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Optimized Structural Design of a Multistorey 3 BHK Bungalow with Shear Wall Using STAAD. Pro

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ABSTRACT: This study presents the optimized structural design of a multi-storey 3 BHK bungalow incorporating shear walls using STAAD Pro. The building is subjected to various load combinations, including Dead Load, Live Load, and Earthquake Load, in compliance with IS 1893:2002 provisions. Base Shear is calculated and the corresponding patterns are plotted for reference. Reinforcement details derived from the STAAD output are systematically grouped and integrated. The project entails a comparative performance evaluation of a reinforced concrete (R.C.C.) structure with a constant column cross-section. For this analysis, a G+3 storey R.C.C. building located in Zone IV is selected, and horizontal seismic forces are computed based on the Equivalent Static Method. Detailed design of R.C.C. components, such as beams and columns, is carried out using Microsoft Excel sheets derived from analytical results. Both column design approaches constant and floor-wise reducing cross-sections are examined. The study systematically compares the formation of plastic hinges in columns and beams, base force, and displacement responses. Additionally, a comprehensive analysis of bending moments and shear forces for both building models is undertaken. Quantity estimation for beams and columns is also performed, facilitating a detailed comparative study of material usage and structural efficiency. The findings aim to inform best practices in the design of multi-storey residential buildings with enhanced seismic performance. The building is initially modelled in STAAD Pro and subjected to Dead Load, Live Load, and Earthquake Load under various Load Combinations. Base Shear is calculated using the provisions of IS 1893:2002, and the obtained pattern is plotted for reference. The reinforcements derived from the STAAD Pro output file are grouped and saved as reinforcement results.

KEYWORDS: G+3 Storey R.C.C. Building, STAAD Pro Software, Shear Wall etc.

I. INTRODUCTION

The structural design of multistorey residential buildings demands a meticulous approach to ensure stability, safety, and efficiency, especially in seismic-prone regions. This study focuses on the optimized structural design of a multistorey 3 BHK bungalow, integrating shear walls, using STAAD Pro. Shear walls are critical in enhancing the lateral load resistance of buildings, particularly under seismic loads.

This research aims to provide a comprehensive analysis and design approaches for reinforced concrete columns: a constant column cross-section. The selected building, a G+3 storey R.C.C. structure located in Seismic Zone IV, is subjected to various load combinations, including Dead Load, Live Load, and Earthquake Load, as specified by IS 1893:2002. Initial modelling is conducted in STAAD Pro, where base shear calculations and reinforcement details are derived by conducting a thorough examination of bending moments, shear forces, and quantity estimations for both design approaches, this research seeks to determine the most efficient and effective structural design strategy. The findings are intended to contribute to the field of structural engineering by providing insights into optimizing the design of multistorey residential buildings for enhanced seismic resilience.

II. METHODOLOGY

STAAD Pro: Designing a G+3 Storied Building

STAAD Pro is a robust structural analysis and design software, widely utilized for creating structural plans for various projects, including bungalows.

Create a New Project: Launch STAAD Pro and select "New Project" from the start page. Choose an appropriate project template and set the desired units for your project.

Define Project Settings: Configure the project settings, including selecting the relevant building code, specifying material properties, and setting analysis parameters.

Create a New Model: Initiate a new model by navigating to "Model" > "New Model" from the menu. Choose the model type, whether 2D or 3D, based on your project requirements.

Draw the Floor Plan: Utilize the drawing tools within STAAD Pro to create the floor plan of the bungalow. This includes delineating walls, columns, beams, and slabs.

Add Elevations and Sections: Develop elevations and sections to accurately define the height and other structural details of the building.

Assign Materials and Properties: Allocate appropriate materials and structural properties to each element in the model, ensuring they align with the design specifications.

Define Analysis Parameters: Set up the analysis parameters, which include applying loads, defining supports, and configuring the analysis options.

Run the Analysis: Execute the structural analysis to compute stresses, moments, and other critical structural responses. STAAD Pro will process the inputs to provide detailed analysis results.

Design and Optimize: Use the analysis outcomes to design and optimize structural elements such as beams and columns. Adjust the design to meet safety and performance criteria.

Generate Reports and Drawings: Produce comprehensive reports and detailed drawings to document the design and analysis results. These documents are essential for project validation and construction.

Additional Tips:

- Utilize built-in templates and example projects within STAAD. Pro to streamline the initial setup process.
- Leverage the software's automation features, such as the "Auto-Generate" function for beams and columns, to enhance efficiency.
- Access various design tools through the "Design" menu, including the "Beam Designer" and "Column Designer" modules.
- Refer to STAAD. Pro's documentation and online resources for in-depth guidance and tutorials on specific features and workflows.

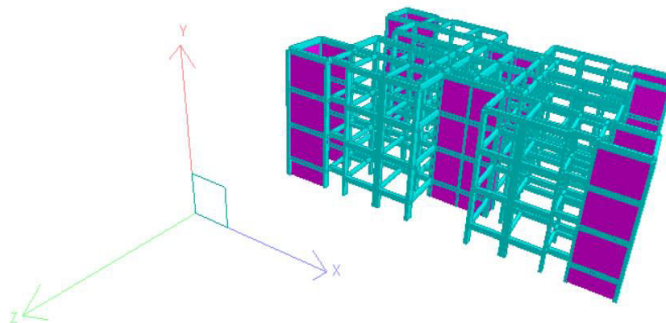


Fig 1. G+3 storied Building

Influence Line Diagram:

Structures are typically analysed for loads with fixed points of application. However, in many cases, such as bridges, structures must be analysed for moving loads that change positions. This scenario is common with bridges subjected to

multiple moving vehicles, forming a train of wheel loads. To design such structures, it is insufficient to analyse for a single load position and calculate stress resultants like bending moments, radial and normal shear forces. Instead, engineers need to determine the maximum stress resultants, both positive and negative, at any section of the structure. They may also need to know the maximum deflection at a specific point under moving loads. Finding these values through trial and error for various load positions is time-consuming and uncertain. The process is simplified by using the concept of an influence line. An influence line is a graph showing the variation of a function, such as reaction, bending moment, shear force, or deflection, at a given point of a structure as a unit load moves across it. The direction of the moving unit load is determined by the expected nature of loading on the structure.

III. EXPERIMENTAL RESULTS

Design of RCC Shear Wall:

The design criteria for RCC shear walls in a G+3 building in STAAD Pro depend on the type, location, and function of the wall, as well as the expected loads and seismic hazard. Key criteria to be considered include stability, strength, ductility, and detailing.

The wall must be capable of resisting buckling and out-of-plane deformation under compressive and shear forces. It should possess sufficient strength to resist the ultimate shear force and moment demand without exceeding the allowable stress or strain.

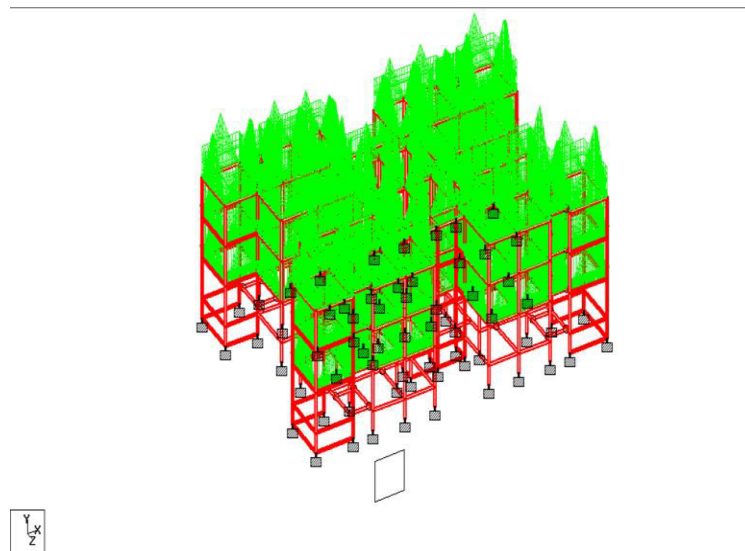
Adequate ductility is required to dissipate energy and mitigate peak forces during cyclic loading. Proper detailing of connections, reinforcements, and construction joints is essential to ensure effective transfer of forces and prevent brittle failure.

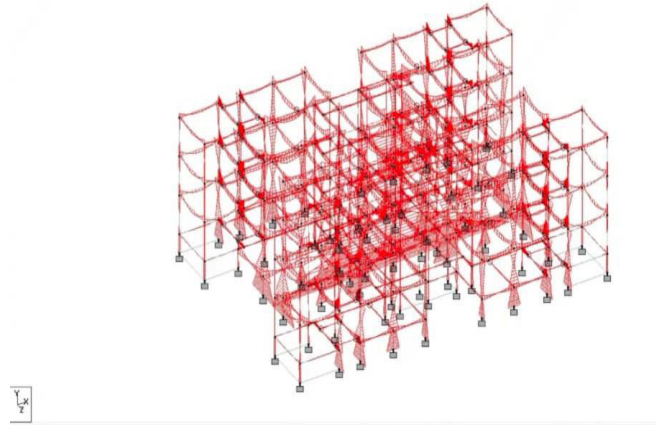
Design of RCC Beams and Columns:

The design of reinforced concrete beams and columns for a G+3 building in STAAD Pro involves transferring structural loads to the foundations through columns, which are vertical compression members with an effective length exceeding three times their least lateral dimension. The columns are reinforced with main longitudinal bars to resist compression and bending, and transverse steel ties to counteract bursting forces.

In this chapter, the RCC design of various components of the selected G+3 building is presented. The same plan is applied throughout, with beams and columns designed for a constant column cross-section at each floor level. The beams and columns are designed using the Limit State method as per SP 16:1980 guidelines.

Fig. G+3 Storied Building for Loading and Bending Moments





IV. CONCLUSION

STAAD Pro is a powerful software tool for structural analysis and design, but mastering it requires a solid understanding of structural engineering principles. Beginners are advised to seek mentorship from experienced structural engineers or consultants to ensure accurate and efficient use of the software in designing complex structures like a G+3 storied bungalows.

The design of a G+3 building with the provision of a shear wall using STAAD Pro demonstrates the effective integration of structural elements to enhance stability and performance under various load conditions. The shear wall significantly contributes to the lateral stiffness and strength of the building, effectively resisting seismic and wind loads. By incorporating the shear wall, the building's ability to resist buckling, out-of-plane deformation, and excessive stresses is enhanced.

The design and analysis of a G+3 building with the provision of a shear wall and constant cross-section columns using STAAD Pro have demonstrated the effective integration of key structural components to enhance the building's stability and performance. The inclusion of shear walls has significantly improved the building's lateral stiffness and strength, making it more resistant to seismic and wind loads. This addition has ensured that the structure can effectively resist buckling, out-of-plane deformation, and excessive stresses.

The use of a constant cross-section for columns across all floor levels has simplified the design and construction processes while maintaining the structural integrity of the building. This approach ensures uniform load distribution and simplifies the detailing and reinforcement of columns.

By employing the Limit State method in accordance with SP 16:1980 for the design of RCC beams and columns, the building meets all necessary safety and performance standards. This methodology ensures that both strength and serviceability criteria are satisfied, providing a reliable and durable structural solution.

Overall, the integration of shear walls and the use of constant cross-section columns in the G+3 building design have resulted in a robust and efficient structural system. The use of STAAD Pro has facilitated precise analysis and optimization, ensuring compliance with relevant codes and standards and enhancing the overall safety, functionality, and longevity of the building.

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