

DESIGN & ANALYSIS OF MULTISTOREY (G+3) RESIDENTIAL BUILDING USING STAAD.PRO & AUTOCAD

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ABSTRACT- In order to compete in the ever growing competent market it is very important for a structural engineer to save time. As a sequel to this an attempt is made to analyze and design a multistoried building by using a software package staad pro. For analyzing a multi storied building one has to consider all the possible loadings and see that the structure is safe against all possible loading conditions.

There are several methods for analysis of different frames like kani's method, cantilever method, portal method, and Matrix method.

The present project deals with the design & analysis of a multi storied residential building of G+3 consisting of 2 apartments in each floor. The dead load & live loads are applied and the design for beams, columns, footing is obtained

STAAD Pro with its new features surpassed its predecessors and comotators with its data sharing capabilities with other major software like AutoCAD.

We conclude that staad pro is a very powerful tool which can save much time and is very accurate in Designs.

Thus it is concluded that staad pro package is suitable for the design of a multistoried building.

Key words: STAAD.Pro, Multi-storey building, Autocad, Concrete mix, Steel strength, Limit state method.

1. INTRODUCTION

In every aspect of human civilization, we needed structures to live. The structures should be built in an efficient manner so that it can serve people and save money. In simple words, the building means an empty surrounded by walls and roofs, in order to give shelter for human beings. In early times humans have lived in caves to protect themselves from wild animals, rain etc. Then, humans developed and built their homes using timbers and lived. Nowadays the recent homes are developed into individual and multi-storey buildings. Buildings are the necessary indicator of social progress of the county. At current situation, many new techniques have been developed for constructions. So, that the buildings are built economically and quickly to fulfil the needs of the people. A building frame is a three-dimensional structure which consists of column, beams and slabs. Because of growing population, high rise buildings are coming into demand. Buildings constitute a part of the definition of civilizations, a way of life advanced by the people. The buildings should be constructed for human requirements and not for earning money. Buildings are built in different sizes, shapes and functions.

2. A BRIEF DESCRIPTION OF SOFTWARE USED

- Auto CAD
- STAAD.Pro

2.1 Auto CAD

Auto Cad is a designing and drafting software which is used for developing 2-dimensional and 3-dimensional structures, developed and sold by Autodesk, Inc. It is a vector graphics drawing programme. It uses primitive entities- comparable to lines, polylines, circles, arcs and text as the foundation for the complex. Auto CAD's native file format, DWG, and to a lesser extent, its interchange file format, DXF

has become the drawing and detailing works were done by creating use of Auto CAD 2014.

2.2 STAAD.PRO

STAAD.Pro is a user-friendly software which is used for analysing and designing of structure by the structural engineers. STAAD Pro provides a lot of precise and correct results than manual techniques. It's the foremost computer code for 3D model generation and multi-material design. The software is fully compatible with all windows operating system but is optimized for windows XP. STAAD.Pro software is used for static or dynamic analysis for structures such as bridges, low rise or high-rise buildings, stadiums, steel structures, etc. First step in STAAD.Pro is to specify the geometry of the structure and then the properties of the members are mentioned. Then the supports are generated and loadings are specified on the structure. Finally, the structure is analysed.

3. BUILDING PLANNING

3.1 GROUND FLOOR

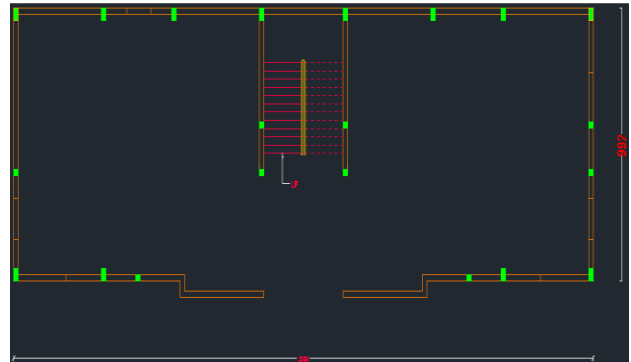


Fig. 1 plan of ground floor

3.2 FIRST, SECOND AND THIRD FLOOR

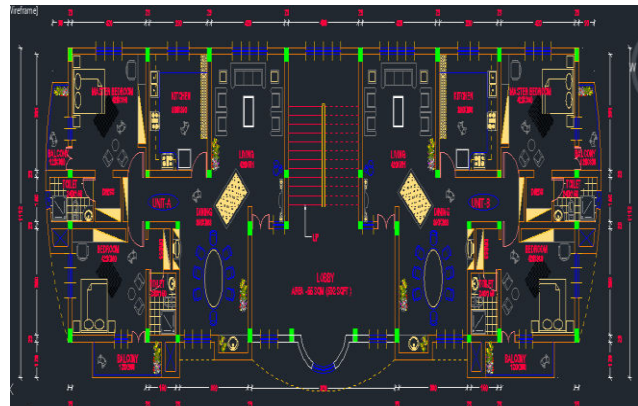


Fig. 11 plan of first, second and third floor

4. LITERATURE REVIEW

Sreeshna K.S (2016) this paper deals with structural analysis and design of B+G+4 storied apartment building. The work was completed in three stages. The first stage was modelling and analysis of building and the second stage was to design the structural elements and the final was to detail the structural elements. In this project STAAD.Pro software is used for analysing the building. The IS:875 (Part 1) and (Part 2) were referred for dead load and live load. Design of structural elements like beam, column, slab, staircase, shear wall, retaining wall, pile foundation is done according to IS Codes.

Amar Hugar et al., (2016) has been discussed that the Computer Aided Design of Residential Building involves scrutiny of building using STAAD.Pro and a physical design of the structure. Traditional way of study shows tedious calculations and such tests is a time-consuming task. Analysis are made quickly by using software's. This project completely deals with scrutiny of the building using the software STAAD.Pro. Finally, the results are compared with physical calculations. The elements are created as per IS:456-2000.

Bandipati Anup et al., (2016) this paper deals with evaluate and plan a multi-storeyed building [G + 2 (3- dimensional frame)] adopting STAAD Pro. The technique used in STAAD.Pro is limit state technique. Initially they have created 2-D frames and cross checked with physical calculations. The exact result should be proved. We tested and created a G + 2 storey building [2-D Frame] instantly for all feasible load combinations. The work has been finished with some more multi-storeyed 2-Dimensional and 3- Dimensional frames beneath various load combinations

Aman et al., (2016) has discussed that the point of the structural engineer is to model a guarded structure. Then the structure is subjected to various types of loading. Mostly the loads put in on the building are considered as static. Finite part analysis that exhibit the result of dynamic load like wind result, earthquake result, etc. The work is conducted using STAAD.Pro software.

Madhurivassavai et al., (2016) he says that the most common problem country facing is the growing population. Because of the less availability of land, multi-storey building can be constructed to serve many people in limited area. Efficient modelling is performed using STAAD.Pro and AutoCAD. Manual International Journal of Pure and Applied Mathematics Special Issue 2798 calculations for more than four floor buildings are tedious and time consuming. STAAD.Pro provides us a quick, efficient and correct platform for analysing and coming up with structures

Borugadda Raju et al., (2015) has been designed and analysed G+30 multi-storey building adopting STAAD.Pro in limit state methodology. STAAD.Pro contains an easy interface that permits the users to produce the mount and the load values and dimensions are inputted. The members are designed with reinforcement details for RCC frames. The analysis is completed for two dimensional frames and then it is done for more multi-storeyed 2-D and 3-D frames under various load combinations.

Anoop. A, (2016) has explained that the scope of the project is to provide a multi storied building of G+ 5 floors. Revit 2011 and Auto CAD 2014 software is used for developing 3-D models. The structure analysis and design are done using STAAD.Pro. The results are checked for selected members using limit state method of design as per IS 456-2000.

Nasreen. M. Khan (2016) has mentioned that logical data is incredibly necessary and essential talent required by each and every engineer. The project encompasses a shear wall round the elevator pit. During this project the structure is meant and tested with the help of STAAD.Pro and the scheming was done physically. Layout of beam, column, slab, shear wall, stair case, shear wall, tank and an isolated footing are done. Finally, the detailing was done using AutoCAD

R.D. Deshpande et al., (2017) has said that the structural analysis may be a branch that involves resolution of working on construction, so as to forecast the reply of real construction such as buildings, bridges, trusses etc. This project makes an attempt to view the construction working of varied elements inthe multi-storied building. Analysis, scheming and evaluation of multi-storied building has been obsessed for Basement+G+2 Building. According to material properties the dead load is calculated, live loads is taken from code

IS875-part 2 and piles are schemed based on protected bearing capacity of soil. For the design of columns and beams limit state method is used.

SK Saleem (2017) has explained that the objective of the project is to detect and scan a multi-storey building. Load calculations are done manually and STAAD.Pro software is used for analysing the structure. STAAD.Pro is the recommended software. STAAD.Pro is user friendly software which allows the users to make the mount and the load values to be given and dimensions. Then the work is continued for 2-D and 3-D frames with different loading conditions.

Deevi Krishna Chaitanya (2017) has said that in order to compete in the ever-growing competent market it is very important for a structural engineer to save lots of time. For this an attempt is made to model and survey a construction using software. For analysing the structure all possible loads are considered to see whether the structure is safe against loading. There are many strategies for analysis of various frames like kani's methodology, cantilever methodology, portal methodology and Matrix methodology. The dead load &live loads are applied. Then, the design for beams, columns, footing are done. STAAD.Pro is a very powerful toll which can save time.

K. Rama Raju et al., (2013) has explained that the building becomes taller, the quantity of structural material needed to withstand the oblique loads rises extremely. Tall buildings design involves conceptual design, preliminary design and lateral loads. Criteria for design are strength and serviceability. Protection ofthe structure is examined against permissible limits, roof displacements, etc.

5. TYPES OF LOADS USED

The loads which are considered for analysis are,

- Dead loads
- Live loads
- Earthquake load

5.1 DEAD LOAD

All permanent loads in the building are considered as dead loads. The dead loads comprise of self-weight of the building, weight of wall, weight of slab, floor finish and permanent materials placed on the building. Dead loads are specified in IS 875 (Part 1).

5.1.1 SELF WEIGHT

In load case we have option called self weight which automatically calculates weights using the properties of material i.e., density and after assignment of dead load the skeletal structure looks red in color as shown in the figure.

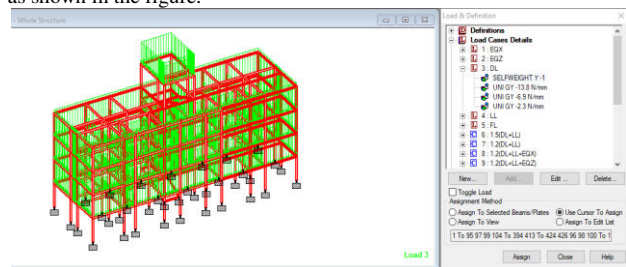


Fig. 3 Self weight show red color;

5.1.2 Wall load external wall

$$\text{Outer wall load} = \text{wall thickness} \times \text{height} \times \text{density}$$

$$= 0.23 \times 3 \times 20$$

$$\text{Outer wall load} = 13.8\text{kn/m}$$

Outer wall load shown given below figure in blue color

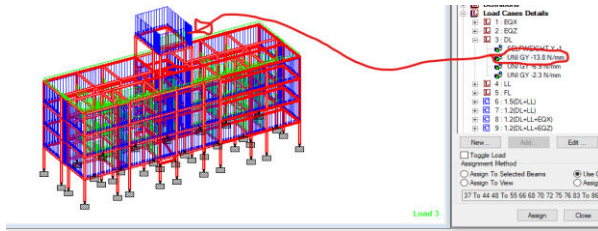


Fig.4 outer wall load

5.1.3 Internal wall load (partition wall)

Internal wall load = $13.9/2$ (thickness of partition wall half of the outer wall)

Internal wall load = 6.9 kN/m

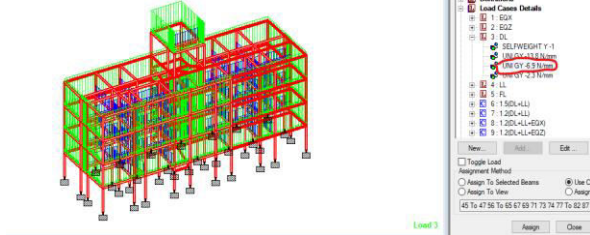


Fig.5 internal wall load shown blue color

5.1.4 Parapet load

Take, thickness of parapet = 0.115m

Height of parapet = 1m

Parapet load = $0.115 \times 1 \times 20$

Parapet load = 2.3kN/m

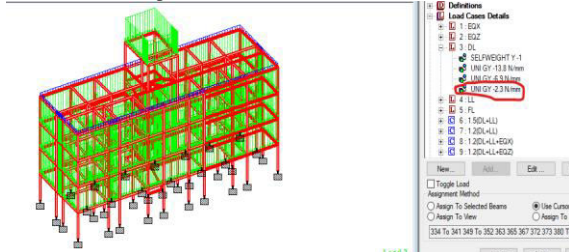


Fig.6 parapet load shown blue color

5.2 Live Loads:

We are taken in live load is floor load

Floor load = Thickness X density

Floor load = 0.156×25

Floor load = 0.0039N/mm

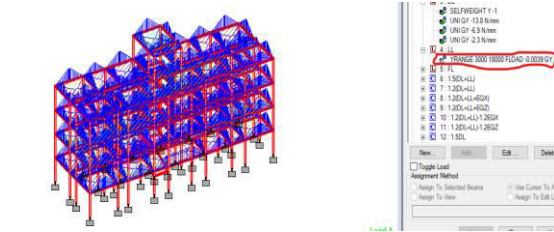


Fig.7 Floor load

5.3 Floor load

Floor load is calculated based on the load on the slabs. Assignment of floor load is done by creating a load case for floor load. After the assignment of floor load our structure looks as shown in the below figure.

The intensity of the floor load taken is: $0.0015\text{N}/\text{mm}^2$

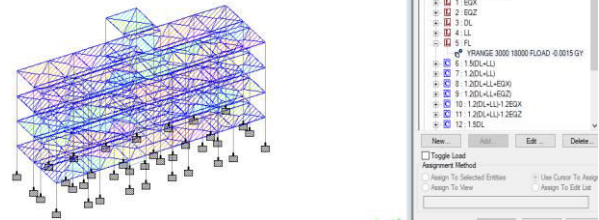


Fig.8 floor load

5.4 Earthquake load

We are taken earthquake load as per IS code 1893-2000

5.4.1 Earthquake load in x-direction

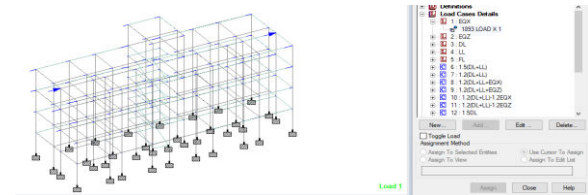


Fig.9 earthquake load in x-direction

5.4.21 Earthquake load in z-direction

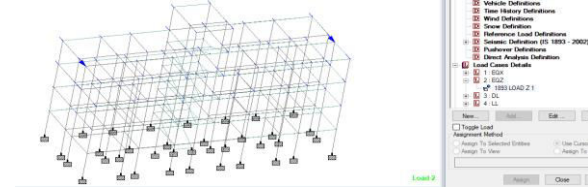


Fig.10 earthquake load in z-direction

5.5 LOAD COMBINATIONS

The different combinations used in the project are

- 1.5(D.L+L.L.)
- 1.2(D.L+L.L)
- 1.2(D.L+L.L+EQX)
- 1.2(D.L+L.L+EQZ)
- 1.2(D.L+L.L)-1.2EQX
- 1.2(D.L+L.L)-1.2EQZ
- 1.5D.L
- 1.5(D.L+EQX)
- 1.5(D.L+EQZ)
- 1.5D.L-1.5EQX
- 1.5D.L-1.5EQZ
- 0.9D.L+1.5EQX
- 0.9D.L+1.5EQZ
- 0.9D.L-1.5EQX
- 0.9D.L-1.5EQZ

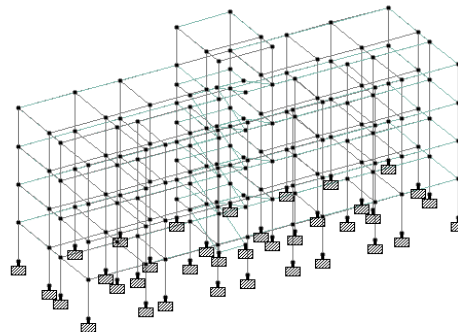


Fig.11 3-D view of the model

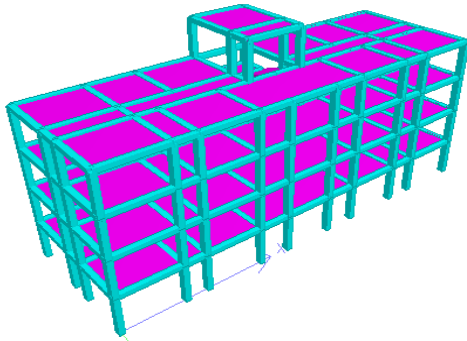


Fig.¹² 3-D Rendered view of the model

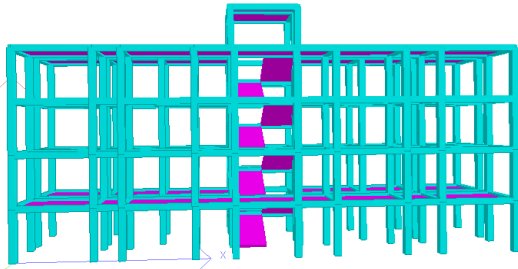


Fig.¹² 3-D Rendered view of the model

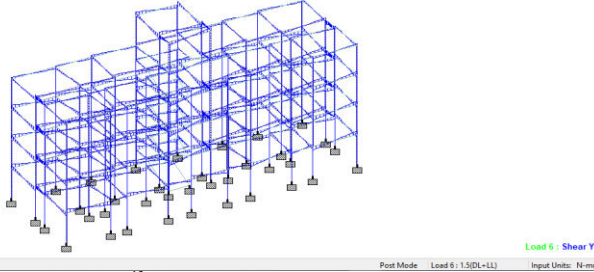


Fig.¹³ Showing Shear Force of all the beams

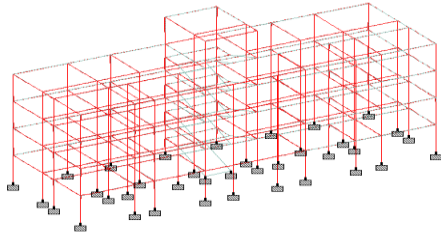


Fig.¹⁴ showing bending moments of all the beams

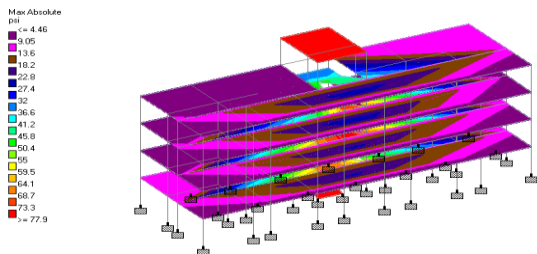


Fig.¹⁵ showing the max absolute of plates

6. STRUCTRE DESIGN

6.1 Beam design (Beam no.196)

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BEAM NO. 196 DESIGN RESULTS

M25 Fe415 (Main) Fe415 (Sec.)

LENGTH: 1750.0 mm SIZE: 350.0 mm X 350.0 mm
COVER: 30.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION	0.0 mm	437.5 mm	875.0 mm	1312.5 mm	1750.0 mm
TOP REINF.	1391.13 (Sq. mm)	815.14 (Sq. mm)	369.29 (Sq. mm)	225.81 (Sq. mm)	225.81 (Sq. mm)
BOTTOM REINF.	735.15 (Sq. mm)	477.82 (Sq. mm)	326.04 (Sq. mm)	225.81 (Sq. mm)	273.81 (Sq. mm)

SUMMARY OF PROVIDED REINF. AREA

SECTION	0.0 mm	437.5 mm	875.0 mm	1312.5 mm	1750.0 mm
TOP REINF.	7-16 ϕ 1 layer(s)	5-16 ϕ 1 layer(s)	3-16 ϕ 1 layer(s)	3-16 ϕ 1 layer(s)	3-16 ϕ 1 layer(s)
BOTTOM REINF.	10-10 ϕ 2 layer(s)	7-10 ϕ 1 layer(s)	5-10 ϕ 1 layer(s)	3-10 ϕ 1 layer(s)	4-10 ϕ 1 layer(s)
SHEAR REINF.	2 legged 8 ϕ	2 legged 8 ϕ	2 legged 8 ϕ	2 legged 8 ϕ	2 legged 8 ϕ

SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM FACE OF THE SUPPORT

SHEAR DESIGN RESULTS AT 537.0 mm AWAY FROM START SUPPORT

VY = 97.01 MX = 0.52 LD= 16
Provide 2 Legged 8 ϕ @ 145 mm c/c

6.2 Column design (Column no.326)

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COLUMN NO. 326 DESIGN RESULTS

M25 Fe415 (Main) Fe415 (Sec.)

LENGTH: 3000.0 mm CROSS SECTION: 450.0 mm X 350.0 mm COVER: 40.0 mm

** GUIDING LOAD CASE: 1 END JOINT: 150 TENSION COLUMN

REQD. STEEL AREA : 1260.00 Sq.mm.
REQD. CONCRETE AREA: 156240.00 Sq.mm.

MAIN REINFORCEMENT: Provide 12 - 12 dia. (0.86%, 1357.17 Sq.mm.)

(Equally distributed)

TIE REINFORCEMENT: Provide 8 mm dia. rectangular ties @ 190 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)

Puz: 2149.88 Muz1: 63.18 Muy1: 84.25

INTERACTION RATIO: 0.15 (as per Cl. 39.6, IS456:2000)

SECTION CAPACITY BASED ON REINFORCEMENT

PROVIDED (KNS-MET)

WORST LOAD CASE: 11

END JOINT: 192 Puz: 2179.03 Muz: 82.41 Muy: 110.68
IR: 0.57

7. Foundation design

SIZE OF FOOTING

Footing No.	Group ID	Foundation Geometry		
		Length	Width	Thickness
-	-			
1	1	6.150 m	6.150 m	0.357 m
2	2	4.500 m	4.500 m	1.311 m
3	3	4.350 m	4.350 m	1.261 m
4	4	4.500 m	4.500 m	1.313 m
5	5	3.900 m	3.900 m	1.161 m
6	6	3.900 m	3.900 m	1.161 m
7	7	4.400 m	4.400 m	1.313 m
8	8	4.450 m	4.450 m	1.311 m
9	9	4.650 m	4.650 m	1.365 m
10	10	6.200 m	6.200 m	0.357 m
11	11	6.600 m	6.600 m	0.407 m
12	12	4.350 m	4.350 m	1.261 m
13	13	4.000 m	4.000 m	1.161 m
14	14	4.350 m	4.350 m	1.261 m
15	15	6.250 m	6.250 m	0.457 m
16	16	6.000 m	6.000 m	0.407 m
17	17	4.600 m	4.600 m	1.315 m
18	18	4.050 m	4.050 m	1.161 m
19	19	4.450 m	4.450 m	1.313 m
20	20	6.650 m	6.650 m	0.407 m
21	21	5.000 m	5.000 m	0.306 m
22	22	4.600 m	4.600 m	1.365 m
23	23	4.500 m	4.500 m	1.313 m
24	24	5.500 m	5.500 m	0.356 m
25	25	5.450 m	5.450 m	0.356 m
26	26	4.500 m	4.500 m	1.313 m
27	27	4.600 m	4.600 m	1.315 m
28	28	5.050 m	5.050 m	0.306 m
29	29	5.500 m	5.500 m	0.356 m
30	30	4.950 m	4.950 m	1.465 m
31	31	4.950 m	4.950 m	1.415 m
32	32	7.400 m	7.400 m	0.507 m
33	33	7.700 m	7.700 m	0.507 m
34	34	5.050 m	5.050 m	1.465 m
35	35	4.900 m	4.900 m	1.415 m
36	36	5.550 m	5.550 m	0.356 m
78	37	6.550 m	6.550 m	0.707 m

Footing No.	Footing Reinforcement			
	Bottom Reinforcement(M _Z)	Bottom Reinforcement(M _X)	Top Reinforcement(M _Z)	Top Reinforcement(M _X)
1	Ø10 @ 65 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 85 mm c/c	Ø16 @ 55 mm c/c
2	Ø12 @ 50 mm c/c	Ø12 @ 50 mm c/c	Ø12 @ 70 mm c/c	Ø12 @ 70 mm c/c
3	Ø12 @ 50 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 50 mm c/c	Ø10 @ 50 mm c/c
4	Ø12 @ 50 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 50 mm c/c	Ø10 @ 50 mm c/c
5	Ø12 @ 55 mm c/c	Ø12 @ 60 mm c/c	Ø10 @ 55 mm c/c	Ø10 @ 55 mm c/c
6	Ø12 @ 55 mm c/c	Ø12 @ 60 mm c/c	Ø10 @ 55 mm c/c	Ø10 @ 55 mm c/c
7	Ø12 @ 50 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 50 mm c/c	Ø10 @ 50 mm c/c
8	Ø12 @ 50 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 50 mm c/c	Ø10 @ 50 mm c/c
9	Ø16 @ 85 mm c/c	Ø12 @ 50 mm c/c	Ø12 @ 70 mm c/c	Ø12 @ 70 mm c/c
10	Ø10 @ 65 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 85 mm c/c	Ø16 @ 65 mm c/c
11	Ø10 @ 65 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 75 mm c/c	Ø16 @ 55 mm c/c
12	Ø12 @ 50 mm c/c	Ø12 @ 55 mm c/c	Ø10 @ 50 mm c/c	Ø10 @ 50 mm c/c
13	Ø12 @ 55 mm c/c	Ø12 @ 55 mm c/c	Ø10 @ 55 mm c/c	Ø10 @ 55 mm c/c
14	Ø12 @ 50 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 50 mm c/c	Ø10 @ 50 mm c/c
15	Ø10 @ 65 mm c/c	Ø10 @ 60 mm c/c	Ø16 @ 55 mm c/c	Ø16 @ 65 mm c/c
16	Ø10 @ 65 mm c/c	Ø10 @ 65 mm c/c	Ø6 @ 75 mm c/c	Ø16 @ 60 mm c/c
17	Ø16 @ 85 mm c/c	Ø16 @ 85 mm c/c	Ø12 @ 70 mm c/c	Ø12 @ 70 mm c/c
18	Ø12 @ 50 mm c/c	Ø12 @ 55 mm c/c	Ø10 @ 55 mm c/c	Ø10 @ 55 mm c/c
19	Ø12 @ 50 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 50 mm c/c	Ø10 @ 50 mm c/c
20	Ø10 @ 65 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 75 mm c/c	Ø16 @ 55 mm c/c
21	Ø8 @ 50 mm c/c	Ø10 @ 75 mm c/c	Ø8 @ 75 mm c/c	Ø16 @ 70 mm c/c
22	Ø16 @ 85 mm c/c	Ø12 @ 50 mm c/c	Ø12 @ 70 mm c/c	Ø12 @ 70 mm c/c
23	Ø12 @ 50 mm c/c	Ø12 @ 50 mm c/c	Ø10 @ 50 mm c/c	Ø10 @ 50 mm c/c
24	Ø10 @ 70 mm c/c	Ø10 @ 70 mm c/c	Ø8 @ 75 mm c/c	Ø16 @ 75 mm c/c
25	Ø10 @ 70 mm c/c	Ø10 @ 70 mm c/c	Ø8 @ 75 mm c/c	Ø16 @ 75 mm c/c
26	Ø16 @ 85 mm c/c	Ø12 @ 50 mm c/c	Ø12 @ 70 mm c/c	Ø12 @ 70 mm c/c
27	Ø16 @ 80 mm c/c	Ø16 @ 85 mm c/c	Ø12 @ 70 mm c/c	Ø12 @ 70 mm c/c
28	Ø8 @ 50 mm c/c	Ø10 @ 75 mm c/c	Ø8 @ 75 mm c/c	Ø16 @ 70 mm c/c
29	Ø8 @ 55 mm c/c	Ø8 @ 50 mm c/c	Ø8 @ 70 mm c/c	Ø16 @ 75 mm c/c
30	Ø16 @ 80 mm c/c	Ø16 @ 85 mm c/c	Ø12 @ 65 mm c/c	Ø12 @ 65 mm c/c
31	Ø16 @ 75 mm c/c	Ø16 @ 80 mm c/c	Ø12 @ 65 mm c/c	Ø12 @ 65 mm c/c
32	Ø10 @ 55 mm c/c	Ø10 @ 60 mm c/c	Ø10 @ 65 mm c/c	Ø16 @ 50 mm c/c
33	Ø10 @ 55 mm c/c	Ø10 @ 55 mm c/c	Ø10 @ 60 mm c/c	Ø20 @ 75 mm c/c
34	Ø16 @ 75 mm c/c	Ø16 @ 80 mm c/c	Ø12 @ 60 mm c/c	Ø12 @ 60 mm c/c
35	Ø16 @ 75 mm c/c	Ø16 @ 80 mm c/c	Ø12 @ 65 mm c/c	Ø12 @ 65 mm c/c
36	Ø8 @ 50 mm c/c	Ø8 @ 50 mm c/c	Ø8 @ 70 mm c/c	Ø16 @ 70 mm c/c
78	Ø8 @ 55 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 55 mm c/c	Ø12 @ 55 mm c/c

LAYOUT OF FOUNDATION

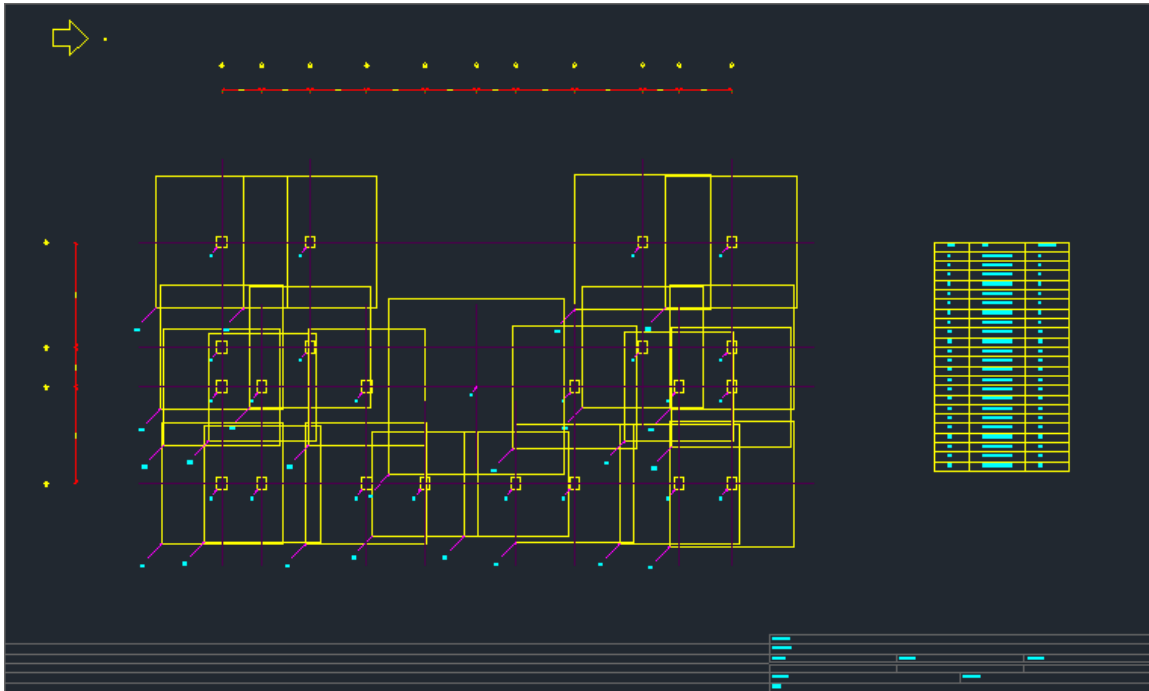


Fig.¹⁶ shows layout of foundations for each and every column.

Reinforcement details of column is shown below

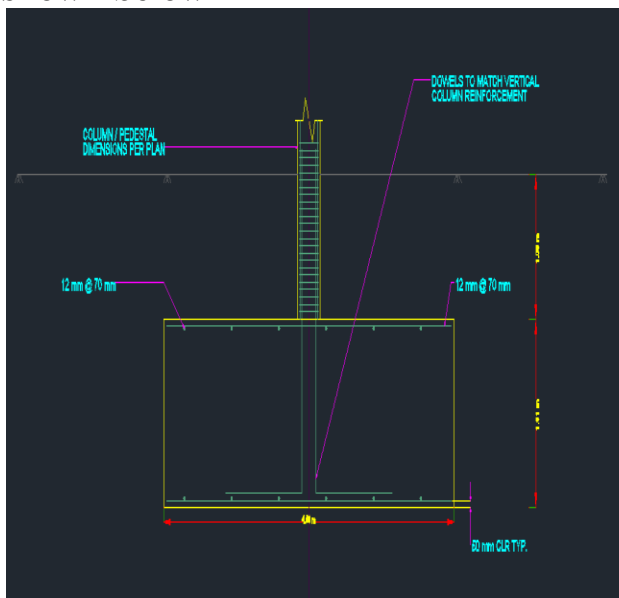


Fig.¹⁷ elevation of reinforcements

PLAN OF REINFORCEMENT

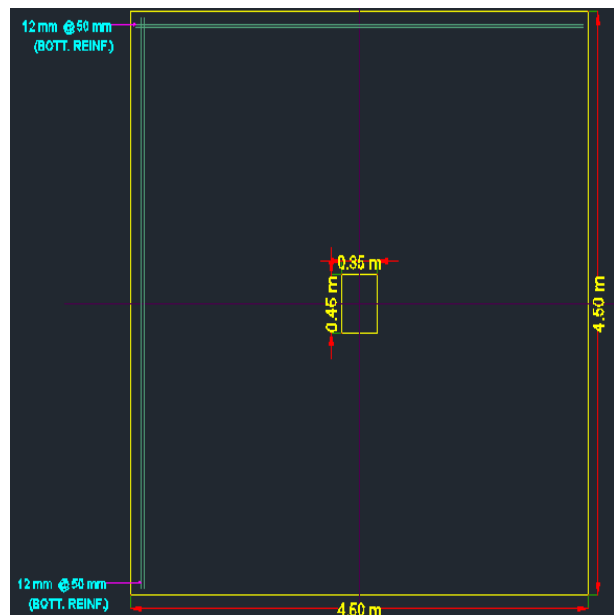


Fig.¹⁸ plan of reinforcement

8. CONCLUSION

Planning, analysis and design of G+3 multi-storey residential building was done. It's a G+3 storied building with parking in the basement and the rest of the floors are occupied with apartments. All the structural components were designed manually and detailed using AutoCAD. The analysis and design were done according to standard

specifications using STAAD.Pro for static and dynamic loads. The dimensions of structural members are specified and the loads such as dead load, live load, floor load and earthquake load are applied. Deflection and shear tests are checked for beams, columns and slabs. The tests proved to be safe. Theoretical work has been done. Hence, I conclude that we can gain more knowledge in practical work when compared to theoretical work.

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