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Nonlinear Static (Pushover) Analysis of G+4 Storey R.C.C. Building

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Abstract

Earthquakes are known to produce one of the most destructive forces on the earth. It can causes loss of life and property and economical loss of the country. Earthquake cannot be prevented, since it is unpredictable, but loss of life of people and damage to the structures can be prevented if later is designed properly. Performance Based Design (PBD) of structure is the modern approach to earthquake resistant design. PBD is applicable to design of new buildings or retrofit to existing buildings. PBD defines various limit state of performance for the building and hence gives clearcut idea about its performance under hazards that is considered.

Present study work is carry out the work on performance level of G+4 storey R.C.C. building using specified limit states as per ATC-40 and Indian code. Analysis has been carried out using ETABS (version 9.5). Three analytical models are considered in present study, namely, Bare Frame (i.e, w/o masonry infill wall), Frame with infill wall as membrane and Frame with infill wall as strut. This paper includes the evaluation of pushover curve, capacity spectrum curve and performance point for pushover analysis applied on G+4 storey R.C.C. building.

Keywords- *Pushover curve, Capacity Spectrum curve, Different analytical model, Performance point, Nonlinear Static Analysis.*

I. INTRODUCTION

Each building need to access for its seismic capacity and characteristic performance of building is required to understand. Hence, performance based seismic analysis is essential for the buildings to understand its behavior and response during earthquake.

Performance based design provides a systematic methodology for assessing the performance capability of a building, system or component. It can be used to verify the equivalent performance of alternatives, deliver standard performance at a reduced cost, or confirm higher performance needed for critical facilities.

In performance based design, identifying and assessing the performance capability of a building is an integral part of the design process, and guides the many design decisions that must be made. FEMA 445 describes a flowchart that presents the key steps in the performance based design process.

Performance based design begins with the selection of design criteria stated in the form of one or more performance objectives. Each performance objective is a statement of the acceptable risk of incurring specific levels of damage, and the consequential losses that occur as a result of this damage, at a specified level of seismic hazard.

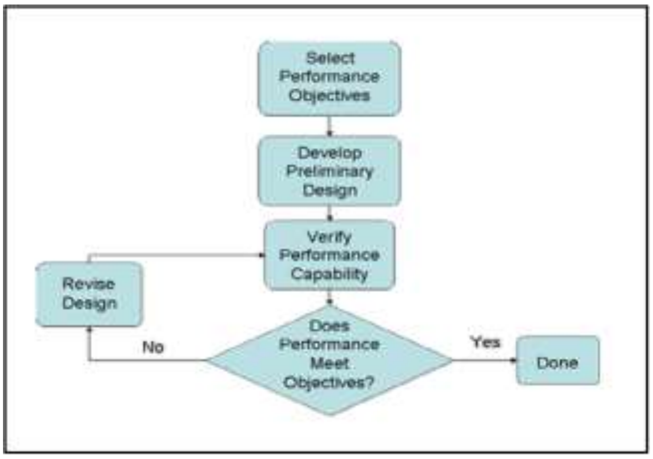

Figure 1: Performance based design flow diagram

II. BUILDING CONFIGURATION

2.1. A G+4 storey RC building of plan dimension 20 m x 15 m as shown in figure (1), each bay of 5m in length, located in seismic zone III on medium soil is considered. The storey height is 3m and slabs are of 150 mm thickness. Brick wall below all beams are 115 mm thick. Consider concrete grade M 25 and steel grade Fe 415, respectively.

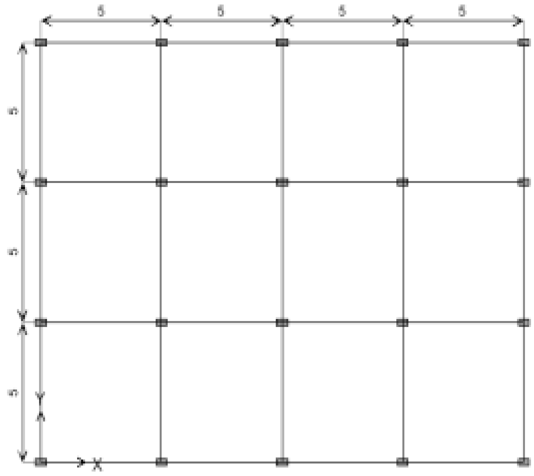

Figure 2: Plan of G+4 storey R.C.C. building

Table 1: Geometric Properties of frame and live loads on slab

Floor	Column size (mm)	Beam size (mm)	Live load on slab (KN/m^2)
G.F.	230x600	230x500	2
1st floor	230x600	230x500	2
2nd floor	230x500	230x450	1.5
3rd floor	230x500	230x450	1.5
4th floor	230x450	230x450	1.5

2.2. Modeling of building

To perform pushover analysis, it is required to prepare analytical model of G+4 storey building. Structural elements like slabs, beams and columns are modelled as rigid diaphragm. However, modeling of masonry infill wall is typical.

In present study, masonry wall is replaced by membrane element with inplane stiffness and as a strut element of some width and thickness. Thus, three analytical models are considered in present study, namely, Bare Frame (i.e, w/o masonry infill wall), Frame with infill wall as membrane and Frame with infill wall as strut.

2.2.1. Bare Frame without infill wall

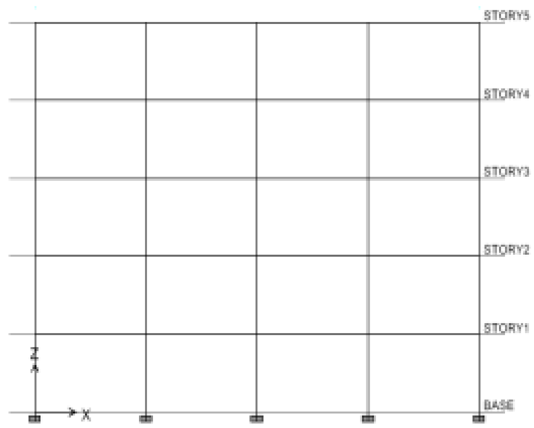

Figure 3: Elevation of G+4 bare frame model

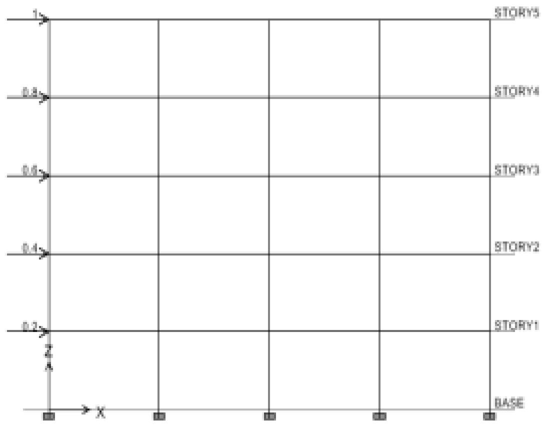

Figure 4: Lateral Loading Pattern

The lateral load is applied in X-direction. The unit load (1kN) is applied at the top of the column and simultaneously reducing by 0.2kN from top to base as shown in figure (4).

2.2.2. Building Frame with infill as membrane wall

This model is prepared as membrane elements to replace with infill wall. The infill walls are provided below all the beams except the first floor beams, in order to estimate real life problem. The thickness of wall is 115 mm.

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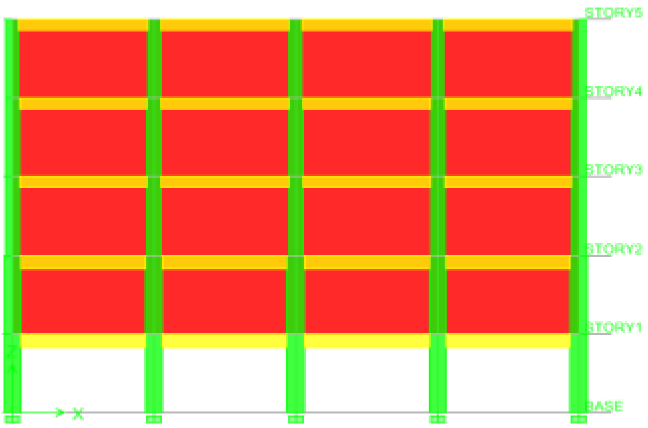

Figure 5: G+4 storey model with infill as membrane wall

2.2.3. Building Frame with infill as equivalent strut

In this model, the diagonal strut is modeled in place of infill wall. Here, the ends of diagonal struts are released for moments and torsion in all the directions, to overcome rigidity effect. We have taken the thickness of the strut is 115 mm and the width of strut is calculated as 1.94 m, for present case.

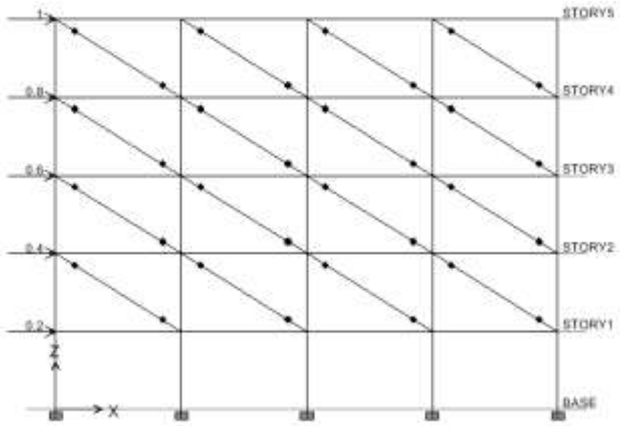

Figure 6: G+4 storey with infill as equivalent strut

III. NONLINEAR STATIC (PUSHOVER) ANALYSIS

3.1. Nonlinear Hinge Property Assignment

ETABS software has default nonlinear hinge property like moment hinge and shear hinge. This hinges are added to all beams, columns and diagonal struts at relative distance zero and one at both the ends to perform pushover analysis.

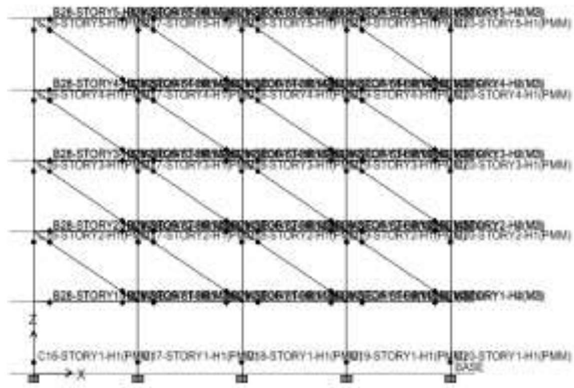

Figure 7: Nonlinear Hinges in beams and columns

3.2. Pushover Analysis and Results of building without Infill Wall

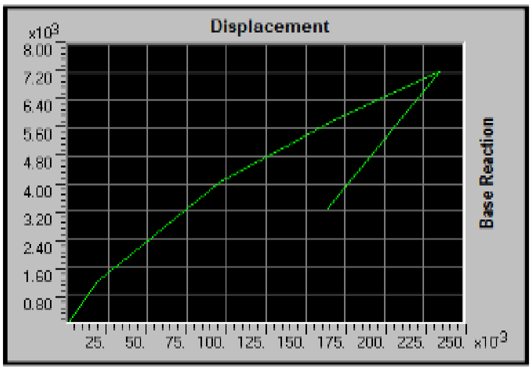

Figure 8: Pushover Curve for G+4 storey Bare Frame

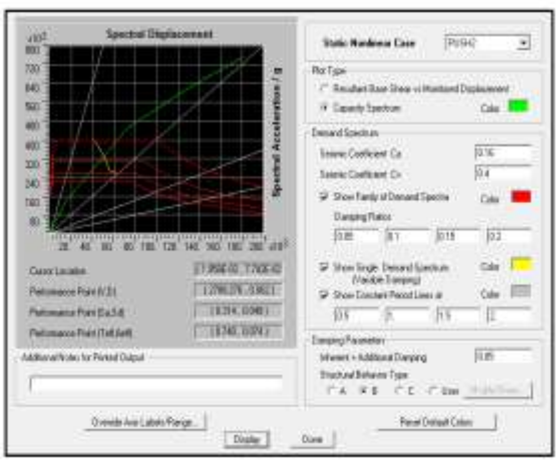

Figure 9: Capacity Spectrum Curve for G+4 storey Bare Frame

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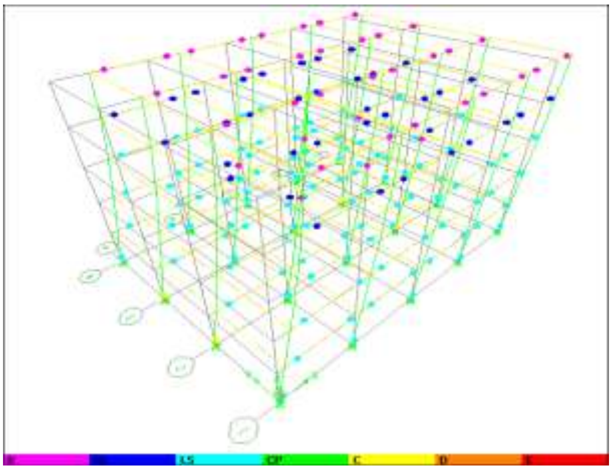

Figure 10: Hinge Formation at Performance Point in Bare Frame model

From figure (10) it is shows that the plastic hinge formation of building is more in Life Safety to Collapse Prevention range, which also resist more seismic force in future. Therefore, overall performance of building is said to be Life Safety to Collapse Prevention.

3.3. Pushover Analysis and Results of building with Infill Wall

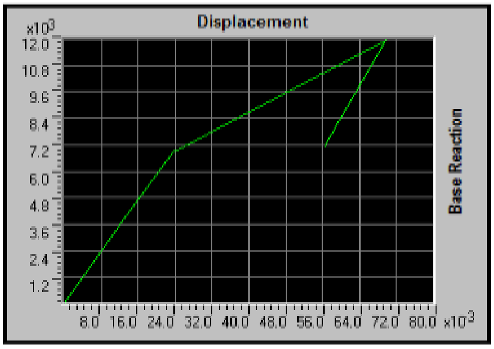

Figure 11: Pushover Curve for G+4 storey InfillFrame

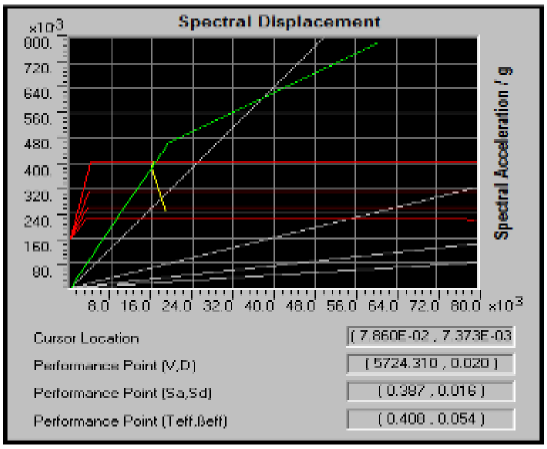

Figure 12: Capacity Spectrum Curve for G+4 storey Infill Frame

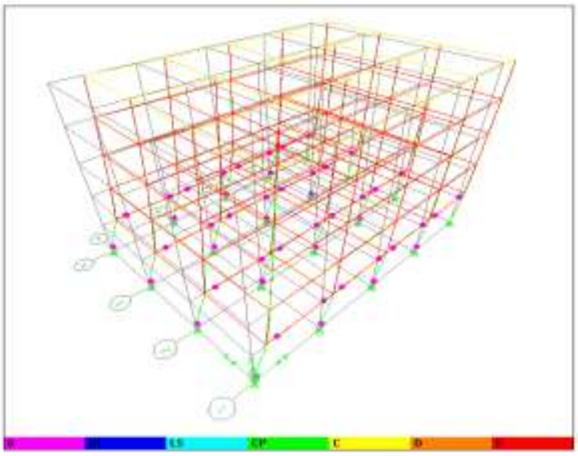

Figure 13: Hinge Formation at Performance Point in Infill Frame model

From figure (13) shows that the plastic hinge formation of building is more in Immediate Occupancy range, which also resist more seismic force in future. Therefore, overall performance of building is said to be Immediate Occupancy.

3.4. Pushover Analysis and Results of building with Equivalent Strut

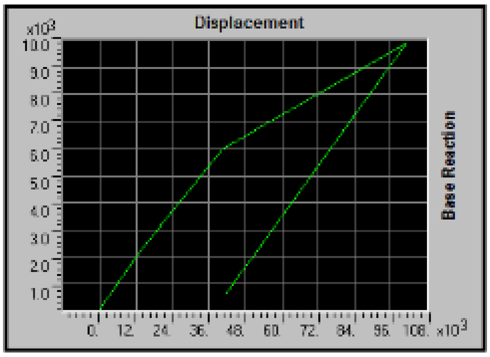

Figure 14: Pushover Curve for G+4 storey Equivalent Strut

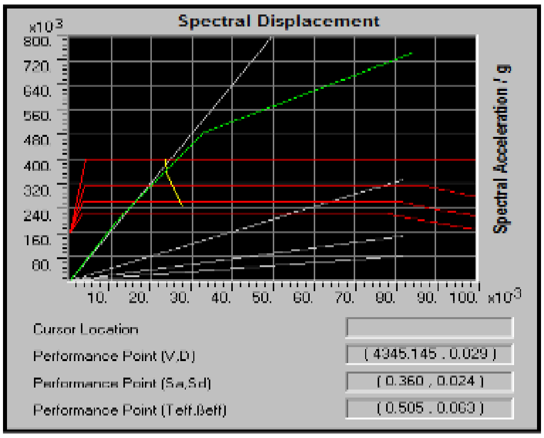

Figure 15: Capacity Spectrum Curve for G+4 storey Equivalent Strut

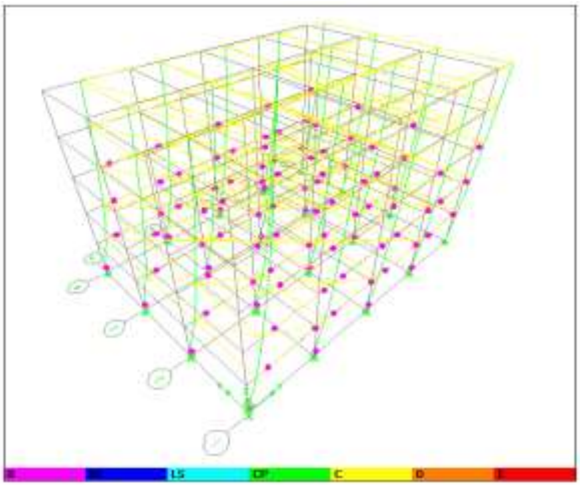

Figure 16: Hinge Formation at Performance Point in Equivalent Strut model

As shown in Figure (16) there was no hinge formation in columns, only plastic hinges are shown in beams. Overall performance of building is of Immediate Occupancy.

VI. CONCLUSION

Following conclusions are made based on work carried out:

1. Different building model developed based on different modeling aspects showed distinct modeling effect on overall results of the building.
2. As new building has designed for an earthquake forces prior to nonlinear analysis its performance was found satisfactory.
3. Building model without infill i.e, bare frame has an overall performance in Life Safety to Collapse Prevention.
4. Building model with infill as membrane wall has an overall performance in Immediate Occupancy level.
5. Building model with infill as equivalent strut has an overall performance in Immediate Occupancy level.
6. It has been observed that, performance point of three models of building lies in nonlinear range.

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