

Design And Structural Analysis Of High-Rise Building

Aaditya Patil¹, Amansing Jadhav², Aakash Pawar³

^{1,2,3}Dept of Civil Engineering

^{1,2,3} R C PATEL INSTITUTE OF TECHNOLOGY, SHIRPUR.

Abstract- This research investigates the analysis and structural design of a G+9 reinforced concrete residential building by utilizing integrated engineering software tools, including AutoCAD, ETABS, and RCDC. The structure is subjected to different types of loads, namely dead, live, wind, and seismic loads, in compliance with the recommendations of IS 875 and IS 1893:2016. The design of essential structural members such as slabs, beams, columns, and footings is performed in accordance with IS 456:2000, adopting the Limit State Method. The study highlights that the use of integrated software systems leads to improved computational accuracy, reduces dependence on manual calculations, and increases overall productivity in the design of multi-storey reinforced concrete structures.

Keywords: Sugarcane Bagasse Ash, Sustainable Concrete Partial Cement Replacement, Compressive Strength, Cost Analysis.

I. INTRODUCTION

Rapid urban expansion, coupled with sustained population growth, has significantly increased the need for vertical development, particularly in densely inhabited urban regions where land resources are scarce. High-rise buildings offer a practical and space-efficient solution for meeting both residential and commercial demands within limited land areas. Nevertheless, the structural design of such buildings involves considerable complexity, as it requires comprehensive assessment of multiple loading conditions, including dead loads, live loads, wind actions, and seismic forces. Among these, lateral loads are especially critical, as they directly affect the stability and performance of tall structures, particularly in areas susceptible to earthquakes and strong winds. Consequently, strict compliance with relevant Indian Standard provisions, such as IS 875 and IS 1893:2016, is necessary to ensure structural safety, serviceability, and long-term durability.

In recent years, advancements in structural engineering have led to the widespread adoption of sophisticated software tools for accurate and efficient analysis and design. Programs such as ETABS enable detailed

modeling and analysis of structures under various load combinations, while RCDC facilitates the design and detailing of reinforced concrete components in accordance with IS 456:2000 using the Limit State Method. The present study focuses on the structural analysis and design of a G+9 reinforced cement concrete (RCC) building through an integrated software-based approach. The objective is to assess the structural response under different loading scenarios and to develop a design that is safe, economical, and compliant with codal requirements, thereby demonstrating the effectiveness of modern computational tools in contemporary structural engineering practice.

II. IDENTIFY, RESEARCH AND COLLECT IDEA

Previous investigations have highlighted the efficiency of ETABS in the structural analysis of multi-storey buildings under the influence of seismic and wind forces.

The paper “*Analysis and Design of High-Rise Building Using ETABS Software*” by Wakale Yogesh Namdev et al. (2022) investigates a G+26 structure using ETABS, emphasizing seismic behavior through parameters such as storey displacement, shear force, and bending moment. It also applies CSI SAFE for foundation work and DETAIL CSI for detailing. The study highlights the usefulness of software in high-rise design but notes dependence on assumptions and excludes advanced analysis, cost, and construction aspects.

The study “*Analysis and Design of Multi-Story Building Using STAAD Pro*” by T. Dinesh Kumar et al. focuses on the analysis and design of a G+10 residential structure using STAAD.Pro. The building is evaluated under gravity loads (dead and live loads) as well as lateral loads such as wind forces, in accordance with Indian Standard design provisions using the Limit State Method. The software employs finite element-based dynamic analysis to model the three-dimensional structural framework and assess its response. A residential building of approximately 30 m height and 9030 sqft area is analyzed to understand its behavior under the applied loading conditions, demonstrating the effectiveness of software-based structural analysis for multi-storey buildings.

The study “3D Modelling of a Stilt + 4 Storey Residential Building Using Revit Architecture Software” by Mohammed Moiz et al. presents the development of a residential building model using AutoCAD for initial planning and Revit Architecture for 3D modeling. The work emphasizes improved coordination, visualization, and accuracy through BIM-based design, while incorporating functional planning, natural lighting, ventilation, and provision of a stilt floor for parking.

The study “Analysis and Design of Multi-Storey Building Using ETABS” by Nirmal S. et al. examines the application of ETABS in the analysis and design of multi-storey structures. The authors emphasize its capability for accurate three-dimensional modeling, efficient handling of repetitive storey elements, and integration with CAD drawings for improved precision and reduced modeling time. The software is also shown to effectively analyze structures under various loading conditions and generate detailed reinforcement design outputs for RCC components. Additionally, ETABS supports multiple structural systems, including reinforced concrete, steel, and composite sections, making it suitable for high-rise buildings. The study concludes that the use of ETABS enhances design accuracy, minimizes manual effort, and improves the overall reliability of structural analysis.

The study “Multi-Storey RCC Building Analysis and Design Using ETABS” by Nagaratna et al. presents the structural analysis of beams and columns using ETABS, while slabs and footings are designed based on IS 456:2000 using the Limit State Method. The research adopts standard material specifications, including M25 grade concrete and Fe415 steel, and focuses on accurate load analysis and modeling of a multi-storey structure. It highlights that the use of integrated software improves coordination between analysis and design, reduces computational time, and minimizes manual errors, making it highly effective for high-rise residential building projects.

III. BACKGROUND STUDY

Rapid urbanization and constrained land availability have driven the construction of high-rise buildings in modern cities. These structures must withstand a combination of gravity, wind, and seismic loads, making their design inherently complex, while conventional manual approaches are often time-consuming and prone to inaccuracies in multi-storey applications.

Advancements in computational engineering have led to the widespread use of tools such as ETABS and RCDC,

which enable detailed modeling, analysis, and design of structures under varied loading conditions and code provisions.

The adoption of integrated software systems improves efficiency, reduces human error, and ensures compliance with design standards, thereby playing a crucial role in achieving safe and economical high-rise reinforced concrete structures.

III. METHODOLOGY

The methodology adopted in this study involves the analysis and design of a G+9 reinforced concrete residential building through an integrated, software-driven approach. The procedure includes architectural planning, structural modeling, evaluation of loading conditions, and the design of key structural components in accordance with applicable Indian Standard provisions.

A. Architectural Planning

The architectural layout of the building was prepared using AutoCAD, with the typical floor plan comprising residential units arranged around a centrally located circulation core for efficient movement. The design emphasizes optimal space utilization, adequate ventilation, and effective functional zoning of areas such as living rooms, bedrooms, kitchens, and balconies. The column grid and overall structural configuration were established in accordance with the architectural requirements to ensure compatibility between planning and structural design.

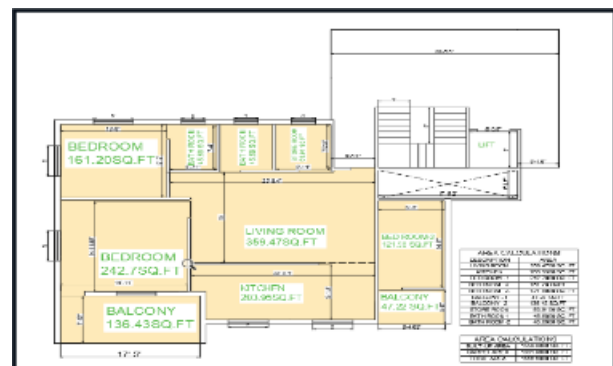


Figure 1 : TYPICAL COMMON FLOOR PLAN OF RESIDENTIAL FLAT

B. Structural Modeling and Analysis

The structural model was developed using ETABS by defining the building geometry, material characteristics, and boundary conditions. Concrete of grade M30 and reinforcement steel of grade Fe500 were adopted in

accordance with IS 456:2000. The structure was evaluated under multiple loading scenarios, including dead, live, wind, and seismic loads, as specified in IS 875 and IS 1893:2016. Linear static analysis was carried out for gravity loads, while seismic effects were assessed using dynamic analysis based on the response spectrum method. Appropriate load combinations were considered as per codal provisions to determine critical structural responses such as bending moments, shear forces, axial forces, and lateral displacements.

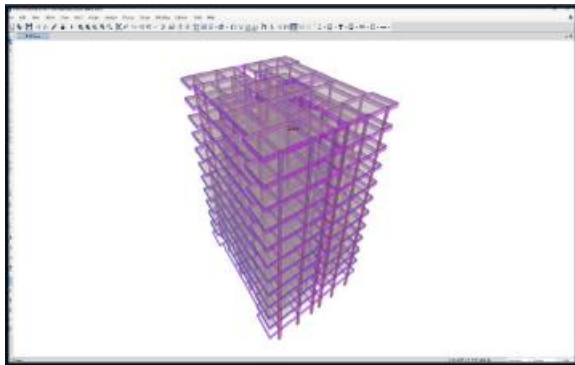


Figure 2: ETABS 3D representation used for the analysis of a multi-storey building structure

C. Load Calculation and Assignment

All structural loads were calculated and assigned as per IS 875 and IS 1893:2016. Dead and live loads were considered based on structural weight and occupancy, while wind and seismic loads were defined using relevant parameters. These loads were applied in both principal directions to ensure realistic structural behavior.

1. Dead Load (IS 875 – Part 1).

Dead load comprises the self-weight of structural components along with other permanent materials acting on the structure. In ETABS, the self-weight is automatically calculated based on the assigned material properties and densities.

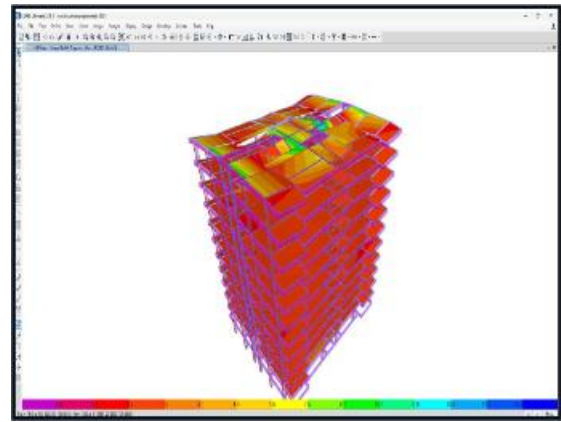


Figure 3: ETABS analysis showing stress distribution under dead load for the G+9 RCC building model

Self-weight of RCC members	(auto-calculated by ETABS)
Concrete density:	25 kN/m ³
Floor Finish :	1.5 kN/m ²
Wall Load (230 mm thick brick wall):	13.8 kN/m
Parapet Wall	2.3 kN/m

2. Live Load (IS 875 – Part 2)

In the proposed high-rise structure, load values were assigned to different functional areas in accordance with IS 875 (Part 2):1987, based on the intended usage of each floor and space.

Floor Finish (tiles + screed): 1.5 kN/m²

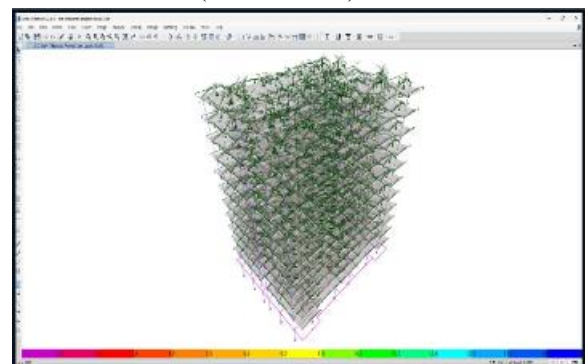


Figure 4 : Live Load Distribution of G+9 RCC Building Model in ETABS

3. Wind Load (IS 875 – Part 3)

Wind loads were determined as per IS 875 (Part 3):1987. For the building situated in Maharashtra, wind actions were applied in both principal directions (X and Y) using ETABS.

Parameter	Value
Basic wind speed (Vb)	39m/sec
Terrain Category	3
Risk Coefficient (k1)	1
Topography Factor (k3)	1
Design Wind Pressure (Vz)	0.39

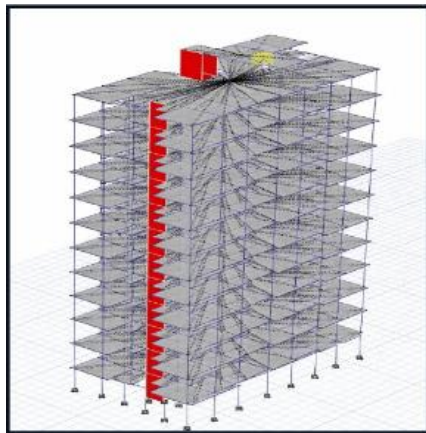


Figure 5: Structural analysis model developed for a 10-storey RCC building

4. Seismic Load (IS 1893:2016 – Part 1)

The structural model in ETABS was subjected to earthquake loading using the Response Spectrum Method as per IS 1893:2016 guidelines.

Parameter	Value
Seismic Zone	3rd
Zone Factor (Z)	0.16
Importance Factor (I)	1.0
Response Reduction Factor (R)	5.0
Soil Type	Medium Soil (Type II)

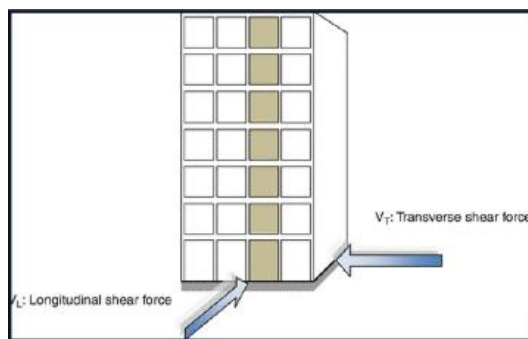


Figure 6: Distribution of longitudinal and transverse shear forces under lateral loading in a multi-storey structure

D. Load Combinations

1. Load Combinations for Strength Design (IS 456:2000, Clause 6.3.2)

Combination	Expression
Dead Load + Live Load	1.5 DL + 1.5 IL (for overturning/stress reversal: 0.9 DL + 1.5 IL)
Dead Load + Wind Load	1.5 DL + 1.5 WL
Dead Load + Live Load + Wind Load	1.2 DL + 1.2 IL + 1.2 WL

2. Implementation in ETABS

Each load combination was created separately in ETABS, and Dead, Live, Wind, and Seismic loads were applied as per the required combination factors. The software then analyzed the structure to obtain internal forces, bending moments, shear forces, axial forces, and displacements for each case. These results were finally used to design structural members, ensuring both strength and serviceability requirements were met.

E. Structural Analysis Execution

Structural analysis of the high-rise building was conducted using ETABS software by developing a detailed 3D model of the structure. The model was evaluated under various loading conditions to determine internal force distribution, stress response, and stability under lateral actions. A three-dimensional stiffness-based analytical approach was adopted, considering the combined effects of both gravity and lateral loads acting on the structure.

F. Result & Discussion

Key observations from the structural analysis indicate that beams were evaluated for maximum bending moments and shear forces, and their dimensions along with reinforcement were finalized to safely resist applied loads while ensuring serviceability. Columns were designed considering strength requirements, slenderness effects, and buckling behavior, with detailed assessment of axial forces and bending moments for each member. For slabs, deflection under gravity and live loads was checked as per IS 456:2000 limits, and slab thickness along with reinforcement was optimized for both strength and serviceability. Overall structural stability was verified through examination of base reactions and support forces to ensure proper load transfer to

the foundation, confirming adequate stiffness and lateral stability under all load combinations.

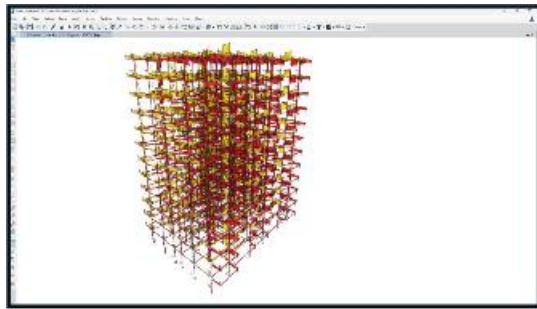


Figure 7: Shear force distribution diagram

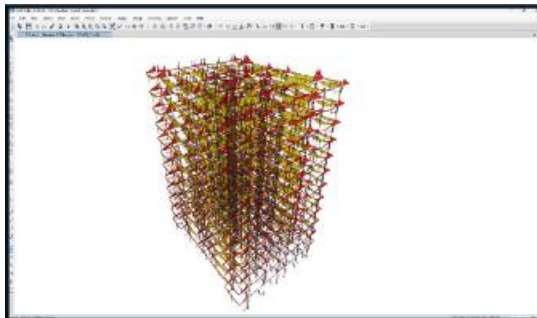


Figure 8: Bending moment distribution

G. Design of Reinforced Concrete Using RCDC

RCDC software was used to finalize the structural design of the high-rise structure, following the guidelines of IS 456:2000 and IS 1893:2016. The design was developed using internal force values derived from ETABS analysis.

Parameter	Specifications / Notes
Material Properties	Use of M30 concrete and Fe415 grade reinforcement
Column & Beam Sections	Initial dimensions based on ETABS structural model
Slab Thickness	130 mm (standard), optimized in RCDC for design criteria
Loads	Dead, Live, Wind, and Seismic loading from ETABS analysis
Support Conditions	Fixed support at foundation as per structural drawing
Design Codes	As per IS 456:2000 and IS 1893:2016

Member Design Procedure :

Columns :

RCDC develops reinforcement detailing such as main bars and ties based on the combined action of axial forces and bending moments.

Beams :

It ensures adequate resistance to bending and shear forces, providing reinforcement details such as primary reinforcement, distribution reinforcement, and stirrups.

Slabs :

Bending action in two directions is accounted for, with reinforcement provided within the specified limits of IS 456:2000.

Footing :

The footing is designed to resist combined axial loads transferred from columns along with bending moments induced by soil pressure. RCDC generates reinforcement detailing, including main bars, distribution bars, and stirrups or link bars. The design follows IS 456:2000 and IS 1904:1986 provisions, ensuring adequate soil bearing capacity, sufficient resistance to shear and bending, and proper anchorage of column reinforcement.

RCDC software was used to automatically produce detailed design outputs for all structural members of the high-rise building using results obtained from ETABS analysis. These outputs, including member dimensions, reinforcement details, and bar schedules, were carefully examined to ensure compliance with IS 456:2000 and IS 1893:2016.

IV.CONCLUSION

The study on “*Design and Structural Analysis of High-Rise Building*” focused on a G+9 RCC residential structure situated in Seismic Zone II, designed as a Moment Resisting Frame. ETABS was used for structural analysis, and RCDC was utilized for foundation design, adhering to IS 456:2000 and applicable Indian Standards. The design employed M20 concrete and Fe415 reinforcement, following the Limit State design approach. Structural elements such as slabs, beams, columns, and isolated footings were evaluated under major load combinations including dead load, live load, and seismic forces. The results confirmed that all critical parameters such as bending moments, shear forces, axial forces, and lateral displacements remained within allowable limits, ensuring both safety and serviceability. The footing design met the soil bearing capacity requirements, ensuring

foundation stability. This project helped in gaining practical knowledge of structural behavior, software-based analysis, and design principles essential for high-rise buildings.

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