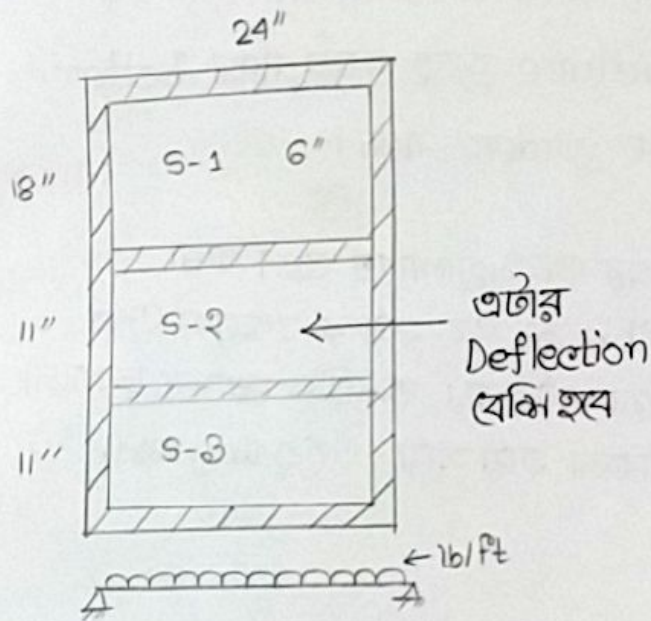


Dr. Md. Shafiul Bari.
(Sunday)

Topics

- 1) Slab
- 2) Footing

□ Column supported Slab: (Flat Plate, Flat Slab)



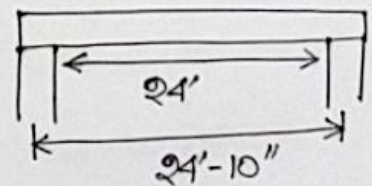
- Theoretically, continuous support এ neg moment থাকবে।
- Short direction এ 'M' বেশি, তাই এখানে main bar দিতে হবে।
- Support এ deflection theoretically zero.
- Rotation বন্ধ হলে deflection ও বন্ধ।
- Deflection বন্ধ হলে M, ও V বন্ধ।

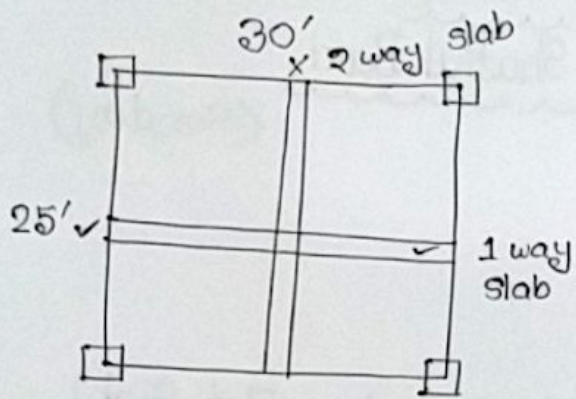
$$W_u = 276 \times 12 + 12 \times \frac{12 \times 12}{144} \times 150$$

L = c/c distance of support

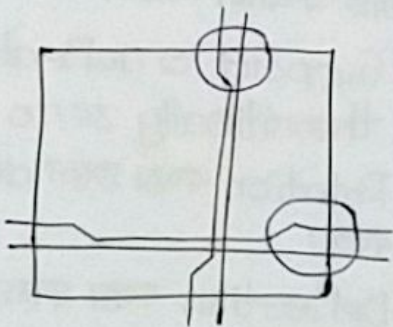
class এ বই আনতে হবে।

- Chapter 12 নড়তে হবে।





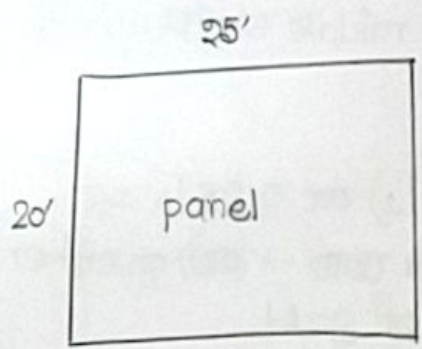
- Column সংখ্যা কমানোর জন্য মাঝে মাঝে Beam দেয়া হয়।
- Depth of beam দ্বারা structure দুটো একই রাখা Better.
- Short span এর beam কে girder বলে।



side এর অংশগুলোতে OKD করা possible না এ. ২ দিক থেকেই OKD আসলে ৩টি বার অন্যটির ভেতরে ঢুকানো হোকিলা হতে পারে। (২ way slab এ)

Lecture-2 Column Supported Slab

p-450, fig-13.16



slab thickness,
S.S, $h = \frac{\text{perimeter}}{165} \times$

$h = \frac{\text{perimeter (inch)}}{160}$

2 way slab

thickness \rightarrow 13.8 (a)
 কইএর 13.8 (b)
 13.8 (c)

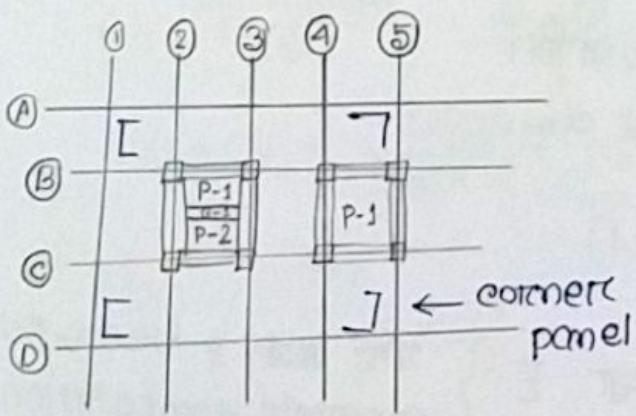
$0.2 < \alpha_m < 2 \rightarrow 13.8(a)$
 (beam $\alpha_m > 2 \rightarrow 13.8(b)$
 supported)

As per ACI code,

$h = \frac{1.8 \left(0.8 + \frac{f_y}{200} \right)}{36 + 9/\beta}$

2 way slab

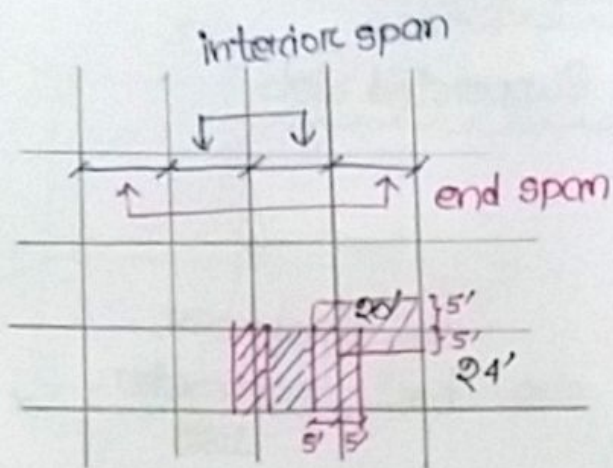
Example 13.2



* যে panel এর সবদিকে panel আছে,
 আটা \rightarrow interior panel.

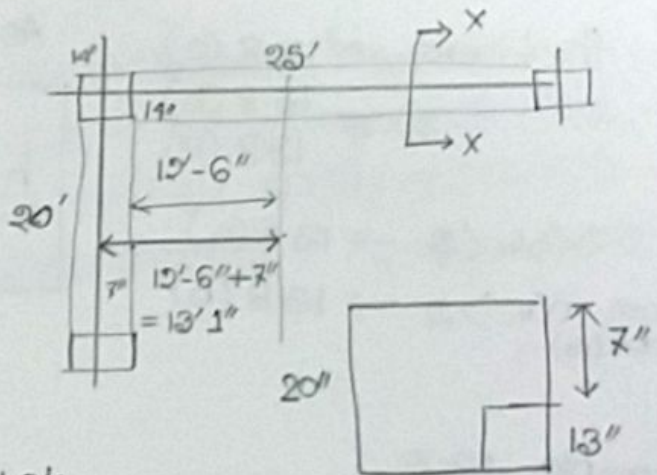
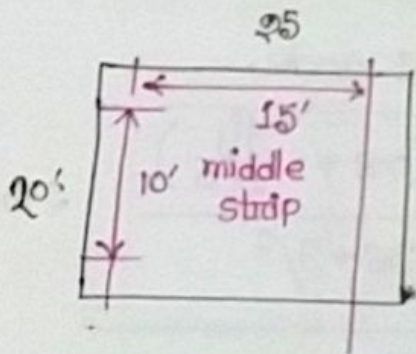
* যে panel এর কোন একদিকে
 discontinuity আছে \rightarrow
 exterior panel.

* ২টি side এ continuity
 এবং ২টি " " discontinuity
 = corner panel



▣ column strip
▣ middle strip

panel - 1) column strip → 0.25 (L₁) or 0.25 L₂ or
2) Middle strip → or on either side of grid.



P → 451

$$\alpha_m = \frac{\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4}{4}$$

একটা panel এর 4 টি বাহু। তাই α 4 টি।
4 টি বাহুর stiffness এর avg হল α_m .

$$\alpha = \frac{E_{cb} I_b}{E_{cs} I_s} \dots (E_c^n 13.4)$$

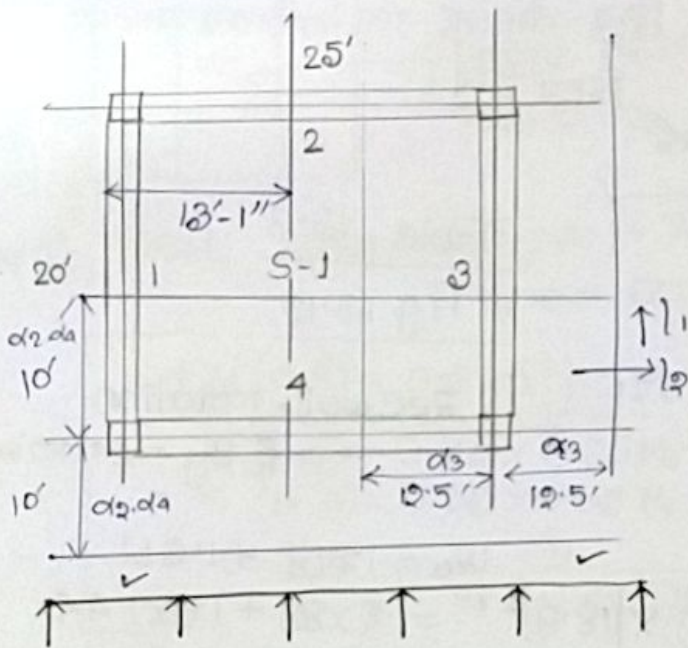
$E_{cb} \rightarrow$ বীক্ষের concrete এর E } যদি slab ও beam এর
 $E_{cs} \rightarrow$ slab " " E } concrete composition
same হয়, তবে $E_{cb} = E_{cs}$

$I_b \rightarrow$ M.O.I of beam provided on that line
 $I_s \rightarrow$ " " slab

- $\alpha_2 = \alpha_3 = \alpha_4 = 0$; For Flat plate with edge beam only.
- यदि edge beam न हो, तो α_1 0 zero.

Lecture-3

Example-13.2



$$0.2 < \alpha_m < 2.0 \quad 13.8a$$

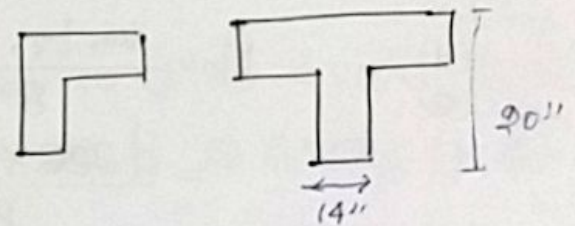
$$\alpha_m > 2.0 \quad h = l_n \quad (13.8b)$$

$$\alpha_m = \frac{\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4}{4}$$

$$\alpha = \frac{E_{cb} I_b}{E_{cs} I_s}$$

2, 4 → end span

1, 3 → interior span



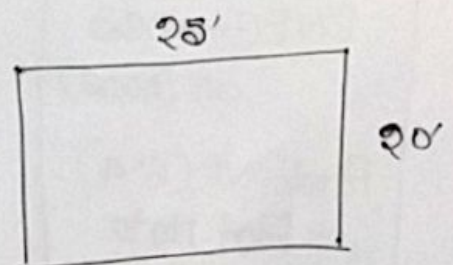
$$\alpha_1 = \frac{E_{cb} I_b}{E_{cs} I_s} = \frac{I_{b1}}{I_{s1}} = \frac{14000}{(13.1 \times 12) \times \frac{7^3}{12}}$$

$$h = \frac{\text{perimeter}}{160} = \frac{6 \times 7.5}{1} \approx 7''$$

$$\alpha_2 = \alpha_4 = \frac{18700}{(20 \times 12) \times \frac{7^3}{12}}$$

$$\alpha_3 = \frac{18700}{(25 \times 12) \times \frac{7^3}{12}}$$

य direction में $M \rightarrow L_1$
 और perpendicular $\rightarrow L_2$



$l_n = \text{clear span}$

$$l_n = 25 \times 12 - 14 = 286''$$

$$\text{OR } 20 \times 12 - 14 = 226''$$

$$h = \frac{\ln(0.8 + \frac{f_y}{200,000})}{36 + 9\beta}$$

$$= \frac{\ln(0.8 + \frac{60,000}{200,000})}{36 + 9(\frac{286}{226})}$$

$$= 6.63''$$

$$\approx 7''$$

* যেহেতু span এর জন্য ফাই thickness, সেটাই provide করবে। যদি কোন একটি panel এ specially ব্রহ্ম thickness দরকার হয়। তবে ওখানে অন্যান্য span এর 't' provide করবে কিন্তু shear reinforcement দিয়ে দিব।

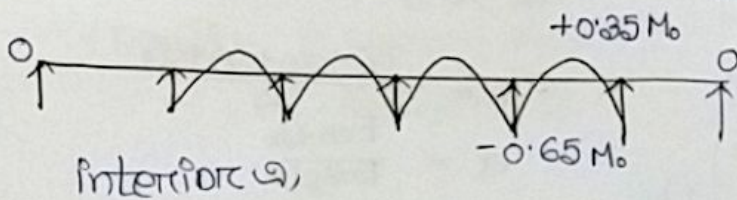


Table 13.3
Fig 13.12

- (a) আন্নাঙ্গের (b) case.
(b)
(c)
(d)
(e)

Ret wall - rotation
fully restrained

$$M_0 = \frac{w_u L^2 l_n^2}{8}$$

$$= \frac{\{336 \times (25')^2\} \times (18.8)^2}{8}$$

$$= 371 \text{ K ft}$$

$$w_u = 1.2DL + 1.6LL$$

$$= 1.2 \times 88 + 1.6 \times 1.44$$

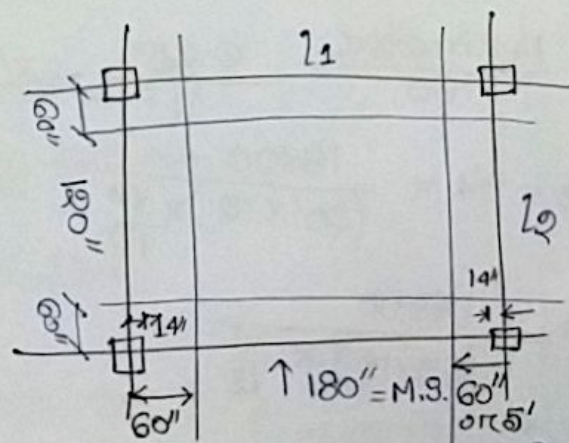
$$= 336 \text{ psf}$$

$$+M = 0.35 M_0$$

$$-M = 0.65 M_0$$

BNBC-1993
৩১৮ (২০০৬)
Part VI (6.4)
Flat plate

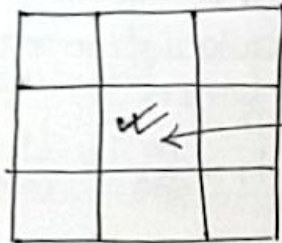
$$c.s = 120'' - 14'' = 106''$$



0.25 l₁, 0.25 l₂ এর মধ্যে মোট ছোট জেট হবে চিট all direction
→ ∞ m strip.

+M (e.s) = 0.35 M₀
-M (e.s) = 0.65 M₀

Flat plate with no beam:



Design করবে
অর্থাৎ $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$, e.z, beam নাই, তাই $I_{beam} = 0$

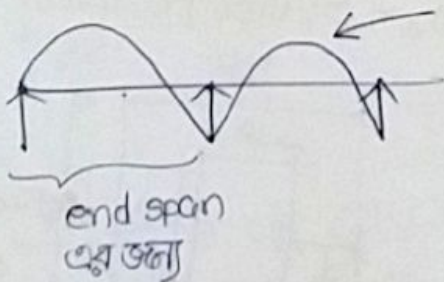
অর্থাৎ, Interior (-ve) = 75%
(+ve) = 60%

$$\begin{aligned} +M (e.s) &= 0.6 \times 0.35 M_0 = \frac{K'}{10'} = K' / ft \\ +M (M.S) &= 0.4 \times 0.35 M_0 \\ -M (e.s) &= 0.75 \times 0.65 M_0 \\ -M (M.S) &= 0.25 \times 0.65 M_0 \\ +A_s (e.s) &= \frac{M_u}{\phi f_y (d - \frac{a}{2})} \end{aligned}$$

13.2

← 12 ϕ @ 4" c/c (e.s)
← 12 ϕ @ 6" c/c (M.S)

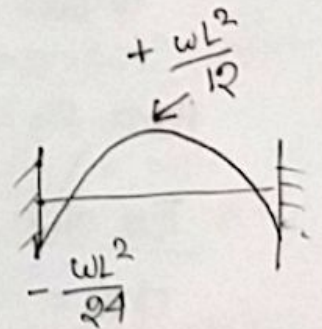
C.T → Flat plate এর উপর



- 1) (+ve) M
- 2) ext (-ve)
- 3) Int (-ve)

middle span
এর জন্য

- 1) (+ve) M
- 2) int (-ve) M



Lecture-4

Slab Design

Thickness \rightarrow $\cdot h =$

Moment \rightarrow reinforcement

$$\phi M_n > M_u$$

$$\phi V_n > V_u$$

Forc. slab $\phi V_c > V_u$ (thickness এখন হতে হয়)

• Abnormal span হলে $\phi V_c < V_u$ হয়, তখন shear reinf. দিবে।

• Flat plate এ $\phi V_c < V_u$ হলে shear reinf. দিবে।

Beam shear

$$\phi V_n = \phi V_c + \phi V_s$$

$$= 2\sqrt{f_c'} bd + \phi V_s$$

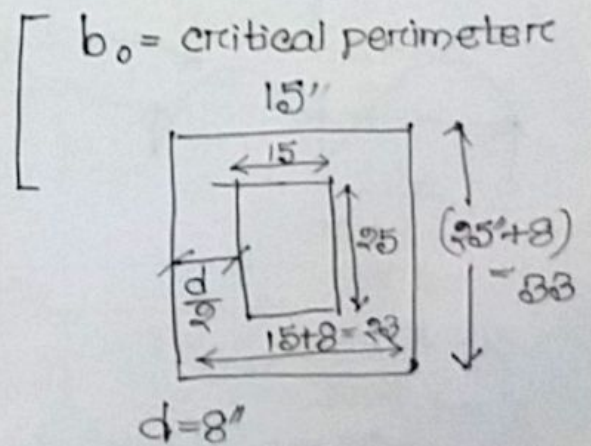
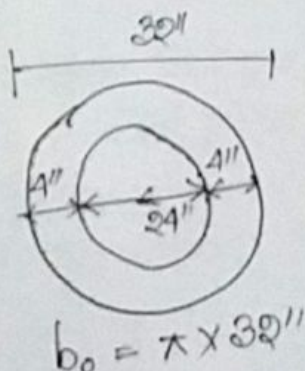
Here, $f_c' = \text{psi}$

In BNBC,
 $0.17\sqrt{f_c'} bd \rightarrow$ in SI unit
 $f_c' = \text{N/mm}^2$
 $= \text{MPa}$

Forc. slab (Punching shear)

$$\phi V_n = \frac{\phi V_c}{2} + \phi V_s$$

$$\phi V_c = \phi 4\sqrt{f_c'} b_o d$$



$$b_o = 56 \times 2 = 112$$

$$= (28 + 33) \times 2 = 112$$

• যেখন Beam না থাকলে Table থেকেও calculation করতে পারি।

$$h = \frac{l_n}{30} = \frac{l_n}{33}$$

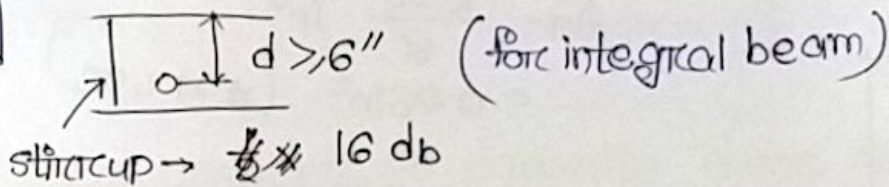
$l_n = \text{max span use}$
করবে

* critical perimeter \rightarrow অর্থাৎ দিলে punch হবে বা fail হবে।

[P-464]

f_c^n \leftarrow where, $n = \frac{1}{3}$ (ACI)
 $n = \frac{1}{3}$ (British)

[Fig 13.24]

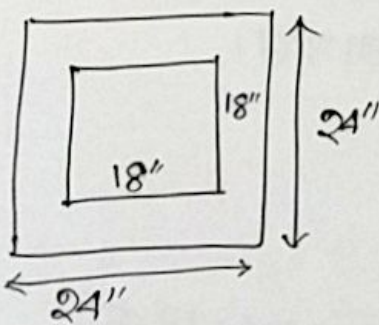


[13.4] Slab thickness = 7 1/2"

$$\therefore W_u = (7.5 \times 12.5 + 25 + 50) \times 1.2 + 1.6 \times 100$$

Here, given, $w_u = 300 \text{ psf}$

$$d = 6''$$

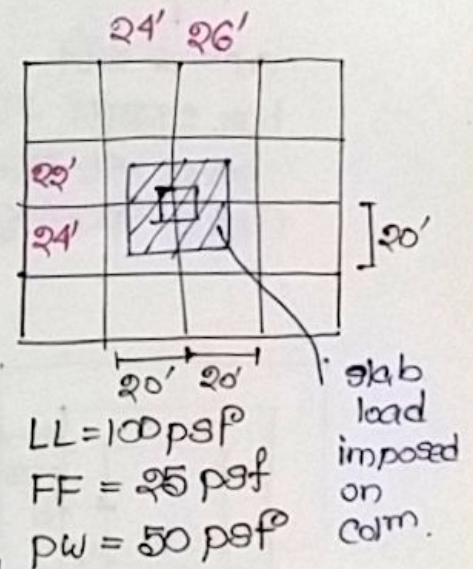


$$b_o = 24 \times 4 = 96''$$

$$V_u = 300 \left[20' \times 20' - \frac{24' \times 24'}{12' \times 12'} \right]$$

$\rightarrow 2 \times 2.5'$

$$= 118.8 \text{ K}$$



যদি • pink dimension হত তবে,

$$V_u = 300 (23 \times 25)$$

$$\phi V_c = 0.75 \times 4 \sqrt{4000} \times 96 \times 6$$

$$= 109.3 \text{ kip}$$

Since $\phi V_c < V_u \rightarrow$ shear reinforcement req.

$$\therefore V_u = \frac{\phi V_c}{2} + \phi V_s$$

$$\Rightarrow 118.8 = 54.6 + \phi V_s$$

$$\therefore V_s = 85.6 \text{ K} < 3 \sqrt{f_c} b_o d$$

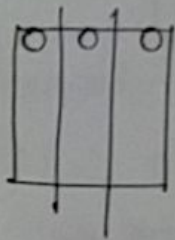
$$= 85.6 \text{ K} < 109.3 \text{ [OK]}$$

Bend up bar দিয়ে shear reinf. provide করা হলে, $V_s \leq 3 \sqrt{f_c} b_o d$ হবে।

meet না করলে integral beam use করুন। তখন

$4\sqrt{f_c} b_o d$ use হবে।

যদি $V_u > 4\sqrt{f_c} b_o d$ হয়, তবে slab thickness বাড়িয়ে দিতে হবে।



exam এ তিন
bar থাকলে ২টা
bend use করে
(খালি spacing এ)

$$A_s = \frac{2.02}{8} \text{ in}^2$$

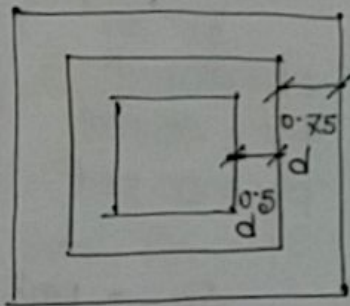
$$= 0.26 \text{ in}^2 \text{ (#5 use)}$$

৪- #5 bar

• মেজাজে থাকুক না কেন symmetric
হতে হবে।

• concrete code সরাসরি বড় size দেবে।

• international এ ছোট dia code use করুন।



• exam এ speciality করে না করলে,
integral beam or bend up bar
এ কোন নিয়ম করা যাবে।

Ex. 13.5

$$\phi V_c = 0.75 \times 4 \sqrt{4000} \times 4 \times 18 \times 6$$

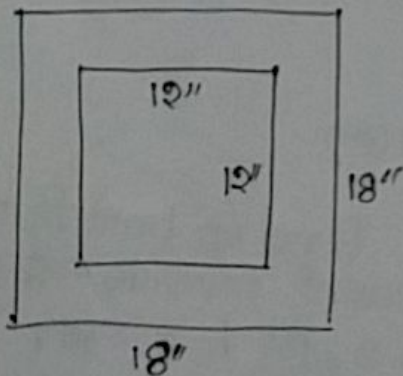
$$= 82 \text{ kIP}$$

$$V_u = 120 \text{ kIP}$$

$\phi V_c < V_u \rightarrow$ shear rein. required

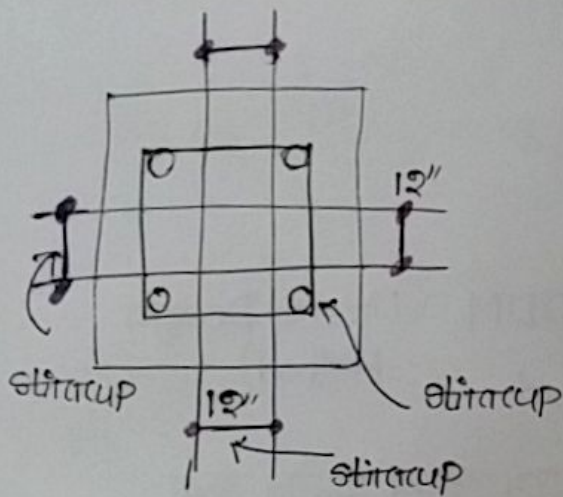
$V_u > 6\sqrt{f_c} b_o d$ তখন shear rein.
লাগবে।

$$\phi V_n (\text{max}) = 122.9 \text{ k} > V_u \text{ [OK]}$$



$$d = 6''$$

Total ৪টা leg in stirrups. ফিরে 4
stirrups in critical perimeter.



$$S = \frac{\phi A_v f_{yd}}{V_u - \phi V_c} = \frac{0.75 \times 8 \times 0.11 \times 60 \times 6}{120 - 41} = 3.01" \text{ c/c}$$

$$S_{max} = \frac{d}{2} = 3"$$

$b_0 = ?$ যখন concrete এর capacity shear এর চেয়ে বেশি।

$$\therefore 120 = 0.75 \times 4 \times \sqrt{4000} \times b_0 \times 6$$

$$\therefore b_0 = 105.4"$$

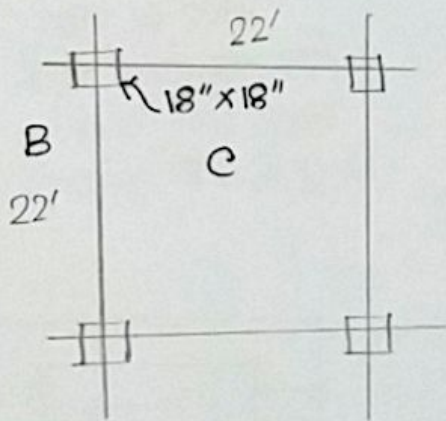
$$\therefore 6 \times 4 + \sqrt{2} \times 4 = 105.4"$$

$$\therefore x = 14.4"$$

Lecture-5

Ex. 13.3 Flat plate Design by DDM. (Direct Design Method).
P-458 — with or without edge support

- কোন span হওয়া বন্ধে অনেক বেশি বড় হয়ে গেলে স্রোটার জন্য thickness বের করে design করার না। বরং shear reinf. provide করবে। thickness use করার regular span এর।



$$f'_c = 4 \text{ ksi}$$

$$f_y = 60 \text{ ksi}$$

$$LL = 100 \text{ psf}$$

$$FF = 20 \text{ psf}$$

Here, $l_1 = l_2 = 22'$
 $l_n = 22' - \underbrace{1.5'}_{\text{colm}} = 20.5'$

$$h = l_n / 30 = \frac{20.5 \times 12}{30} = 8.2'' \approx 8.5''$$

Colm strip = 11'
 Middle strip = 11'

$$W_u = 1.2 \text{ D.L} + 1.6 \text{ LL}$$

$$= 1.2 [8.5 \times 12 \times 5 + 20] + 1.6 \times 100$$

$$= 0.312 \text{ ksf} \quad (150 \div 12)$$

$$M_o = \frac{W_u l_2 l_n^2}{8}$$

$$= \frac{0.312 \times 22 \times (20.5)^2}{8}$$

$$= 361 \text{ K}$$

- $0.25 l_1$ ও $0.25 l_2$ এর মধ্যে যেটা smaller স্রোটার on both side হল colm strip.

• Interior span:

$$+ M = 0.35 M_o$$

$$- M = 0.65 M_o$$

Far colm strip:

$$+M = 60\% \text{ of } (35\% \text{ of } M_0)$$

$$= 0.6 \times 0.35 \times 361 = 76 \text{ K} / 11 \text{ ft} = 6.91 \text{ K}'$$

$$-M = 75\% \text{ of } (65\% \text{ of } M_0)$$

$$= 0.75 \times 0.65 \times 361$$

$$= 176 \text{ K}' / 11 \text{ ft} = 16 \text{ K}' / \text{ft}$$

$$(-A_s) = \frac{16 \times 12}{0.9 \times 60 \times (7 - 0.35)} \quad [\text{Let } a = 0.7]$$

$$= 0.53 \text{ in}^2 / \text{ft} \quad (12 \text{ mm } \phi @ 9 = \frac{0.175 \times 12}{0.53} = 3.9'' \text{ c/c}) \quad \begin{matrix} h = 8.5'' \\ d = 7'' \end{matrix}$$

$$a = \frac{0.53 \times 60}{0.85 \times 4 \times 12} = 0.79''$$

$$(+A_s) = \frac{6.91 \times 12}{0.9 \times 60 \times (7 - \frac{0.8}{2})} = 0.23 \text{ in}^2 \quad (10 \text{ mm } \phi @ 5.5'' \text{ c/c})$$

Middle strip:

$$-A_s = \frac{1}{3} A_s(-) \text{ for c.s} = 0.175 \text{ in}^2$$

$$+A_s = \frac{2}{3} A_s(+) \text{ for c.s} = 0.153 \text{ in}^2$$

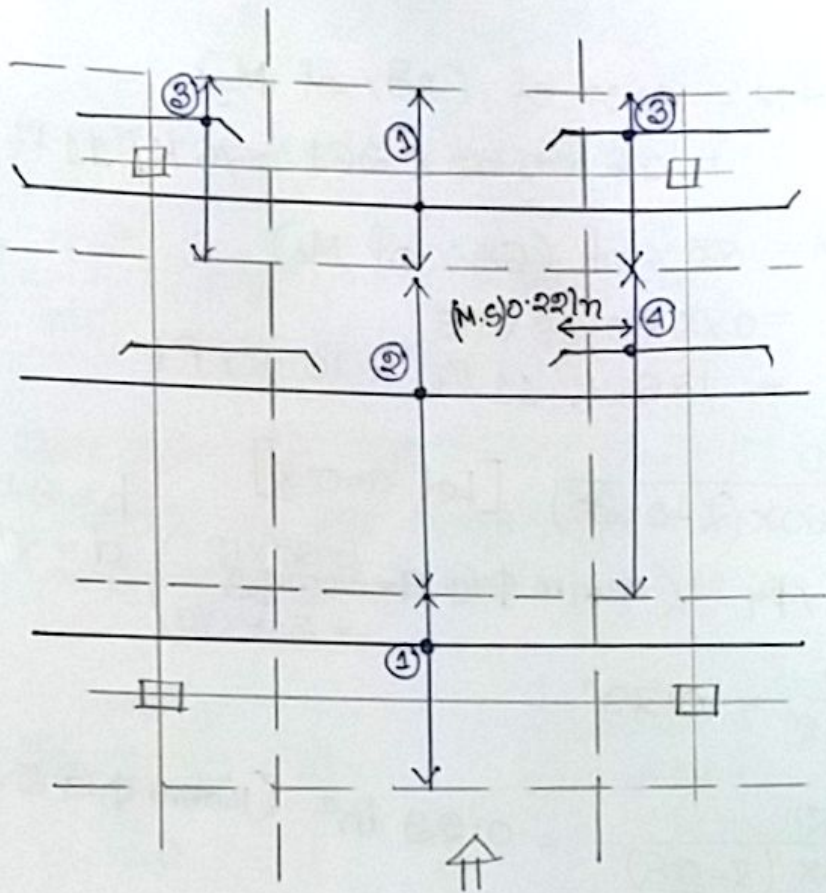
$A_{s, \min}$ will be provided

$$\therefore \begin{cases} -A_s = 0.18 \text{ in}^2 \\ +A_s = 0.18 \text{ in}^2 \end{cases}$$

$$10 \phi @ 7'' \text{ c/c}$$

$$\begin{aligned} A_{s, \min} &= 0.0018 b t \\ &= 0.0018 \times 12 \times 8.5 \\ &= 0.18 \text{ in}^2 \end{aligned} \quad \left. \vphantom{A_{s, \min}} \right\} \text{ for slab}$$

$$* 12 \text{ mm } \phi \rightarrow \frac{\pi}{4} d^2 \rightarrow A = 0.175$$



Bottom bar
Top bar

① 10 mm ϕ @ 5.5" c/c [C.S.]

② 10 mm ϕ @ 7" c/c bot bar [M.S.]

③

④

কি P-447 (Detailing) Fig-13.14

স্থাপন

বই এর জমা page

Art. 20.8

P-447 \rightarrow cont.

for seismic resistance

Last para Imp.

without \rightarrow flat plate

with drop panel \rightarrow flat slab

C.S = 0.3ln Top bar

M.G = 0.22ln Top bar

• C.S এর bottom bar কাজে যাবে না

• M.G " " " 50% কাজে যাবে

• support এর ডিগ্র 6" ডুবিয়েই হবে not

Theory

Q. Colm, flat plate এর জন্য ACI code provision.

- যেখানে (-ve A_s) দরকার নাই, তবুও $\frac{1}{4}$ of A_s provide
- $\frac{-A_s}{3} = +A_s$ provide করতে হবে (support এ দিতে হবে)
(for earthquake load)
- bottom এ extra bottom আরতে পারে due to stress reversal in seismic design.

[Flat plate \rightarrow for flexure
 \rightarrow for shear

২টা ও থাকবে Term এ (from each)

Theory
 Q. Form, flat plate এর জন্য ACI code provision.

- অথানে (-ve A_s) দরকার নাহি, শুধুও $\frac{1}{4}$ of A_s provide
- $\frac{-A_s}{3} = +A_s$ provide করতে হবে (support এ দিতে হবে)
 (for earthquake load)
- bottom এও extra bottom আবারে পারে due to stress reversal in seismic design.

[Flat plate \rightarrow for flexure
 \rightarrow for shear

২টা ও থাকবে Term এ (from each)

Flat plate design - for

1) flexure

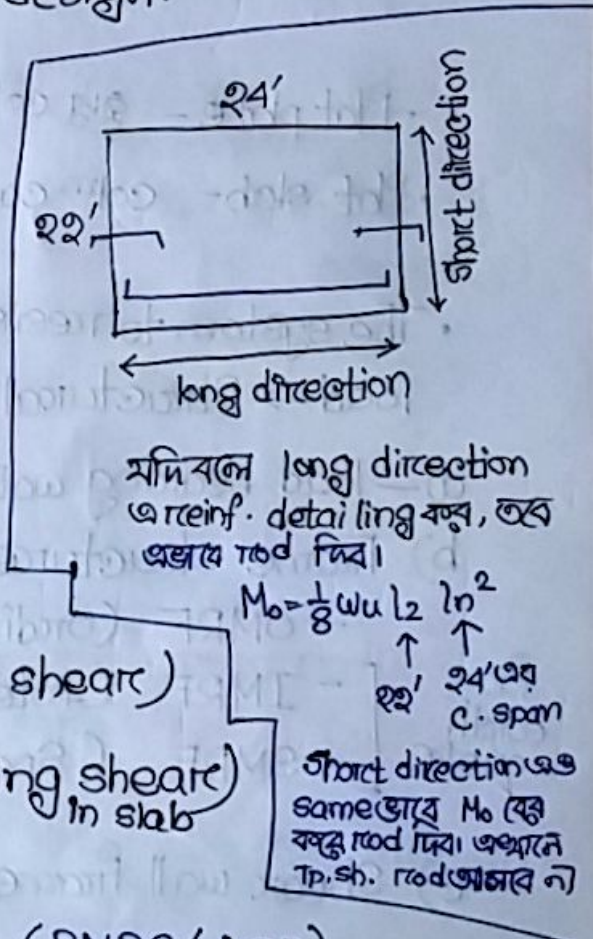
2) shear $\rightarrow V_u = \phi V_n$
 $= \phi V_c + \phi V_s$

$\phi V_c \rightarrow \phi 2 \times \sqrt{f_c} b d$ (beam shear)

$\phi V_c \rightarrow \phi 4 \lambda \sqrt{f_c} b_o d$ (punching shear)
 in slab

For beam $\rightarrow \phi V_s = V_u - \phi V_c$

slab $\rightarrow \phi V_s = V_u - \frac{\phi V_c}{2}$ (BNBC/ACI)



C.T → 3/5/17
Flat plate structure

Lecture-6

Chapter-16

Footing And Foundations

- যদি interior beam থাকে → 2, 1 way slab
- " " " না থাকে → flat plate, flat slab
edge beam থাকতেও পারে,
নাও পারে।

• flat plate - স্তম্ভ col^m, no column capita।

• flat slab - col^m capita থাকে।

• The system to resist the lateral load → structural lca system



a) — load bearing wall system (col^m - ২, part VI, chap-1, structural system)

b) Frame structure

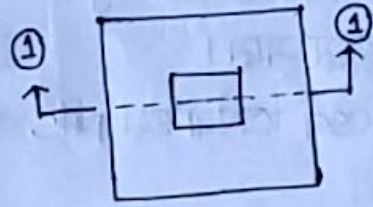
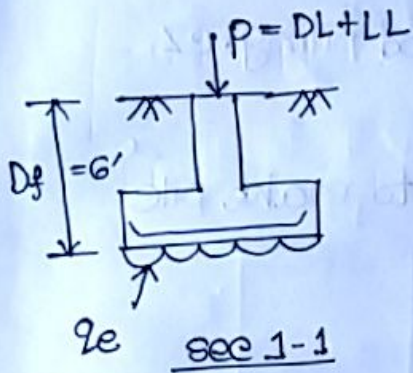
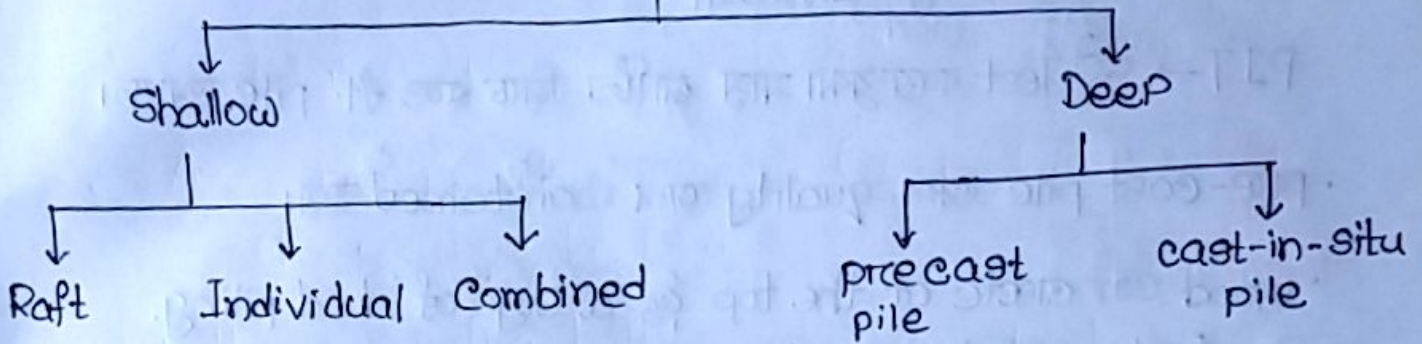
— OMRF (Ordinary moment resisting frame)

for
earth
quake [— IMRF (Intermediate " " " ")

— SMRF (Special " " " ")

c) Shear wall frame structure (Reinforced concrete wall system)

Foundation System



$DL = 400K$
 $LL = 300K$
 $q_a = 4 \text{ Ksf (bearing capacity)}$
 $D_f = 6'$

v.v. gm for practical life

- load analysis
- soil এর bearing capacity বের করা

- 1) stress soil এর bearing capacity এর মধ্যে থাকতে হবে
- 2) x-sectional area মনে sufficient হওয়া
- 3) settlement

P- ৫৪৪ ex 16.3

Footing design + pile cap design

- 1) area
- 2) thickness
- 3) reinforcement

• Cast-in-situ \rightarrow এই pile এর quality maintain করা
থায় difficult.

PIT \rightarrow এই Test করতে কতকটা সময় লাগে নিচে বক্ত ৫০ ft. pile আছে।

• pre-cast pile ভাল, quality ভাল maintained হয়।

• Good concrete at the top is a sign of bad piling. \because bad concrete may be somewhere else.

• Bad concrete at the top is a sign of good piling. \because ভাল concrete রয়েছে মাঝে।

উপরের concrete ভেঙে যেতে পারে pile এর to make pile

cap. $\frac{1}{2} \times 10 = 5$

উপরের

২-৫

১-১

উপরের

উপরের

উপরের

উপরের

উপরের

১০
৩.৯

উপরের

Lecture - 7

$d = 6''$

Ex-16.2

Working load নিম্ন (not factored load)

$$\gamma_{avg} = \frac{100 + 150}{2} = 125 \text{ pcf}$$

Minimum $D_f = 1 \text{ m}$

$$\begin{aligned} q_e &= q_a - \gamma_{avg} \cdot D_f \\ &= 5000 - 125 \times 5 \\ &= 4375 \text{ psf} \end{aligned}$$

$$\therefore A = \frac{(225 + 175) \text{ K}}{4.375 \text{ Ksf}}$$

$$A = 91.5 \text{ ft}^2 \approx 9'9'' \times 9'9'' \text{ or } 9'6'' \times 9'6''$$

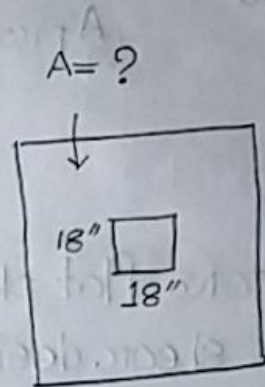
$$\therefore L = \frac{A}{B} = \frac{91.5}{8} = 11'5''$$

যদি sq. column নেই তবে,

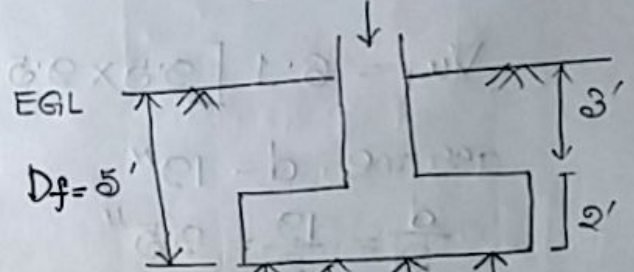
$$B = \sqrt{91.5} = 9.57' \approx 9'7''$$

→ Area এর হ্রস্ব working load দিবে।

→ length of footing and As এর বর্ধিত factored load দিবে

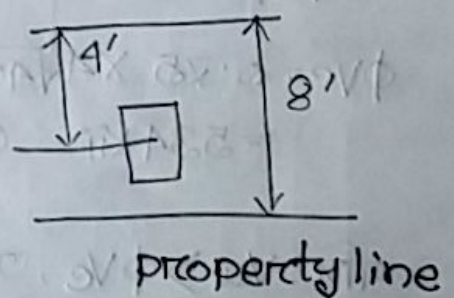


DL = 225 K
LL = 175 K



$\gamma_{soil} = 100 \text{ pcf}$
 $\gamma_{con} = 150 \text{ pcf}$

Q. 1 side is restricted due to property line.



$$\therefore q_u = \frac{1.2DL + 1.6LL}{A_{\text{provided}}} = 6.1 \text{ ksf}$$

$$A = 9'6'' \times 9'6'' = 9.5' \times 9.5'$$

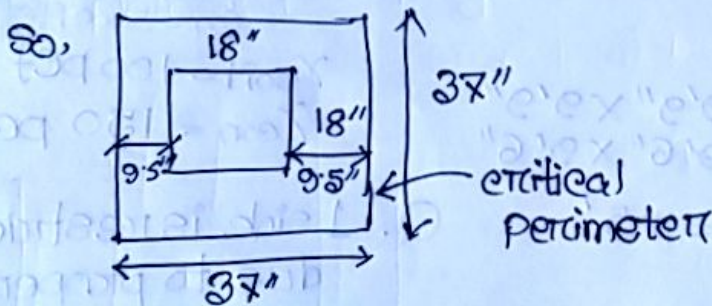
অতঃপর flat plate এর মত punching shear বসছে বসাবে।
 অর্থাৎ, shear design এ,

$$V_u \leq \phi V_n = \phi V_c + \left[\phi V_s \right]$$

$$V_{u1} = 6.1 \left[9.5 \times 9.5 - \frac{37'' \times 37''}{12 \times 12} \right] \text{ ksf} \quad \text{যদি footing size}$$

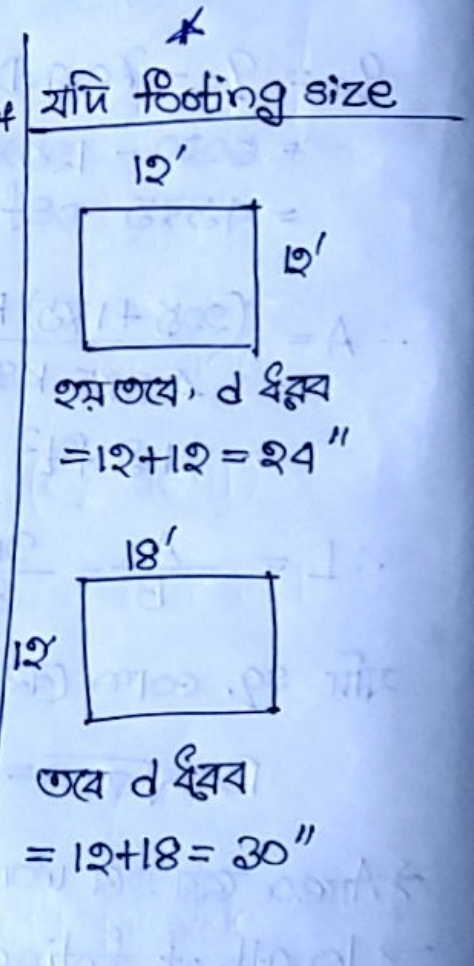
assume, $d = 19''$

$$\frac{d}{2} = \frac{19}{2} = 9.5''$$



$$\therefore V_{u1} = 492 \text{ kip}$$

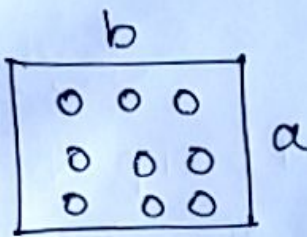
$$\phi V_c = 0.75 \times 4 \sqrt{4000} \times \frac{4 \times 37 \times 19}{1000} = 534 \text{ kip OK}$$



যদি $V_u > \phi V_c$, তখন depth change করতে হবে, বাড়াবা A ও change হবে।

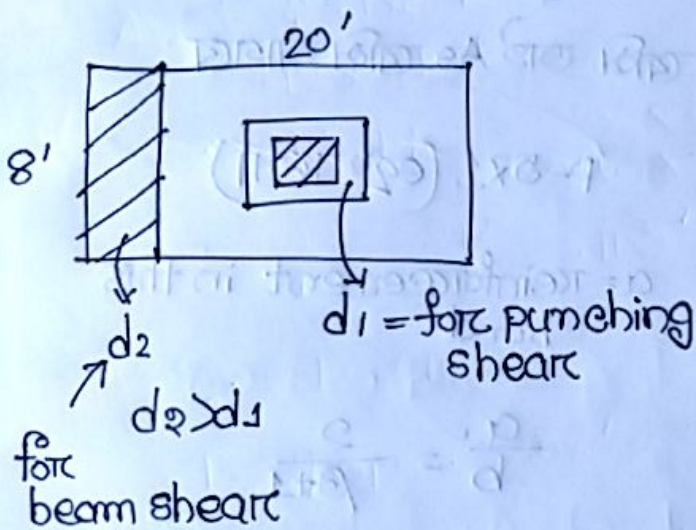
For pile cap

তখন, বিস্তার, $d = [(a+b) \times 1.5]$ inch



Beam shear

যদি $l_2/l_1 > 2$ হয়, তবে,



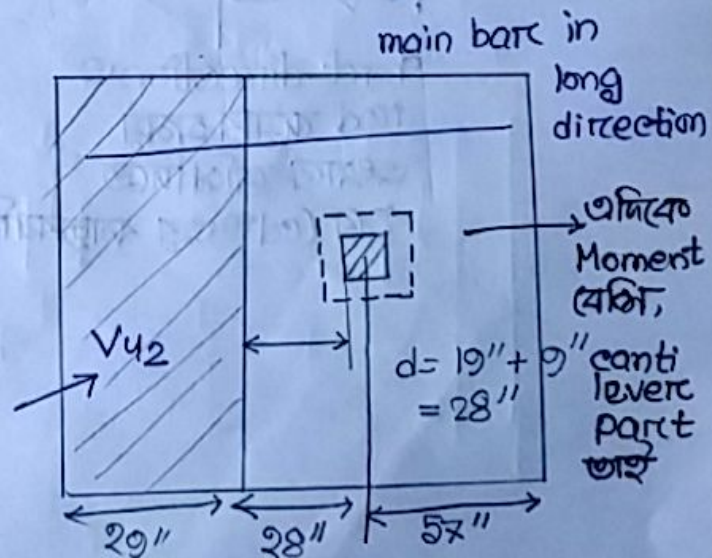
square হলে $d_1 > d_2$ হবে

• তাই, rectangular footing হলে beam shear + punching shear both check করতে হবে।

• For square footing punching shear depth govern করে।

$$9.5' \times 12'' = \frac{114''}{2} = 57''$$

$$= \frac{28''}{29''}$$



* ধরা যাক panel $22' \times 20'$.

+ দিয়ে দেয়া নাই।

তখন, $t = \left(\frac{l_n}{30}\right)$ দিয়ে এর বন্ধন। এটা use করার ক্ষেত্রে হল কোন Shear Rein. use করা যাবে না।


এই math এ, $t = \frac{22 - \frac{21}{12}}{30} = 8.1" \approx 8.5"$

Then W_u এর বন্ধন।

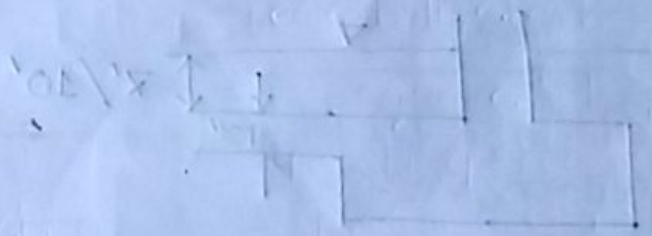
Then check দিতে হবে, S.R নাগছে কিনা।

যেহেতু $t = \frac{l_n}{30}$ formula দিয়ে t এর কাজেছি, তাই S.R use করা যাবে না। তাই অবশ্যই ensure করতে হবে যে $V_u < \phi V_c$ হয়।

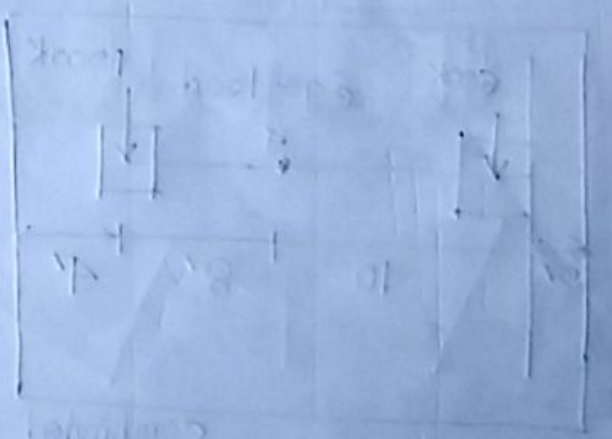
যদি না হয় তবে t বাড়িয়ে দিতে হবে যে $\phi V_c > V_u$ অর্থাৎ concrete যেন V_u এখানে বহুতে পারে।

* c.1 ②
 panel এর ডিটেইলিং

* Reinforcement Detailing ②



Panel এর ডিটেইলিং

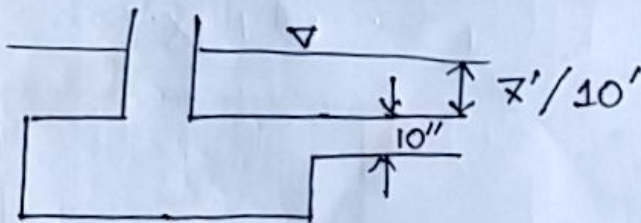


Lec-8

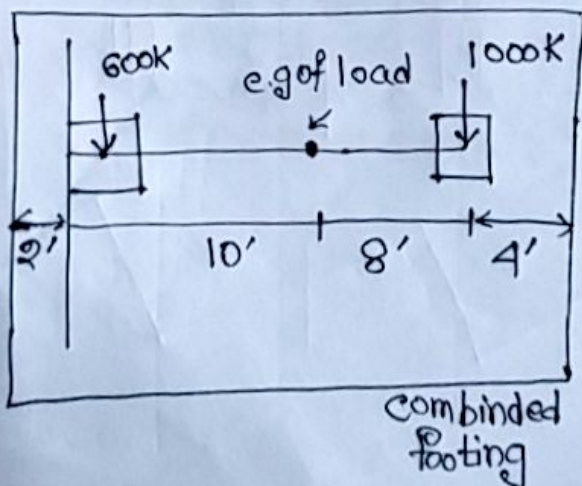
□ Combined Footing: (16.7) p-574

□ 16.8 → Two-Column Footing:

- বিভিন্ন ভাগ সমস্ত Tally করার জন্য individual footing দেয়া যায়। combined footing economic না।
- Basement Floor এর জন্য → এর column একত্রে মিলিয়ে combined footing করার।
- যদি semi basement হয়, ২'-10' নিচে (মাটির) basement এখন, ~~এমন~~ individual footing করার but একটা connecting slab দিয়ে Top এ connect করে দিবে। economic হবে।

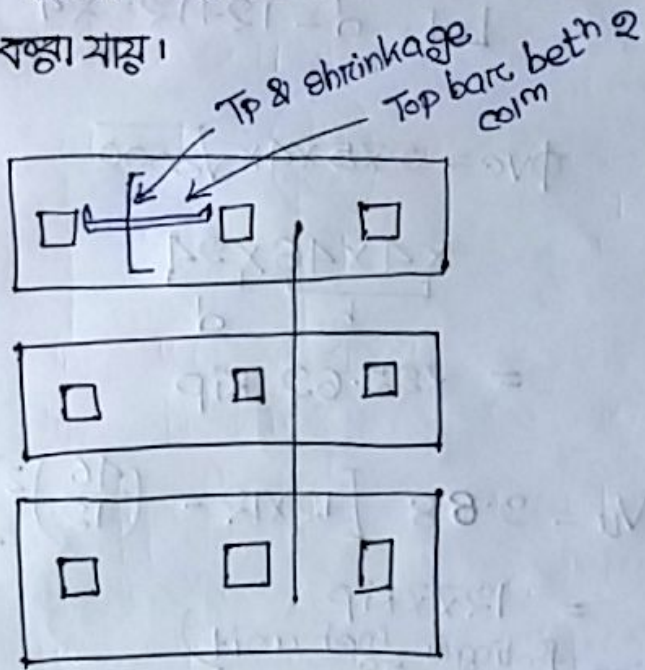


- C.G. of load and C.G. of footing should co-incide → for combined footing.



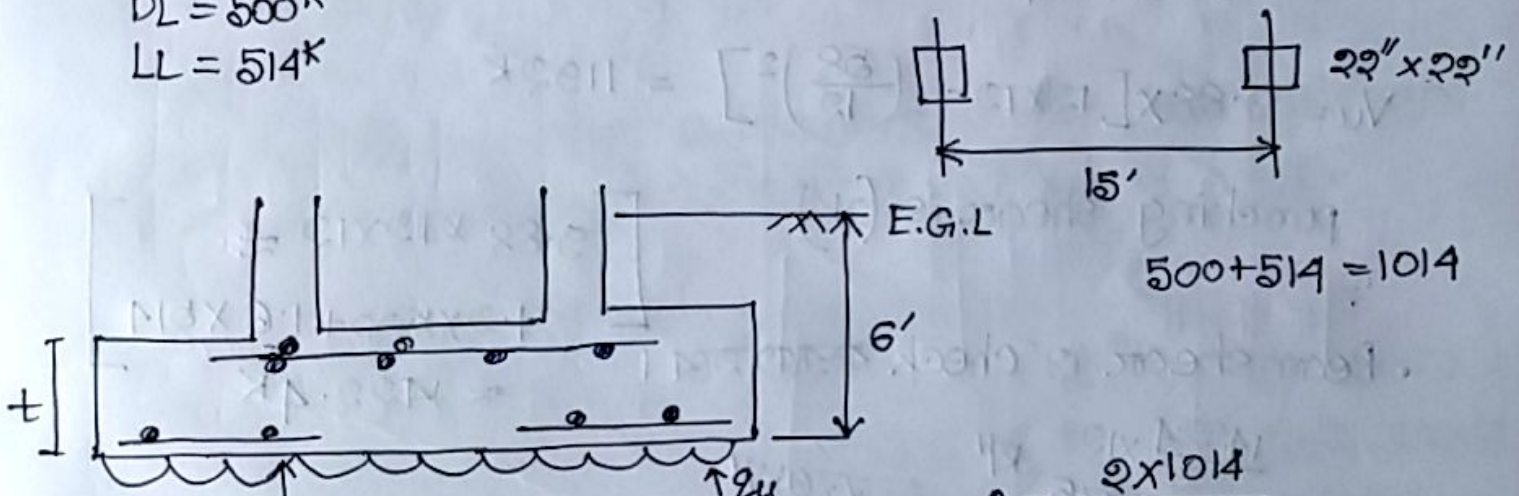
- load ও footing এর C.G. same না হলে moment আসবে

• Both direction এ combined না যন্ত্র ৩টি direction এ combined বসানো যায়।



Exercise 16.4

DL = 500K
LL = 514K



$q_a = 8000 \text{ psf}$

$q_e = 8000 - 6 \times 125 = 7250 \text{ psf}$

$q_u = \frac{(1.2 \times 500 + 1.6 \times 514) \times 2}{12 \times 24}$
 $= 9.88 \text{ K/ Ksf}$

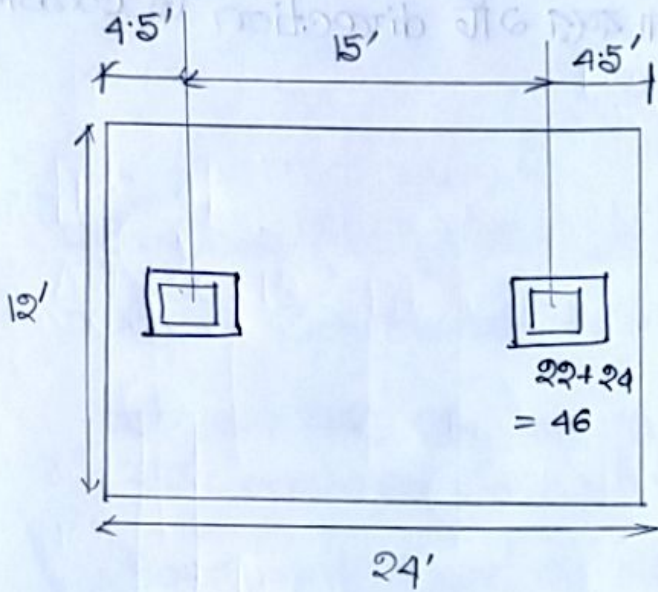
$A = \frac{2 \times 1014}{7.25}$
 $= 279.72$
 $\approx 280 \text{ ft}^2$

$L = 2B$ (footing)

$2B \cdot B = 280$

$\therefore B = 11.83' \approx 12'$

$\therefore A =$



Let, $d = 12 + 12 = 24''$

$$\phi V_c = 0.75 \times 4 \times \sqrt{3000} \times \underbrace{4 \times 46}_{b_o} \times \underbrace{24}_{d}$$

$$= 725.62 \text{ kip}$$

$$V_u = 9.88 \left[12 \times 12 - \left(\frac{46}{12} \right)^2 \right]$$

$$= 1277 \text{ kip}$$

Let, $d = 12 + 24 = 36''$
 (addition of 2 arms of combined footing in inch unit)

$$\phi V_c = 0.75 \times 4 \times \sqrt{3000} \times \underbrace{4 \times (36 + 22)}_{b_o} \times 36$$

$$= 1372 \text{ kip}$$

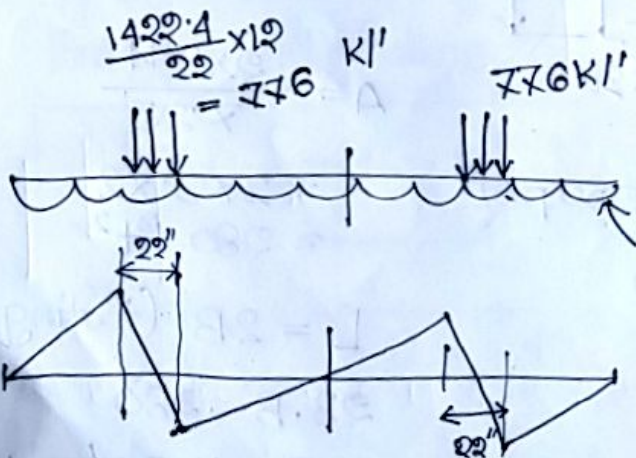
$$V_u = 9.88 \times \left[12 \times 12 - \left(\frac{58}{12} \right)^2 \right] = 1192 \text{ K}$$

punching shear is (OK)

• Beam shear is check করতে হবে।

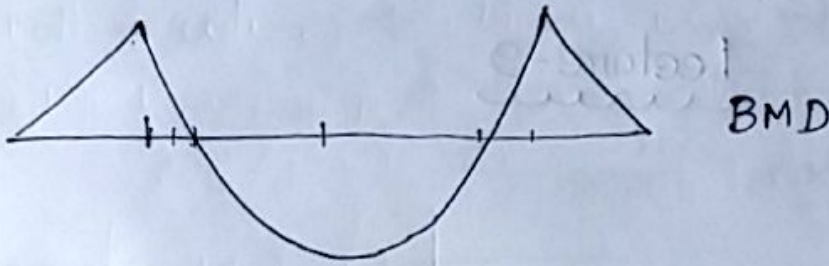
$$\left[9.88 \times 12 \times 12 \approx 1.2 \times 500 + 1.6 \times 514 \right]$$

$$\approx 1422.4 \text{ K}$$



$$9.877 \times 12 = 118.52 \text{ K/ft}$$

SFD



Example 16.3

• rectangular slab এর $\frac{L}{B}$ ratio > 2 হলে

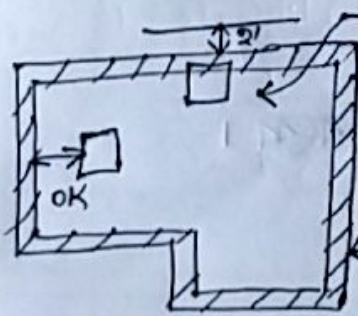
$$q_e = 8.6000 - (6 \times 1.25 + 100) = 5.15 \text{ psf}$$

অনেক অক্ষম beam shear govern করে।
 সেক্ষেত্রে 't' বেঞ্চি লাগবে compared to punching shear.

* Transverse beam \rightarrow reinforcement in short direction

Math

- combined footing বসলে settlement uniform হবে। স্মার্ট নসুম হলে combined footing use করা যায়।
- Raft foundation এ বসলেই bearing failure হয় না। এ.এ. স্মার্টির অনেক নিচে গেলে স্মার্টি কাজে হয় অনেক বেঞ্চি। এই বেঞ্চে ফেলা স্মার্টি আরো lower layer soil এ pressure দেয়, কিন্তু বেঞ্চে যেখানে এই upper layer soil হয়ে যায় বলে নিচের soil এর উপর exerting pressure অনেক কমে যায়।

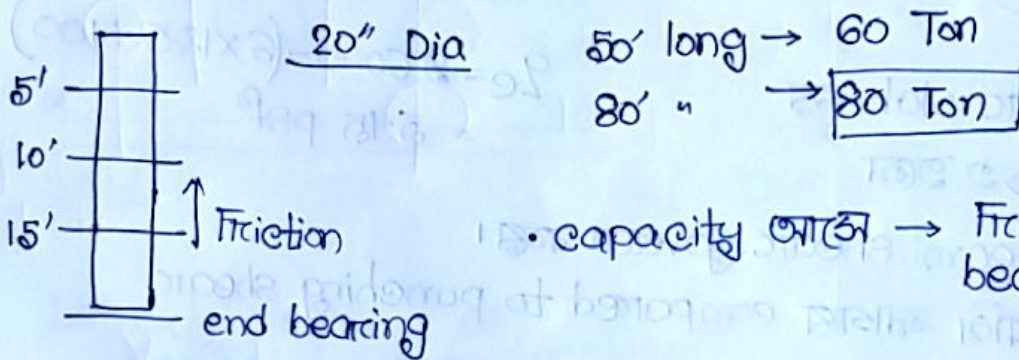


কলাম এখানে থাকলে ২' এর একটা combined strip দেয়া হবে স্মার্টি এর বাইরে।
 ← Raft foundation wall

Lecture-9

P-584

Art. 16.10 Pile Caps :



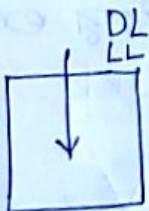
• capacity আসে → Friction ও end bearing থেকে

• length বাড়লে → capacity বাড়ে, But এর মধ্যে একটি fixed part থাকে যেটা হল structural capacity. ← এটা অর্গেস করলে গেলে, length বাড়লেও আর capacity বাড়ে না।

• Area of the footing বেশ করার সমস্যা → working বা service load use হয়।

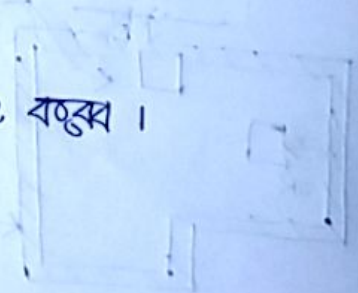
16.1, 16.2 eqn

↓ 600 mm (welding) fit space
In rod of pile



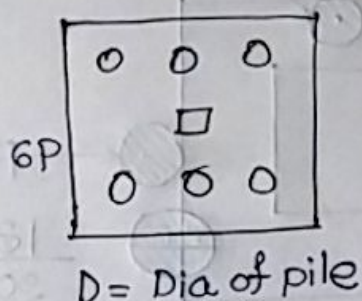
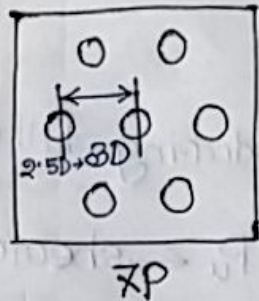
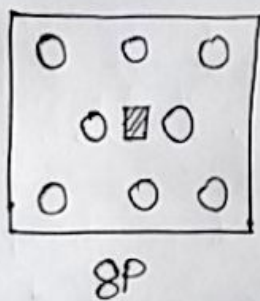
$$\frac{600K}{160K} \approx 3.75 \approx 4 \text{ nos.}$$

• যদি সমস্যা হয়, 6 টি না দিয়ে 5 টি pile বসায়।



$P_1 \rightarrow 60' \rightarrow 140K$
 $P_2 \rightarrow 80' \rightarrow 180K$

Dia same হওয়া ভাল, নইলে caging change করতে হয়।
 এখানে length change করা হচ্ছে।

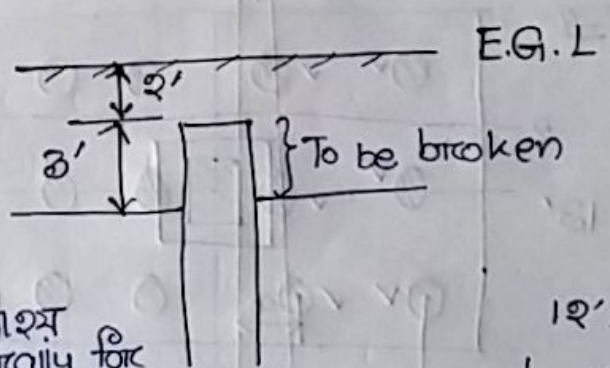
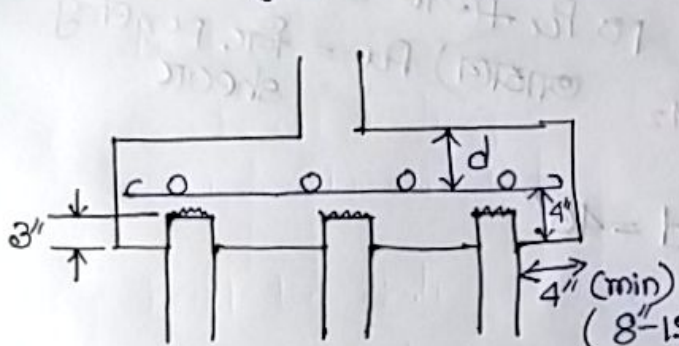


D = Dia of pile

$$q_u = \text{per pile \& amp; ultimate capacity} = \frac{1.2DL + 1.6LL}{4}$$

P-586 Fig 16.22 BNBC-part VI \rightarrow chap 3

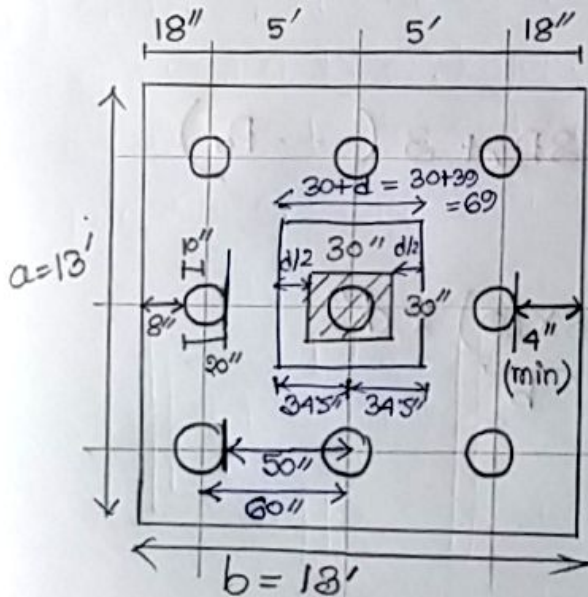
• Footing এর minimum depth



12' x 14'

$$d = 12 + 14 = 26''$$

(assume)



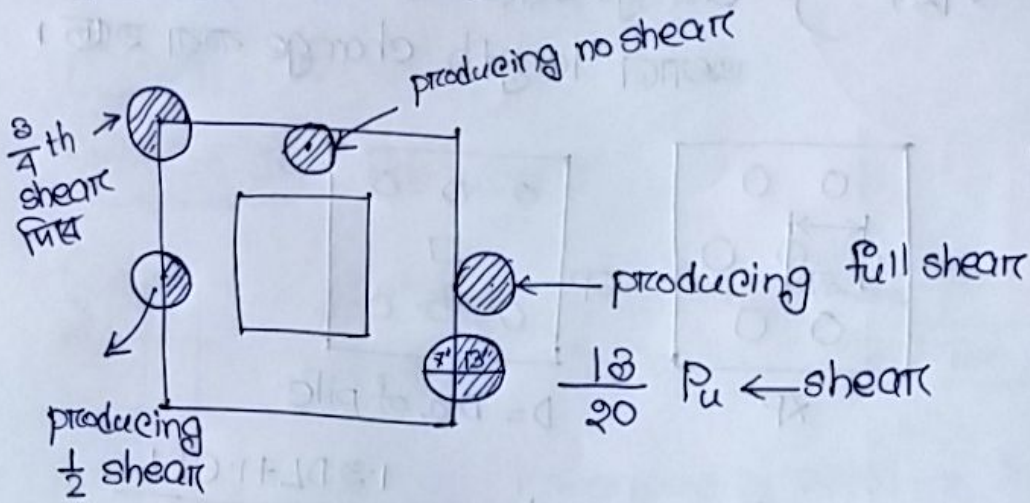
$$d = 1.5(a+b) \text{ inch}$$

assume করার জন্য

$$d = 1.5(13+13) = 39''$$

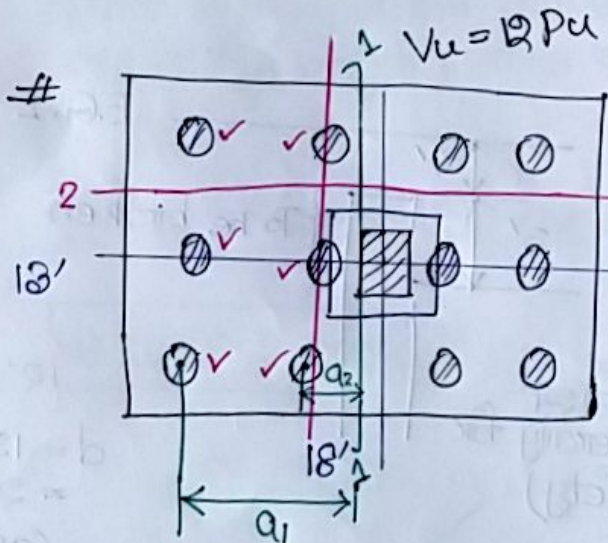
$$\frac{69}{2} = 34.5''$$

P-586 ছোট অক্ষরে লিখা..... (a)



$$V_u = 8P_u$$

$$\phi V_c = 0.75 \times 4 \sqrt{f'_c} b_o d$$



$10 P_u + (2 \text{ টি থেকে fraction আসবে}) P_u = \text{সিঁচ পুনঃ shear}$

$$d = 46''$$

$$\text{সিঁচ beam shear} = V_{u2} = 3P_u + 3 (\dots P_u)$$

$$V_{u3} = 4P_u$$

$$\phi V_c = 0.75 \times 2 \sqrt{f'_c} \times \underbrace{(18 \times 13)}_b \times d''$$

$$b = 13'$$

M_{2-2} তে moment বসে।

Reinforcement \rightarrow दि face of the ed^m अ

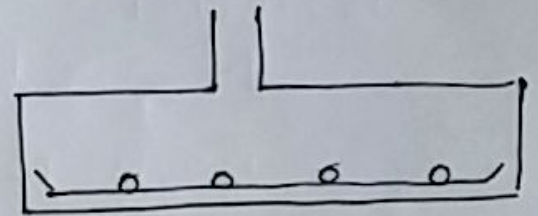
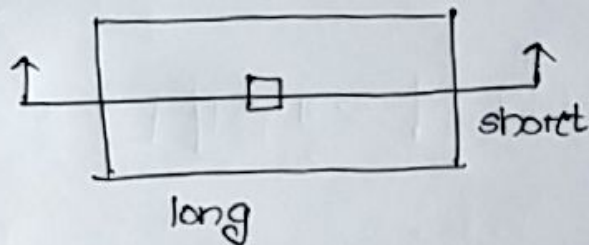
$$M_{1-1} = \sigma P_u \times a_1 + \sigma P_u a_2$$

• Moment long direction अ बेकि, ez, $M = \frac{wL^2}{2}$

L यत बेकि M तत बेकि

• Rod दि Bottom अ, ez bottom अ Tension.

• सेठार d बेकि \rightarrow सेठार main bar



• single footing हल long direction अ rod बेकि, moment बेकि.