chapter-4

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SHEAR

The Section of a Structural member may be Subjected to shear force due to flexure, Punching or torsion. Accordingly, the shear may be flexural shear, Punching shear or torsional shear.

Flextural Shear :-

The shear accosite with change of bending moment along the splan is known as flexureal shear.

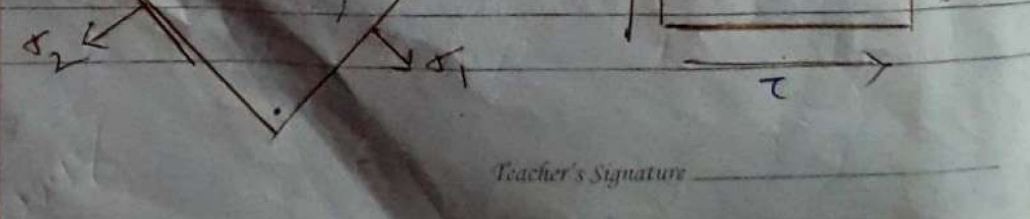
Torsion Shear :-

When a member is subjected to a torsion it is subjected to torsion sheare. In accisite Structure torsion Shear is Same are.

The beam are classified as Shallow & depth depending an the ratio of effective depth to the overall depth (l/D) the beam are classified as deep if $l/D < 2$ for Simple Supported beam.

$l/D < 2.5$ —— Contineous beam

Diagonal tension & Diagonal Compression



Teacher's Signature

$$\sigma_1 \text{ or } \sigma_2 = \frac{\sigma}{2} \pm \sqrt{(\sigma/2)^2 + \tau^2}$$

The measure principal Stress is tensile & its denoted as diagonal Tension.

$$\sigma_1 = \sigma/2 + \sqrt{(\sigma/2)^2 + (\tau)^2}$$

The mineral principal stress is compressive an is denoted as diagonal. compression.

$$\sigma_2 = \sigma/2 - \sqrt{(\sigma/2)^2 + (\tau)^2}$$

Diagonal tension:-
This ~~mean~~ meas that near the Support for a Simple Supported beam where bending moment is zero & on N.A. of any Section the principal Section is equal to shear Stress & is incliend at 45° it is known as diagonal tension.

Diagonal compression:-
The other principal Stress is inclined at 135° & is compressive. This is known as diagonal compression

Limit State theory:-
Shear Stress is derived by using elastic theory. In this derivation the resistance to shear provided by reinforcement is ignored. In limit

State theory: this is considered when concrete cracks due to shear is the shear resisted by:

(i) Above neutral axis shear resistance is provided by the uniform shear stress in un cracked concrete.

(ii) Along the crack shear resistance is provided by the vertical component of force due to the interlocking of aggregates.

(iii) At the tensile reinforcement shear is resistance by the both action of the longitudinal bars.

→ τ_v is defined as nominal shear stress $\tau_v = \frac{V_u}{bd}$

where

τ_v = nominal shear stress

V_u = Design shear

b = width

d = effective depth

Shear reinforcement in beam:-

shear reinforcement shall be designed to resist a shear force V_{us}. As the concrete is weak in tension the shear

- failure is caused by diagonal tension with crack at 45° to the beam axis. The shear reinforcement shall be provided by reinforcement which crush the cracks.

- These shear reinforcement minimize the size of diagonal tension crack.

- The provision of shear reinforcement is made by any of the following forms.

  - Vertical Stirrups
  - Inclined Stirrups
  - Bent up bars along with Stirrups.

Vertical Stirrups:-

Stirrups are commonly used shear reinforcement.

- These consist of a series of vertical closed bar spaced along the beam Span.

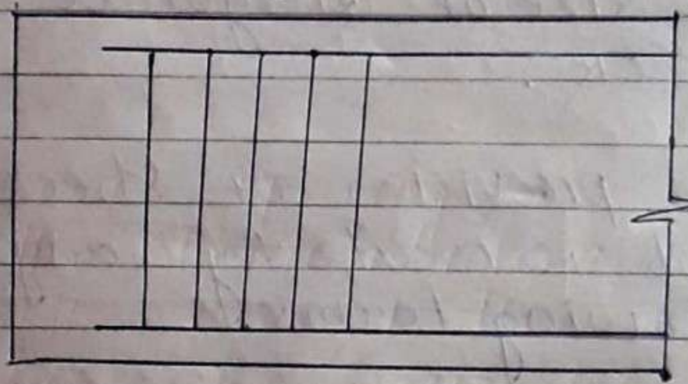
- The first Stirrup shall be provided within 50 mm from the face of the Support.

- The primary function of a Stirrup are.

(i) To resist a part of the shear

(ii) To resist the growth of the inclined cracks & improved aggregate interlock.

(iii) To tie the longitudinal bars in place.



Inclined Stirrup:-

A series of inclined stirrup near the support causing a 45° crack as shown in fig:-

Bent up bars along with stirrup

The bent bars are not used for the shear reinforcement. So in most cases we used only vertical stirrup as shear reinforcement.

& 60° to the longitudinal axis of the beam.
If a bar is bent at a distance from the support less than d.

maximum of spacing :-

The shear reinforcement are provided to prevent the shear crack in the beam. The horizontal distance b/w to successive cracks is approximately equal to the effective depth.

Stirrup shall be provided such that they cross the crack & also no crack shell remain unreinforced.

The max^m spacing of stirrup shall be
(i) .75 d

(ii) ~~d for inclined stirrup~~

(iii) 300mm

• when a beam requires compression reinforcement in case of double reinforce section the arrangement of shear reinforcement shall be
- φ ≮ a mcch / 4 or 6mm
- Sv ≯ 6

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Design for shear:-

Due to the shear stress there are cracks in concrete perpendicular to the diagonal tension. As the load increases these cracks more up ward.

most of the cracks stop when they reach the havaily stressed region of compression zone. If there is a further increase of load a critical diagonal cracks may tear through the beam.

The shear reinforcement is designed either using the vertical stirrups or by a combination of stirrups & bent bar crushing the cracks.

Now concrete can resist a shear for

$$V_{uc} = \tau_c bd$$

$$V_{us} = V_u - V_{uc} = V_u - \tau_c bd$$

where,

V_{us} = Strength of shear reinforcement.

V_u = Shear force due to applied load.

V_{uc} = Shear capacity of concrete with out shear reinforcement.

Distance of first bent up bars from support usually the bars are bent at 45°

& 60° to the longitudinal axis of the beam.
If a bar is bent at a distance from the support less than d.

maximum of spacing :-

The shear reinforcement are provided to prevent the shear crack in the beam. The horizontal distance b/w to successive cracks is approximately equal to the effective depth.

Stirrup shall be provided such that they cross the crack & also no crack shall remain unreinforced.

The max^m spacing of stirrup shall be

(i) .75 d

~~(ii) d for inclined stirrup~~

(iii) 300mm

- When a beam requires compression reinforcement in case of double reinforce section the arrangement of shear reinforcement shall be

$-\phi \not< \frac{3}{4}$ a much (?) or 6mm

$- S_v \not> 6$

How to Calculate Development Length

LSM (For M_{25} grade concrete & Fe-415 grade steel)

Dia of Bar $\phi = 12$ mm

Stress in bar $\sigma_s = 415 N/mm^2$

Design bond stress, $\tau_{bd} = 2.24 N/mm^2$

$$L_d = \frac{\phi \sigma_s}{4\tau_{bd}} = \frac{\sigma_s}{4\tau_{bd}} \times \phi = \frac{415}{4 \times 2.24} \times \phi = 46.316 \times \phi$$

$$= 46\phi$$

Therefore, for bar of $\phi = 12$mm, development length (L_d) $= 46 \times 12 = 552$ mm is required.

WSM (For M_{25} grade concrete & Fe-415 grade steel)

Dia of Bar, $\phi = 12$ mm

Stress in Bar, $\sigma_s = 230 N/mm^2$

Design bond stress, $\tau_{bd} = 1.44 N/mm^2$

$$L_d = \frac{\phi \sigma_s}{4\tau_{bd}} = \frac{\sigma_s}{4\tau_{bd}} \times \phi = \frac{230}{4 \times 1.44} \times \phi = 39.93\phi$$

$$= 40\phi$$

Therefore for bar of $\phi = 12$mm, development Length (L_d) $= 40 \times 12 = 480$ mm is required

Reference

1. https;//www.courshero.com
2. Text book of auther " H.J.SAHA"

Problem 1: possible quastions

Determine the shear reinforcement of the simply supported beam of effective span 8 m whose cross-section is shown in Fig. 6.14.1. Factored shear force is 250 kN. Use M 20 and Fe 415.

2

Design the bending and shear reinforcement of the tapered cantilever beam of width b = 300 mm and as shown in Fig. 6.14.2 using M 20 and Fe 415 (i) without any curtailment of bending reinforcement and (ii) redesign the bending and shear reinforcement if some of the bars are curtailed at section 2-2 of the beam. Use SP-16 for the design of bending reinforcement.

3.

Example of Embedment Length of Deformed bars

Calculate the required embedment length of the deformed bars in the following two cases: (12 inches of concrete below top reinforcement). Assume that #3 stirrups are used for shear and stirrup spacing based on shear calculations is 6.0 in. throughout the beam, S=6.0 in., d=15 in., $A_s^{required}$ = 1.6 in.^{2}

A) 3#7 bars top reinforcement in single layer in a beam with No. 3 stirrups
f'_c = 4,000 psi (normal weight)
f_{yt} = 60,000 psi and f_y = 60,000 psi
clear spacing between bars are $2d_b$, clear side cover is 1.5 inches on each side.

B) Same as part (A), except that the clear spacing between bars is equal to *one* inch. The bars are epoxy coated.

(1)

CHAPTER-6 SLAB

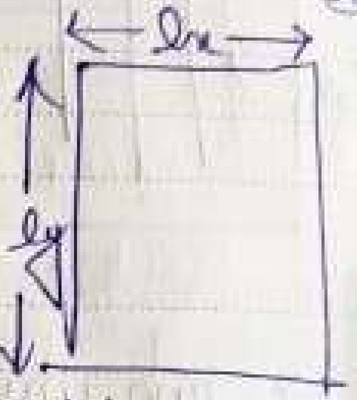
The main design criteria of a slab is deflection followed by BM & SF.

→ Classification

1. Based on Aspect ratio (l_y/l_x)

(i) $\frac{l_y}{l_x} > 2$ → One way slab

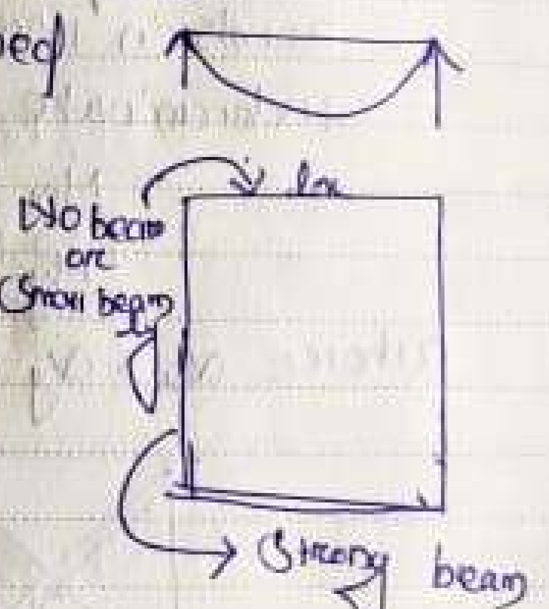
(ii) $\frac{l_y}{l_x} \leq 2$ → Two way slab (Supported on all 4 edges)



→ The minm steel is required in a slab to avoid sudden or failure of the slab.

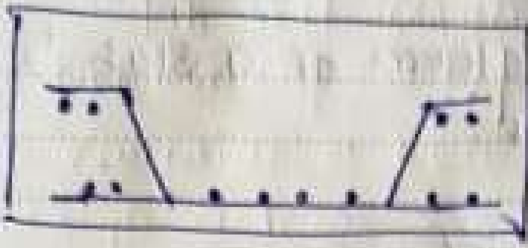
→ The maximum spacing of reinforcement is based on 'crack width criteria'

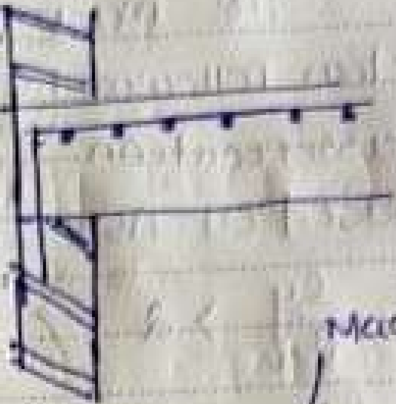
Longer direction (l_y) is restrained by providing stronger beams whereas shorter dirn are supported with small beams or sometimes no beams at all.

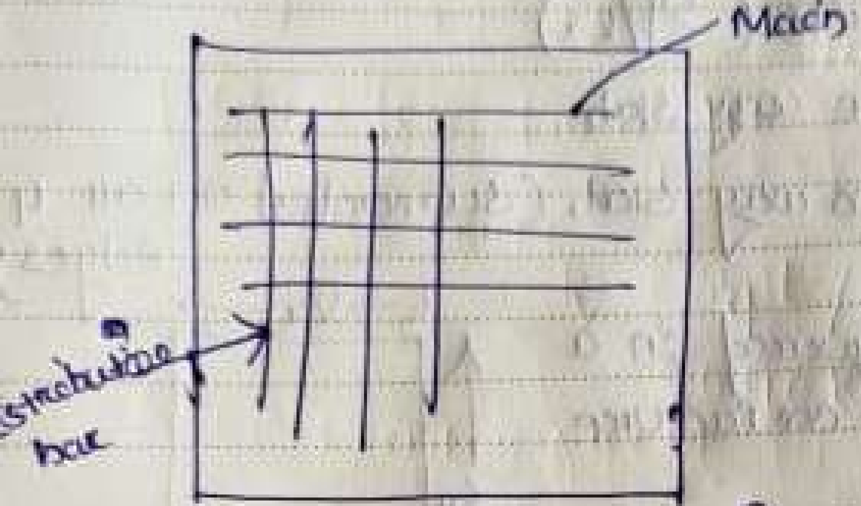


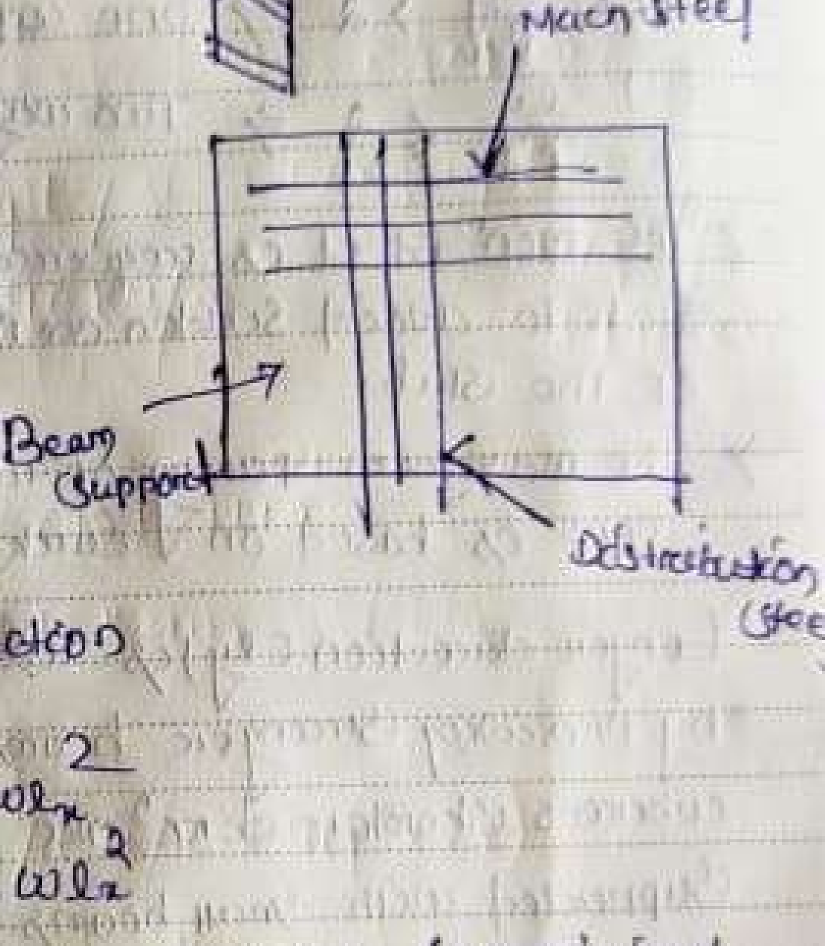
13 WED

One-way (determinate)







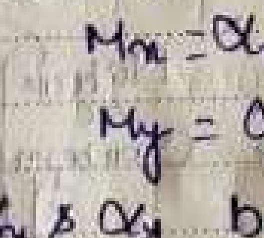


14 THU

→ Two way
- Bends in two direction
- Indeterminate

$$M_x = \alpha_x w l_x^2$$
$$M_y = \alpha_y w l_x^2$$

where α_x & α_y bending moment coefficient.



Square slab

Q.1 Simply supported one way slab

A rectangular reinforced concrete slab is simply supported on two masonry walls 250 mm thick and 3.75m apart. The slab has to carry a distributed permanent action of $1kN/m^2$ (excluding slab self-weight) and a variable action of 3.0 kN/m^2. The materials to be used are grade C25 concrete and grade 500 reinforcement. The slab is outside buildings which subjected to 1hr fire resistance and design for 50 years design life. Design the slab. Assume [illegible] dia of bar = 12 mm.

Slab thickness

Minimum thickness for fire resistance = 80mm

Estimated thickness considering deflection control

$h = 3750/26 = 144$ mm $\simeq 150$ mm

Min^m cover with regard to bond $C_{bond} = 12$ mm

" " " " " " $C_{min\,dur} = 20$mm

Min required axis distance for R60 fire resistance, $a = 20$mm

$C_{min,fire} = a - \phi_{bar}/2 = 20 - .5(12) = 14$ mm

Allowance in design for deviation? $\Delta C_{dev} = 10$mm

Nominal cover $C_{nom} = C_{min} + \Delta C_{dev} = 20 + 10 = 30$mm

17 SUN

Load calculate

Slab self weight = 3.75 KN/m^2
Permanent load = 1 KN/m^2
Variable action = 3 KN/m^2

Design action = 1.35 (4.75) + 1.5 (3.00)
= 10.91 KN/m^2

Consider 1m width = W_d = $n_d \times 1$ mm

Shear force:
$V = W_d L/2$
= 20.46 KN/m

Bending Moment
$M = W_d L^2/8$
= 19.18 KNm

Main Reinforcement

18 MON

Effective depth
$d = 150 - 30 - .5(12) = 114$ mm

Design M_{ED} = 19.18 KNm

$K = M/bd^2 f_{ck}$
$= (19.18 \times 10^6) / (1000 \times 114^2 \times 25)$
$= .059 < K_{bal} = .167$

$z = d[.5 + \sqrt{.25 - K/1.134}] = .94d \leq .95d$

$A_s = M/.87 f_{yk} z$
$= 19.18 \times 10^6 / .87 \times 500 \times .94 \times 114$
$= 412$ mm^2/m

Min^m & Max^m reinforcement area.

$A_{s,min} = .26(f_{ctm}/f_{yk})bd = .26(2.60/500)bd$

$= .0014bd = 160\ mm^2/m$

$A_{s,max} = .04A_c = .04(1000)150 = 6000\ mm^2/m$

SHEAR

$V_{ED} = 20.46\ KN$

Design shear resistance,

$V_{Rd,c} = [.12k(100\rho_1 f_{ck})^{1/3}]bd$

$k = 1 + (200/d)^{1/2} \le 2.0 = 2.32 \le 2.0$

$\rho_1 = A_{s1}/bd \le .02 = 432/1000 \times 114$

$= .004 \le .02$

$V_{Rd,c} = [.12 \times 2(100 \times .004 \times 25)^{1/3}] \times 1000 \times 114$

$= 58.95\ KN$

$V_{min} = [.035k^{3/2} f_{ck}^{1/2}]bd$

$= .035 \times 2^{3/2} \times 25^{1/2} \times 1000 \times 114$

$= 56.43\ KN$

$V_{Rd,c} > V_{ED}$

$58.95\ KN > 20.46\ KN$ — OK

DEFLECTION

Percentage of required tension reinforcement,

$\rho = A_{s,req}/bd = 412/1000 \times 114 = .0036$

Reference reinforcement ratio,

$\rho_0 = (f_{ck})^{1/2} \times 10^{-3} = (25)^{1/2} \times 10^{-3} = .005$

$K = 1.0$

$(L/d)_{basic} = K\left[11 + 1.5\sqrt{f_{ck}}\frac{\rho_0}{\rho} + 3.2\sqrt{f_{ck}}\left(\frac{\rho_0}{\rho} - 1\right)^{3/2}\right]$

$= 1.0[11 + 10.42 + 3.88] = 25.3$

Modification factor for span less than 7m = 1.0

$A_{s,prov} \times A_{s,req} = 1.1 \leq 1.5$

$(L/d)_{allowable} = 25.3 \times 1 \times 1.1 = 27.83$

$(L/d)_{act} = 3750/114 = 32.9 > (L/d)_{allow} = 27.83$ — not OK

Increase area of steel provided to 566 mm²/m

$A_{s,prov}/A_{s,req} = 1.37 \leq 1.5$

Therefore allowable span-effective depth ratio

$(L/d)_{allowable} = 25.3 \times 1 \times 1.37$

$= 34.66 > (L/d)_{act}$

$= 32.9$ — OK

CRACKING

$h = 175$ mm < 200 mm

Main bar =

$S_{max,slab} = 3h \leq 400 = 400$ mm

Max bar spacing = 200 < $S_{max,slab}$ — OK

Secondary bars:

$S_{max,slab} = 3.5h \leq 450 = 450$

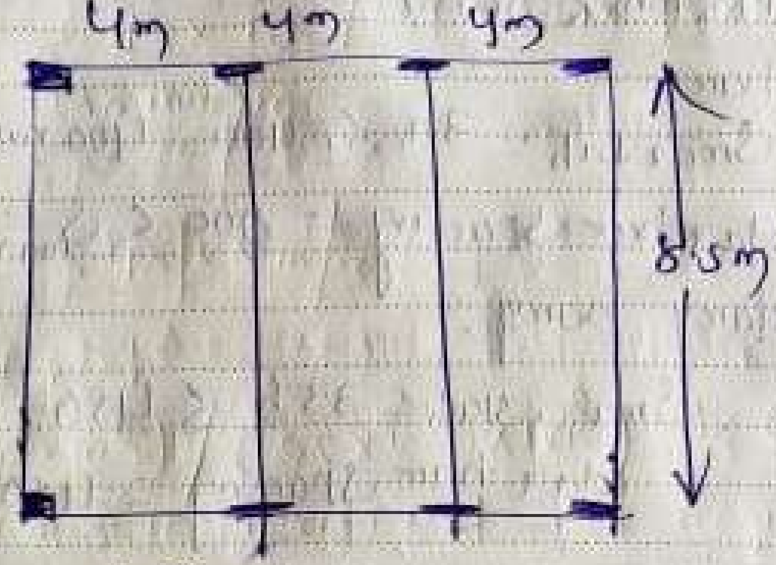
Max bar spacing = 450 < $S_{max,slab}$ — OK

Two-way slab

Q. Fig shows the part of the 2nd floor plan of a reinforced concrete office building.

The slab carries characteristic permanent action of 1.5 kN/m² of finishes, ceiling and services and characteristic variable action of 4.5 kN/m². The construction materials considered for the concrete consist of grade C_{25}, whereas, for steel reinforcement consist of grade 500. The density of concrete is taken as 25 kN/m³.

25 MON



Load calculation

Slab self-weight = .15 x 25 = 3.75 kN/m²

permanent load = 1.5 kN/m²

Total permanent action = 5.25 kN/m²

26 TUE

Variable action = 4.50 kN/m²

Design act? = nd 1.35(5.25) + 1.5(4.50)

= 13.84 kN/m²

Ly/Lx = 3250/3000 = 1.1 < 2.0 (Two-way slab)

3 edges discontinous (one short edge continous)

Short span $M_{sx1} = \beta_{sx1} n l_x^2$ = .054 x 13.84 x 3²

= 6.73 kNm/m

Long span $M_{sy,1} = \beta_{sy,1} n l_x^2 = .044 \times 13.84 \times 3^2$
$= 5.48 \; KNm/m$

$M_{sy2} = \beta_{sy,1} n l_x = .058 \times 13.84 \times 3^2$
$= 7.22 \; KNm/m$

<u>Main Reinforcement</u>

$d_x = 150 - 25 - .5(10) = 120mm$

$d_y = 150 - 25 - 1.5(10) = 110mm$

Min^m and Max^m reinforcement area,

$A_{s\,min} = .26(F_{ctm}/F_{yk})bd$
$= .26(2.6/500)bd$
$= .0013(1000)120$
$= 156 \; mm^2/m$

$A_{s\,max} = .04 A_c = .04(1000)150 = 6000 \; mm^2/m$

$M_{sx,1} = 6.73 \; KNm/m$

$K = M / F_{ck} bd^2$
$= (6.73 \times 10^6) / (25 \times 1000 \times 120^2) = .019 < K_{bal} = .167$

∴ Compression reinforcement not required.

$z = d[.5 + \sqrt{.25 - K/1.134}] = .098d \leq .95d$

$A_s = M / .87 F_{yk} Z$

$= 6.73 \times 10^6 / .87 \times 500 \times .95 \times 120$

$= 138 \ mm^2/m$

Long Span

$M_{sy1} = 5.45 \ KNm/m$

$K = M / f_{ck} b d^2$

$= (5.45 \times 10^6) / (25 \times 1000 \times 110^2) = .018 < K_{bal} = .167$

Compression reinforcement not required

$z = d[.5 + \sqrt{.25 - K/1.134}] = .95d \leq .95d$

$A_s = M / .87 F_{yk} Z$

$= 5.45 \times 10^6 / .87 \times 500 \times .95 \times 110$

$= 121 \ mm^2/m$

Long Span (Support)

$M_{sy2} = 7.22 \ KNm/m$

$K = M / f_{ck} b d^2$

$= (7.22 \times 10^6) / (25 \times 1000 \times 110^2) = .024 \leq K_{bal} = .167$

$z = d[.5 + \sqrt{.25 - K/1.134}] = .95d \leq .95d$

$A_s = M / .87 f_{yk} z$

$= 7.22 \times 10^6 / .87 \times 500 \times .95 \times 110$

$= 159 \ mm^2/m$

SHEAR

Shear force, Short span

$V_{sx1} = \beta_{vs1} n l_x = .33 \times 13.84 \times 3 = 13.7 \ kN/m$

Long span

$V_{sx1} = .30 \times 13.84 \times 3 = 12.46 \ kN/m$

$V_{sx2} = .45 \times 13.84 \times 3 = 18.64 \ kN/m$

$V_{ED} = 18.64 \ kN$

Design shear resistance

$V_{RD,C} = [.12k(100\rho_1 f_{ck})^{1/3}] bd$

$k = 1 + (200/d)^{1/2} \leq 2.0 = 2.34 \leq 2.0$

$\rho_1 = A_{s1}/bd \leq 0.02 = 159/1000 \times 110 = .0015 \leq .02$

$V_{Rd,c} = [.12 \times 2.0(100 \times .0015 \times 25)^{1/3}] \times 1000 \times 110$

$= 41.02 \ kN$

$V_{min} = [.035 k^{3/2} f_{ck}^{1/2}] bd = .035 \times 2^{3/2} \times 25^{1/2} \times 1000 \times 110$

$= 54.45 \ kN$

1 MON

$V_{Rd,c} = 54.45 \text{ kN} > V_{ED} = 18.64 \text{ kN}$

DEFLECTION

% of required tension reinforcement,

$\rho = A_{s,req}/bd = 138/1000 \times 120 = .0012$

Reference reinforcement ratio,

$\rho_0 = (f_{ck})^{1/2} \times 10^{-3} = (25)^{1/2} \times 10^{-3} = .005$

$K = 1.3$

$(L/d)_{basic} = K\left[11 + 1.5\sqrt{f_{ck}}\frac{\rho_0}{\rho} + 3.2\sqrt{f_{ck}}\left(\frac{\rho_0}{\rho} - 1\right)^{3/2}\right]$

$= 1.3[11 + 31.25 + 90.16] = 172.13$

2 TUE

$A_{s,prov}/A_{s,req} = 225/138 = 1.63 \leq 1.5$

(ok)

Therefore allowable span-effective depth ratio –

$(L/d)_{allowable} = 172.13 \times 1 \times 1.5 = 258.2$

Actual span-effective depth ratio.

$(L/d)_{act} = 3000/120 = 25 < (L/d)_{allowable}$

(OK)

2008 SEPTEMBER

(12) (14)

3 WED

CRACKING

h = 150 mm < 200mm

Main bar,

$S_{max,slab} = 3h \leq 400 = 450 \leq 400$

Max bar spacing = 350 ≤ $S_{max,slab}$

Secondary bar –

$S_{max,slab} = 3.5h \leq 450$ — OK

$= 525 \leq 450$

Max bar spacing = 425 ≤ 450 — OK

4 THU

Refference

1. A Text book of author "H.J. SAHA"
2. https://lecturenotes.in
3. https://www.courseshero.com

Possible Qustions

1. A simply supported slab clear Area of 12m x 8.5m for a hall construction in a school. The slab is supported on beams of size 225 x 500 mm spaced at 4m centers. The slab thickness is to be designed 150mm. Given the characteristic permanent action is 1.5 KN/m² (excluding self-weight), characteristic variable action is 4.0 KN/m² with a design life of 50 years, Fire exposure = 90, exposure class = XC1, characteristic conc. f_{ck} = C25/30, high yield steel strength, f_{yk} = 500 N/mm², unit weight of concrete = 25 KN/m³, use dia of reinforcement = 10mm.

2. Design a slab on the room dimension 8m x 3m simply-supported on 230 mm thickness. The live load on the slab is 2KN/m² & F.F .5 KN/m² use M20 & Fe 415. ~~des~~

3. Design a slab for an internal room dimension 12m x 5m by using M20 & Fe 415 which live load of 2.25 KN/m² & simply supported on 230 mm thick wall.

11 THU

CHAPTER-7

Limit State of collapse: compression

Assumptions

The c/s area of Longitudinal bars (Main bars) shall not be less than ·8% of Agross of column (Long column, Short column, LSM, WSM) but at the same time it shall not exceed 6% of Agross of column

→ But if lapping of column bar is required then it shall not exceed 4% of Agross of column.

→ In pedestrical Minimum area of Longitudinal bars shall be ·15 of Agross of column.

12 FRI

The overall length of a column shall not exceed

(a) If both ends are restrained $L < 60$ times (b ~~d~~)

(b) If one end is restrained $L \leq 100 \frac{b^2}{D}$

Note

Every RCC Column must be provided with minimum Longitudinal bars (Main bars) due to

13 SAT

(a) Flexural stress (Bending tension) developed due to eccentricity of loads.

(b) To take care of stress developed by shrinkage and creep in concrete.

(c) Minm no of Longitudinal bars provided in a column shall be 4 in Rectangular columns and 6 in circular columns.

Defination

A column is defined as a vertical compression member which is mainly subjected to axial load and the effective length of of which exceed 3 times its least lateral dimension.

14 SUN

$$\frac{\text{Length}}{\text{least lateral dimension}} > 3$$

Types of Reenforcement

1. Tied column
2. Spiral column
3. Composite column
4. Inclined column

Tied column

In which the main longitudinal bars are contined within closely spaced lateral Ties.

Spiral column

Spiral column having main longitudinal reein-forcement enclosed within closely spaced and continously wound spiral reenforcement when a continious bar or heavy wire is wrapped around the longitudinal bar in the form of a helical spiral.

Composite columns

In which the longitudinal reenforcement is in the form of structure steel sec?.

17 WED

Minimum Eccentricity (e_{min})

Every column must be designed by considering min^m Eccentricity

$$e_{min} = \frac{L}{500} + \frac{b}{30} \leq 20\,mm$$

L = Unsupported length of column
b = Least Lateral dimension of the column.

Min^m Eccentricity for bending about major axis of bending x-x bisecting the depth (D)

$$e_{min} = \frac{L_x}{500} + \frac{D}{30} \nless 20\,mm$$

18 THU

Min^m Eccentricity for bending about Minor axis of bending y-y bisecting the width (b) of the column.

$$e_{miny} = \frac{L_y}{500} + \frac{b}{30} \nless 20\,mm$$

Design of Short Columns

Step-1 — Effective length
Step 2 — Slenderness ratio

$$\frac{l_{ex}}{D} \text{ and } \frac{L_{ey}}{b} < 12 \text{ — Short column}$$

$\frac{l_{ex}}{D}$ and $\frac{l_{ey}}{b} > 12$ — Long column

Step-3 Minimum Eccentricities

$e_{min} \not< .05D$

$e_{min} = \frac{L}{500} + \frac{D}{30} \leq 20mm$

Step-4 Longitudinal Reinforcement

$P_u = .4 f_{ck} A_c + .67 f_y A_{sc}$

P_u = Axial ultimate Load

A_c = Area of Concrete

A_{sc} = Area of Longitudinal Reinforcement

$A_c = A_g - A_{sc}$

A_g = Gross Area of the sec of column

$P_u = .4 f_{ck} A_g + (.67 f_{ck} - .4 f_{ck}) A_{sc}$

Step-5 Transverse Reinforcement (pg no 49)

(i) Dia of Ties should not be less than

* $\frac{1}{4}$ th of Longer diameter of Longitudinal bars
* 6 mm

(ii) pitch should not be more than

* – 16 x dia of smallest longitudinal bar
* – 300mm
* – 48φ

(6)

SEPTEMBER 2008

Compression member with helical Reinforcement

$$Pu = 1.05(.4 f_{ck} A_c + .67 f_y A_{sc})$$

Pg no 71 code book

$$\frac{\text{Volume of Helical}}{\text{Volume of core}} \geq .36\left(\frac{A_g}{A_c} - 1\right)\frac{f_{ck}}{f_y}$$

Problem-1 Possible problems

A rectangular column of size 400 mm x 550 mm fixed at one end and hinged at the end. Its unsupported length is 4.2 m. Determine the slenderness ratio of the column and state whether it is a long column or short column.

Given Data

Unsupported Length (L) = 4200 mm

$L_{eff} = .80L$

$= .80 \times 4200 = 3660$ mm

(ii) Slenderness ratio with respect to Major axis

$l_x = \frac{l_{eff}}{D} = \frac{3300}{550} = 6.11 < 12$

(iii) Slenderness ratio with respect to Minor axis

$l_y = \frac{l_{eff}}{b}$

$= \frac{3300}{400} = 8.4 < 12$

Both of its slenderness ratio are less than 12

The column is short column.

problem-2

A RCC column 3.3m effective length and 400mm dia is reinforced with 8 bars 20 mm dia Fe 250 steel. Find the safe load the column can carry if it is wound by spiral reinforcement with 8mm mild steel bar around the compression reinforcement at a pitch of 50 mm clear cover for main bars is 40mm. Use M_{15} grade concrete.

Given data

$L(eff) = 3.3m = 3300mm$

$A_{sc} = 8 \times \frac{\pi}{4} \times 20^2 = 2513.27\ mm^2$

$(P) = 50mm$, clear cover $= 40mm$

$f_{ck} = 15 N/mm^2$, $f_y = 250 N/mm^2$

(i) Slenderness Ratio (λ)

$\lambda = \frac{L_{ef}}{LLD} = \frac{330}{400} = 8.25 < 12$ (Short column)

(ii) Minimum Eccentricity (e_{min})

$e_{min} = \frac{L}{500} + \frac{LLD}{30} = \frac{3300}{500} + \frac{400}{30}$

$e_{min} = 19.93mm$

$\cdot 05D = \cdot 05 \times 400 = 20mm$

$e_{min} < \cdot 05D$

Strength of column

$P_u = 1\cdot 05 (\cdot 4 f_{ck} A_c + \cdot 67 f_y A_{sc})$

$\frac{\text{Volume of Hellical}}{\text{Volume of Core}} \geq \cdot 36 \frac{f_{ck}}{f_y} \left(\frac{A_g}{A_c} - 1 \right)$

$= 400 - (2 \times 40) - \left(\frac{8}{2} + \frac{8}{2} \right)$

$= 312 mm$

Length of Hellical in pitch Height } $= \sqrt{\pi D^2 + 50^2}$

$= \sqrt{\pi \times 312^2 + 50^2}$

$= 981 \cdot 45 mm$

Area of hellical reinforcement $= \frac{\pi}{4} d^2$

$= \frac{\pi}{4} \times 8^2 = 50 \cdot 27 mm^2$

% of hellical pitch (h) } = 9 length of helic in pitch ht × Area of bar

$= 981 \cdot 45 \times 50 \cdot 27$

$= 49337 \cdot 49 mm^3$

Core dia = Dia of column − Both side clearco

$= 400 - (2 \times 40) = 320 mm$

$A_c = \frac{\pi}{4} d^2 = \frac{\pi}{4} \times 320^2 = 80424 \cdot 77 mm^2$

3 MON

% of core per pitch height } = Area of core × P
= 80424 × 50
= 4021238.5 mm^2

$\cdot 36 \frac{f_{ck}}{f_y}\left(\frac{A_g}{A_c}-1\right) = \cdot 36 \times \frac{15}{250}\left(\frac{125664}{80424.77}-1\right)$
$= \cdot 121$
$\cdot 0121 \geq \cdot 122$ (con^n-1 is satisfied)

Case-I
Max^m pitch should be less than 75 mm
$\frac{1}{6}$ × core dia = $\frac{1}{6}$ × 320 = 53.33 mm

Case-II
Min^m pitch 25 mm = 3 × dia of helix
= 3 × 8 = 24 mm — (OK)

4 TUE

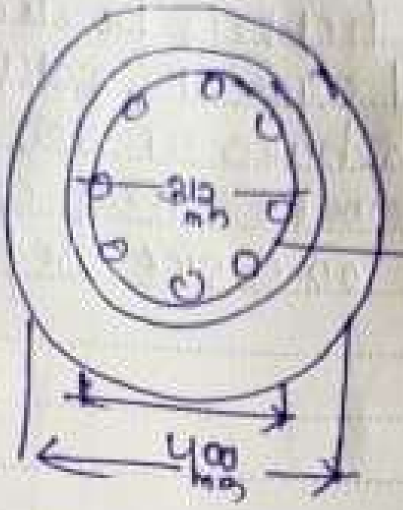
Provide 8mm dia spiral at a pitch of 50 mm
$P_u = 1.05(\cdot 4 f_{ck} A_c + \cdot 67 f_y A_{sc})$
$= 1.05(\cdot 4 \times 15(125664 - 2513.27) + \cdot 67 \times 250 \times 2513.27)$
= 1217871 N

P_u = 1217.87 kN

Safe working load = $P = \frac{P_u}{PSF}$
$= \frac{1217.87}{1.5}$ = 811.914 kN

P = 811.914 kN

5 WED



Possible Qustions

1. The Effective length of a rectangular RC column of 250 mm x 500 mm size are found to be 4.6 m and 2.5 m with respect to the Major and Minor axes respectively. State whether the column is a short or long column.

6 THU

2. What is Maxm permitted unsupported long of a Rcc column of size 300 mm x 450 mm
   (i) Both ends are fixed
   (ii) One end fixed and one end free.

7 FRI

Q. A 450mm dia reinforced concrete column 3m long effectively held in position at both ends but not restrained against rotation, is reinforced with 8 bars of ~~20mm~~ 25mm dia. Determine the ultimate load and safe working load if M_{30} & Fe 500 were used.

Footing

Definition

Footing are structure members used to support columns and walls and to transmit and distribute their loads to the soil in such way that the ~~bend~~ load bearing capacity of the soil isn't

8 SAT

exceeded, excessive settlement, differential settlement, or rotation are prevented and adequte safety against overturning or sliding is maintained.

Types of footing

Wall footing

These are used to support structure walls that carry loads for other floors to support nonstructural walls.

Isolated / single footing

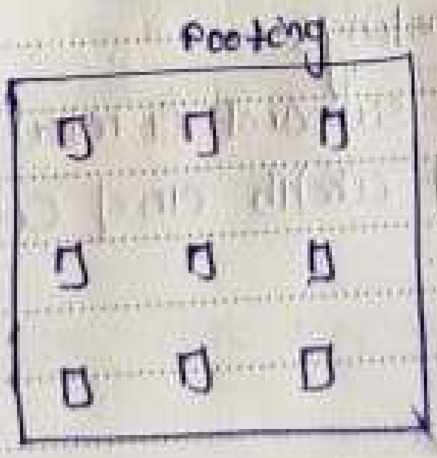
These are used to support single columns. These are used when columns are spaced at relatively long distances.

Combined footing

These are usually support two columns or 3 columns not in a row.

Raft / Mat foundation

These type of foundation consist of one footing usually placed under the entire building area. They are used, when soil bearing capacity is low, column loads are heavy single footing cannot be used, piles are not used and differential settlement must be reduced.

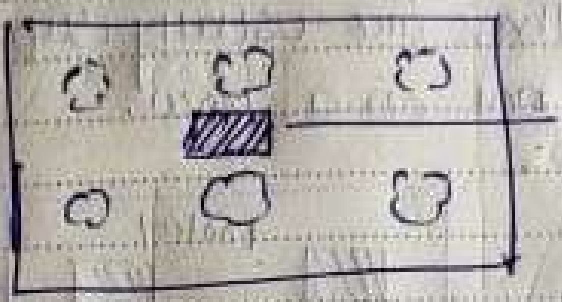


Plan

11 TUE

Pile cup

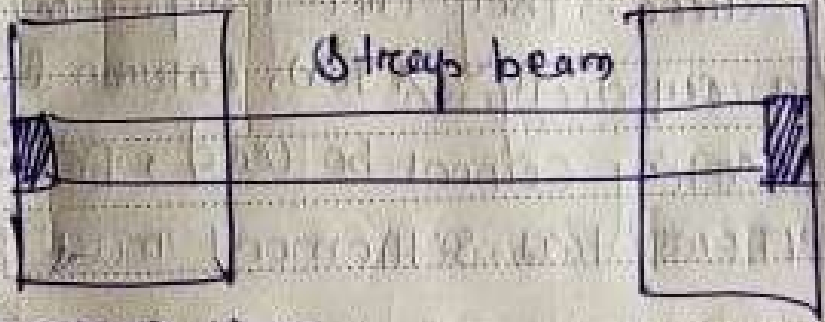
These are thick slabs used to tie a group of piles together to support and transmit column loads to the piles.



Cuntilever or strap footing

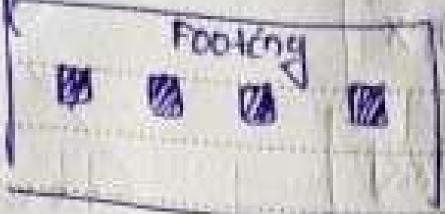
These are consist of two single footings connected with a beam or a strap and support two single columns.

12 WED



Continous ~~beam~~ footings

These support a row of 2 or more columns. They have limited width and continue under all columns.



plan

Design consideration

Footing must be designed to carry the column loads and transmit them to the soil safely while satisfying code limitations.

1. The area of the footing based on the allowable bearing soil capacity two-way shear or punch out shear.
2. One-way bearing
3. Bending moment steel reinforcement required.
4. Bearing capacity of columns at their base,
5. Dowel requirements.
6. Development length of bars
7. Differential settlement

→ Isolated footing design is similar to that of slabs i.e designed for bending and checked for shear

B.M

Critical sec^n for BM is at the face of column

Refference

1. A text book of "H. J. SAHA"

2. https://lecturenotes.in