BUILDING STRUCTURAL ANALYSIS WITH DEAD AND LIVE LOADS IN STAAD.PRO FOR A G+5 REINFORCED CONCRETE STRUCTURE

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Abstract - To guarantee sufficient strength, stability, and serviceability under applied loading circumstances, structural analysis is a crucial step in the design process of reinforced concrete (RC) structures. For more precise and time-saving structural analyses, modern structural engineering practices rely heavily on finite element-based software. A G+5 reinforced concrete structure was analyzed structurally under dead and live loads using STAAD in this research.Professional Connect Edition. In compliance with IS 456:2000 and IS 875 (Part 1 and Part 2), a three-dimensional analytical model was created by specifying the building's geometry, materials, sections of members, support conditions, and loads. A total of 558 frame members, 144 slab plate elements, and 245 joints make up the structure. The technique of matrix stiffness was used to conduct linear static analysis, and self-weight and uniformly distributed live loads were used to provide gravity loading. Measurements of axial forces, bending moments, shear moments, nodal displacements, and support responses were used to assess the structural response. The analytical model was shown to be reliable via validation procedures that included checking the geometry, member connection, and static equilibrium. Under the specified loading circumstances, the findings show that the structure is strong and serviceable, proving that STAAD was successful.Pro as a trustworthy instrument for the evaluation of structures with reinforced concrete frames.

Important Terms - Subjects included include: IS 456:2000, IS 875, Dead Load, Live Load, Matrix Stiffness Method, Finite Element Analysis, Reinforced Concrete Building, axial force, shear force, nodal displacement, structural analysis, and STAAD.Pro CONNECT Edition.

1. INTRODUCTION

Because of their strength, durability, and economy, reinforced concrete (RC) framed structures are among the most extensively used structural systems for residential, commercial, and institutional construction. For these structures to be structurally safe, it is crucial to accurately assess the internal forces and deformations caused by various loading circumstances. The stresses on members, responses on supports, and displacements needed for safe and cost-effective structural design may be found using structural analysis. The design process has been greatly enhanced by the advancements in computer-based structural analysis. Applications like STAAD.Engineers may now conduct 3D finite element analyses much more quickly and accurately than before with the help of Pro. In accordance with national design requirements, the program enables precise geometric modeling, material property assignment, load combination production, and structural behavior assessment under different loading circumstances. Throughout their lifespan, the majority of reinforced concrete structures are subjected to loading conditions that primarily include gravity. The self-weight of structural elements and permanent building components are considered dead loads, whereas the loads exerted during occupancy are considered active loads. Beam, column, slab, and foundation behaviour evaluations need precise estimate and application of these loads.

Using STAAD.Pro CONNECT Edition, the researchers in this work modeled and analyzed a G+5 reinforced concrete structure. Parts 1 and 2 of IS 875 and IS 456:2000 were followed for the analysis. Stresses, displacements at nodes, axial forces, shear forces, and bending moments were used to assess the structural response. Confirming the building's sufficiency under gravity loading circumstances, the inquiry showcases the use of finite element analysis in structural engineering.

II. EVALUATION OF EXISTING LITERATURE

According to the research, finite element analysis is now a must-have for designing and analyzing reinforced concrete structures. When used to multi-storey three-dimensional frames, conventional analytical techniques become more difficult, but they are successful for basic constructions. Thanks to advancements in structural analysis software, engineers can now simulate intricate structural systems with more precision and less computing overhead. The stand.Because it unifies modeling, analysis, design, and post-processing in a unified interface, Pro is among the most popular structural analysis applications. Several studies have revealed that STAAD.Deflections, shear forces, axial forces, support reactions, and bending moments are only some of the structural responses that Pro can reliably anticipate under varying loads. As a result, the program is now considered an industry standard for engineers working with composites, steel, and reinforced concrete. Geometry verification, connection tests, and equilibrium verification are three ways that researchers have stressed the significance of verifying analytical models. For accurate analytical findings, it is crucial to correctly assign material attributes, support conditions, and loads. The execution of structural analysis in accordance with generally acknowledged engineering standards and the subsequent production of safe structural designs are guaranteed by conformity with IS 456:2000 and IS 875.The literature evaluation verifies that, in comparison to manual calculations, finite element-based structural analysis greatly reduces computing effort while providing accurate predictions of structural behavior. The results of this study provide credence to using STAAD.Using the PRO CONNECT Edition, you may study the effects of gravity on structures made of reinforced concrete.

III. METHODOLOGY

3.1 Study Framework

The structural behavior of a G+5 reinforced concrete (RC) building exposed to gravity loads is evaluated in this work using a numerical modeling technique. We used STAAD to build the whole analytical model.All structural analyses were carried out using the PRO CONNECT Edition software in compliance with the requirements of IS 456:2000 and IS 875 (Part 1 and Part 2). The inquiry includes structural modeling, applying loads, doing linear static analysis, and evaluating the structural reactions that come from it.

3.2 Explanation of the Model's Structure

For this research, we used a standard G+5 reinforced concrete framed structure. There are 144 slab plate elements, 558 frame members, and 245 joints in the analytical model. For effective load transmission from the slabs to the supporting beams and columns, the structural system makes use of reinforced concrete slabs, columns, and beams organized in a regular grid.

3.3 Characteristics of Materials and Their Building Elements

The M25 grade concrete reinforced with Fe500 steel structural parts were modeled. Below is a summary of the member dimensions that were used in the analytical model. In accordance with the applicable rules of the Indian Standard, the density, modulus of elasticity, and Poisson's ratio were ascribed to the material attributes. All column bases were equipped with fixed support conditions to simulate a foundation that is very stiff.

Structural Component	Size
Beam	230 mm × 300 mm
Column	230 mm × 400 mm
Slab Thickness	120 mm

3.4 Modeling of Structures

The STAAD program was used to create the three-dimensional analytical model.By specifying the building's shape, member connection, and slab plate elements, the PRO CONNECT Edition may be used. At regular grid intersections, joint coordinates were set up, and the space frame was completed by connecting beams and columns. The use of four-noded plate elements to depict the floor slabs allowed for a realistic distribution of loads from the slabs to the beams. It was necessary to double-check the geometry to make sure the quantity of joints, members, and plate elements was accurate before running the analysis.

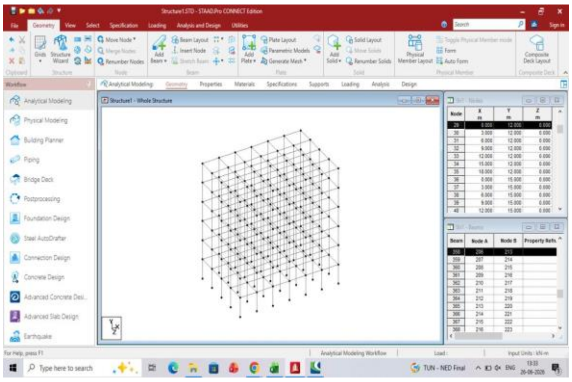

Fig. 1. The G+5 building's beam and column network shown in a three-dimensional bare-frame skeleton.

3.5 Problems with Loading

Using the following load instances, the structural model was subjected to gravity loading: Dead Load (DL): STAAD was programmed to automatically produce the self-weight of every structural component, hence there are no human hands involved in this process.The material's density and sectional characteristics provide the basis for the pro. The global Y-direction was negatively affected by the self-weight. All floor slabs were subjected to a uniformly distributed live load of 2.0 kN/m² via the use of the floor load capability in STAAD.Pro. The program translated the floor loading into comparable loads that the beams supporting the structure had to bear.

3.6 Mixing Loads

We ran the numbers using this combination of ultimate limit state loads:

$$[1.5(DL + LL)]$$

The design requirements of the Indian Standard state that this combination of loads constitutes the controlling gravity loading condition.

3.7 Approach to Analysis

The matrix stiffness approach that is available in STAAD was used to do the linear static analysis. Professional Connect Edition. The program calculated the forces inside the members, displacements at the nodes, and reactions at the supports when the structural model and loading specification were finished. It was necessary to confirm the analytical model by checking its geometry, connection, and static equilibrium before delving into the findings. Verifying the computational model's correctness was done by comparing the total applied loads with the support reactions.

3.8 Assessment of Work Performance

Using these engineering factors, we were able to assess the G+5 reinforced concrete building's structural response:

- Maximum moment of bending
- Highest rate of shear
- Columns' axial forces
- Dislocation of nodes
- Encourage responses
- Distribution of stress on plates

The STAAD was used to obtain these response characteristics.Analyzed the building's structural behavior under the imposed gravity loads using the pro output database. The understanding offered in the Results and Discussion section was built from the acquired results.

IV. FINAL THOUGHTS AND FINDINGS

4.1 An Introduction to Structural Analysis

The G+5 reinforced concrete building's structural study was carried out with great success utilizing STAAD.Professional Connect Edition. Under gravity loading, which included dead load, live load, and the governing load combination of 1.5(DL + LL), the three-dimensional finite element model was examined. For every part of the structure, from beams and columns to slabs and supports, the program produced comprehensive data. Support responses, plate stresses, nodal displacements, axial pressures, shear forces, and bending moments were used to assess the structural response. The analytical findings shed light on the reinforced concrete building's behavior under the specified loading circumstances.

4.2 Checking the Stability of Structures

To make sure the numerical model was accurate, we checked it before we interpreted the analytical findings. Consistency of geometry, connection of members, support conditions, and static equilibrium were all verified in the model. No joints were found to be unstable, and no modeling flaws were detected, according to the research. Additional validation of the analytical model's correctness and confirmation of global equilibrium was achieved when the total applied structural loads were determined to be equal to the sum of the support responses. The findings produced are trustworthy for structural assessment, as shown by these verification processes.

4.3 Variation in Bending Moment

We used STAAD to get the bending moment diagrams.The beam members that were exposed to both live and dead loads simultaneously saw the greatest bending moments, according to pro. Due to their greater tributary loading area, interior beams often suffered higher bending moments compared to exterior beams. Effective redistribution of moments throughout the structural frame was made possible by the continuous beam action and strong beam-column connections. Beam sections that were used provide sufficient resistance to the loads that were applied, as seen by the bending moment distribution.

4.4 Distribution of Shear Forces

As one would anticipate from a reinforced concrete frame construction, the shear force diagrams revealed that the strongest shear forces were generated close to the beam supports and the extremities of the columns. As the beam members approached their mid-span, the shear forces progressively diminished. According to the results, the structural frame system moves the slabs' gravity loads to the beams and then the columns' without putting too much strain on the shears.

4.5 Force along an axis in a column

According to the findings of the axial force analysis, the columns support the whole weight of the building, which is transmitted from the floor slabs and beams. Because the inner columns supported a larger tributary area, the compressive axial pressures acting on columns close to the building's center were greater than on columns at the building's edges. Efficient load transmission through the structural frame system is shown by the distribution of axial forces, which also indicates that the specified column diameters are adequate for the applied gravity loading.

4.6 The Movement of Nodes

The findings of the nodal displacement show that the permanent supports had the smallest displacement and the roof had the most vertical displacement. This pattern of displacement is typical of multi-story reinforced concrete framed constructions that experience gravity stress; it increases steadily from the base to the highest floor. The calculated displacements were within the permitted range for serviceability, which means that the structural stiffness and overall stability were good.

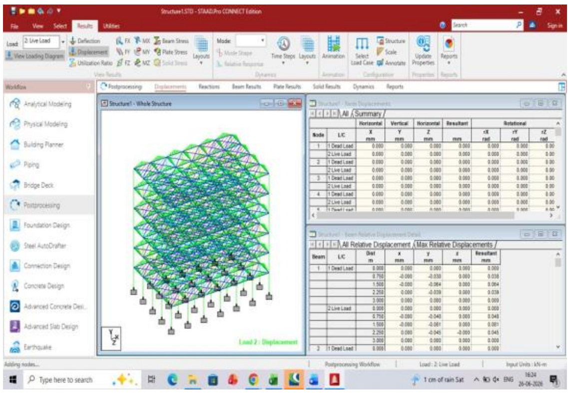

Fig. 2. Analysis of the structure-wide distribution of the resulting nodal displacement

4.7 Backing Responses

Through the use of the fixed column supports, the imposed structural loads were successfully transmitted to the foundation, as verified by the support reaction analysis. The structure satisfies the conditions of static equilibrium because the reaction forces roughly match the total dead and live loads operating on it. Uniform load transmission throughout the foundation system is shown by the distribution of responses across the supports, which represents the symmetry of the structural structure.

Column position	Tributary area	Relative reaction
Corner column	¼ panel (≈ 2.25 m²)	Lowest
Edge column	½ panel (≈ 4.5 m²)	Intermediate
Interior column	1 panel (≈ 9.0 m²)	Highest

Table 1. Showing the dispersion of responses to vertical supports

4.8 Subject under consideration

G+5 reinforced concrete building operates adequately under required gravity loading circumstances, according to the analytical findings. The STAAD-based finite element analysis.The internal force distribution, member stress distribution, and structural displacement distribution were all faithfully recorded by Pro CONNECT Edition. Results from the response parameters show that the chosen structural design offers sufficient strength, stability, and serviceability, and verification tests validated the analytical model's accuracy. According to the research, STAAD provides more evidence.Improve the efficiency and accuracy of structural analysis compared to traditional manual techniques with the help of Pro, an efficient and dependable software platform for analyzing reinforced concrete structures.

Response quantity	Dead Load	Live Load
Max. relative beam deflection (mm)	≈ 0.14	≈ 0.18
Max. absolute plate stress (N/mm²)	≈ 0.041	≈ 0.058
Predominant displacement direction	Vertical (Y)	Vertical (Y)
Static equilibrium difference	0.000	0.000
Analysis status	No error / warning	No error / warning

Table 2. An overview of the findings from the study

V. CONCLUSION

This research detailed the STAAD-based structural analysis of a G+5 reinforced concrete structure that was tested under both live and dead loads.Professional Connect Edition. Building information according to IS 456:2000 and IS 875 (Part 1 and Part 2) was used to create a three-dimensional finite element model. This model included the building's geometry, materials, dimensions, members, support conditions, and loads. The structure's reaction to gravity loads was examined using linear static analysis. Analytical findings proved that the created structural model accurately portrayed the building's behavior when it came to reinforced concrete. The behavior of the support responses, nodal displacements, axial forces, shear forces, and bending moments were in line with what one would anticipate from a typical reinforced concrete frame with many stories. The internal pressures on the interior beams and columns were greater than on the outside ones because of the bigger tributary loading areas, but the structural loads were effectively transferred to the foundation because of the permanent support conditions.

The accuracy of the numerical model was validated by the verification processes carried out prior to analyzing the findings. Verifying the geometry, checking the connection of members, and achieving global static equilibrium all proved that the model was stable and faithfully depicted the desired structural system. Additional confirmation of the finite element analysis's dependability was provided by the near correspondence between the applied loads and the computed support responses.

The analysis also verifies that, under the specified gravity loading circumstances, the chosen structural structure is strong enough and serviceable enough. There was sufficient structural frame stiffness as the estimated nodal displacements were within permissible limits. In a similar vein, the distribution of axial forces, shear forces, and bending moments demonstrated that the chosen beam and column sections could securely withstand the loads. Based on the results of the inquiry, STAAD.Pro CONNECT Edition is a solid and efficient platform for structural analysis of reinforced concrete structures. By streamlining the process of modeling and analysis, the program offers thorough and reliable information on the behavior of structures. This study's technique may be used to analyze and design comparable multi-storey reinforced concrete structures, making structural engineering safer and more cheap.

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