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Nonlinear Time History Analysis Of Mass And Geometric Regular And Irregular Multi Storey Moment Resisting RCC Frames

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ABSTRACT

From past earthquake it is observed that if the structures are not properly analyzed and constructed with the required quality, then it may lead great destruction and loss to human lives. It is proved that many of structure are totally or partially damaged due to earthquake. So it is necessary to determine seismic response of such buildings. There are different techniques of seismic analysis of structure. Among them time history analysis is one of the most important techniques for structural seismic analysis generally the evaluated structural response in non linear in nature. Mass irregularity is considered to exist where the seismic weight of any storey is more than 200 percent of that of its adjacent storey. Mass irregularity is an important factor which affects the response of the structure under seismic loads. This is introduced by increasing the weight of some floors relative to the other floors. Geometric irregularity is an irregular asymmetry in shape; an irregular spatial pattern. Mostly the regular (rectangular) geometric shape are consider in building design. But sometimes due to space restriction or aesthetic purpose the demand of irregular or different shape of building are increase.In this project work seismic analysis of RCC building with mass and geometric irregularity with and without shear wall are carried out. Here a G+10 stories building with mass and geometric irregularity has been modeled for seismic analysis. In this thesis design of structure for this building is carried out by using ETABS software. After being analyzed, structural response such as Storey displacement, Storey drift, and Base shear are compared.

Keywords: Time History Analysis, RCC Frames, ETABS, Base shear, Storey Drift, Storey displacement.

I. INTRODUCTION

1.1 IRREGULARITIES

Uneven distributions of mass, strength, and stiffness along the height of the building may be the cause of the irregularity in the building structures. One of the main causes of building breakdowns during earthquakes is irregularities such as mass, stiffness, plan, and torsion.

KINDS OF IRREGULARITIES

- Vertical stiffness irregularity.
- Weight (mass) irregularity.

- Geometric irregularity.
- In-plane discontinuity.
- Out-of-plane offsets.
- Discontinuity in capacity (weak storey)
- Torsional sensitivity.
- Non-orthogonal systems.

MASS IRREGULARITY

Mass irregularity is considered to exist where the seismic weight of any storey is more than 200 percent of that of its adjacent storey. Mass irregularity is an important factor which affects the response of the structure under seismic loads. This is introduced by increasing the weight of some floors relative to the other floors. The effect of irregularity depends on the structural model used, location of irregularity and analysis method.The mass irregularity must not be taken into account for top storeys or roofs.

GEOMETRIC IRREGULARITY

An irregular asymmetry in shape; an irregular spatial pattern. Mostly the regular (rectangular) geometric shape are consider in building design. But sometimes due to space restriction or aesthetic purpose the demand of irregular or different shape of building are increase.

II. REVIEW OF LITERATURE

[1] Prof. Swapnil B -et al (2015)

They had carried out research on comparative analysis of the combined RC-masonry's seismic behaviour. In their study, irregularity is examined between G+9 multi-story R.C.C. and Composite buildings and taken into account as mass. Using SAP 2000 software, equivalent static and response spectrum methods are employed to analyse the building in accordance with IS 1893 (Part 1):2002. According to the study, composite structures with uneven mass will perform better than R.C.C. structures.

[2] Asha Vijayan -et al (2016)

With the aid of the ETABS programme, they had used a time history analysis method to examine the multi-story RCC building while taking into account mass irregularity at various floor levels. The first step is to simulate a typical G+11-story building across the building. The model consists of a G+11-story building with irregular mass distribution on the first, fifth, and tenth floors by altering the dead load on the structure. By using time history analysis, compare these three models. Compare the structure's natural frequency, base shear, and tale drift as well. Which led them to the conclusion that constructions with no mass anomalies are better able to withstand seismic loads. If there are any large imperfections, they should be concentrated on the bottom, top, or any core portions of construction components.

[3] Alhamd Farqaleet -et al (2016)

In this study, they had taken 5 buildings models of 10 storeys each and results of linear and nonlinear time history analysis and pushover analysis are compared with the one of the regular model. The analysis is done for zone IV. And they got the results as follows. Due to lesser stiffness of stories in stiffness irregular building models, the floor displacement is more in stiffness irregular structure than regular structure. Mass irregular structure has swimming pool in 4th and 8th. With increase in mass of stories, there is increase in inertia force generated in those stories and the moment of the inertial force is more leading to larger displacements as compared to regular structure. For models with stiffness irregularity, the stiffness is reducing as compared to regular structure and hence the modal time period is increasing and therefore decreasing the base shear. Mass irregular structures with heavy masses on two floors have greater base shear as compared to regular structure.

[4] P.Narasimharao -et al (2017)

In this study, twelve-storeyed vertical irregular RCC building is selected to analyze the behavior of the structural members due to change of mass and inter-storeyed height. This building is situated in seismic zone IV. It is composed of special moment-resisting frame system. The superstructure is designed with ETABS software. The structure is initially analyzed and designed with static analysis. It is found that the safety factor values are satisfied within allowable limits. And then, this structure is analyzed with dynamic (time history analysis) based on change of mass and inter-storeyed height. The results of column size in dynamic analysis are greater than that in static analysis.

[5] N.Anvesh -et al (2015)

In this study, they had taken G+10 mass regular and irregular RCC building to carryout design of the considered mass regular and irregular building as per code IS 875 Part III criteria for wind loads. By the results they had concluded that size of the structural members also increases for buildings with mass irregularity, since the load acting in mass irregular building is more the displacements in buildings with mass irregularity are less than the mass regular structure, and it was observed that drifts in mass regular building are more than the mass irregular building.

III. OBJECTIVES

1. To study the behaviour of RC building (G +10 Storey) with mass & geometric irregularities by using nonlinear Time History Analysis.

2. To investigate the performance of multistoried RC building under seismic forces such as base shear, story drift, story displacement with and without shear wall.

3. To compare the structural behavior of buildings with and without change of mass & geometric irregularities of building.

IV. METHODOLOGY

4.1 ETABS

Etabs is a distinctive piece of software made for assessing and planning building constructions. Etabs stands out from other programmes since it can handle all the activities required for structural analysis and design. It contains cutting-edge graphics and potent algorithms in a very user-friendly environment. When he established the privately held company in 1975, Ashraf co-authored the first structural engineering software package for the personal computer. He has since created a variety of goods and their skills.

4.2 Advantages and Characteristics of ETABS

1. The ETABS input, outcome, and mathematical response methods were specifically developed to take advantage of the unique physical and mathematical properties associated with building-type designs.

2. The need for the special purpose programme is now more clear than ever as structural engineers use nonlinear dynamic analysis in practise and take advantage of today's more powerful computers to create a larger analytical model.

3. Since completing numerous significant projects in recent years, ETABS is now regarded as the industry standard.

Material properties :

1. Grade of concrete (M30)

2. Grade of steel (Fe500)

3. Density of concrete (25 KN/m3)

4. Density of brick wall (19.20KN/m3)

5. Flooring finish (1KN/m2)
6. Live load (3KN/m2)
7. Live load at mass irregular story (4KN/m2)

Members properties :

Thickness of RC slab = 150mm

Column size

Interior column : (500X500)mm

Exterior column : (450X450)mm

Beam size

Beam : (230X500)mm

Storey height (3.25m)

Calculations of the load :

Wall load on beam: 2.75x19.2x.23=12.144KN/m

Floor finish : 1KN/m2

Live load : 3KN/m2

4.3 MODELLING IN ETABS

The methodology comprises of analysis of a G+10 story building with mass & geometric irregularities with and without shear wall using nonlinear time history analysis in ETABS 2016.

General description of the models:

Model 1: A RC mass regular building without shear wall.

Model 2: A RC mass regular building with shear wall.

Model 3: A RC building with mass irregularity at 3^{rd}, 6^{th} & 9^{th} story without shear wall.

Model 4: A RC building with mass irregularity at 3^{rd}, 6^{th} & 9^{th} story with shear wall.

Model 5: A RC geometric irregular building without shear wall.

Model 6: A RC geometric irregular building with shear wall.

Techniques for analysis

Time history analysis :

Here, the seismic analysis of the structure is being done utilising the time history approach. When the assessed structural response is nonlinear, it is a crucial technique for structural seismic analysis. A representative earthquake time history for the structure under consideration is needed to do such a study. Time history analysis examines in detail how dynamically a structure responds to a given loading that may change over time. The seismic reaction of a structure to a representative earthquake's dynamic loading is ascertained through time history analysis.

To compare the outcomes of these analyses, the following parameters are used:

Base shear : It is an approximate projection of the strongest sideways force that seismic occurrences expected to produce when acting on the building's foundation.

Storey drift : The floor level directly beneath it moves horizontally, or "storey drift". The "storey drift ratio" computes this drift by dividing the storey drift by the height of the relevant storey within the building.

Storey displacement : The lateral movement of a floor level in relation to a building's base is referred to as "story displacement." The lateral force-resisting system prevents the structure from moving significantly in a sideways direction.

V. .RESULTS

5.1 BASE SHEAR

Table 1 BASE SHEAR

BASE SHEAR (kN)	
M1	1818.1999
M2	3555.4372
M3	2142.6987
M4	3600.1518
M5	1070.4982
M6	3215.9214

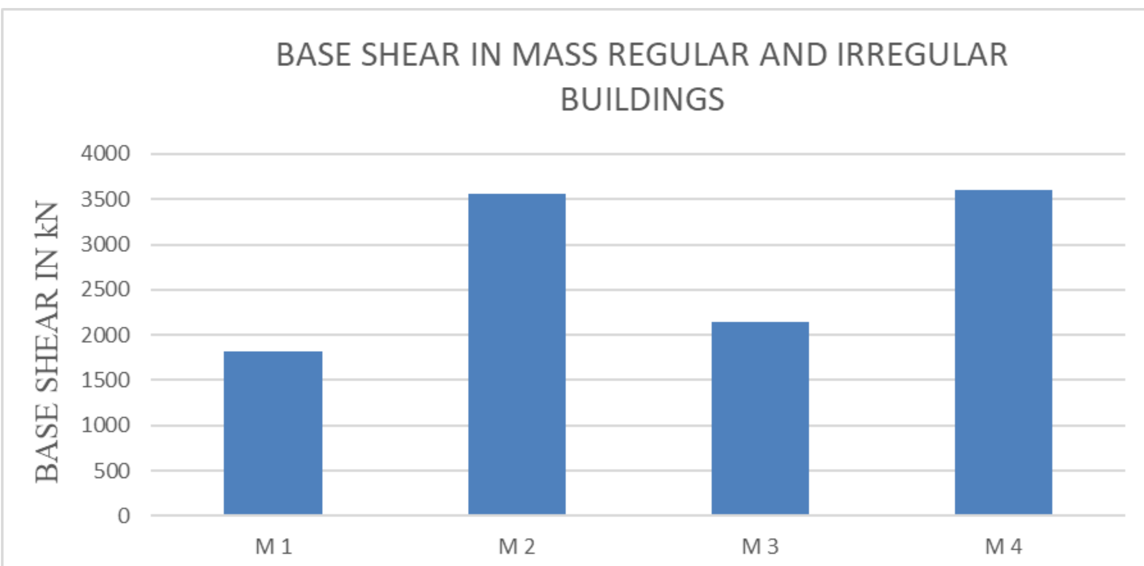

Fig.1.BASE SHEAR

It is evident from the base shear comparison graph above that the 1st model has the lowest value and the 4th model has the highest value.

Base shear is increased by shear wall inclusion and base shear is also increased by mass growth.

The 4th model, which includes a shear wall and higher mass at various stories of the building, produces the best results when the above four models of mass regular and irregular RC buildings are compared.

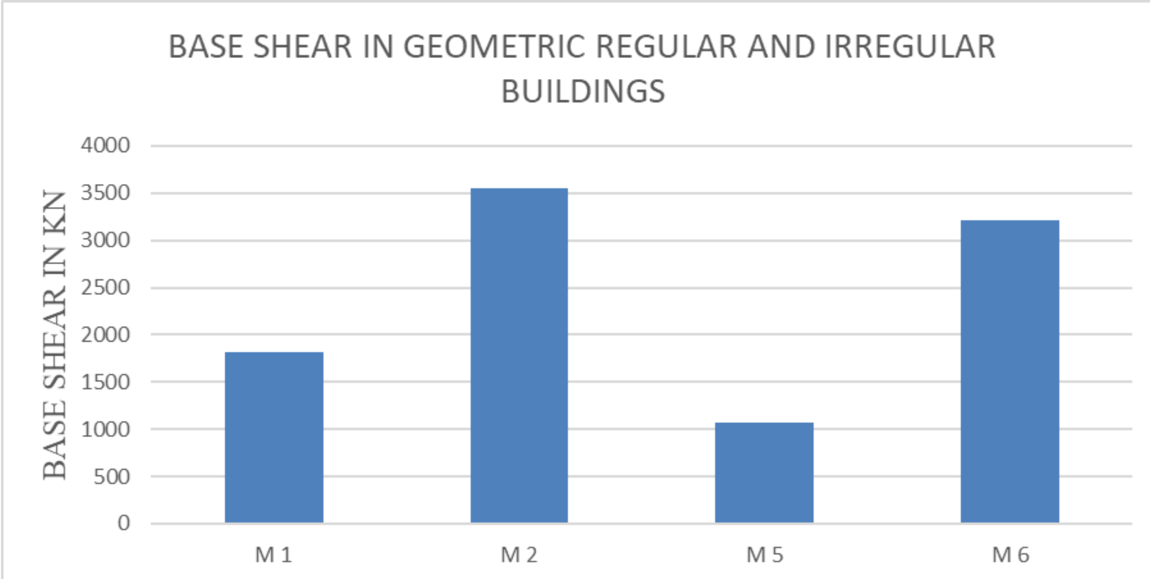

Fig.2.BASE SHEAR

It is evident from the base shear comparison chart above that the 2nd model has the highest value and the 5th model has the lowest value.

The base shear also decreases when the geometry of the building changes or the plan area of the building gets reduced.

The 1st model, which includes a shear wall and has a larger plan area than the models with irregular shapes, performs the best when the above four models of geometric regular and irregular RC buildings are compared.

5.2 STOREY DRIFT

Table 2 STOREY DRIFT

Story level	STORY DRIFT					
	M1	M2	M3	M4	M5	M6
STORY 10	0.000271	0.000638	0.000271	0.000632	0.000322	0.000602
STORY 9	0.000447	0.000661	0.00052	0.000706	0.000491	0.000647
STORY 8	0.000605	0.000679	0.000605	0.000674	0.000648	0.000658
STORY 7	0.000733	0.00069	0.000733	0.000685	0.000774	0.000664
STORY 6	0.000832	0.000688	0.000893	0.000742	0.000871	0.000657
STORY 5	0.000905	0.000668	0.000905	0.000662	0.000941	0.000634
STORY 4	0.000956	0.000629	0.000956	0.000624	0.000988	0.000594
STORY 3	0.000988	0.000569	0.00112	0.000631	0.001015	0.000533
STORY 2	0.001002	0.000486	0.001002	0.000482	0.001023	0.000451
STORY 1	0.000988	0.000376	0.000988	0.000373	0.001001	0.000346
GF	0.000861	0.000247	0.000861	0.000246	0.000855	0.000231
PLINTH	0.000309	0.000112	0.000309	0.000112	0.000303	0.000097
BASE	0	0	0	0	0	0

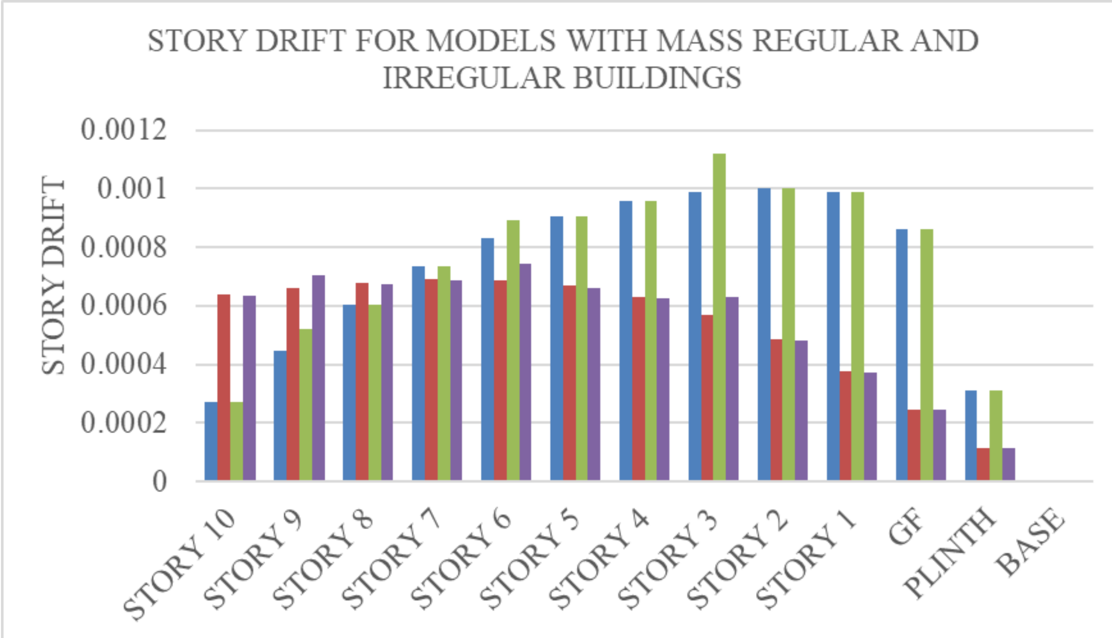

Fig.3.STOREY DRIFT

From the above story drift comparison graph, it is clear that the lowest value is observed in 4th model and the highest value is observed in the 3rd model.

As the inclusion of shear walls in RC building reduces the story drift but as the mass increases it also increases the story drift.

Among the above 4 compared mass regular and irregular RC buildings 4th model gives the best result as it has inclusion of shear wall.

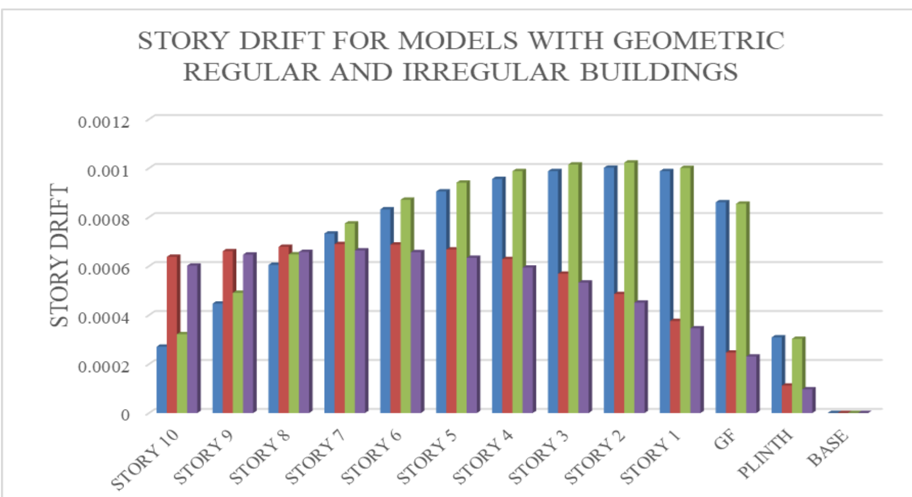

Fig.4 STOREY DRIFT

From the above story drift comparison graph, it is clear that the lowest value is observed in 6th model and the highest value is observed in the 5th model.

As the inclusion of shear walls in RC building reduces the story drift.

Among the above 4 compared mass regular and irregular RC buildings 6th model gives the best result as it has inclusion of shear wall.

5.3 STOREY DISPLACEMENT

Table 3 STOREY DISPLACEMENT

Story level	STORY DISPLACEMENT					
	M1	M2	M3	M4	M5	M6
STORY 10	27.929	20.263	26.724	19.91	29.017	19.354
STORY 9	27.063	18.337	25.243	17.123	27.989	17.429
STORY 8	25.633	16.225	24.335	15.052	26.417	15.36
STORY 7	23.697	14.051	22.215	12.43	24.344	13.256
STORY 6	21.352	11.842	20.253	10.72	21.866	11.132
STORY 5	18.689	9.642	17.569	8.321	19.078	9.031
STORY 4	15.792	7.505	14.362	6.34	16.066	7.002
STORY 3	12.732	5.491	11.331	4.125	12.902	5.103
STORY 2	9.57	3.669	8.27	2.834	9.654	3.398
STORY 1	6.363	2.114	5.633	1.298	6.381	1.957
GF	3.204	0.915	2.805	0.812	3.18	0.851
PLINTH	0.463	0.168	0.362	0.117	0.455	0.145
BASE	0	0	0	0	0	0

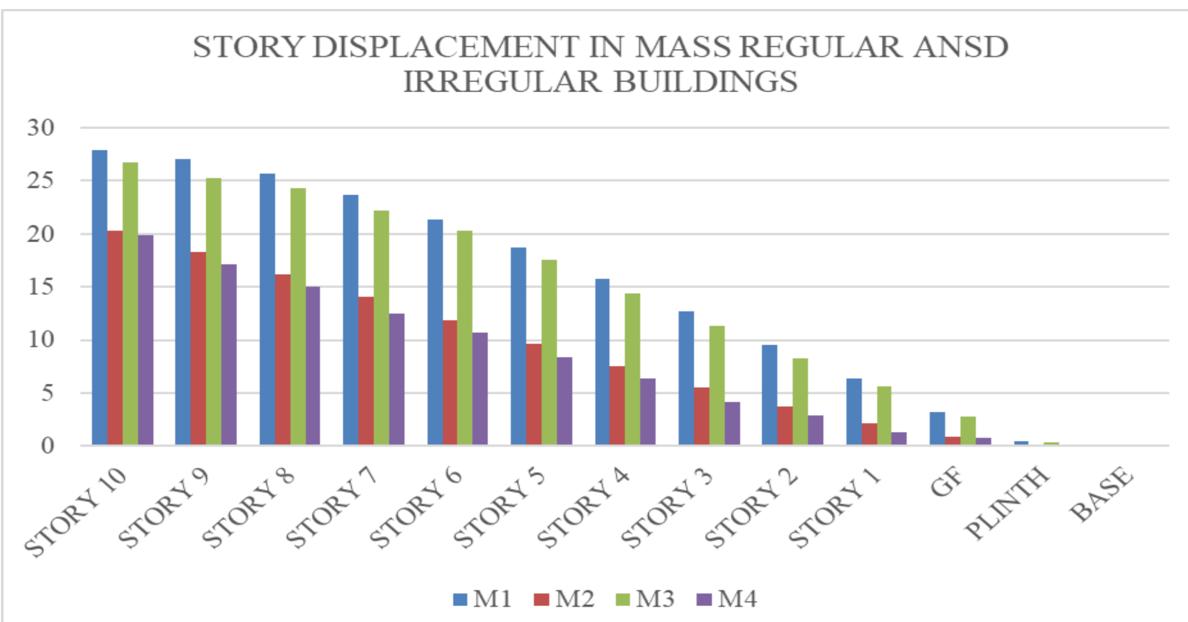

Fig.5.STOREY DISPLACEMENT

From the above story displacement comparison graph it is clear that the lowest value is observed in 4th model and the highest value is seen in the 1st model.

As the inclusion of shear walls and increase in mass in RC building reduces the story displacement.

Among the above 4 compared mass regular and irregular RC buildings 4th model gives the best result as it higher mass value and it has inclusion of shear wall.

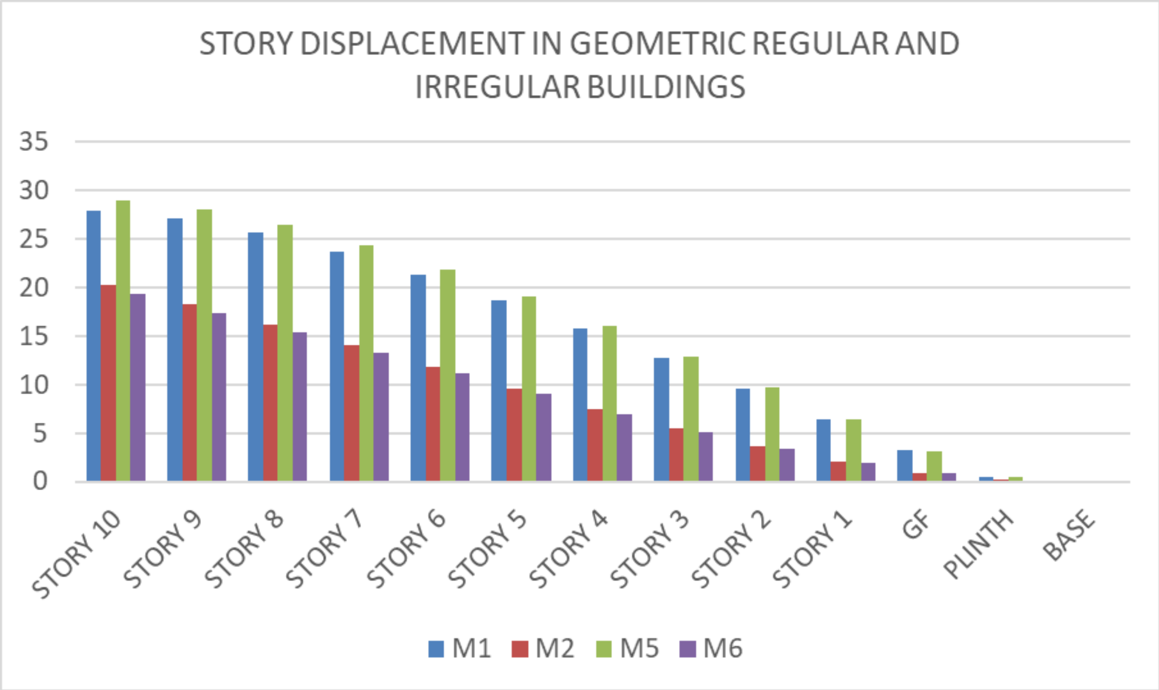

Fig.6.STOREY DISPLACEMENT

From the above story displacement comparison graph it is clear that the lowest value is observed in 6th model and the highest value is seen in the 5th model.

As the inclusion of shear walls in RC building reduces the story displacement.

Among the above 4 compared geometric regular and irregular RC buildings 6th model gives the best result as it has inclusion of shear wall.

VI. CONCLUSION

After analysing all the results, the following conclusions can be drawn:

1. The base shear of mass irregular building is more than a mass regular building due to variation in loading conditions.

2. The base shear of geometric regular building is more than a geometric irregular building due to greater plan area.

3. The base shear increases by the inclusion of shear walls.

4. The story displacement is less for mass irregular building and also by the inclusion of shear wall.

5. The story displacement is less for geometric irregular building with shear wall.

6. The story drift changes at the mass irregular story level and will be relatively less when compared to regular model.

7. The story drift is less for geometric regular and irregular building with shear wall when compared to without shear wall.

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