International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 04 | April - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

Structural Analysis and Design of a Multi-Storey Residential Building as per IS Codes Using ETABS

Paramata Haritha[1], Sarella Chakravarthi[2]
[11]PG Student, Civil Engineering Department
[2.]AssociateProfessor,Civil Engineering Department
Srinivasa Institute of Engineering and Technology, Cheyyuru (V), Amalapuram, India

---***---

Abstract - The structural analysis and design of multi-storey residential buildings require rigorous evaluation to ensure safety, serviceability, and compliance with codal provisions, particularly in seismic-prone regions. This study presents the comprehensive analysis and design of a G+4 reinforced concrete residential building using ETABS software, in accordance with Indian Standard codes IS 456:2000, IS 875 (Part 1 & Part 2):1987, and IS 1893 (Part 1):2016. The structure is modeled as a three-dimensional space frame, and gravity loads including dead load and live load are considered as per IS 875, while seismic forces are evaluated using the equivalent static method prescribed in IS 1893.

Design of structural elements including slabs, beams, and columns is carried out as per limit state method in IS 456, ensuring strength, ductility, and serviceability requirements are satisfied. Load combinations are generated in compliance with codal recommendations, and structural performance under seismic loading is assessed through drift and stability checks. The results indicate that the building exhibits acceptable seismic behavior with storey drifts within permissible limits, confirming the adequacy of the structural system. This study highlights the effectiveness of ETABS as a robust tool for the seismic analysis and design of reinforced concrete multi-storey buildings, facilitating accurate modeling, efficient design, and compliance with Indian seismic design standards

Key Words: *ETABS, Different loads, Indian Stands Codes. Structural members.*

1.INTRODUCTION

These days, multi-story buildings are necessary in urban areas because of the fast population growth and high land prices. In densely populated areas, multi-story residential buildings offer an efficient way to accommodate people. These buildings are made to maximize floor area in a constrained amount of built-up space and are several stories above ground.

The planning and design necessary to create a building that is both safe and effective are included in structural analysis. Based on its unique design parameters, including applied loads, soil characteristics, dynamic forces, and available built-up area, every project is unique. The theoretical design details of a residential apartment building are presented in this study. In order to ascertain factors like moisture content, bearing capacity, and soil type, the necessary soil investigations were first conducted.

To avoid shear and bending failures, appropriate design parameters for beams, slabs, columns, and footings were supplied based on the computed loads. A G+4 residential building was designed using the Limit State Method in accordance with IS 456:2000, guaranteeing sufficient strength and stability under maximum design loads, including flexure, compression, shear, and torsion.

The swift urbanization, population expansion, and escalating land costs in metropolitan areas have rendered the construction of multi-storied residential buildings a pragmatic and essential solution. These structures effectively optimize constrained land by ascending vertically instead of spreading horizontally, thus housing a greater population within a reduced footprint. A multi-storied edifice comprises multiple levels erected above ground, engineered to optimize spatial efficiency, structural integrity, and economic viability.

This project involves the theoretical design of a G+4 residential apartment building that takes into account all pertinent structural parameters. Initially, research was done on the soil to identify key characteristics like:

- Content of moisture
- SBC, or safe bearing capacity
- Soil type and classification
- Features of density and compaction

The safe design of foundations depends on these soil parameters. Appropriate footing types and dimensions were chosen to guarantee safety against settlement and shear failure based on the soil bearing capacity and

applied structural loads. The following calculations were used to design the
structural elements, including slabs, beams, columns, and footings:

• Dead load, or the self-weight of finishes and structural components
• Live load (standard occupancy load)
• Combinations of floor loads
• Mechanism of load transfer from slab to beam to column to footing to soil

1.3 Major Software Used in building Projects

1.3.1 Drafting and Planning Software

AutoCAD: Used for 2D drafting and basic 3D modeling.
Preparation of floor plans, elevations, sections, and working drawings.

Autodesk Revit: Used for Building Information Modeling (BIM). Helps in architectural, structural, and MEP design in an integrated model.

Sketch Up: Used for 3D visualization and conceptual design., Easy modeling for residential buildings.

1.3.2 Structural Analysis and Design Software

STAAD.Pro: Used for structural analysis and design of buildings. Checks bending moment, shear force, axial force, and deflection.

ETABS: Mainly used for multi-storied building analysis. Suitable for RCC and steel structures. SAP2000**.** Used for advanced structural analysis. Suitable for complex structures

1.3.3 Estimation and Project Management Software

Microsoft Project: Used for planning and scheduling construction activities. Helps in tracking progress and resource allocation.

Primavera P6: Used for large-scale project planning and control.

MS Excel: Used for quantity takeoff, cost estimation, and mix design calculations

2.1 LITERATURE REVIEW

1. Analysis And Design Of G+2 Residential Building By Using E-tabs Author: N.Lingeshwaran, Year: 2017

Summary: This work looks into how a home structure behaves when designed with ETABS, following the Limit State approach. Strength, usability, long-term performance, and cost stay balanced through careful planning. Movement, internal forces, and resistance to bending get checked at each level. When beams could not handle stress, adjustments came through resizing both beams and columns. Reinforcement details then followed those updated dimensions closely.

2. Design and Analysis of a Residential building using ETABS integrated with concept Author:Ujjwal Bhardwaj, Year: 2018

Summary : Here comes the breakdown of how a tall reinforced concrete home gets shaped with help from ETABS, while keeping eco-friendly ideas in mind. Shaking from quakes shapes part of the testing, handled through an advanced 3D method built into the tool. Different ways of checking stress show up - some steady, others shifting, a few bending rules with curves instead of straight lines. Beams and posts turn into thin lines on screen, yet floors, barriers, slopes, and steps appearas full surfaces. Precision grows when each piece acts like it would in real life, fitting together just right inside the model. Out of ETABS came numbers checked by hand using rules from IS456:2000. Before ground was broken, ideas borrowed from nature shaped how the structure took form - cutting emissions while favoring earth-friendly methods.

3. Design and Analysis of Residential Multistory Building (G+3) by using ETABS Author: Mr. Kundan Kulbhushan., Year: 2019

Summary: Looking at how a three-story home stands up, this work uses ETABS to check its frame. Weight from materials sets one kind of stress, people and furniture add another. Wind pushes side ways, while quakes bring sudden shaking forces into play. Forces traveling down columns show up clearly when viewed through axial measurements. Shear reveals where sections might slide past each other under pressure. Bending tells us how beams twist under uneven weight. Visual maps display how gravity spreads across floors. Another drawing tracks force paths along vertical supports. Side pressures appear in separate diagrams showing sway risks. Even rebar patterns are drawn out - showing steel layout lengthwise. Each image helps see how parts resist real-world demands.

4. Design and Analysis of Residential Building by using ETABS Author: Dr. Valsson Varghese
Year: 2021

Summary: Looking at how tall concrete buildings stand up under stress, this report checks shapes like boxes, Cs, Ls, and straight lines. Fifteen floors high, the structure got built inside a computerusing ETABS. Instead of numbers alone, it uses visuals tied tightly to calculations, all stored together neatly. Though different tools exist,

5. Analysis, Design and Estimation of G+4 Residential Building Author: Prof. Aradhana Chavan, Year: 2021

Summary: Looking into a Four- level home structure, where cars park downstairs and two bedroom units sit above. Held up by reinforced concrete, its behavior gets checked when weighed down by everyday use, its own weight, plus shaking during quakes. Rules followed include Indian standards from 1987 for loads, along with an updated seismic guide from 2016. After running calculations inside ETABS, the digital tool handed out exact steel layouts for uprights and horizontal supports alike. Each beam, each column - shaped by data pulled straight from simulation once modeling wrapped up.

2.3 Objectives of the Work

1. To carry out the structural analysis and design of the building to ensure safety, stability, and serviceability without structural failure.
2. To understand and apply the fundamental principles of structural engineering in accordance with relevant Indian Standard (IS) Codes.
3. To study and evaluate the design parameters of structural components such as beams, columns, slabs, and other load-bearing elements.
4. To develop a detailed three-dimensional (3D) structural model using ETABS for Comprehensive analysis and efficient design optimization.

2.4 Scope of the Work

This research looks at how a tall reinforced concrete structure behaves when studied through ETABS software. Modeling work comes first, followed by checking how forces move through key parts like floors, supports, vertical members, and base elements. Each piece gets reviewed using rules laid down in Indian Standard guidelines. Tools inside the program help shape decisions about size, layout, strength during the process. Despite varying conditions, each structure faces multiple pressures - dead weight first, then shifting human activity added in, followed by wind pushes alongside earthquake shakes according to Indian standards. Bending stress shows up when numbers stay fixed during slow simulations, revealing how beams react along with cuts across sections and pulls through columns while floors shift slightly and gaps grow between levels. Strength checks come next under a system that balances safety against practical use, keeping shapes stable without wasting material even as rules demand careful limits.

2.5 Problem Statement

Faster city growth pushes taller homes and offices into the sky. When loads are guessed wrong, walls crack or floors sag too much. Because of this, smart tools must step in to map how structures respond when pressed by weight, wind, or time. Bad math up front invites trouble later sometimes serious harm. Clear sight into stress points helps avoid disaster before concrete hardens. Starting off simply, hand math using IS Codes teaches basics well. Yet when buildings grow taller, doing it by hand gets messy fast. Tools like ETABS handle big jobs much quicker. Still, knowing how to set up models right matters a lot. Picking correct loads plays a key role too. Reading outputs the right way keeps designs safe. Without clear grasp of these steps, mistakes can slip through.

3.1 METHODOLOGY

3.2 Flow Chart of Methodology

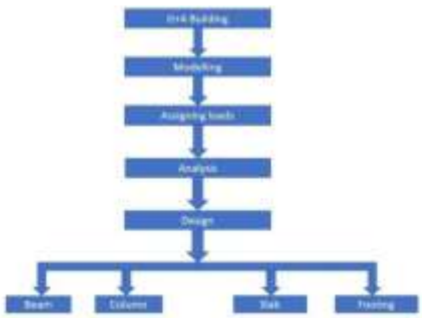
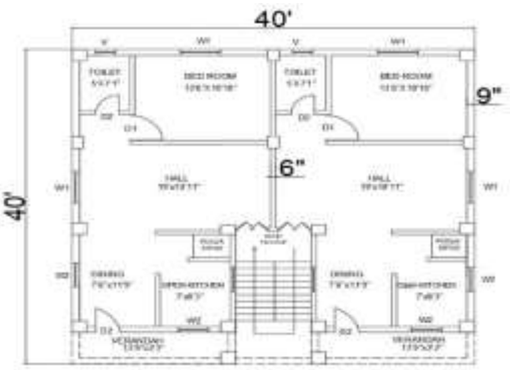


Image No : 3.2 Flow Chart of Methodology

3.3 Software used in this Work

The following softwares are used for the design of G+4 Residential building in this project.

1.AUTOCAD Software.
2.ETABS Software.
3.STAAD Foundation.



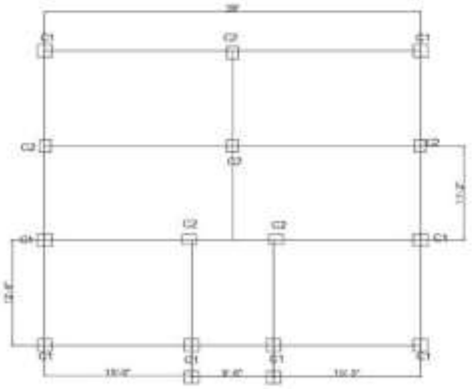
3.4.4 Information of the Building

Number of stories = 5
Storey height = 3m
Number of bays along X-direction = 5
Number of bays along Y-direction = 5
Size of square column = 450 x 450mm

Size of Rectangular column = 350 x 450mm

The material is used for construction is reinforced concrete with M-30 grade concrete and Fe-500 grade of steel.

3.4.5 Column Configuration of the Building



4.1 MODELING OF RESIDENTIAL BUILDING

4.3 Dimensions of the Residential Building

Master Bedroom = 13’6” x 10’10”

Bedroom = 7’0” x 8’3”

Kitchen = 4.5m x 4.5m

Hall = 19’0” x 10’11”

Toilet =5’0” x 7’1”

Pooja = 3’5” x 3’0”

All Dimensions are in Feets and inches plan is same for all Storeys

Door (D1) = 1.2m x 2.1m

Door (D2) = 0.9m x 2.1m

Window (W1) = 2.1 m x 1.2 m

Window (W2) = 1.9 m x 1.2 m

4.5.9 Design of Structural Members

Start at design-concrete, move into frame design, begin the check process, open view – all members show completed status.

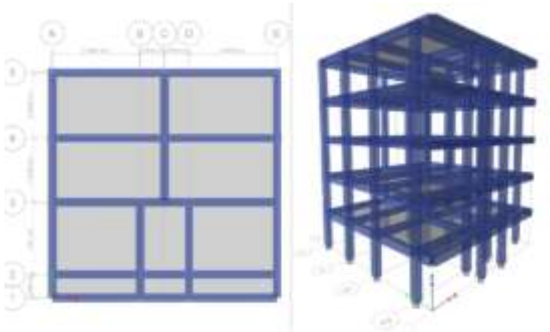
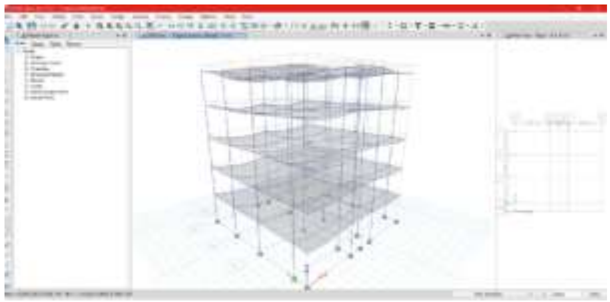


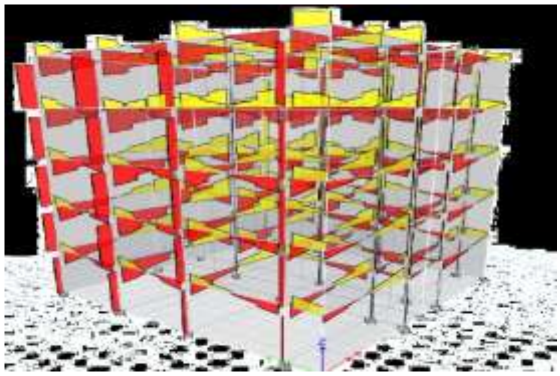
Image No : 4.5 Modeling of G+4 Residential building

4.6.1.4 Applications of Loads Over the Buildings

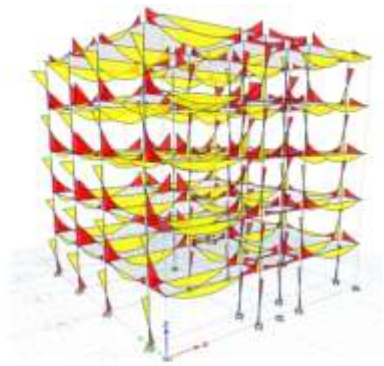
4.7 Analysis of G+4 Residential Building



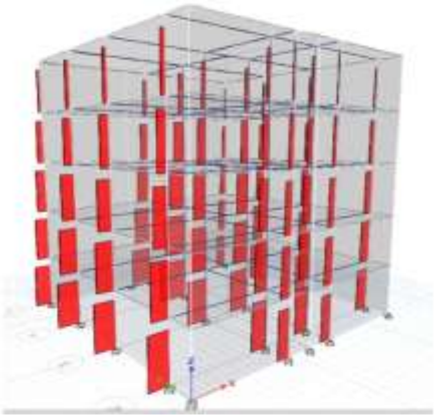
4.8 Shear force



4.9 Bending Moment

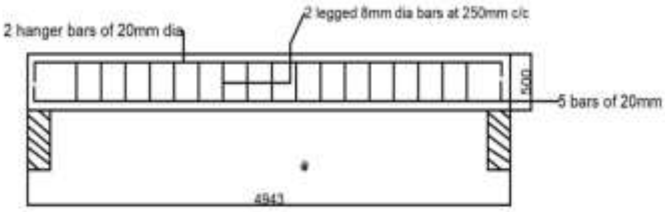


4.10 Axial Force



4.8 Design of Concrete Elements

4.8.1 Design of Beams



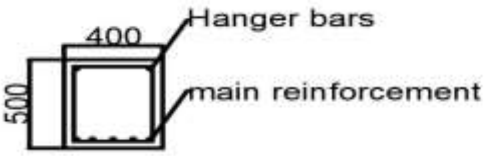


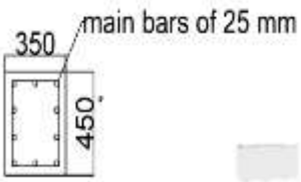
Table No: 4.8.1Detailing of Beam

Detailing of Beam Design		
S.No	Parameter	Range Value
01	Width of beam	400 mm
02	Depth of beam	500 mm
03	Area of Steel Required	1570.99 mm^2
04	Top Reinforcement	5 Bars of 20 mm Diameter
05	Bottom Reinforcement	2 Bars of 20 mm Diameter
06	Stirrupus	8 mm Dia bar @ 250 mm C/C
07	Concrete	1.0 m^3

4.8.2 Design of Columns

4.8.2.1 Rectangular column Design

4.8.2.2 Square column Design



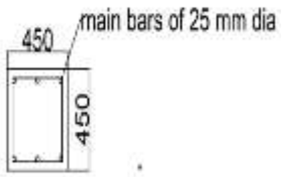


Table No: 4.8.2.1 Detailing of Rectangular Column Design

Detailing of Rectangular Column Design		
S.No	Parameter	Range Value
01	Width of beam	350 mm
02	Depth of beam	450 mm
03	Area of Steel Required	4623.09 mm^2
04	Number of Bars	10
05	Dia of Bars	25 mm
06	Leteral ties	8 mm Dia bar @ 300 mm C/C
07	Concrete	0.4725 m^3

Table No: 4.8.2.2 Detailing of Square Column Design

Detailing of Square Column Design		
S.No	Parameter	Range Value
01	Width of beam	450 mm
02	Depth of beam	450 mm
03	Area of Steel Required	2069.06 mm^2
04	Number of Bars	06
05	Dia of Bars	20 mm
06	Leteral ties	8 mm Dia bar @ 300 mm C/C
07	Concrete	0.4725 m^3

4.8.3 Design of Slabs

Table No: 4.8.3 Detailing of Slab Element

Detailing of Slab Element		
S.No	Parameter	Range Value
01	Length of Spans	Lx = 3.45m & Ly= 4.94
02	Depth of Slab	150 mm
03	Area of Steel in Lx	180.28 mm^2
04	Area of Steel in Ly	210. 37 mm^2
05	Spaceing of Bars	10 mm Dia bar @ 300 mm C/C in Both Directions
06	Torsional Steel Distance	690 mm
07	Spaceing of Bars	10 mm Dia bar @ 200 mm C/C in Both Directions

4.8.4 Design of Footings

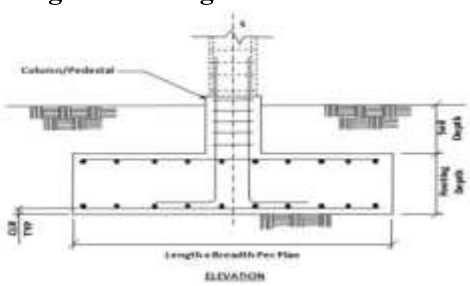


Table No: 4.8.4 Detailing of Footings

Detailing of Footings		
S.No	Parameter	Range Value
01	Column Size	450 x 450 mm
02	Sizen of Fooing	5.45 x 5.45 m
03	Depth of Footing	0.711 m
04	Area of Steel top Mx	9491.38 mm^2
05	Area of Steel top Mz	9126.38 mm^2
06	Torsional Steel Distance	690 mm
07	Spaceing of Bars	12 mm Dia bar @ 65 mm C/C in Both Directions
08		08 mm Dia bar @ 50 mm C/C in Both Directions
09		

5.1 CONCLUSION FUTURE SCOPE

1. A three-dimensional model of the building was developed, and various loads such as dead load, live load, and wind load were defined and assigned as per code provisions. Appropriate load combinations were considered following the Limit State Method as per IS 456 and IS 875.
2. The analysis results, including storey displacement, storey drift, base shear, bending moments, shear forces, and axial forces, were carefully evaluated. The maximum displacement was observed at the top storey, which is typical for multi-storey buildings under lateral load
3. The design of beams, columns, and slabs was carried out based on the critical load combinations, and the required reinforcement was determined accordingly. The results confirm that the structural members are safe against bending, shear, and axial forces.
4. which is typical for multi-storey buildings under lateral loads. However, all displacement and drift values were found to be within permissible limits, indicating adequate lateral stability and stiffness of the structure.

5.2 Future Scope

1. The present study focuses on the analysis and design of a G+4 residential building using ETABS under dead load, live load, and wind load conditions. Although the structure satisfies safety and serviceability requirements as per relevant IS codes, there are several areas where further research and development can be carried out.
2. In future studies, seismic analysis can be incorporated in detail using response spectrum or time history methods as per IS 1893 to evaluate the performance of the building in earthquake-prone zones. Performance-based design approaches may also be adopted to study structural behavior beyond elastic limits
3. The project can be extended by comparing different structural configurations such as the inclusion of shear walls, bracings, or different column orientations to improve lateral stability. Optimization techniques can be applied to reduce material consumption and achieve a more economical design.
4. Further scope also includes foundation analysis using advanced geotechnical considerations, soil-structure interaction studies, and the use of other structural software for comparative analysis. The incorporation of sustainable construction materials and green building concepts can also be explored to enhance environmental performance.
5. Thus, the project provides a foundation for advanced structural studies and can be expanded to include dynamic analysis, cost optimization, and performance evaluation under extreme loading conditions.

REFERENCES

[1] Abhay Guleria (2014) “Structural Analysis of a Multi-Storey Building Using ETABS for different Plan Configurations”, International Journal of Engineering Research Technology (IJERT) Vol. 3 Issue 5, ISSN: 2278-0181

[2] Chandrashekar and Rajashekar (2015), “Analysis and Design of Multi Storied Building by Using ETABS Software”, International journals of scientific and research vol.4: issue.7: ISSN no. 2277-8179.

[3] Balaji and Selvarasan (2016), “Design and Analysis of multi-storeyed building under static and dynamic loading conditions using ETABS”, International Journal of Technical Research and Applications e-ISSN: 2320-8163, www.ijtra.com Volume 4, Issue 4, PP. 1-5

[4] Abhay Guleria, Structural Analysis of a Multi-Storeyed Building using ETABS for different Plan Configurations, May 2014.

[5] Structural Design of concrete structure using E-Tabs, Shivam Asawa, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) Volume 14, Issue 1 ver. 4 (Jan – Feb 2017), PP 49-51

[6] IS 456 Plain and Reinforced Concrete – Code of Practice, Bureau of Indian Standards, New Delhi, 2000.

[7] IS 875 (Part 1–5) Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, BIS.

[8] IS 1893 (Part 1) Criteria for Earthquake Resistant Design of Structures, BIS.

[9] IS 13920Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces, BIS, 2016.

[10] IS 800 General Construction in Steel – Code of Practice, BIS, 2007.

[11] IS 10262Concrete Mix Proportioning – Guidelines, BIS. Charts

BIOGRAPHIES

Paramata Harithawas born in Nangavaram, India, in 2002 . He received the Bachelor's degree in Civil engineering from the of University Jawaharlal Nehru Technological University, Kakinada, in 2024 . She is currently pursuing the Master degree in Structural Engineering from the University of Jawaharlal Nehru Technological University, Kakinada. Her research interests include new concrete technology, structural engineering, and more