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Design and Analysis of G+3 Building Using Staad.Pro

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Abstract – The design and analysis of a G+3 building using STAAD.Pro involve a comprehensive approach to structural engineering, ensuring safety, durability, and efficiency. This study focuses on the architectural layout, load calculations, and stability assessments required for mid-rise residential structures. STAAD.Pro facilitates precise modelling and simulation, allowing engineers to evaluate various load combinations, including dead loads, live loads, wind loads, and seismic forces, in compliance with IS codes such as IS 456- 2000 and IS 875-1987. The software enables finite element analysis, reinforcement detailing, and optimization of structural components, ensuring cost-effectiveness and sustainability. Additionally, the study integrates modern construction materials and energy-efficient practices to enhance the building's performance while minimizing environmental impact. By leveraging advanced computational techniques, this approach ensures long-term resilience, functionality, and structural integrity, making STAAD.Pro an essential tool for efficient and reliable residential building design.

***Key Words*:** Staad.Pro, Structural design, G+3 building, Structural analysis, Load calculations, Material optimization.

1. INTRODUCTION

In the modern construction industry, the need for efficient and safe design of multi-storeyed structures is more critical than ever. Urban development demands buildings that serve multiple purposes while optimizing land usage. A G+3 mixed-use building — with commercial occupancy on the ground floor and residential units on upper floors — is one such efficient model that is widely adopted in urban zones.Structural design and analysis are the backbone of ensuring the stability, strength, and durability of such buildings. With the advent of computer-aided design software like STAAD.Pro, civil engineers can now analyse complex structures under various loading conditions with greater precision and efficiency.This journal focuses on the planning, structural analysis, and design of a Ground plus Three-storey (G+3) mixed-use building using STAAD.Pro.

The building is designed as per Indian Standard codes including IS 456:2000 for reinforced concrete design, IS 875 for loading standards, and IS 1893 for seismic design. The aim is to analyse the structure under dead loads, live loads, wind loads, and seismic forces to ensure safety, economy, and compliance with national standards. The study highlights a practical approach to structural modelling, load application, and design checks within STAAD.Pro, making it a valuable reference for students, designers, and engineers involved in similar projects.

2. LITERATURE SURVEY

1. R. Subramanian (2010), "Design of Reinforced Concrete Structures" This book lays a foundational understanding of structural analysis and design in accordance with IS 456:2000. It emphasizes the importance of accurate load calculations, reinforcement detailing, and design principles for different building components. The methodologies explained are highly relevant when using STAAD.Pro for RC structure design.
2. K.S. Ramakrishna, et al. (2016), "Analysis and Design of G+3 Residential Building using STAAD.Pro" This study involved the modelling and analysis of a G+3 residential structure in STAAD.Pro, highlighting the advantages of automated load calculations, 3D visualization, and design checks. The analysis considered dead loads, live loads, wind loads, and seismic forces as per IS 875 and IS 1893.
3. S.M. Yunus and R. Khadirnaikar (2017), "Comparison of Manual and STAAD.Pro Analysis of a G+3 Structure" This paper provided a comparative evaluation of manual calculations and STAAD.Pro results for a four-storey residential building. The study found that STAAD.Pro significantly reduces time and human errors, offering higher accuracy and multiple design iterations efficiently.
4. IS 456:2000 and IS 875 (part 1 to 5) These Indian Standard codes serve as the base for structural design and load considerations. They provide design specifications for reinforced concrete members and guidelines for calculating different types of loads (dead, live, wind, earthquake), which are directly implemented in STAAD.Pro analysis
5. Dr. N. Krishna Raju (2012), "Advanced Reinforced Concrete Design". This textbook gives a deeper insight into structural behaviour under loads, critical for structural modelling. The knowledge supports STAAD.Pro modelling by guiding decisions about cross- sections, reinforcement, and stability criteria.
6. Prashanth T., et al. (2019), "Design and Analysis of G+3 Commercial Building using STAAD.Pro" This paper presented the structural design and analysis of a commercial G+3 building with a focus on lateral load resistance. STAAD.Pro built-in wind and seismic analysis features were utilized, ensuring compliance with IS 1893:2016.
7. S. K. Duggal (2015), "Earthquake-Resistant Design of Structures" The author emphasizes the importance of seismic design, which is a crucial component of STAAD.Pro analysis features. This work supports the selection of appropriate parameters in STAAD.Pro to ensure earthquake resilience in G+3 buildings.

3. OBJECTIVES

1. To plan a G+3 building using Staad.Pro
2. To perform structural modeling of building using Staad.Pro software.
3. To calculate and apply appropriate load including dead, live, wind, and seismic loads using Staad.Pro software.
4. To analysis the structure for stability, strength, and serviceability under various loading condition.
5. To ensure that the design is safe, economical, and compliant with IS codes.
6. To interpret the analysis results and recommend improvements in design based on structural behavior.

4. METHODOLOGY

4.1 Planning of the Building layout

- A typical floor plan is prepared considering mixed-use occupancy. The ground floor is assigned for commercial activities, and the upper floors for residential use.
- Standard room dimensions and spacing are assumed for uniformity.

4.2 MODELING IN STAAD Pro

1. Creating Nodes:
- A node was created at the base (0,0,0) to represent the foundation level.
- Another node was placed at the top level of the column (e.g., at 0,3,0 for 3-meter height).

2. Defining Geometry:
- A vertical member (beam/column) was created by connecting the base and top nodes.
- This member represents the reinforced concrete column of the structure.

3. Assigning Supports:
- The bottom node was assigned a fixed support to simulate the foundation, which restrains all translations and rotations.

4. Defining Material Properties:
- The material was set to Concrete M25 (fck = 25 MPa).
- Steel used was Fe500 for reinforcement (fy = 500 MPa).

5. Assigning Section Properties:
- The column was given a rectangular cross-section, typically 400 mm × 400 mm.

6. Load Assignments:
- Self-weight of the structure was included automatically.
- Additional dead loads and live loads were applied at the top of the column.
- In some cases, wind load was also applied according to IS 875 (Part 3).

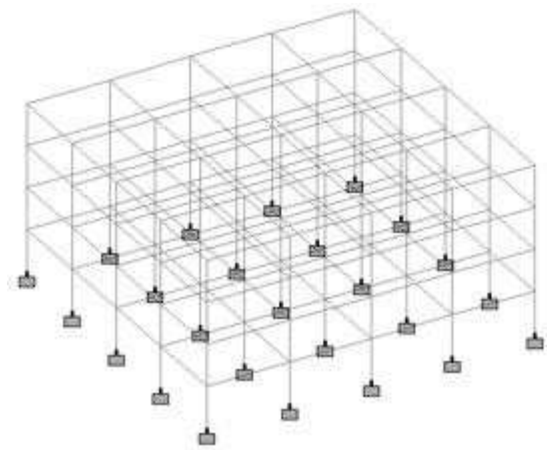

FIG 1: The Model of Structure with All Beams and Nodes.

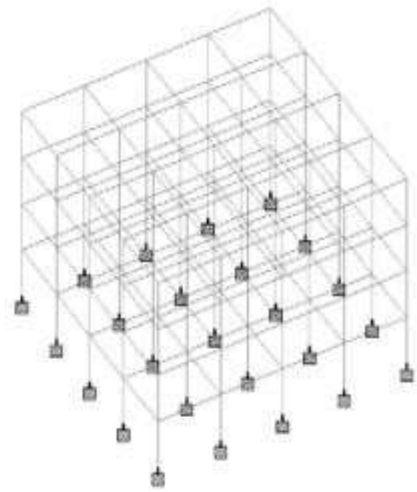

FIG 2: The model with the fixed supports

7. Creating load combinations:
- Load combinations such as (DL + LL), (DL + WL), etc., were defined as per IS code.

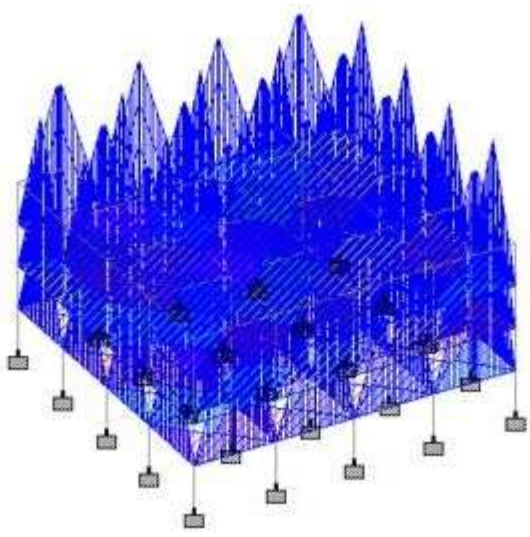

FIG 3: Assigning Concrete Material to the Multi Storey Building

8. Saving and Analyzing the Model:

- The model was saved and the **analysis was run** to check for axial force, bending moment, shear force, and displacement.

FIG 4: 3d Rendered model after specifying the properties to member.

9. Checking Errors and Viewing Results:

- The structure was checked for modeling or support errors.
- All outputs were viewed in the post-processing mode for structural behavior and design forces.

5. DEAD LOAD

In structural engineering, a dead load (also known as a static or permanent load) refers to the constant load acting on a structure due to the self-weight of structural elements and all permanently attached components. This includes:

- The self-weight of primary structural elements such as beams, columns, slabs, and walls.
- The weight of non-structural elements like flooring materials, false ceilings, partitions, and cladding.
- The load from permanent fixtures and equipment, such as plumbing systems, HVAC units, and built-in machinery that are fixed in position.

Dead loads are considered invariable over time and are typically calculated based on the unit weight (density) of materials used in construction. They form a fundamental part of the load combinations used in structural analysis and design, ensuring the structure's safety and serviceability under all expected conditions.

6. LIVE LOAD

The second vertical load that is considered in plan of a structure is forced loads or live loads. Live loads are either portable or moving burdens with no quickening or effect. These heaps are thought to be delivered by the planned utilize or inhabitance of the building including weights of versatile parcels or furniture and so forth.

Live load continues changing now and again. These heaps are to be reasonably expected by the planner. It is one of the significant loads in the plan. The base estimations of live loads to be expected are given in IS 875 (section 2) – 1987. It relies on the expected utilization of the building.

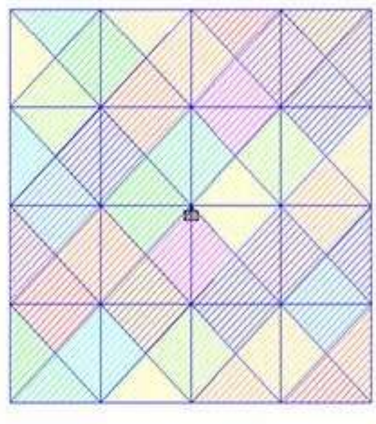

FIG 5: Application of Live load on the structure.

7. SESIMIC LOAD

Seismic loading is one of the basic concepts of earthquake engineering which means application of an earthquake generated agitation to a structure. It happens at contact surfaces of a structure either with the ground or with adjacent structures or with gravity waves from tsunami.

8. WIND LOAD

Wind is a mass of air that moves in a mostly horizontal direction from an area of high pressure to an area with low pressure. The wind load is defined as the load on a structure due to the action of wind. High winds can be very destructive because they generate pressure against the surface of a structure. The effect of the wind is dependent upon the size and shape of the structure.

Calculating wind load is necessary for the design and construction of safer, more wind-resistant buildings and placement of objects such as antennas on top of buildings.

9. CONCLUSION

In this study, the design and structural analysis of a G+3 mixed-use building was successfully performed using STAAD.Pro, following the guidelines of relevant Indian Standard codes. The building was modelled with appropriate assumptions for material properties, dimensions, and loading conditions, including dead, live, wind, and seismic loads. The analysis results showed that the structural members are adequately designed, with all critical parameters such as bending moments, shear forces, and deflections within permissible limits. The use of STAAD.Pro enabled precise modelling and efficient analysis, ensuring the building's structural stability, safety, and economic feasibility. Overall, the project demonstrates the effectiveness of computer-aided design tools in optimizing building performance and highlights the importance of a code-compliant, systematic approach in structural engineering

10. FUTURE SCOPE

The present study focuses on the structural design and analysis of a G+3 mixed-use building; however, future work can expand this research in several directions. The design can be extended to higher-rise structures, incorporating dynamic analysis for more accurate assessment under seismic conditions. Integration of advanced structural systems such as shear walls, moment-resisting frames, or base isolation techniques can further enhance building performance in high-risk zones. Additionally, incorporating Building Information Modelling (BIM) alongside STAAD.Pro can improve coordination between architectural and structural components. Sustainability aspects, such as the use of green materials, energy-efficient designs, and life-cycle cost analysis, can also be explored to create more eco-friendly structures. Finally, experimental validation of analytical results or software comparisons with other structural design tools can provide deeper insights and reinforce the credibility of computational methods

11. REFERENCES

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