Study on Rigid and semi rigid diaphragm in multistoried structure Using E-tabs

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Abstract - *In this study, seismic analysis of multistory reinforced concrete structure has been carried out by considering two types of floor diaphragm. The floor diaphragm means the interaction of the lateral load with lateral load resisting vertical elements is achieved by the use of floor system. For the analysis ETABS software has been used, the analysis was carried out in structure with two different floor diaphragm, that is rigid floor diaphragm and semi rigid diaphragm. And this comparative study is done with three different type of structures, that is RC structure without diaphragm , rigid diaphragm and semi rigid diaphragm with shear wall structure and the results are collected in terms of Base shear, Maximum storey displacement, and Maximum storey drifts for Z-II and medium soil type.*

Key Words: **Diaphragms ,shear wall, base shear, storey displacement, storey drift.**

1. INTRODUCTION

Diaphragm is a structural element that transmits lateral loads to the vertical resisting elements of structure (such as shear wall, frames) Diaphragms are typically horizontal, but can be sloped such as in a gable roof on a wood structure or concrete ramp in a parking garage. The diaphragm forces tend to be transferred to the vertical resisting elements primarily through in-plane shear stress. The most common lateral loads to be resisting from wind and earthquake actions, but other lateral loads such as lateral earth pressure or hydrostatic pressure can also be resisted by diaphragm action. the diaphragm of a structure often does double duty as the floor system or roof system in building, or the deck of a bridge, which simultaneously supports gravity loads. Diaphragms are usually constructed of plywood or board in timber construction metal deck or composite metal in steel construction or concrete slab in concrete construction. Rigid diaphragms transfer load to frames or shear walls depending on their flexibility and their location in the structure. The flexibility of a diaphragm affects the distribution of lateral forces to the vertical components of the lateral force resisting elements in a structure, semi rigid diaphragms distribute the lateral forces based on the stiffness of the slab.

2. LITERATURE REVIEW

Dhiman Basu and Sudhir K. Jain (2004) [1], In this paper studied even though a rigid floor diaphragm is a good assumption for seismic analysis of most buildings, several building configurations may exhibit significant flexibility in floor diaphragm. However, the issue of static seismic analysis of such buildings for torsional provisions of codes has not been addressed in the literature. Besides, the concept of center of rigidity needs to be formulated for buildings with flexible floor diaphragms. In this paper, the definition of center of rigidity for rigid floor diaphragm buildings has been extended to unsymmetrical buildings with flexible floors. A superposition-based analysis procedure is proposed to implement code-specified torsional provisions for buildings with flexible floor diaphragms. The procedure suggested considers amplification of static eccentricity as well as accidental eccentricity. The proposed approach is applicable to orthogonal as well as no orthogonal unsymmetrical buildings and accounts for all possible definitions of center of rigidity.

Gardiner et al. (2008) [2], research investigates the magnitude and trends of forces in concrete floor diaphragms, with an importance on transfer forces, under earthquake loading. This research considers the following items: inertial forces which develop from the acceleration of the floor mass; transfer forces which develop from the interaction of lateral force resisting elements with different displacement patterns, such as wall and frame elements; and difference of transfer forces due to different strengths and stiffness of the structural elements. The magnitude and trends of forces in the floor diaphragms have been determined using 2-dimensional inelastic time history analysis.

Wakchaure M.R (2012) [3], analysed the effect of masonry walls on high rise buildings. A various arrangements of analysis in linear dynamic is carried out. G+9 R.C.C. framed building is modeled for the analysis. Earthquake time history is applied to the framed building and various cases of analysis are taken. Approach to analyse this work is software (ETABS). Analysis is calculated and comparative result of all the models on the basis of various parameters like beam force, column force and displacement.

Patil et al. (2015) [4], analyzed and designed a high rise building under wind load. G+19 storey building was studied for its behavior in wind loading. The results of the study were in terms of diaphragm displacement due to wind force, change in reinforcement in column, change in behavior of beam, storey drift, storey shear, displacement of the structure, and torsion due to wind force. Due to high wind pressure in tall structures displacement of the diaphragm is more and this creates additional stresses in building components.

2.2 OBJECTIVES:

1. Analyzing the RC structure without diaphragm, rigid diaphragm and semi rigid diaphragm structure by Equivalent static analysis & response spectrum analysis method with the help of E-TABS V 15.0 software.
2. To compare the behavior of the structure with semi rigid and rigid diaphragm structure with the structure without diaphragm.
3. To evaluate effect of wind load and seismic load for structure with and without diaphragms.
4. To compare the parameters like base shear, story displacement, story drift of structures with shear wall.

3. MODELLING AND ANALYSIS

The structure consists of columns, beams and slabs. Analysis of the structure is done using ETABS. Dead load, live load and earthquake load are considered for analysis.

3.1 Material property

Grade of concrete M25 and M30
Grade of steel = Fe 500

Young's modulus of concrete = 25000Mpa

Young's modulus of steel =200000Mpa

Unit weight of steel = 78.0KN/m^3

Unit weight of concrete = 25 KN/m^3

3.1.2 Geometry of model

Size of beams for G+12, storey = (400x600)mm

Size of columns = (400x400)mm

Thickness of slab = 200mm

Thickness of wall = 230mm

Story height = 3m

3.1.3 Consideration of loads

The dead load is considered as per IS 875-1987 (Part I-Dead loads). The imposed load is considered as per IS 875-1987 (Part II-Imposed loads).

3.1.4 Earthquake Load (EL)

The earthquake load is considered as per the IS 1893-2002(Part 1). The factors considered are

- Zone factors = 0.1 (zone 2)
- Importance factor = 1.0
- Response reduction factor = 5
- Soil condition = Medium soil
- Damping = 5%

3.1.5 Wind Load

The wind load is considered as per the IS 875-1987 (Part III). The factors considered are

- Basic wind speed = 44m/s.
- Location = Hyderabad.

3.2 About the Models

Model-1: RC structure without diaphragm

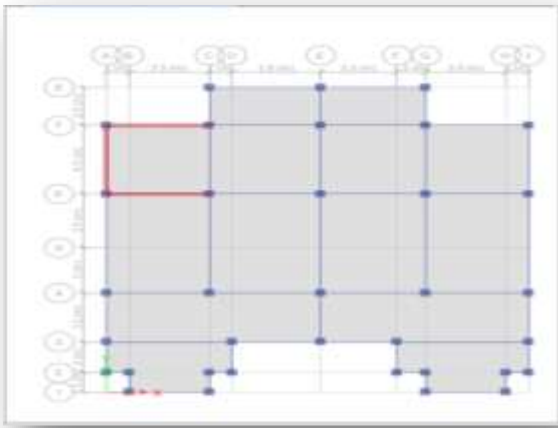


Fig.1: Floor Plan

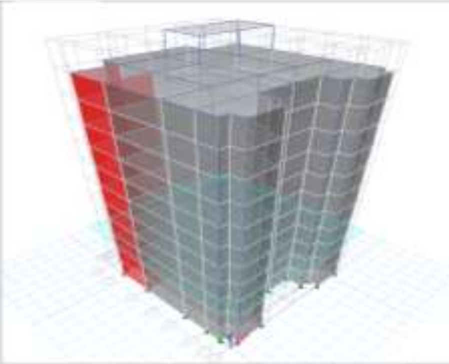


Fig 2: 3D view of RC structure without diaphragm

Model 2: with Rigid diaphragm

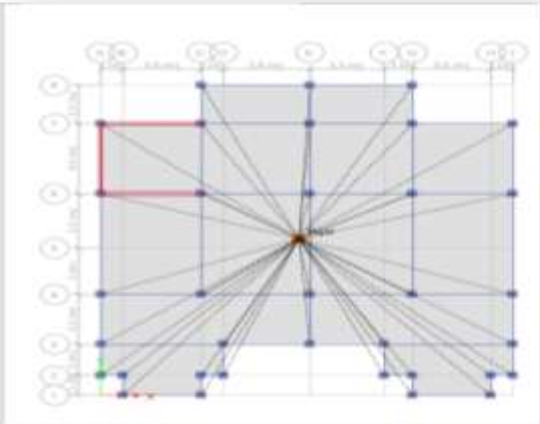


Fig 3: Floor plan for rigid diaphragm

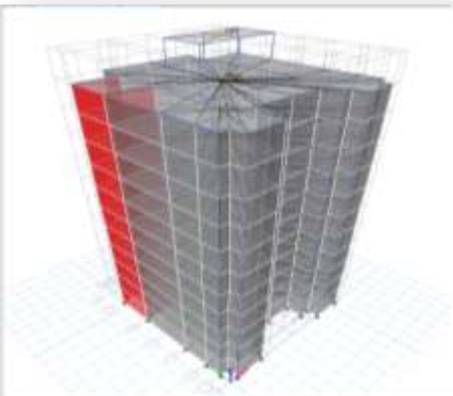


Fig 4: 3D view for rigid diaphragm

Model 3: with semi rigid diaphragm

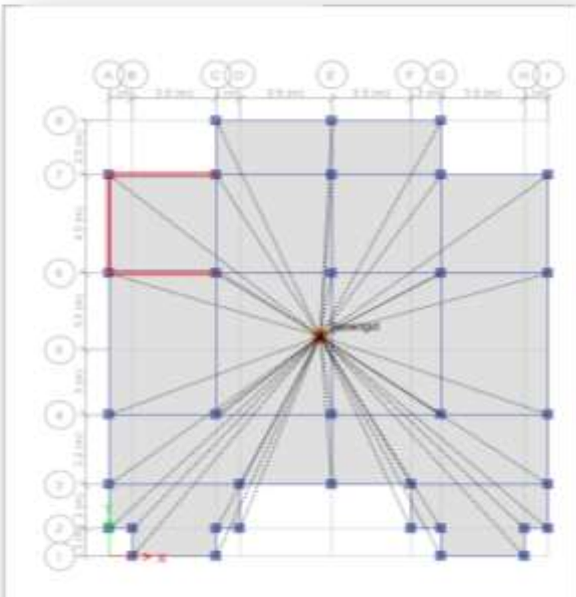
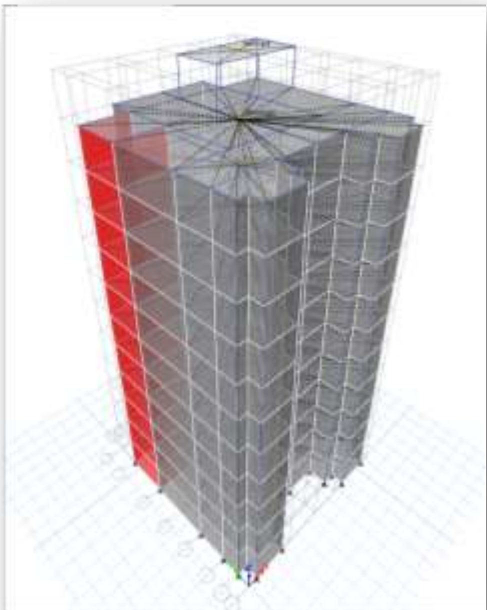


Fig 5: Floor plan for semi rigid diaphragm

Fig 6: 3D view for semi rigid diaphragm



4. RESULTS AND DISCUSSION

4.1 Analysis by Equivalent static method

4.1.1 Base shear

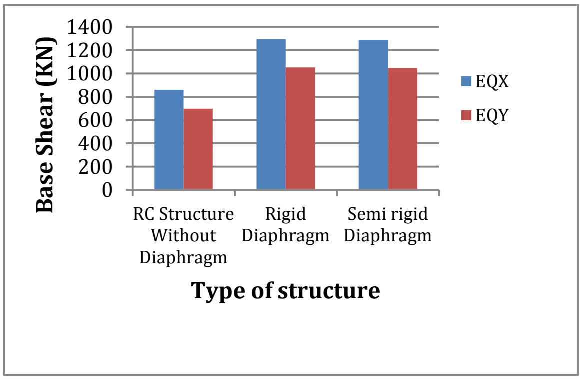


Fig 4.1 Variation of base shear for different floor diaphragm Structures

4.1.2 Maximum displacement

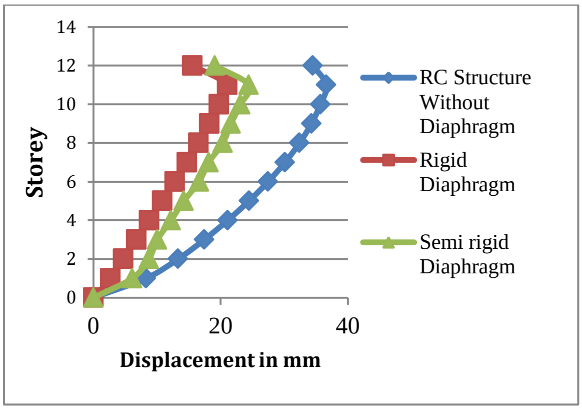


Fig 4.2 maximum displacement for ESA along x direction

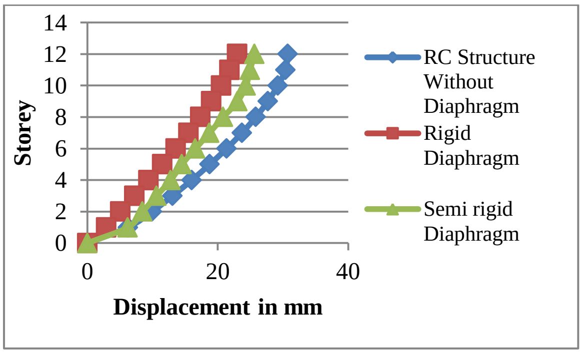


Fig 4.3 maximum displacement for ESA along y direction

4.1.2. Maximum Storey Drift

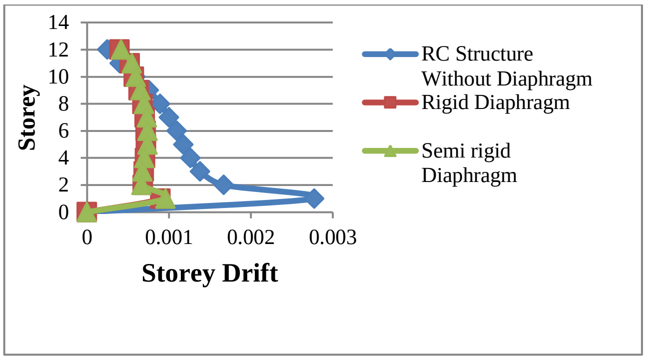


Fig 4.4 maximum storey drift for ESA along x direction

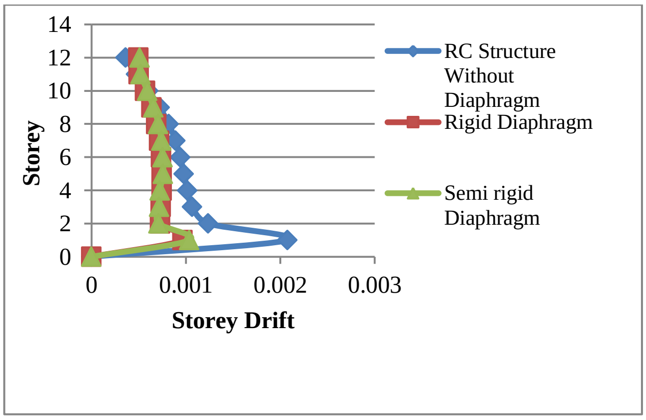


Fig 4.5 maximum storey drift for ESA along y direction

4.2 Aalysis by Response spectrum method

4.2.1 Base shear

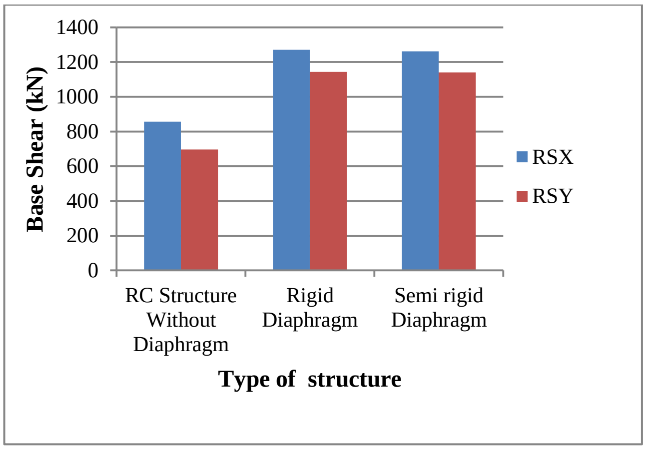


Fig 4.6 Variation of base shear for different floor diaphragm Structures

4.2.2 Maximum displacement

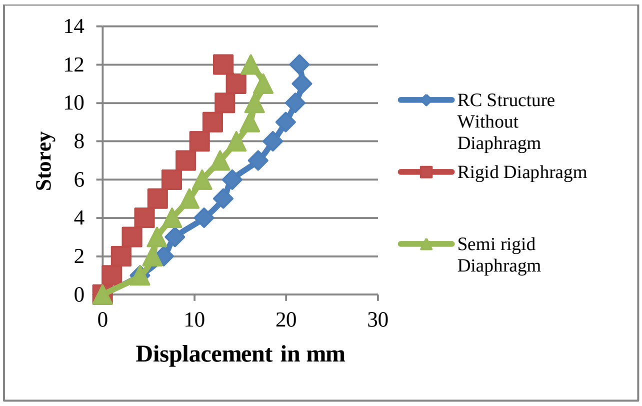


Fig 4.7 maximum displacement for RSA along x direction

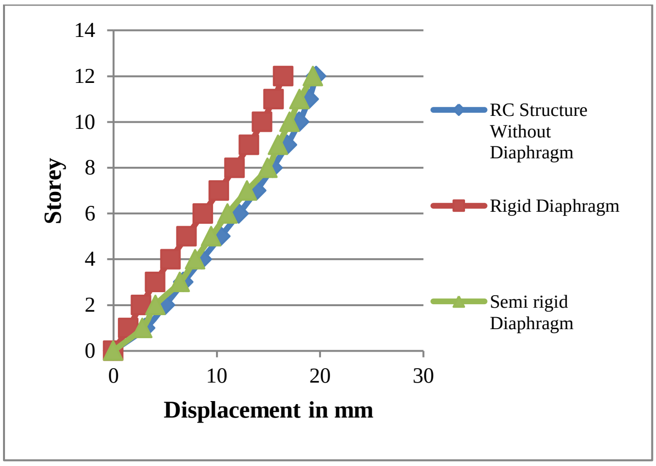


Fig 4.8 maximum displacement for RSA along y direction

4.2.3. Maximum Storey Drift

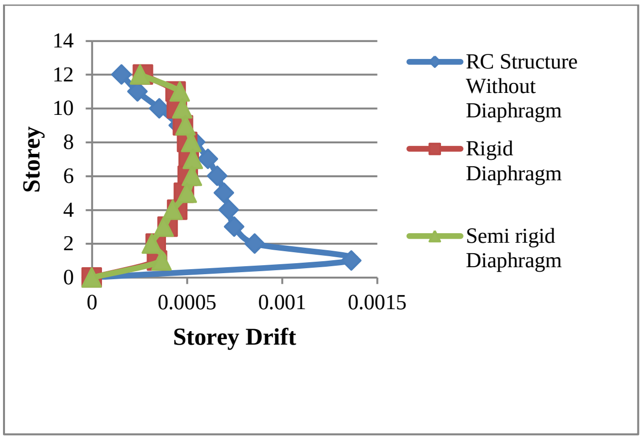


Fig 4.9 maximum storey drift for RSA along x direction

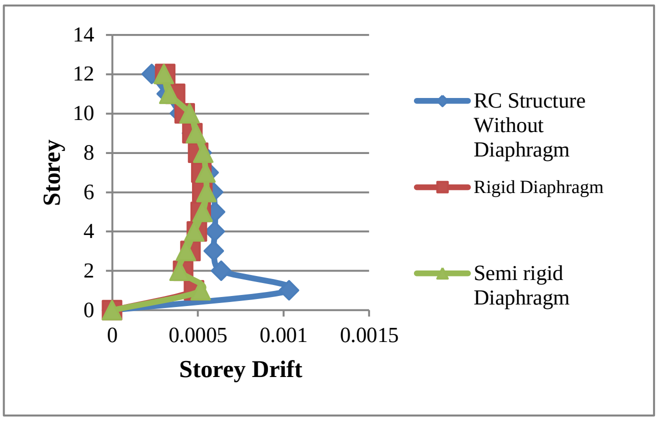


Fig 4.10 maximum storey drift for RSA along y direction

4.3 Effect of wind

4.3.1 Base shear

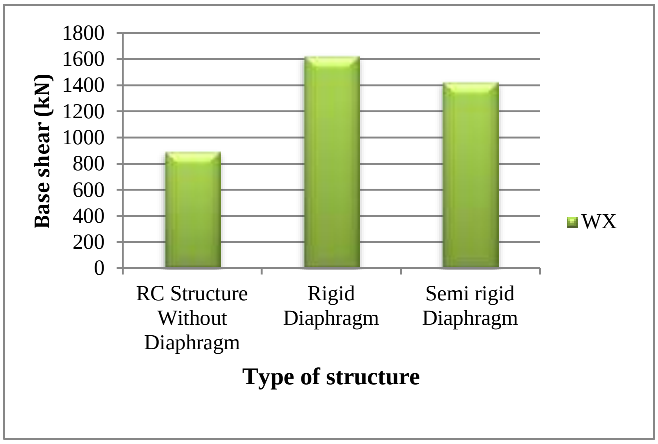


Fig 4.11: Variation of base shear for different floor diaphragm Structures

4.3.2 Maximum displacement

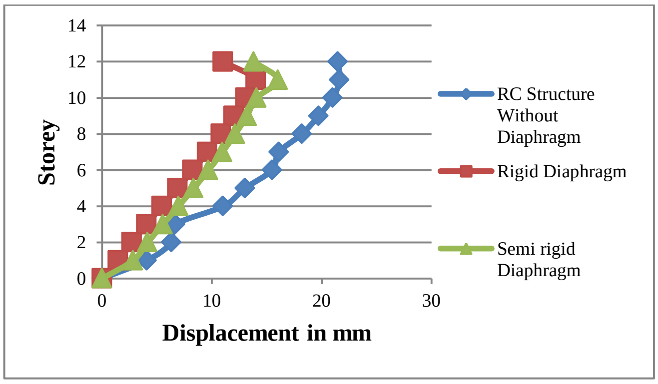


Fig 4.12: Maximum storey displacement due to wind load in x direction

4.3.3. Maximum Storey Drift

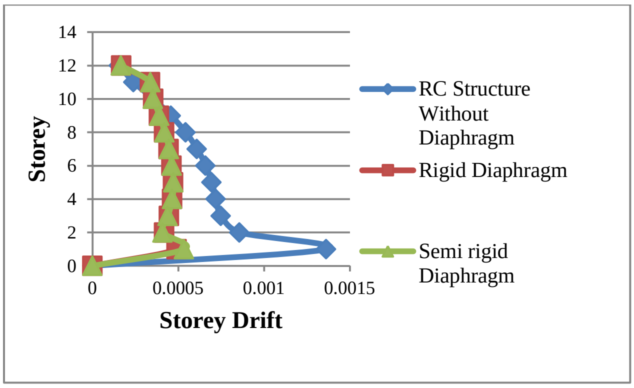


Fig 4.13: Maximum storey drift due to wind load in x direction

4.4: DISCUSSIONS

- The displacement in both directions reduced for rigid diaphragm structure as compared to the semi rigid diaphragm structure.
- The displacement at storey12 for EQX values for rigid diaphragm model, it is 55% and EQY value 25% less than RC structure without diaphragm
- The displacement at storey12 for EQX values for rigid diaphragm model, it is 25% and EQY value 12% less than semi rigid diaphragm structure
- Maximum storey displacement is observed in without diaphragm structure for both direction and minimum in a rigid diaphragm means rigid diaphragm provide better stiffness.
- The displacement for RSX values for rigid diaphragm model, it is 38.7 % less than that of without diaphragm structure and 25% less than that of semi rigid diaphragm models.
- The displacement for RSY values for rigid diaphragm model, it is 16.26% less than that of without diaphragm structure and 12% less than that of semi rigid diaphragm models.
- The story drifts follows a non-liner pattern which can be observed in the graphs, however this non-linearity decreases in case of structures with rigid diaphragm compared to structures without diaphragm structure.
- This is because rigid diaphragm structure increases the rigidity of the structure and hence one can observe the comparative reduction in drift.

5. CONCLUSIONS

- The value of base shear for rigid diaphragm structure increases by 57% and 45% respectively for static and response spectrum analysis compared to without diaphragm structure which is due to the increase in mass of the structure.
- The rigid diaphragm is more efficient in reducing displacement than without diaphragms.
- Displacement reduces by 20% and 45% in rigid diaphragm structure when compared to semi rigid and without diaphragms.
- In comparison, the structure without diaphragm and rigid diaphragm the storey drift is less in rigid diaphragm structure than without diaphragm structure.
- Rigid diaphragm structure shows better performance in reducing storey drift when compared to without diaphragms and semi rigid diaphragms.
- As the result of comparison between two mentioned analysis it is observed that the Lateral displacement, base shear and storey drift obtained by static and wind analysis is higher than dynamic analysis.

Scope for future work

1. The current study involves linear static and the response spectrum analysis the same work can be extended for non linear static and dynamic analysis i.e. Pushover analysis and time history analysis.
2. Study can be extended to the Shear force and bending moment, story stiffness etc.
3. Study can be mode on the different zones and different type of soil conditions for rigid and semi rigid diaphragms structure.

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