Planning, analysis and design of G+3 Residential building

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Abstract Structural engineers are facing the challenge of striving for the most efficient and economical design with accuracy in solution, while ensuring that the final design of a building must be serviceable for its intended function over its design lifetime. In the present study G+3 building at Salem, Tamilnadu, India is analyzed (Slabs, Beams, Columns and Footings) using Staad pro software. In order to design them, it is important to first obtain the plan of the particular building that is, positioning of the rooms (Living 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 dead loads, which depends 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 Fe 500 as per IS:1786-1985. Safe bearing capacity of soil is adopted as 300kN/m^2 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. F`or designing of columns and beams, it is necessary to calculate the moments they are subjected to. For this purpose, frame analysis is done by limit state method. Designing of slabs depends upon its type (one way, two way slab), the end conditions and the loading. From the slabs, the loads are transferred to the beam. Thereafter, the loads from the beams are taken by the columns. Finally, the sections must be checked for all the components with regard to strength and serviceability.

***Key Words*: Beams, Columns, Design, STAAD Pro, Shear force, bending moment and Axial force.**

1. INTRODUCTION

Building construction is the engineering deals with the construction of building such as residential houses. Buildings are the important indicator of social progress of the county. Every human has desire to own comfortable home on an average generally one spends his two-third life times in the house. The security civic sense of the responsibility. A design of R.C building of G+6 storey frame work is taken up. The building in plan (16.6 x 10.9) consists of columns built monolithically forming a network. The size of building is 16.6 x 10.9m. The number of columns is 28**.** It is residential complex. The design is made using software on structural analysis design (STAAD Pro). The building subjected to the vertical loads. The vertical load consists of dead load of structural components such as beams, columns, slabs etc and live loads.

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. The design process of multi-storied 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+3 building at Salem, Tamil nadu, India is designed.

2. METHODOLOGY

PLANNING	Using Auto CADD
3-D MODELLING	Elevation of building by using Revit Architecture.
ANALYSIS	Analysis of RCC framed structure. Shear Force and Bending Moment calculations.
DESIGN	Design of Slab, Beam, Column, Footing and Staircase.

3. BUILDING DATA FOR ANALYSIS

Utility of Building	:	Residential Building
Area of the site	:	87 x 68.38 (ft)
Building Height	:	43 ft
Number of Storey	:	(G+3)
Type of construction	:	R.C.C Framed Structure
Shape of Building	:	Rectangular
Number of staircase	:	One
Number of Lift	:	One
Type of Walls	:	Brick Wall
Thickness of Slab	:	4.72” (120mm)
Thickness of External Wall	:	9“(230mm)
Thickness of Internal Wall	:	3.93” (100mm)
Dimensions of Column	:	C1 230x450 mm
C2 230x230 mm		
Dimensions of Beams	:	B1 230x300 mm

4. ANALYSIS DESIGN OF STRUCTURAL ELEMENTS

The modeling analysis is done in the STAAD PRO, the design analysis results are as follows,

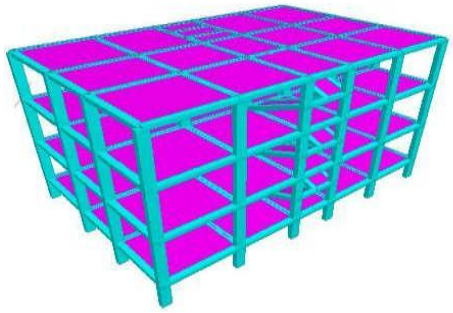


Fig1. 3D modeling in STAAD PRO

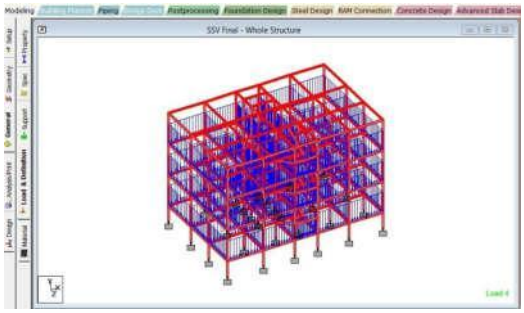


Fig2. Wall load diagram

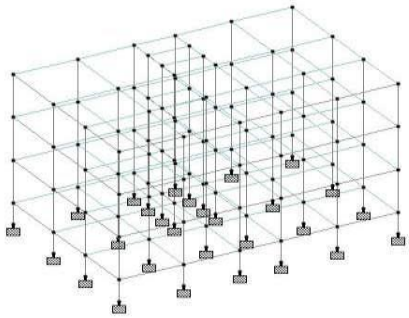


Fig3. Skelton structure of building

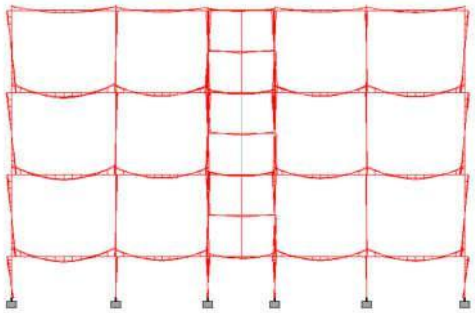


Fig4. Bending moment diagram

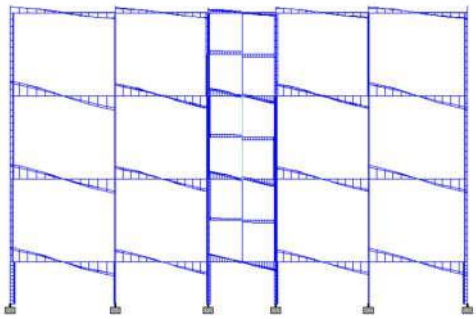


Fig5. Shear force diagram

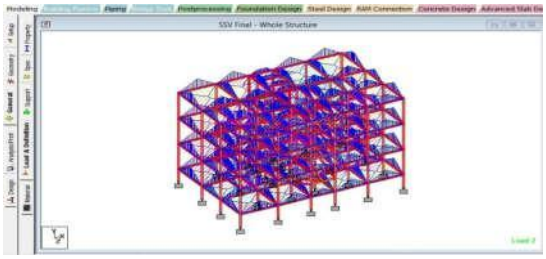


Fig6. Envelope diagram showing max Bending & Shear

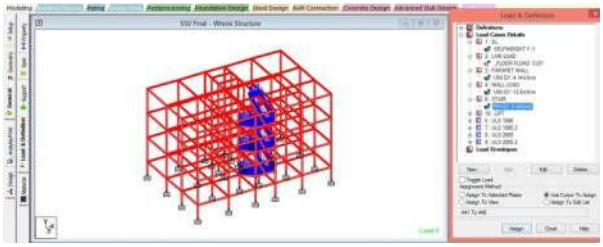


Fig 7 Load due to staircase

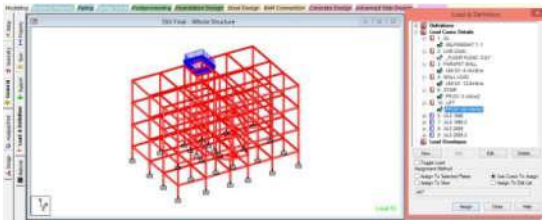


Fig 8 load due to lift

5. DESIGN OF RCC ELEMENTS

The RCC are slab, beam, column, footing and stair case etc…

5.1 .Design of slab

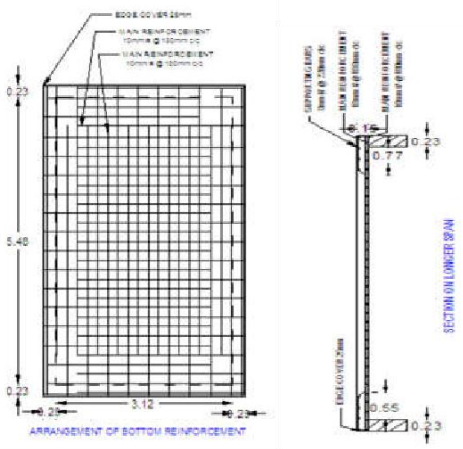
Slabs are most widely used structural elements forming floor and roof of building. Slab support mainly transverse load and transfer them to supports by bending actions more or one directions. On the basis of spanning direction: It is two type (one way slab, two way slab).

5.1.1 .One way slab:

When the slab is supported on two opposite side parallel edges, it spans only in the directions perpendicular to the supporting edges. It bends in one directions and main steel is provided in the directions of the span. Such a slab is known as one- way slab.

5.1.2. Two way slab:

When the slab is supported on four edges and the load distribution is also on four edges of the panel. The reinforcement is provided on both the sides. Such slab is known as two way slab. Fig 7 shows the slab detailing. HYSD of 10 mm dia @ 180 mm C/C is placed along Longer & shorter span with 8mm dia @ 220 mm c/c across the span.



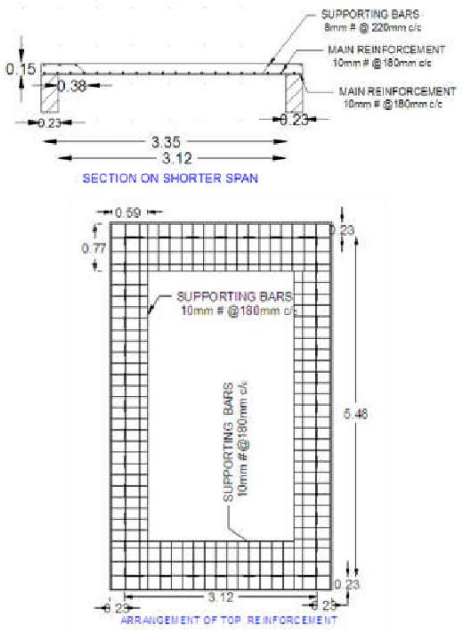


Fig7. Two way slab reinforcement

5.2 .DESIGN OF BEAM

A reinforced concrete beam should be able to resist tensile compressive and shear stresses induced in it by the loads on the beam. Concrete is fairly strong in compression but weak in tensile strength. Plain concrete beams are thus evaded in carrying capacity by the low tensile strength. Steel is very strong in tension. Thus the weakness of concrete is overcome by the provision of reinforcing steel in the tension zone around the concrete to make a reinforced concrete beam. The designing of the beam mainly consist of fixing the breadth and depth of the beam and arriving at the area of steel and the diameters of bars to be used. The breadth of the beam is generally kept equal to the thickness of the wall to avoid offset inside the room. It shall not exceed the width of the column for effective transfer of the load from beam to column. The depth of the beam is taken by L/10 to L/6. Therefore in the present design all beams are in rectangular shape having the breadth and depth of the beam is 230mm and 300mm respectively. There are two types of reinforced concrete beams

(i) Single reinforced beams

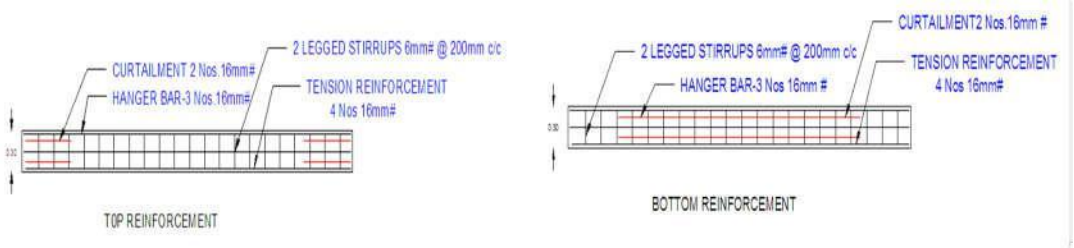
(ii)Double reinforced beams

(i) Single reinforced beams:

In singly reinforced, simply supported beams steel bars are placed near the bottom of the beam where they are effective in resisting in the tensile bending stress.

(ii) Double reinforced beams:

It is reinforced in both compression and tension zone. The necessities of steel of compression region arise due to two reasons. Fig 8 shows the Beam detailing. 4 nos 16mm dia are placed in tension zone with 2 legged stirrups of 6mm @ 200mm c/c and 3 nos of 16mm dia bars are provided in compression zone.



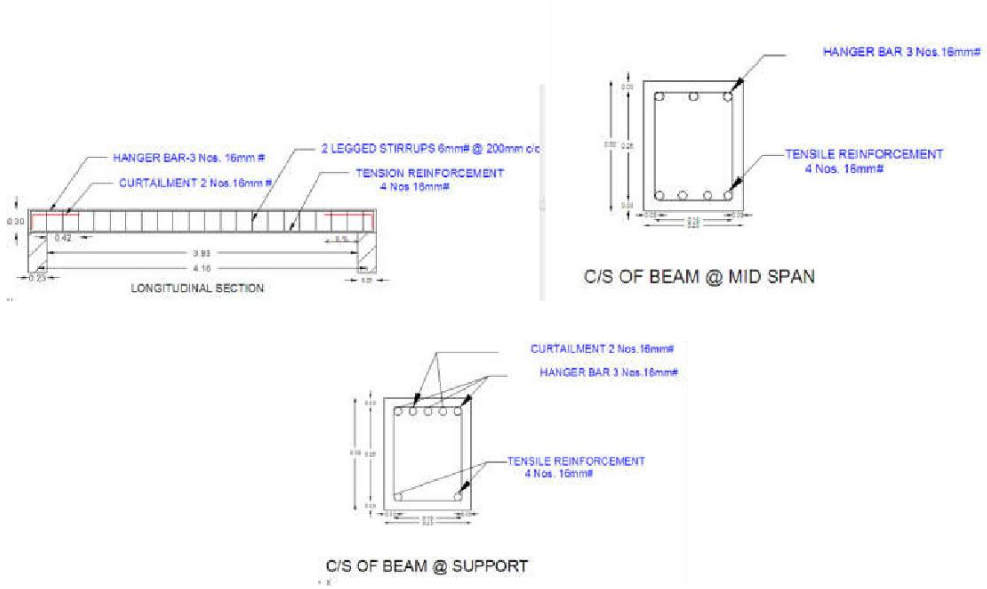


Fig 8. Beam reinforcement

5.3. DESIGN OF COLUMNS

A column in general may be defined as a member carrying direct axial load which causes compressive stresses of such magnitude that these stresses largely control its design. The columns are subjected to axial loads (Pu) and uniaxial bending moment (Mu). The column section shall be designed just above and just below the beam column joint and larger of the two reinforcements shall be adopted. The design carried on basis of IS 456:2000. The fig 9 shows the detailing arrangement of reinforcement in column 16 mm diameter bar with 200 mm center to center spacing is provided.

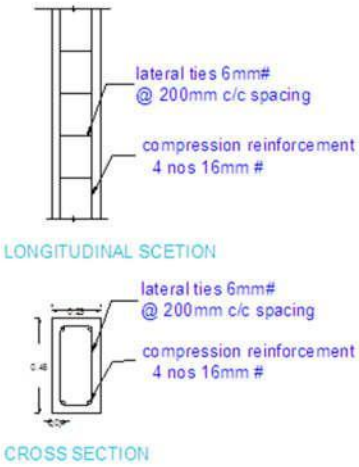


Fig 9 .Column reinforcement

5.4. FOOTING

Foundations are structural elements that transfer loads from the building or individual column to the earth .If these loads are to be properly transmitted, foundations must be designed to prevent to curtail differential settlement and to provide adequate safety against sliding and overturning. Foundation design involves a geotechnical study to establish the most appropriate type of foundation and a structural design to determine footing dimensions. Because compressive strength of the soil is generally much weaker than that of the concrete, the contact area between the soil and the footing is much larger than that of the columns and walls. The present study indicates that the site is located in granite rock which is suitable for shallow foundation. To determine the bearing capacity of soil, undisturbed samples of soil are tested in the laboratory and found that the Safe bearing capacity of soil is 300kN/m^2 at a depth of 6ft and same soil should extent 1.5 times the width of footing below the base of footing.

Depending on the bearing capacity of soil and designing of structure isolated square footings and rectangular footing of M-20 mix and reinforced with HYSD bars of Fe-500. Isolated rectangular sloped footing is adopted. The slope is provided to decrease the concrete in the construction which results into economic construction. A pedestal is used to carry the loads from metal columns through the floor and soil to the footing when the footing is at some depth in the ground. And an isolated column footing transfers the loads from a single column to the supporting soil. The footing is designed for flexure, punching or two-way shear, and flexural or one-way shear. The net bearing capacity of soil beneath determines the size of the footing and similarly punching shear governs the depth of the footing. Fig 10 shows the sectional detailing of the reinforcement in footing.

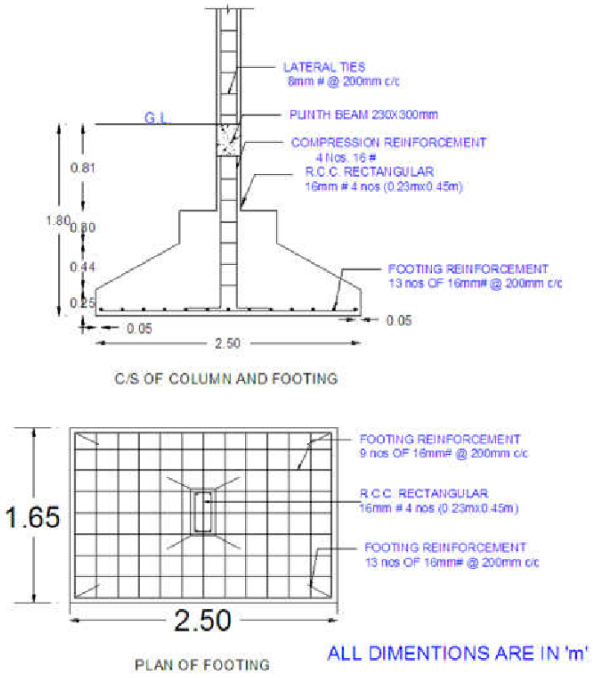
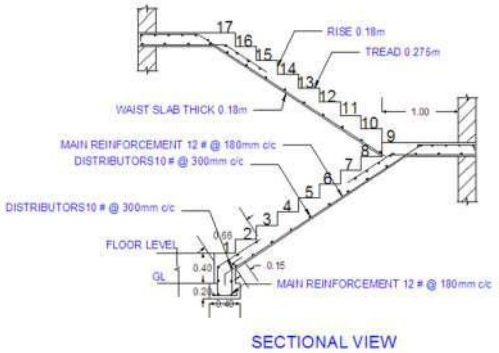


Fig10. Column and footing reinforcement.

5.5. DESIGN OF STAIR CASE:

Stairs consist of steps arranged in a series for purpose of giving access to different floors of a building. The location of stairs requires good and careful consideration. In the present design Dog-legged staircase is proposed. The dimensional details of breadth, length and height are 0.9m, 3.43 m, and 1.44 m respectively. Fig 11 shows the reinforcement detailing in staircase and the plan view of the staircase.



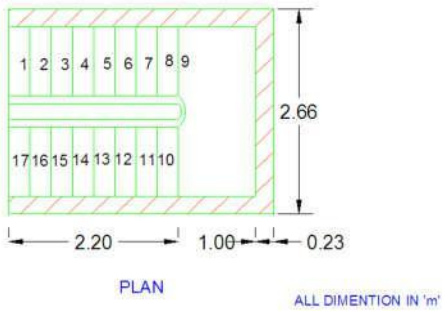


Fig11. Staircase reinforcement and plan view

6. CONCLUSIONS

i. Structural frame works are modeled in STAAD and analyzed.
ii. Load combinations as per Indian Standards and guidelines are followed to ensure the safety of Building in both Ultimate state and serviceability state.
iii. Structural components are designed for max bending & shear which further warrants the well-being of Structure.
iv. Cross sectional details of all components are not bargained and meanwhile economical section is ensured which avoids the national wastage.
v. Detailing is presented using Auto CADD for clarity.

Analyzing and detailing software aids time wastage and also adds in accuracy of results.

CODE BOOKS

i. IS 456-2000 code book for design of beams, columns and slabs
ii. SP-16 for design of columns.

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