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Non-Linear Static Analysis of RCC Frames

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***Abstract* – With the lot of loss of life and property due to failure of structure caused by earthquake, now it is necessary to pay an attention to the adequate accuracy of strength in RC frame structures. Non-static analysis is called pushover analysis which had been used for analysis of structures. After analysis results were compared for different number of bays and different number of storey of buildings. This whole analysis procedure carried out in SAP2000 software with the use of code FEMA-356.**

***Index Terms* – Pushover Analysis, SAP2000, FEMA-356**

I. INTRODUCTION

The major cause for building damage is due to seismic effect. As the ground shakes, building loses its stability and gets collapsed.[1] Earthquakes are one of the most deadly and highly unpredictable dynamic forces acting on a structure. The buildings which appeared to be strong enough, may crumble like house of cards during an earthquake and deficiencies may be exposed. Experiences from the past earthquakes demonstrate that most of the buildings collapsed were found to be seismically deficient because of lack of awareness regarding seismic behavior of structures. The design of earthquake resistant structures is a challenge as well as a motivation for all designers.[2] So for any structure, seismic analysis is mandatory as it resists the structure against the seismic forces. In different parts of world, different methods of seismic analysis are practiced. We consider two different seismic approaches for our study:
i. Force Based Design Method (FBD)
ii. Direct Displacement Based Design Method (DDBD)[1]
This distinction is an implication of the fact that an earthquake can be visualized to impart forces on the structure or induce displacements in it. Seismic design of buildings has been traditionally force based. In general, most earthquake code provisions implicitly require that structures be able to resist minor earthquakes without any damage, moderate earthquakes with negligible structural damage and some non-structural damage.[3]

II. PUSHOVER ANALYSIS

Pushover analysis s an approximate analysis method in which the structure is subjected to monotonically increasing lateral forces with an invariant height-wise distribution until a target displacement is reached. Pushover analysis is consists of a series of sequential elastic analysis, superimposed to approximate a force-displacement curve of the overall structure.[4]

There are different Performance and hazard levels. Form hinge properties, these performance levels are evaluated.

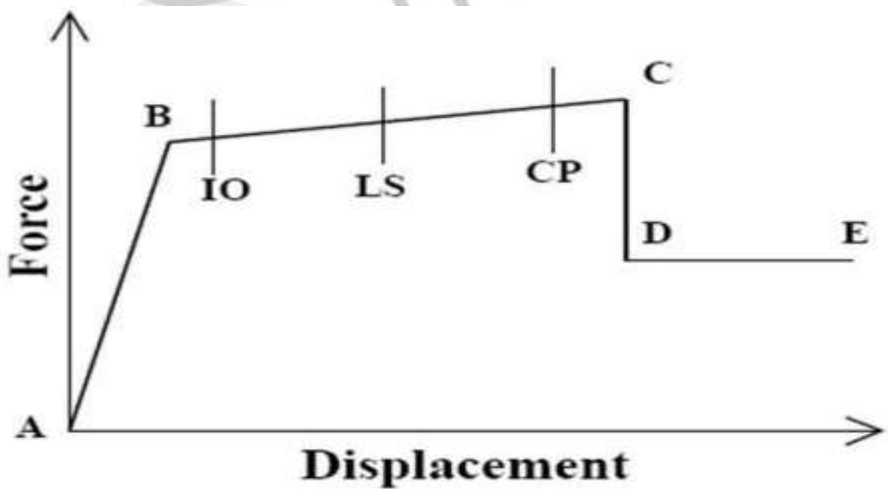

Figure 1: Performance Objectives

III. MODELING PROCESS

Here two buildings of different heights were selected for the analysis with four different bay conditions i.e. 6x4, 6x6, 8x6 and 8x8 numbers of bay frames with 10 and 20-storey building. Dead load, Live Load, Floor Finish and Earthquake Load in X and Y-direction were applied on structure.

Beams and Column sections were different for different floors. Thickness of slab is 125 mm. Height of each floor is 3.1 m.

Earthquake load is applied as per IS 1893:2002 for zone V.

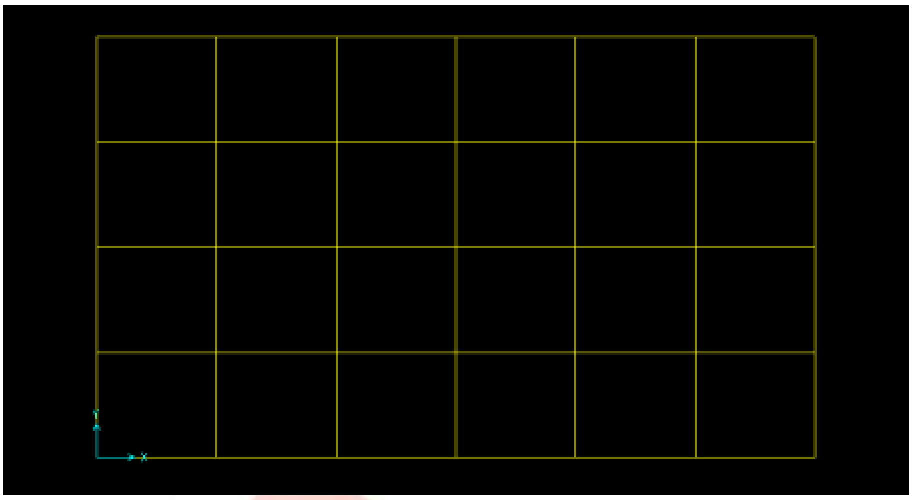

Figure 2: Plan of 6x4 number of bay frame building

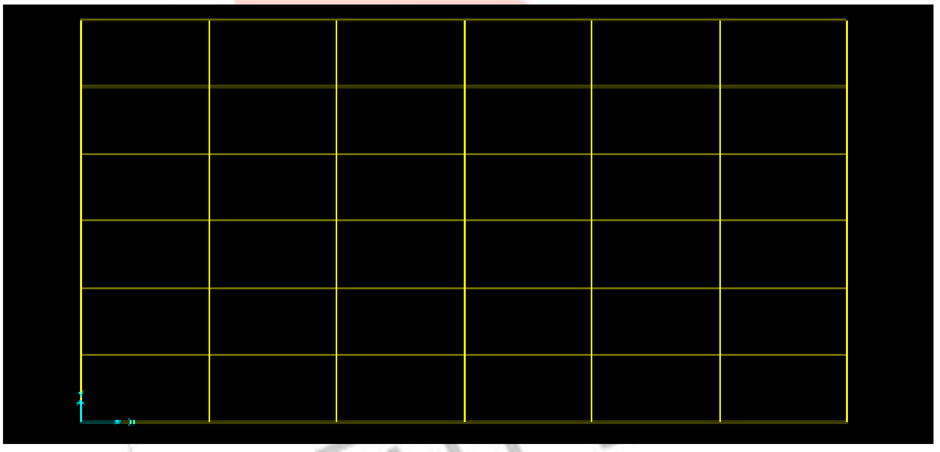

Figure 3: Plan of 6x6 number of bay frame building

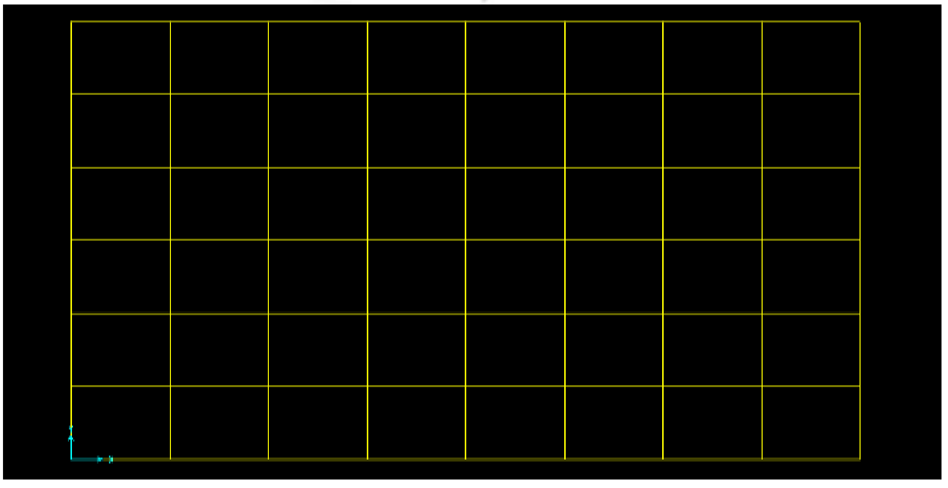

Figure 4: Plan of 8x6 number of bay frame building

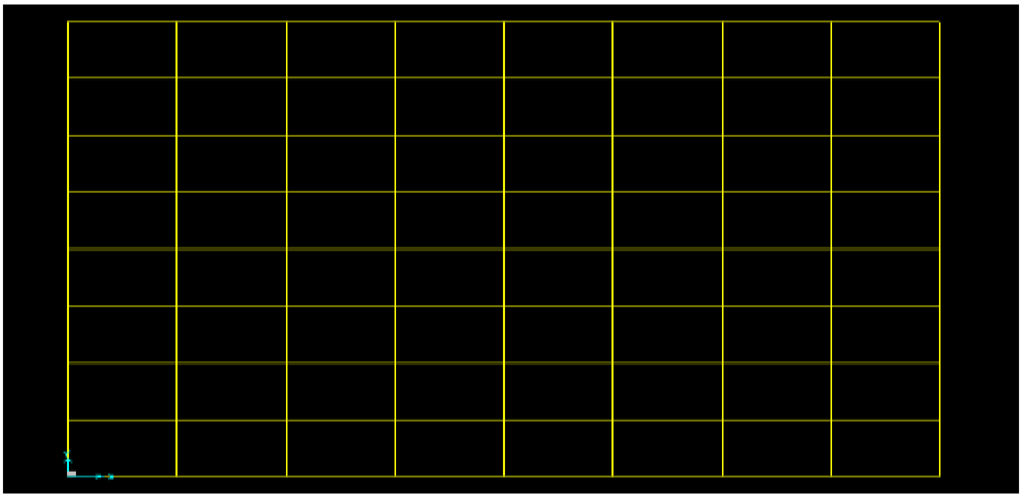

Figure 5: Plan of 8x8 number of bay frame building

IV. Analysis process

After completion of modeling process next step which carried out was analysis of building. Here we carried out non-linear static pushover analysis. According to this analysis we had provided hinge to beams and columns of whole building. These hinge properties are taken as per FEMA-356.

V. Results

Here, results were developed in terms of different building configurations like hinge property, performance level, displacement, base shear.

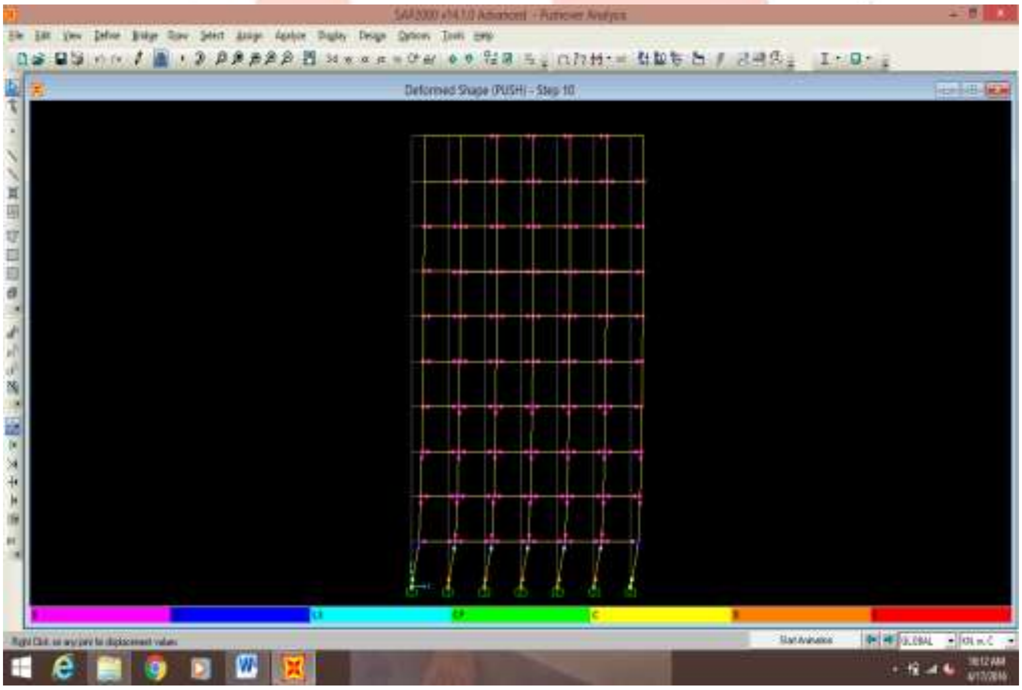

Figure 6: Hinge formation of 10-storey Building

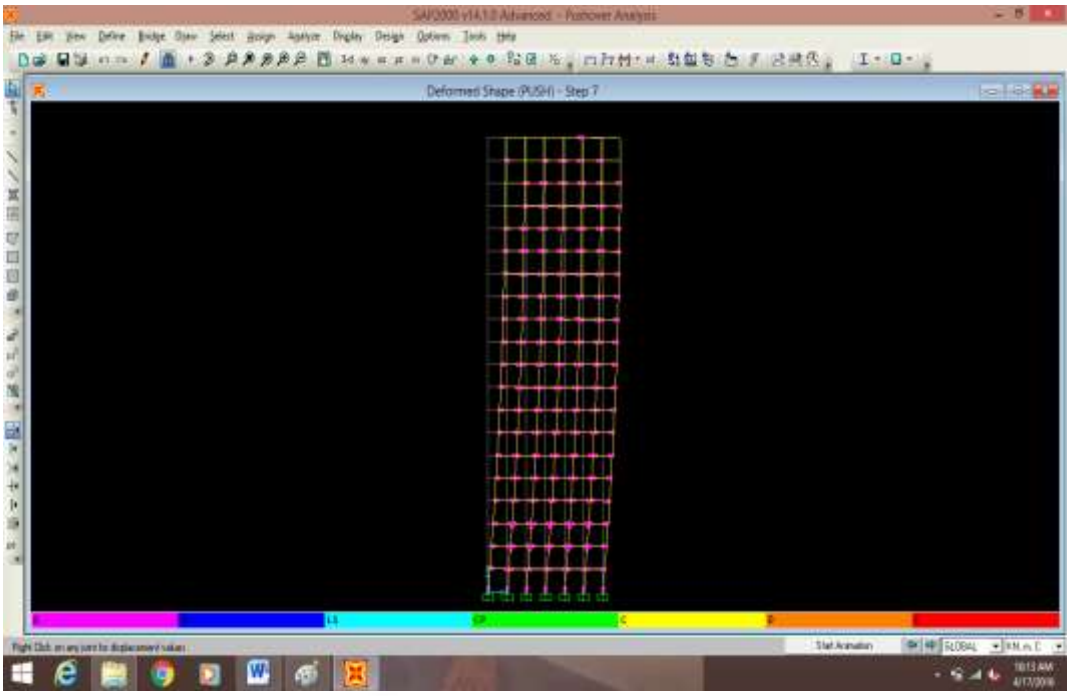

Figure 7: Hinge formation of 20-storey Building

In above figure, different colors of dots represent the hinge property, according to which performance level of building should be recognized. Blue hinge shows Immediate Occupancy Level, Light Blue hinge shows Life Safety Level and Green Hinge shows Collapse Prevention Level. Here, lower floors of 10-storey building had performance level between Life Safety and Collapse Prevention.

Displacements and Base shear according to Performance Point

According to the performance point we got displacement and base shear of all building model. If displacement is more than target displacement then that structure seems to fail. We set target displacement to 500 mm.

Following are the graphs for displacement and base shear comparison of buildings having different storey heights and having different numbers of bay.

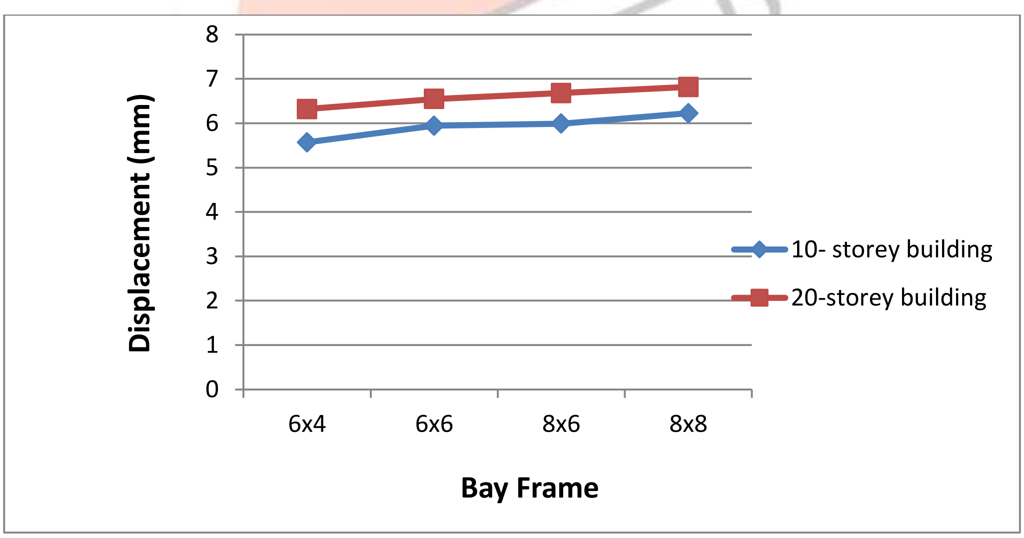

Figure 8: Graph of Displacement

This graph shows that displacement of 10-storey building is lesser than the displacement of 20- storey building, which means as the height increases displacement also increases. This displacement occurred in building according to performance point. There is very minor difference between displacement values of different numbers of bay frame buildings, but as numbers of bay increases value of displacements also increases.

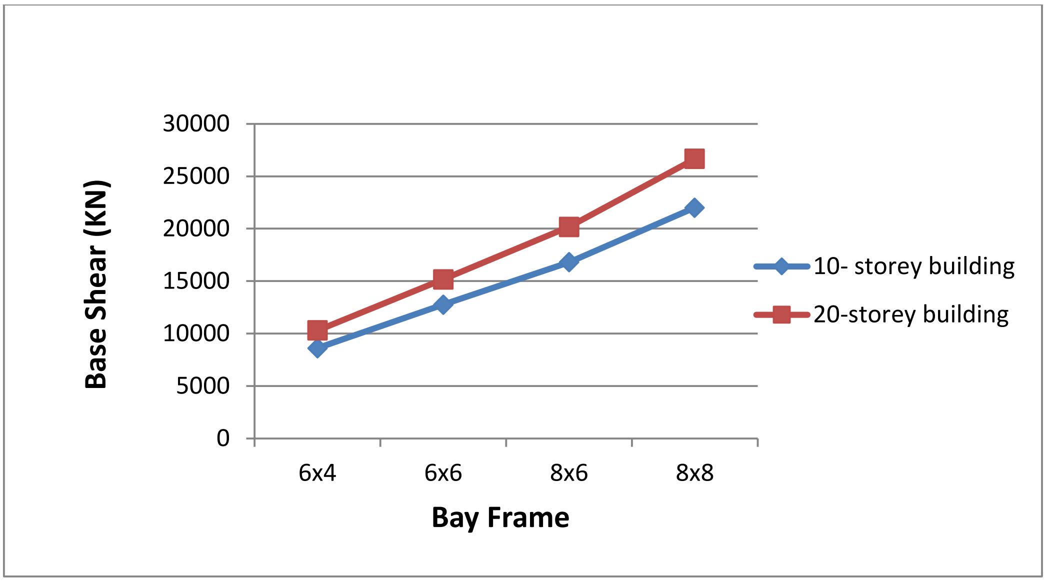

Figure 8: Graph of Base Shear

This base shear graphs shows that base shear is higher in 20-storey building than 10-storey building. But there is a huge difference of base shear in buildings of different numbers of bay frame. The value of base shear in 6x4 number of bay frame 10-storey building is 8601.654 KN and the value of base shear in 8x8 number of bay frame 10-storey building is 21998.572 KN. Same way. The value of base shear in 6x4 number of bay frame 20-storey building is 10297.251 KN and the value of base shear in 8x8 number of bay frame 10-storey building is 26659.92 KN.

VI. Conclusion

- In case of pushover analysis for base shear, it shows higher difference with change in number of bay frame.
- Formation of plastic hinges in case of pushover analysis reveals the performance level of building. 10-storey building needs retrofitting at lower floors because it lies between life safety and collapse prevention level.
- Also we conclude that as number of bay increases, the load carrying capacity also increases but corresponding displacement have negligible variation.

VII. Acknowledgment

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