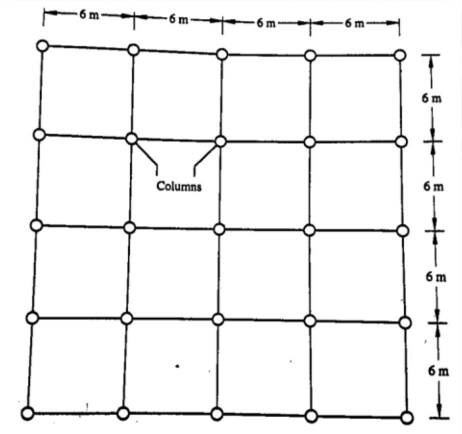
DESIGN AND DRAWING AN EXTERIOR PANEL OF FLAT SLAB

2.2 Design And Drawing An Exterior Panel Of Flat Slab

Example 2

Design a exterior 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. Height of storey is 3m, thickness of slab in column strip is 300mm, thickness of slab in middle strip is 200mm.



Step1 : Dimensions of flat slab

thickness of slab in column strip = 300mm

thickness of slab in middle strip = 200mm

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 : Stiffness stipulations

Stiffness of column ‘ Kc’ = 4EI / L

= [4 x E x (400^4)] / (64 x 3000)

= 1.67 x 10^6 E

Column both at top and bottom

Stiffness of column Kc = 2 x (1.67 x 10^6 E)

Stiffness of slab is given by

Stiffness of slab ‘ Ks’ = 4EI / L

= [4 x E x (6000 x 300^3)] / (12 x 6000)

= 9 x 10^6 E

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αc = Kc / Ks

= 2 x (1.67 x 10^6 E) / 9 x 10^6 E

= 0.37

IS 456 : 2000 pg.no. 56, Table 17

Ratio L1 / L2 = 1 / 1

= 1

αc min = 0.7

Step3 : 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

Step4 : 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

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Interior negative design

$=\{0.75 – \{0.1 / [1 + (1/\alpha c)] \} \}M$

$=\{0.75 – \{0.1 / [1 + (1/0.7)] \} \}274$

= 194 KNm

Interior positive design

=$\{0.63 – \{0.28 / [1 + (1/\alpha c)] \} \}$M

=$\{0.75 – \{0.28 / [1 + (1/0.7)] \} \}$274

= 141 KNm

Exterior negative design

= $\{0.65 / [1 + (1/\alpha c)] \}$ M

= $\{0.65 / [1 + (1/0.7)] \}$ 274

= 73 KNm

Interior negative design

Column strip = 75% x M

= 0.75 x 194

= 146 KNm

middle strip = 25% x M

= 0.25 x 194

= 48 KNm

Exterior positive design

Column strip = 60% x M

= 0.60 x 141

= 85 KNm

middle strip = 40% x M

= 0.40 x 141

= 56 KNm

Exterior negative design

Column strip = 75% x M

= 0.75 x 73

= 55 KNm

middle strip = 0

Step4 : Check for thickness of slab

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

thickness of slab near drop (column strip)

d = 146 x 10^6 / (0.138 x 20 x 3000)

= 133 mm

thickness of slab (middle strip)

d = 56 x 10^6 / (0.138 x 20 x 3000)

= 83 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 = $\pi/4$ (D+d)^2 x Wu

= $\pi/4$ (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

$\tau c = 0.25 \times \sqrt{fck}$

$= 0.25 \times \sqrt{20}$

$= 1.118 N/mm^2$

Permissible Shear stress $= ks \times \tau c$

$= 1 \times 1.118$

$= 1.118 N/mm^2$

$1.118 > 0.4$

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

$134 \times 10^6 = (97.48 \times 10^3\ Ast) [(1 – 2.56 \times 10^{-5}\ Ast)]$

$134 \times 10^6 = (97.48 \times 10^3\ Ast) – (2.49\ Ast^2)$

$134 \times 10^6 - (97.48 \times 10^3\ Ast) + (2.49\ Ast^2) = 0$

(using calculator) mode > Eqn > degree > 2

a $= 2.49$

b $= - 97.48 \times 10^3$

c $= 134 \times 10^6$

x1 $= 37721.9 mm^2$

x2 $= 1426 mm^2$

Ast = 1426 mm^2

Ast for per meter = 1426/3

= 475.33mm^2

Provide 12mm dia bars

Spacing = 1000 x [(πd^2 / 4) / Ast]

= 1000 x [(π x 12^2 / 4) / 475.33]

= 237.93 ~ 240mm

Provide 12mm dia bars at 240mm 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

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

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

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58 x 10^6 = (0.87 x 415 x Ast x 270)[(1- 415 x Ast)/ (3000 x 270 x 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 = $- 97.48 \times 10^3$

c = 58×10^6

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

= $1000 \times [(\pi \times 12^2 / 4) / 201.44]$

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

= 1000 x [(π x 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