Non-linear Static Analysis of RC Frame Building with and without Shear Wall

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Abstract — **Earthquakes are known to produce one of the most destructive forces on earth. Performance Based Design is the modern approach for earthquake resistant design. The present study is an attempt to understand the fundamentals of Performance Based Design with and without R.C.C. shear wall building and to check which one is more effective.**

Keywords — **Non-linear static analysis, RC frame, ETABS 9.7.**

I. INTRODUCTION

In the performance-based design approach, acceptability criteria are established in term of performance level or damage levels for a specified earthquake ground motion. As per current performance-based design practice, the structures are considered capable to resist minor earthquake without significant damage, moderate earthquakes with repairable damage and major earthquakes without collapse.

Performance Level

A performance level is described in term of limiting damage condition which may be considered satisfactory for a given building. The target performance objective is divided into Structural Performance Level and Non-structural Performance Level. Based on the combination of these two performances the overall building performance is determined.

Structural Performance Level

- Immediate Occupancy (SP-1): Limited Structure damage with basic vertical and lateral force resisting system retaining most of their pre-earthquake characteristics and capacities.
- Damage Control (SP-2): This term is actually not a specified value but damage is considered somewhere between Immediate Occupancy and Life Safety.
- Life Safety (SP-3): Significant damage with some margin against total or partial collapse. Repair may not be economically feasible.
- Limited Safety (SP-4): This term is actually not a specific level. It is somewhere between Life Safety and structure stability.
- Structural Stability (SP-5): Substantial Structure damage in which the structure system is on the verge of experiencing partial or total collapse. Significant risk of injury exists. Repair may not be technically or economically feasible.

Not Considered (SP-6): Placeholder for situation where only non-structural seismic evaluation or retrofit is performed.

Non-structural Performance Level

- Operational (NP-A): Non-structural elements are generally in place and in working condition. Backup system for failure of external utilities, communications and transportation has been provided.
- Immediate Occupancy (NP-B): Non-structure elements are generally in place but may not be working in condition.
- Life Safety (NP-C): Considerable damage to non-structural component and system but no collapse of non-structural heavy items.
- Reduced Hazards (NP-D): Extensive damage to non-structural component but should not include collapse of large and heavy items that can cause significant injury to groups of people.
- Not Considered (NP-E): Non-structural element, other than that have an effect on structural response, are not evaluated.

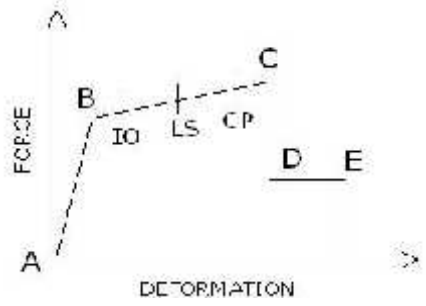


Fig.1 Force-deformation for pushover hinge

Various performance levels are considered depending on type of damages in the structure. Negligible impact on building is considered at an operational level. Building is safe to occupancy but possibly not useful until the repaired is considered as an immediate occupancy level. Building is safe during event but possibly not afterward is considered as a life safety level and building is very near to collapse is considered as collapse prevention.

Steps involved in this analysis procedure:

1. Evaluation of Capacity of building i.e. Representation of the structure's ability to resist a force.
2. Evaluation of Demand curve i.e. Representation of earthquake ground motion.
3. Determination of Performance point i.e. Intersection point of demand curve and capacity curve.

Necessity of RCC shear wall

- Shear wall are one of the excellent means for providing earthquake resistance for multi-storey structure.
- Shear wall resist the wind and earthquake forces and transfer that load to foundation. Well designed system of shear wall in the building frame improves its seismic performance significantly.
- Shear walls are used to resist the lateral loads due to wind and earthquake.
- They are provided between the columns lines.

Purpose of RCC shear wall

- To improve the behavior of the very flexible frames, which are more prone to earthquake, by stiffening them with shear walls.
- To avoid column shear failures due to inter-storey distortion.
- To avoid column shear failure in sway due to P- effect (i.e. Secondary bending resulting from product of vertical load and lateral deflection.)
- To reduce lateral drift.
- To reduce reinforced concrete joint detailing problem.

II. OBJECTIVES AND SCOPE

The main objective of present work is to evaluate the seismic performance of reinforced concrete frame building with and without RCC shear wall using ETABS 9.7. Objectives of the present work are as follow:

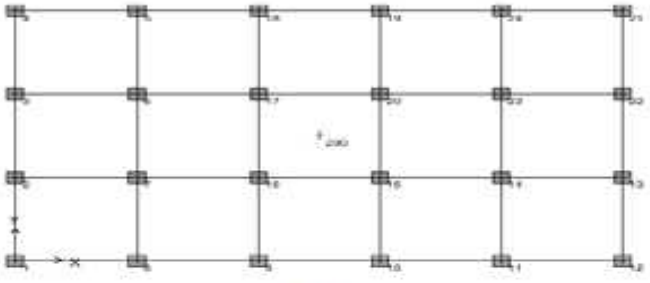
1. To study of nonlinear hinge properties as per IS code and failure effect on structural element.
2. To evaluate storey-displacement.at performance point.

III. NUMERICAL STUDIES

The seismic performance analysis of overall plan of 15m x 25m for G+15 storied frame structure with 3.2m storey height and provides shear wall on different positions are analyzed using pushover analysis. The non-linear static analysis used in the study as obtained from IS 1893 (part 1): 2002. The study is conducted by taking the soil base as medium soil and important factor is 1.0 and zone III. All beams are of size 300 mm x 750 mm and Column size of 675 mm x 675 mm. Materials are used concrete of M25 grade and steel of Fe415 grade.

LOAD CONSIDERED: slab and shear wall thickness are 0.15m and 0.25m respectively. Imposed load: 3 KN/m^2 and floor finish: 1.5 KN/m^2

The analysis results for different models are represented in tabular and graphical form for analysing, comparison and understanding.



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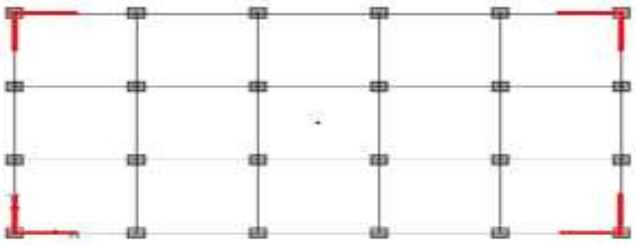

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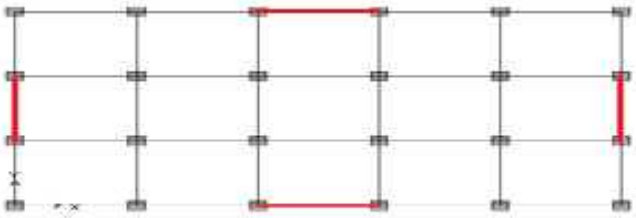

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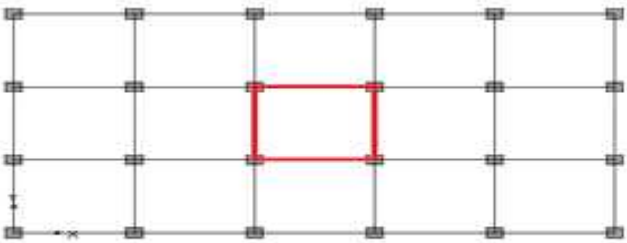

TYPE D

In figure shown, red line of the grid which is represents the shear wall in different position of rectangular type of the building.

IV. RESULTS AND DISCUSSION

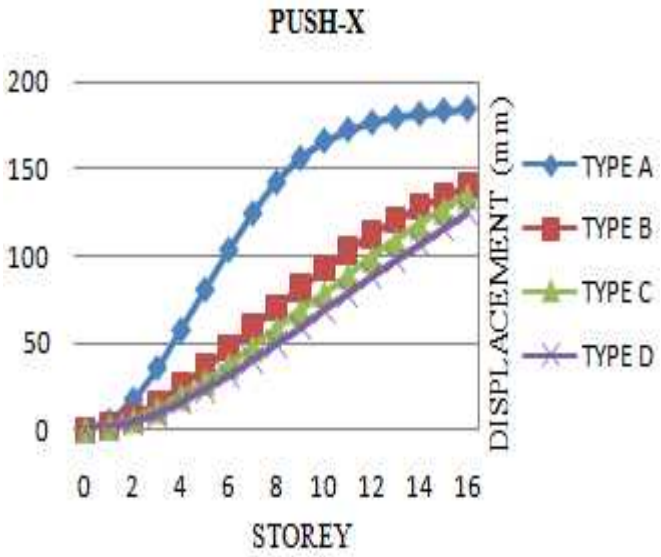

Fig. 2 Storey-displacement at performance point in X-Direction

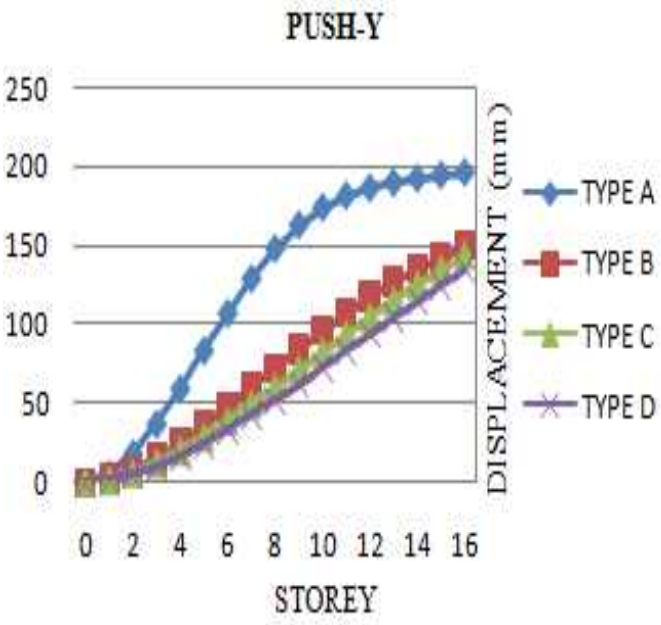

Fig. 3 Storey-displacement at performance point in Y-Direction

From the comparison of results, I concluded that the displacement at each storey at performance point, Performance of type D building is better than another types of building.

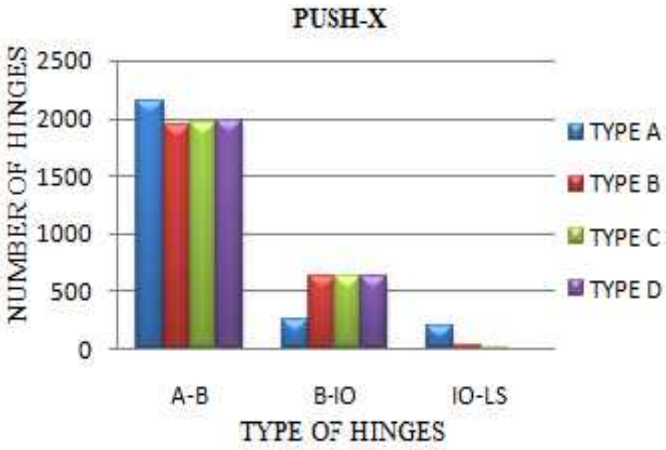

Fig. 4 Number of hinges at different deformation level in X-Direction

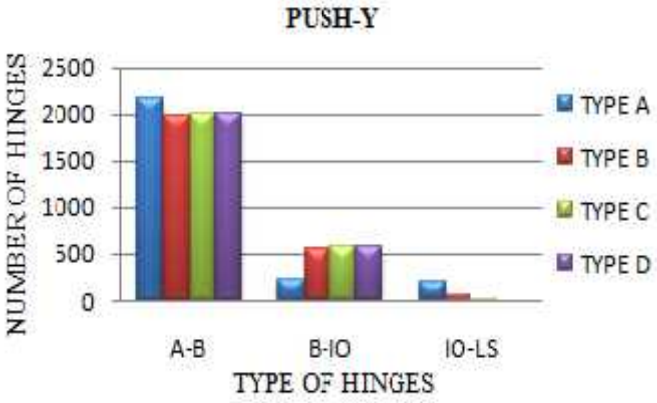

Fig. 5 Number of hinges at different deformation level in Y-Direction

From the comparison of results, I concluded that the number of hinges at different deformation level in both the direction at performance point, Performance of type D building is better than another types of building.

V. CONCLUSIONS

On the basis of the numerical studies, I carried out non-linear static pushover analysis to find the performance of reinforced concrete frame building using different positions of RCC shear wall for a G+15 model with storey height 3.2m.

From the comparison of results, I carried out the seismic performance of the building is improved by providing the shear wall at Inner core of the building (Type D) when the overall plan of the building is rectangular.

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