Critical Analysis of Column Displacement and Forces in Selected Column for a Structure with Diaphragm at Different Levels

Bhavana R. Sawarkar
P G Student
Department of Civil Engineering
Yeshwantrao Chavan College of Engineering, Nagpur

Prof. B. P. Nandurkar
Professor
Department of Civil Engineering
Yeshwantrao Chavan College of Engineering, Nagpur

Abstract

The demand of irregular high rise building is increasing rapidly. The Indian Standards 1893-2002(I) recommends simple, regular and symmetric configuration from earthquake safety point of view for all high rise structure. The code also restricts Horizontal irregularities in the structure as these may result in enormous amount of force at various levels in the building. Therefore analysis of irregular building needs to be carried out. The objective of this paper to understand the variation in displacement and development of forces in selected columns due to placement of diaphragm at different level. The study takes into consideration of diaphragm and column. Five model of G+10 building is analysed with diaphragm at different level using STAAD Pro. Response of this model under earthquake loads is critically studied. Major finding of this study includes due to diaphragm, there is a significant increasing in displacement and forces in irregular and asymmetric structure as compare regular and symmetric structure.
Keywords: Axial force, Bending moment, Diaphragm, Displacements, Earthquake load, Shear force etc

I. INTRODUCTION

For reinforced concrete building frame which composed of columns, beams and slabs the flexural stiffness of slabs is generally ignored in the conventional analysis. However, in reality, the floor slabs may have some influence on the lateral response of the structures. Consequently, if the flexural stiffness of floor slab is totally ignored, the lateral stiffness of the building may be underestimated.

As a common practice in the design process, and for economical purposes, the columns are categorized based on the load transferred to them. In a multi-story building, the columns in the first level are subjected to enormous loading, and such loading can cause axial deformations in these columns that are proportional to the load carried by the columns. Naturally, such differential deformations can lead to load redistribution within the same floor level.

These floor slabs acts as a floor diaphragm in lateral load distribution. Thus the diaphragms are horizontal systems (generally floors and roofs) that transfer the lateral loads between vertical resisting systems (such as shear walls, frames etc.). In this the floor slab acts as a diaphragm placed between vertical resisting elements .The diaphragm of a structure often does double duty as the floor system or roof system in a building, which simultaneously supports gravity loads.

II. AIM AND OBJECTIVE

- Aim: - Critical Analysis of Column Displacement and forces in selected column for a structure with diaphragm at different levels.
- Objective:- To achieve above aims, following objectives were set
  1) To understand the variation in displacement of column due to placement of diaphragm at different level.
  2) To understand development of forces in selected beams and column due to placement of diaphragm at different level.

III. METHODOLOGY

A RCC high rise building of G+10 stories with floor height 3.5m subjected to earthquake loading has been considered .In this regard ,STAAD ProV8i software have been considered as tool to perform. Critical analysis of column displacement and forces in selected column for a structure with diaphragm in different level is analyzed. Displacements, bending moment, shear force and axial forces have been calculated for selected columns to find out the effect of different position of diaphragm in the building.

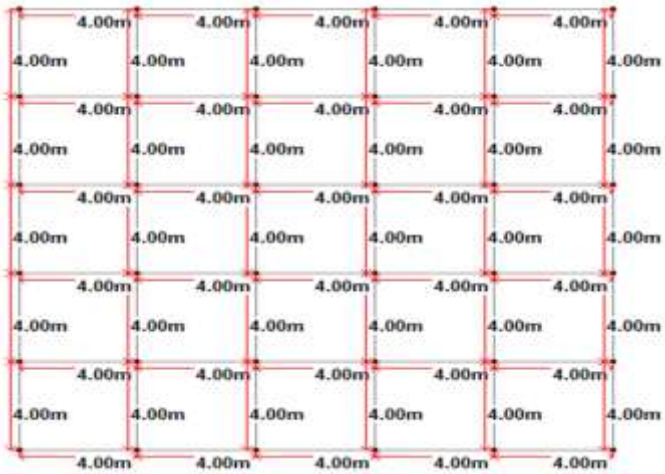

Fig. 1: Plan of the Building with Dimensions

- Model 1: A building with diaphragm at regular interval of 3.5 m as shown in figure 4.3
- Model 2: A building where alternate diaphragm has been placed at center of Ground floor as shown in figure 4.4
- Model 3: A building where alternate diaphragm has been placed at center of Ground floor and first floor as shown in figure 4.5
- Model 4: A building where alternate diaphragm has been placed at center of all floor as shown in figure 4.6
- Model 5: A building where alternate diaphragm of two continuous bays has been placed at center on all floor as shown in figure 4.7

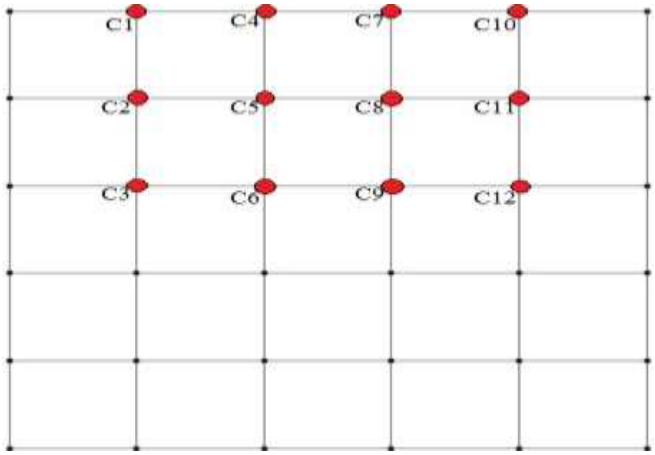

Fig. 2: Plan of the Building with selected column

The plan of the building as shown in Fig. 1 has been considered to carry out the study. The structural configuration and dimension of the building structure are 20m x 20m with size of beams is 400 mmx230 mm, Size of columns is 300mm x 300mmand thickness of slab is 120mm.The plan of the building with selected column as shown in Fig 3.2.In this case the earthquake force is predominant hence the structure is analysed for the seismic loading. Effectiveness of diaphragm at different level has been studied in five models

Loading consideration Dead Load (DL) and Live load (LL) have been taken. Seismic load calculation has been done based on the IS 1893(Part 1) (2002)"s approach. Load combination 1.5(DL+LL), 1.2(DL+LL±EQ), 1.5(DL±EQ), 0.9DL±1.5EQ along X direction and along Z direction has been consider.

IV. ANALYSIS

- Type of frame: Ordinary RC moment resisting frame fixed at the base
- Zone : II
- City : Nagpur
- Importance Factor : 1
- Number of storey: G+10
- Floor height: 3.5 m
- Density of concrete: 25 KN/m3
- Density of infill: 20 KN/m3

- Type of soil: Medium
- Equivalent static force analysis: As per IS 1893(Part-1):2002
- Damping of structure: 5 percent

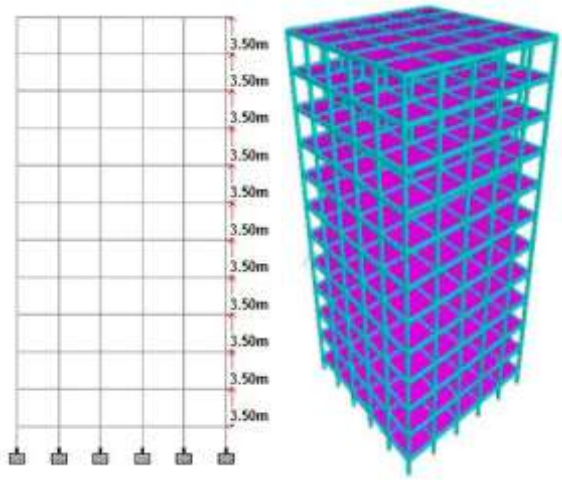

Fig. 3: Elevation and 3D View of the Model 1

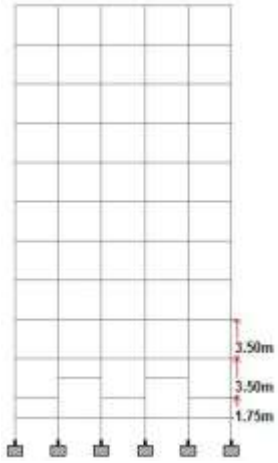

Fig. 4: Elevation of the Model 2

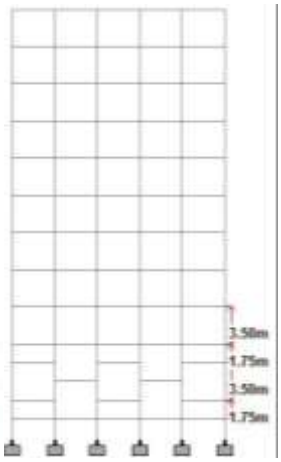

Fig. 5: Elevation of the Model 3

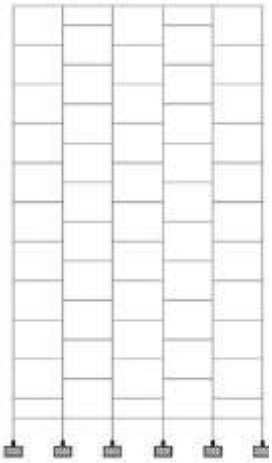

Fig. 6: Elevation of the Model 4

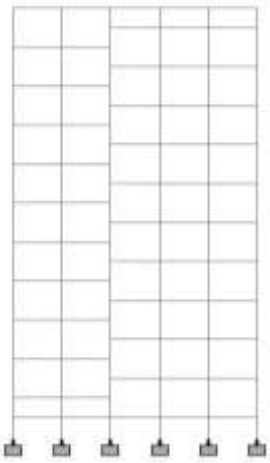

Fig. 7: Elevation of the Model 5

V. RESULT AND DISCUSSIONS

A. Overview

RCC G+10 building is analysed for the five different models related to location of diaphragm in different level for 12 different columns in zone II. Parameters like axial force, shear forces, moment sand lateral displacements is calculated. Graphical representation of data is discussed in this chapter.

For selected columns, model 1 to model 5 is considered for analysis in zone II. Graphical representation of data is shown in Fig no.5.1 to 5.44.

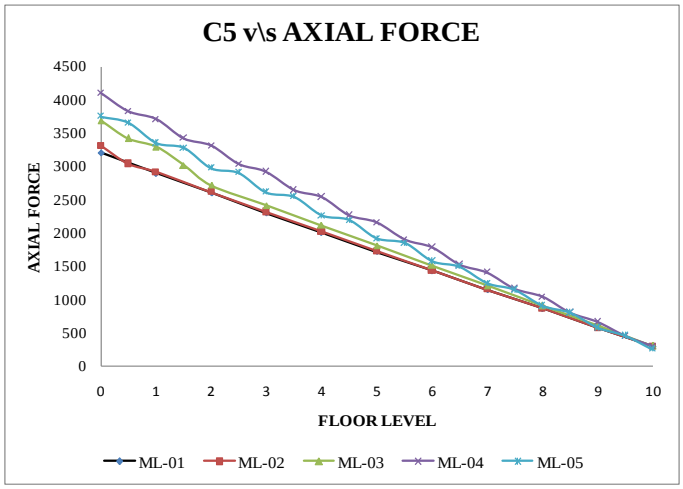

Fig. 8: Axial force for Column

B. Axial Force

1) It is observed that axial force is increasing in models where diaphragms are placed as compared to the regular model. Otherwise, it follows the regular model.
2) Maximum axial force is developed in model 4 as compared to all models due to presence of the diaphragms up to the top storey.

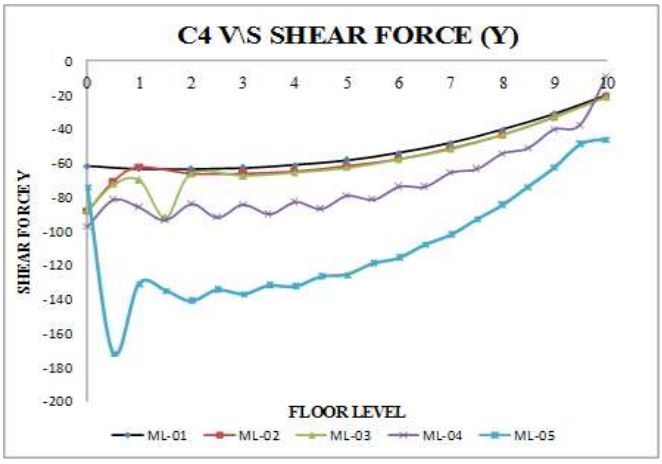

Fig. 9: Shear force in Y-direction for column

C. Shear Force In Y - Direction

1) Shear force is maximum in model 2 on the ground floor because the diaphragms has provided at that floor level.
2) Maximum shear force in y - direction is developed at all columns (model 5) as compared to other models and it is observed that shear force is drastically increasing at ground floor (model 5).
3) Provision of diaphragms increase shear force in Y direction of all columns as compared to regular column and it is reduced with floor is increased.

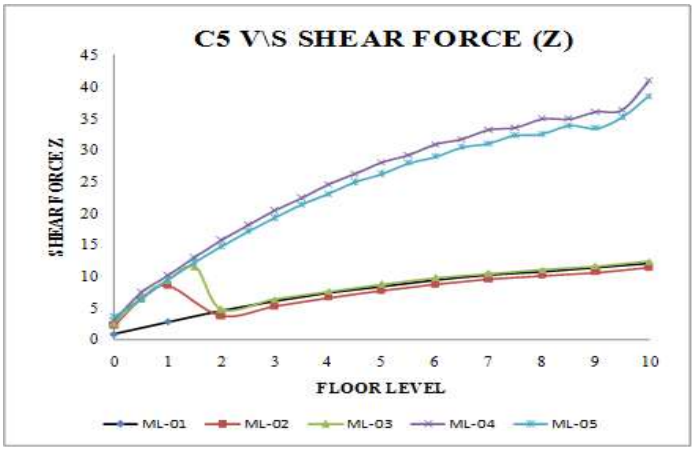

Fig. 10: Shear force in Z-direction for column

D. Shear Force In Z-Direction

1) There is a significant increase in shear force in model 4 and model 5 at compare to other models, but there also increase in shear force at ground floor and first floor in model 2 and model 3 where diaphragms have provided.
2) Use of the diaphragms increases shear force value in Z direction in all columns.

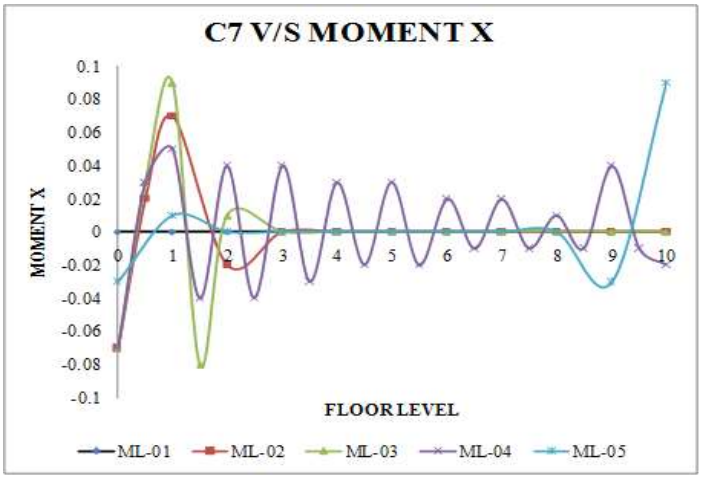

Fig. 11: Moment in X-direction for column

E. Moment in X-Direction

1) When the diaphragms are provided sudden changes occurs in torsion, that is at initial floor and top floor it is very high and at intermediate floor very less.(As per various cases).
2) When the diaphragms are provided, the twisting moment is developed in all columns for models as compared to the regular model (model 1).

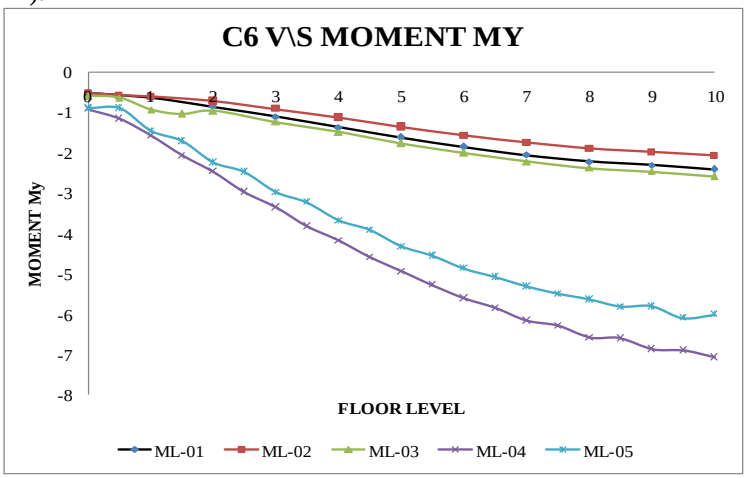

Fig. 12: Moment in Y-direction for column

F. Moment In Y-Direction

1) When the diaphragms are provided sudden changes occurs in the moment in Y direction as compared to the regular model.
2) Maximum moment in Y direction is developed in all columns due to model 4 than other models.

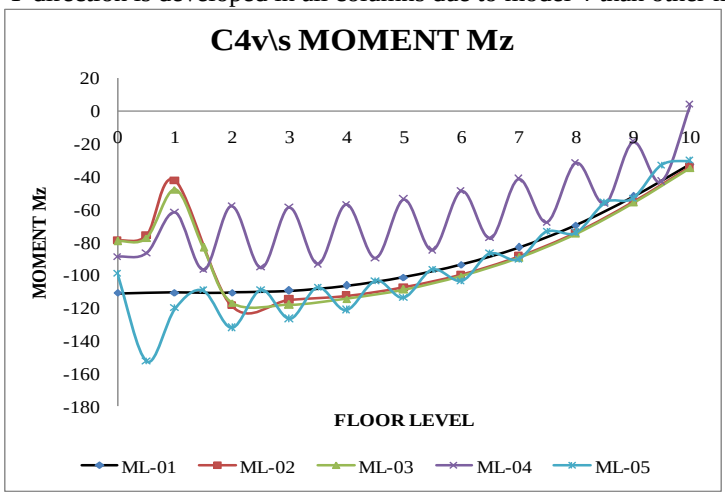

Fig. 13: Moment in Z-direction for column

G. Moment in Z-Direction

1) It is observed that the moment gradually decreases from ground floor to top floor for all models along Z direction, but by a provision of the diaphragms it reduces certainly from ground to top floor as the compare to the regular model.
2) Maximum moment in the Z direction is developed in each column in case of model 5.

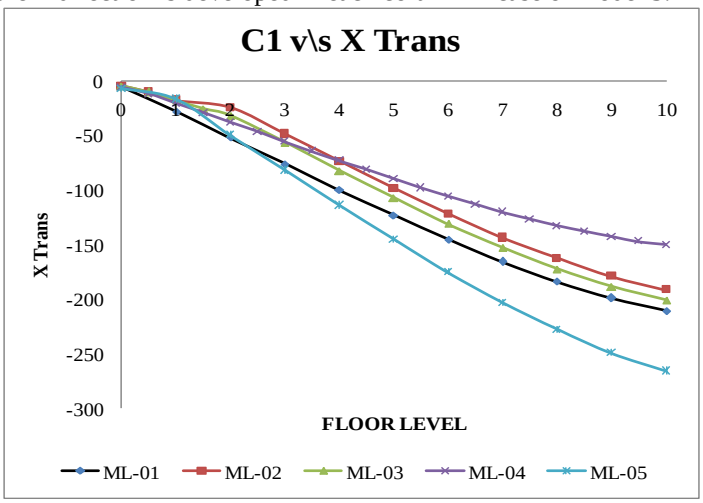

Fig. 14: Displacement in X-direction for column

H. Displacement In X-Direction

1) It is observed that the maximum displacement in the X direction is developed in model 5 and its minimum displacement in the X direction is developed in model 4 as compared to other model.
2) It is observed that displacement in the X direction is significantly increased as the floor is increased, but minimum displacement in X direction seen where diaphragms are provided. That's means use of diaphragm reduces the displacement in X direction of the structure.

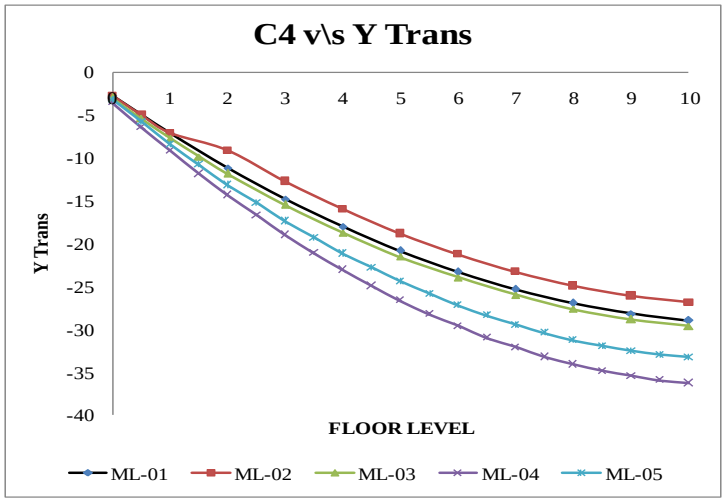

Fig. 15: Displacement in Y-direction for column

I. Displacement In Y-Direction

1) It is observed that the displacement gradually increases from ground floor to top floor for all the cases along Y direction by provision of the diaphragms.

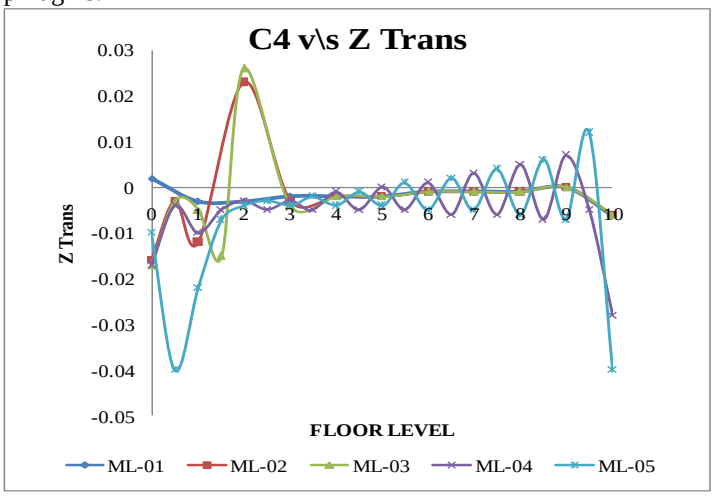

Fig.16 Displacement in Z-direction for column

J. Displacement In Z-Direction

1) When the diaphragms are provided sudden changes occurs in displacement in Z direction, that is at initial floor and top floor it is very high and at intermediate floor very less as per various columns.

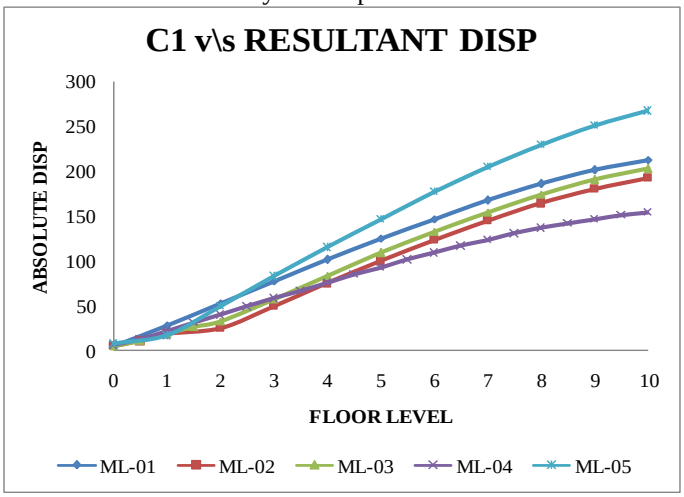

Fig. 17: Resultant displacement for column

K. Resultant Displacement

1) It is observed that maximum resultant displacement occurs in model 5 and it is minimum resultant displacement occurs in model 4 as compared to other model.
2) It is observed that resultant displacement is significantly increased as the floor is increased, but minimum resultant displacement occurs where the diaphragms are provided. That means use of diaphragms reduces resultant displacement of the structure.

L. Summary

The results of the previous chapter are represented in graphical form in this chapter. Important observations were noted and conclusions are drawn from important observations.

VI. CONCLUSIONS

- Buildings with diaphragms are connected at different level in single column axial force is found higher as compared to building with diaphragm at regular interval.
- Diaphragm induced at any floor results in developed of substantial Shear force in Y direction on that floor and adjoining floor. Shear forces are very high in y-direction at all floor levels if the diaphragms are induced.
- There is sudden variation in shear force in the y-direction at the level where the alternate diaphragm of two continuous bay's has been placed at the center on all floors.
- When diaphragms are placed at the different level, shear force in the z-direction decreases eventually, especially for where alternate diaphragm has been placed at the center of all floors.
- Drastic variation in moment in x-direction can be seen at initial floor levels at all columns where diaphragms are placed.
- Increase in moment in y-direction are seen where the diaphragms are placed at the floor level.
- Placing of diaphragm at different level in models decreases the moment in z-direction.
- Structures modeled with diaphragms at different level can experience low displacements X- direction than structures modeled with diaphragm at regular interval
- The displacement gradually increases significantly from ground floor to top floor for all the cases along the Y-direction by provision of the diaphragms.
- If diaphragms are connected at different level sudden changes occurs in displacement in the z -direction, (that is, at initial floor and top floor it is very high and at the intermediate floor it is constant).

VII. FUTURE SCOPE

- The present research gives the effect of earthquake load for Zone II on a building with diaphragm placed in different level. Future research into the seismic design of other Zone, Zone III, IV and V for same buildings should be undertaken.
- Future work should be done to investigate the performance of Structure at the different type of soil remedial action should be needed.
- Lateral force resisting element like bracing, shear wall, etc. must be taken into account for future research, especially for high rise structures.
- Wind load also plans a significant role in high-rise building so Future research should be done taking into account the forces and displacement effects of the wind load for structures.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the contributions of Yeshwantrao Chavan College of Engineering, Nagpur for their valuable support.

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