2.1 Design Of Flat Slab With And Without Drops By Direct Design Method Of IS Code

Flat slab

Flat slab is a reinforced concrete slab supported directly by concrete column without use of beams.

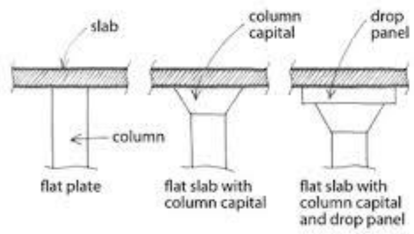


Fig.2.1. Flat slab

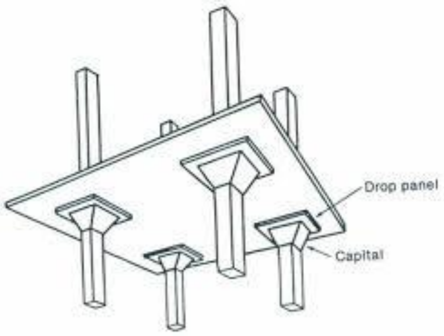


Fig.2.2. Flat slab with drop and capital

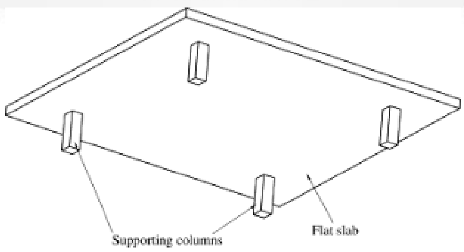


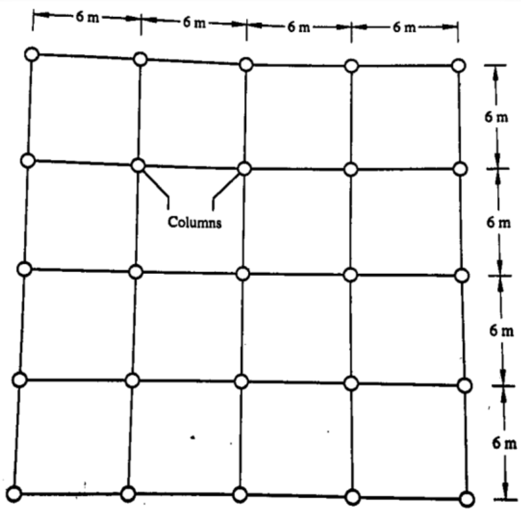
Fig.2.3. Flat slab with supporting columns

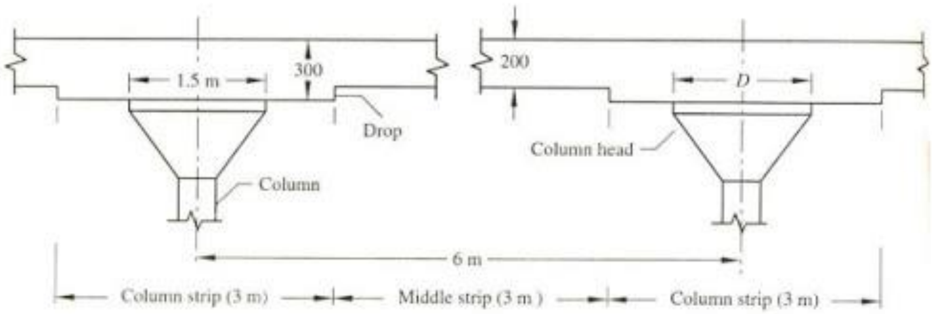
Fig.2.4. Flat slab without drop

Fig.2.5. Flat slab with drop

Example 1

Design a interior panel of flat slab floor system for a warehouse 24m x 24m divided into panels of 6m x 6m , live load = 5KN/m^2 , column size 400mm diameter and M20 grade concrete Fe415 HYSD bars.





Step1: Dimensions of flat slab

Thickness of slab at mid span (middle strip)

Span to depth ratio = 26

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% tension reinforcement 0.4

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Span to depth ratio = 26 x modification factor

fs = 0.58xfy

= 0.58 x 415

= 240.7 N/mm^2

Modification factor = 1.3

Span to depth ratio = 26 x 1.3

= 33.8

span / depth = 33.8

depth = 6000 / 33.8

d = 177.5mm ~ 170mm

over all depth D = 170 + 30

= 200 mm

Thickness of slab at drops = 200 + 100

= 300 mm

Column head diameter = 0.25 x L

= 0.25 x 6

= 1.5m

Length of drop = L/3

= 6/3

= 2m

Drop width = 1.5 x 2

= 3m

Column strip = drop width = 3m

Width of middle strip = 3m

Step2: Find load

Live load = 5 KN/m^2

Dead load = 0.5(0.3+0.2) x 25

= 6.25 KN/m^2

Floor finish = 0.75 KN/m^2

Total load W = 12 KN/m^2

Factored load Wu = 12 x 1.5

= 18 KN/m^2

Step3 : Find bending moment

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Total moment M = [(W x Ln)/ 8]

Ln = 6 - 1.5

= 4.5m

W = Wu x L2 x Ln

= 18 x 6 x 4.5

= 486 KN

Total moment M = [(486 x 4.5) / 8]

= 274 KNm

(a) Column strips moment (70%)

Negative BM = 49% x M

= 49/100 x 274

= 134 KNm

Positive BM = 21% x M

= 21/100 x 274

= 58 KNm

(b) Middle strips moment (30%)

Negative BM =15% x M

= 15/100 x 274

= 41 KNm

Positive BM = 15% x M

= 15/100 x 274

= 41 KNm

Step4 : Check for thickness of slab

$$d = \sqrt{\frac{Mu}{0.138 \times fck \times b}}$$

thickness of slab near drop (column strip)

d = 134 x 10^6 / (0.138 x 20 x 3000)

= 127 mm

thickness of slab (middle strip)

d = 41 x 10^6 / (0.138 x 20 x 3000)

= 70 mm

thickness of slab near drop (column strip)

Overall depth at drops D = 300mm

Effective depth d = 300 – 30

= 270mm

thickness of slab (middle strip)

Overall depth (middle strips) D = 200mm

Effective depth d = 200 – 30

= 170mm

Step5 : Check for shear stress

Total load on circular area

W = π/4 (D+d)^2 x Wu

= π/4 (1.5 + 0.27)^2 x 18

= 44.3 KN

Shear force = Total load – load on circular

= (18 x 6 x 6) – 44.3

= 603.7 KN

Shear force per meter of perimeter = 603.7 / (D+d)

= 603.7 / (1.5+0.27)

= 340.66 KN

Shear stress τv = shear force / bd

= 341.07 x 10^3 / (3000 x 270)

= 0.42 N/mm^2

Permissible Shear stress = ks x τc

ks = 0.5 + βc

βc = L1/L2

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βc = L1/L2

= 6/6

=1

Ks = 0.5 + 1

= 1.5 > 1

τc = 0.25 x$\sqrt{fck}$

= 0.25 x$\sqrt{20}$

= 1.118N/mm^2

Permissible Shear stress = ks x τc

= 1 x 1.118

= 1.118N/mm^2

1.118 > 0.4

Permissible shear stress > Shear stress

Hence safe

Step6 : Find Reinforcement

(a) For Column strip (i) (Negative BM)

Mu = (0.87 fy Ast d)[(1- Ast fy) / (b d fck)]

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134 x 10^6 = (0.87 x 415 x Ast x 270)[(1- 415 x Ast)/(3000 x 270 x 20)]

134 x 10^6 = (97.48 x 10^3 Ast) [(1 – 2.56 x 10^-5 Ast)]

134 x 10^6 = (97.48 x 10^3 Ast) – (2.49 Ast^2)

134 x 10^6 - (97.48 x 10^3 Ast) + (2.49 Ast^2) = 0

(using calculator) mode > Eqn > degree > 2

a = 2.49

b = - 97.48 x 10^3

c = 134 x 10^6

x1 = 37721.9mm^2

x2 = 1426mm^2

Ast = 1426 mm^2

Ast for per meter = 1426/3

= 475.33mm^2

Provide 12mm dia bars

Spacing $= 1000 \times [(\pi d^2 / 4) / Ast]$

$= 1000 \times [(\pi \times 12^2 / 4) / 475.33]$

$= 237.93 \sim 240mm$

Provide 12mm dia bars at 240mm c/c

Find distribution reinforcement

Ast (dist) $= (0.12 / 100) \times bD$

$= (0.12 / 100) \times 3000 \times 300$

$= 1080$

per meter $= 1080/3$

$= 360\ mm^2$

Provide 10mm dia bars

Spacing $= 1000 \times (\pi d^2 / 4) / Ast$

$= 1000 \times [(\pi \times 10^2 / 4) / 360]$

$= 218mm$

Provide 10mm dia bars at 220mm c/c

(a) For Column strip (ii) (Positive BM)

Mu $= (0.87\ fy\ Ast\ d)[(1- Ast\ fy) / (b\ d\ fck)]$

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$58 \times 10^6 = (0.87 \times 415 \times Ast \times 270)[(1- 415 \times Ast)/ (3000 \times 270 \times 20)]$

$58 \times 10^6 = (97.48 \times 10^3\ Ast)[(1 - 2.56 \times 10^{-5}\ Ast)]$

$58 \times 10^6 = (97.48 \times 10^3\ Ast) - (2.49\ Ast^2)$

$58 \times 10^6 - (97.48 \times 10^3\ Ast) + (2.49\ Ast^2) = 0$

(using calculator) mode > Eqn > degree > 2

a = 2.49

b = - 97.48 x 10^3

c = 58 x 10^6

x1 = 38544.2mm^2

x2 = 604.32mm^2

Ast = 604.32 mm^2

Ast for per meter = 604.32/3

= 201.44mm^2

Provide 12mm dia bars

Spacing = 1000 x [(πd^2 / 4) / Ast]

= 1000 x [(π x 12^2 / 4) / 201.44]

= 561.44 ~ 300mm

Provide 12mm dia bars at 300mm c/c

Find distribution reinforcement

Ast (dist) = (0.12 / 100) x bD

= (0.12 / 100) x 3000 x 300

= 1080

per meter = 1080/3

= 360 mm^2

Provide 10mm dia bars

Spacing = 1000 x (πd^2 / 4) / Ast

= 1000 x [(π x 10^2 / 4) / 360]

= 218mm

Provide 10mm dia bars at 220mm c/c

b) For Column strip (Negative and positive BM)

Mu = (0.87 fy Ast d)[(1- Ast fy) / (b d fck)]

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41×10^6 = (0.87 x 415 x Ast x 170)[(1- 415 x Ast)/(3000 x 170 x 20)]

41×10^6 = (61.37×10^3 Ast) [(1 – 4.06×10^{-5} Ast)]

41×10^6 = (61.37×10^3 Ast) – (2.49 Ast^2)

41×10^6 - (61.37×10^3 Ast) + (2.49 Ast^2) = 0

(using calculator) mode > Eqn > degree > 2

a = 2.49

b = - 97.48×10^3

c = 41×10^6

x1 = 23959mm^2

x2 = 687.24mm^2

Ast = 687.24 mm^2

Ast for per meter = 687.24/3

= 229.08mm^2

Provide 12mm dia bars

Spacing = 1000 x [(πd^2 / 4) / Ast]

= 1000 x [($\pi \times 12^2$ / 4) / 229.08]

= 493.70 ~ 300mm

Provide 12mm dia bars at 300mm c/c for both positive and negative moments

Find distribution reinforcement

Ast (dist) = (0.12 / 100) x bD

= (0.12 / 100) x 3000 x 200

= 720

per meter = 720/3

= 240 mm^2

Provide 10mm dia bars

Spacing = 1000 x (πd^2 / 4) / Ast

= 1000 x [(π x 10^2 / 4) / 240]

= 327 ~ 300mm

Provide 10mm dia bars at 300mm c/c for both positive and negative moments

Step7: Check for deflection control

pt = 100 Ast / bd

= 100 x 229.08 / 1000 x 170

= 0.134

fa = 0.58 x 415

= 240.7

modification factor = 1.8

(L/d)max = modification factor x 26

= 1.8 x 26

= 46.8

(L/d)prov = span / depth

= 6000 / 170

= 35.2

(L/d)max > (L/d)prov

Hence safe