Comparative Study of Seismic Analysis between Conventional RC Frame and Flat Slab with Drop

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Abstract— The speed growth of population in urban areas and the consequent pressure on limited space considerably influenced tall building constructions in developing countries like India. These tall buildings can be constructed using various structural systems. At present, normally conventional RC Frame buildings are adopted for the construction. These structures are usually adopted to overcome the large moments developing due to the applied loads. On other hand, the flat slab structural systems in which slab is directly rested on columns have been used in many buildings constructed recently due to the advantage of increased clear floor to floor heights to meet the economical, easier form work, shorter construction period and architectural demands. In the present work conventional RC frame and Flat Slab building of G+3, G+7, and G+11 storey structural models are considered. The vulnerability of purely frame and purely flat slab models for seismic load is analyzed considering different soil conditions and seismic zones. An attempt is made to compare the response of conventional RC frame model and flat slab model for earthquake load. The analysis is carried out with both equivalent static method and response spectrum method. Parameters like lateral displacement, time period, storey drift and base shear are computed using analytical software and comparison is made between both structural systems and the results are presented.

Key words: Seismic Analysis, RC Frame

I. INTRODUCTION

Earthquake resistant design of reinforced concrete structures is a continuing area of research since the earthquake engineering has started. The structures still damage due to one or the other reason during earthquakes. In spite of all the weaknesses in the structural system, either code imperfections or error in analysis and design, the configuration of structural system has played a vital role in catastrophe.

The speed growth of urban city populations and consequent pressure on limited space considerably influenced the low rise, medium rise and tall structures. Generally beam slab structures are used for these buildings. This tall building subjected to both lateral and vertical loads. In tall structures Lateral loads due to seismic and wind governs the design rather than the vertical loads. The structure designed for vertical load cannot resist these lateral loads. Lateral loads are quite variable and increases as height of the structure increases. The lateral loads are considerably higher in the top storey than the bottom storey due to which building act as cantilever. These lateral forces induce sway in the frame. In many of the seismic areas there are several instances of failure of structures due to improper design for seismic loads or seismic loads may not considered for the design. All these response of the structure to earthquake has shown the importance of earthquake resistant design.

The trend of irregular plan and high rise building in urban areas are common due to the concentration and increase of population, rapid increase of land cost, limited availability of land and since they provide such a high ratio rentable floor space per unit area of land.

A traditional common practice in construction is to support slab by beam and beams supported by column this may be called as beam slab load transfer construction technique. The beams reduce the available net clear ceiling height. Hence to improve aesthetical and structural aspect of multi storey, shopping mall, offices, warehouses, public community hall etc. are constructed in such a way where slabs are directly supported on columns. This types of slab directly supported on column is termed as flat slab.

The construction of reinforced concrete buildings with flat slab systems has become widely used in some high seismicity European countries. This type of structures is particularly common in South European countries, such as Italy, Spain and Portugal, both for office and residential buildings.

The flat slab building gives many advantages over conventional type building in terms of use of space, architectural flexibility, easier formwork and shorter construction time. Flat slab structures are one of the most popular floor systems in commercial buildings, residential buildings and many other structures. The Flat slab framed structures are favored by both architecture and client. In conventional framed structures slab is resting on the beams, forces are transferred from slab to beams and then beams to columns. But in Flat slab framed structures forces is transferred from slab to the columns directly.

Flat slab systems are more popular in residential building, office, schools, hospitals and hotels. Absence of beam members allows lower storey heights and as a result cost saving in partition walls, vertical cladding, plumbing, mechanical systems and a large number of other items of construction especially for medium and high rise structures. They provide flexibility for partition, location and allow passing and fixing services easily.

II. OBJECTIVES

The objectives of the study are:

- The objective of the work is to study the behavior of flat slab frame with different heights.
- To study and compare Conventional R.C frame and flat slab R.C. frame with different height for different combinations of static loading
- To study the vulnerability of purely frame and purely flat-slab models considering different factors such as Storey drift, lateral displacement, time period and base shear for different

combinations of dynamic loading with varied building height.

- To study and compare the response of Conventional R.C.C structure and flat slab R.C.C structure for different soil conditions and earthquake zones

III. METHOD OF ANALYSIS

A. The Present Study Done for the Below Mentioned Analysis

- Equivalent static analysis Method
- Response spectrum method.

IV. PARAMETRIC STUDY

In the present work six structural models of conventional reinforced concrete frame structures and Flat Slab frame structures of G+3, G+7 and G+ 11 storey's are considered. The performance of flat slab and its vulnerability of purely frame and purely flat slab models under different loading conditions, types of soil are analyzed considering all earth quake zones. Structural analysis package ETABS is used for the analysis in the present study.

- Model-1: G+3 conventional RC frame
- Model-2: G+7 conventional RC frame
- Model-3: G+11 conventional RC frame
- Model-4: G+3 flat slab with drop
- Model-5: G+7 flat slab with drop
- Model-6: G+11 flat slab with drop

These above mentioned models were analyzed and compared by equivalent static method and response spectrum analysis method.

V. DATA CONSIDERED FOR MODELING

Building properties	Type of Structure					
	conventional			Flat slab		
Building Height(m)	G+3 12	G+7 24	G+11 36	G+3 12	G+7 24	G+11 36
Story Height	3	3	3	3	3	3
Grade of concrete	M 30			M 30		
Grade of steel	Fe 415			Fe 415		
Size of Beams	300x600 mm			NIL		
Size of columns	750x750 mm			750x750 mm		
Depth of slab	175 mm			200 mm& 150 mm drop		
Dead load and live load [As per IS 875 (Part I and II):1987]						
Dead load	automatically calculated by the ETABS software					
Wall load on beams	10.25KN/m					
Floor finish	3 KN/m^2					
Live load	4 KN/m^2					
Percentage of imposed load	50%					
Earthquake Load Parameters [As per IS1893 (Part I) :2002]						
zone	II, III, IV and V					
Soil type	I,II and III					
Response reduction factor	5					
Importance factor	1.5					
Structure type	SMRF					

Table 1: Data of the modeled structure considered for the study

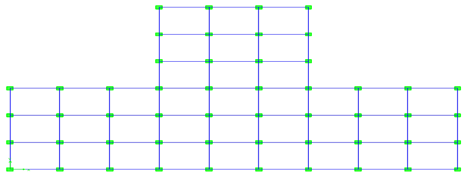

Fig. 1: Plan of the model

Plan dimension: 54m x 36m
Spacing of columns: 6m

Note- The building being irregular centre of mass and centre of rigidity does not coincide, the distance between these two is called eccentricity (e). Lateral force multiplied by this 'e' cause a torsion moment which must be resisted by the structure in addition to the normal seismic force, so torsion provision is needed to consider in the analysis.

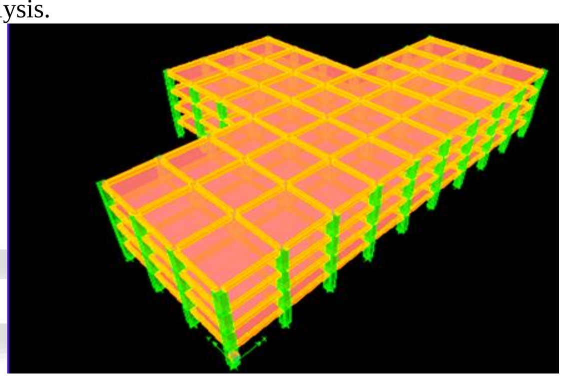

Fig 2: Storey conventional, model 1

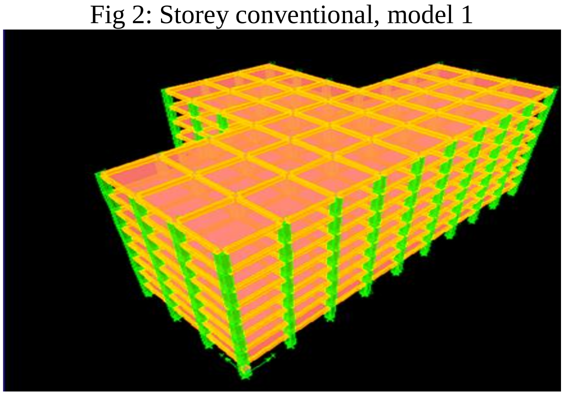

Fig 3: G+7 Storey conventional, model 2

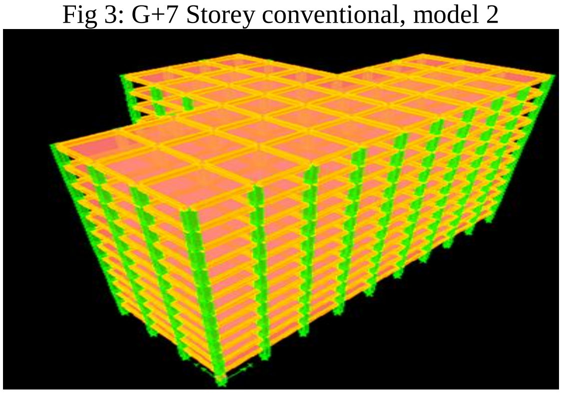

Fig 4: G+11 Storey conventional, model 3

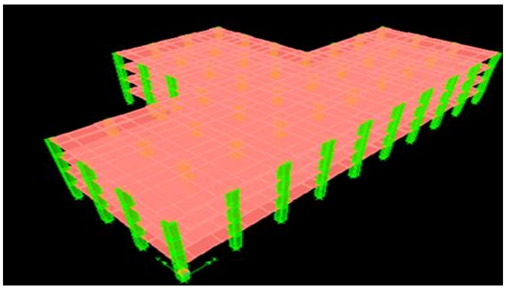

Fig 5: G+3 Storey flat slab, model 4

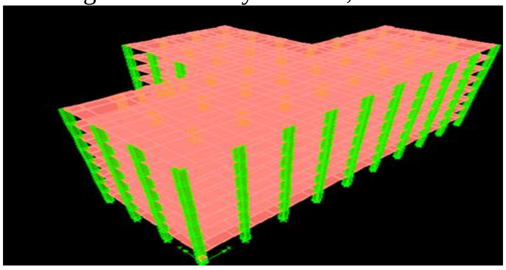

Fig 6: G+7 Storey flat slab, model 5

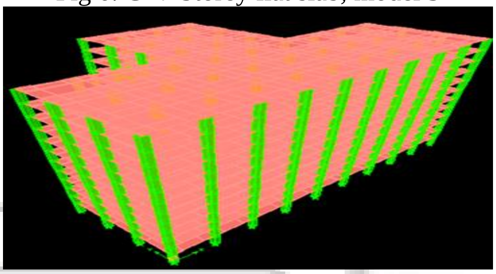

Fig 7: G+11 Storey flat slab, model 6

VI. RESULTS AND DISCUSSION

A. *Displacement*

1) *Hard Soil Conditions*

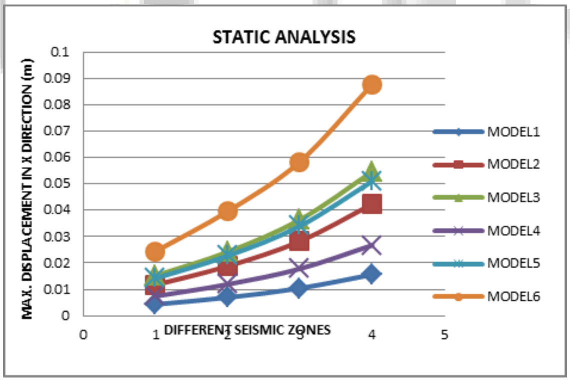

Fig 8: Comparison of displacement for different seismic zones with different models in x direction

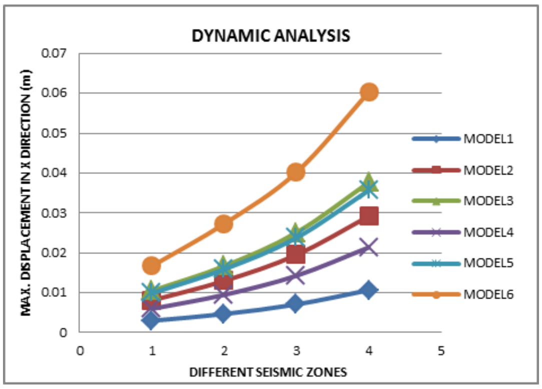

Fig 9: Comparison of displacement for different seismic zones with different models in x direction

2) *Medium Soil Conditions*

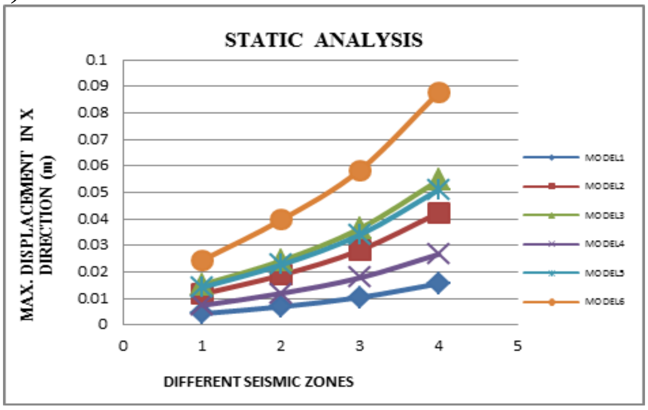

Fig 10: Comparison of displacement for different seismic zones with different models in x direction

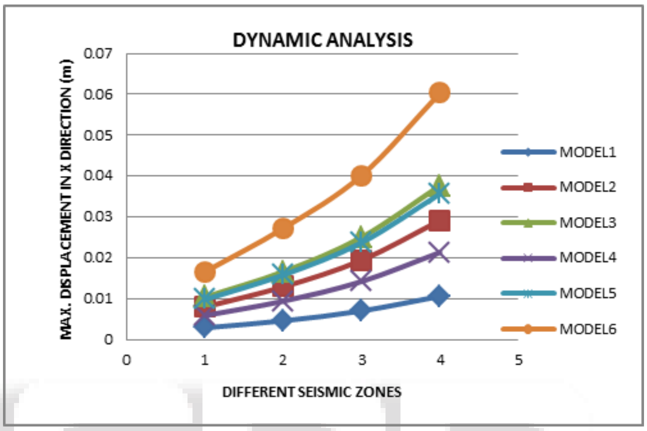

Fig 11: Comparison of displacement for different seismic zones with different models in x direction

3) *Soft Soil Conditions*

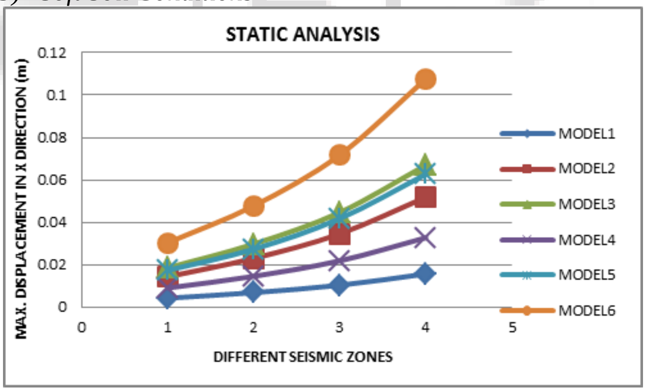

Fig 12: Comparison of displacement for different seismic zones with different models in x direction

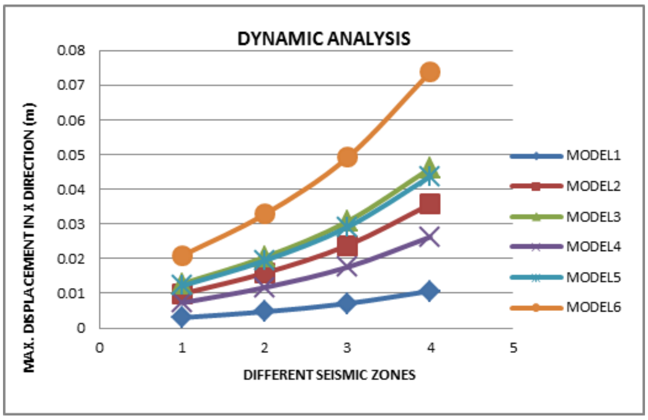

Fig 13: Comparison of displacement for different seismic zones with different models in x direction

B. Base Shear

1) Hard Soil Conditions

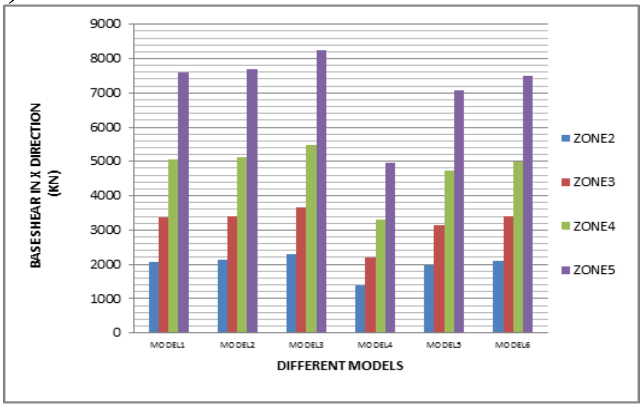

Fig 14: Comparison of base shear for different seismic zones with different models in x direction (STATIC)

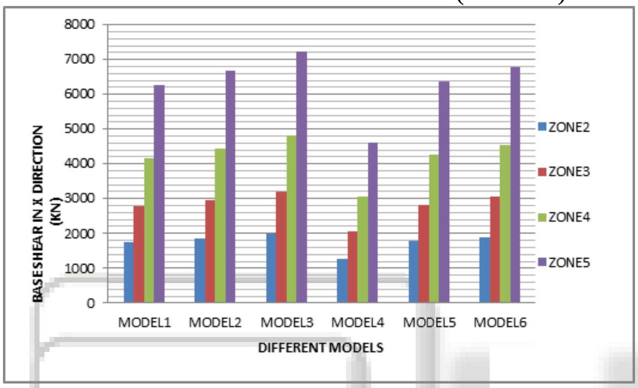

Fig 15: Comparison of base shear for different seismic zones with different models in x direction (DYNAMIC)

2) Medium Soil Conditions

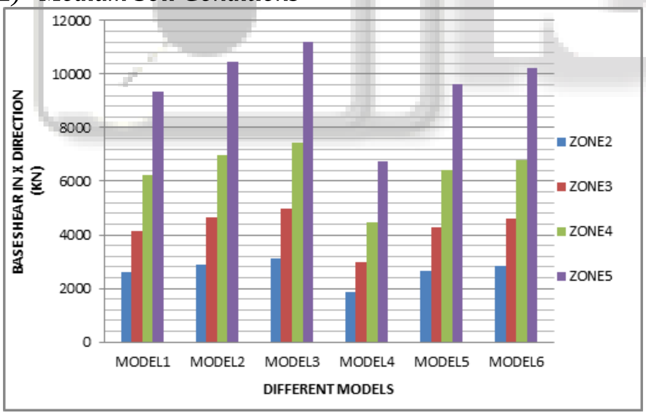

Fig 16: Comparison of base shear for different seismic zones with different models in x direction (STATIC)

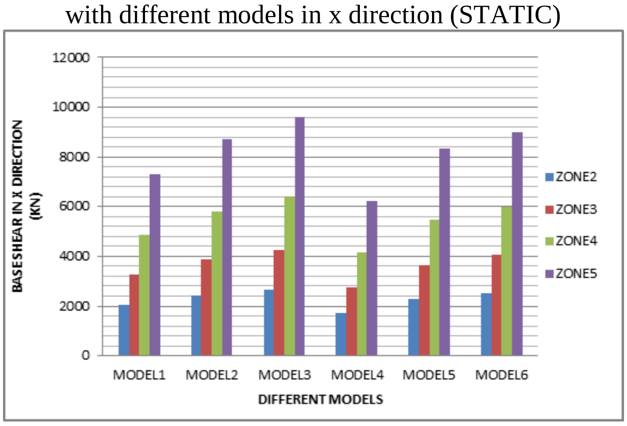

Fig 17: Comparison of base shear for different seismic zones with different models in x direction (DYNAMIC)

3) Soft Soil Conditions

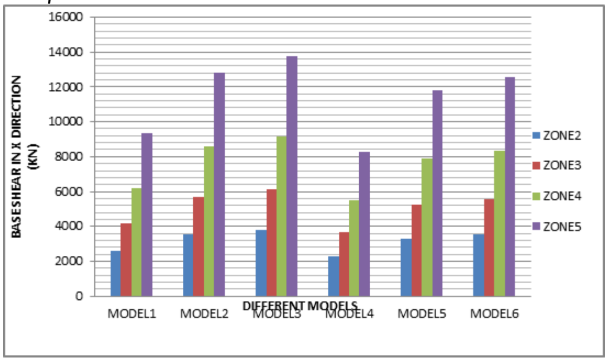

Fig 18: Comparison of base shear for different seismic zones with different models in x direction (STATIC)

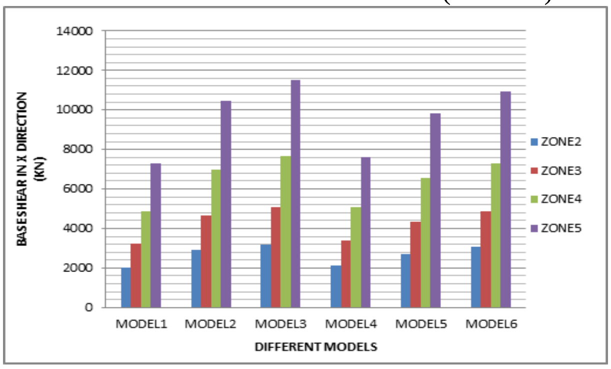

Fig 19: Comparison of base shear for different seismic zones with different models in x direction (DYNAMIC)

C. Time Period

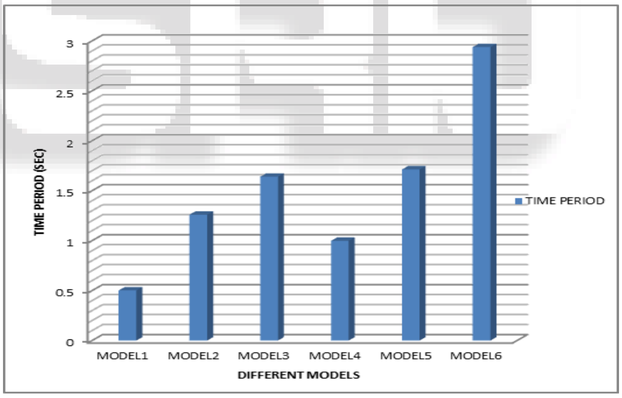

Fig 20: Comparison of fundamental natural time period for different seismic zones with different models

D. Storey Drift

1) Hard Soil Conditions

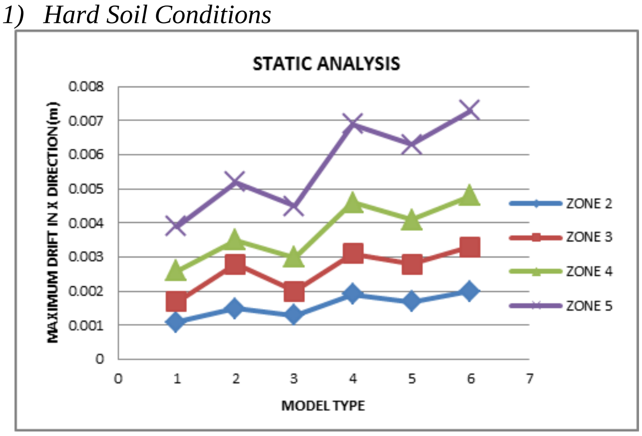

Fig 21: Comparison of storey drift for different seismic zones with different models in x direction

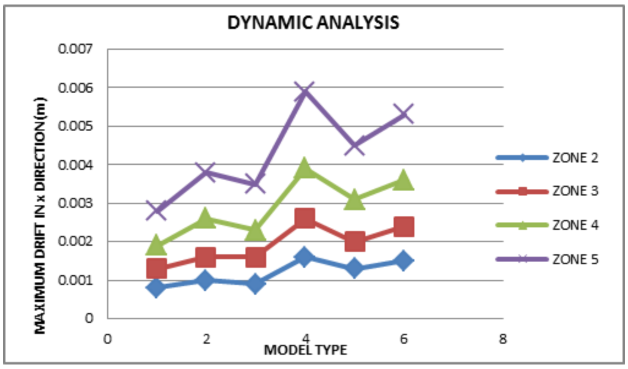

Fig 22: Comparison of storey drift for different seismic zones with different models in x direction

2) *Medium Soil Conditions*

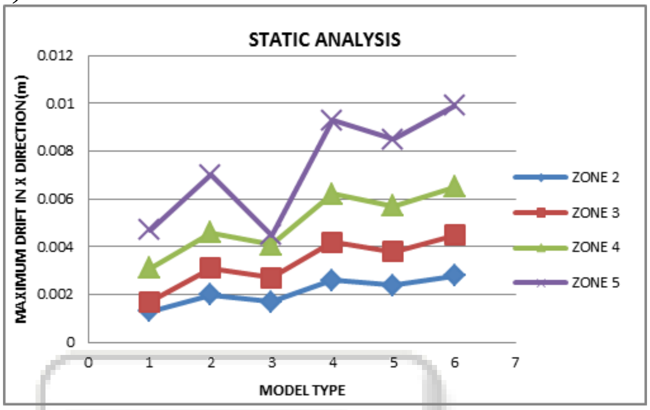

Fig 23: Comparison of storey drift for different seismic zones with different models in x direction

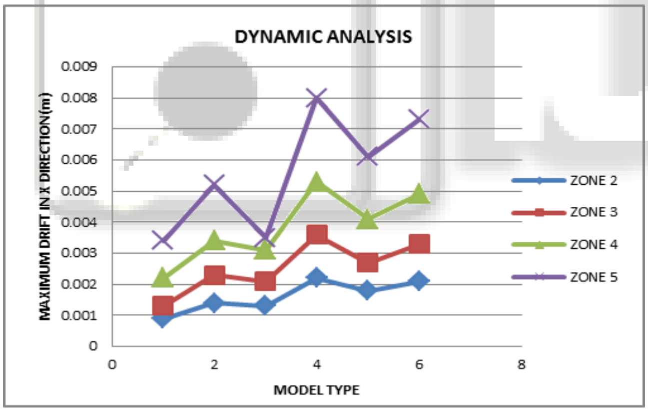

Fig 24: Comparison of storey drift for different seismic zones with different models in x direction

3) *Soft Soil Conditions*

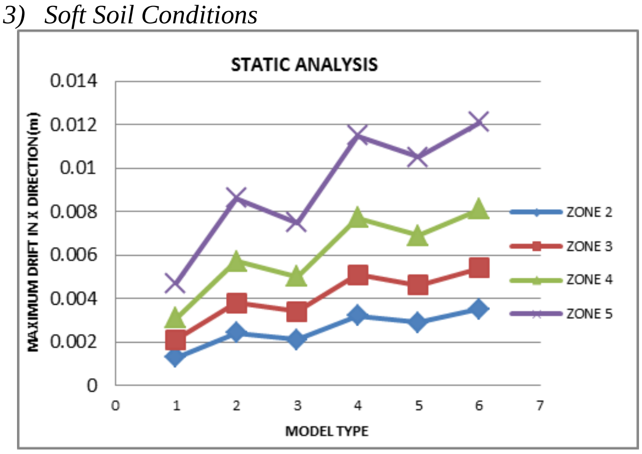

Fig 25: Comparison of storey drift for different seismic zones with different models in x direction

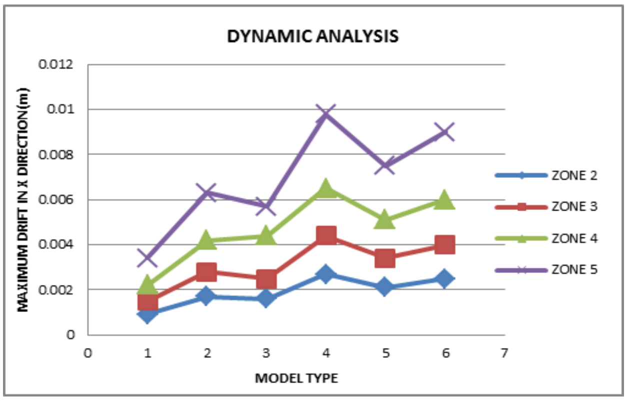

Fig 26: Comparison of storey drift for different seismic zones with different models in x direction

VII. CONCLUSION

Based on the outcomes of the analysis following conclusions are drawn

- The natural time period increases as the height of structure increases, irrespective of type of structure viz. flat slab structure, conventional structure. In comparison of the flat slab model and conventional R.C.C frame model, the time period is more for flat slab model than conventional frame since the conventional RC frame is stiffer than the flat slab model. The difference between the two varies from 32-50%.
- In the comparison of the conventional R.C. frame models (model1, 2, 3) and flat slab with drop models (model4, 5, 6), the design base shear is more for conventional models than flat slab models since its natural period is greater than the conventional RC frame model. The percentage variation is found to be from 18-25%
- It can be observed from the analysis, maximum drift occurs at middle height of the structural models.
- In the comparison of the conventional R.C.C frame models (model1, 2, 3) and flat slab with drop models (model4, 5, 6), the maximum drift value more for flat slab models than conventional models varies 32-58%as a result of this, additional moments are developed. Therefore, the columns of such buildings should be designed by considering additional moment caused by the drift.
- By observing the above results the displacement of the structure varies with varying the seismic zones and slab systems .It can be observed that displacement will be higher in seismic zone V and lower value in seismic zone II.
- Lateral displacement of conventional R.C.C building is less than the flat slab building because the structure is stiffer than flat slab structure. The difference between the two varies from 35-52%.
- Displacement, drift and base shear values are almost same in both the directions (x&y) varying 2-5% due to horizontal irregularity
- Existing structural flat slab models (model4,5,6) and conventional models (model 2and3) exceeding the drift limitation as per IS 1893-2002in seismic zone V with soft soil conditions and flat slab models(model 5and 6) exceeding the drift limitation as per IS 1893-2002in

seismic zone V with medium soil conditions. For improving deflection conditions of these structural models in higher seismic zones lateral load resisting system should be adopted or column stiffness should be increased.

- As the result of comparison between two mentioned analysis it is observed that the Lateral displacement, base shear and storey drift obtained by static analysis is higher than dynamic analysis. Hence the structure design is governed by static analysis for the models considered for the analysis
- When compare flat slab with conventional method, flat slab is best for horizontal plan irregularity buildings.

VIII. Scope for Future Work

- The structure can be analyzed with effect of Shear Wall
- The structure can be analyzed with and without infill.
- Analysis can be carried out for buildings with vertical irregularity.
- Analysis of the structure using time history method

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