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Linear and Nonlinear Analysis of G+15 Story Building with and without Shear Wall by using Time History Analysis Method

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***Abstract:** This research study aims to analyze and compare the structural behavior of a G+15 story building with and without shear walls using the time history analysis method. The inclusion of shear walls in high-rise buildings has gained significant attention due to their ability to enhance structural stability and reduce lateral loads during seismic events. In this study, a linear and nonlinear analysis approach is adopted to assess the dynamic response of the building under seismic excitations.*

The methodology involves the creation of a three-dimensional finite element model of the G+15 story building using a commercial software package. The structural properties, including material characteristics and boundary conditions, are defined based on relevant design codes and standards. Two scenarios are considered: one with shear walls distributed strategically throughout the building, and another without any shear walls.

The time history analysis is performed by subjecting the model to a set of seismic records representing different design earthquakes. The dynamic responses of the building, such as inter-story drifts, base shear, and structural displacements, are evaluated and compared between the two scenarios.

The findings of this study demonstrate that the inclusion of shear walls significantly improves the seismic performance of the G+15 story building. The building with shear walls exhibits reduced inter-story drifts, lower base shear, and improved overall structural stability compared to the building without shear walls. These results highlight the importance of incorporating shear walls in the design of high-rise buildings in seismically active regions.

***Keywords:** shear wall, time history analysis, high-rise building, seismic performance, inter- story drift, base shear.*

I. INTRODUCTION

Worldwide, there is a huge demand for the construction of high-rise buildings due to the increasing population Earthquake-resistant design of engineering structures is one of the most important ways of future earthquake damage. Earthquake design of the structure is based on ground motion specification from previous earthquake results. Therefore, it is very important to be able to overcome the damage of any important earthquake-resistant structure according to the seismic frequency. However, earthquake forces are varied and unpredictable, so software tools must be used to analyze structures under any seismic forces. Earthquakes develop different intensities in different places, and the damage induced in buildings in these places also varies according to the type of structure. Therefore, it is necessary to study the seismic behavior of RC prefabricated buildings for different seismic intensities. Seismic intensities in terms of various responses such as base shear, lateral displacement. Different types of analysis are used to identify the seismic resistance and behavior of a building at applied seismic frequencies.

Earthquakes are natural hazards under which disasters are mainly caused by damage or collapse of buildings and other man-made structures. Experience has shown that for new constructions, establishing earthquake resistant regulations and their implementation is the critical safeguard against earthquake induced damage. As regards existing structures, it is necessary to evaluate and strengthen them based on evaluation criteria before an earthquake.

Earthquake damage depends on many parameters, including intensity, duration and frequency, content of ground motion, geologic and soil condition, quality of construction. Time history analysis is the response of the structure including inertial effects, this is advanced to spectrum response analysis and provides basic acceleration, displacement and duration. This is useful for very tall structures to know how the structure behaves under any seismic attacks. This analysis requires previous earthquake data to perform the analysis. It is astep-by-step analysis of the structure's response to a specified load that may change over time.

A. Aim

The aim of this study is to perform a comparative analysis of a G+15 story building with and without shear walls using the time history analysis method. The objective is to investigate the structural response, including linear and nonlinear behavior, to assess the effectiveness of shear walls in enhancing the building's seismic performance.

B. Time History Analysis

In order to investigate the exact nonlinear behavior of structures, a nonlinear time history analysis must be performed. In this method, the structure is subjected to real ground motion records.This makes this method of analysis quite different from all other methods of approximate analysis because the inertial forces are directly determined from these ground motions and the building responses in either deformations or forces are calculated as a function of time with respect to the dynamic properties. structures. In Etabs, non-linear time analysis can be performed as follows: 1. Building models are created and vertical loads (dead and service loads), member properties and non-linear member behavior are defined and assigned to the model. The ground motion record is defined as a function of acceleration versus time. Next, the analysis and time history parameters are defined in order to perform a nonlinear time history analysis. The total analysis time is the number of output time steps multiplied by the output time step size. To fit the time history of the target response spectrum,there are two options in ETABS.

In Etabs 2016, the nonlinear time-history analysis can be carried out as follows:

1) The models representing the buildings are created and vertical loads (dead load and live load), member properties and member nonlinear behaviors are defined and assigned to the model.
2) The ground motion record is defined as a function of acceleration versus time.

Here after, the analysis and the time history parameters are defined in order to perform a nonlinear time history analysis. The total time of the analysis is the number of output time steps multiplied by the output time-step size. To match time history to target response spectra,there are two options in ETABS 2016. These are „spectral matching by time domain‟ and spectral matching by frequency domain‟ options. In „spectral matching by time domain‟ option, the damping values with the first and second periods are assigned. Using these values, the program calculates the mass proportional and stiffness proportional coefficients. „Spectral matching by frequency domain‟ has the same interface but this time frequency values instead of periods are assigned. In the analysis of the analytical models spectral matching by time domain‟ option is used. The user graphic face of Etabs 2016 while defining the output steps and time step size for nonlinear time history analysis. The Concept of seismic design is to provide building structure with sufficient strength and deformation capacity to sustain seismic demands imposed by ground motion with adequate margin of safety. Even if the probability of occurrence of earthquake within the life span of structures is very less, strong ground motion would generally cause greater damage to the structure. For designing the structures for this combination having less probability and extreme loading, a criterion is adopted in such a way that a major earthquake, with a relatively low probability of occurrence is expected to cause significant damage which may not be repairable but not associated with loss of life Performance based seismic design is gaining popularity from last decades. Many countries are separate document over this method such as FEMA, ATC etc. Recently formulated Euro codes EC2 and EC8 [Euro code 2, Euro code 8] are also based on performance-based design philosophy. But Indian codes are still silent over this method. Even the IS 1893(part I): 2007 draft doesn’t talk about performance based seismic design ETABS software was used for the design of building.

II. LITERATIRE REVIEW

Gaurav Kapgate , Prof. D. L. Budhlani Structures need to have suitable earthquake resistant features to safely resist large lateral forces that are imposed on them during frequent earthquakes. Ordinary structures for houses are usually built to safely carry their own weights. Lateral forces can produce the critical stresses in a structure, set up undesirable vibrations and, in addition, cause lateral sway of structure, which could reach a stage of discomfort to the occupants. Shear wall is one of the most commonly used lateral load resisting element in high rise building. In this study, the non-linear El-centro time history analysis is carried out for special moment resisting frame under earthquake loading using computer software E-TAB 2016.

Mindala Rohini, T. Venkat Das An earthquake occurs in the form of seismic waves due to sudden release of energy and results in ground shaking. During earthquake, seismic waves propagate through the soil which results in structural damage due to movements within the earth’s crust. It impacts the behavior of interaction of components like building, foundation, underlying soils and also overall system behavior.When earthquake occurs, the behavior of a building depends on distribution of mass, strength and stiffness. Generally, the buildings are subjected to various types of forces throughout their existence. The forces can be static forces due to dead and live loads and dynamic forces due to earthquake.

In this study, the analysis is carried out for seismic response of (G+15)residential building for zone-III and Zone-V regions through response spectrum method and time history method in ETABS. The parameters likestorey displacement, storey drift and storey shear are observed for specified zones

Prajapati Ramdev, Prashant R. Barbude, Dr. A.P. Patil Linear Time History analysis of G+12 storied RCC building considering 4 different time histories is carried out. The time history data of Bhuj earthquake, Chamba earthquake, Chamoli earthquake and NE (Myanmar) earthquake has been considered. Here, a G+12 stories building has been modelled using Etabs software for seismic analysis and time history analysis. This paper highlights the effects of different time histories of different region on the same structure. The effects under considerations are story shear, building deflection and story drift.

PAWAN R. THAKARE TABS stand for Extended Three Dimensional Analysis of Building Systems. ETABS integrates every aspect of the engineering design process. In the present situations of construction industry, the buildings that are being constructed regaining significance, in general, those wise the best possible outcomes which are referred to members like beams and columns in multi storeys R.C structures. This software mainly used for structures like high-rise buildings, steel and concrete structures. The paper aims to analyze a high-rise building of 15 floors (G+15) by considering seismic, dead and live loads. The design criteria for high-rise buildings are strength, serviceability and stability. The version of the software used is ETABS 2016.In the present study, we are mainly determining the effects of lateral loads on moments, shear force, axial force, base shear, maximum displacement and tensile forces on structural system are subjected and also comparing the results of zone 2 and zone 3.

III. RESULTS AND OBSERVATIONS

Time history analysis is a computational method used in structural engineering to simulate the dynamic response of a structure subjected to time-varying loads or ground motions. Unlike static analysis, which assumes a steady state condition, time history analysis considers the actual variation of loads or ground motions over time.

The process of time history analysis involves the following steps:

1) Selection of Ground Motion Records: The first step is to select appropriate ground motion records or accelerograms that represent the seismic activity or other dynamic forces that the structure may experience. These records are usually obtained from historical earthquakes or simulated using mathematical models.
2) Modeling the Structure: The next step is to create a numerical model of the structure using appropriate software. The model should accurately represent the geometry, material properties, and structural components of the actual building. This typically involves dividing the structure into finite elements and defining the properties of each element.
3) Definition of Boundary Conditions: The boundary conditions of the structure need to be defined to simulate its interaction with the surrounding environment. This includes fixing or restraining certain degrees of freedom to represent the supports and connections of the structure.
4) Application of Loads: In time history analysis, the ground motion records selected in step 1are applied to the numerical model as input loads. The accelerations, velocities, or displacements from the ground motion records are applied to the appropriate nodes of the model at each time step.
5) Numerical Integration: The dynamic equations of motion are numerically integrated using methods such as Newmark's method or the Wilson-θ method. These integration methods allow the determination of the structural response at each time step based on the applied loads,mass, stiffness, and damping properties of the structure.
6) Analysis and Output: The time history analysis calculates the response of the structure in terms of displacements, velocities, accelerations, and internal forces at each time step. These results can be visualized through animations, time history plots, or contour plots to understandhow the structure behaves under dynamic loads.
7) Evaluation and Interpretation: The obtained results are evaluated and interpreted to assess the structural performance and response. This may involve comparing the computed response with design criteria, code requirements, or acceptance criteria for different performance levels.

A. *Problem Statement*

Statement Of Project

Design data

1) Building type. : Residential building
2) No.of storeys. : G+15
3) Building shape : Rectangular

4) Geometrical details
a) Plan dimension : 25m×30m
b) beam size : 300mm×500mm
c) Column size : 500mm×600mm
d) slab size : 150mm

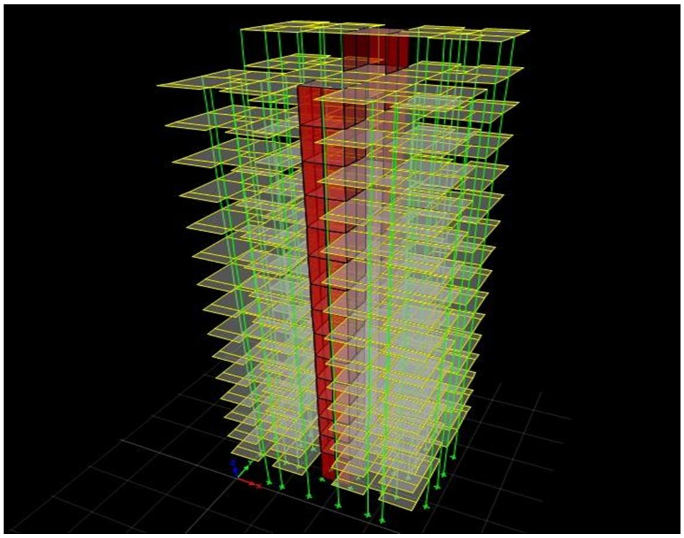
5) Material details
a) Concrete grade
- For Beam : M40
- For Column. : M45
- For Slab. : M40

b) Steelgrade : HYSD reinforcement of Fe 415 & Fe 500

6) Type of construction. : R.C.C Framed structure
7) Load Pattern
a) Dead Load
b) Live Load : 3.5 KN/m
c) Live Roof. : 1.5 KN/m
d) Floor Finish. : 1.2 KN/m
e) Wall load. : 13.8 KN/m

8) Seismic Properties
a) Zone Factor : 0.3
b) Soil Type : Hard Rock
c) Response Reduction Factor : 8.5Importance Factor : 1.5
Time History Function: ElcentroDampinf Ration : 5%

9) Load Pattern
a) Dead Load
b) Live Load : : 3.5 KN/m
c) Live Roof. : 1.5 KN/m
d) Floor Finish : 1.2 KN/m
e) Wall load. : 13.8 KN/m


3D MODEL OF STRUCTURE FROM ETABS

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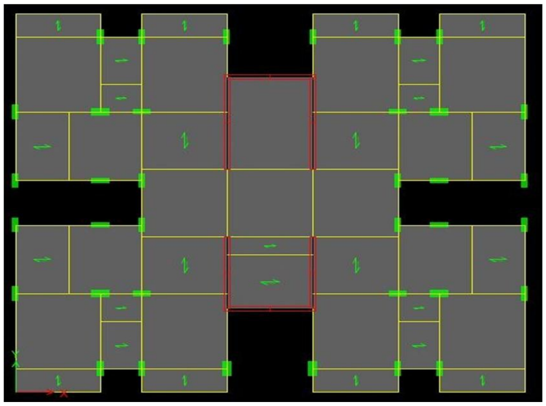
2D Model of Structure from ETABS

B. Nonlinear Time History Technique

The only strategy to depict the genuine nature of a structure during tremor is through non- linear dynamic investigation or nonlinear time-history investigation. The strategy dependsgonlyyon the direct numerical combination of differential equations of motion, taking into account theyelasto-plastic deformation8of a structural element. This is a significant strategy for structural seismic investigation, particularly when the assessed basic reaction is nonlinear. To conduct such an investigation, a agent seismic time history is needed for a structure being assessed. Time history examination is a bit by bit investigation of dynamic Freaction of a structure to a predefined loading that may differ with time. Time history investigation is utilized to decide the seismic response of model to the dynamic loading of a typical earthquake. Time-history investigation is a bit by bit examination of the dynamical reaction of a structure to a particular loading that may differ with time. The investigation might be linear or nonlinear.

Table 1: Comparison of Base shear

		Base shear (kN)	
Direction	Bare Frame	Outer shear wall	Inner shear wall
X- dir	261.066	272.784	267.1
Y-dir	251.938	302.34	289.728

The displacements for 10 & 15 Storey Building shows a decrease in 78% and 74%respectively which are mentioned in the tables.

Storey level	Displacements without Shear wall	Displacements with Shear wall
Storey 14	271.576	72.56
Storey 13	251.881	67.106
Storey 12	233.966	55.862
Storey 11	211.593	50.099
Storey 10	191.289	44.289
Storey 9	170.145	38.488
Storey 8	149.788	32.761
Storey 7	129.767	27.185
Storey 6	110.167	21.846
Storey 5	90.068	16.835
Storey 4	70.251	12.254
Storey 3	51.659	8.209
Storey 2	33.668	4.817
Storey 1	16.774	0.208
Ground level	3.532	0.0514

IV. CONCLUSIONS

1) The analysis of the G+15 story building using time history analysis method provides valuable insights into the structural behavior under seismic loads.
2) The inclusion of shear walls significantly enhances the structural performance of the building by improving its resistance to lateral forces.
3) In the linear analysis, the building's response is determined by assuming linear material behavior and neglecting the effects of nonlinearities.
4) The linear analysis can provide a quick and approximate assessment of the building's response, but it may not capture the actual behavior accurately.
5) The nonlinear analysis takes into account the effects of material nonlinearity, such as yielding and stiffness degradation, providing a more realistic prediction of the building's behavior.
6) The nonlinear analysis reveals that the presence of shear walls effectively reduces the building's deformations and accelerations during seismic events.
7) The maximum inter-story drifts and base shear forces are significantly lower in the building with shear walls compared to the one without shear walls.
8) The inclusion of shear walls redistributes the lateral loads and improves the load- carrying capacity of the structure.
9) The nonlinear analysis also highlights the importance of considering higher modes of vibration, as they can have a significant influence on the building's response.
10) The time history analysis method allows for the consideration of ground motion records, which are essential in capturing the dynamic nature of seismic events.
11) The analysis shows that the building's response is highly dependent on the characteristics of the ground motion input.
12) The structural design should consider the specific site conditions and potential seismic hazards to ensure the building's safety and performance.
13) The results of the analysis can guide engineers and designers in optimizing the structural configuration of multi-story buildings.
14) Shear walls should be carefully located and designed to maximize their effectiveness in resisting lateral loads.
15) The nonlinear analysis emphasizes the need for appropriate detailing and reinforcement to ensure ductile behavior and prevent premature failure.
16) The time history analysis method provides a more rigorous assessment of thebuilding's response compared to simplified design approaches.
17) The findings of this study contribute to the body of knowledge on the behavior ofmulti-story buildings under seismic loads.
18) Further research and experimentation are necessary to validate the results andexplore other factors that may influence the building's response.

A. *Scope of Future Work*

1) Advancements in technology and computing power will enable more detailed and accurate analysis of G+15 story buildings with and without shear walls using time history analysis methods.
2) Future research will focus on developing more sophisticated numerical models and algorithms to simulate the behavior of buildings under dynamic loading conditions, allowing for better prediction of structural response and performance.
3) The integration of artificial intelligence and machine learning techniques will enhance the analysis process by automating certain tasks, improving efficiency, and providing more accurate results.
4) The development of advanced materials with improved strength, durability, and seismic resistance properties will contribute to the future scope of linear and nonlinearanalysis of high-rise buildings.
5) The incorporation of sustainability and energy efficiency considerations will become a significant aspect of future analysis, leading to the optimization of building designs and the implementation of green building strategies.
6) With the increasing focus on resilience and risk management, future research will explore the impact of extreme events, such as earthquakes and tsunamis, on G+15 story buildings, aiming to develop robust structural systems that can withstand such hazards.
7) Advances in sensor technology and data collection methods will facilitate the monitoring and real-time assessment of building performance, allowing for the identification of potential issues and the implementation of proactive maintenance strategies.

8) The future scope of analysis will include the study of human behavior and occupantcomfort in high-rise buildings, considering factors such as wind-induced vibrations, noise, and vibrations caused by transportation systems.

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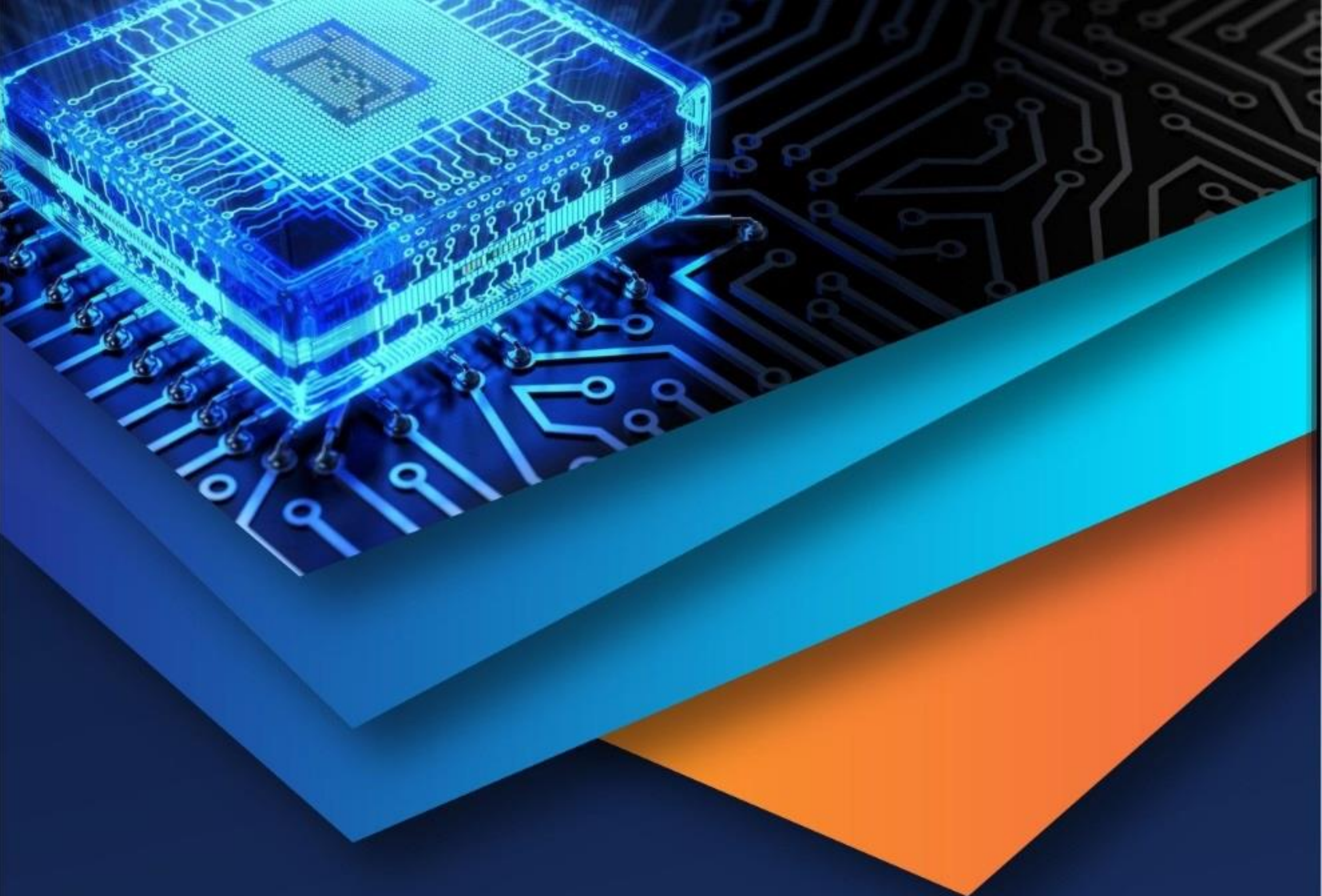

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