"Application of STAAD.Pro in Analysis and Design of a G+3 Commercial Building"

Manik Maiti 1,*, Debajit Banik 2, and Tanvir Hossain 3

1 Civil Engineering Department, Global Institute of Science and Technology, Haldia, India

2 Civil Engineering Department, Global Institute of Science and Technology, Haldia, India

3 Civil Engineering Department, Global Institute of Science and Technology, Haldia, India

* Correspondence: manikgisthaldia@gmail.com

ABSTRACT - In modern construction, the structural design of multi-storey commercial buildings is of paramount importance. This study presents the design and analysis of a G+3 reinforced concrete commercial building using STAAD.Pro software. Loads are calculated as per IS 875 standards, and structural members such as slabs, beams, and columns are designed in compliance with IS 456:2000. Earthquake resistance is ensured using IS 1893:2002 guidelines, while soil bearing capacity tests inform the foundation design. The Response Spectrum Analysis (RSA) method was used to validate seismic performance. Results show that software-based analysis improves accuracy and efficiency compared to manual calculations. The novelty of this work lies in demonstrating the efficiency of STAAD.Pro for seismic safety and time-saving in structural design workflows.

.

Keywords: STAAD.Pro; Structural Analysis; IS Codes; Seismic Load; Reinforced Concrete; Multi-Storey Building

I. INTRODUCTION

Structural analysis and design are critical to ensuring that a high-rise building can stand safely and perform effectively throughout its lifespan. A well-designed structure must be capable of resisting loads without experiencing excessive deformation or movement, which could otherwise lead to fatigue in structural elements, cracking or failure of partitions, fixtures, or finishes, and inconvenience or discomfort to occupants [1–2]. The design must consider various factors, including movements and forces induced by temperature changes, creep, shrinkage, cracking, and imposed loads. It is also essential to verify that the structure is constructible within the acceptable manufacturing and construction tolerances of the selected materials [3–4]. Furthermore, the structural system should integrate seamlessly with architectural requirements and must allow for proper accommodation of building services such as ventilation, lighting, plumbing, and electrical systems. In this project, a G+3-storey commercial building has been analyzed and designed using STAAD.Pro software for structural analysis and AutoCAD software for architectural and structural drafting. Various load combinations, as per relevant IS codes, have been considered to ensure the structural integrity and safety of the building under both normal and extreme conditions.

II. LITERATURE REVIEW

V. Varalakshmi: Design and analysis of a G+5 multi-storey building at Kukatpally, Hyderabad, India. In this study, various members of the structure such as columns, beams, footings and slabs are analyzed and designed using a well-known software. The safe bearing capacity of the soil is tested [5].P. Jayachandran: Design and analysis of a G+4 multi-storey building at Salem, Tamil Nadu, India. This study includes design and analysis of footings, columns, beams and slabs using two software namely STAAD.PRO and RCC Design Suite [6].L.G. Kalurkar: Design and analysis of a G+5 multi-storey building using composite structure in earthquake zone-3. A three-dimensional modeling and analysis of the structure is done using SAP 2000 software. Equivalent static method analysis and response spectrum analysis methods are used for the analysis of both composite and RCC structures. The results were compared and it was found that composite structures are more economical [7]. Das (2000) found that the structures designed by ELF method performed reasonably well. He concluded that capacity-based criteria should be applied appropriately around irregularities [8]. Saddadi et al. (2007) presented an analytical method for seismic assessment of RC frames using nonlinear time history analysis and push-over analysis. The results of the analytical models were verified against available experimental results. He observed that flexible and inflexible frames behaved very well under earthquakes [9]. Kim and Elnashai (2009) observed that buildings designed for earthquakes using contemporary codes survived the earthquake loads. However, vertical motion significantly reduced the shear capacity of vertical members [10].

III. OBJECTIVE AND SCOPE

Commercial buildings typically offer a variety of services such as medical centers, banking facilities, retail stores, mobile and internet services, and food and beverage outlets. Therefore, it is crucial to ensure that such buildings are capable of withstanding seismic activities. The primary objective of this study is to design and draft a (G+3) story building and assess its structural safety against earthquakes. For this purpose, a four-story building has been designed and modeled at Itamogra-II Gram Panchayat under Mahishadal Block of the Purba Medinipur Zilla Parishad. Structural components such as columns, beams, footings, and slabs have been analyzed and designed using the widely-used civil engineering software STAAD.Pro. Prior to structural analysis, the safe bearing capacity of the soil at the project site was tested to ensure a stable foundation design.

IV. MATERIAL AND METHODOLOGY

The columns in the commercial building are arranged in a uniform grid pattern. The building has four stories, with a floor-to-floor height of 3 meters. A portion of the ground floor is utilized for parking purposes.The dimensions of the building are as follows: Length: 37.238 meters, Width: 11.931 meters, Height of each floor: 3 meters, Area of each floor: 444 square meters. The structural members have the following dimensions: Columns: C1, C2: 300 mm × 450 mm C3: 300 mm × 500 mm, Tie Beam (TB): 250 mm × 450 mm ,Major Roof Beam: 250 mm × 400 mm, Slab Thickness: 125 mm**.** A detailed summary of all structural elements is provided in Table 1 below.

Table 1: Methodology

Utility of building	Commercial building
No. of storey	G+3
Grade of concrete	M20
Grade of steel	Fe500 grade
Type of steel bars	HYSD
Unit weight of concrete	25kN/M3
Story height	3.0M

Figure 1: Plan of Building

Civil Engineering Design Steps

Sl. No	Design Steps
1	Requirement Collection / Project Brief
2	Preliminary Study & Feasibility
3	Conceptual Design
4	Load Calculations
5	Structural Analysis
6	Structural Design
7	Geotechnical Design
8	Other Civil Components
9	Drafting and Detailing

value	Dead and Live load
3.75 KN/m^2	Slab load (dead load)
16.6kN/m	Wall load (dead load)
1.5kN/m^2	Floor finish (dead load)
5kN/m^2	Live load

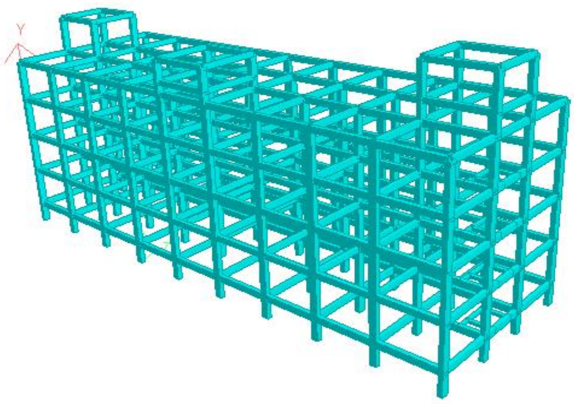
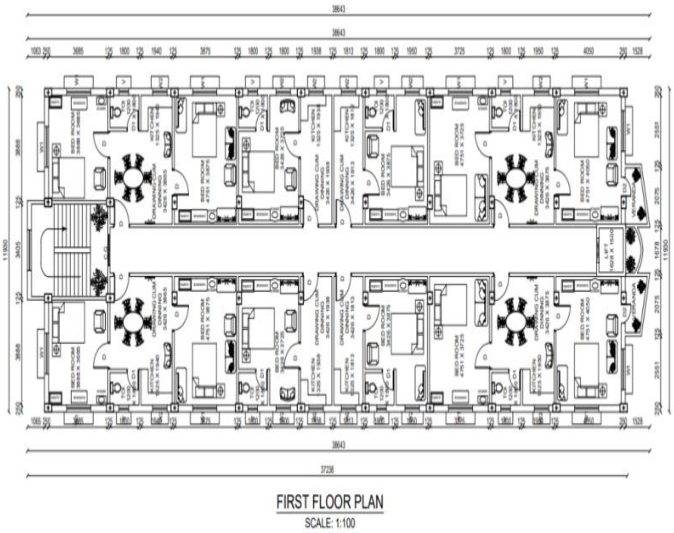


Figure 2 : 3D Form of the Building



This structure has been analyzed and designed considering seismic load, live load. IS-1893-2002 for seismic load and IS : 875 (Part 2) - 1987 for live load has been used and member load as dead load and self-load as beam, column and slab which is automatically applied.

V. STRUCTURAL MODELING

The commercial building is a four-story regular reinforced concrete (RC) structure. It has been analyzed and designed considering gravity loads (dead and live loads) as well as load combinations, as per standard design codes. The structural frame includes column nodes placed at 5-meter intervals along both the X-axis (transverse direction) and Z-axis (longitudinal direction).

Beams are provided with cross-sectional dimensions of 250 mm × 400 mm along both the X and Z axes. Figure 1 shows the plan of a six-story hospital building with 7 bays in the X-direction and 6 bays in the Z-direction. Each floor has a uniform height of 3 meters. Figure 2 presents the elevation views of frames (A-A) and (01-01) of a four-story commercial building. In this case: Beam cross-section: 300 mm × 600 mm, Column cross-section: 500 mm × 500 mm Subsequent figures illustrate the following aspects of the structure: Figure 3: G+3 Story Commercial building Figure 4: Live load distribution acting on the structure, Figure 5: Brick wall load on the structure, Figure 6: Bending moment diagram of the structure, Figure 7: Floor load distribution, Figure 8: Composite load acting on the structure, Figure 9: 3D view of the building, Figure 10: torsion and shear, Figure 11 Shear diagram in Y direction (Load case-5) condition.
Figure 12: Concrete Design beam no 942

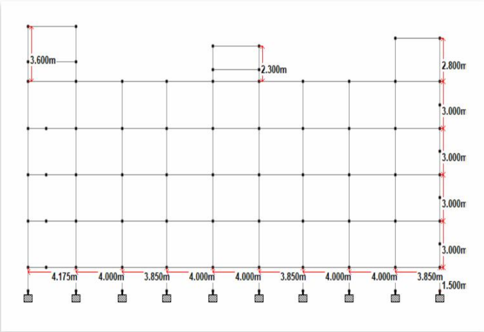


Figure 3: whole Structure Elevation (longitudinal Direction)

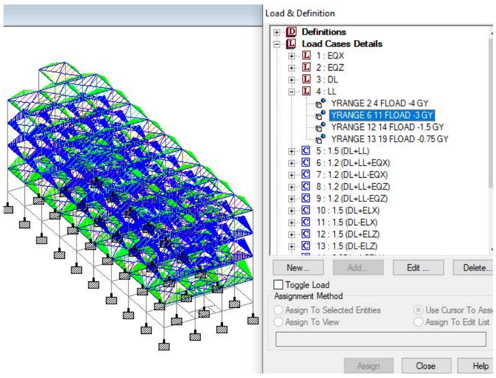


Figure 4: Live Load Distribution on Floor

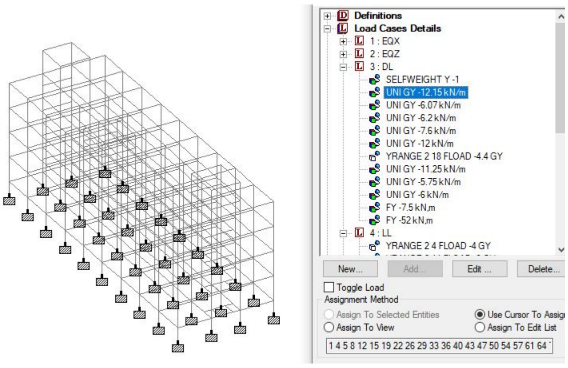


Figure 5: Member load distribution

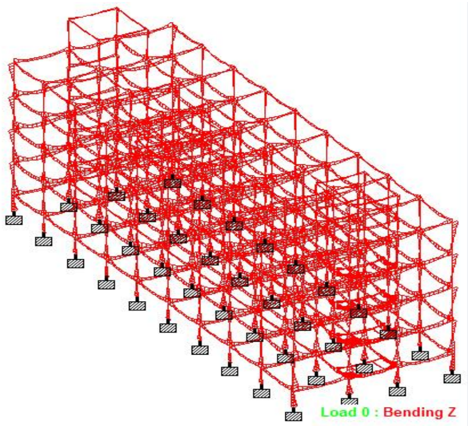


Figure 6: Bending in Z direction

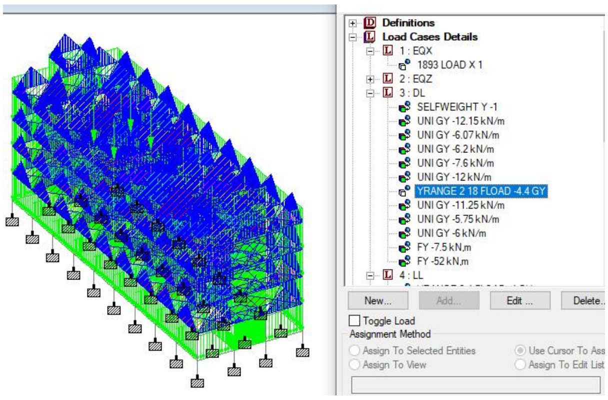


Figure 7: Floor Load due to DL

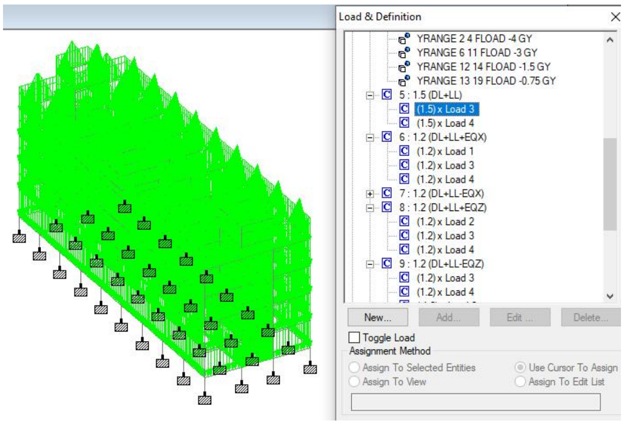


Figure 8: factored Load combination

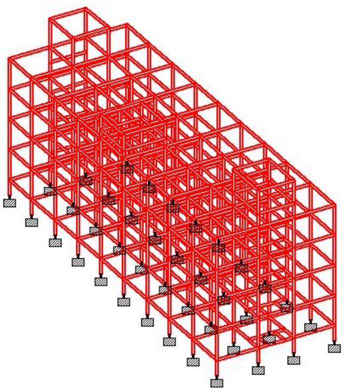


Figure 9: Whole structural view

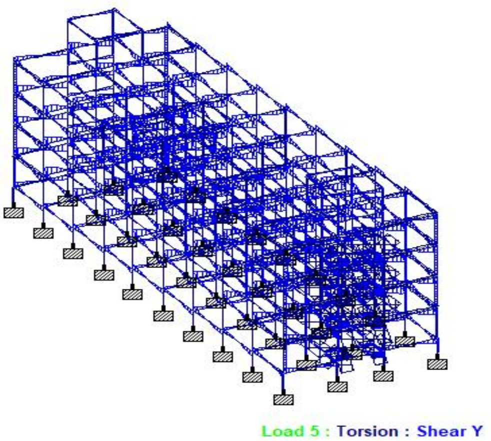
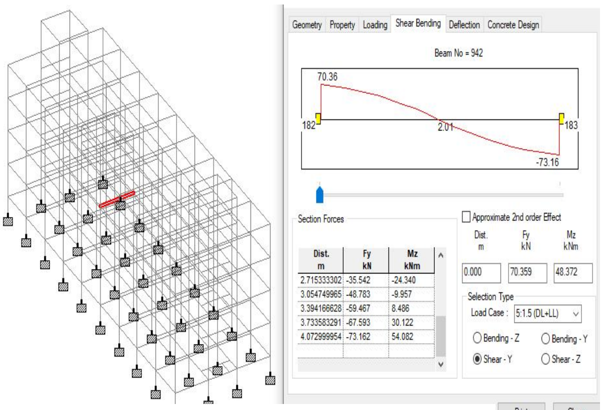


Figure10: Torsion and Shear diagram



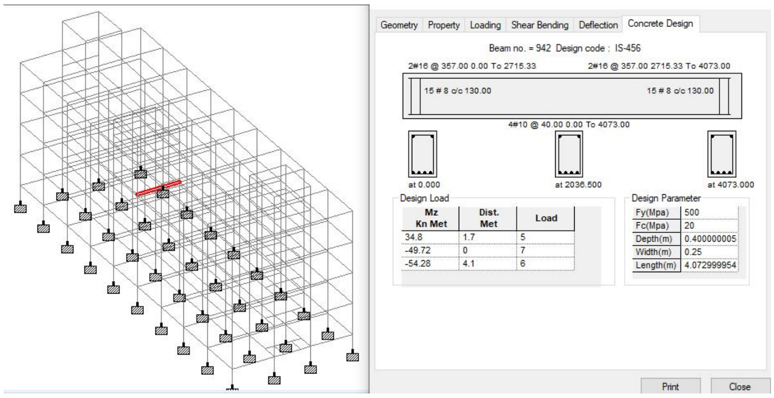


Figure12: Concrete Design beam no 942 (Load case-5)

VI. ANALYSIS

Prior to conducting the structural analysis, the Response Spectrum Analysis (RSA) parameters were predetermined. RSA is a widely used dynamic analysis method that evaluates the structural response to earthquake-induced vibrations by analyzing frequency-dependent behavior over a range of natural periods. In this study: The maximum frequency is 5.998 cycles/second, The minimum frequency is 2.43 cycles/second, The peak story shear is 8789 kN The maximum base shear is 8111 kN, To ensure compliance with code requirements, a customized scale factor was applied. The analysis results indicate that, after applying this scaling, the dynamic base shear obtained from RSA closely matches the static base shear as prescribed by seismic design codes. This alignment confirms that the dynamic seismic effects captured through RSA have been effectively calibrated to meet the static design criteria, ensuring both safety and code compliance.

VII. CONCLUSION

In this study, the drawing of a G+3 commercial building

was prepared using AutoCAD software, and the structural analysis and design were carried out using STAAD Pro software. The analysis and design were performed in accordance with the Indian Standard Code IS 456:2000, specifically focusing on the design and analysis of beams and columns. For earthquake-resistant design, IS 1893:2002 was followed. Dead loads were considered based on IS 875 (Part 1), and live loads were considered according to IS 875 (Part 2). Concrete grade M20 and High Yield Strength Deformed (HYSD) bars of grade Fe415 were used as per IS 1786:1985. The use of STAAD Pro enabled the structural analysis of the multistoried building to be completed much faster and more accurately compared to manual analysis. The software provides detailed information for each structural member, making the design process more streamlined and effective.

Although using software may take some time in the design phase, it significantly enhances accuracy and efficiency. Overall, the use of STAAD Pro and AutoCAD software has made the processes of structural analysis, design, and drafting more modern, precise, and time-efficient.

REFRENCE

1. [1] Sakib Salam Sofi and Ashish Kumar "Analysis and Design of Multistorey Building by Using Staad Pro Software" IJIREM, April 2022.
[2]Thesis of Mr. M. I. Adiyanto, University Sains Malaysia, MALAYSIA, 2008. Analysis and design of 3 storey hospital Structure subjected to seismic load.
[3]Agarwal Pankaj and Shrikhande Manish "Earthquake resistant design of structure" PHI, Learning Pvt. Ltd. New Delhi-2010.
[4]Murty C.V.R. and Jain. S. K "A Review of IS-1893- 1984 Provisions on seismic Design of Buildings". The Indian concrete journal, Nov.1994.
[5]Thesis of Mr. Aslam, ANNA UNIVERSITY: CHENNAI, 60005, April 2012.Sesimic analysis and design of multi Storey Hospital building.
[6]Griffith, M. C. and Pinto, A. V. (2000), Seismic Retrofit of RC Buildings - AReview and Case Study, the Bureau of Indian Standards, 1987.
[7]IS 875 (part2) Imposed loads (second revision), New Delhi 110002: Bureau of Indian Standards, 1987.
[8]M. L. Gambhir, Fundamentals of Reinforced Concrete Design, New Delhi-110001: PHI Learning Private Limited, 2010.

Author Contributions

Conceptualization, M.M.; methodology, D.B.; software, T.H.; validation, M.M. and D.B.; writing—original draft preparation, M.M.; writing—review and editing, D.B. and T.H. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

The data presented in this study are available on request from the corresponding author.

Acknowledgments

The authors would like to thank the Department of Civil Engineering, Global Institute of Science and Technology, Haldia, India, for their support in carrying out this research work.

Conflicts of Interest

The authors declare no conflict of interest.