

Analysis of G+5 Multistored Building

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ABSTRACT: The design process of structural planning and design requires not only imagination and conceptual thinking but also sound knowledge of science of structural engineering besides the knowledge of practical aspects, such as recent design codes, bye laws, backed up by ample experience, intuition and judgment. The purpose of standards is to ensure and enhance the safety, keeping careful balance between economy and safety. In the present study G+6 building at Ananthapuramu is designed (Slabs, Beams, Columns and Footings) using Auto CAD software. In order to design them, it is important to first obtain the plan of the particular building that is, positioning of the particular rooms (Drawing room, bed room, kitchen toilet etc.) such that they serve their respective purpose and also suiting to the requirement and comfort of the inhabitants. Thereby depending on the suitability; plan layout of beams and the position of columns are fixed. Thereafter, the loads are calculated namely the dead loads, which depend on the unit weight of the materials used (concrete, brick) and the live loads, which according to the code IS:456-2000 and HYSD BARS FE415 as per IS:1786-1985. Safe bearing capacity of soil is adopted as 350KN/M² at a depth of 6ft and same soil should extent 1.5 times the width of footing below the base of footing. Footings are designed based on the safe bearing capacity of soil. For designing of columns and beams, it is necessary to know the moments they are subjected to. For this purpose, frame analysis is done by limit state method. Designing of slabs depends upon whether it is a one - way or a two way slab, the end conditions and the loading. From the slabs, the loads are transferred to the beam. Thereafter, the loads (mainly shear) from the beams are taken by the columns. Finally, the sections must be checked for all the four components with regard to strength and serviceability.

I. INTRODUCTION

Buildings come in a wide amount of shapes and functions, and have been adapted throughout history for a wide number of factors, from building materials available, to weather conditions, to land prices, ground conditions, specific uses and aesthetic reasons. A Multi-Storey is a building that has multiple floors above ground in the building. Multi-storey buildings aim to increase the floor area of the building without increasing the area of the land the building is built on, hence saving land and, in most cases, money (depending on material used and land prices in the area). The design process of multi-storey building requires not only imagination and conceptual thinking but also sound knowledge of science of structural engineering besides the knowledge of practical aspects, such as recent design codes, bye laws, backed up by ample experience, intuition and judgment. The purpose of standards is to ensure and enhance the safety, keeping careful balance between economy and safety. In the present study G+6 building at Ananthapuramu, India is designed (Slabs, Beams, Columns and Footings).

Architecture is an interdisciplinary field, drawing upon mathematics, science, art technology, social sciences, politics, history and philosophy. Vitruvius states: "architecture is a science, arising out of many other sciences, and adorned with much and varied learning: by the help of which judgment is formed of those works which are result of other arts". Most modern-day definition of "good buildings" recognize that because architecture does not exist in a vacuum, architectural form cannot be merely a completion of historical precedent, fictional necessities; and socially aware concerns, but must also be a transcendence synthesis of all of the former and a creation of worth in and of itself. As Nunziarodanini stated, "through its aesthetic dimension architecture goes beyond the functional aspects that it has in common with other human sciences...through its own particular way of expressing values, architecture can stimulate and influence social life without presuming that, in and of itself, it will promote social development. To restrict the

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meaning of formalism to art for art's sake is not only reactionary; it can be a purposeless quest for perfection or originality which degrades fro, into a mere

instrumentally” The term can be used to connect the implied architecture of abstract things such as music or mathematics the apparent architecture of natural things, such as geological formations or the structure of natural things such as geological formations or the structure of natural things such as geological formation or the structure of biological cells, or explicitly planned architectures of human made things such as software, computers, enterprises, and databases, in addition to buildings. In every usages an architecture may be seen as subjective mapping fro, a human perspective (that of the user in the case of abstract or physical artifacts) to the elements or components.

II. LITERATURE REVIEW

Major advances in both design and new material assisted roman architecture. Design was enhanced architectural developments in the construction of arches and roof domes. Arches improved the efficiency and capability of bridges and aqueducts (fewer supports columns were needed to support the structure), while domed roofs not only permitted the building of larger open areas undercover, but also lent the exterior an impressive. he social unit that lives in a house is known as a household. Most commonly, a household is family unit of a same kind, though households can be other social groups, such as single person, or groups of unrelated individuals. Settled agrarian and industrial societies are composed of household units living permanently in housing of various types, according to a variety of farms of lands tenure. English-speaking people generally call any building there routinely occupy “home”. Many people leave their houses during the day for work and recreation, and return to them to sleep or for other activities.

III. DESIGN METHODOLOGY

Design of slab

i) Data:-

Clear span = 4.83 m

Wall thickness = 0.23 m

Live load = 2 kn/m²

Floor finish = 1 kn/m²

Fck = 20 kn/m²

Fy = 415 kn/m²

dx = 4.83 m, dy = 6.02 m

dy/dx = 6.02/4.83 = 1.246 < 2

hence the slab is to be designed as a two way slab.

ii) Thickness of slab :-

Assume effective depth = span/28

$$= 4830/28$$

$$d = 172.5 \text{ say } 175 \text{ mm}$$

Adopting clear cover 20 mm & using 10 mm bars

Overall depth ; D = 175 + 20 + 10/2

$$D = 200 \text{ mm}$$

iii) Effective span:-

Least of the following,

$$L_x = 4.83 + 0.175 = 5.005 \text{ m}$$

$$L_y = 6.02 + 0.175 = 6.195 \text{ m}$$

$$L_y/L_x = 6.195/5.005 = 1.238$$

iv) Loads :-

$$\text{Self wt of slab} = 0.200 \times 1 \times 25$$

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$$= 5 \text{ kn/m}^2$$

$$\text{Live load} = 2 \text{ kn/m}^2$$

$$\text{Floor finish} = 1 \text{ kn/m}^2$$

$$\text{Total load} = 8 \text{ kn/m}^2$$

$$\text{Factored load (Wu)} = 1.5 \times 8 = 12 \text{ kn/m}^2$$

v) Design moments & shear forces :-

The slab is simply supported on all the four sides. The corners are not held down. Hence moment coefficients are obtained from table 27 of IS 456.

$$\alpha_x = 0.074$$

$$\alpha_y = 0.056$$

$$M_{ux} = \alpha_x \omega l_x^2$$

$$= 0.074 \times 12 \times 5.005^2$$

$$= 22.24 \text{ kn-m}$$

$$M_{uy} = \alpha_y \omega l_y^2$$

$$= 0.056 \times 12 \times 5.005^2$$

$$= 16.83 \text{ kn-m}$$

$$\text{Factored shear force (Vu)} = W_u.l/2$$

$$= 12 \times 5.005/2$$

$$= 30.03 \text{ KN}$$

vi) Min depth required :-

The minimum depth required to resist the bending moment

$$M_u = 0.138 f_{ck} b d^2$$

$$22.24 \times 10^6 = 0.138 \times 20 \times 1000 \times d^2$$

$$d = \sqrt{(22.24 \times 10^6 / 0.138 \times 20 \times 1000)}$$

$$d = 89.76 \text{ mm} < 175 \text{ mm}$$

vii) Reinforcement :-

Along x- direction

$$M_{ux} = 0.87 f_y A_{st} d (1 - f_y A_{st} / f_{ck} b d)$$

$$22.24 \times 10^6 = 0.87 \times 415 \times A_{st} \times 175 (1 - 415 \times A_{st} / 20 \times 1000 \times 175)$$

$$A_{st} = 368.05 \text{ mm}^2$$

Using 8 mm dia bars , spacing of bars

$$S = a_{st} / A_{st} \times 1000$$

$$= (\pi/4 \times 8^2) / 368.05 \times 1000$$

$$= 136.57 \text{ mm say } 130 \text{ mm}$$

Maximum spacing is (1) $3d = 3 \times 175 = 525 \text{ mm}$

(2) 300 mm whichever is less

Hence, provide 8 mm bars at 130 mm c/c Along y-direction. These bars will be placed above the bars in x-direction

$$\text{Hence, } d = 175 - 8 = 167 \text{ mm}$$

$$M_{uy} = 0.87 f_y A_{st} d (1 - f_y A_{st} / f_{ck} b d)$$

$$16.83 \times 10^6 = 0.87 \times 415 \times A_{st} \times 167 (1 - 415 A_{st} / 20 \times 1000 \times 167)$$

$$A_{st} = 289.54 \text{ mm}^2$$

Using 8 mm dia bars, spacing of bars

$$S = a_{st} / A_{st} \times 1000$$

$$= (\pi/4 \times 8^2) / 289.54 \times 1000$$

$$= 173.6 \text{ mm say } 170 \text{ mm}$$

Max. spacing is (1) $3d = 3 \times 167 = 501 \text{ mm}$

(2) 300 mm whichever is less

Hence, provide 8 mm bars at 170 mm c/c

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viii) Reinforcement in Edge strip :-

$$\begin{aligned} A_{st} &= 0.12\% \text{ of gross area} \\ &= 0.12/100 \times 1000 \times 200 \\ A_{st} &= 240 \text{ mm}^2 \end{aligned}$$

Using 8 mm dia bars, spacing of bars

$$\begin{aligned} S &= a_{st}/A_{st} \times 1000 \\ &= (\pi/4 \times 8^2) / 240 \times 1000 \\ &= 209.44 \text{ mm say } 200 \text{ mm} \\ \text{Max. Spacing is (1) } 5d &= 5 \times 175 = 875 \text{ mm} \\ &\text{(2) } 450 \text{ mm whichever is less} \end{aligned}$$

Hence provide 8 mm bars at 200 mm c/c in edge strips in both directions

ix) Torsion Reinforcement :- Area of reinforcement in each layer

$$A_t = \frac{3}{4} A_{stx} = \frac{3}{4} \times 368.05 = 276.04 \text{ mm}^2$$

$$\begin{aligned} \text{Distance over which Torsion reinforcement is to be provided} &= 1/5 \text{ short span} \\ &= 1/5 l_x \\ &= 5005/5 \\ &= 1001 \text{ mm} \end{aligned}$$

Using 6 mm bars, spacing

$$\begin{aligned} S &= a_{st}/A_{st} \times 1000 \\ &= (\pi/4 \times 6^2) / 276.04 \times 1000 \\ &= 102.43 \text{ mm say } 100 \text{ mm} \end{aligned}$$

Hence provide 6 mm bars at 100mm c/c at all the four corners in four layers

x) Check for deflection :-

For simply supported slabs basic value of l/d ratio = 20

Modification factor tension steel F1

$$\begin{aligned} \text{\% of steel,} \\ &= A_{st}/bd \times 100 \\ &= (368.05/1000 \times 175) \times 100 \\ &= 0.21 \text{ \%} \end{aligned}$$

$$F_s = 0.58 \times f_y = 0.58 \times 415 = 240 \text{ N/mm}^2$$

From fig 4 of IS 456, modification factor = 1.5

$$\text{Maximum permitted l/d ratio} = 1.5 \times 20 = 30$$

$$L/d \text{ provided} = 5005/175 = 28.6 < 30$$

Hence deflection control is safe

B) DESIGN OF BEAM:

1) Data:

$$\begin{aligned} f_{ck} &= 20 \text{ N/mm}^2 \\ f_y &= 415 \text{ N/mm}^2 \\ l &= 6.02 \text{ N/mm}^2 \end{aligned}$$

2) Depth of beam :

Selecting the depth in range of 1/12 to 1/15 based on stiffness

$$\begin{aligned} d &= 6020/15 \\ &= 401.33 \text{ mm} \\ \text{Adopt } d &= 410 \text{ mm} \\ D &= 450 \text{ mm} \end{aligned}$$

3) Effective span:

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C/c distance between the supports = $6.02+0.23$
= 6.25m
Clear span + d = $6.02+0.41$
= 6.43m

Hence effective span = 6.25m

4) loads :-

Self weight of the beam = $0.23 \times 0.45 \times 1 \times 25$
= 2.58kn/m²
Load from slab = 8kn/m²
Total load = 10.58kn/m²
Factored load = $1.5 \times 10.58 = 15.87$ kn/m

5) factored B.M (Mu) & S.F:-

Factored B.M (Mu) = $Wul^2/8$
= 15.62×6.25^2
= 77.548kn-m

Factored s.f (Vu) = $Wul/2$
= 15.882×6.25
= 49.63kn

6) Depth required:-

The min depth req to resist b.m
 $M_u = 0.138 F_{ck} b d^2$
 $77.548 \times 10^6 = 0.138 \times 20 \times 250 \times d^2$
D = 349.5 < 410mm
Hence ok

7) Tension reinforcement:-

$M_u = 0.87 F_{yA_{st}}(1 - F_{yA_{st}}) F_{ck} b d$
 $A_{st} = 0.87 \times 415 \times A_{st} \times 410 (1 - 415 \times A_{st})$
 $20 \times 230 \times 410$
A_{st} = 604.19mm²

Provide 4 bars of 16φ bars
A_{st} provided = 804.248mm²

8) design shear stress :-

Nominal shear stress (T_v) = V_u/bd
= $49.63 \times 10^3 / 230 \times 410$

DESIGN OF COLUMN

Load from beam = 76.765 KN
Self wt of column = $0.23 \times 1 \times 25$
= 5.75 Kn/m
Total load = 82.515 Kn/m
Factored load (wu) = 1.5×82.515
= 123.77 Kn/m
Length of column = 3.0 m
L_{eff} = 0.65 l
= 0.65×3000
= 1950 mm
Check type of the column,
 $1950/230 = 8.478 < 12$
Hence designed as a short column.

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Side of the column on one side = 230 mm

Net gross area of column is A_g

Assuming 1% of steel,

$A_{sc} = 1\% A_g = 0.01 A_g$

Area of concrete, $A_c = A_g - A_{sc} = A_g - 0.01 A_g = 0.99 A_g$

For axially loaded short columns,

$P_u = 0.4 f_{ck} A_c + 0.67 f_y A_{sc}$

$123.77 \times 10^3 = 0.4 \times 20 \times 0.99 A_g + 0.67 \times 415 \times 0.01 A_g$

$A_g = 115667.5 \text{ mm}^2$

Since the column is rectangular & one side of the column is 230 mm, dimension of the other side

$A_g / 230 = 115667.5 / 230 = 502.9 \text{ mm}$ say 500 mm

Adopt 230 mm \times 500 mm rectangular column,

$A_{sc} = 0.01 A_g = 0.01 \times 115667.5$

$= 1156.675 \text{ mm}^2$

Provide 6 mm bars of 16 mm diameter,

A_{sc} provided = 1206.4 mm^2

Lateral ties :-

a) $\phi/4 = 1/4 \times 16 = 4 \text{ mm}$

b) 6 mm

Hence, adopt 6 mm diameter bars

Pitch of the ties shall be minimum of

a) least lateral dimension of column = 230 mm

b) 16 times of the dia of longitudinal bar = 16×16

= 256 mm

c) 300 mm

DESIGN OF FOOTING

a) Data :-

Axial load = 307.068 KN

Size of the column = 280 \times 500 mm

S.B.C of soil = 200 kn/m^2

$F_{ck} = 20 \text{ kn/m}^2$

$F_y = 415 \text{ kn}$

1) Size of footing:

Load from the column = 307.068 kn

Self wt from of footing = 10% of column load = 307.068/10

Total load on the soil = 337.775 kn

Area of footing = $337.775 / 200 = 1.689 \text{ m}^2$

Provide 1.2 \times 1.5 m footing so that the cantilever projection of the footing from the column face is same equal to

1.2 - 0.23 1.5 - 0.5

(-----) = (-----) = 0.5 m

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Area of footing provided = 1.2 \times 1.5 m

2) Upward soil pressure:

Factored load $P_u = 1.5 \times 307.068$

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$$= 460.602\text{kn}$$

Soil pressure at ultimate load =

$$Q_u = P_u / \text{area of footing}$$

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$$Q_u = 460.602 / 1.2 \times 1.5 = 255.89\text{kn/m}^2 = 0.26\text{n/mm}$$

3) Depth of footing from B.M consideration:

The c critical section for B.M will be at the face of the column as shown $M_u = q_u l (B-b/8)^2$

$$= 0.16 \times 1500 (1200 - 230/8)^2$$

$$= 5.733 \times 10^6 \text{N-mm}$$

4) Reinforcement:

$$M_u = 0.87 F_y \times 415 \times A_{st} \times 450 (1 - 415 A_{st} / 20 \times 1500 \times 250)$$

$$A_{st} = 557.25\text{mm}^2$$

Using 16mm diameter bars, spacing of bars

$$S = a_{st} \times B / A_{st}$$

$$= 304.42\text{mm}$$

Hence provide 12mm bars at 300mm/c

5) Check for one way shear:

The critical section for one way shear is at a dist d from the face of the column as shown in the fig ;

Fact S.F = V_u = soil pressure from the shaded area.

IV. CONCLUSION

In the present study G+5 building at Ananthapuramu, is designed (Slabs, Beams, Columns and Footings). The loads are calculated namely the dead loads which depend on the unit weight of the materials used (concrete, brick) and the live loads using the code IS:456 -2000 and HYSD BARS FE415 as per IS:1786-1985. The safety of G+5 reinforced concrete building will depend upon the initial architectural and structural configuration of the total building, the quality of the structural analysis, design and reinforcement detailing of the building frame to achieve stability of elements and their ductile performance. Proper quality of construction and stability of the infill walls and partitions are additional safety requirements of the structure as a whole.

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