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Evaluation of the Behavior of High-Rise Regular Section Building using Pushover Analysis

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Abstract: hin the framework of resorting to high-rise buildings while prioritizing sustainability, preserving agricultural land, and minimizing horizontal expansion, a comprehensive understanding of the behavior of such buildings is essential, whether they are existing structures or are being tested after design. In this article, we conducted an analysis of a 10-story building using thrust analysis to determine how the structure responds to lateral loads, identify the locations of plastic joint formation and points of weakness, and understand the failure mechanism. Our findings revealed that plastic joints initially formed at the column bases and then spread to the other floors, with a higher concentration in the lower floors, both in the beams and columns. This indicates that the studied uniform structure performed well under these loads.

Keywords: h-rise buildings, Pushover Analysis, regular section, behavior, plastic hinges.

Introduction

High-rise buildings are a solution adopted by governments to utilize land, limit horizontal expansion, and promote vertical expansion to preserve agricultural land and green spaces, and to some extent, support sustainable development. Therefore, it is essential to understand the seismic behavior of such buildings and structural systems, as traditional analytical methods cannot accurately predict the actual response of these types of buildings, especially in the evaluation phase rather than the design phase. We can say that impulse analysis offers an opportunity to understand and evaluate such structures and can be adopted as a fundamental tool for assessing these buildings, determining their performance levels, and assessing their sustainability.

This analysis works by gradually applying lateral loads to the building until the potential displacement or collapse mechanism is reached. This method identifies the weakest floors, how plastic joints form in structural elements, and how they plasticize, thus more realistically identifying the building's weaknesses. This method is of great importance in high-rise buildings and is the subject of scientific research for many researchers. In this research, we aim to evaluate the behavior of a regularly shaped high-rise building using impulse analysis to understand its seismic performance and response.

Pushover analysis is a practical tool for assessing the behavior of structures after they have passed their elastic state, particularly when studying their resistance to lateral loads. This type of analysis helps determine amplitude curves and the distribution of plastic joints within the structure. Furthermore, it allows for the determination of seismic performance levels and the development of recommendations and codes. Several international standards address this, such as ATC40, FEMA356[1][2][3][4], and FEMA440, which serve as the framework for pushover analysis.

In the study of high-rise buildings, the higher phases become crucial, as the inertial response pattern changes after the formation of plastic joints in the structural load-bearing elements[5][6][7][8].

This method has evolved to include spectral frameworks or spectral amplitude curves and to simplify the scaling equations, which have been shown to dominate the initial phase. [GOEL] implemented a model where the response of each phase is collected separately, and then the results are combined to reduce the error caused by the higher phases and thus improve the accuracy of the results[9][10][11][12]. also worked on integrating modeling elements into impulse analysis procedures. This resulted in better performance in identifying the locations of plastic joint formation in the structure. Several problems also arise in high-rise buildings, particularly concerning the interaction between beams and columns and the elasticity of secondary elements[13][14][15][16].

Through previous studies, which included several research projects on impulse analysis in building evaluation, we have observed the effectiveness and usefulness of this method in identifying structural weaknesses and efficiency.

AIM of The RESEARCH

In this research, we will study the behavior of a seismic building with a regular cross-section by using impulse analysis, identifying the locations of plastic joint formation, estimating performance levels, and assessing the effect of lateral loads on it.

The Importance of the Research:

The trend towards tall buildings necessitates the development of methods and approaches that keep pace with this evolution and facilitate designers' understanding of their behavior, how to interact with them, and how to evaluate this behavior both before and after the design process is complete. This makes impulse analysis ideal for achieving this. Therefore, this research aims to establish this principle and explore the aspects of this analysis and how it contributes to this goal.

Methodology

In this research, we will construct a numerical model of a 10-story building with 5m spacing between columns in both directions, given its symmetrical plan, using ETABS 2016 software. This involves modeling its complete structural system, representing its geometric characteristics, adding potential loads, defining the plastic joints that are likely to form, performing a thrust analysis, and interpreting the resulting data.

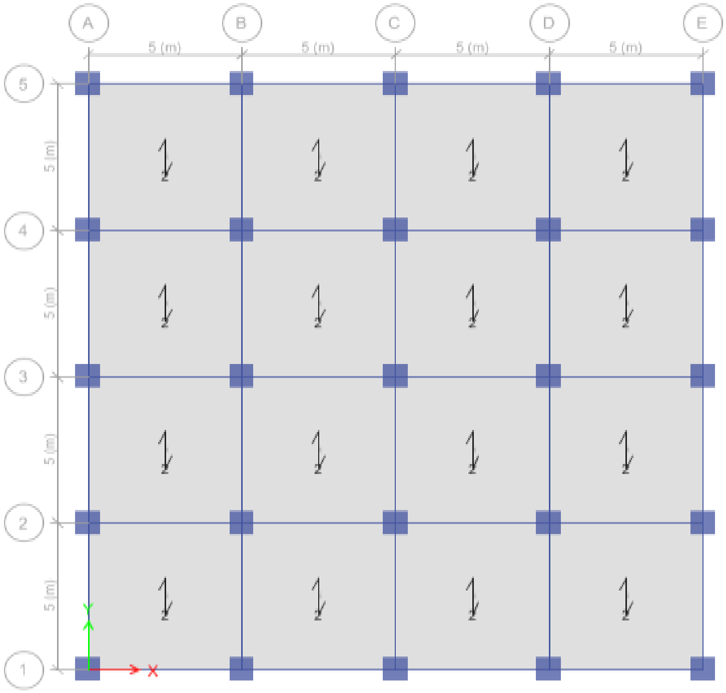

Fig 1. Plan of the Building

Result and discussion

This study is aimed at determining the influence of electronic diagnostic systems (OBD, ECU, sensor monitoring) used in modern automotive engines on the efficiency of service and repair processes. The obtained results confirmed that diagnostic technologies have a significant impact on the quality of maintenance, the speed of fault detection, and economic efficiency[9].

To complete this model, the modeling process was carried out using ETABS 2016 software. The building's characteristics were represented in terms of the dimensions of columns, beams, and slabs, as shown in the following table. In addition, we added the loads that the building might be subjected to, in terms of dead loads and live loads, and defined all the building's characteristics. The resulting model is shown in Figure 2.

Table 1. Model Properties

	Cm	
Column	80X80	16ϕ25
Beam	25X90	12ϕ16
Roof is Hordy	25cm	

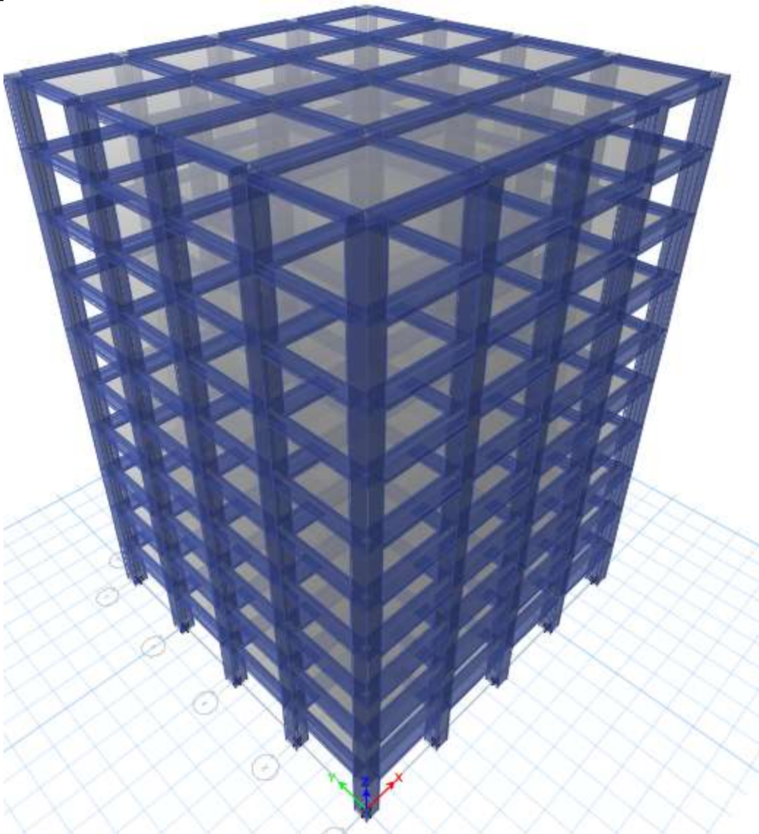

Fig 2. Building Model

By performing pushover analysis, we were able to determine the locations of plastic joint formation during seismic activity. From Figure [3], we can observe the location of the first plastic joint formation, which occurs at the base of the building as a result of the bending and tensile forces occurring there. The formation of plastic joints continues throughout the building.

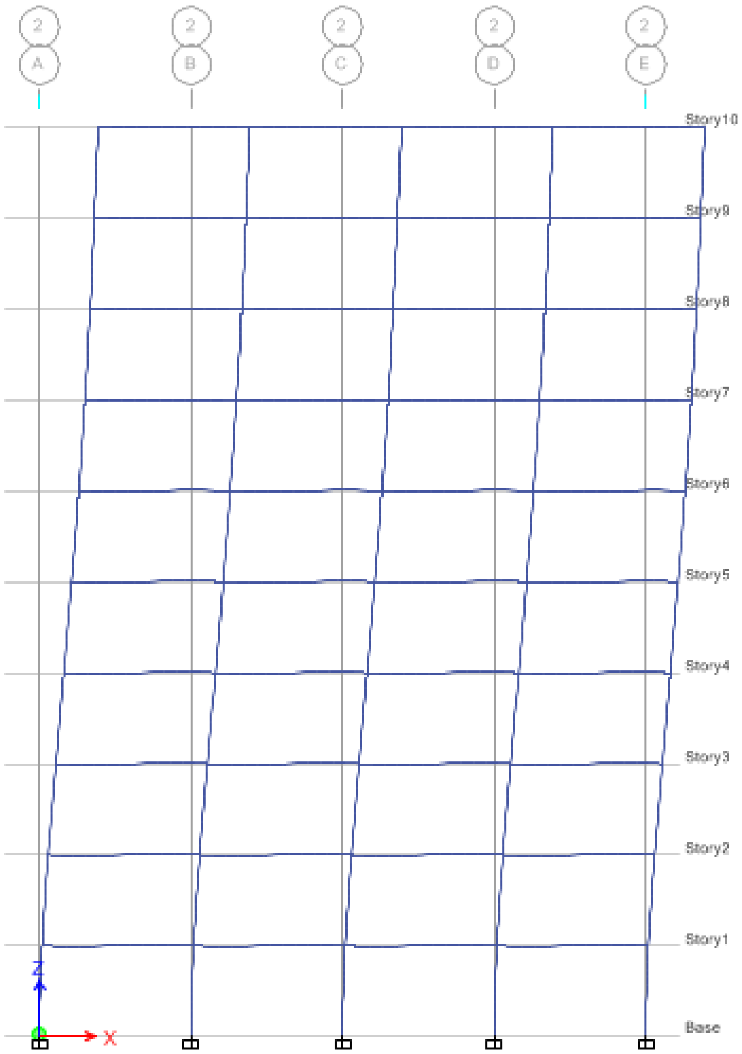

Fig 3. First Plastic Hing

Also, through the following figure, we can observe the location of the failure joints, which are concentrated in the lower floors of the building, where they are more prone to failure. We also note that the plasticity of the beam joints in the lower floors is greater than in the upper areas of the building.

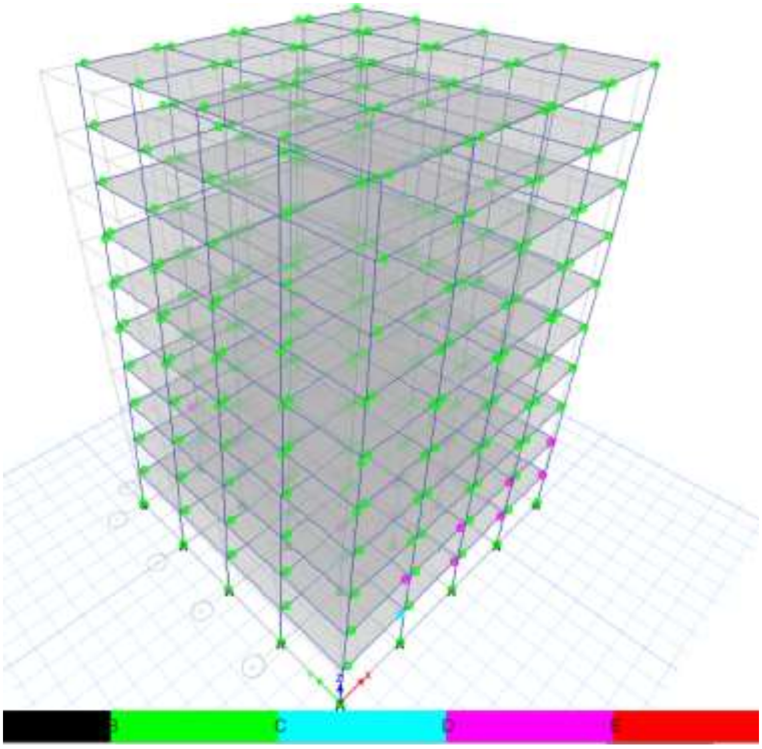

Fig 4. Model At the end of Analysis

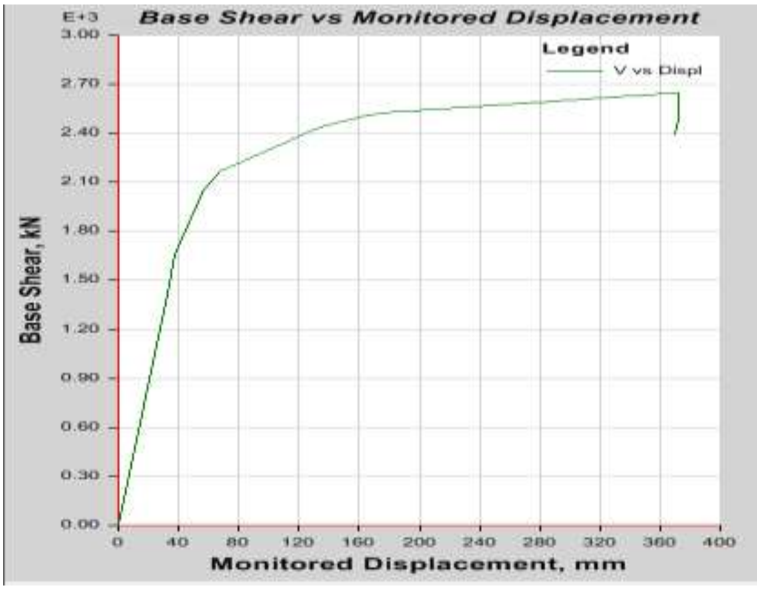

Fig 5. BASE Shear, Displacement

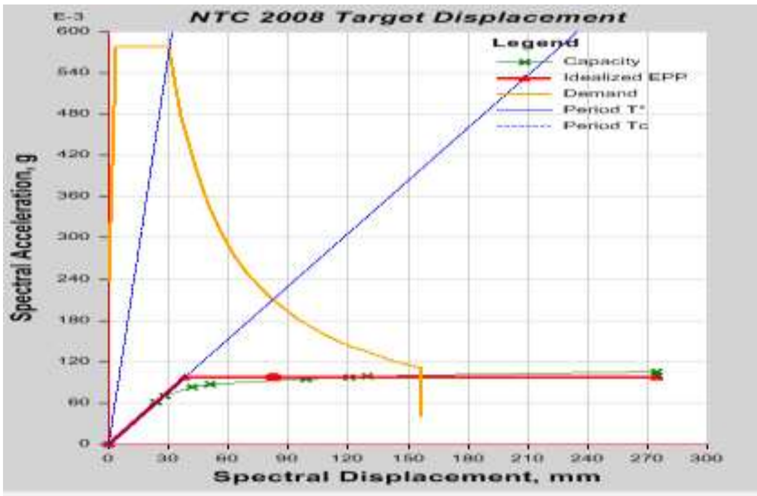

Fig 6. Target Displacement

The previous figure shows the amplitude curve and the power curve, the transition from linear to nonlinear behavior, and the effect of damping on the seismic response. This figure also shows the structure's ability to achieve acceptable performance levels before reaching the stage of loss of strength and stiffness.

Conclusion

Through this study, we were able to evaluate the use of thrust analysis on tall buildings with regular structural frameworks using ETABS 2016 software. Through this model, the locations of plastic joint formation and damage locations, which were mainly concentrated in the lower floors, were identified. The performance point was determined where the structure exhibited sufficient stiffness before plasticization began. Through this analysis, it became clear to us that it provides a clear and sufficient explanation of the structure's behavior, especially with regard to understanding the mechanism of failure, in addition to the critical elements and evaluating the seismic performance levels for regular buildings.

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