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Design and Analysis of Residential Building

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Abstract - *This Project is Generally Based on Theoretical Design And Analysis of structural framed building. Planning, Analysis and design of G+4 residential building structure by using IS-Code method , manually designed and over verifies by using software. Planning of any types of building is done by national building code (NBC) in India, Hence the residential building is properly planned in accordance with the national building code of India. The reinforced concrete framed structure consisting of G+4 with adequate facilities. All the structure member are designed using limit state method with reference of IS:456-2000. Different load active on the member (beam, column) are considered according to the code IS:875(part1,part2,part3).*

Key Words: **Residential Building, Staad-pro V8i Analysis, Multi-stories Building, Design and Analysis of Framed Building, NBC.**

1. INTRODUCTION

Now a days due to overpopulation and high cost of land, multi-storied building is more essential for metropolitan city. Multi-storied Residential building is the perfect solution for living of high populated area. A multi-storied building, which posses multiple floor above the ground level, which aim to increase the floor area of building in shortest built up area.

Structure analysis is a subject which involves designing, planning to built up a perfect building. Basically each project are different with their design criteria such as incoming load, soil properties, dynamic load, built up area etc. Here we provided the details to complete a residential apartment theoretically.

We firstly collected some required data to measure the soil specific such as moisture content, bearing capacity of soil, types of soil etc. We provided the perfect parameter in beam, slab, column and footing with the consideration of incoming load to avoid shear and bending collapse. In accordance with limit state method of collapse in IS-456:2000 we built G+4 building which deal with strength and stability of structure under maximum design load flexure, compression , shear and torsion .

2. LETARATURE REVIEW:

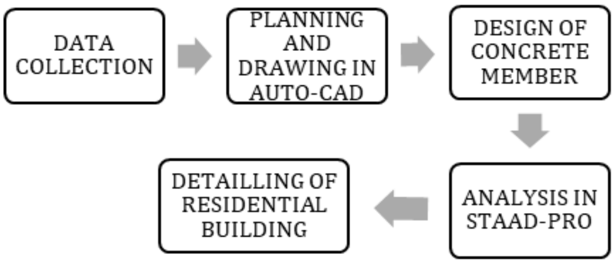
P.P. Chandurkar et. al. (2013): Study of G+9 building: Had presented study of G+9 building having three meters height for each storey. The whole building design had carried out according to IS code for seismic resistant design and the building had considered fixed at base. Structural element for design had assumed as square or rectangular in section. They had done modelling of building using ETAB software in that four different models were studied with different positioning of shear walls.

Mohit Sharma et.al. (2015): To study the dynamic analysis of multi-storeyed Building:
He considered a G+30 storied regular reinforced concrete framed building. Dynamic analysis of multi-storeyed Building was carried out. These buildings have the plan area of 25m x 45m with a storey height 3.6m each and depth of foundation is 2.4 m. & total height of chosen building including depth of foundation is 114 m. The static and dynamic analysis has done on computer with the help of STAAD-Pro software using the parameters for the design as per the IS:1893-2002 Part-1 for the zones- 2 and 3. It was concluded that not much difference in the values of Axial Forces as obtained by static and dynamic analysis.

M. S. Aainawala et. al. (2014): Comparative study of multi-storeyed R.C.C. Buildings with and without Shear Walls:
He did the comparative study of multi-storeyed R.C.C. Buildings with and without Shear Walls. They applied the earthquake load to a building for G+12, G+25, G+38 located in zone II, zone III, zone IV and zone V for different cases of shear wall position. They calculated the lateral displacement and story drift in all the cases. It was observed that Multi-storeyed R.C.C. Buildings with shear wall is economical as compared to without shear wall. As per analysis, it was concluded that displacement at different level in multi-storeyed building with shear wall is comparatively lesser as compared to R.C.C. building without shear wall. Which is important for building design and use of shear walls.

M. Mallikarjun et. al. (2016): on analysis and design of a multi-storied residential building of ung-2+G+10: Carried study on analysis and design of a multi-storied residential building of ung-2+G+10 by using most economical column method and the dead load and live load was applied on the various structural component like slabs, beams and found that as the study is carried using most economical column method this was achieved by reducing the size of columns at top floors as load was more at the bottom floor. The economizing was done by means of column orientation in longer span in longer direction as it will reduce the amount of bending and the area of steel was also reduced.

3. METHODOLOGY



4. WORK PROGRESS

4.1 BASIC DATA

i. Type of building – Residential building.
ii. Type of structure –multi storey rigid jointed framed
iii. No. of storey – 5 (G+4)
iv. Floor to floor height – 3.04 m.
v. External walls – 230 mm including plaster
vi. Internal walls – 150 mm inculing plaster
vii. Bearing capacity of soil – 200 KN/m^2
viii. Height of plinth – 0.6 m.

NOTE:-Others required data assume using NBC(national building code) for planning and IS:456-2000 for concrete design work.

4.2 PLAN OF RESIDENTIAL BUILDING

Fig1: Plan of Residential Building.

4.3 DESIGN OF BUILDING COMPONENTS

DESIGN OF SLAB

Given data :

Lx = 3.36 m Ly = 3.89 m

Ly/Lx = 1.16 < 2 hence it's a two way slab

Live load = 2 KN/M^2, Floor finish = 1 KN/M^2

M. Factor = 1.3 [For HYSD]

L/d = 28 x M.F. =>3360/d = 28 x 1.3

d = 92.30mm.

Assume D=140mm and d=120mm .

Effective span :

Width of the support = 230mm

Clear span = 3360 + 230 = 3590 mm

1/12 x 3590 = 299.16 mm > 230 mm

L_y = 3590 mm & L_x = 4120 mm

Load calculation:

Self-weight of slab = 0. 140 x 25 = 3.5 KN/M^2

Live load = 1KN/M^2 Floor finish = 2 KN/M^2

Ultimate load = 1.5 x 6.5 = 9.75 KN/M^2

Moment calculation:

$M_x = \alpha_x \times w \times l_x^2$ $M_y = \alpha_y \times w \times l_x^2$

L_y/L_x = 1.15 [From table 26 page- 91 IS 456 ;2000]

$\alpha_x = 0.079$ & $\alpha_y = 0.060$

M_x = 0.079 x 9.75 x 4.12^2 = 13.075 KN.M

M_y = 0.060 x 9.75 x 4.12^2 = 9.93 KN.M

Check for flexure:

d_x provide = D -15 -10/2 = 120 MM

d_y provide = d -10/2 = 115 MM

$Mu = Mu_{limit}$

13.075 x 10^6 = 0.14 x 20 x 1000 x d^2

$d_{required.}$(68.33 mm)<$d_{provided}$(120mm) :: Hence safe in flexure

Reinforcement calculation:

$Ast_x = \frac{0.5 \times 20}{415} \left(\sqrt{1 - \frac{4.6 \times 13.075 \times 106}{20 \times 100 \times 120 \times 120}} \right) 120 \times 1000 = 319.59$ mm^2

Spacing along X direction-

$= \frac{\text{Area of 1 bar x 1000}}{Astx} = \frac{\frac{\pi}{4} x\ 100 \times 1000}{319.59} = 245 = 220$ mm say

Provide 10 mm φ @220 mm c/c .

$Ast_y = \frac{0.5 x\ 20}{415} \left(\sqrt{1 - \frac{4.6\ x 9.93 \times 106}{20\ x\ 100\ x\ 120\ x\ 120}}\right) 120 \times 1000 = 239.20$ MM²

Spacing along Y direction-

$= \frac{\text{Area of 1 bar x 1000}}{Astx} = \frac{\frac{\pi}{4} x\ 100\ x\ 1000}{239.20} = 328 = 300$ mm say

::Provide 10 mmφ 300 mm c/c .

Check for shear:

$V_u = \frac{Wu \times Lx}{2} = \frac{9.75\ x\ 3.59}{2} = 17.50$

$T_u = \frac{Vu}{bd} = \frac{17500}{120\ x\ 1000} = 0.145$ N/M²

$T_{cmax} = 2.8$ N/M² [Page = 63 Table – 20 IS 456 :2000]

$Pt\% = \frac{Ast}{bd} \times 100 = \frac{319.59}{120\ x\ 1000} \times 100 = 0.266$

$T_c = 0.36$ N/M² < T_{cmax} ::Hence safe in shear .

Reinforcement in edge strip:

$A_{st} = 0.12/100 \times 1000 \times 140 = 168$ mm²

Spacing = 299 = 280 mm say

::Provide 8 mm φ @ 280 mm c/c .

Torsion reinforcement at corners:

Maximum middle strip Reinforcement = 357mm²

Reinforcement each of the four layer = ¾ x 357 = 267.75 mm²

A_{st} in each layer at each corner where one edge is discontinuous = 0.50 x 267.75 = 133.87 mm²

Length of bars = Lx/5 = 3590/5 =718 = Say 720 mm.

DESIGN OF BEAM

Given data :

Length (L) = 5.50 M Width (b) =0.230 M

Depth cover (d') = 35 MM

Grade of Concrete (F_{ck}) =20 N/MM²

Grade of steel (F_y) =415 N/MM²

Load calculation:

L/d =20 [page -37 clause-23.2.1,IS:456-2000]

d=5500/20 = 275

:: Provide D = 600 MM. & d =(600-35)=565 MM.

Self-weight of beam = 25 x .23 x.38 =2.185 KN/M²

Self-weight of wall = 19 x .23 x 2.66 =11.62 KN/M²

Total Incoming load on beam from slab.

Self-weight of slab = 25 x 0.1 = 2.5 KN/M²

Live load = 2KN/M² , Floor finish =1 KN/M²

Total load = 5.5 x Area of slab = 5.5 x 4.184 = 23.012 KN.

$\tan 45^0 = h/b$ => h= 3.59/2 = 1.8 M.

Area of section 1 & 2 = ½ x 1.8 x 1.8 = 3.23 M²

Area of section 3 & 4 = 3.23 + (4.12 – 3.59) x 1.8 = 4.184 M²

Point load concrete due to Beam = 8.395 KN/M.

Load from Slab = (5.5 x 0.515) =3.22 KN/M.

Total load on beam = (23.012 + 3.22) = 26.23

We can assume 1 M length of beam.

Total length of beam = 5.50 M

Total load = (26.23/5.50 + 2.185) = 6.95 KN/ M

Ultimate total = (6.95 + 11.62 + 8.395) = 27.26 KN/M

Ultimate load = (1.5 X 27.26) = 40.99 KN /M

Moment calculation:

$M_u = (W_u \times L_{eff})/ 8 = 40.9 \times 5.50^2 / 8 = 154.64$ KN.M

Check for flexure:

$M_U = M_{ulimit} => 154.64 \times 10^6 = 0.14 \times 20 \times 230 \times d^2$

d = 490 < d(provided)= 565 mm

:: Safe in flexure.

Reinforcement calculation:

$Ast = \frac{.5\ x\ 20}{20} \left(\sqrt{1 - \frac{4.6\ x\ 154.65\ x\ 1000000}{20 \times 230 \times 565 \times 565}}\right) 230 \times 565 = 882.910$ MM²

:: No of bars required of 16 mm dia. $= \frac{882.91}{\frac{\pi}{4} x\ 16 \times 16} = 4.39 = 5$ say

Provide 5# 16 mm diameter.

Check for shear:

$V_u = \frac{Wu\ x\ l}{2} = \frac{40.9 \times 5.50}{2} = 112.475$ KN

$T_u = \frac{Vu}{bd} = \frac{112475}{230\ x\ 565} = 865.5$ N/MM²

T_{cmax} = 2.8 [page 73 table 19 IS:456-2000]

:: $T_u < T_{cmax}$ :: Hence ok .

$Pt\% = \frac{Ast}{bd} \times 100 = \frac{5 \times \frac{\pi}{4} \times 16 \times 16}{230 \times 565} \times 100 = 0.774$

Tc = 0.56 [page 73 Table-19 IS:456-2000]

:: Hence safe in shear.

Minimum shear reinforcement:

$Sy = \frac{0.87 x 415 x 2 x \frac{\pi}{4} x 36}{112475 - 0.56 x 230 x 565} \times 565 = 290.54 \text{ mm}^2$

Minimum spacing:

$Sv = \frac{0.87 x 415 x 56.54}{0.4 x 230} = 221\text{mm}.$

:: Provide 2 legged 6 mm diameter @ 220mm c/c .

:: Size of the beam (9"X24")

DESIGN OF COLUMN

Given data:

ROOF,

Live load = 2KN/M²

Floor Finishing = 1KN/M²

FLOOR,

Live load = 4KN/M²

Floor Finishing = 1KN/M²

Load calculation:

ROOF,

Live load = 2KN/M²

Self-wt. of slab = 0.140 x 25 =3.5 KN/M²

Floor finish = 1KN/M²
Total Load = 6.5KN/M²
Ultimate load = (1.5 x 6.5) KN/M²=9.75KN/M²

FLOOR,

Live load = 4KN/M²

Floor finish = 1KN/M²

Self wt. of slab = 0.140 x 25 =3.5 KN/M²

Total Load = 8.5KN/M²

Ultimate load = (1.5 x 8.5) KN/M²

=12.75KN/M²

WALL,

Wt. of internal walls = [0.152 x (3.04 – 0.380) x19]

=7.68KN/M²

Ultimate load = (1.5 x 7.68) KN/M²

=11.52KN/M²

MAIN BEAM,

Size of Beam = (230 x 450)mm

Wt. of Beam = [0.230 x (0.450 – 0.140) x 25]

= 1.78KN/M²

Ultimate load = (1.5 x 1.78) KN/M²

=2.67KN/M²

SECONDARY BEAM,

Size of Beam = (230 x 380)mm

Wt. of Beam = [0.230 x (0.380 – 0.140) x 25]

= 1.38KN/M²

Ultimate load = (1.5 x 1.38) KN/M²

=2.07KN/M²

Ultimate load = 1.5[(0.23 X 0.40) X 25]

= 3.9675 KN/M²

Total secondary beam load = 6.0375KN/M²

Floor Area Transferring Load On Column

= (3.515 x 3.10)

= 10.89m²

- Length Of Walls = (2.90 – 0.38)/2 +3.21/2
  = 2.86m
- Length Of Main Beam = (2.90 – 0.38)/2 + 2.47/2
  = 2.495m
- Length Of Secondary Beam = 2 x (3.12/2)
  = 3.21m

Load on column in kN :

1. Roof & 4th Floor :-
   - Roof slab = 10.89 x 9.75
     = 106.17 KN
   - Walls = 2.86 x 11.52 = 32.95 KN
   - Main Beam = 2.495 x 4.71 = 11.75 KN
   - Secondary Beam = 3.21 x 6.0375 = 19.38 KN

   Total Load = 170.25 KN
2. 4th & 3rd Floor: -

Load from upper floor=170.25 KN

- Roof slab = 10.89 x 12.75 = 138.85 KN
- Walls = 2.86 x 11.52 = 32.95 KN
- Main Beam = 2.495 x 4.71 = 11.75 KN
- Secondary Beam = 3.21 x 6.0375 = 19.38 KN

Total Load = 202.93 KN

3. 3rd & 2nd Floor:-

Load from upper floor=373.18 KN.

- Floor slab = 138.85 KN.
- Walls = 32.95 KN.
- Main beam =11.75 KN.
- Secondary beam = 19.38 KN.

Total load = 576.11 KN.

4. 2nd & 1st Floor:-

Load from upper floor = 576.11 KN.

- Floor slab = 138.85 KN.
- Walls = 32.95 KN.
- Main beam =11.75 KN.
- Secondary beam = 19.38 KN.

Total load = 779.04 KN.

5. 1st Floor & Plinth:-

Load from upper floor = 779.04 KN.

- Floor slab = 138.85 KN.
- Walls = 32.95 KN.
- Main beam =11.75 KN.
- Secondary beam = 19.38 KN.

Total load = 981.97 KN.

6. Column Between Plinth and Footing :-

- Load from upper floor = 981.97 KN

Assume no floor slab at plinth and consider only plinth beam and no walls.

- Wt. of main beam = 11.75 KN
- Wt. of complete column =[3+3.04+3.04+3.04+3.04+3.04] x (0.2 x 0.61) x 25= 63.83KN

Total load = (981.95+63.83) = 1045.78KN.

Design of column at ground floor :

P_U = 981.95 KN ~ 982 KN

M_{ux} = 15 KN.M (assume)

M_{uy} = 11 KN.M (assume)

Size of column = (230 x 450) MM

Effective length = 60 MM

b = 230 MM , D = 450 MM & d' = 60 MM

Max^m unsupported length of column

l = 3.04 - (0.450/2) - 0.45/2 = 2.59 M

Effective length (IS 456-2000 , P.N 94, T- 28)

L_{eff} = 0.65l = 0.65 x 2.59 = 1.68 M = 1680 MM

L_{ex}/D = 1680/450 = 3.75 >12

L_{ey}/b = 1680/230 = 7.30 >12 [IS:456-2000 Pg.No-42]

L_{ex}/D & L_{ey}/b is less then 12 then than Assume short column.

::consider as short column.

Selecting trial section :

P_u = 982 KN

$M_u = 1.5\sqrt{Mux^2 + Muy^2}$

$= 1.5\sqrt{20^2 + 18^2}$

= 30.49 KN.M

d'/D = 60/450 = 0.133 $\approx$ 0.1

Pu /Fck.b.d = (30.49 x 10^6)/(20x230x450^2)

= 0.033

P/Fck = 0.02

P = 20 x 0.02 = 0.4%.

ASC = 0.4 x 230 x 450 = 414 MM^2

Provided = 6#12MMØ [678.58MM^2]

Actual Pt % = 678.58 x 100/ (230 x 600)

= 0.65%

Checking iteration formula:

$$\left[\frac{Mux}{Mux1}\right]^{\wedge}\alpha_n + \left[\frac{Mxy}{Mxy1}\right]^{\wedge}\alpha_n \le 1$$

1. To find out Mux_1 :

d'/D = 0.133 $\approx$ 0.10

P/ Fck = 0.65/20 = 0.032

Pu/Fck.b.d^2 = 982 x 10^3/(20 x 230 x 450) =0.474

Mux1/ Fck.b.d^2 = 0.02 [sp.16 P.g N.o – 137]

Mux1 = 0.020 x 20 x 230 x 450^2

= 18.63 KN.M

2. To find out Muy_1 :

d'/D = 60/230 = 0.26 $\approx$ 0.20

P/ Fck = 0.65/20 = 0.032

Pu/Fck.b.d^2 = 982 x 10^3/(20 x 230 x 450)

= 0.474

Mux1/ Fck.b.d^2 = 0.02 [Sp.16 pg. No.–137]

Muy1 = 0.02x 20 x 230 x 450^2

= 18.63 KN.M

To find out α_n :

Pu/ pu$_z$ = α_n

pu$_z$ = 0.45 Fck AC + 0.75 Fy ASC

AC = (230 x 450) – ASC

= (230 x 450) - (678.58)

= 102821.42 MM^2

ASC = 678.58 MM^2

pu$_z$ = (0.45 x 20 x 102821.42) +

(0.75 x 415 678.58)

= 1136.60 KN

Pu = 982 x 10^{3}KN

Pu/ pu$_z$ = (982 x 10^3)/ (1136.60 x 10^3)

= 0.86

α_n = (2 x 0.86) 0.8 = 2.15

$$[\frac{15}{33.12}]^{2.15} + [\frac{11}{33.12}]^{2.15} \leq 1$$

::Provided 6#12MMØ [678.58 MM^2]

Lateral ties :

Dia. Of lateral ties (IS 456 – 2000 Pg. NO. 49)

i. 1/4 x 12 = 3 MM
ii. 12 MM

Provide 8 MM Dia. On Ties.

Pitch :

i. Least lateral dimention = 230MM
ii. 16 x 12 (dia. Of bar) = 192 MM
iii. 300MM.

::Provided 8 MMØ@150 MM c/c .

Fig2: Loads on Column

4.4 STAAD-PRO OUTPUT ANALYSIS

In our project we considered a G+4 residential building for planning design & analysis. The each floor contents 4 no's of 2BHK flat. Hear we analyses 1 flat area up to the top floor. So staad pro output is on the basis of 1 flat area.

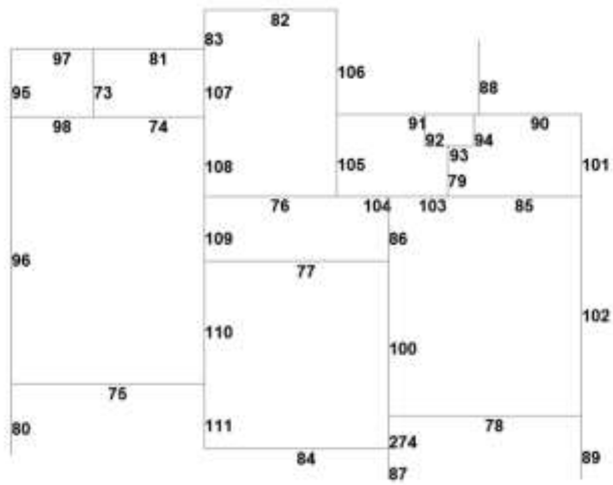


Fig3: Beam no. of ground floor building plan.

Table -1: Detailing of beams

Sr. No	Beam No.	Top bar	Bottom bar	Spacing of stirrup
1	73,76,77, 79,80.81, 82,84,90, 91,95, 100,106, 107,109	2#10mm	2#10mm	2-L 8mm@110mm
2	74,108,	2#12mm	2#12mm	2-L

	98,83			**8mm@110mm**
3	**75,78,85, 86,93,97, 102**	**2#12mm**	**2#10mm**	**2-L 8mm@110mm**
4	**87,88,89, 92**	**2#10mm**	**2#10mm**	**2-L 8mm@200mm**
5	**94**	**3#10mm**	**2#12mm**	**2-L 8mm@100mm**
6	**96,105**	**4#10mm**	**2#12mm**	**2-L 8mm@110mm**
7	**101**	**2#10mm**	**4#10mm**	**2-L 8mm@110mm**
8	**103**	**4#10mm**	**2#10mm**	**2-L 8mm@110mm**
9	**104**	**2#10mm**	**2#12mm**	**2-L 8mm@110mm**
10	**110**	**4#10mm**	**2#10mm**	**2-L 8mm@110mm**
11	**111**	**2#10mm**	**4#10mm**	**2-L 8mm@110mm**
12	**274**	**2#12mm**	**2#12mm**	**2-L 8mm@200mm**

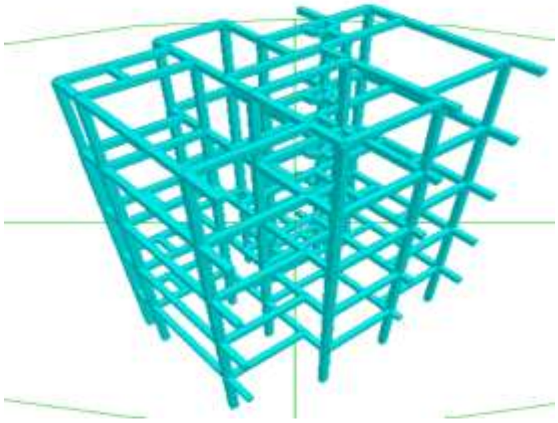


Fig4: 3D render model of building.

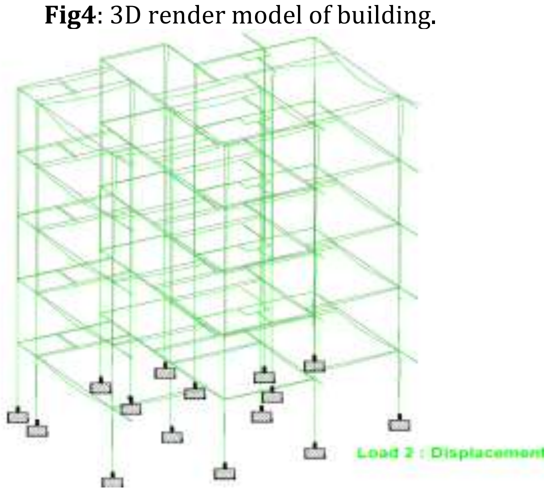


Fig5: displacement on concrete member.

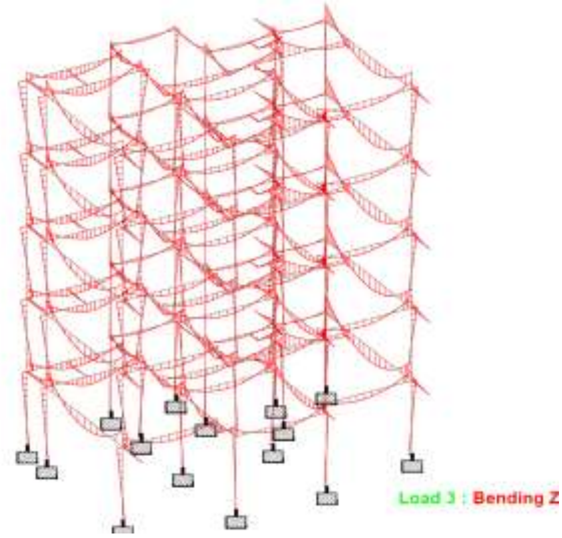


Fig6: bending on z axis

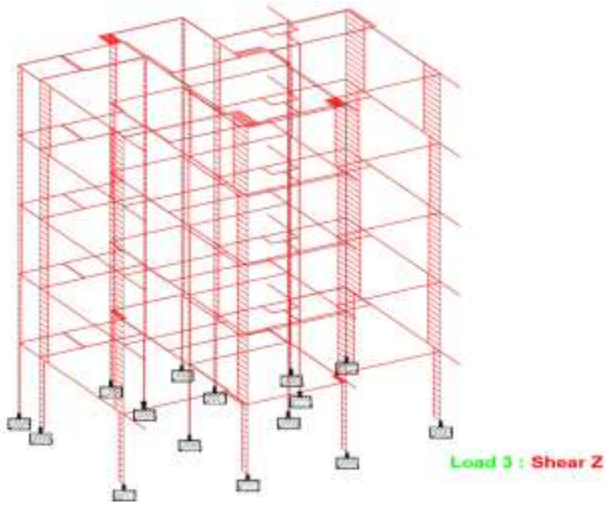


Fig7: shear forces on member

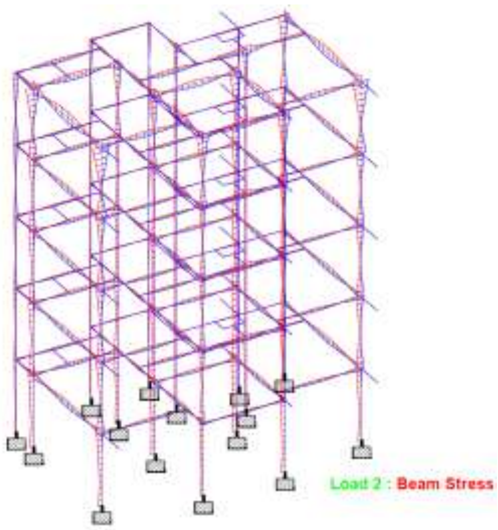


Fig8: stress on concrete member

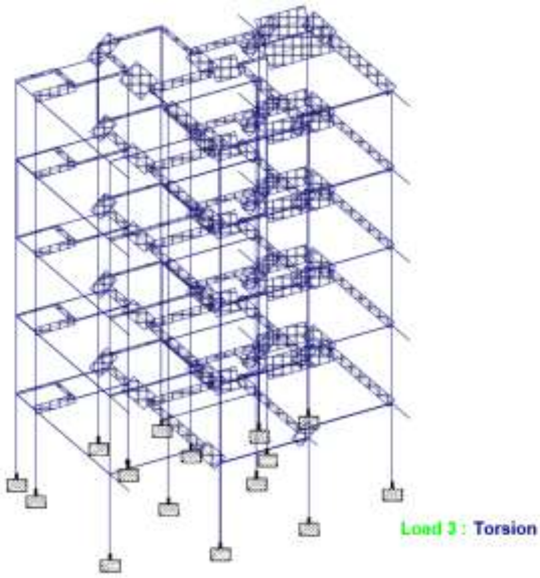


Fig9: Torsion on roof slab

5. CONCLUSIONS

After analysing the G+4 storey building structure, concluded that structure is safe in loading like dead load, live load, wind load and seismic load.

Member dimensions (Beam, Column, Slab) are assigns by calculating the load type and it's quantity applied on it. Auto-cad plan gives detailed information of the structure members length, height, depth, size & numbers etc.

STAAD PRO has the capability to calculate the reinforcement needed for any concrete section. The program contains a number of parameters which are designed as per IS: 456(2000). Beams are designed for flexure, shear and torsion and its give the detail number, position, spacing of reinforcement.

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