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Seismic Evaluation of RCC Frames with Plan Irregularities Using Push Over Analysis

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ABSTRACT

This study presents a comparative seismic performance evaluation of high-rise reinforced cement concrete (RCC) buildings with different plan irregularities using nonlinear static pushover analysis. Using ETABS software, G+15 storey buildings were modeled with three plan geometries (rectangular, square, circular) and two types of irregularities (L-shape and diaphragm discontinuity). The analysis focused on structural performance parameters such as storey displacement, storey drift, base shear, and time period. The results reveal that plan irregularities significantly influence the seismic response, with L-shaped and diaphragm-discontinuous configurations showing increased displacement and torsional effects.

Keywords – *ETABS, plan irregularities, plan geometries*

I. INTRODUCTION

Rapid urbanization has prompted the construction of high-rise reinforced cement concrete (RCC) buildings, often with complex plan geometries due to architectural requirements. In seismic zones, these irregular configurations, such as L-shaped projections or diaphragm discontinuities, affect building performance by introducing torsion, stress concentration and irregular load paths. Traditional linear methods often fall short in accurately predicting the response of such structures under seismic loading. This study adopts nonlinear static pushover analysis to assess and compare the seismic performance of G+15 RCC buildings with different plan irregularities. The result aim to guide better design strategies for high-rise buildings in earthquake-prone areas.

A. Nonlinear Static Analysis (Pushover Analysis)

Pushover analysis which is an iterative procedure is looked upon as an alternative for the conventional analysis procedures. Pushover analysis of multi-story RCC framed buildings subjected to increasing lateral forces is carried out until the present performance level (target displacement) is reached. The promise of performance based seismic engineering (PBSE) is to produce structures with predictable seismic performance. The recent advent of performance-based design has brought the nonlinear static pushover analysis procedure to the forefront. Pushover analysis is a static non-linear procedure in which the magnitude of the structural loading along the lateral direction of the structure is incrementally increased in accordance with a certain pre-defined pattern. If 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 story shear or in terms of fundamental mode shape. 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 the structure are identified. After this progressive post elastic analysis of the structure the designer can make necessary changes in the design configuration in order to obtained desired plastic hinge sequence under the applied lateral loads. In addition, pushover analysis is also used to ascertain the capability of the structure to withstand a certain level of input motion defined in terms of a response spectrum. The pushover analysis is more convenient than full dynamic analysis because of computational time. With pushover analysis, results took considerably much lesser time than dynamic analysis. Thus, pushover analysis is more practical for use in a design office. After the structure has been designed or retrofitted using appropriate codes or design guidelines, is that it yields additional information on the limit states, the plastic hinge sequence and the force redistribution caused by a seismic event. The designer can make changes in the design configuration in order to obtain a desired plastic hinge sequence under applied lateral loads. The pushover analysis also yields detailed member information such as maximum inter-story drift demands and plastic hinge rotations, thereby increasing the effectiveness and efficiency of design. The performance of the structure was a phenomenon that structure must have the capacity to resist demands of the earthquake. Performance point represents the condition for which seismic demand imposed on the structure was equal to the seismic capacity.

B. Aim of the Present Work

The aim of the project is to evaluate and compare the seismic performance of a high-rise RCC building with varying plan irregularities and geometries using nonlinear static pushover analysis. The objective is to understand how different configurations influence the structural behaviour under seismic loading and to identify how the irregularities affect the performance and safety of high-rise buildings.

C. Objectives

1. **To model a high-rise (G+15) RCC building** with various plan geometries such as rectangular, square and circular geometry using ETABS software.
2. **To introduce plan irregularities and geometric variations** in each model to simulate real-world asymmetry and mass/stiffness discontinuity.
3.
4. **To perform nonlinear static pushover analysis** on each model to assess seismic performance in terms of:
    - Storey displacement
    - Storey drift
    - Base shear
    - Time period
5. **To compare the seismic responses** of all geometrical configurations with irregularities.
6. **To draw conclusions** for better seismic design practices for high-rise RCC buildings with plan irregularities.

II. METHODOLOGY

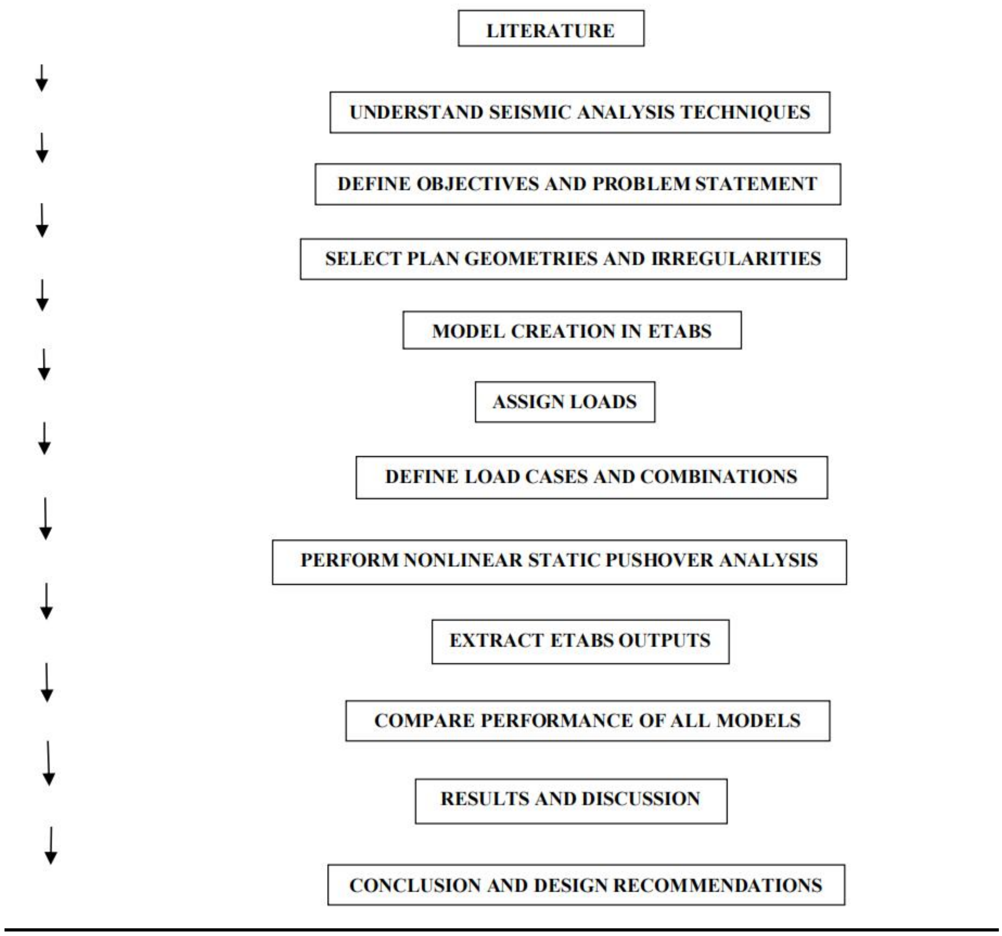

Fig. Methodology

2.1 Modeling Approach

G+15 RCC buildings were modeled in ETABS with M40 concrete and Fe500 steel, categorized as:

- Square,Rectangular, and Circulargeometries
- Each with two irregularities: L-shape re-entrant corners and diaphragm discontinuities

2.2 Material and Structural Properties

- Concrete: M40
- Steel: Fe500
- Beam: 300 mm x 600 mm
- Column: 600 mm x 600 mm
- Slab: 150 mm thick

2.3 Loading Parameters

- Dead Load: Auto-calculated
- Live Load: 4 kN/m² (floors), 2 kN/m² (roof)
- Wall Load: 7.8 kN/m
- Seismic Load: Zone III (Pune), IS 1893:2016
- Wind Load: As per IS 875 (Part 3):2015

2.4 Pushover Analysis Procedure

Pushover loads were applied incrementally in X and Y directions. Hinges were assigned per FEMA 356. ETABS outputs such as pushover curves, performance points, storey displacement, and drift were analysed.

III. RESULTS AND ANALYSIS

-Storey Displacement

Circular geometry exhibited the least displacement due to symmetric mass distribution. L-shape irregularities caused higher displacements at upper storeys due to torsional amplification.

-Storey Drift

Drift exceeded IS 1893 limits in L-shape and diaphragm-cut square and rectangular plans. Irregularities introduced soft-storey effects in mid and upper levels.

-Base Shear

Circular models had the highest base shear capacity, followed by square and rectangular. Irregularities reduced base shear capacity by ~10-20%.

-Time Period

Circular models had shorter time periods due to higher stiffness. L-shape and diaphragm cut models showed increased fundamental time periods, implying flexible behaviour.

-Pushover Curves

Circular geometry reached performances points at higher base shear and displacement, indicating better ductility and energy absorption. L-shape irregular models failed earlier, showing rapid strength degradation and hinge concentration near re-entrant corners.

IV. Conclusion

The study concludes that:

-Plan irregularities substantially affect affects seismic performance.

-Circular geometry is most seismically efficient due to its symmetric shape and uniform stiffness.

- L-shape and diaphragm irregularities introduce torsion, increase displacement/ drift, and reduce base shear capacity.

-Pushover analysis effectively reveals weak zones, hinges patterns and collapse mechanisms, making it an essential tool for evaluating irregular high-rise structures.

V. SCOPE FOR FUTURE WORK

-Incorporate soil-structure interaction and foundation flexibility.

- Evaluate performance under near-fault ground motions using nonlinear time-history analysis.

-Extend the study to structures with shear walls, braced frames, or base isolation.

-Consider aging effects, material degradation and P-delta impacts over building life.

VI. References

1. IS 1893 (Part 1): 2016, BIS, New Delhi.
2. FEMA 356: Prestandard for Seismic Rehabilitation of Buildings, 2000.
3. Chopra A.K. (2017). Dynamics of Structures. Pearson.
4. Paulay T. and Priestley M.J.N. (1992). Seismic Design of Reinforced Concrete and Masonry Buildings.
5. Deekshithay L. & Kiran Kuldeepk N. (2018). IJCIET.
6. Bhagat A.S. & Bhilare M.B. (2021). IJERT.
7. Mehta A. & Shah M. (2015). IJSRD.
8. Additional references as cited in the original thesis document.

Etabs software

Structural and Earthquake Engineering Software, "ETABS 2016", Computers and structures, Inc.