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Seismic Response of Irregular Structures

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ABSTRACT

The main objective of earthquake engineering is to analyse, design and build a structure in such a way that the damage to the structure and its structural component during an earthquake is minimized. A large number of papers have focused to study the effect of irregular structures. Being inspired from the work contributed in the study on effect of earthquake on irregular shaped building this research work presents effect of plan and shape configuration on irregular shaped structures. Building with irregular geometry responds differently against seismic action. Plan geometry is the parameter which decides its performance against different loading conditions. This research work aims to evaluate the behaviour of irregularity (plan and shape) on structure under seismic effect. To workout the performance of structure, equivalent static analysis and response spectrum analysis has been adopted. For achieving this objective by using structural based software ETABS 19. Estimation of response such as: lateral displacement, storey drift, and base shear are carried out. Based on these parameters we have compared response of each model. Results are expressed in form of graphs and bar charts. From research it is observed that to minimize the effect of earthquake simple plan and configuration like regular shape must be adopted at the planning stage.

Keywords— *ETABS, Irregular plan, Irregular shape, Equivalent static analysis, Response spectrum analysis, Lateral displacement, Storey drift and Base shear*

1. INTRODUCTION

Many buildings in the present scenario have irregular configuration both in plan and elevation, which in future may subject to devastating earthquakes. In case, it is necessary to identify the performance of the structures to withstand against disaster primarily due to earthquake. Irregularities are not avoidable in construction of buildings; however, the behavior of structures with these irregularities during earthquake needs to be studied. Adequate precautions can be taken. A detailed study of structural behavior of the buildings with irregularities is essential for design and behavior in earthquake. Several related studies have focused on evaluating the response of regular structures. However, there is a lack of understanding of the seismic response of irregular structures. Therefore, a comprehensive evaluation of the effect of vertical and horizontal irregularities on the seismic demand of building structures is greatly needed. [10]. A large portion of India is susceptible to damaging levels of seismic hazards. Hence, it is necessary to take into account the seismic load for the design of structures. In buildings the lateral loads due to earthquake are a matter of concern. These lateral forces can produce critical stresses in the structure, induce undesirable vibrations or cause excessive lateral sway of the structure. Sway or drift is the magnitude of the lateral displacement at the top of the building relative to its base. The structure should withstand moderate level of earthquake ground motion without structural damage, but possibly with some structural as well as non-structural damage. The results are studied for response spectrum method. [1]. In recent earthquake so many reinforced concrete structures are damaged, it indicates the assessment of the seismic behavior of structures is how important. So everyone must have to design a satisfactory level of safety is a concern. The main objectives of this study are the seismic performance of RC frame building. Also conduct static analysis and dynamic analysis methods based on IS codes. A structural frame modeled as residential building frames. The storey displacements, base shear, and storey drift in the response spectrum analysis are compared. [3]. ETABS is the present-day leading software in the market. Many design companies use this software for their project analysis and design purpose. So, this research work mainly deals with the comparative analysis of the results obtained from the analysis of a multi-storied building structure when analyzed using ETABS software. [7].

2.1 Summary

Extinct earthquakes events demonstrate that, buildings with irregularity are vulnerable to earthquake damages. However, each of these choices of shapes and structure has significant bearing on the performance of building during strong earthquake. So the symmetry and regularity are usually recommended for a sound design of earthquake resistant structure. Considering the effect of plan and shape configuration on structure, present work is carried out to observe which plan and shape configuration of structure perform well in earthquake and must be adopted.

2. SYSTEM DEVELOPMENT

The expected behaviour of structures as observed in physical world cannot be replicated with the high degree of precision hence there is need to develop a system based on the classified approach which will establish a bridge between the physical and stimulated world. But as we know that we engineer always, try to adopt certain assumption to make complex physical problem easier which leads to approximate solution hence, we have developed 6 models in software namely ETABs 19 to study the behaviour of irregular structures. Specification for all above mentioned structural models are same and are given as follows.

Table 1: Load Data

Live Load	3 kN/m2 as per IS 875
Floor Finish Load	1 kN/m2 as per IS 875

Table 2: Seismic Definition Specifications

Earthquake Zone	III
Damping Ratio	5%
Importance Factor	1.2
Type of Soil	Medium Soil
Type of Structure	All General RC Frame
Response Reduction Factor	5 [SMRF]
Time Period	Program Calculated
Foundation Depth	2.1m
Poison's Ratio	0.2

Table 3: Geometric Data

Density of RCC considered	25 kN/m3
Thickness of slab	150mm
Depth of beam	500mm
Width of beam	350mm
Dimension of column	350 mm x 500mm
Density of infill	20 kN/m3
Thickness of out wall	230mm
Height of second floor	4 m
Height of each floor	3.5m
Poison's Ratio	0.2
Conc. Cube Comp. Strength, fck	20000 N/mm2
Bending Reinforcement yield strength, fy	500000 N/mm2
Shear Reinforcement yield strength, fys	500000 N/mm2
Beam Rebar Cover	35mm
Column Bar Size	16 ϕ

These 6 models are shaped by considering Plan irregularities i.e. the plan area for each structure is same only there is difference of geometry i.e. horizontal (plan and shape). For all types of structure total number of storey are 15.

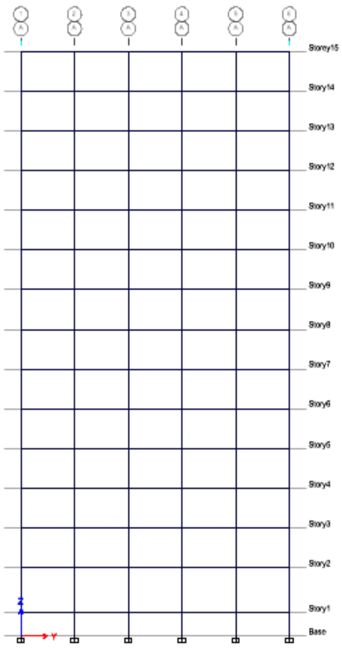

Fig.1 Elevation

Plan of each building models consider are shown below:

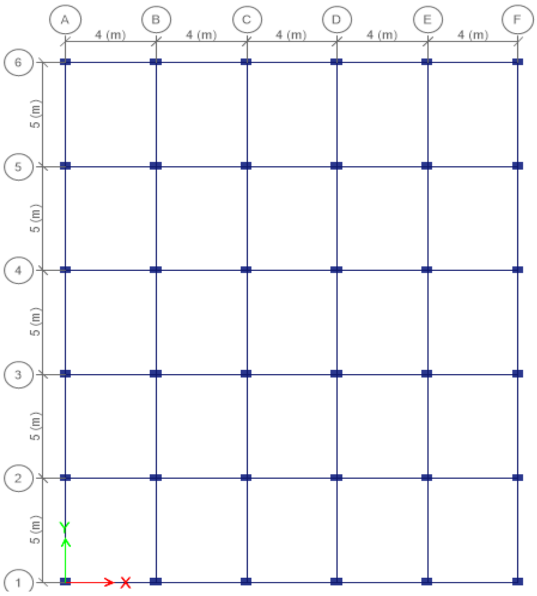

Fig.2 Regular Square Shape (S1)

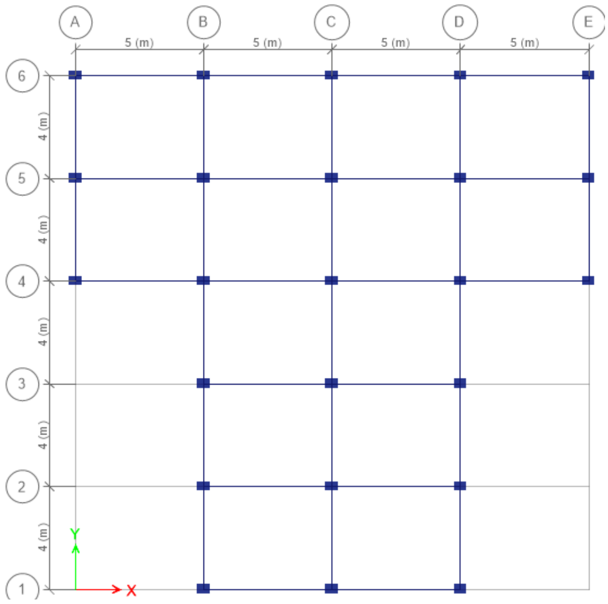

Fig.3 T-Shape (S2)

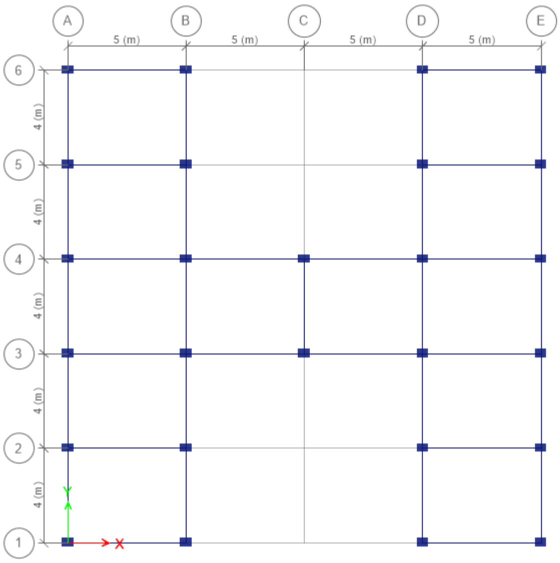

Fig.4 H-Shape (S1)

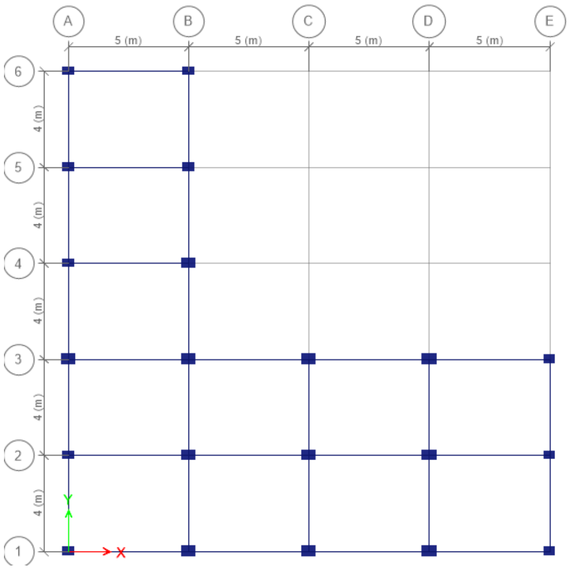

Fig.5 L-Shape (S4)

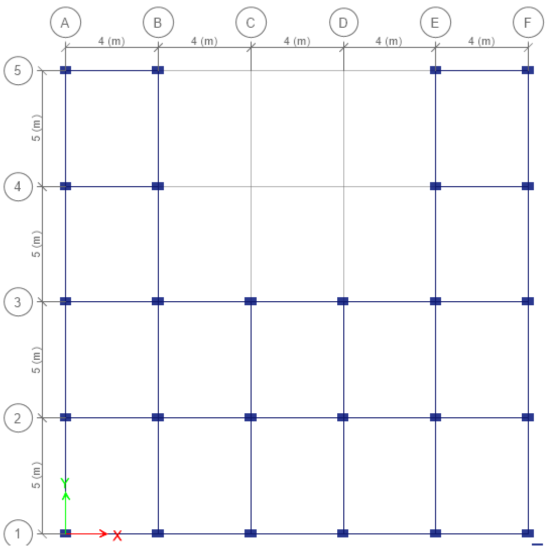

Fig.6 C- Shape (S5)

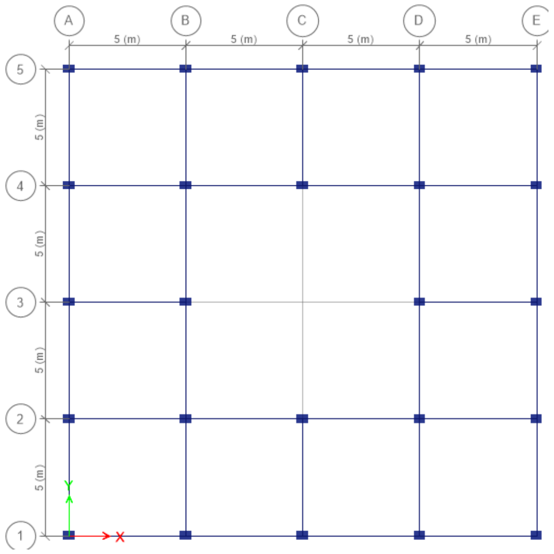

Fig.7 Square Shape with Core (S6)

3. PERFORMANCE ANALYSIS

There are several numbers of factors affecting the behaviour of building out of which of storey drift and lateral displacement are consider for study in this work. For this, building model in zone III is considered. Equivalent static analysis and Response spectrum analysis are carried out on the entire model using software ETAB. An analysis results are demonstrated with the help of tables and charts. After Run analysis of structure corresponding Lateral Displacement and Storey Drift should be noted. It should not exceed the IS code (IS: 1893-2016) recommendation i.e. Storey Drift in any storey shall not exceed 0.004times the storey height. For that we have to redefine column with heavy section to prevent excessive drift.

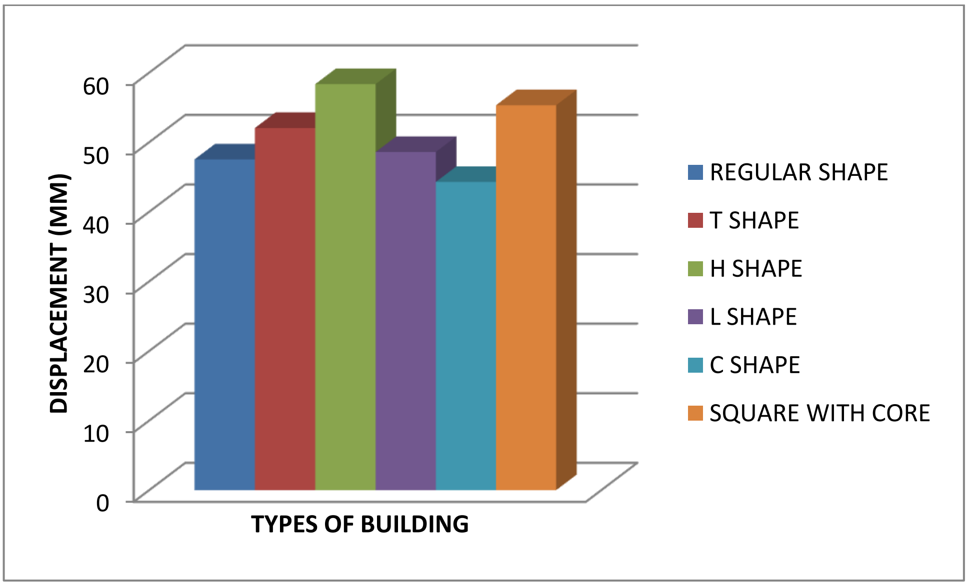

Fig. 8 Nodal Lateral Static Displacement in X-Direction

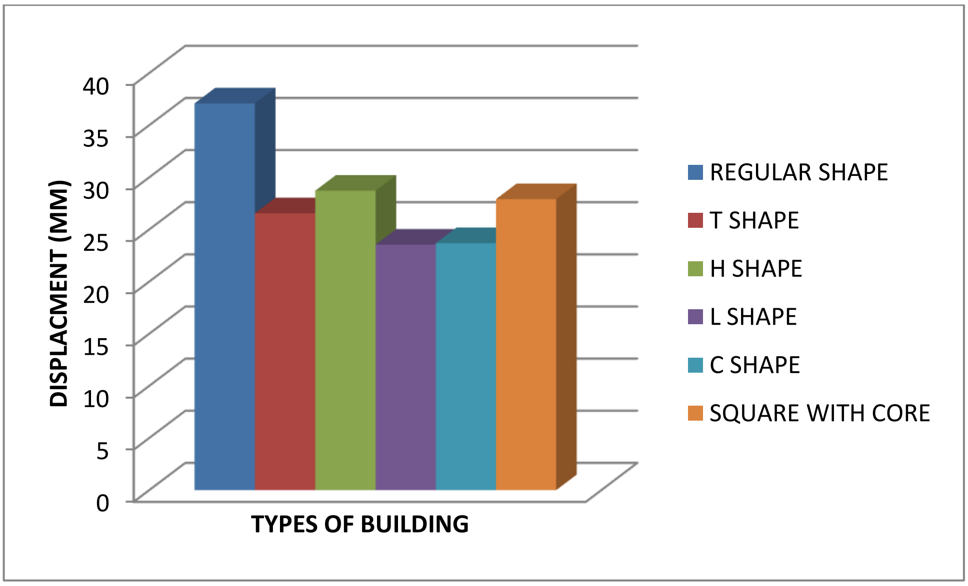

Fig. 9 Nodal Lateral Dynamic Displacement in X-Direction

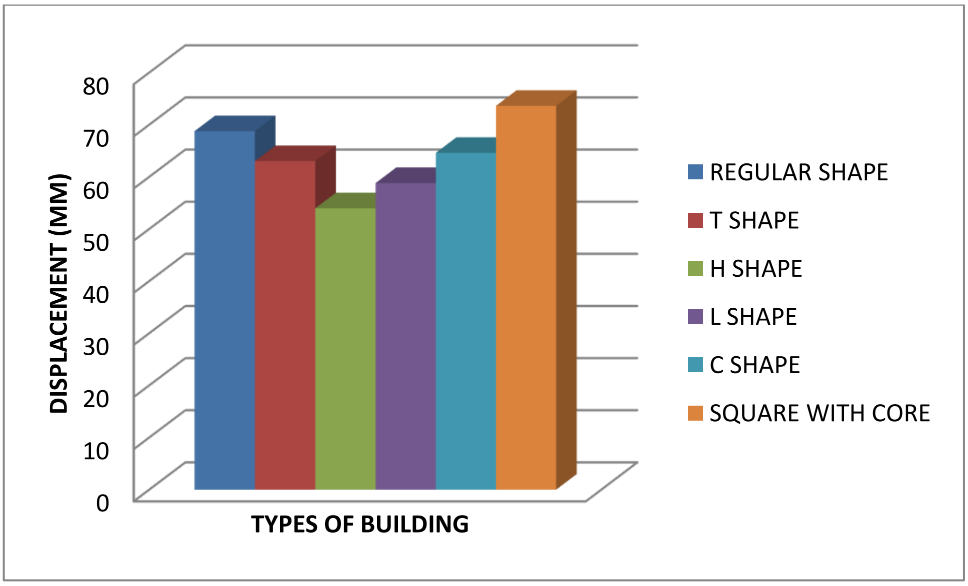

Fig. 10 Nodal Lateral Static Displacement in Y-Direction

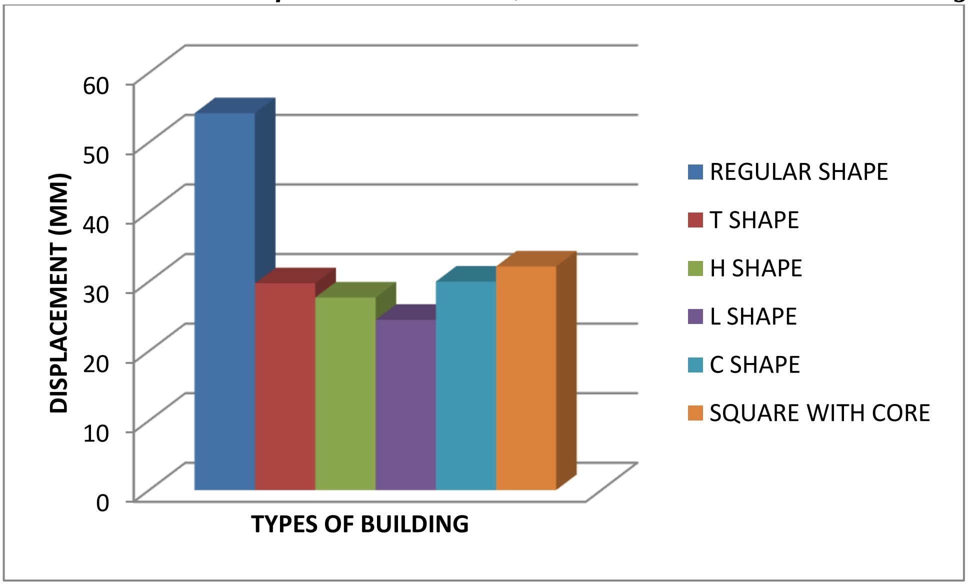

Fig. 11 Nodal Lateral Dynamic Displacement in Y-Direction

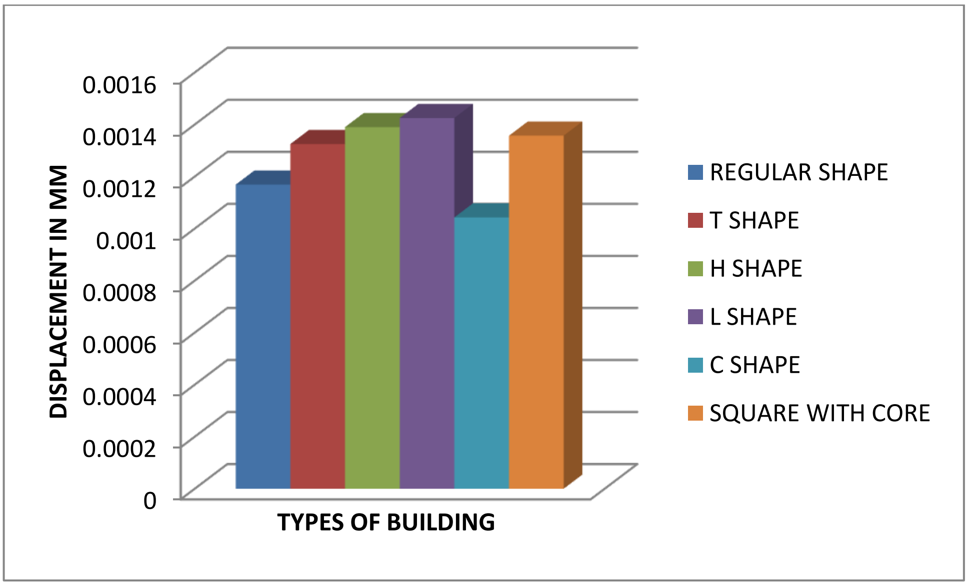

Fig. 12 Static Storey Drift in X-direction

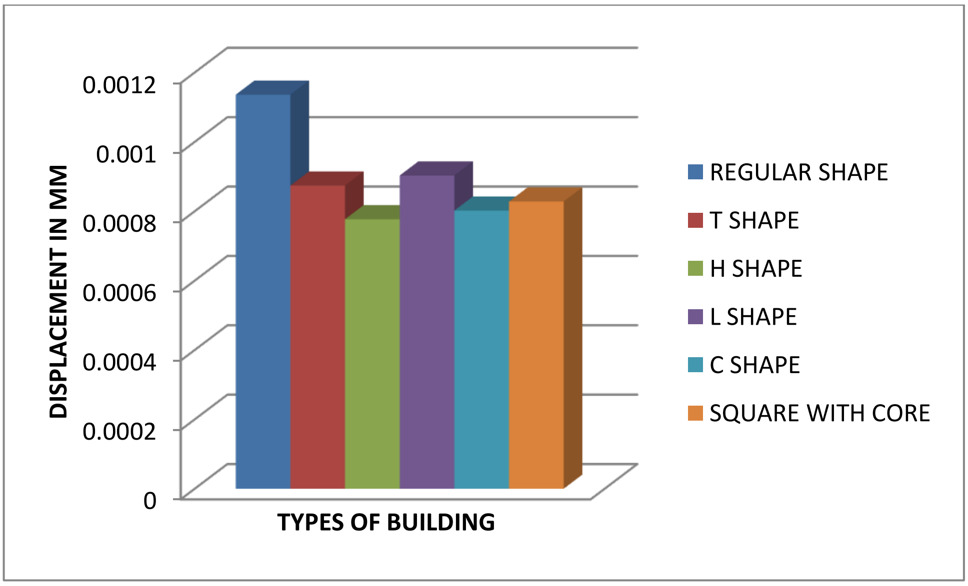

Fig. 13 Dynamic Storey Drift in X-direction

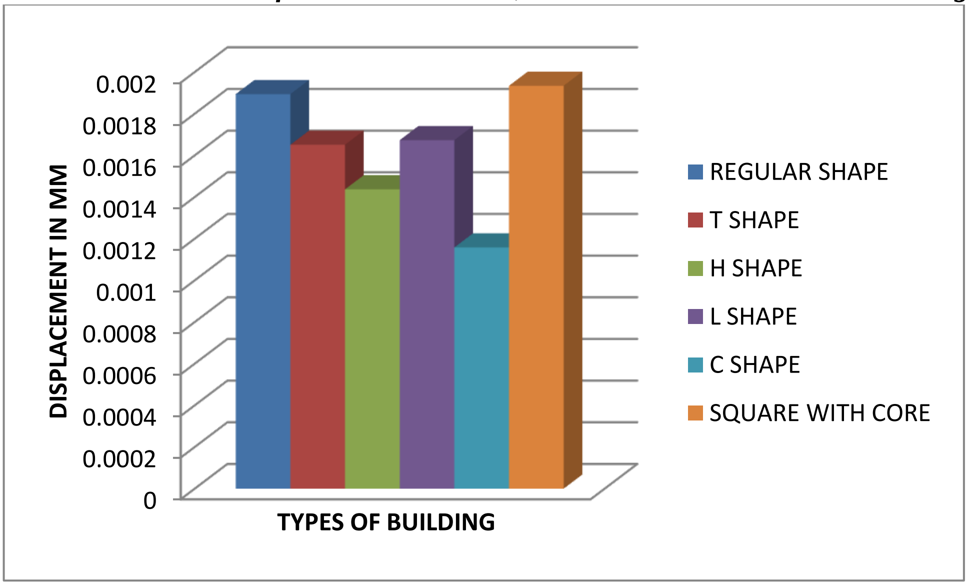

Fig. 14 Static Storey Drift in Y-direction

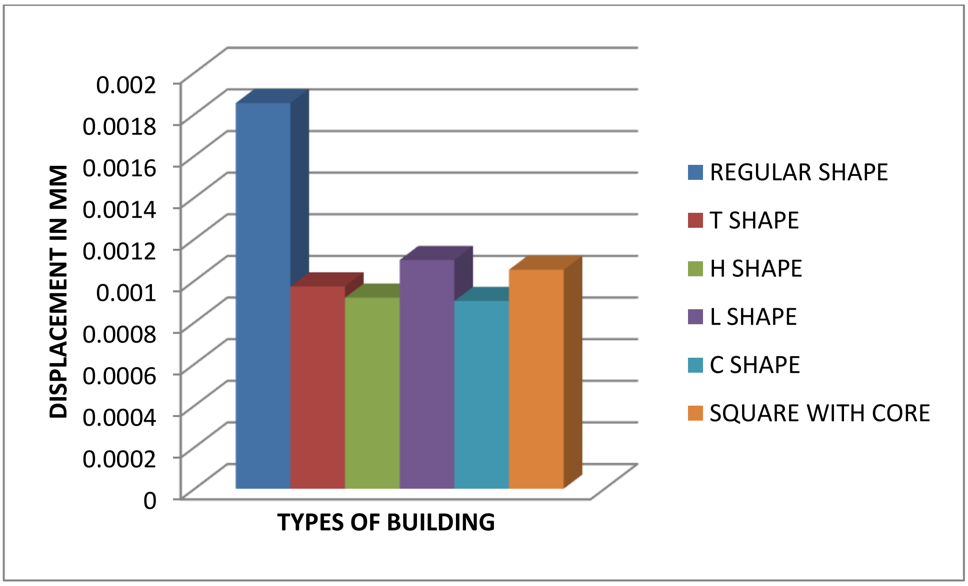

Fig. 15 Dynamic Storey Drift in Y-direction

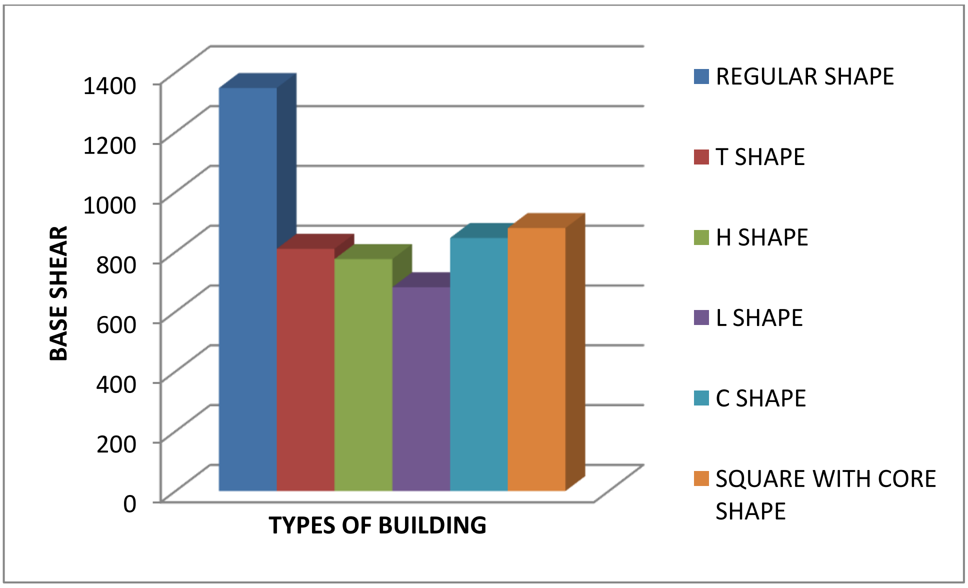

Fig. 16 Base Shear (EQ X)

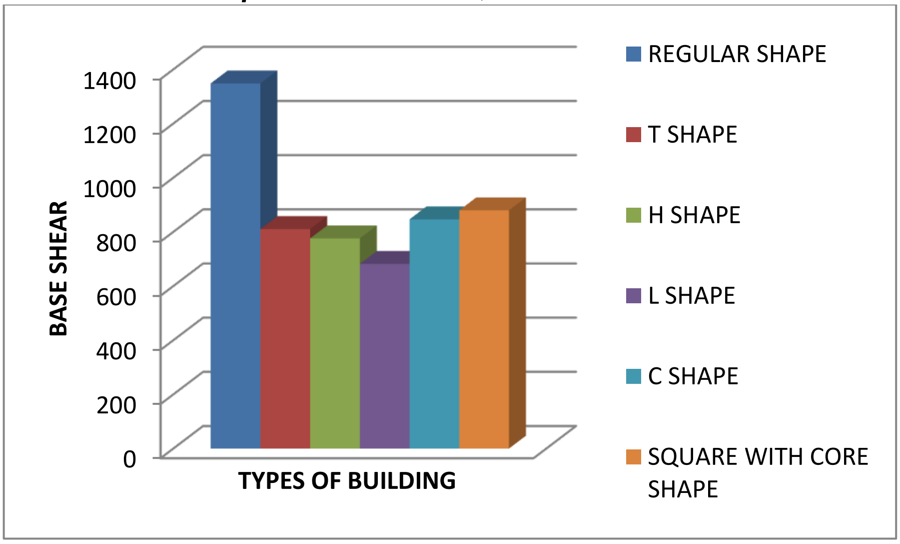

Fig. 17 Base Shear (EQ Y)

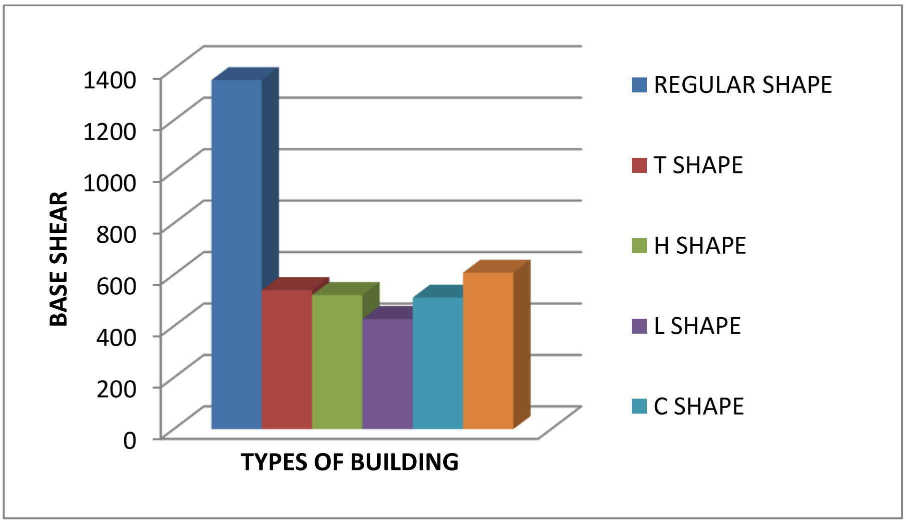

Fig. 18 Base Shear (RS X)

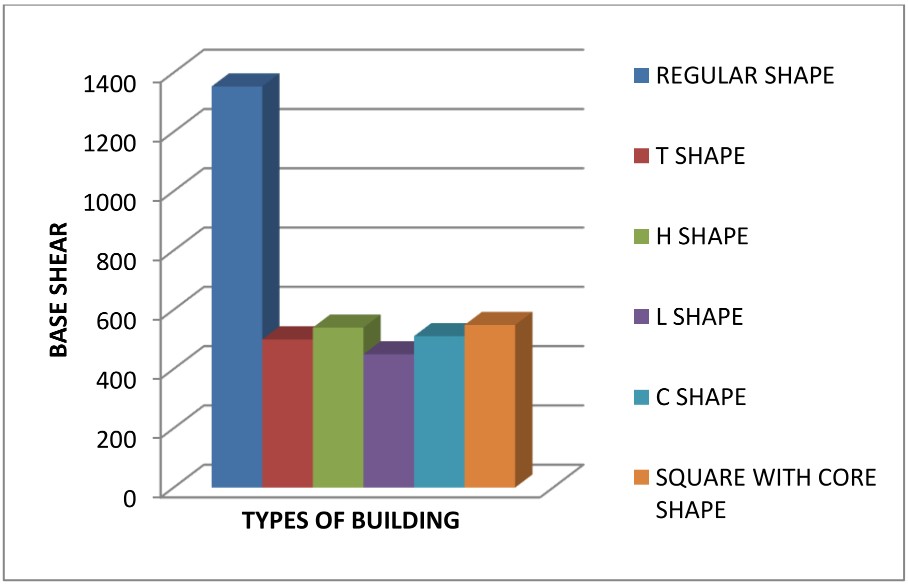

Fig. 19 Base Shear (RS Y)

By observing above both the graphs of base shear, it is observed that L shape gives lesser base shear than other 5 models in both X-direction and Y-direction. But it has been sighted in literature L shape geometry of structure subjected to earthquake perform poor and fails under torsional effects. As a result, show that L shape building has lesser base shear, these may be due to lesser plan area as in comparison to other plans of buildings. Considering all these above factors the storey base shear for regular building is highest compare to irregular shape building. Hence, finally we may say that simple shape geometry of structure must be adopted to minimize the effects of seismic actions.

4. CONCLUSIONS

A. DISPLACEMENT

1. From linear static analysis observed that there is an increase of lateral displacement of models T, H and Square with core shape as compared to other models' Regular shape, L and C shape in X direction.
2. From linear dynamic analysis observed that there is an increase of lateral displacement of models Regular, H, T and Square with core shape as compared to other models L and C shape in X direction.
3. From linear static analysis observed that there is an increase of lateral displacement of models Regular, C and Square with core shape as compared to other models T, H and C shape in Y direction.
4. From linear dynamic analysis observed that there is an increase of lateral displacement of models Regular, T, C and Square with core shape as compared to other models H and L shape in Y direction.
5. Static analysis gives higher values for maximum displacement of the stories in both X and Y direction.
6. The results of equivalent static analysis are approximately uneconomical because values of displacement are higher than dynamic analysis except regular shape model.

B. STOREY DRIFT

1. From linear static analysis observed that there is an increase of storey drift demand of models H, T and L shape as compared to other models Regular, square shape with core and C shape in X direction.
2. From linear dynamic analysis observed that there is an increase of storey drift demand of models Regular, T and L shape as compared to other models H, C and Square with core shape in X direction.
3. From linear static analysis observed that there is an increase of storey drift demand of models square with core, L, T and Regular shape as compared to other models H and C shape in Y direction.
4. From linear dynamic analysis observed that there is an increase of storey drift demand of models Regular, Square with core and L shape as compared to other models T, H, and C shape in Y direction.
5. It is observed that storey drift for all the stories is found to be within the permissible limits.

C. BASE SHEAR

1. From linear static analysis and linear dynamic analysis, it is observed the base shear in X and Y direction there is an increase of base shear of model Regular shape only as compared to all other models T, H, L, C and Square with core shape.
2. Base shear is calculated by using IS 1893-2016 code provision with the help of ETAB for all six models and illustrate the comparison of base shear using Equivalent static analysis and Response spectrum method the lower base shear is getting in L-shape building and the higher base shear is getting in Rectangular shape building.

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