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Analysis And Design Of A Multistorey Residential Building (C+ Stilt + 5 Floor) Using Staad Pro

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Abstract: Shelter is one of the three basic and most important needs of mankind and deserves much importance. Since the early age man has built structures mainly of stone and brick masonry. After the invention of port land cement in the 19th century later on steel took care of tension, the whole scenario of construction was revolutionized. In the project of "**ANALYSIS AND DESIGN OF MULTISTOREY BUILDING**", we have adopted Limit state method of analysis and design purpose. The design is in confirmation with IS-456:2000. The analysis of frames has been performed by "**STAAD PRO**" i.e. "**FINITE ELEMENT METHOD**". In this attempt we use to apply our knowledge acquired in the past four years of study. We are happy that we could complete the work successfully and, in this process, acquired more knowledge. This work posed us many important problems, thus forcing us to have a detailed study in to the subject. This helped to us to have a look towards the practical aspect of our subject even though the project work concerned only to the analysis and design of Multistorey Building.

Index Terms – Construction, analysis, aspect, Limist state method.

I.INTRODUCTION

The rapid industrialization and population explosion has given rise to acute storage of housing especially in urban and metropolitan areas where the density of population increases day by day, demand an eye for housing at a large scale. This problem can be solved by construction of multistoried buildings.

The factors influencing the construction of multistoried buildings are the cost of land, where water supply sanitary schemes are electric power.

1.1 STATEMENT OF PROJECT

Salient Features

1. Utility of Building: Residential Building :Residential Building
2. No .of Stones :G+5
3. Shape of the building :Rectangular
4. No. of staircase :One
5. No. of lifts :One
6. Types of construction :R.C.C Frames Structure
7. Types of walls :Brick Wall

Geometric Details

Floor to floor height	:	3.0 m
Height of plinth	:	1.5 m above G.L
Depth of foundation	:	1.2 m below G.L

Materials:

Concrete grade	:	M25
All steel grades	:	FE500
Bearing capacity of soil	:	450 KN/m2

II DESIGN OF SLABS

2.1 DESIGN CONSTANTS:

Using M25& Fe500 grade of concrete & steel

fck (Characteristics strength for M25) = 25N/mm2

fy (Characteristics strength for steel) = 500 N/mm2

2.2 LOAD ON SLABS:

- Dead load:

Self-weight of slab: This load acts as UDL and is calculated after assuming the 1m wide square strip & suitable thickness by stiffness consideration.

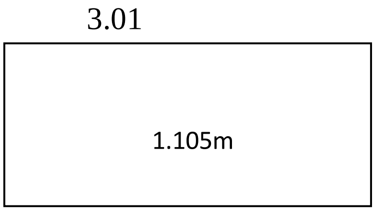
Floor finish load: This load also acts as UDL and is calculated after assuming suitable intensity over 1m wide strips.

- Live load:

This is the temporary load on its intensity depends on type & occupancy of building. As per IS: 875 - Part IV, the intensity of live load is taken.

2.3 DESIGN OF ONE-WAY SLAB (S2)

2.3.1 Preliminary Data



Short span L_x = 1.105m

Long span L_y = 3.01m

Clear cover to the reinforcement d_1= 25 mm

Diameter of the bar used ø = 10

mmAspect ratio L_y / L_x= 3.01/1.105= 2.72m

= 2.72m> 2

Hence the slab is to be designed as one-way slab.

Assume thickness of slab as 125mm.

Effective depth = 125-25-10/2 =100mm

2.3.2 Calculation of Loads

Live Load = 3 kN/m^2

Weight of slab = 0.125x1x25 = 3.125kN/m^2

Weight of flooring = 1kN/m^2

Total Load = 7.125/m^2

Total Factored Load W_u= 1.5 × 7.125 = 10.68kN/m^2

Factored Bending Moment M = W_u*L_y ^{2}/8 = 2kn m

Depth of slab required d = √ (M/0.133*b* f_{ck})

= √(2 x10^6/(0.133 x1000x25)) = 25 mm< 100mm

As d_{reqd}<d_{prov},the section is **SAFE**

Adopt overall depth D = 125 mm

2.3.3 Area of Steel Required

A_{st} = 0.5f_{ck}bd/f_y[1-√(1-4.6M/ f_{ck}bd^2)]

=47 mm^2

As per clause 26.5.2.1, minAst= 0.12% of bD

= 0.12 × 1000 × 125/100 = 150mm^2

Ast < Ast min

Therefore Ast = Ast min =150mm2

Spacing of 10mm diameter bars is given

S= (a_{st} /A_{st}) * 1000 = π*10*10*1000/4*150 = 523 mm

As per clause 2.3.3 b, spacing should be least of the following:

2.7.1.1 3 × effective depth

= 3×100= 300mm2. 300 mm

3. 523mm

Provide 10 mm diameter (main steel) at spacing of 300 mm c/c.

Asr provided = π * 10 *10*1000 / (4*300) = 262mm^2

2.3.4 Distribution reinforcement:

Assume 10mm dia bars

Min A_{st}= 0.12% bD

= 0.12 × 1000 × 125/100= 150 mm^2

Spacing of 10 mm diameter bars is given by

S= (a_{st} /A_{st})1000 = 50.24*1000/140 = 140mm

As per clause 26.3.3b, spacing should be least of the following;

2.3.4.1 3 × effective depth = 3 × 100= 300mm2.

Provide 10 mm diameter bars (distribution steel) at spacing of 140mm c/c.

2.3.5 Check for Shear:

Shear force Vcr = (2*2.72/2) *(((2.72*0.5) -(0.23*0.5)+0.124)/ (0.5*2.72)) = 3KN

Nominal Shear Force τ_v = V_u/bd = 3.01*1000/1000*100 =0.030

N/mm^{2}Percentage of Steel P_t = A_{st} *100/b*d

= 561*100/1000*100=0.561%

For M25 grade concrete, τ_c= 0.51N/mm^{2}Since T_v< T_c

So**, SAFE** in Shear.

2.3.6 Check for deflection:

L/d = 2.72*1000/(40*0.8) =9.68

f_s = 0.58*f_y * A_{st} required /A_{st} provided

= 0.58*500*180/194 = 270 N/mm^2

Based on P_t and f_s, modification factor

=1.63Max L/d = 0.8*20*1.63 = 26.08 > 9.68

So, **SAFE** in deflection

2.4 DESIGN OF TWO-WAY SLAB (S1)

2.4.1 Preliminary Data

Grade of concrete M20=fck = 25N/mm² Grade of steel Fe500 =fy= 500 N/mm²

Short span L_x = 3.178 m

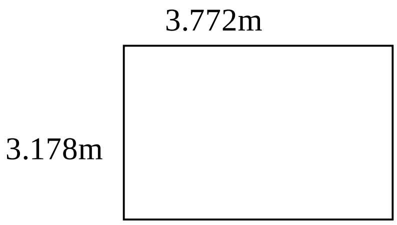
Long span L_y = 3.772m

Clear cover to the reinforcement = 20 mm

Diameter of the bar used ø = 10 mm

Aspect ratio L_y / L_x = 3.772/3.178

= 1.19<2



Hence the slab is to be designed as two-way slab.

End condition: Two Adjacent Edges Discontinuous.

2.4.2 Step 2: Thickness Of Slab

For continous slab, Span/depth = 40*(0.8), depth

= 3.772 *1000/40*0.8depth = 100 mm

Taking Clear cover = 20mm Overall depth = 100+20+10/2=125 Assuming overall depth as 125mm

Effective depth d = 125-20-10/2=100mm

2.4.3 **Step 3: Calculation of Loads:** Dead load:

Self weight of slab = 25*0.125 = 3.125kN/m²

Floor finish = 1 kN/m²

Live load:

Live load = 2 KN/m²

Accidental load=1 KN/m²

Total load =3.125+1+2+1 =7.125 kN/m²

Total Factored Load W_u = 1.5 × 7.125 = 10.69 kN/m²

2.4.4 Step 4: Bending Moment Calculations:

For ly/lx =1.19 , Two Adjacent Edges Discontinuous

From page 91 of IS 456:2000 clause 24.4.1.

Bending Moment Coefficients are:

$\alpha_x(+) = 0.049$ $\alpha_x(-) = 0.068$

$\alpha_y(+) = 0.035$ $\alpha_y(-) = 0.047$

Calculation of Bending Moments

$M_x\ (-ve) = \alpha_x * w_u * {}_x l^{\,2} = 0.035 \times 10.69 \times 3.77^2 = 5.35$ kN-m

$M_x\ (+ve) = 0.049 \times 10.69 \times 3.77^2 = 5.351$ kN-m

$M_y\ (-ve) = 0.047 \times 10.69 \times 3.77^2 = 5.07$ kN- m

$M_y\ (+ve) = 0.068 \times 10.69 \times 3.77^2 = 3.78$kN-m

Bending Moment = 8 kN-m

Shear Force = $W_u * L_x/2$ = 10.69*3.77/2 = 20.15 kN

2.4.5 Check for depth:

$d_{(eff)} = \sqrt{8*10^6/0.133*25*1000} = 50 < 100$ mm.

It is Safe.

2.4.6 Area of Steel:

$A_{st(-x)} = 0.5 f_{ck} bd/f_y [1-\sqrt{(1-4.6M/ f_{ck} bd^2)}]$

$= 0.5*25*1000*100/ 500\ [1-\sqrt{1- 4.6*8*10^6/25*1000*100^2}]$

$= 176\ mm^2$

$A_{st(+x)} = 127\ mm^2$

$A_{st(-y)} = 120 mm^2$

$A_{st(+y)} = 89 mm^2$

Minimum A_{st} as per clause 26.5.2.1, = 0.12% bD

A_{st} = 0.12/100 * 1000 * 125 =150 mm^2

2.4.7 Spacing for Reinforcement:

Spacing $_{x(+ve)}$ = $A_Ø/A_{st}$ *1000 =π*10*10*1000/ (4*150.) =523mm

Maximum spacing should be less than 3d or 300 = 3*100 or 300mm

Provide 10mm Ø bars at 300 mm c/c spacing

Spacing $_{x(-ve)}$= 446 mm

Provide 10 mm Ø bars at 300 mm c/c spacing

Spacing $_{y(+ve)}$ =127mm

Provide 10 mm Ø bars at 300 mm c/c spacing

Spacing y(-ve) = 523mm,

Provide 10 mm Ø bars at 300 mm c/c spacing.

Ast Provided:

Ast provided = AØ * b/ spacing

$A_{st}(-x) = (\pi/4 * 8^2) * 1000 /230 = 176\ mm^2$

$A_{st}(+x) = 127\ mm^2$

$A_{st}(-y) = 150\ mm^2$

$A_{st}(+y) = 150\ mm^2$

2.4.8 Check for Shear:

Shear force V_{cr} = (10.69*3.77/2) *(((3.77*0.5) -(0.23+0.1))/ (0.5*3.772)) = 17KN

Nominal Shear Force $T_V = V_u / bd = 17*10^3 / 1000*100 = 0.17 N/mm^2$

Percentage of Steel(Pt)= 100 * Ast provided / b*d =100*262/ (1000*100) =0.262

From table 19 to IS 456:2000

Tc max= 0.366

Tv< Tc max

It is **SAFE** in Shear**.**

2.4.9 Check for Deflection:

L/d = 3.178*1000/100 =31.78

$f_s = 0.58*f_y * A_{st}$ required / A_{st} provided

$= 0.58*500*218/219 = 289\ N/mm^2$

Based on P_t and fs, modification factor =1.828

Max L/d

= 0.8*40*1.828 = 58.496 >38.18

So, **SAFE** in deflection.

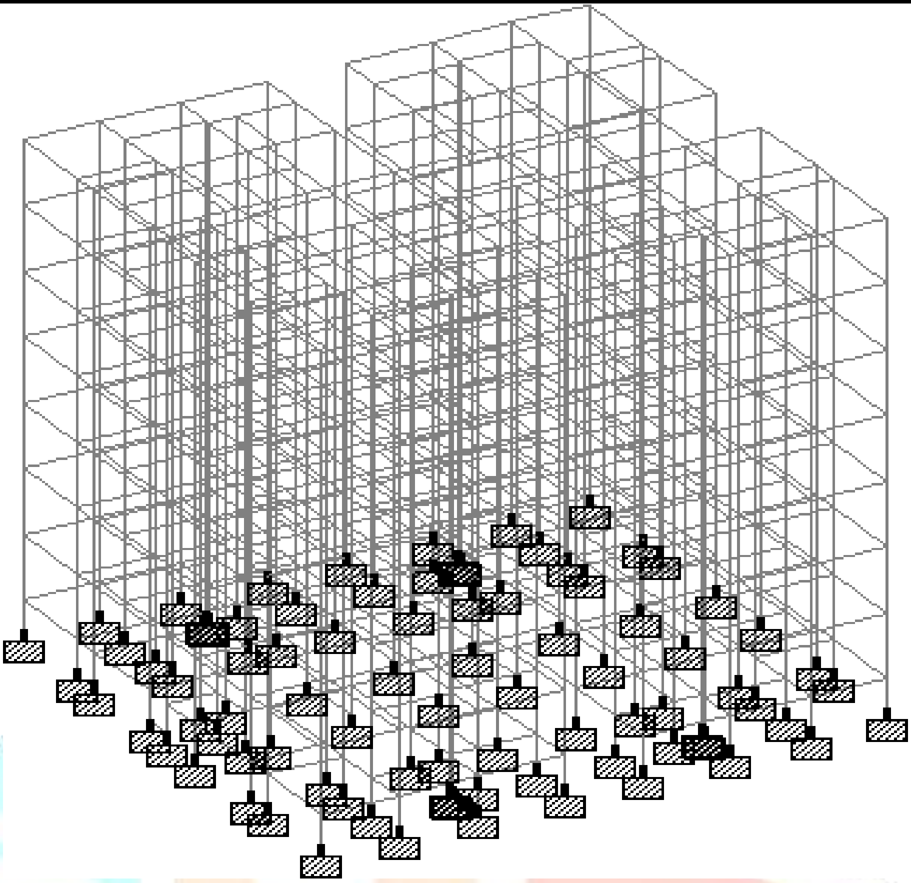


Fig 1 Isometric View of Building

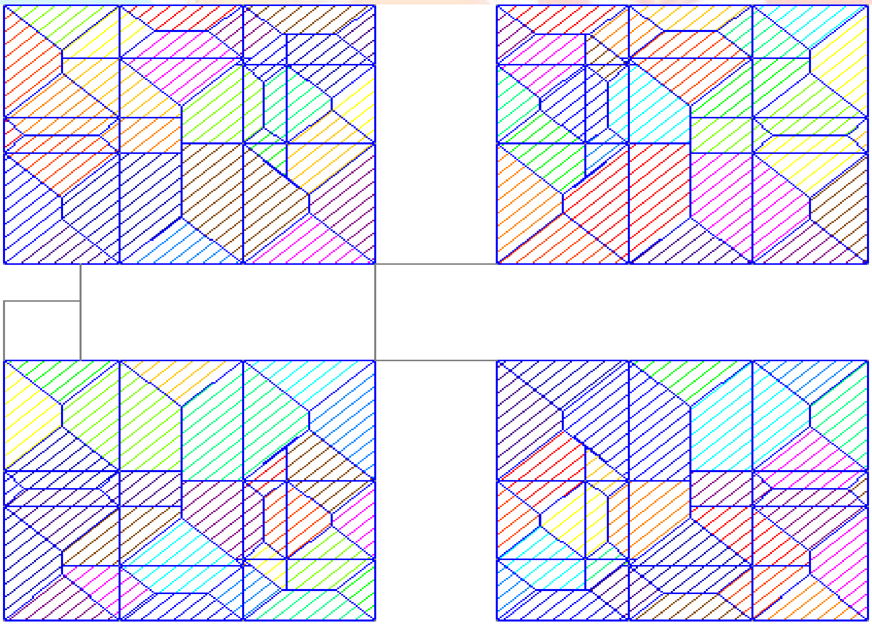


Fig 2 Floor Loading Diagram

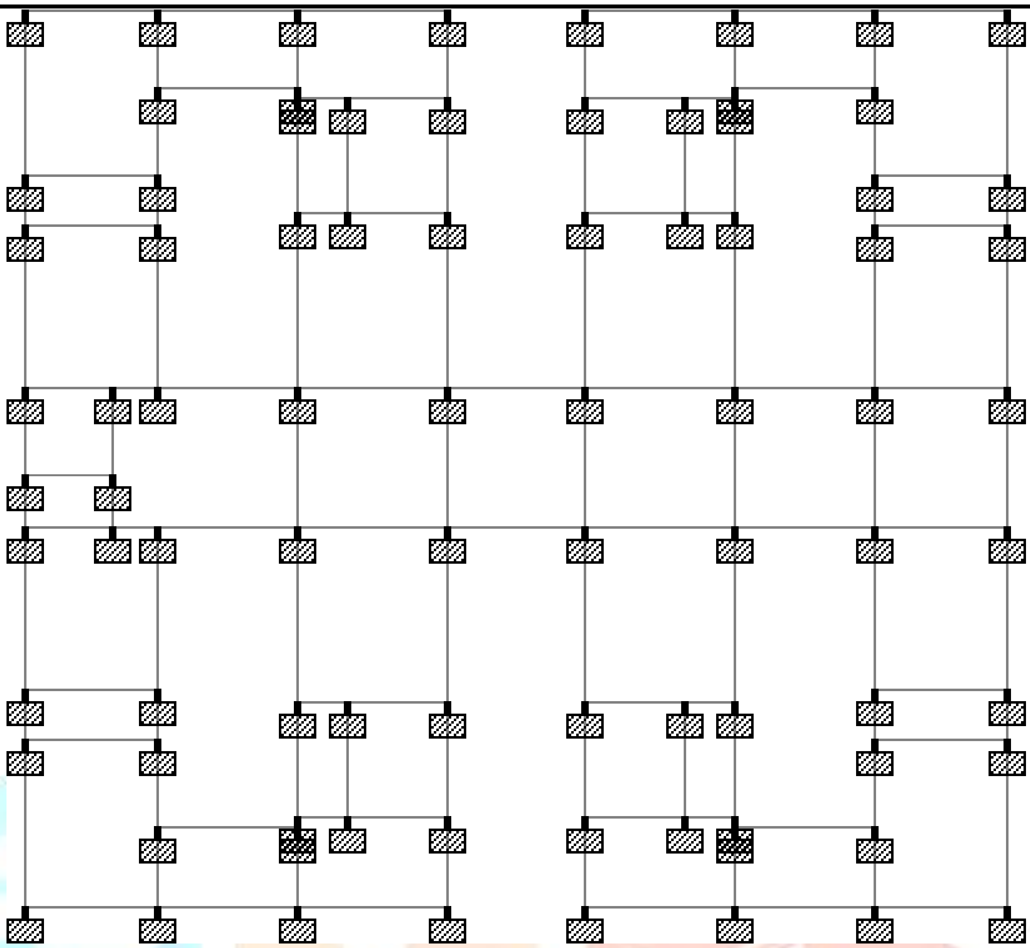


Fig 3 Plan of the Building

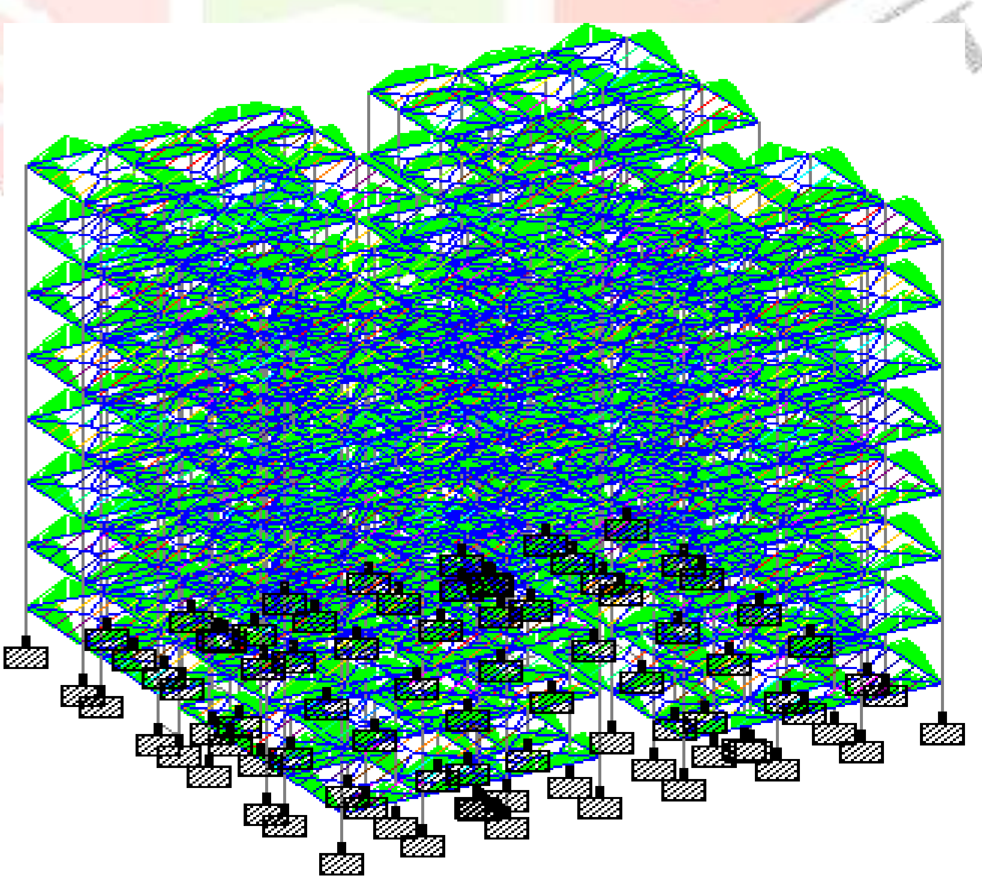


Fig 4 Loading Diagram of Building

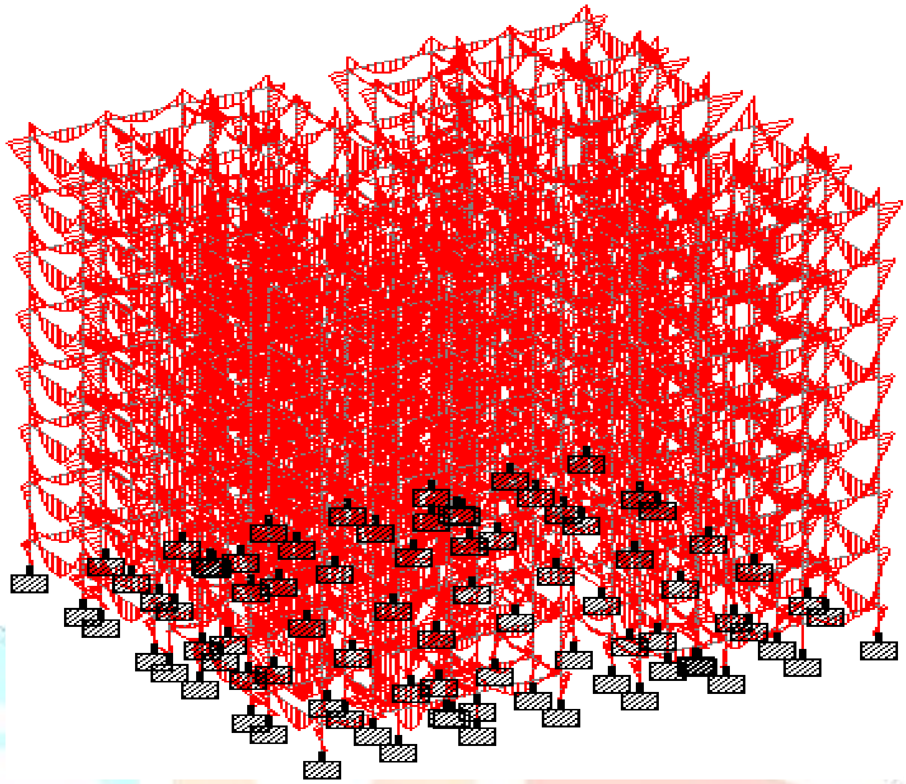


Fig 5 Bending Moment Diagram of Building

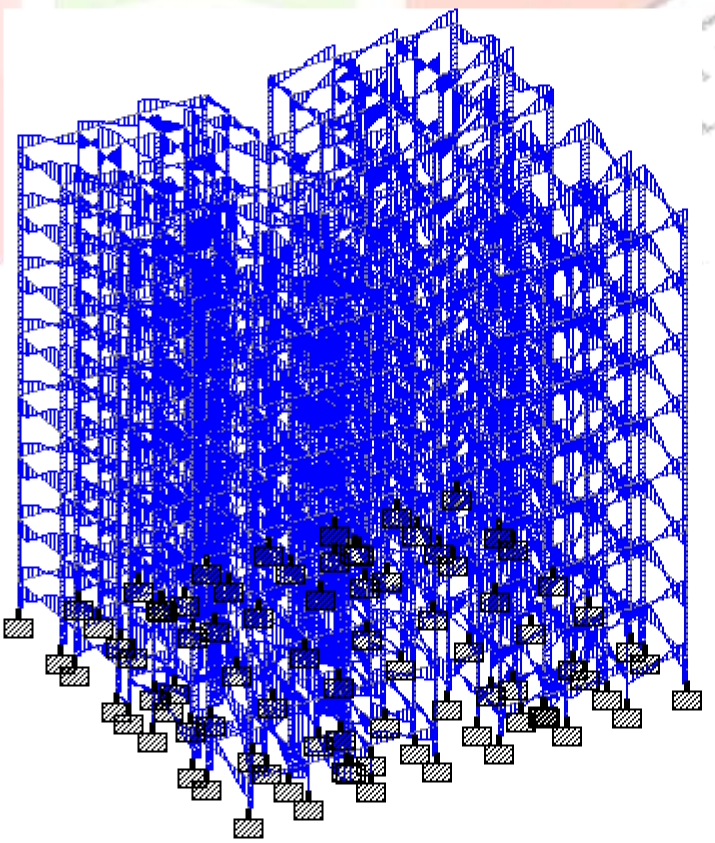


Fig 6 Shear Force Diagram of Building

III. DESIGN FOR FLEXURE (BEAM: - C1C2)

3.1 End span section

Length of beam L = 3.772 mt

For Fe 500 Steel fy = 500N/mm2

For M20 Concrete fck = 25 N/mm2

For M20 & Fe 500 Xumax / d = 0.46

Width of the beam b = 230 mm

Nominal cover to reinforcement = 30 mm

Using 20 mm dia bars

Effective depth of beam, d= 565-30-20 = 305 mm

Design bending moment of the section Mu = 86.53KNm

Limiting moment of resistance Mu lim = 0.133 x fck x b x d x d

= 0.133 x 25 x 230 x 305 x 305

= 96 KNm

As Mu is less than Mu lim, the section is to be designed as singly reinforced beam

3.2 Left End Section

Design bending moment Mu = 86.53KNm

$86.53 \times 10^6 = 0.87 \times 500 \times Ast \times 305 \times (1-(500*Ast/25*230*305))$ Ast = 866.665 mm^2

Ast (min) = (0.85 x b x d) / fy = 0.85 x 230 x 305 / 500 = 119.25 mm^2

Provide 2 bars of 12mm dia & 3 bars of 20 mm dia at the left end section of beam C1C3.

3.3 Right End Section

Design bending Moment Mu = 87.28KNm

$87.28 \times 10^6 = 0.87 \times 500 \times Ast \times 305 \times (1-(500*Ast/25*230*305))$ Ast = 877.917 mm^2

Ast (min) = (0.85 x b x d) / fy = 0.85 x 230 x 305 / 500 = 119.255 mm^2

Provide 2 bars of 12mm dia &3 bars of 20mm dia at the right end section of beam C1C3.

Mid Span section

Design bending Moment Mu = 44.027 KNm

$447.027 \times 10^6 = 0.87 \times 500 \times Ast \times 305 \times (1-(500*Ast/25*230*305))$

Ast = 371.316 mm^2

Ast (min) = (0.85 x b x d) / fy = 0.85 x 230 x 305 / 500 = 119.25 mm^2

Provide 3 bars of 12 mm dia & 2 bars of 12mm dia at the mid span section of beam C1C3

3.4 Design for shear

Ultimate shear force, Vu = Vcu = 132.4 KN

Nominal shear stress τV = Vuc / bd

= 132.4 x1000 / (230 x 535)

= 1.383 N/mm2

As per IS 456:2000 should not be more than max i.e $\tau Cmax$ = 3.1 N/mm2

Percentage steel reinforcement at end span section (Ast/bd) x100 = 1281.76 x100/(230 x305)

= 1.486

As per IS 456 table 19, τC = 0.738 N/mm^2

$\tau V > \tau C$ and $\tau V < \tau Cmax$

Shear capacity of concrete section Vuc1 = τC x b x d =0.738*230*305

= 51.77 KN

Shear to be resisted by stirrups Vus = 96.16 KN

Using 8mm 2 legged HYSD bars as stirrups

Spacing is given by Sv = 0.87 x fy x Asv x d / Vus

= 0.87 x 500 x 2 x 50.26 x 305 / 96.16 x 1000

= 170.48 mm

Spacing of stirrups should not be more than least of the following

1) Sv = 170.48 mm

2) Sv = (Asv x fy x 0.87) / 0.4 x b

= 2 x 50.26 x 500 x 0.87 / 0.4 x 230== 475.28 mm

3) Sv = 0.75 x d = 0.75 x 305 = 228.75 mm

4) Sv = 300 mm

Therefore, provide 8mm dia 2-legged stirrups at 170 mmc/c throughout its length.

IV. Conclusion

Structural Aided Design is easy and also time effective whereas the manual calculations are tedious and time consuming. For structural Analysis and design of different structural items suchas Footings, Columns, Beams, Slabs, Staircases etc. in this proposed Multistory Building Design project different load combinations was considered and the deflection shape of the building was studied. The bending moment and shear force were calculated and presented graphically. One critical beam case and column case was shown in detail. The slabs, footings and stair case were designed manually and the details of reinforcement were shown in auto-cad drawings. Through this project we understood about what is Architecture, how the building is planned, Structural analysis and design is done, consideration of different loads, codes etc.

The various methods in analysis and design of structures, and in addition to this we understood the basics to be followed during analysis and designing a structure both manually and through STAAD Pro Software.

- We were able to successfully analyze and design the structural elements of multistorey building.
- STAAD PRO was found to be useful for analysis.
- This GROUP PROJECT enables us to go into the market with an excellent background regarding design of R.C.C.

V. Reference

1. S. Ramarutham "Design of Reinforced concrete structures".
2. S. Ramarutham "Analysis of structures".
3. N.Subramanian "Design of Reinforced concrete structures".
4. Dr.B.C Punmia "Comprehensive R.C.C design".

Code of Practice:

- Steel Design - IS:800-2007
- Concrete Design - IS:456-2000
- Dead load - IS:875 part 1-1987
- Live load - IS:875 part 2-1987

Software used:

- AUTOCAD
- STAAD PRO
- MS OFFICE