DYNAMIC ANALYSIS OF REINFORCED CONCRETE BUILDING WITH FLOOR MASS IRREGULARITIES WITH SHEAR WALLS

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Abstract - *Now a days, increase in population leads to demand of structures for accommodation (i.e., Residential) and for business purpose (i.e., commercial, educational, industrial etc.). It is almost impossible to provide or meet the requirements of peoples in horizontal manner on this earth. The only solution to this problem is growth in vertical direction. Hence to meet this demand multi storied structures are constructed for residential and commercial purposes. Some Structures are also constructed with different slab thicknesses for parking on intermediate stories, shopping malls, to mount machineries on floors, to store water. It is not so easy to develop multi storied structures because the structure must be earthquake resistant. In this project we are studying the seismic effect on the structure due to mass irregularity (difference in floor mass) and also due to presence of shear walls using Response Spectrum Method.*

In this project we are considering G+7 storey structure with one regular and one with mass irregular structure having heavy masses in 2nd, 4th, 6th and 8th floors. And also analysing the above structures by positioning the shear walls at Centre of the periphery walls. Zone IV is considered for analysis. Modelling and analysis is carried out using ETABS 2015.

Key Words: *Mass Irregularity, Response Spectrum Analysis, Equivalent Static Analysis, ETABS 2015.*

1. INTRODUCTION

Earthquakes are the most dangerous or hazardous of all Natural calamities, which cause great loss of engineering structures and human life. Hence it becomes necessary for the structural engineer to check the seismic performance of the structures by analysing analytically before executing in practice, which will help to resist during minor earthquakes and gives sufficient warning during major earthquake before collapsing, so that it becomes easy to save the lives. The structural performance during earthquake depends on many factors like stiffness, ductility, mass discontinuity etc. The buildings with regular (plan) geometry and having uniformly distributed mass and stiffness suffers much less damage compared to irregular configurations. But now-a-days the peoples turn towards the architectural and aesthetic look which leads the architects and engineers to plan irregular configurations. The dynamic analysis of these irregular structures gives the seismic performance against earthquake. This seismic performance can be further improved by positioning the shear walls at suitable position.

1.1 Objectives

The objective of this thesis is to access the behavior of mass regular and mass irregular structure with and without shear wall under Equivalent Static Method and Response spectrum method. The study on the behaviour and response of structure is carried out by creating models and analysing in ETABS 2015.

The main objectives of this project are

1. To study the response of structures with and without mass irregularity under static and dynamic analysis.
2. To study the effect of shear wall in the mass regular and mass irregular structural models.
3. Study of parameters like Displacement, Storey Drift, and Modal Periods.

1.2 Mass Irregularity

The uneven distribution of mass in the structure is referred as mass irregular structure. As per IS: 1893-2002, the structure is referred as mass irregular when the seismic weight of any storey is more than 200 per cent of that of its adjacent storey. This irregularity affects the seismic response of the structure by increasing the ductility demand at a few locations and leads to unpredicted high mode effects. This happens when the mass of structure at one storey is substantially in excess of that at the other storey immediately above or below it. This condition is generally exists in industrial structures where heavy equipment are to be located at some storey. The common structures where mass irregularity used are:

i. In industries to mount heavy machineries.
ii. For swimming pools at intermediate or top storey.
iii. In shopping malls.
iv. In vehicle showrooms etc.

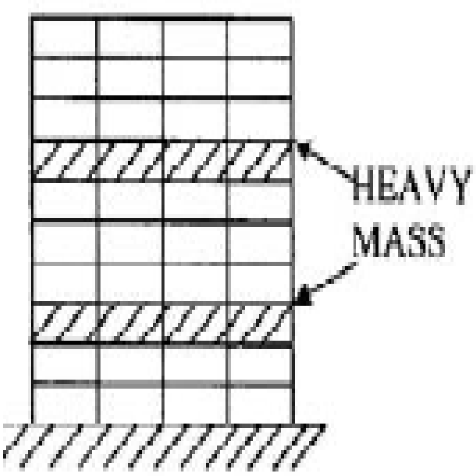

Figure 1 MASS IRREGULARITY

2. BUILDING DESCRIPTION

The main aim of this modelling is to study the behaviour of mass regular and mass irregular structure. For this study, 8(G+7) stories structure is considered. In mass irregular structure the slab thickness of 2nd, 4th, 6th and 8th floors are considered as 300mm and for remaining all floors including regular structure as 150mm. The general details of the structure is as follows.

Table 1 GENERAL DESCRIPTION OF BUILDING

Description	Regular structure	Irregular structure
Type of structure	Commercial	Commercial
No. of stories	8 (G+7)	8 (G+7)
Height of building	28 m	28 m
Bay width in both directions	4m	4m
Column size	(300X600)mm	(300X600)mm
Beam size	(300X600)mm	(300X600)mm
Slab thickness	150 mm	150mm & 300mm
Height of the floor	3.5m	3.5m
Concrete grade for Beams	M_{25}	M_{25}
Concrete grade for Slab	M_{25}	M_{25}
Concrete grade for Columns	M_{30}	M_{30}
Shear wall thickness	200 mm	200 mm
Grade of Steel	Fe500	Fe500

Table 2 CODAL VALUES

As per IS: 1893-2002		
Description	**Regular structure**	**Irregular structure**
Zone	IV (Severe)	IV (Severe)
Soil type	II (Medium)	II (Medium)
Response Reduction Factor, R	5	5
Importance Factor, I	1	1

Table 3 LOADS ON BUILDING

Loads		
Description	**Regular structure**	**Irregular structure**
Live load on floor	4.0 kN/sq.m	4.0 kN/sq.m
Live load on roof	2.0kN/sq.m	2.0kN/sq.m
SDL on floor	1.0 kN/sq.m	1.0 kN/sq.m
SDL on roof	2.0kN/sq.m	2.0kN/sq.m
Wall load	13.34kN/m	13.34kN/m
Parapet load	4.6 kN/m	4.6 kN/m

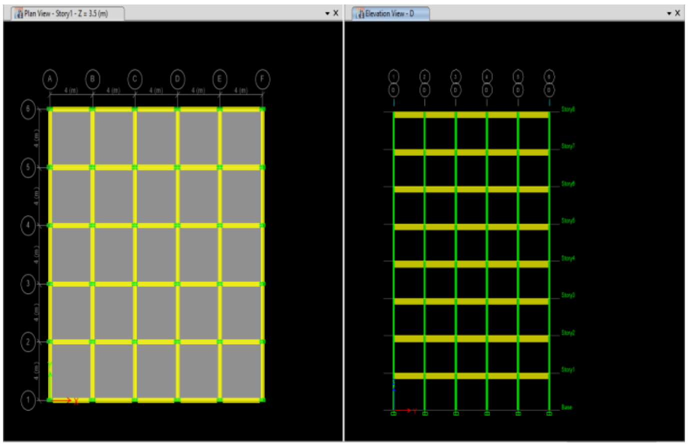

Figure 2 MASS REGULAR AND MASS IRREGULAR MODEL

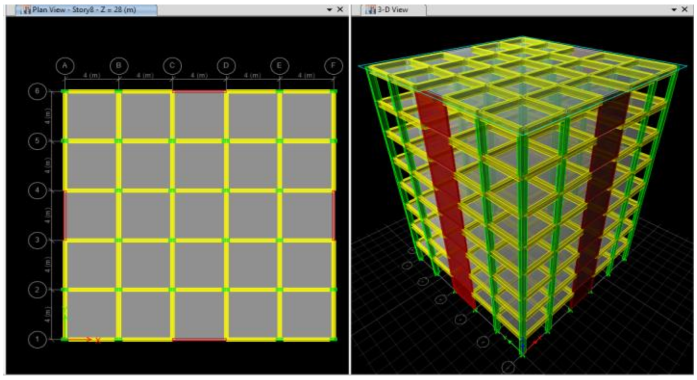

Figure 3 MASS REGULAR AND MASS IRREGULAR MODEL WITH SHEAR WALL

2.1 MODEL LABELS:

M_1 = Regular model with slab thickness 150 mm.

M_2 = Irregular model with alternative slab thickness of 150 mm & 300 mm.

M_3 = Regular model (M_1) with Centre Shear Wall.

M_4 = Irregular model (M_2) with Centre Shear Wall.

2.2 PROCEDURE OF MODELLING AND ANALYSIS.

The above details are used to create mass regular and mass irregular models using ETABS 2015. Using grid lines models can be generated. In material properties option materials like concrete, steel etc. are defined and then in section properties option beams, columns and slabs are defined. All these defined elements are assigned to the models. The base of all columns are fixed by assigning fixed support from restraints option to avoid translations and rotations. After generating the model we have to assign loads (Dead load, Live Load, wall load, SDL, etc.). First models are checked for errors and then analysis is performed.

In this article an attempt has been made to compare mass regular and mass irregular models in Equivalent static and Response spectrum method of analysis. Then for the same models shear walls are provided at centre of periphery walls and compared with results which obtained without shear walls in terms of displacement, storey drift and time periods.

3. RESULTS & DISCUSSIONS

3.1 DISPLACEMENT

Table 4 DISPLACEMENT OF M_1 & M_2 IN X-DIRECTION

STORIES	M_1		M_2	
	EQ X	RS X	EQ X	RS X
Story8	22.8	18.8	25.5	21
Story7	21.6	18.1	24.1	20.1
Story6	19.6	16.7	21.8	18.5
Story5	16.8	14.7	18.6	16.3
Story4	13.5	12.2	15	13.5
Story3	9.9	9.2	11	10.2
Story2	6.2	5.9	6.8	6.6
Story1	2.5	2.5	2.8	2.7
Base	0	0	0	0

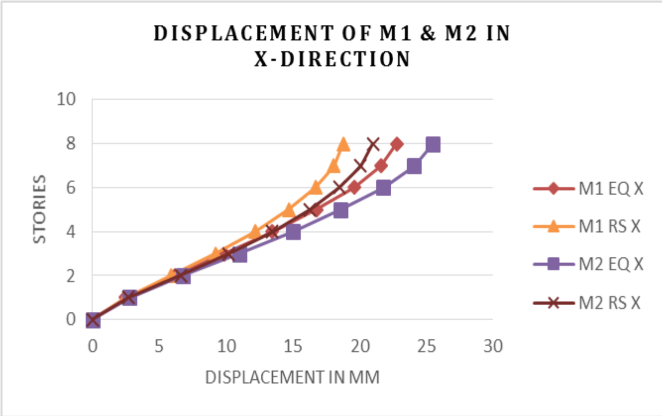

Figure 4 DISPLACEMENT OF M_1 & M_2 IN X-DIRECTION

Figure 4 clearly shows that displacement is less in response spectrum method compared to static method. Also displacement is more in mass irregular model compared to mass regular model.

Table 5 DISPLACEMENT OF M_1 & M_2 IN Y-DIRECTION

STORIES	M_1		M_2	
	EQ Y	RS Y	EQ Y	RS Y
Story8	48.9	39	54.7	43.7
Story7	46.8	37.7	52.1	42.1
Story6	42.6	35.1	47.4	39.1
Story5	36.9	31.2	40.9	34.7
Story4	30.1	26.4	33.3	29.3
Story3	22.5	20.6	25	22.9
Story2	14.7	14	16.2	15.6
Story1	6.7	6.7	7.4	7.4
Base	0	0	0	0

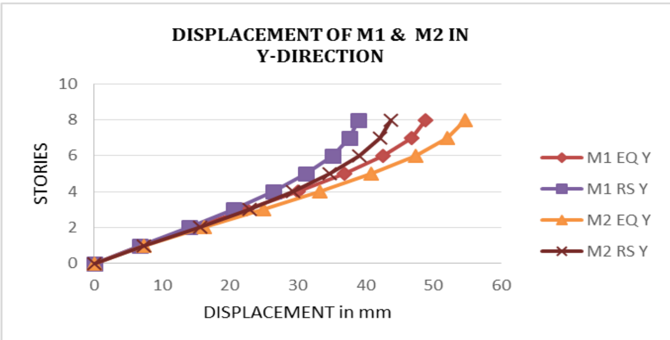

Figure 5 DISPLACEMENT OF M_1 & M_2 IN Y-DIRECTION

Table 6 DISPLACEMENT OF M_3 & M_4 IN X-DIRECTION

STORIES	M_3		M_4	
	EQ X	RS X	EQ X	RS X
Story8	16.2	13.7	18.2	15.3
Story7	14.7	12.6	16.5	14
Story6	12.9	11.1	14.4	12.3
Story5	10.6	9.3	11.9	10.4
Story4	8.1	7.3	9	8.1
Story3	5.5	5	6.1	5.6
Story2	3	2.8	3.3	3.1
Story1	1	0.9	1.1	1
Base	0	0	0	0

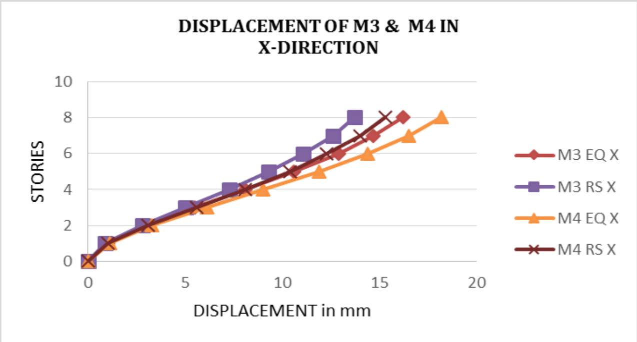

Figure 6 DISPLACEMENT OF M_3 & M_4 IN X-DIRN.

Table 7 DISPLACEMENT OF M_3 AND M_4 IN Y-DIRN.

STORIES	M_3		M_4	
	EQ Y	RS Y	EQ Y	RS Y
Story8	25.6	21	28.8	23.4
Story7	22.9	18.9	25.6	20.9
Story6	19.7	16.4	22	18.2
Story5	16	13.5	17.9	15
Story4	12	10.3	13.4	11.4
Story3	8	7	8.9	7.7
Story2	4.2	3.8	4.7	4.2
Story1	1.3	1.2	1.5	1.4
Base	0	0	0	0

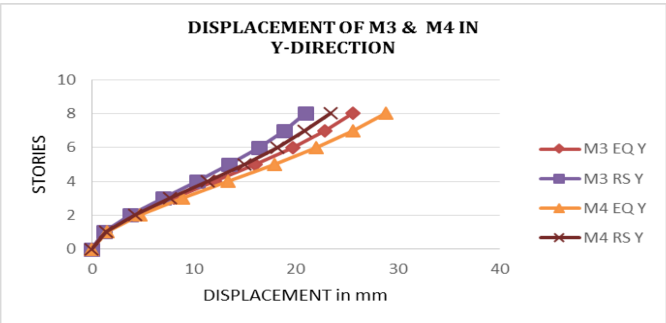

Figure 7 DISPLACEMENT OF M_3 AND M_4 IN X-DIRN.

Table 8 DISPLACEMENT OF ALL MODELS IN X-DIRN.

STORIES	WITHOUT SW		WITH SW	
	M_1	M_2	M_3	M_4
Story8	18.8	21	13.7	15.3
Story7	18.1	20.1	12.6	14
Story6	16.7	18.5	11.1	12.3
Story5	14.7	16.3	9.3	10.4
Story4	12.2	13.5	7.3	8.1
Story3	9.2	10.2	5	5.6
Story2	5.9	6.6	2.8	3.1
Story1	2.5	2.7	0.9	1
Base	0	0	0	0

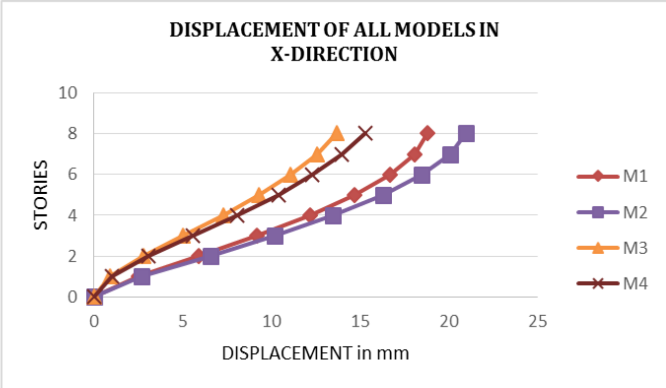

Figure 8 DISPLACEMENT OF ALL MODELS IN X-DIRN.

Table 9 DISPLACEMENT OF ALL MODELS IN Y-DIRN.

STORIES	WITHOUT SW		WITH SW	
	M_1	M_2	M_3	M_4
Story8	39	43.7	21	23.4
Story7	37.7	42.1	18.9	20.9
Story6	35.1	39.1	16.4	18.2
Story5	31.2	34.7	13.5	15
Story4	26.4	29.3	10.3	11.4
Story3	20.6	22.9	7	7.7
Story2	14	15.6	3.8	4.2
Story1	6.7	7.4	1.2	1.4
Base	0	0	0	0

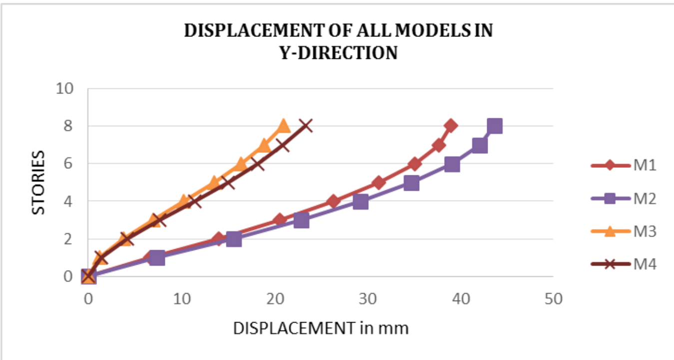

Figure 9 DISPLACEMENT OF ALL MODELS IN Y-DIRN.

Above tables and figures clearly shows that displacement is less in Response Spectrum Method compared to Static Method. Also the displacement is more for mass irregular model compared to mass regular model. The displacements are reduced when shear walls are provided for the same models.

3.2 STOREY DRIFT

Table 10 STOREY DRIFT OF M_1 AND M_2 IN X-DIRN.

STORIES	M_1		M_2	
	EQ X	RS X	EQ X	RS X
Story8	0.00033	0.00024	0.0004	0.0003
Story7	0.00058	0.00045	0.00066	0.00052
Story6	0.00079	0.00062	0.0009	0.00071
Story5	0.00094	0.00076	0.00105	0.00085
Story4	0.00103	0.00087	0.00115	0.00097
Story3	0.00107	0.00096	0.00119	0.00106
Story2	0.00105	0.00099	0.00116	0.0011
Story1	0.00072	0.00071	0.00079	0.00078
Base	0	0	0	0

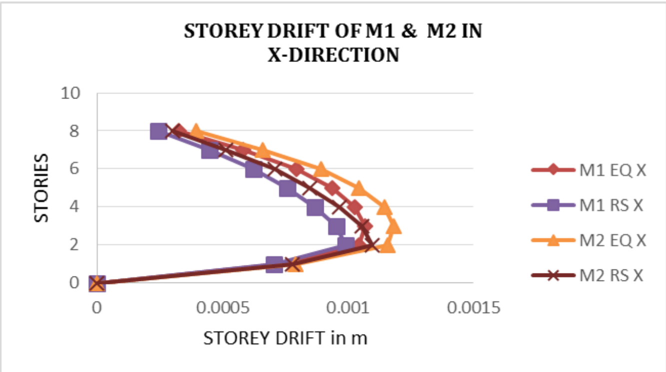

Figure 10 STOREY DRIFT OF M_1 AND M_2 IN X-DIRN.

Table 11 STOREY DRIFT OF M_1 AND M_2 IN Y-DIRN.

STORIES	M_1		M_2	
	EQ Y	RS Y	EQ Y	RS Y
Story8	0.00059	0.00048	0.00074	0.000611
Story7	0.00118	0.00097	0.00133	0.001104
Story6	0.00164	0.00133	0.00186	0.001507
Story5	0.00195	0.00157	0.00217	0.001747
Story4	0.00215	0.00176	0.00239	0.001968
Story3	0.00225	0.00194	0.00249	0.002152
Story2	0.00227	0.00211	0.00252	0.002354
Story1	0.00192	0.0019	0.0021	0.002108
Base	0	0	0	0

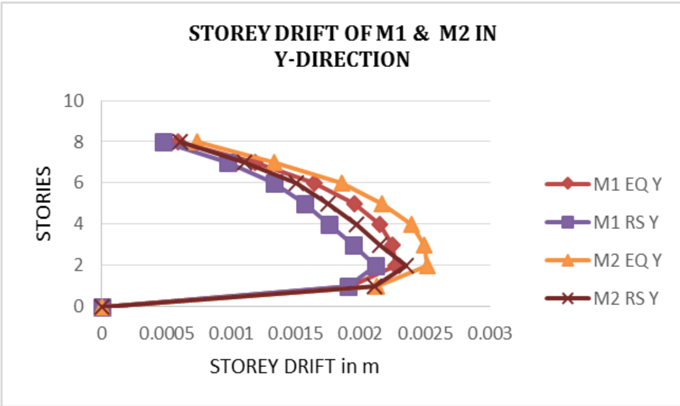

Figure 11 STOREY DRIFT OF M_1 AND M_2 IN Y-DIRN.

Table 12 STOREY DRIFT OF M_3 AND M_4 IN X-DIRN.

STORIES	M_3		M_4	
	EQ X	RS X	EQ X	RS X
Story8	0.000425	0.000342	0.00049	0.0004
Story7	0.00053	0.000429	0.0006	0.00049
Story6	0.000638	0.000523	0.00072	0.00059
Story5	0.000718	0.000602	0.0008	0.00067
Story4	0.000749	0.000648	0.00084	0.00072
Story3	0.000713	0.000638	0.00079	0.00071
Story2	0.000578	0.000534	0.00064	0.00059
Story1	0.000281	0.000267	0.00031	0.0003
Base	0	0	0	0

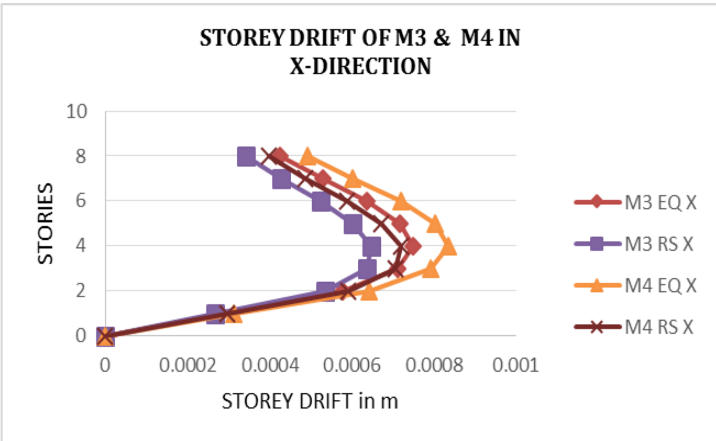

Figure 12 STOREY DRIFT OF M_3 AND M_4 IN X-DIRN.

Table 13 STOREY DRIFT OF M_3 AND M_4 IN Y-DIRN.

STORIES	M_3		M_4	
	EQ Y	RS Y	EQ Y	RS Y
Story8	0.00079	0.00064	0.00091	0.00074
Story7	0.00092	0.00074	0.00104	0.00084
Story6	0.00105	0.00085	0.00118	0.00095
Story5	0.00114	0.00093	0.00128	0.00104
Story4	0.00116	0.00097	0.00129	0.00107
Story3	0.00107	0.00092	0.00119	0.00101
Story2	0.00083	0.00074	0.00092	0.00082
Story1	0.00038	0.00035	0.00042	0.00039
Base	0	0	0	0

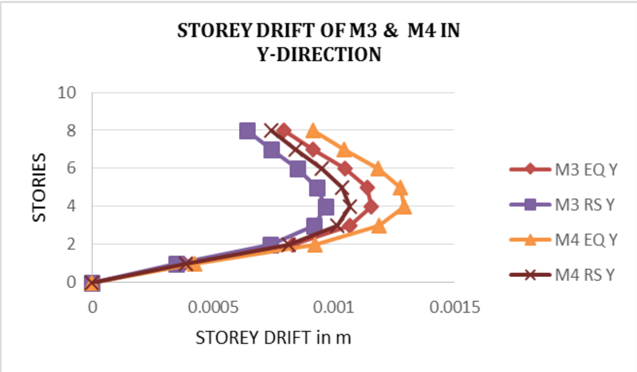

Figure 13 STOREY DRIFT OF M3 AND M4 IN Y-DIRN.

Table 14 STOREY DRIFT OF ALL MODELS IN X-DIRN.

STORIES	WITHOUT SW		WITH SW	
	M_1	M_2	M_3	M_4
Story8	0.00024	0.00030	0.00034	0.00039
Story7	0.00044	0.00051	0.00042	0.00048
Story6	0.00062	0.00070	0.00052	0.00058
Story5	0.00076	0.00084	0.00060	0.00067
Story4	0.00087	0.00096	0.00064	0.00071
Story3	0.00095	0.00105	0.00063	0.00070
Story2	0.00099	0.00109	0.00053	0.00059
Story1	0.00070	0.00078	0.00026	0.00029
Base	0	0	0	0

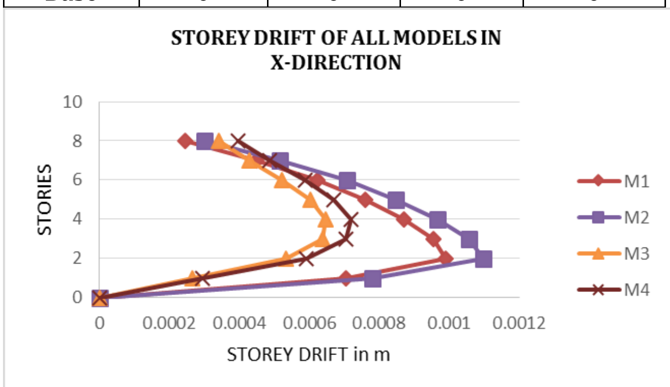

Figure 14 STOREY DRIFT OF ALL MODELS IN X-DIRN.

Table 15 STOREY DRIFT OF ALL MODELS IN Y-DIRN.

STORIES	WITHOUT SW		WITH SW	
	M_1	M_2	M_3	M_4
Story8	0.00048	0.00061	0.00064	0.00074
Story7	0.000977	0.00110	0.00074	0.00084
Story6	0.001331	0.00150	0.00084	0.00095
Story5	0.001572	0.00174	0.00093	0.00103
Story4	0.00176	0.00196	0.00096	0.00106
Story3	0.001942	0.00215	0.00091	0.00101
Story2	0.002114	0.00235	0.00073	0.000816
Story1	0.001903	0.002108	0.00035	0.000387
Base	0	0	0	0

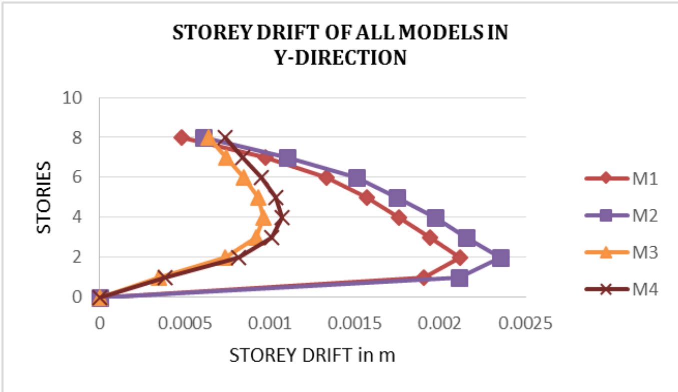

Figure 15 STOREY DRIFT OF ALL MODELS IN Y-DIRN.

Above tables and figures indicates that storey drift is more in static method compared to response spectrum method. Storey drift is more in mass irregular model compared to mass regular model. Maximum storey drift is observed in 2nd storey in the absence of shear wall. When shear walts are provided, maximum storey drift is obtained in 4th storey.

3.3 MODAL PERIOD

Table 16 TIME PERIOD IN SECS

MODELS	TIME PERIODS IN SECS		
	MODE 1	MODE 2	MODE 3
M_1	1.752	1.253	1.179
M_2	1.859	1.322	1.252
M_3	1.163	0.942	0.753
M_4	1.255	1.017	0.811

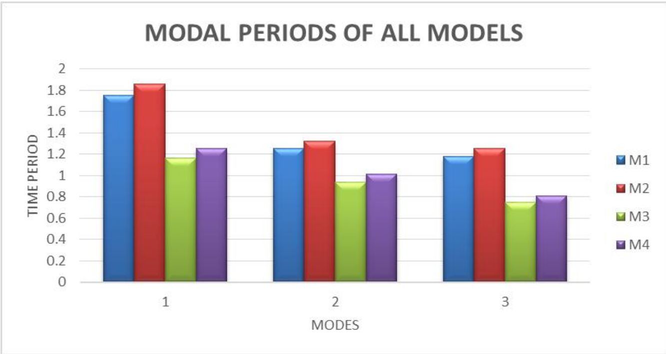

Figure 16 TIME PERIOD IN SECS

Table 16 & figure 16 gives the time period of all models for first three modes. Figure clearly indicates that for mass irregular model time period is more relative to mass regular model. Shear walls reduces time period in both mass regular and mass irregular models.

4 CONCLUSION

i. Displacement & storey drift are more in static method compared to response spectrum method.
ii. Displacement of all models is more in Y-direction compared to X-direction.
iii. Displacement of mass irregular models is more compared to mass regular models. This Displacement of the models can be reduced by providing shear walls.
iv. Storey drift is more in mass irregular model compared to mass regular model.
v. Shear wall reduces the storey drift in the structures by providing strength to the structure.
vi. Time period also varies with mass for the same dimension of the structure.
vii. As the floor mass increases, time period also increases. This can be reduced by providing shear wall in advantageous position.

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