

$$d = \sqrt{\frac{M}{bR}} = \sqrt{\frac{1119 \times 12}{12 \times 118.8}} = \sqrt{9.44} = 3.04 \text{ say } 3.00$$

$$D = \frac{1.00\text{in.}}{4.00\text{in.}}$$

Use 4in. Slab

$d = 3$in.

Floor Slab: Steel

Interior Span:

$A_s = pdb = .0068 \times 3 \times 12 = .2348$ sq.in.

3/8 in. ϕ @ 5 1/2 in. o.c. Intr.

Bond Stress @ Support:

$v = \frac{V}{bjd} = \frac{520.3}{12 \times .88 \times 3} = 16.42$"/sq.in.

For 3/8 in. ϕ :

$u = \frac{vb}{\Sigma} = \frac{16.42 \times 5.5}{3.142 \times 3/8} = 76.7$"/sq.in.

Computation for Floor Slab (B) using $M = \frac{WL^2}{8}$

Allowable $f_c = 750$ $f_s = 20{,}000$ $n = 15$ $v = 120$ $u = 120$

Clear Span 11ft. - 6in.	Live load	40
Bearing Span 12ft. - 6in.	Slab 6in.	75
	Plaster metal lath	10
	Flooring	5
	Partitions	16
		146#/sq.ft.

$M = \frac{WL^2}{8} = \frac{146x\overline{11.5}^2}{8} = 2415ft.^{\#}/ft.$ strip

$V = \frac{WL}{2} = \frac{146x11.5}{2} = 1680 = 840^{\#}$

Thickness:

$$d = \sqrt{\frac{M}{bR}} = \sqrt{\frac{2415x12}{12x118.8}} = \sqrt{20.35} = 4.52 \text{ say } 5.00$$

$D = \frac{1.00in.}{6.00in.}$

Use 6in. Slab

$d = 5in.$

Floor Slab: Steel

Interior Span:

$A_s = pdb = .0068x12x5 = .408$

1/2 in.ϕ @ 5 1/2 o.c. for Intr.

Bond Stress @ Supports:

$v = \frac{V}{bjd} = \frac{840}{12x.88x5} = 15.9^{\#}/sq.in.$

For 1/2 in.ϕ :

$u = \frac{vb}{\Sigma o} = \frac{15.9x5.5}{3.142x1/2} = 55.5^{\#}/sq.in.$

Computation for Floor Slab (C) using $M = \frac{WL^2}{8}$

Allowable $f_c = 750$ $f_s = 20,000$ $n = 15$ $v = 120$ $u = 120$

Clear Span 11ft. - 00in.	Live load	40
Bearing Span 12ft. - 00in.	Slab 5 1/2in.	69
Assume 12in.beam	Plaster metal lath	10
	Flooring	5
	Partitions	16
		140 #/sq.ft.

$M = \frac{WL^2}{8} = \frac{140 \times \overline{3.142}^2}{8} = 2120 ft.^{\#}$/ft. strip. Interior Span

$V = \frac{WL}{2} = \frac{1530}{2} = 765^{\#}$

Thickness:

$$d = \sqrt{\frac{M}{bR}} = \sqrt{\frac{2120 \times 12}{12 \times 118.8}} = \sqrt{17.7} = 4.21 \text{ say } 4.50$$

$D = \frac{1.00in.}{5.50in.}$

Use 5.5in. Slab

d - 4.5in.

Floor Slab: Steel

Interior Span:

$A_s = pdb = .0068 \times 12 \times 4.5 = .367$

1/2 in.$^{\phi}$ @ 6 1/2 in. o. c. Intr.

Bond Stress @ Supports:

$$v = \frac{V}{bjd} = \frac{765^{\#}}{12 \times .88 \times 4.5} = 16.1^{\#}/\text{sq. in.}$$

For 1/2 in. ϕ :

$$u = \frac{vb}{\Sigma o} = \frac{16.1 \times 6.5}{3.142 \times 1/2} = 66.5^{\#}/\text{sq. in.}$$

[illegible]

$$[illegible]$$

$$[illegible]$$

[illegible]

$$[illegible]$$

[illegible]

[illegible]

$$[illegible]$$

[illegible]

$$[illegible]$$

$$[illegible]$$

Computation for Floor Slab (D) using $M = \frac{WL^2}{8}$

Allowable $f_c = 750$ $f_s = 20{,}000$ $n = 15$ $v = 120$ $u = 120$

Clear Span 12ft. - 00in.	Live load	40
Bearing Span 13ft.-00in.	Slab 6in.	75
Assume 12in. beam	Plaster metal lath	10
	Flooring	5
	Partitions	16
		146#/sq.ft.

$M = \frac{WL^2}{8} = \frac{146\times 12^2}{8} = 2630$ ft.#/ft. strip. Interior Span

$V = \frac{WL}{2} = \frac{1751}{2} = 875.5$#

Thickness:

$$d = \sqrt{\frac{M}{bR}} = \sqrt{\frac{2630\times 12}{12\times 118.8}} = \sqrt{22.3} = 4.72 \text{ say } 5.00$$

$$D = \frac{1.00\text{in.}}{6.00\text{in.}}$$

Use 6in. Slab

d - 5in.

Floor Slab: Steel

Interior Span:

$A_s = pdb = .0068\times 5\times 12 = .407$

1/2 in.ϕ @ 5 1/2 in. o.c. for Intr.

Bond Stress @ Supports:

$$v = \frac{V}{bjd} = \frac{875.5}{12\times .88\times 5} = 16.63\text{\#/sq. in.}$$

For 1/2in.ϕ :

$$u = \frac{vb}{\Sigma o} = \frac{16.63\times 5.5}{3.142\times 1/2} = 58.3\text{\#/sq.in.}$$

Bibliography

Reinforced Concrete Structures

by Peabody

Reinforced Concrete Construction

Vol 1 and 2 by Hool

Reinforced Concrete Design

by Sutherland and Clifford

Publications

by the Portland Cement Association

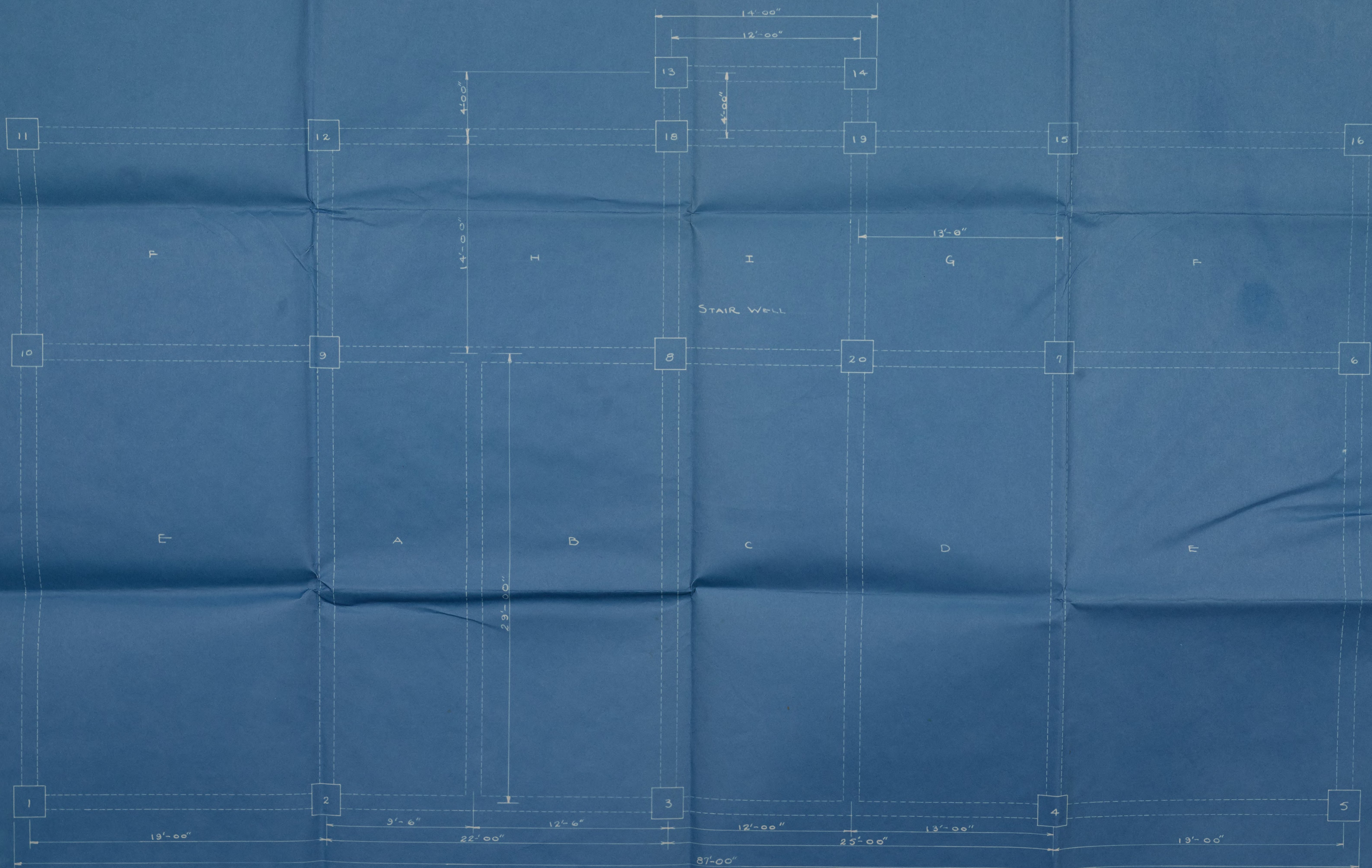
[redacted]

[redacted]

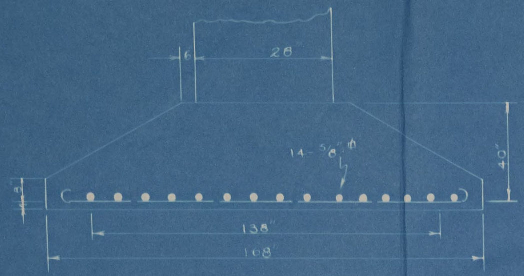
Pocket has:
4 plans

BEAM - GIRDER - FLOOR SLAB & COLUMN LAY OUT

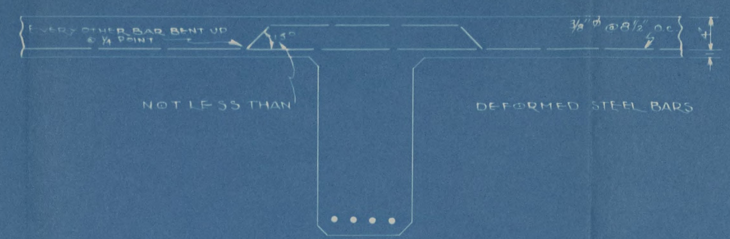
SCALE 1=40



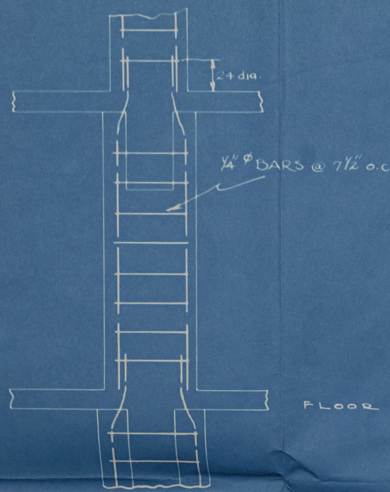
BECHTOLD



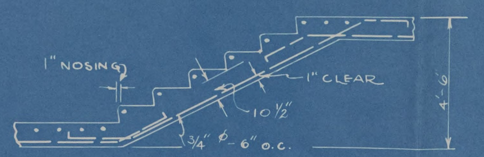
Footing
Scale 1=30



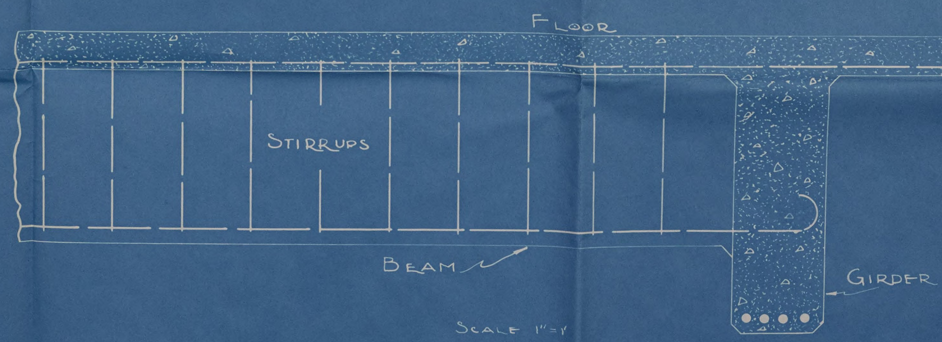
Floor Slab
Scale 1"=1'



Column
Scale 1"=1'



Stair Slab

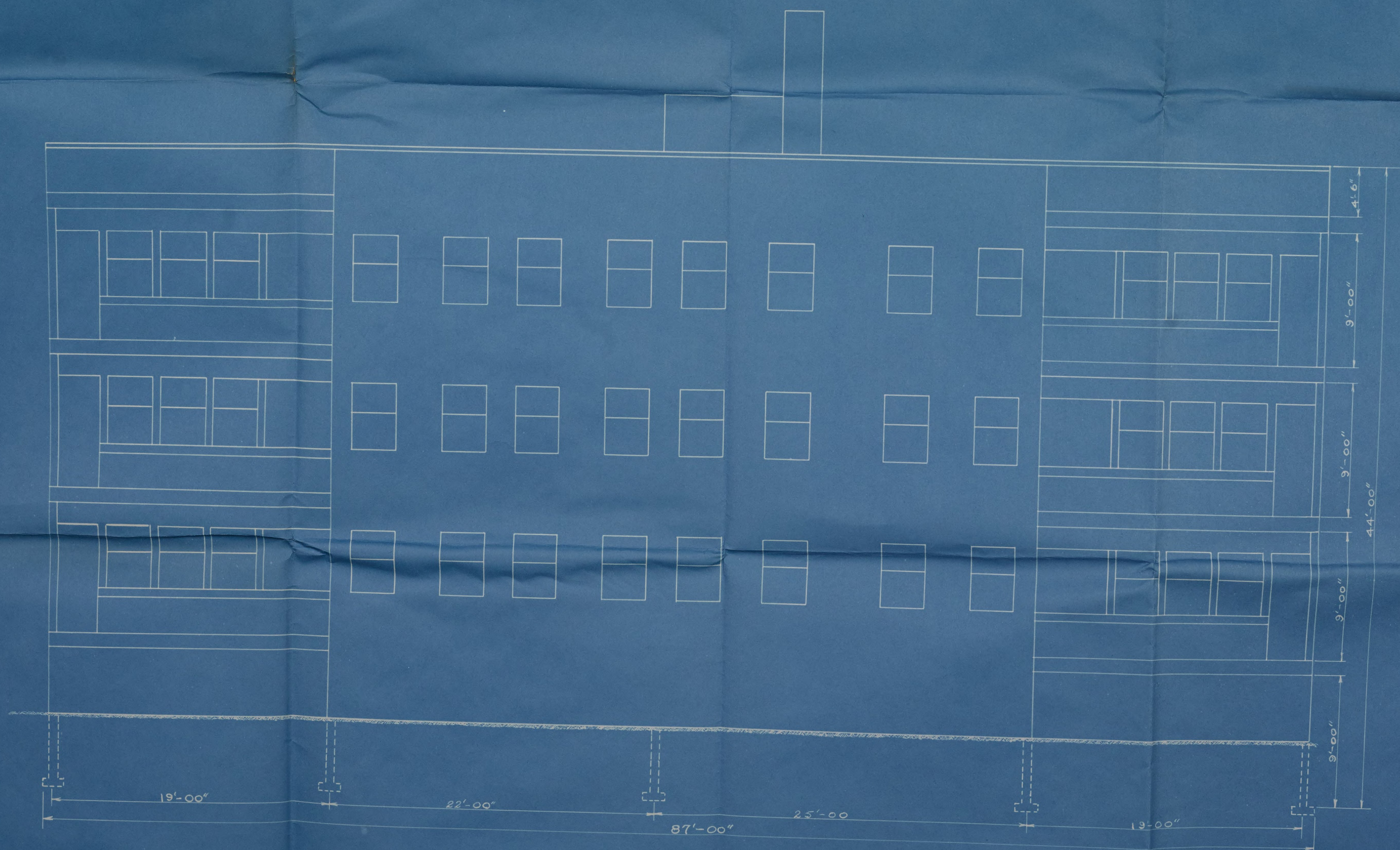


Scale 1"=1'

Typical Steel Placement
Scale noted

Bechtold

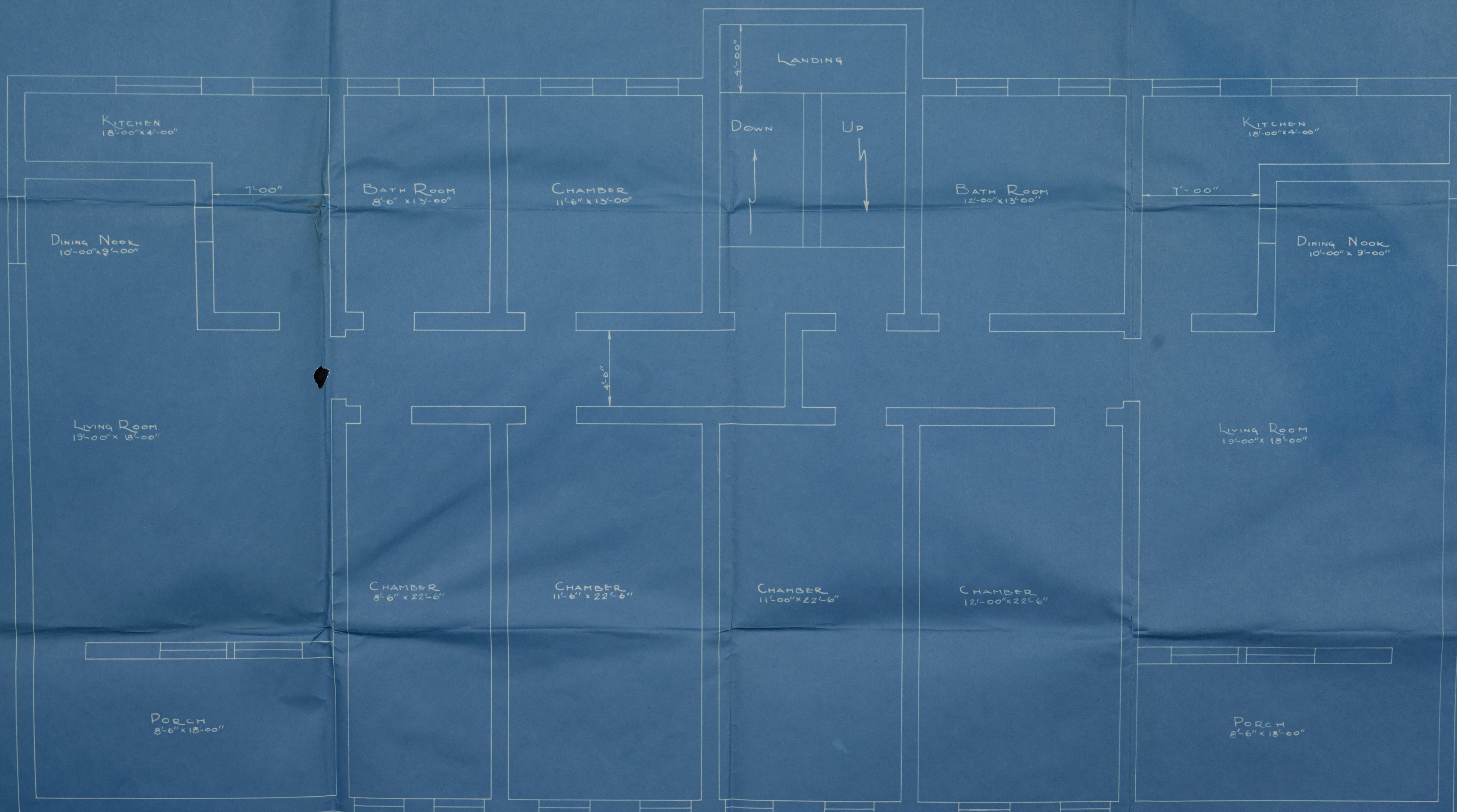
FRONT ELEVATION
SCALE 1:50



BECHTOLD

Floor Plan

Scale 1:40



Bechtold