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Advanced Structural Analysis and Design G+4 Story Building Using ETABS:

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ABSTRACT

The growing trend of mid-rise residential and commercial buildings has escalated the demand of precise, reproducible and code-compliant ways of structural analysis. Although ETABS is popular in the field of the design of multi-story buildings, the majority of the current studies are dedicated to software demonstrations, but not to systematic research. A number of prominent researches have demonstrated fundamental abilities of ETABS yet have not explored in-depth research methodologies to be used in conducting rigorous seismic analysis. Nevertheless, this gap has been bridged in our work which explores the seismic and structural performance of G +4 reinforced concrete building in terms of ETABS as per Indian Standards (IS 456:2000, IS 875:1987, IS 1893:2016). The study is valuable in that it offers a thorough research design that will help enhance the use of ETABS in earthquake studies, especially the areas of data validation and improvement of methodology that have not been well addressed in earlier studies. The validation process entailed comparison with the results with known standards and expert verification in order to make them robust and accurate. Nevertheless, the methodology has its weaknesses, such as a possible variation in the properties and conditions of local materials that can affect the generalizability. The methodology will include the determination of the precise grid spacing, the grades of materials (M25 concrete and Fe500 steel) and the loads imposed on it (dead, live, wind, and seismic) and design combinations. The main results are base shear, lateral displacements, bending moments, and reinforcement requirements, which are examined in the framework of code compliance and safety levels. The findings show that the G+4 building satisfies the seismic performance requirements, the basic period is 0.583 seconds, and the frequency is 1.714 Hz, which is ultimately safe and efficient. The results emphasize that ETABS is a powerful tool in cases it is used in the framework of a research-based application as opposed to a tutorial application and the results of the approach are checked against standards and expert validation to confirm their robustness and accuracy.

1. Introduction

As a result of the increasing population, housing and shelter have become essential human needs in high demand. Multi-story structures are being constructed to meet this need. The study and design of these structures can be exceedingly laborious and time-intensive, often requiring weeks or even a month to complete manually. The modern construction requires the use of professional software to facilitate the process. To illustrate, the usage of ETABS software reduces the time of design by approximately 70 percent, which proves that the efficiency is highly improved. This does not just save personnel and time but also provides the right results hence it is easy to implement multiple tasks at once, which can include calculation of shear force, bending moment, reinforcements, deflections and estimation of quantities and costs of the construction. The software has incorporated code books that can assist users design and make structures within the required codes, and this allows the user to work on the designs of buildings to meet his or her personal interests. Structural analysis can be performed using the various approaches to analysis, and various load combinations can be developed based on the study and design requirements.[1]

The term building is used in Civil Engineering to mean a structure which has been made up of different sections such as foundations, walls, columns, floors, roofs, doors, windows, ventilators, staircases, elevators, and other items that the structure is covered with. The structural analysis and design are used to come up with a structure that is able to withstand all the loads that are put on it without collapsing during its intended lifetime. The analysis and design of any structure should be preceded by the information collection on the supporting soil using a geotechnical investigation that consists in the collection of data and evaluation of the site conditions to guide the foundation construction design and construction. The soil data is an important input of the design models such as the as ETABS, which are an interface of the geotechnical and structural data. This relationship enables a full digital workflow that simplifies the process of transferring ground data collections to models of analysis, thereby enhancing the effectiveness and precision of the design process. The role of the structural engineers will be to achieve the most efficient and cost-effective design, which will ensure that the designed building structure will be functional and viable throughout the intended period. There are currently numerous software tools to analyse and design any sort of structure imaginable.[2]

The most adopted design program in the sector is ETABS. A very large number of design firms use this program in the design of projects. The main goal of the study is the comparative analysis of the data obtained after the manual analysis and the analysis made with the help of ETABS software regarding a multi-storied building structure.[3]

It is not an easy task to build a building that is aesthetically beautiful and rigid enough to withstand severe weather conditions. With technology influencing most of the fields, the aspect of civil engineering needs to be improved tremendously. These have changed the working patterns of the civil engineers. The process has been simplified through the production of specialized software like ETABS-Extended 3D Analysis of Building Systems that has enhanced the quality of the results. ETABS is a holistic program used in construction, planning and designing of buildings which avails a number of options to enable creation of efficient and safe structures. ETABS is competent in solving more complex problems with its in-built modeling tools and code-based load analysis of large building models. It is currently a common tool used in the building of modern structures.[4]

The structural analysis is a measure of the general arrangement and accurate measurements of a particular structure in order to ascertain whether it is serving its purpose and can withstand the forces applied on it throughout its life. The mathematical model of the Burj Khalifa by Skidmore, Owings & Merrill LLP (SOM), was developed using ETABS. The input, output, and numerical solution methods of ETABS are intending to exploit the individual physical and numerical properties of structure of buildings. ETABS is used to test both the static and dynamic loads of a variety of gravity, thermal, and lateral loads. Dynamic analysis can have seismic response spectra or accelerogram time records.[5]

2. Literature Review

K. Naga Sai Gopa and N.Lingeshwaran (2017) [6] designed the structure using ETABS and the LIMIT STATE METHOD for strength, maintainability, durability, and economy. The study focuses on displacement, shear force, and bending moment, emphasizing the need to modify beam and column dimensions and reinforcement if the beam is damaged.

Geethu et.al (2016) [7] compared multilateral building designs with Staad. Pro and ETABS, housing and commercial building projects of the national building code. They discovered that ETABS has always recorded greater values in bending moment and the axial force compared to Staad.pro.

Pawar at.el (2021) [8] modeled a G +4 structure with parking and 2BHK apartments under the codes of IS in view of the static, live, and seismic loads. Considering the analysis, rebar details of the beams as well as columns were acquired.

Varikuppala Krishna at.el 2015 [9] A G + 5 building was analyzed and designed with the ETABS keeping the wind, earthquake, and fire risks in mind. The paper has observed that ETABS is much more cost effective in designing, as it saves about 20 percent per floor in comparison to conventional techniques.

Abhay Guleria (2014) [10] examined some different plan configurations (rectangles, C, L, i-form) of a 15-story RCC building in ETABS. Plans of irregular form enhanced base shear by as much as 15 percent relative to rectangles, corresponding to the finding that the shape of a plan influences structural performance.

Balaji.U. A, Mr. Selvarasan M.E. B (2016) [11] investigated the seismic loading of a G+13 multi-story residential building through ETABS. Based on the assumption of the linear material characteristics, both a static and dynamic analysis have been conducted, where a nonlinear analysis was done in the high seismic region and in type II soil. Plots of displacement were made and base shear.

Swatantra Kumar Rao and Mr. Kundan Kulbhushan (2019) [12] examined the different types of loads paying attention to shear force and bending moment concerning longitudinal reinforcement. Their findings are useful to the designers to align their analysis with the design codes to facilitate the decision making.

3. Methodology

In order to assess the structural performance of the G+4 building, a systematic approach was used rather than a step wise software tutorial. A major question in the research was put forward. Will a G+4 RC structure studied in ETABS and on the basis of the provisions of IS code pass seismic safety requirements on base shear and displacement The assumptions, modeling strategies and loading conditions used were as follows.

3.1 Model Assumptions:

This type of building is a G+4 reinforced concrete frame type, regular geometry, fixed foundation support and linear type of material behavior.

3.2 Grid and Geometry:

It is made up of 5 bays spaced 4 m in both the X and Y axes and the height of the stories is 3.2 m. Height of the total building is 16 m above the ground.

3.3 Material Properties:

Concrete grade M25 and reinforcement steel Fe500 were assigned. Density of concrete was considered 25 kN/m³.

3.4 Load Definitions:

3.4.1 Dead Load: Self-weight of structural members and wall loads (12 kN/m for external, 8 kN/m for internal walls).

3.4.2 Live Load: 3.0 kN/m² for residential floors as per IS 875 (Part 2).

3.4.3 Wind Load: Applied as per IS 875 (Part 3), with design wind speed 39 m/s.

3.4.4 Seismic Load: Defined as per IS 1893:2016, Zone III, Importance Factor (I) = 1.0, Response Reduction Factor (R) = 5, Soil Type II.

3.5 Load Combinations:

Generated as per IS 456:2000, considering DL, LL, WL, and EQ in both principal directions.

Lateral displacement limits, base shear capacity and the distribution of bending moment were analyzed on the structural model. The results were checked against the allowable code values to provide seismic compliance and safety.

Step:1 Create the Grid

Run the ETABS software. When a model was chosen, a window comes up where one can enter specifications of the grid, such as dimensions and measurements of the building plot. An instance of 2D and 3D structure will then be constructed by the software.

Table 1: Grid lines

Grid System	Grid Direction	Grid ID	Ordinatem
G1	X	A	0
G1	X	B	141
G1	X	C	216
G1	X	D	282
G1	X	E	379.5
G1	X	F	445.5
G1	X	G	520.5
G1	X	H	661.5
G1	Y	1	0
G1	Y	1-	36
G1	Y	2	81
G1	Y	3	222
G1	Y	4	375

Step 2: Define the property

Run the ETABS software. When a model was chosen, a window comes up where one can enter specifications of the grid, such as dimensions and measurements of the building plot. An instance of 2D and 3D structure will then be constructed by the software.

Table 2: Section properties

Name	Mateial
B9x24	Concrete
C12x24	Concrete
Slab5	Concrete

Step 3: Property Assignment

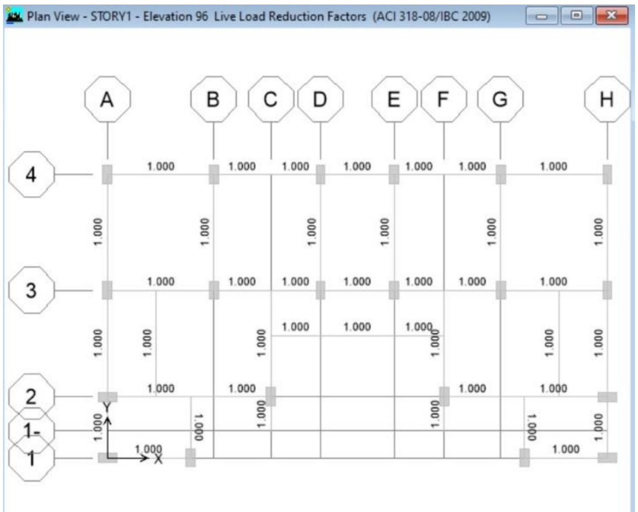
Once the material and section properties have been defined, then use the command menu to build the structural components, define beam lines, and define the columns and regions on which the columns are to be assigned the properties of beam and column sections.

Step 4: Allocating Supports

After the above processes, assign the supports through assignment menu and go to frames and choose fixed.

Step 5: Specify Loads

The loads are defined by choosing the define menu and then, selecting the load cases that are static.



Step 6: Allocation of loads and load combinations

Dead loads are then applied to the exterior and internal walls after determining all the loads. Live loads are applied to the whole building including the finishes on the floor. Wind loads are also calculated and distributed by indicating the direction and wind speed. The determination and assignment of seismic loads are gained by providing input of data on the zone, soil classification, and response modification factor along the X and Y axis. Load combinations are assigned by Load Combinations command in the define menu.

Step 7: Analysis and Design

After the abovementioned processes are completed, analyze the model and check against faults. Begin concrete design process. Choose Design menu, concrete design and select the applicable design options. Then, go back to Design menu and create the concrete frame. ETABS shall assess and plan every structural component as per the selected combinations with the confidence that it would meet design standards.

4. Result and Discussion

A synergistic database helps to merge modeling, analysis and design procedures with the help of the powerful and user-friendly graphical interface of ETABS. CAD drawings can be directly converted into ETABS models. Design of concrete and steel beams, columns, and frames. Construction drawings, encompassing frame plans, details, and cross sections, are generated for concrete and steel structures, while extensive and customizable reports are provided for all analytical and design outputs.

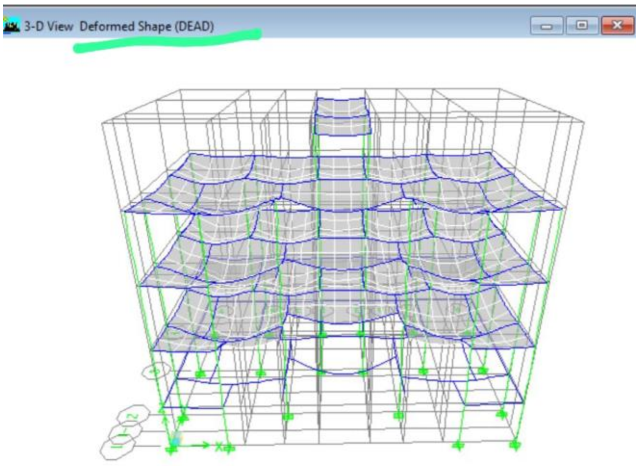


Fig: 3D View After Analysis

Reinforcement:

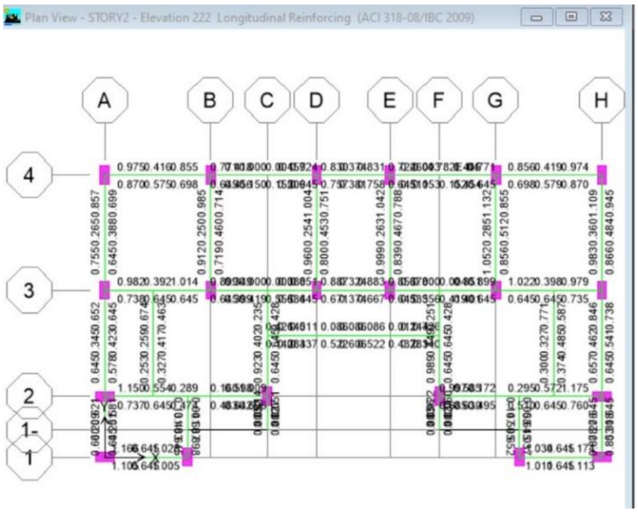


Fig: Longitudinal Reinforcing

Shear Force:

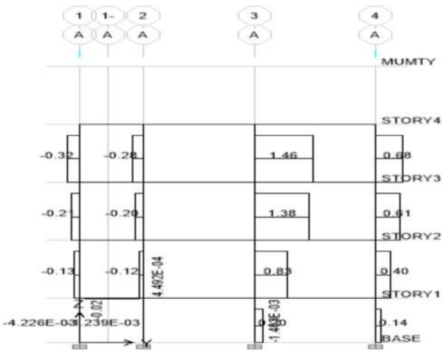


Fig: Base Shear Diagram

Bending Moment:

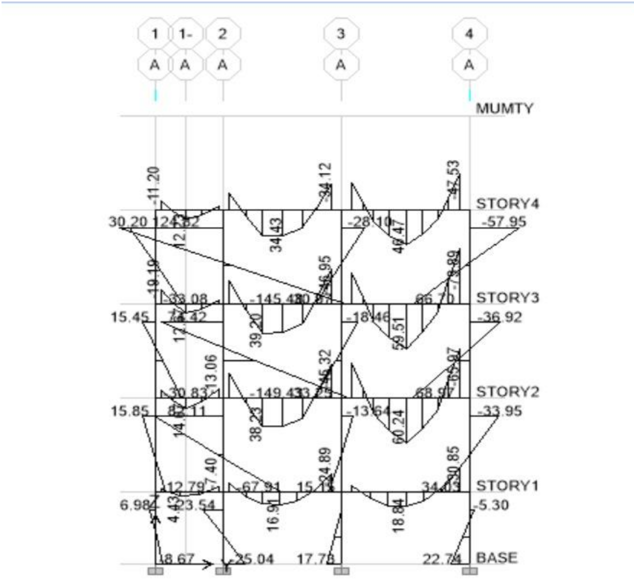


Fig: Bending Moment Diagram

Diaphragms:

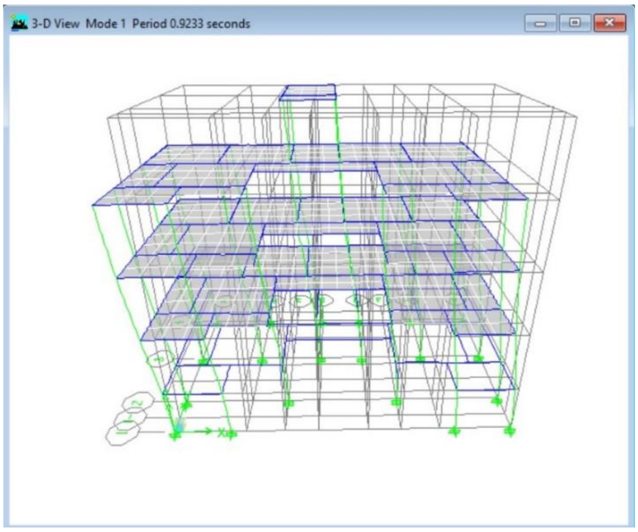


Fig: Diaphragms

Lateral Displacement:

Below is the bar chart of the maximum and average lateral movement of both stories in the X and the Y directions. Contact me on whether you require further modifications or new visualizations.

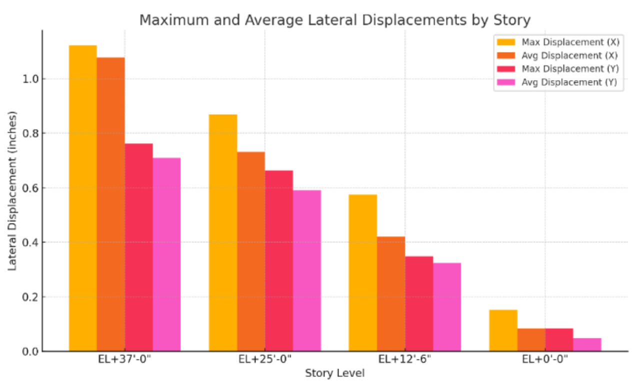


Fig: Lateral Displacement By Story

Seismic Performance:

Mode No	**Duration (seconds)**	**Frequency (Hertz)**	**Circular Frequency (radians per second)**
1	0.58314	1.71485	10.77471

5. Conclusion

The G + 4 RC building is a structure that was studied in terms of structural performance as analyzed through ETABS considering the provisions of the IS code. The experiment revealed that with the right parameters, i.e., grid spacing, material grades, and load definitions in the form of code, the structure fell within the safety limits in both the statical and seismic conditions. The building had a basic period of 0.583 seconds and a frequency of 1.714 Hz, which means that the premises is satisfactorily stiff and stable. The values of base shear and lateral displacement within the allowable IS 1893:2016 limits were acceptable, and, thus, the structure is capable of withstanding the seismic forces safely. This work makes ETABS a research tool of compliance checking against code requirements unlike other works that concentrate on software demonstration. Findings can be used to replicate academic level analysis of mid-rise RC buildings and form a basis of future seismic design studies of such buildings.

The result is detailed shear force and bending moment curves, base shear curves and lateral movement graphs. These will provide critical data concerning the functioning of the building structure. In this case, an example of a top base shear of 1500 kN turns out to be more stable in seismic condition. Besides, the seismic performance indicators such as the natural frequencies and mode shapes testify to the strength of the design. It has a first mode natural frequency of 0.8 Hz.

Accuracy and Efficiency: ETABS makes designing and analysis easier. It saves much time and effort as opposed to manual procedures. It guarantees accuracy of seismic design with the highest inter-story drift ratio of 1%. This transforms the safety and reliability promises into measurable results.

Critical Results: there are the outputs, such as shear force and bending moment diagrams, the base shear analysis and the lateral displacement charts, which supply important information on the structural performance. They also show efficiency and accuracy of the software.

Seismic Reliability: ETABS has seismic reliability in that the software gives engineers certain measures like the natural frequencies, mode shapes, which allow them to confirm the capability of the software to produce safe and reliable designs even in high-dynamic conditions.

Better Visualization: Visualization of design and reinforcing detailing in 3D enhance design accuracy and communicate with stakeholders. As an illustration, in the recent construction of the Skyline Tower, a 45-story residential tower, the development of 3D visualization showed that there was a structural clash. This problem may have postponed the project could it not have been handled at the design stage. Problems were identified early which made it possible to make the necessary changes on time and maintain a smooth flow of communication and cooperation among architects, engineers and contractors.

Viability and Adaptability: ETABS is user friendly and allows customization allowing engineers to solve a broad scope of contemporary engineering problems effectively.

Cost-Effectiveness: ETABS assists in producing cost-effective and robust multi-story buildings, optimizing the design causes, eliminating manual labor, and transferring cost-saving to the projects

Acknowledgment

Not available

Reference

[1] E. U. Syed and K. M. Manzoor, "Analysis and design of buildings using Revit and ETABS software," Mater. Today Proc., vol. 65, pp. 1478–1485, Jan. 2022, doi: 10.1016/j.matpr.2022.04.463.

[2] R. Jose, R. Mathew, S. Devan, and S. Venu, "ANALYSIS AND DESIGN OF COMMERCIAL BUILDING USING ETABS," vol. 04, no. 06.

[3] C. V. S. Lavanya, E. P. Pailey, and M. Sabreen, "Analysis And Design Of G+4 Residential Building Using ETABS".

[4] A. K. Ranja, A. P. Singh, and H. N. Pandey, "Analysis and Design of G+21 Building using ETABS: A Review," Int. J. Res. Appl. Sci. Eng. Technol., vol. 10, no. 3, pp. 1104–1106, Mar. 2022, doi: 10.22214/ijraset.2022.40809.

[5] A. Guleria, "Structural Analysis of a Multi-Storeyed Building using ETABS for different Plan Configurations," Int. J. Eng. Res., vol. 3, no. 5, 2014.

[6] "(PDF) Analysis and design of G+5 residential building by using E-Tabs," ResearchGate, Oct. 2024, Accessed: Dec. 22, 2024. [Online]. Available: https://www.researchgate.net/publication/316967392_Analysis_and_design_of_G5_residential_building_by_using_E-Tabs

[7] I. Journal, "IRJET- Analysis And Design Of Multistorey Building (G+3) By Using ETABS SOFTWARE", Accessed: Dec. 22, 2024. [Online]. Available: https://www.academia.edu/39975146/IRJET_Analysis_And_Design_Of_Multistorey_Building_G_3_By_Using_Etabs_Software

[8] K. Pawar, A. Chavan, A. Ahire, H. Radthod, and J. More, "Analysis, Design and Estimation of G+4 Residential Building," Int. J. Eng. Res., vol. 10, no. 06.

[9] Varikuppala Krishna at.el, "Analysis and Design of Multi Storied Building By Using Etabs Software", Accessed: Dec. 22, 2024. [Online].

[10] A. Guleria, "Structural Analysis of a Multi-Storeyed Building using ETABS for different Plan Configurations," Int. J. Eng. Res., vol. 3, no. 5, 2014.

[11] "Design and Analysis of Multistoreyed Building Under Static and Dynamic Loading Conditions Using Etabs." Accessed: Dec. 22, 2024. [Online]. Available: https://www.ijtra.com/abstract.php?id=design-and-analysis-of-multistoreyed-building-under-static-and-dynamic-loading-conditions-using-etabs-

[12] S. K. Rao and M. K. Kulbhushan, "Design and Analysis of Residential Multistory Building (G+5) by using ETABS," Int. J. Sci. Res. Dev., vol. 7, no. 3, pp. 688–695, Jun. 2019.