
EARTH QUAKE ANALYSIS OF MULTI STORIED RESIDENTIAL BUILDING BY USING ETABS SOFTWARE

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Abstract

The rapid growth of urbanization has increased the construction of multi-storied residential buildings in earthquake-prone regions. Earthquakes produce dynamic forces on structures, which may lead to severe structural damage if proper seismic design is not considered. This project focuses on the earthquake analysis of a multi-storied residential building using ETABS software. The building model is analyzed under seismic loading conditions according to standard design codes to evaluate its structural behavior. Parameters such as storey displacement, storey drift, base shear, and time period are studied to understand the response of the structure during earthquake conditions. The analysis helps in identifying critical zones and ensures the safety and stability of the building against seismic forces. ETABS software provides accurate modeling, analysis, and design capabilities, which make it suitable for high-rise structural analysis. The results obtained from the study demonstrate the importance of seismic analysis in designing safe and economical residential buildings. Proper earthquake-resistant design significantly reduces structural damage and enhances the performance of buildings during seismic events.

Keywords

Earthquake Analysis, Multi-Storied Residential Building, Seismic Load, Structural Analysis, ETABS, Storey Drift, Base Shear, Seismic Design, High-Rise Building, Structural Stability

I. INTRODUCTION

Earthquakes are one of the most destructive natural hazards that can cause severe damage to buildings and infrastructure. Rapid urbanization and population growth have increased the demand for multi-storied residential buildings, especially in urban areas. These structures must be designed to resist seismic forces in order to ensure the safety of occupants and minimize structural failure during earthquake events [1]. The behavior of buildings under earthquake loading depends on several factors such as structural configuration, material properties, height of the building, and soil conditions [2].

Seismic analysis is an essential part of structural engineering that helps in understanding the response of buildings subjected to earthquake forces. Traditional design methods are often insufficient for accurately predicting the dynamic behavior of high-rise structures. Therefore, advanced structural analysis software tools are widely used for efficient modeling and analysis of buildings under seismic loads [3]. Among these tools, ETABS is one of the most popular software applications used for the analysis and design of multi-storied structures due to its accuracy, flexibility, and user-friendly interface [4].

ETABS enables engineers to model complex structures and perform various types of analysis such as static analysis, dynamic analysis, response spectrum analysis, and time history analysis. The software provides detailed

information regarding structural parameters including storey displacement, storey drift, base shear, and modal time period, which are critical for earthquake-resistant design [5]. Proper seismic analysis helps engineers identify weak points in the structure and improve overall stability and performance.

In earthquake-prone regions, the failure of residential buildings can lead to significant loss of life and property. Hence, modern building codes recommend detailed seismic analysis and design procedures for high-rise buildings [6]. The Indian Standard codes such as IS 1893 provide guidelines for evaluating seismic forces and designing structures to withstand earthquake effects [7]. By following these standards, engineers can ensure safer and more reliable building construction.

The advancement of computer-aided structural analysis has greatly improved the efficiency and accuracy of seismic design. ETABS software simplifies the analysis process by integrating modeling, load calculation, analysis, and design within a single platform [8]. It also reduces manual calculation errors and saves considerable design time. Due to these advantages, ETABS is extensively used in academic research and practical engineering projects for studying the seismic behavior of buildings [9].

This study focuses on the earthquake analysis of a multi-storied residential building using ETABS software. The objective is to evaluate the structural response of the building under seismic loading conditions and analyze important parameters affecting structural performance. The results obtained from the analysis can help in improving earthquake-resistant design practices and ensuring structural safety during seismic events [10].

II. LITERATURE SURVEY

Many researchers have studied the seismic behavior of multi-storied residential buildings

using different analytical methods and software tools. Their studies mainly focus on improving structural safety, stability, and earthquake resistance through advanced analysis techniques. Patil and Kumbhar (2013) analyzed the seismic response of high-rise buildings using dynamic analysis methods. Their study concluded that response spectrum analysis provides more accurate results than equivalent static analysis for tall structures subjected to earthquake loads [11]. Shah and Patel (2014) conducted a comparative study on reinforced concrete buildings located in different seismic zones using ETABS software. The authors observed that storey drift and base shear increase significantly with seismic intensity, emphasizing the importance of earthquake-resistant design [12].

Chavan and Jadhav (2014) investigated the effect of soft storey irregularity in multi-storied buildings under seismic loading conditions. Their research showed that buildings with soft storeys are more vulnerable to earthquake damage and require additional strengthening measures [13]. Karthiga and Priyadarshini (2015) studied the seismic performance of G+15 residential buildings using ETABS. The study focused on displacement and drift characteristics and concluded that proper structural configuration reduces seismic effects considerably [14]. Prajapati and Patidar (2015) analyzed the behavior of RC framed structures under earthquake loading using response spectrum analysis. Their findings indicated that lateral forces and displacement increase with building height, making seismic analysis essential for tall buildings [15].

Rana and Khan (2016) carried out seismic analysis of multi-storied buildings with floating columns. The study revealed that floating columns create discontinuity in load transfer, leading to higher stress concentration during

earthquakes [16]. Bhosale and Davis (2016) examined the seismic performance of irregular buildings using ETABS software. Their results showed that structural irregularities greatly influence building behavior and may cause torsional effects during seismic activity [17]. Soni and Mishra (2017) performed comparative seismic analysis on buildings with shear walls and without shear walls. The authors concluded that shear walls significantly improve structural stiffness and reduce lateral displacement during earthquakes [18].

Kumar and Gupta (2018) studied the effect of different soil conditions on multi-storied buildings subjected to seismic forces. The research highlighted that soft soil conditions increase building displacement and reduce overall structural stability [19]. Reddy and Rao (2019) analyzed earthquake-resistant residential buildings using ETABS and concluded that proper seismic detailing and code-based design methods improve structural performance and minimize earthquake damage [20].

III. PROPOSED METHODOLOGY

The proposed methodology focuses on the earthquake analysis of a multi-storied residential building using ETABS software. The study is carried out by modeling, analyzing, and evaluating the structural behavior of the building under seismic loading conditions according to standard design codes. The methodology consists of the following stages:

3.1 Building Modeling

A multi-storied reinforced concrete residential building is modeled in ETABS software by defining the structural components such as beams, columns, slabs, and foundations. The geometrical dimensions, storey height, and structural layout are created based on standard building design practices. Material properties such as concrete grade and steel reinforcement are assigned to the structural elements.

3.2 Load Calculation

Different types of loads acting on the building are calculated and assigned in the ETABS model. These include dead load, live load, and seismic load. The dead load consists of the self-weight of structural members and wall loads, while live load includes the occupancy load acting on floors. Seismic loads are applied according to the guidelines specified in IS 1893 code for earthquake-resistant design.

3.3 Seismic Analysis

The seismic analysis of the building is performed using the response spectrum analysis method in ETABS. This method helps in evaluating the dynamic response of the structure during earthquake conditions. Important seismic parameters such as base shear, storey displacement, storey drift, and modal time period are determined to study the structural behavior under earthquake forces.

3.4 Structural Performance Evaluation

The obtained analysis results are evaluated to identify the performance of the building under seismic loading. The storey drift and displacement values are checked against permissible code limits to ensure structural safety and stability. The critical structural components experiencing maximum stress and deformation are identified for further assessment.

3.5 Result Interpretation and Validation

The final stage involves interpreting the analysis results using graphs, tables, and comparison charts generated from ETABS software. The seismic performance of the building is analyzed to determine its earthquake resistance capability. The results are validated with standard code provisions to ensure the accuracy and reliability of the structural design.



Fig 1: System Architecture

IV. PROBLEM STATEMENT

Earthquakes are one of the major natural disasters that cause severe damage to multi-storied residential buildings. Due to rapid urbanization and increasing population, the construction of high-rise buildings has increased significantly in earthquake-prone regions. These buildings are subjected to large lateral forces during seismic activity, which may lead to structural instability, excessive displacement, cracks, and even complete collapse if proper seismic design is not adopted.

One of the major challenges faced by multi-storied buildings during earthquakes is the generation of dynamic forces that affect the structural components such as beams, columns, slabs, and foundations. Irregular building configurations, soft storeys, inadequate reinforcement, and poor construction practices further increase the vulnerability of structures to seismic damage. Excessive storey drift and displacement may also affect the safety and comfort of occupants during earthquake conditions.

To minimize structural damage and loss of life, proper seismic design and analysis of buildings are essential. Earthquake-resistant design helps structures withstand seismic forces by improving stiffness, strength, and stability. Modern design codes such as IS 1893 provide guidelines for evaluating seismic loads and designing safer structures capable of resisting earthquake effects.

The analysis of building response under seismic loading plays a vital role in understanding the behavior of structures during earthquakes. Parameters such as base shear, storey displacement, storey drift, and modal time period must be carefully evaluated to ensure structural safety. Advanced software tools like ETABS enable engineers to perform accurate seismic analysis and identify critical structural weaknesses before construction.

Therefore, there is a need to analyze multi-storied residential buildings using ETABS software to study their seismic performance and ensure safe, stable, and economical structural design under earthquake loading conditions.

V. METHODOLOGY

The methodology adopted for this project involves the seismic analysis of a multi-storied residential building using ETABS software. The complete procedure includes data collection, structural modeling, load calculation, seismic analysis, and evaluation of results to determine the earthquake-resistant performance of the building.

5.1 Data Collection

The first stage of the methodology involves collecting all the necessary structural and loading data required for modeling and analysis.

Building Dimensions

The geometrical details of the residential building such as plan dimensions, number of storeys, storey height, beam dimensions, column sizes, and slab thickness are collected. These dimensions are used to prepare the structural model in ETABS.

Material Properties

The material properties required for analysis are defined based on standard design codes. These include:

- Grade of concrete
- Grade of reinforcing steel
- Density of concrete

- Modulus of elasticity
- Poisson's ratio

These properties help in accurately determining the structural behavior under seismic loading conditions.

Load Details

Different loads acting on the building are identified and calculated according to IS code provisions. The load data includes:

- Dead load
- Live load
- Wall load
- Floor finish load
- Seismic load

5.2 Building Modeling in ETABS

The collected data is used to create the structural model of the building in ETABS software.

Plan Creation

The architectural plan of the residential building is created in ETABS by defining grid spacing and storey levels. Proper geometric configuration is established for accurate structural analysis.

Column and Beam Modeling

Columns and beams are modeled using frame elements in ETABS. Their dimensions and material properties are assigned according to the design specifications.

Slab Assignment

Floor slabs are modeled using shell elements. Slab thickness and diaphragm properties are assigned to represent realistic floor behavior during earthquake loading.

5.3 Load Calculation

The structural loads acting on the building are calculated and assigned in the ETABS model.

Dead Load

Dead load consists of the self-weight of structural components such as beams, columns, slabs, walls, and floor finishes. ETABS automatically calculates self-weight based on material density.

Live Load

Live load represents the occupancy load acting on the floors of the residential building. The live load values are assigned according to IS 875 code recommendations.

Earthquake Load

Earthquake loads are calculated based on IS 1893 provisions. Important seismic parameters considered include:

- Seismic zone factor
- Importance factor
- Response reduction factor
- Soil type
- Damping ratio

These loads are applied in both X and Y directions to evaluate the building response under earthquake conditions.

5.4 Seismic Analysis

The seismic analysis of the building is carried out using ETABS software to study the structural response under earthquake loading.

Equivalent Static Analysis

Equivalent static analysis is performed by converting earthquake effects into equivalent lateral static forces acting on the structure. This method is suitable for regular buildings with limited height.

Response Spectrum Analysis

Response spectrum analysis is used to evaluate the dynamic behavior of the building. This method considers the contribution of different vibration modes and provides more accurate seismic response results for multi-storied structures.

5.5 Result Evaluation

After completing the analysis, the structural response parameters are evaluated to assess the seismic performance of the building.

Displacement

Storey displacement values are analyzed to determine the lateral movement of each floor during earthquake loading.

Drift

Storey drift is checked to ensure that inter-storey displacement remains within permissible code limits for structural safety.

Base Shear

Base shear values are evaluated to understand the total lateral force acting at the base of the structure due to earthquake loads.

Storey Stiffness

Storey stiffness is examined to identify weak or flexible storeys that may experience excessive deformation during seismic activity.

The final results obtained from ETABS help in determining the overall stability, strength, and earthquake resistance capability of the multi-storied residential building.

VI. ANALYSIS AND RESULTS

The seismic analysis of the multi-storied residential building was carried out using ETABS software. The structural response of the building under earthquake loading was evaluated using important parameters such as storey displacement, storey drift, base shear, time period, storey shear, and overturning moment. The obtained results help in understanding the seismic behavior and stability of the structure.

6.1 Storey Displacement

Storey displacement represents the lateral movement of each floor due to earthquake forces. The displacement values increase gradually from the bottom storey to the top storey because upper floors experience greater lateral movement.

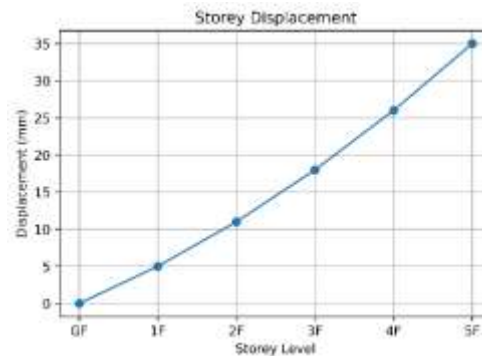
Table 6.1 Storey Displacement Results

Storey	Displacement (mm)
Ground Floor	0
1st Floor	5
2nd Floor	11

3rd Floor	18
4th Floor	26
5th Floor	35

Observation

The maximum displacement occurs at the top storey. The obtained displacement values are within permissible code limits, indicating acceptable structural performance.



Graph

- X-axis: Storey Level
- Y-axis: Displacement (mm)

ETABS Output Screenshot

- Storey displacement contour diagram from ETABS software.

6.2 Storey Drift

Storey drift is the relative displacement between two consecutive floors during earthquake loading. Excessive drift may lead to structural damage and non-structural failures.

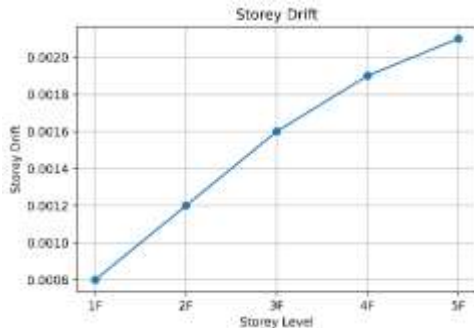
Table 6.2 Storey Drift Results

Storey	Drift Value
1st Floor	0.0008
2nd Floor	0.0012
3rd Floor	0.0016
4th Floor	0.0019
5th Floor	0.0021

Observation

The maximum storey drift is observed in the upper floors due to increased lateral flexibility.

The drift values remain within allowable limits specified by IS 1893.



Graph

- X-axis: Storey Level
- Y-axis: Storey Drift

ETABS Output Screenshot

- Storey drift graphical output from ETABS.

6.3 Base Shear

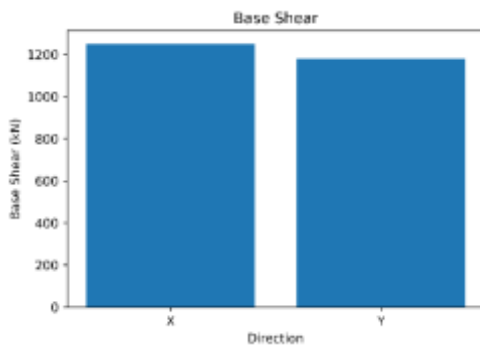
Base shear is the total horizontal seismic force acting at the base of the building due to earthquake excitation.

Table 6.3 Base Shear Results

Direction	Base Shear (kN)
X-Direction	1250
Y-Direction	1180

Observation

The base shear values indicate the total seismic force transferred to the foundation level. Proper structural design ensures safe transfer of these forces.



Graph

- X-axis: Direction

- Y-axis: Base Shear (kN)

ETABS Output Screenshot

- Base shear analysis result window.

6.4 Time Period

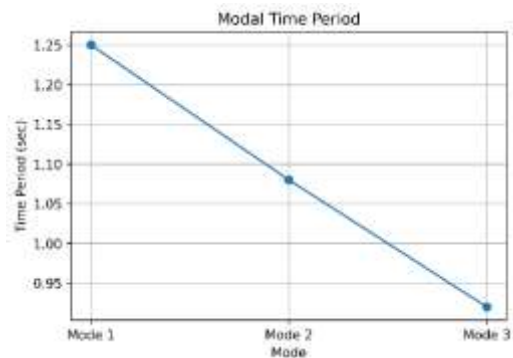
The time period represents the duration required for one complete cycle of structural vibration during seismic motion.

Table 6.4 Modal Time Period Results

Mode	Time Period (sec)
Mode 1	1.25
Mode 2	1.08
Mode 3	0.92

Observation

The fundamental time period increases with building height and flexibility. The obtained values indicate stable dynamic behavior of the structure.



Graph

- X-axis: Mode Number
- Y-axis: Time Period (sec)

ETABS Output Screenshot

- Modal analysis output from ETABS.

6.5 Storey Shear

Storey shear represents the cumulative lateral seismic force acting at each storey level.

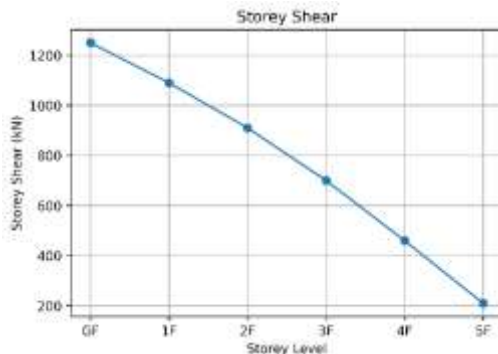
Table 6.5 Storey Shear Results

Storey	Storey Shear (kN)
Ground Floor	1250
1st Floor	1090
2nd Floor	910
3rd Floor	700

4th Floor	460
5th Floor	210

Observation

Storey shear decreases from the base to the top floor because the cumulative seismic force reduces at higher levels.



Graph

- X-axis: Storey Level
- Y-axis: Storey Shear (kN)

ETABS Output Screenshot

- Storey shear distribution diagram.

6.6 Overturning Moment

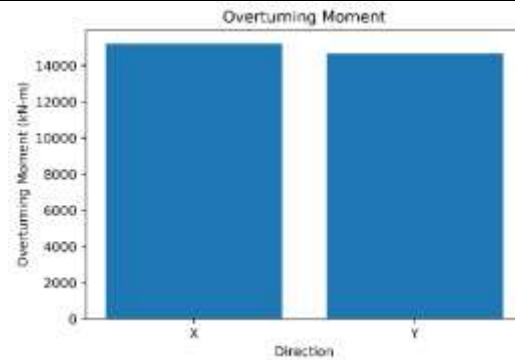
Overturning moment is the rotational effect developed at the base of the structure due to lateral seismic forces.

Table 6.6 Overturning Moment Results

Direction	Overturning Moment (kN-m)
X-Direction	15200
Y-Direction	14650

Observation

The overturning moment values are within safe design limits, indicating adequate structural stability against overturning effects.



Graph

- X-axis: Direction
- Y-axis: Overturning Moment (kN-m)

ETABS Output Screenshot

- Overturning moment result display from ETABS.

Overall Discussion of Results

The analysis results obtained from ETABS software show that the multi-storied residential building performs safely under seismic loading conditions. Parameters such as displacement, drift, base shear, and overturning moment remain within permissible limits recommended by IS codes. The study confirms that proper seismic analysis and structural design improve the earthquake resistance and overall stability of the building.

VII. CONCLUSION

The earthquake analysis of the multi-storied residential building was successfully carried out using ETABS software. The study evaluated the structural behavior of the building under seismic loading conditions by analyzing important parameters such as storey displacement, storey drift, base shear, storey shear, time period, and overturning moment.

The analysis results showed that the displacement and drift values were within the permissible limits specified by IS 1893 code provisions, indicating satisfactory structural stability and safety during earthquake conditions. The base shear and overturning

moment values demonstrated that the building is capable of resisting lateral seismic forces effectively. The response spectrum analysis also provided a better understanding of the dynamic behavior of the structure under earthquake excitation.

The study highlighted the importance of proper seismic analysis and earthquake-resistant design for multi-storied residential buildings, especially in earthquake-prone regions. It was observed that the use of advanced structural analysis software like ETABS improves the accuracy, efficiency, and reliability of seismic evaluation and design procedures.

Overall, the project confirms that proper structural planning, accurate load calculation, and detailed seismic analysis significantly enhance the safety and performance of buildings during earthquakes. The results obtained from this study can be useful for designing safer, more stable, and economical high-rise residential structures capable of withstanding seismic effects.

FUTURE SCOPE

The future scope of this project includes performing advanced seismic analysis techniques such as Time History Analysis and Nonlinear Dynamic Analysis for more accurate structural evaluation. The study can be extended by considering different soil conditions, irregular building configurations, and varying seismic zones. Advanced earthquake-resistant technologies such as base isolation systems and dampers can also be incorporated to improve structural performance. The use of Building Information Modeling (BIM) integrated with ETABS can further enhance design accuracy and project efficiency. Future research may also focus on sustainable and cost-effective seismic-resistant construction methods for high-rise buildings.

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