Seismic Behavior of Circular Building with Mass Irregularity

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Abstract - *Earthquake has a high potential to cause a wide spread damage in densely populated areas which causes heavy loss of human life and high economic losses. This cause of damage is due to lack of knowledge of engineers and hence resulting in improper design of structures. Hence, it is necessary to ensure adequacy of the structures against horizontal earthquake effects. Many buildings in the present scenario have irregular configurations both in elevation and plan. In this study a circular building having vertical mass irregularity is analyzed by equivalent static method (Linear static method) using ETABS. Five models are generated with vertical mass at different story of the circular building, and the results obtained from software after the application of seismic forces are then observed and compared. The main parameters considered in this study to compare the seismic performance of different models are storey displacement, storey drift and base shear.*

Key Words: Seismic Force, Circular Building, Mass Irregularity, Equivalent Static Method, Storey displacement, Storey Drift , Base Shear .

1.INTRODUCTION

Irregular buildings constitute a large portion of the modern urban infrastructure. Structures are never perfectly regular and hence the designers routinely need to evaluate the likely degree of irregularity and the effect of this irregularity on a structure during an earthquake. Hence, it is necessary to ensure adequacy of the structures against horizontal earthquake effects. Need for research is required to get economical and efficient lateral stiffness system for high seismic prone areas. For optimization and design of high rise building with different structural framing systems subjected to seismic loads[1]. In the past, round houses were much more common. They were the shape of choice because they were strong, energy efficient, good for ventilation and air circulation, less vulnerable in strong winds and they used the least amount of materials relative to floor area. In a round house there are dozens of interconnected points which give the building a unique combination of flexibility and strength – qualities which make them significantly safer in earthquakes. So technically circular houses or buildings can be much better to withstand seismic forces.

The Indian Standard code IS-1893: 2002 (Part-I) defines a number of structural irregularities. The code suggests a different approach of analysis for irregular structures. There are two types of irregularities: vertical and plan irregularity.

Vertical Irregularities are mainly;

A. Stiffness Irregularity

> *1) Soft Storey:* A soft story is one in which the lateral stiffness is less than 70 percent of the story above or less than 80 percent of the average lateral stiffness of the three story's above.

> *2) Extreme Soft Storey* : An extreme soft story is one in which the lateral stiffness is less than 60 percent of that in the story above or less than 70 percent of the average stiffness of the three story's above.

B. Mass Irregularity

> Mass irregularity shall be considered to exist where the weight of any storey is more than 200 percent of that of its adjacent story's. The effective mass is the real mass consisting of the dead weight of the floor plus the actual weight of partition and equipment. Excess mass can lead to increase in lateral inertial forces, reduced ductility of vertical load resisting elements. In Case of roofs, irregularity need not be considered.

C. Vertical Geometric Irregularity

> A structure is considered to be Vertical geometric irregular when the horizontal dimension of the lateral force resisting system in any story is more than 150 percent of that in its adjacent story.[3]

Irregularity of mass distribution in vertical and horizontal planes can result in irregular response and complex dynamics. Numerous examples of building that collapse due to the presence of excessive vertical load have been identified in Mexico earthquake, 1985.
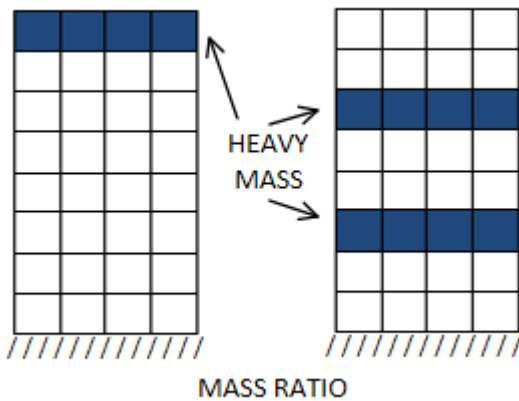
Fig: Mass Irregularity

2. DESCRIPTION OF STRUCTURAL MODELS

The current study has five models of a circular building of 21 storeys (G+20) having diameter of 50 meters and storey height of 3.5meters for all storeys. Is being considered to have mass at different stories such as 7th, 14th and 21st .

Table -1: Description of Structural Models.

General Specifications	
Number of storey	21
Storey height	3.5m
Plan area	1963.49m²
Height of the building	73.5m
Size of Beam	400mm×600mm
Size of Column	600mm×900mm
Thickness of Slab	150mm
Grade of concrete	M30
Grade of Steel	Fe500
Live load	3.5 kN/m2
Roof live load	1.5kN/m²
Heavy Mass	15kN/m2
Floor Finish	1 kN/m2

Earthquake Parameters	
Zone	IV
Zone factor	0.24
Importance Factor (I)	1.5
Soil type	Type-II(medium soil)
Response reduction factor (R)	5

3. MODELS FOR ANALYSIS

For the present study, five different models are being analysis by Equivalent static Analysis . the analytical model of the buildings includes influence of the heavy mass at different storeys of the structure i.e. at 7th floor, 14th floor and 21th floors respectively.

MODEL1: Regular Frame
MODEL2: Frame having heavy mass at 7th floor
MODEL3: Frame having heavy mass at 14th floor
MODEL4: Frame having heavy mass at roof
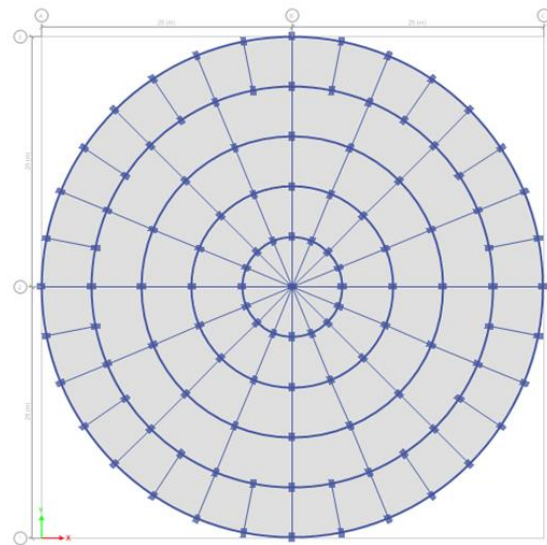MODEL5: Frame having lumped masses at 7th, 14th, roof respectively.
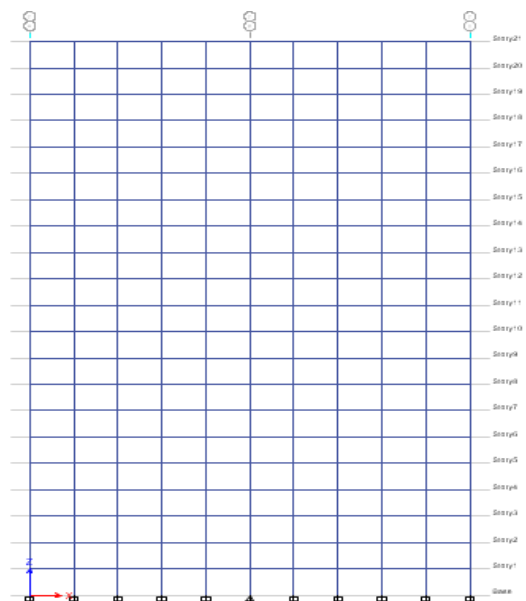

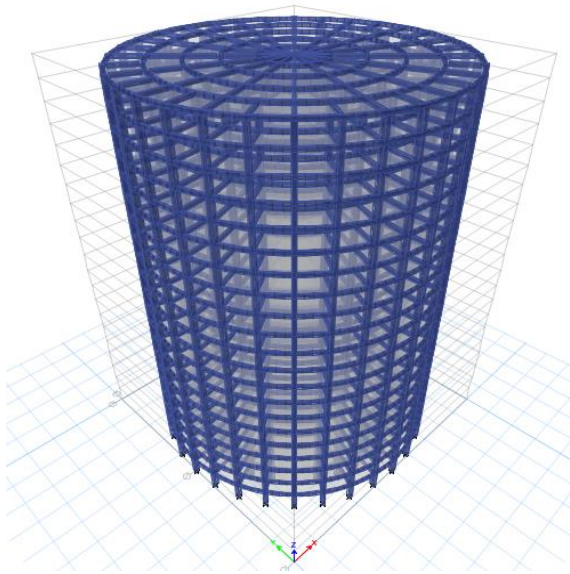**Fig-2** Plan of the Building for all Models

Fig-3 Section of the model 1
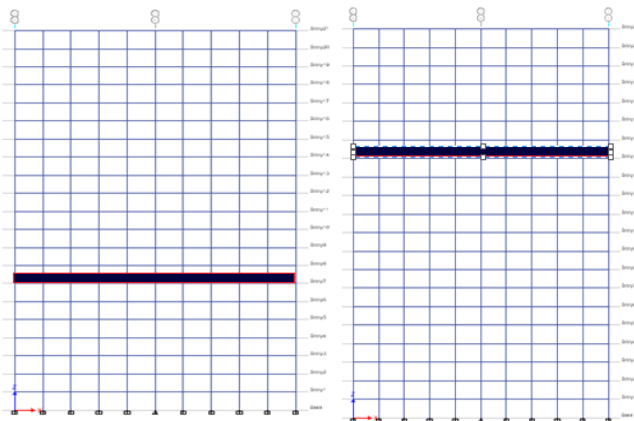
Fig -4 3D view of the model 1

Fig -5 Model 2 with Heavy mass at 7th Floor.

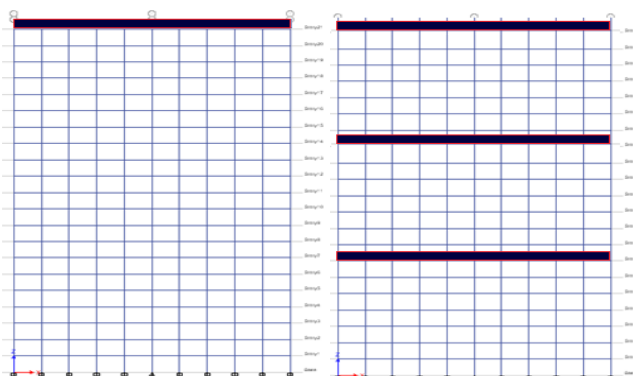**Fig -6** Model 3 with heavy mass at 14th Floor

Fig -7 Model 4 with Heavy mass at Roof.

Fig -8 Model 5 with heavy mass at 7th , 14th Floor and Roof

4. RESULTS AND DISSCUSSIONS

Total five models have been analyzed by Equivalent Static Analysis [ESA] for all structural models. The results are obtained from ETABS software for the parameters storey displacement, storey drift and base shear and whereas the results are graphically presented below.

4.1 STOREY DISPLACEMENT:

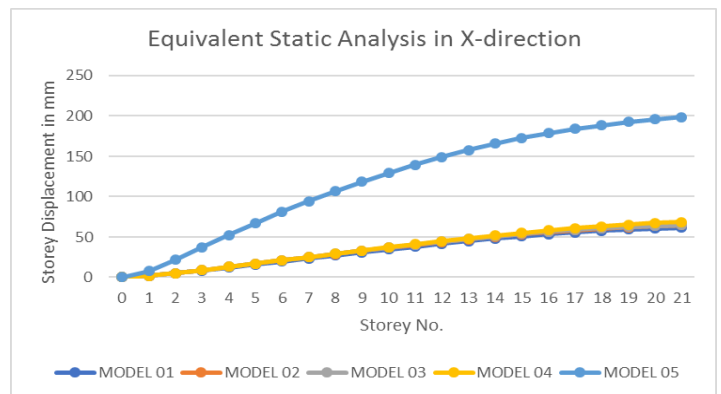The Storey Displacement is known as the total displacement of its storey with respect to the ground.

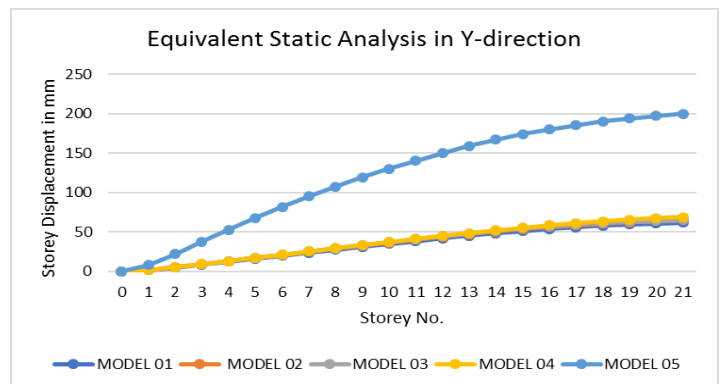**Chart -1**: Storey Displacement vs Storey in X-direction.

Chart -2 : Storey Displacement vs Storey in Y-direction.

The model 05 has the maximum storey displacement values along both the directions comparing to the other models. due to the heavy masses at multiple storeys.

Now from comparing storey displacement values of model 2, 3 and 4 with model 1. the values get increased by 4.84 %, 5.13 % and 10.6 % respectively. due to the shifting of heavy mass upwards storeys.

4.2 STOREY DRIFT :

The Storey Drift is known as the ratio of displacement of two consecutive floor to the height of that

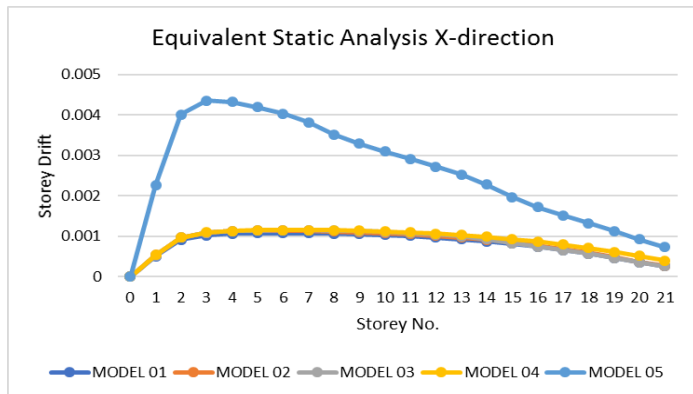floor. The permissible storey drift according to is 1893-2002 is limited to 0.004 times the storey height.

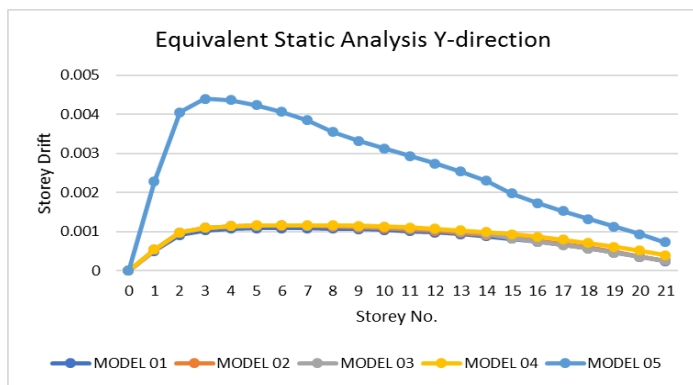**Chart -3**: Storey Drift vs storey in X-direction.

Chart -4: Storey Drift vs Storey in Y-direction.

The model 05 has the maximum storey drift values along both the directions comparing to the other models. due to the heavy masses at multiple storeys.

Now from comparing Storey drift values of 7th storey of model 1 and model 2 . the storey drift in model 2 increases by 5.44 % .

Even Comparing storey drift values of 14th Storey of model 1 and model 3 , the storey drift in model 3 increases by 5.71 %.

Also Comparing storey drift values of roof storey of model 1 and model 4 , the storey drift values increases by 36.34 %.

From model 2 , 3 and 4 . the storey drift values for those storey lieing below the heavy mass storey remins high in Storey drift value .

4.3 Base Shear :

Base shear ia an estimate of the maximum expected lateral force that will occur due seismic ground motion at the base of the structure .
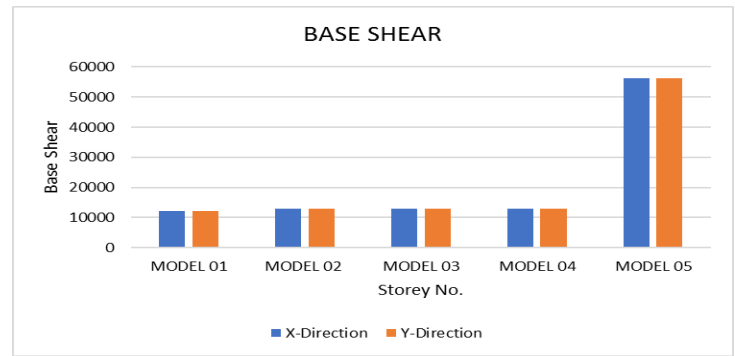

Chart -5: Base Shear vs Storey in both X and Y direction.

5. CONCLUSIONS

[1] The values of storey displacement and storey drift increases as the heavy mass shifts upwards.

[2] The location of heavy mass in the building does not affect the base shear considerably.

[3] The base shear values are considerably high in building having vertical mass irregularity.

[4] More mass means higher inertia forces therefore lighter building sustain the earthquake shaking better.

[5] The values of base shear, storey displacement and storey drift are considerably to be high for the model 5 having heavy mass at multiple floors.

ACKNOWLEDGEMENT

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