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Research Paper

Investigation of Inelastic Structural Performance of G+10 Building Structure Under Seismic Load condition

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Abstract *The inelastic capacity of structural systems is a crucial determinant of their performance and durability during seismic occurrences. Comprehending and precisely forecasting inelastic behaviour guarantees greater structural safety, less damage, and improved post-earthquake operability. This research examines the inelastic capacity and seismic resilience of several structural systems, concentrating on steel, composite, and reinforced concrete frames exposed to varying seismic intensities characteristic of Indian earthquake zones. Analytical modelling and dynamic simulations are conducted using ETABS, using sophisticated analytical methods like response spectrum analysis, nonlinear static pushover analysis, and nonlinear direct integration time-history analysis. This analysis assesses critical structural reactions, such as plastic hinge development, narrative drift, lateral stiffness, ductility, peak strength, energy dissipation, and joint accelerations. The research adheres to national and international design standards, including IS 800:2007, IS 875 (Parts I, II, and IV), IS 1893:2016, AISC 360 (2010 & 2016), and FEMA 440, to guarantee uniformity in performance assessment.*

In the present study the analysis of G+10 building model is carried out by using Response spectrum analysis method, time history analysis method and pushover analysis methods. The building models are analyzed with the help of ETABS Software package. The results like acceleration, time period, storey shear and base shear etc are studied as per obtained results.

Key words: structural systems, ETABS, G+10, response spectrum, time history, pushover

1. INTRODUCTION

Seismic performance study is a crucial element in assessing the structural integrity and resilience of buildings, especially in areas susceptible to seismic activity. High-rise structures, owing to their elevation and intricate structural demands, are profoundly affected by lateral pressures during seismic events. These forces may be catastrophic if not sufficiently mitigated during the design process. This research conducts a thorough seismic analysis of a high-rise steel structure, assessing its response to seismic stresses via the use of several bracing techniques. Bracing systems are essential components in the structural design of steel edifices, engineered to withstand lateral pressures produced by earthquakes and other seismic occurrences. Their contribution to improving a building's seismic performance is significant, since they alleviate the impacts of dynamic loading by providing stiffness and strength.

During seismic activity, the building experiences dynamic motion, as the structure's inertia forces oppose the acceleration induced by the earthquake. These forces, sometimes termed seismic loads, are external forces that must be considered in the building's design. High-rise structures endure substantial lateral stresses during seismic events because to their elevation and the mass distribution inside the structure. Lateral pressures may induce swaying in the structure, and insufficient design might result in significant structural damage. Consequently, it is essential to precisely quantify and delineate these lateral pressures to guarantee the structure is engineered to endure seismic occurrences. The primary component affecting earthquake performance is the ductility of the structure.

Ductility enables a structure to experience substantial deformation without failure, which is essential during an earthquake. Structures

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that are well-designed and possess enough ductility often exhibit superior performance during seismic occurrences, since they are capable of absorbing and dissipating the energy produced by the tremors. Recent years have seen substantial progress in high-rise building design, notably due to enhanced processing power and sophisticated software. Currently, engineers can develop intricate three-dimensional finite element models of structures, facilitating more precise simulations of seismic performance. Nonetheless, these models provide substantial quantities of data, making it simple for minor differences or imperfections in the model to be neglected. Engineers must be meticulous and proficient in structural behaviour and finite element modelling to guarantee analytical correctness.

The selection of a modelling technique may profoundly influence the distribution of forces and stresses inside the structure, possibly resulting in variations in the outcomes produced by various engineers. In conclusion, seismic performance analysis is essential for guaranteeing the safety and stability of high-rise structures during seismic occurrences. The choice of the suitable bracing system and the use of sophisticated seismic analysis methods are crucial for optimising structural design. Advancements in advanced modelling tools and enhanced processing capacity enable engineers to design structures capable of enduring natural pressures.

Nonetheless, meticulous evaluation of the results and a comprehensive grasp of structural behaviour are crucial for guaranteeing the dependability of seismic performance research.

2 RESERCH METHODOLOGIES

2.1 Response spectrum method

The representation of maximum response of idealized single degree freedom system having certain period and damping, during earthquake ground motions. This analysis is carried out according to the code IS 1893-2002 (part1). Here type of soil, seismic zone factor should be entered from IS 1893-2002 (part1). The standard response spectra for type of soil considered is applied to building for the analysis in ETABS 2013 software. Following diagram shows the standard response spectrum for medium soil type and that can be given in the form of time period versus spectral acceleration coefficient (Sa/g).

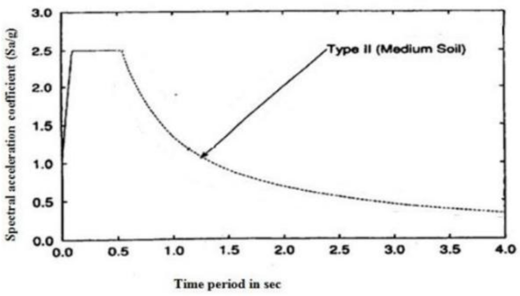


Fig 1: Response spectrum for medium soil type for 5% damping

This approach permits the multiple modes of response of a building to be taken in to account (in the frequency domain). This is required in many building codes for all except very simple or very complex structures. The response of a structure can be defined as a combination of many special shapes (modes) that in a vibrating string correspond to the “harmonic” computer analysis can be used to determine these modes for a structure.

2.2 Time history method

A suitable ground motion and recognised dynamics principles are required for the use of this technique. The building's mathematical model is exposed to accelerations based on seismic data, which reflect the predicted earthquake underneath the structure.

Once damping ratios of the visco elastically damped structure are evaluated, seismic response analyses can be carried out using available dynamic analysis programs. Figure 4.9 shows a typical time history response prediction and test result of a five story model under 0.6g Hachinohe earthquake (Chang et al. 1995). In this study, the VE damper assemblies are modelled as truss elements in the modified computer program ETABS with the inclusion of modal strain energy method. Similar studies have been carried out extensively and the results conclude that the elastic time-history response of visco elastically damped structures can be well predicted if damping ratios of the structure can first be accurately predicted.

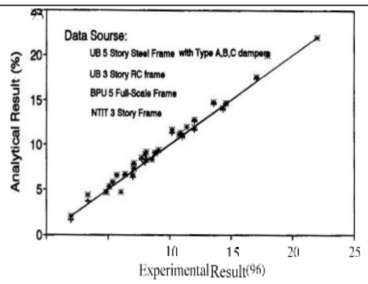


Fig 2: Experimental Result V/s Analytical Results

2.3 Pushover analysis

Pushover analysis is a static non-linear procedure in which the magnitude of structural loading along the lateral direction of the structure is incrementally increased in accordance with the certain predefined pattern. It is generally assumed that the behaviour of the structure is controlled by its fundamental mode and the predefined pattern is expressed either in terms of storey shear or in terms of fundamental mode shapes. With the increase in magnitude of lateral loading, the progressive non-linear behaviour of various structural elements is captured, and weak links and failure modes of structure re identified. In addition, pushover analysis is also used to ascertain the capability of structure to withstand certain level of input motion definedin terms of a response spectrum.

Pushover analysis is of two types, force and displacement controlled respectively. In the force control, the total lateral force is applied to the structure in small increments. In the displacement control, the displacement of top storey of structure is incremented step by step, such that required horizontal force pushes the structure laterally.

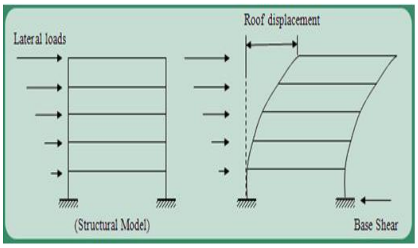


Fig 3: Displacement

2.4 Building Model in ETABS Software

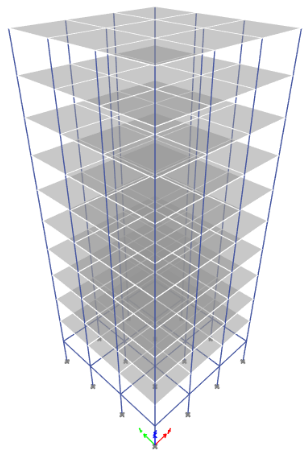
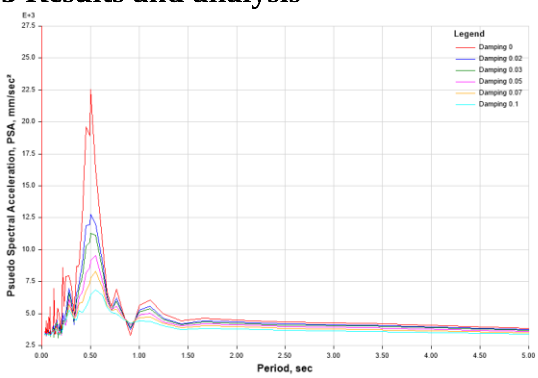


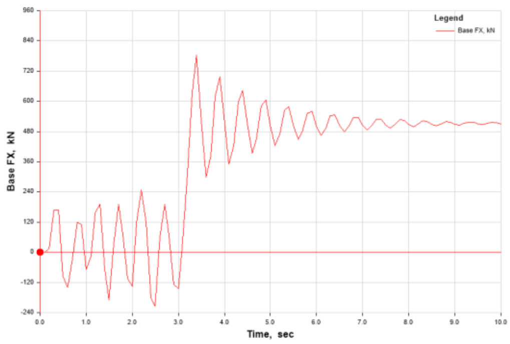
Fig 4: G+10 Building 3D Model

3 Results and analysis



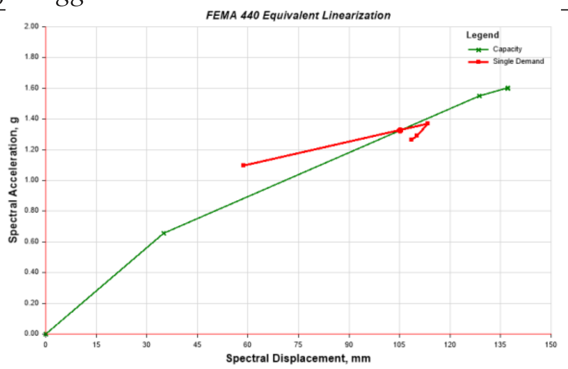
Plot 1: Spectral acceleration Vs Time period plot

Maximum Values obtained as per plot are T= 0.5, Spectral Acceleration = 22521.3 mm/sec^2



Plot 2: Base shear Vs Time period plot

Maximum Values obtained as per plot are T = 3.4, Base = 784.5kN



Plot 3: FEMA 440 Plot

Maximum Values obtained as per plot are Sd= 137.089, Sa= 1.60

Plot 4: NTC 2008 target displacement plot

Maximum Values obtained as per plot are Sd= 89.9 Sa=1.68

4. Conclusions

This paper strengthens the fact that earthquakes are still among the most devastating natural hazards, which can result in harmful structural damage and gradual failure of buildings that do not have proper seismic detailing. The concept of retrofitting comes out as a necessity to increase structural strength, service life and resilience, especially in old and weakened structures. Column jacketing, steel bracing and fibre-reinforced polymers techniques are very useful in enhancing ductility and energy ejection and can minimize the chances of collapse following severe movements of the ground. The integrated shear walls and dual systems also show improved performance in lateral load resistance, which justifies the use of these in seismic-prone areas. The behaviour of inelasticity, namely, the formation of plastic hinges, the decrease in the stiffness and the absorption of energy is highly important in predicting seismic performance. State-of-the-art analysis packages like ETABS offer nonlinear pushover and response spectrum analysis as well as time-history analysis, which is useful for performance-based seismic design. Generally, this piece of work demonstrates the necessity of strong design standards, systematic retrofitting and further research to provide safer and more resilient built environments.

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