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EFFECT OF FLOATING COLUMN ON SEISMIC RESPONSE OF MULTISTORY BUILDING

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Abstract: Different parts of the world has seen adverse effects in high rise multi-storey buildings due to earthquakes because of different irregularities present and inadequately designed structures. A structure is regarded as vertically irregular if it has irregular distribution of stiffness, strength and mass along the building height. Irregular building provided with floating column makes it much more irregular with discontinuous load path and are probable to collapse during earthquake. Floating column due to discontinuity in load path makes the performance of building weak. In the present study high rise G+10 building with regular structure and with irregularity are studied and analyzed with and without floating column. The critical position of floating column has been studied for different locations around the periphery columns for both regular and irregular structures for zone V. The study highlights the response of G+10 high rise regular and vertically irregular building with and without presence of floating columns subjected to earthquake forces. The various response parameters such as base shear, storey drift, node displacement, shear forces and bending moments are studied in the various models. The results are compared to determine the effects of presence of floating column in a building.

Keywords: *Floating Column, Base Shear, Storey Drift, Node Displacement, Shear Force, Bending Moment*

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I INTRODUCTION

High rise building frames with floating columns at one or more positions have a major risk to collapse during strong earthquakes. In recent times, buildings are required with free space with lesser number of columns due to functional and aesthetical requirement. The structural response to seismic forces critically depends on the overall size, shape and geometry and also the way in which the forces are carried to the ground. During the earthquake, the forces developed at different floor levels in a structure must be transferred through the shortest path to the base or footing. Floating column present in a structure makes a discontinuous load transfer path which effects the performance of the structure and make it weak. Building which have floating column does not rest on foundation directly but rest on beams that transfer the load through the beams and adjacent columns. Buildings with vertical irregularity and floating column have discontinuity so the earthquake forces transfers abruptly with jump at the level of discontinuity. The floating column is a vertical member of a structure which at its lower ends rest on a beam and doesn't rest on a foundation. The seismic inertia forces that get generated at the floor levels in a structure must be brought down along the height of the structure as we move downwards towards the ground. In seismic active areas the floating column are highly undesirable. A building should be simple and regular in configuration with good strength and stiffness. Buildings with regular and simple geometric configuration in its plan and elevation go through lesser damage than irregular structures.

II. OBJECTIVE OF STUDY

The main aim of this study is Seismic response of High rise irregular building (Vertical Irregularity) with and without floating columns. Following are the specific

Objectives of this research:-

1. To study the various literatures.
2. To model and design the regular and vertically irregular structure with and without floating column.
3. To study and analyze the behaviour of RCC framed High Rise building with and without floating column under earthquake load.
4. To compare the structural response of all the building models with respect to :- Base shear node displacement Shear forces Bending Moments Storey drifts
5. To study the effect of varying the location of floating column on both regular and irregular models of a multistoried building.
6. To identify the best building configuration which suffers minimum damage from the earthquake forces in high seismic region.

III. PROBLEM STATEMENT

As per review of papers, researchers have done study on floating columns or discontinuity of column in a building and comparing those results with the normal building. Several analysis method both static and dynamic have been used to determine the response of structure due to earthquake loads. Also on the basis of irregularity literatures, some study has been done by researchers on different types of irregularity taken for consideration and comparing the regular and irregular structures.

In the present study vertical geometric irregularity along with floating columns is taken into consideration and is analyzed using Equivalent static analysis method as per IS 1893 (Part 1) using Staad-Pro. A G+10 structure having floating columns and vertically asymmetric will be compared a symmetric structure having no floating columns. Also the position of floating column has been varied to find out the most critical position. A total of 16 models are modeled to study the responses of vertically irregular structures. The results of models having a change in the load path due to floating column will be compared with references model having no floating column. Effect of change in shape of building (vertical irregularity) will also be studied in the present work.

The analysis results will be determined in terms of Base shear, Seismic weight, Storey drift, Node displacement, bending moment, shear force, lateral & axial forces acting on column. The result of the regular models will be compared for different asymmetrical models having different position of floating columns and will be plotted.

IV. METHDOLOGY & MODELLING APPROACH

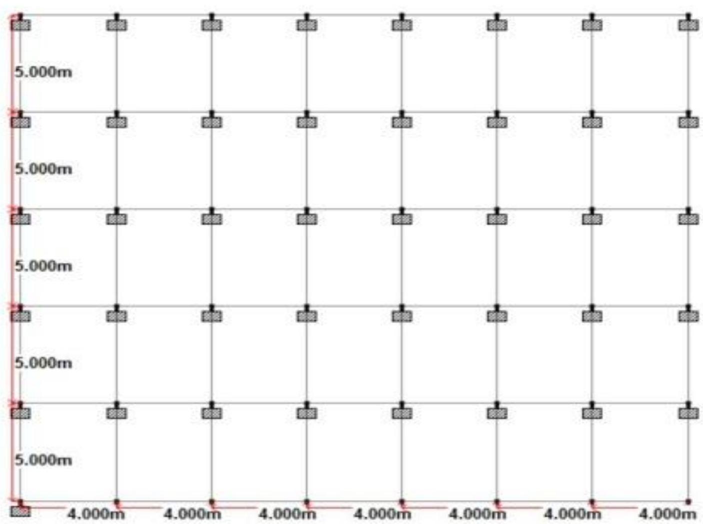
Methodology:

Seismic analysis is known as a part of structural analysis and is carried to determine the response of a structure subjected to earthquake forces which is required for structural design and assessment of a building in an earthquake prone region. In the present study seismic response of high rise building having vertical geometrical irregularity with and without floating column will be studied and analyzed using Staad-Pro with static analysis. In this study G+10 storey frame has been modeled. Total 16 models with and without floating column and a regular and vertically irregular frame has been modeled and studied. Position on floating column has been varied at outer, middle and inner periphery of the building at the base of the structure to find out the critical position. The building model consists of elements such as beam, column, wall, slab and foundation and the non-structural elements are not modeled. Each column and beam in a structure is modeled as two noded beam. The floor height provided is 3.2 Meter and the properties of elements are defined. The floor slabs are assumed to act as diaphragms. The walls connected rigidly to columns and beams and the wall load is distributed uniformly over the beams which transfer it further to the columns. The model is analyzed for Zone V and situated at medium soil Type II and the response is studied to determine the seismic weight, storey drift, node displacement, base shear, bending moments and shear forces in different directions.

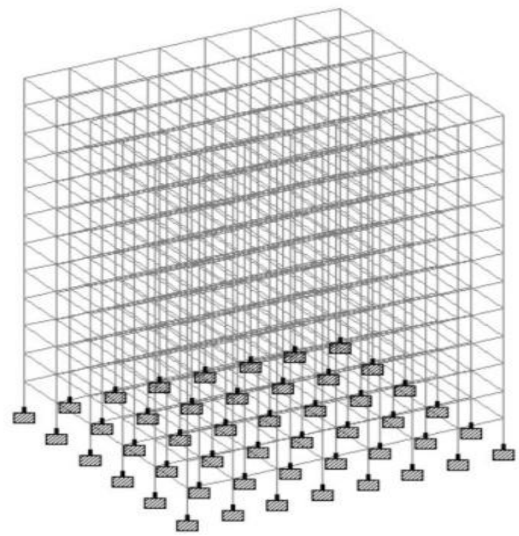
Modelling:

A G+10 high rise building with special moment resisting frame is analyzed in the research to study the behavior of the building with & without vertical irregularity along with floating column and without floating column building models due to seismic forces. The floating columns are provided at the base only in all the models but their locations are varied along the outer, middle and inner periphery column of the structure. Total 16 models as being modeled to carry out the structural analysis and research using Staad Pro which are as follows:-

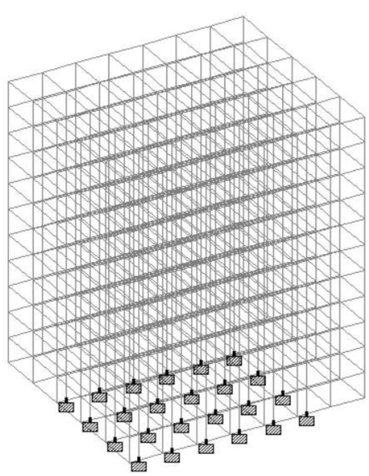
- Model 1: The model-1 is a rectangular building model with no vertical irregularity and no floating column.
- Model 2: The model-2 is a rectangular building model with no vertical irregularity and outer periphery floating column.
- Model 3: The model-3 is a rectangular building model with no vertical irregularity and middle periphery floating column.
- Model 4: The model-4 is a rectangular building model with no vertical irregularity and inner periphery floating column.
- Model 5: The model-5 is a rectangular building model with Type-1 vertical irregularity and no floating column.
- Model 6: The model-6 is a rectangular building model with Type-1 vertical irregularity and outer periphery floating column.
- Model 7: The model-7 is a rectangular building model with Type-1 vertical irregularity and middle periphery floating column.



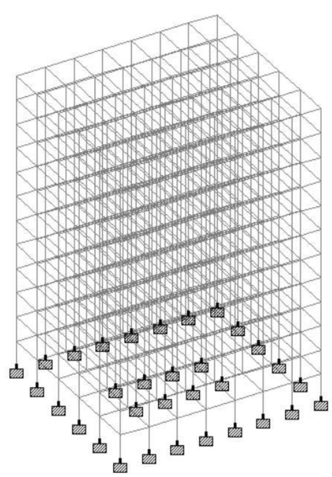
Model-1



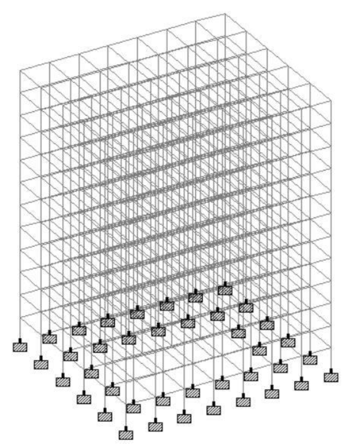
Model-2



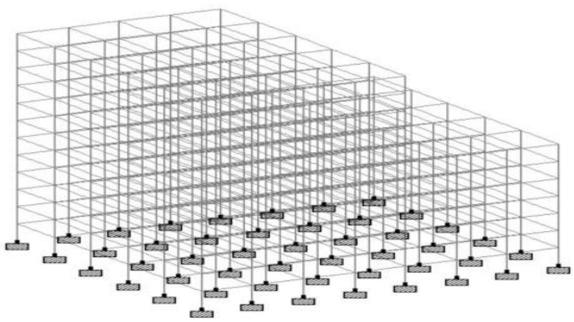
Model-3



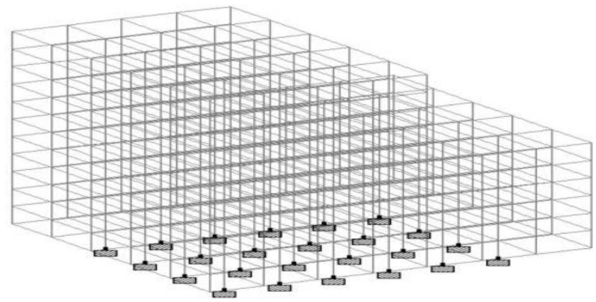
Model-4



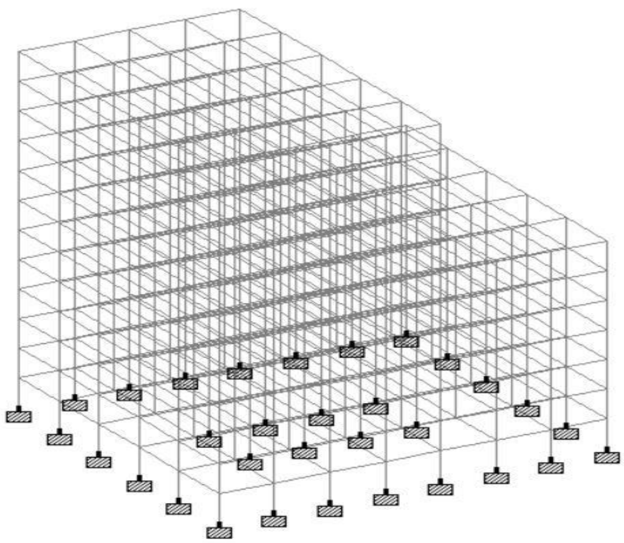
Model-5



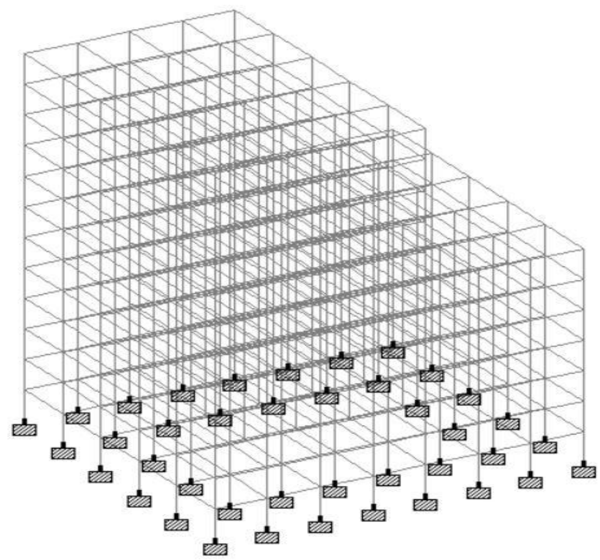
Model-6



Model-7



Model-8



Model-9

V. ANALYSIS OF STRUCTURE

Input Parameters

I) Material Data		
1	Grade of concrete	M25
2	Grade of Steel	FE 415
3	Unit weight of RCC	25 kn/m3
4	Unit weight of Brick	19.2 kn/m3 = 20 kn/m3

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II) Structural Data		
1	Type of structure	SMRF
2	Support	Fixed
3	Type of soil	Medium soil Type II
4	Size of beam	400mm X 400mm
5	Size of column	
	Upto 6th Floor	400mm X 900mm
	Above 6th Floor	400mm X 500mm
6	Depth of slab	125mm
7	Thickness of wall	200 mm
III) Architectural Data		
1	Number of stories	G+10
2	Floor height	3.2 m
3	Height of structure	35.2 m
4	Dimension of plan	28m X 25m
5	Size of Bay	4M in X direction & 5M in Z direction
6	Number of bay	7 in X direction & 5 in Z direction
IV) Seismic Data		
1	Seismic Zone	V
2	Response reduction factor	5
3	Importance factor	1
4	Damping ratio	5%
5	Zone Factor	0.36 (Zone V)

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V) Loads		
1	Live load	3 kn/m2
2	Floor finish	1 kn/m2
3	Wall load on storey	11.2 kn/m2
4	Parapet Wall load	4 kn/m2

Load Combinations :

The following load combinations are considered for the design and analysis as per code IS 1893 (Part 1) : 2002 clause no.- 6.3.1.2,

Where,

DL= Dead load LL = Live load EL = Earthquake Load

EQX, EQY= Earthquake load in the X and Y directions, Respectively

1.5(DL + IL)

1.2(DL+ IL ± EL)

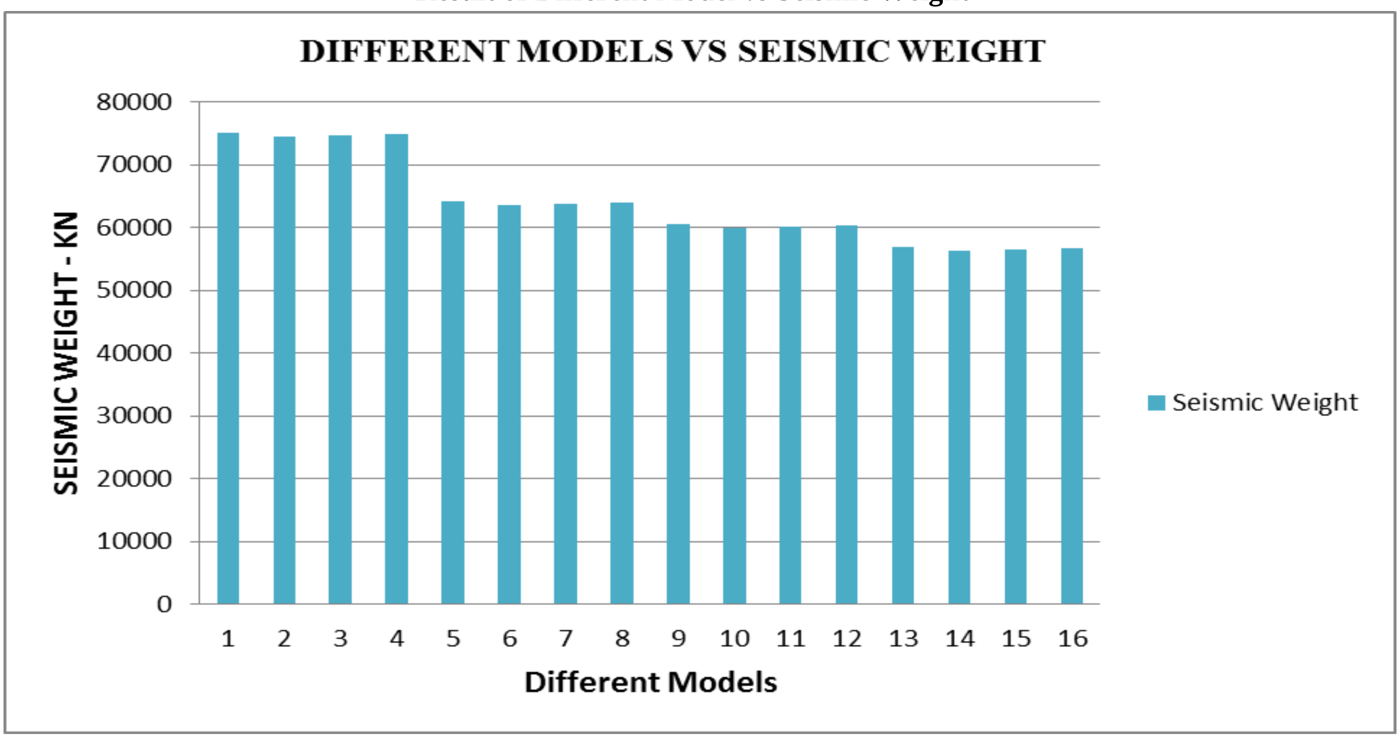
1.5(DL ± EL)

0.9DL ± 1.5 EL

VI. RESULTS & DISCUSSIONS

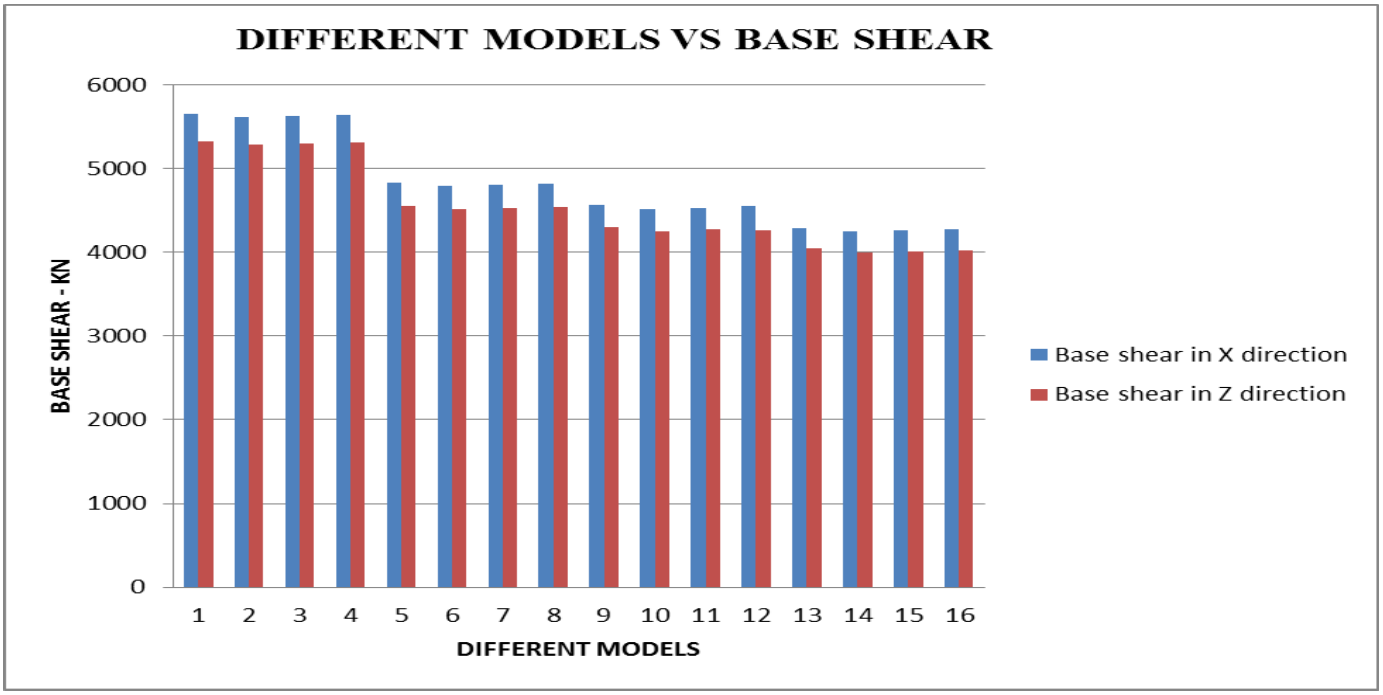
The seismic response of G+10 regular and irregular structure with and without floating columns has been analysed to determine response parameters and the results of the seismic weight, base shear, node displacement, inter storey drift are presented through tables and graphs for all the models.

Result of Different Model vs Seismic Weight



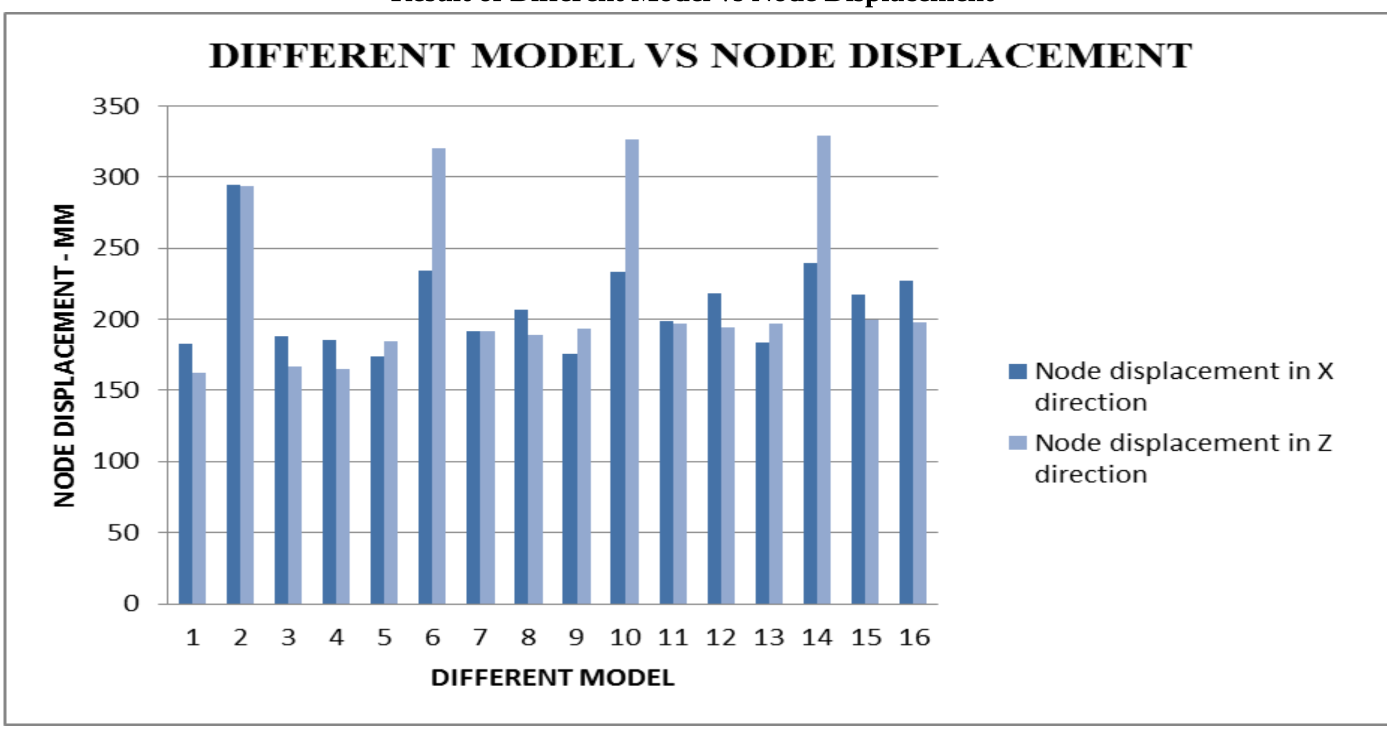
From the data acquired, it is seen that the seismic weight of the models without any vertical irregularity are higher as compared to the ones which have irregularity. The seismic weight goes on decreasing for the models with irregularity and is least for models with higher irregularity (i.e Case-4).

Result of Different Model vs Base Shear



The Base Shear values are higher for the models without vertical irregularity (i.e Case-1) which is 5654.27 kN and are almost same for all the models in that case. The base shear goes on decreasing for the models with irregularity and is least for the most irregular models (i.e Case-4). Also the base shear values are higher for all the models in X direction as compared to models in Z direction.

Result of Different Model vs Node Displacement



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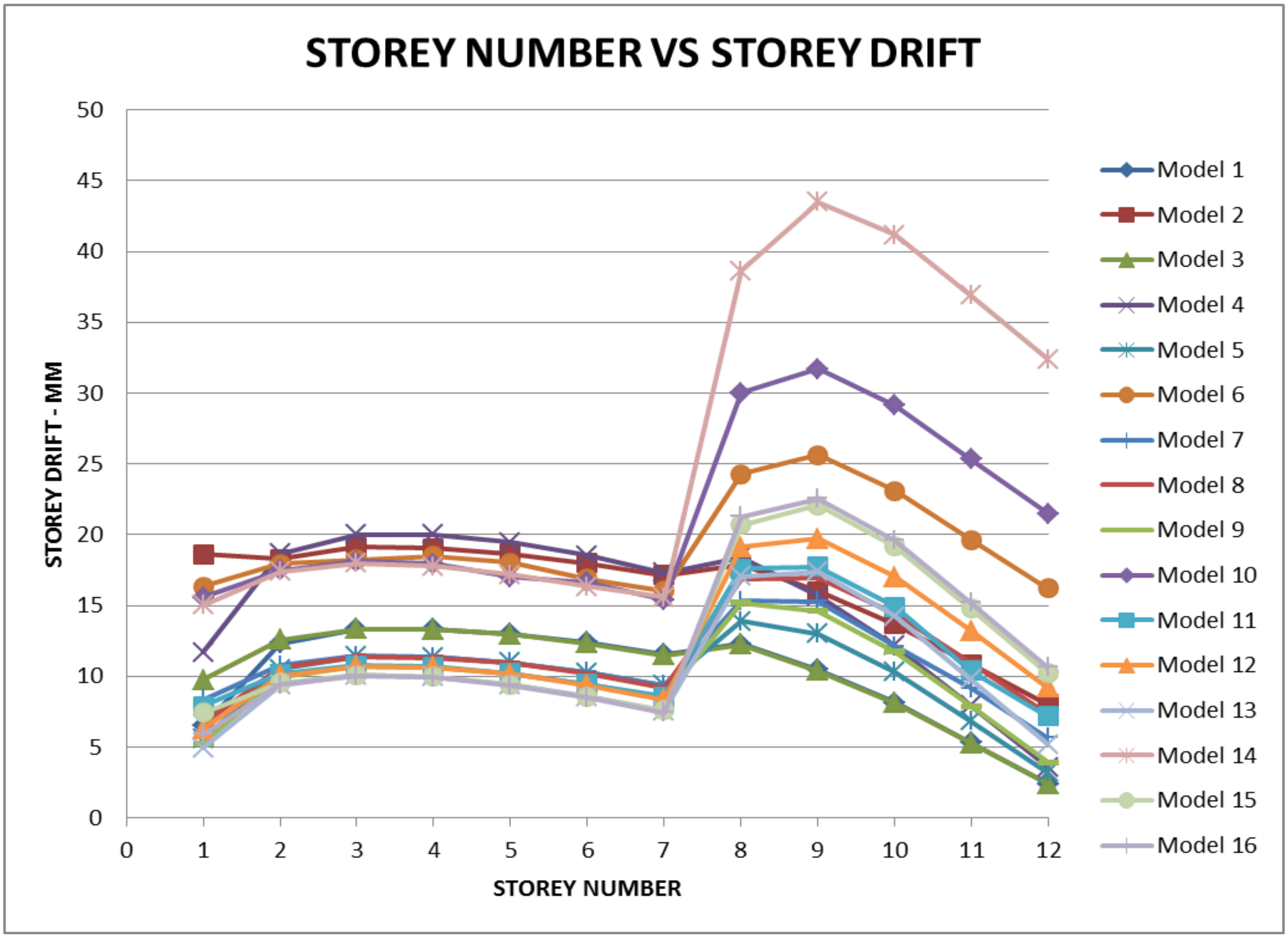
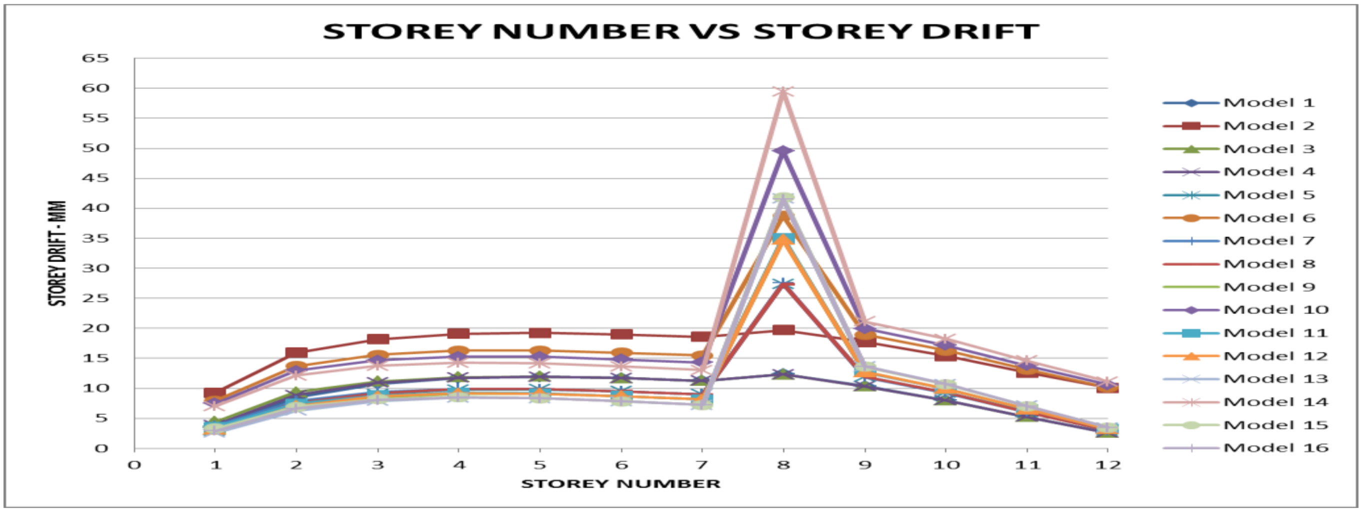
The graph of the Node Displacement indicates that the maximum node displacement has occurred in the model 2, 6, 10, 14 (Model 2- regular structure with outer periphery floating column; Model 6- Type 1 Irregularity with outer periphery floating column; Model 10- Type 2 Irregularity with outer periphery floating column & Model 14- Type 3 Irregularity with outer periphery floating column). Hence the node displacement is maximum for models with outer periphery floating column for both regular and irregular structures. The node displacement is still higher in Z direction for these models otherwise in all other models it is more in X direction. So It is seen that due to the seismic forces the displacement is more in the structure with larger number floating column and irregularity in structure.

Result of Storey Number VS Storey Drift in X Direction



From the storey drift plot it can be observed that the storey drift is maximum for one storey and goes on decreasing as we move to top or bottom stories in a model. The drift values may rise at some other stories but it is maximum only at one story. The drift value rises from 7th storey and reaches to maximum at 9th storey and decreases back for all the models. The maximum value of drift is found for model-14 which touches a value of 43.51 mm. It is evident for the graph that the storey drift increases for the model with floating column as compared to model without floating column. Hence higher the vertical irregularity and floating column present in the structure increases the storey drift of the structure.

Result of Storey Number VS Storey Drift in Z Direction



The story drift plot with the storey number shows that for all the models the drift values increase from the 1st storey to the 7th storey, then there is a sudden increase in a drift value and reaches to maximum at the 8th storey and decreases back from 9th to 12th storey. The maximum drift value is observed for the model-14 with drift value of 59.46 mm. The storey drift value is also higher for models with floating column than the model without floating column. The drift is higher for irregular models with floating columns as compared to regular models. Hence irregularity with floating column causes increase in the drift of the structure.

VII. CONCLUSION

- The seismic response of High rise regular and vertically irregular buildings with and without floating column has been studied and analysed under the earthquake forces. Floating columns has been provided at the outer, middle and inner periphery to find the most adverse position and the response of regular and irregular frames has been analyzed for base shear, node displacement, storey drift, shear forces and bending moments. On the basis of results of study the following conclusion are drawn:-
- It is observed that the seismic weight and the base shear of the regular building are higher as compared to the irregular ones.
- It is evident that the drift is maximum for the model with highest irregularity and when floating column is present at outer periphery of the structure (i.e model 14).
- The models with floating column has higher storey drift and the irregular models with floating column showed higher drift when compared with regular ones without any floating column. The highest storey drift is experienced at 10th storey in X direction and 8th storey in Z direction.
- The result observed from the storey drift response along the height of a building shows that the middle stories of the structure gets more affected than the upper and the lower stories.
- From the analysis it is observed that the floating column at different locations of a building results into variation in response to earthquake forces and the most critical case is providing the floating column at the outer periphery of the structure.
- As we can see that the results of node displacement are very high for building with floating column. It is not advisable to provide floating column in an earthquake prone Zone V.
- As per the various parameters studied and the results observed, it is clear that the seismic performance of regular frame is found better than the corresponding irregular frames for all the cases, so it is suggested to build a regular frame structure to minimize the effects due to earthquake forces.
- Also the node displacement, shear forces, bending moments, and drift are higher for structure having floating column, Hence it is concluded that providing floating column in a high rise building in a high seismic zone is vulnerable and should be avoided. So a irregular building with floating column becomes highly susceptible to damage in high seismic zone, hence a

regular building without floating column should be preferred and constructed.

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