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THREE CUBE ARCHITECTS

DOOR NO.1, HESSAAZ, 5/ 846 N3 FIRST FLOORS
SASTHRI NAGAR, EAST NADAKKAVU, CALICUT - 673006
Phone no – 0495-4016665
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STRUCTURAL DESIGN CALCULATION

Residential Apartment Building at S.F.No: 533/3B of Kalikkanaicken Palayam Village, Perur Taluk, Coimbatore

INTRODUCTION

Grade of concrete = M20
Grade of steel = Fe 500
Live load = 3 kN/m^2
Floor finish = 1 kN/m^2
Slab thickness = 12 cm
Unit weight of concrete -25kN/m^3

COLUMN LOAD CALCULATION

Column C1

Size of column = 20 cm x 50 cm L_y= 1.73m and L_x=2.35 m

a) Self weight of column =0.2 x 0.5 x 3 x 25 =7.5kN
b) Masonry load = (Influential length x width of wall x height of wall x unit weight of masonry x no: of floors)+(parapet wall load)= 117.19kN
c) Beam load = Influential length x width of beam x depth of beam x unit weight of concretex (no: of floors +1) = 95.96kN
d) Slab load = [(Influential area x(self weight + live load + floor finish) x (no: of floors -1)]+(roof slab load) = 138.85 kN
Total column load = 359.5kN

DESIGN

DESIGN OF FOOTING

C1-Column size – 20 cm x 50 cm
Load on column = 359.5kN
Assume self-weight of footing 10 %
Total load = 395.45kN
Soil bearing capacity = 160kN/m^2
Area Required = Total load/ SBC = 2.47 m^2
Area provided = 1.5m x 1.5m
Soil Pressure = $\frac{\text{column Load}}{\text{area}}$ = 159.78kN/m^2
Factored BM at face of column along X-direction = 75.945kNm
Factored BM at face of column along Y-direction = 44.94kNm

For BRINDAYAN DEVELOPERS

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Greatest Factored BM (M_u) =75.945kNm
Factored BM = $2.67bd^2$
Effective depth required = 137.7 mm
Provided500 mm depth with a cover of 40mm
Effective depth = 460mm
Provide an edge thickness of 200mm
Ast required =385mm^2
Provide 12 mm dia bars at 180mm c/c.

Check for one way shear

Critical section is at a distance of effective depth from face of column
Critical one way shear (V_u) = soil pressure x shear area = 45.54kN
Critical depth by interpolation d' = 247.69mm
Factored shear stress =$1.5V_u/bd'$ =0.184 N/mm^2
Percentage steel provided = $\frac{100A_{st}}{bd^2}$= 0.169
Permissible stress from IS 456:2000 = 0.35 N/mm^2
ThereforeSafe

Check for punching shear

Critical section is at a distance of d/2 from face of column
Area of critical section = 1.6164 m^2
Punching shear = 258.268kN
Factored punching shear (V)=387.4kN
Perimeter of critical section = 3.24m
Actual shear stress = V/b_0d =0.26N/mm^2
β_c = 0.4
$k_s = 0.5 + \beta_c$ = 0.9
τ_c = 1.118 N/mm^2
Permissible shear stress = $k_s\tau_c$ = 1.006 N/mm^2
Therefore Safe

Check bearing stress

A_1 = 5.5 m^2
A_2 = 0.1 m^2
$\sqrt{\frac{A_1}{A_2}}$= 7.42 Limit to 2
Permissible bearing stress = $0.45f_{ck}\sqrt{\frac{A_1}{A_2}}$=18 N/mm^2
Actual bearing stress = 3.595N/mm^2
Therefore Safe

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DESIGN OF COLUMN

Design of Column (C1)

Size of column = 20cm x 50 cm
Total load on column = 359.5kN
Factored load = 539.25kN
Add 10% = 593.18 kN
Assume minimum eccentricity 2cm
Design Moment = 11.86kNm
Uniaxial Moment capacity in x-direction

$\frac{P_u}{f_{ck}\,bd}$= 0.319

Assume reinforcement distributed equally on 2 sides for f_y 500, $\frac{d'}{d}$= 0.10 and $\frac{p}{f_{ck}}$= 0.06

From Chart 36 corresponding $\frac{M_u}{f_{ck}\,bd^2}$= 0.11

M_{UX1} = 95.139kNm
From Chart 63 for f_{ck} = 20 N/mm²p = 1.2

$\frac{P_{uz}}{A_g}$= 13.5andp_{UZ} = 1350kN

$\frac{P_u}{P_{uz}}$= 0.563

$\frac{M_{ux}}{M_{ux1}}$= 0.1597

$\frac{M_{uy}}{M_{uy1}}$= 0.1597

From chart 64, Permissible value of $\frac{M_{uy}}{M_{uy1}}$= 0.98

Therefore safe
Provide6 no.s –16 mmϕ bars

Design of ties

Pitch(least of the following):-

1. Least lateral dimension = 300 mm
2. 16d = 256 mm
3. 300 mm

Maximum pitch = 200mm
Minimum diameter of bar

1. ¼ of longitudinal bar = 3mm
2. 6mm

Provide 8mm ϕ bars @ 200mm c/c

For BRINDAVAN DEVELOPERS

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DESIGN OF PLINTH BEAM

DESIGN OF PLINTH BEAM (PB1)

Size of the beam = 20x30
Span = 2.25 m
d_{eff} = 265mm
Load on beam = wall load + self weight
= 12+ 1.5 = 13.5 kN/m
Factored load = 20.25kN/m
Design moment on beam (from IS-456- 2000)
Mu –ve(middle) = $wl^2/20$ = 5.12kNm
Mu +ve(support) = $wl^2/20$ = 5.12kNm
Shear force (Vu) = 0.4 x w.l= 18.225kN
Mu -ve/bd^2 = 0.36
Mu +ve/bd^2 = 0.36
Using table fromIS:456-1978, on the basis of Mu/bd^2 and fy-415, value of Pt is,
Percentage of steel (p_t) at midspan= 0.327
So, Ast = 1.73cm^2
Percentage of steel (p_t) at supports= 0.327
So, Ast = 1.73cm^2
So provide steel as 2-12mmϕ on tension and 2-12mmϕ on compression side at support and midspan.

Stirrups:
Shear stress, $\tau_v = V_u/bd$
=0.34 N/mm^2
From table 61 for M20,τ_c = 0.33 N/mm^2 for p_t = 0.088
$V_{us} = V_u - \tau_c bd$ =18.20kN
V_{us}/d =0.68kN/cm
From table 62, provided 8mmϕ@ 20 cm c/c

Check for deflection:
Actual ratio of span/effective depth = 8.49
Max (span/26) = 8.65(from IS:456-2000)
Therefore Safe

For BRINDAVAN DEVELOPERS

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DESIGN OF BEAM

DESIGN OF BEAM(B1)

Size of the beam = 20x30
Span = 2.25m
d_{eff} = 270 mm
Load on beam =slab load + wall load + self weight
= 7.8+12+1.5 = 21.31kN/m
Total load per m = 21.31kN/m
Factored load = 31.97kN/m
Design moment on beam (from IS-456- 2000)
Mu –ve(support) = $wl^2/12$ = 16.04 kNm
Mu +ve(middle) =$wl^2/10$ = 13.37 kNm
Shear force (Vu) = 0.6 x w.l= 42.96kN
Mu -ve/bd^2 = 1.1 Mu +ve/bd^2 = 0.917
Using tables on IS:456-1978 value ofp_t
Percentage of steel (P_t) at middle = 0.272
Percentage of steel (P_t) at supports = 0.232
A_{st} required at middle = 1.632 cm^2
A_{st} required at support = 1.392 cm^2
Provide steel as 3no.s-12mm ϕ on tension and 2no.s-12mm ϕon compression side at support and at midspan.

Stirrups:
Shear stress, $\tau_v = V_u/bd$
= 0.795 N/mm^2
From table 61 for M20,τ_c = 0.33 N/mm^2 for p_t = 0.20
$V_{us} = V_u - \tau_c bd$ =42.95kN
V_{us}/d = 1.59kN/cm
From table 62,
Provide 8mm ϕ @ 20 cm c/c

Check for deflection:
Actual ratio of span/effective depth =8.29
Max (span/26) = 8.615 (from IS:456-2000)
Therefore Safe

For BRINDAYAN DEVELOPERS

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DESIGN OF SLAB

DESIGN OF SLAB (S1)

Sample calculation:
Grade of materials:
Concrete mix = M20
Steel = Fe 500
Size of slab = 2.60 m x 3.85 m
L_x= 2.60 m and L_y = 3.85m
Span ratio(L_y/L_x) = 1.5

Design of two way slab

Load on slab = D.L+L.L+F.F
= 3+3+1 = 7kN/m^2
Factored load (w) = 10.5kN/m^2
Thickness of Slab = 120 mm
Bending Moment Coefficients: (From IS 456-2000)
Table 26 for L_y/L_x = 1.5

Design moments:

a_x= 0.089
a_y= 0.056
M_{ux}= a_x w l_x^2 = 6.32kNm
M_{uy}= a_y w l_x^2 = 3.97 kNm
Spacing (using IS 456-1978)
Provide 8mmϕ bar

Short span:	Long span:
Support = 16cmc/c	Support = 18cmc/c
Middle =16cmc/c	Middle = 18cmc/c

Check for deflection:

Using SP16 (From chart 22)
Span/d_{eff} = 21.67
Assume b =1000mm
Percentage of steel = 100 Ast/bd = 0.311
From chart 22,
Max (span/d) = 28>21.67
Therefore Safe

For BRINDAVAN DEVELOPERS

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DESIGN OF STAIR

Type of stair: Dog-legged staircase with waist slab

- Stair room size = 2 x 4.24 m^2
- Height between floors = 3.0 m;
- Rise = 180 mm
- Tread = 250 mm;
- Width of flight= landing width= 1.1 m
- Live load = 5.0 kN/m^2
- Finishes load =1kN/m^2

Assume the stairs to be supported on 200 mm thick masonry walls at the outer edges of the landing, parallel to the risers. Use M 20 concrete and Fe 415 steel. Assume mildexposure conditions.

Assume 9 risers and 8 treads in a single flight.

Inclined length of step = $\sqrt{180^2+250^2}$
= 308 mm

Effective span = c/c distance between supports
= 1.1 + (8 x 0.250) +1.1= 4.22 m

Assume a waist slab thickness ≈l/20
= 4220 /20= 211≈ 220 mm.

Assuming 20 mm clear cover (*mild* exposure) and 12 mm ϕ main bars,
Effective depth *d*= 220 – 20 – 12/2 = 194 mm.

The slab thickness in the landing regions may be taken as 200 mm, as the bending moments are relatively low here.

LOADS ON GOING:

(1) Self-weight of waist slab = 25 × 0.22 × 308/250 = 6.78kN/m^2
(2) Self-weight of steps = 25 × (0.5x0.18) = 2.25kN/m^2
(3) Live load + Finishes = 6 kN/m^2
Total load =15.03kN/m^2
Factored load = 15.03 × 1.5 = 22.55kN/m^2

LOADS ON LANDING:

(1) Self-weight of slab = 25 × 0.20 = 5.00 kN/m^2
(2) Live load + Finishes = 6 kN/m^2
Total load =11 kN/m^2
Factored load = 11 × 1.5 = 16.5kN/m^2

For [illegible] DEVELOPERS
Managing Partner

DESIGN MOMENT

Reaction,R = (16.5 x 1.2)+(22.55x2)/2 = 42.35kN/m

Maximum moment at midspan,

M_u = (42.35 × 2.2) – (16.5 × 1.2) × (2.2 – 1.2 /2) – (22.55) × $(2.2-1.2)^2/2$
= 50.22kNm/m

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MAIN REINFORCEMENT

R $= \frac{M_u}{bd^2}$ $= \frac{50.22\ X\ 10^3}{1000\ X\ 194^2}$ =1.334MPa

From Table 2 SP 16

P_t =0.401

A_{st}reqd = 777.9 mm²

Required spacing of 12 ϕ bars = 152.3 mm

Provide 12 mmϕ bars @ 15 cm c/c

DISTRIBUTORS

A_{st}reqd = 0.12 % of cross-sectional area = 300 mm² / m

Spacingof 8 mm ϕ bars = 261.6 mm/m

Provide 8 ϕ @ 200c/c as distributors.

Place : Coimbatore

Dated: 02/08/2024

Signature of the Structural Engineer:

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Signature of the Architect

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Signature of the Owner of the Building

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