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STUDY OF PUSHOVER ANALYSIS OF VERTICAL IRREGULAR STRUCTURES

S.M.Patil[1], Y.M.Pudale[2], V.V.Nair[3]

[1] *Assistant Professor,Department of Civil Engineering,P.V.P.I.T, Budhgaon (India)*

[2]*Assistant Professor,Department of Civil Engineering,P.V.P.I.T, Budhgaon (India)*

[3]*Assistant Professor,Department of Civil Engineering,P.V.P.I.T, Budhgaon (India)*

ABSTRACT

The seismic performance of building frame changes with the variation or the discontinuity in stiffness, strength and mass of the building. This causes the irregularity of the building. The common type of irregularity is the vertical irregularity. So that pushover analysis is one of the method to study the seismic behavior of vertical irregular structure when the structure is subjected to earthquake forces. The vertical irregularity that is irregularity in elevation is considered for present study. Five G+7 RCC building frames having different percentage of irregularity are considered for the present study and it is designed and analyzed by using design and analysis software ETABS v9.5.0..All the building frames are designed as per the IS 456:2000 and IS1893:2002.The purpose of this concerned work is to compare the pushover result obtained in terms of parameter story drift, story displacement, story shear, Base shear, spectral displacement and spectral acceleration of different vertical irregular structure and to study the effect of increase in vertical irregularity.

Keywords : Pushover Analysis, Story Drift, story Shear, Story Displacement spectral acceleration, spectral displacement

I INTRODUCTION

Pushover analysis is an approximate analysis or non linear static analysis in which the building frame is subjected to invariant height wise distribution for lateral loads of certain shape. The present study is concerned with the seismic behavior of vertical irregular structure. Stiffness irregularity, mass irregularity, strength irregularity and setback irregularity these are the various types of irregularity, but here irregularity in elevation is considered. The irregularity in the building structures may be due to irregular distributions in their mass, strength and stiffness along the height of building. When such buildings are constructed in high seismic zones, the analysis and design becomes more complicated.

Vertical geometric irregularity exist, when the horizontal dimension of lateral force resisting system in any adjacent storey is more than 150% of that in an adjacent storey. For this study vertical geometry is obtained by reducing the number of bays in vertical downward direction. Five building frames are considered with variation in percentage irregularity

The scope of the present work is to study the effect of vertical irregularity.

Description of building Frame:

Design data :

No. Bays along X axis	6
No. Of bays along Y axis	6
Spacing along X axis	4.5m
Spacing along Y axis	3m
Storey height	3m
No. Of floors	G+7
Size of columns	C_1=520X480mm for ground floor,1st, 2nd and 3rd floor C_2=340x300mm for 4th,5th,6th7th floor
Size of beams	B_1=420X380mm for 1st ,2nd,3rd and 4th Floor B_2=340X320mm for 5th,6th,7th and 8th Floor

Type of structure : RC Moment Resisting Frame

Seismic zone III

Zone factor :0.16

Number of storey : G+7

Floor height : 3m

Base Floor height : 3m

Slab Thickness : 150 mm thick

Wall : 230mm thick brick masonry wall

Live load : 4.0 kN/m^2

Floor Finish : 1.0 kN/m^2

Earthquake load : As per IS-1893 (Part 1)200 2

Type of soil : Type II

M30,Fe415, Stress Strain Relationship as per IS456:2000

Modelling On ETABs :

Model-1 : Regular Structure

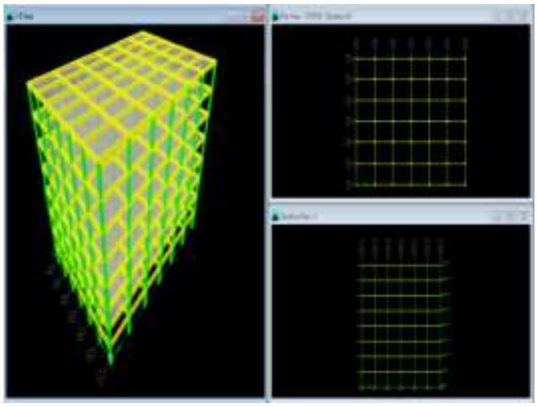


fig.1 Elevation and 3D view of model M-1

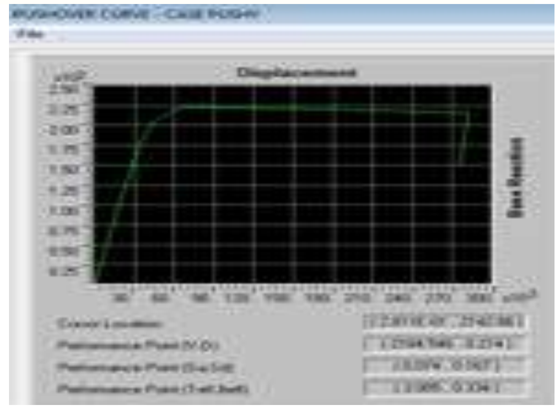


fig.2 Pushover curve for model M-1

Model-2 : Irregular Structure (300%)

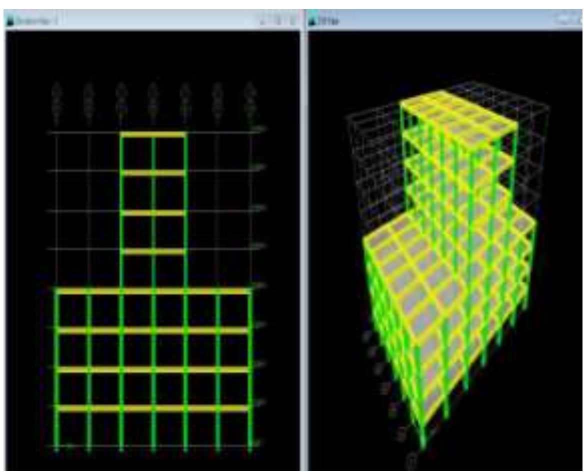


Fig.3 elevationand 3D view of model M-2

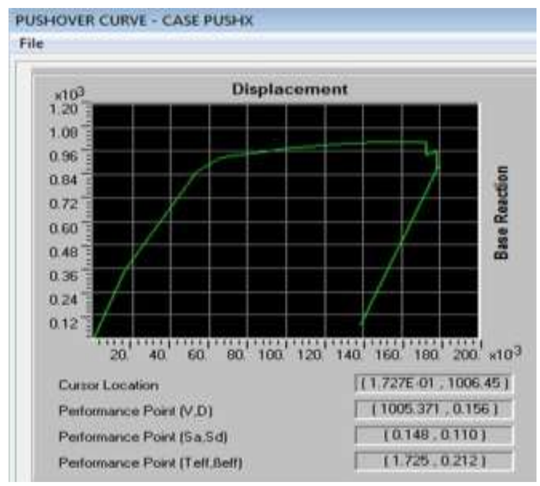
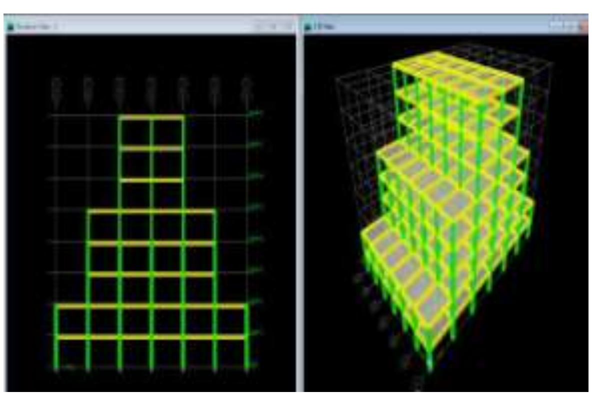


Fig.4 Pushover curve for model M-2

Model-3 : Irregular Structure (200%)



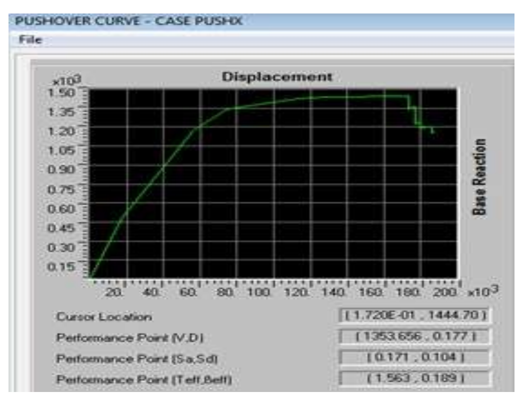


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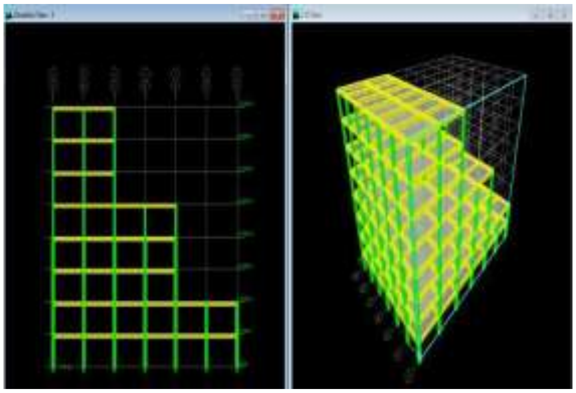
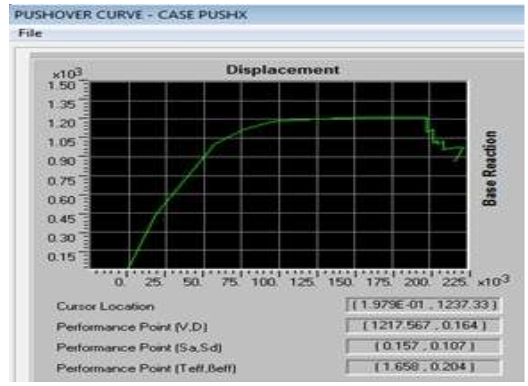
Fig.5 elevationand 3D view of model M-3 **Fig.6 Pushover curve for model M-3**

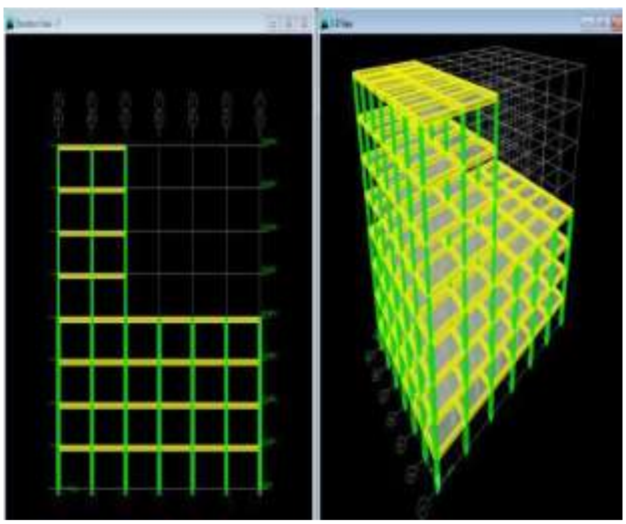




Model-4 : Irregular Structure (200%)

Fig.7 Elevation and 3D view of model M-4 **Fig.8 Pushover curve for model M-4**

Model-5 : Irregular Structure (300%)



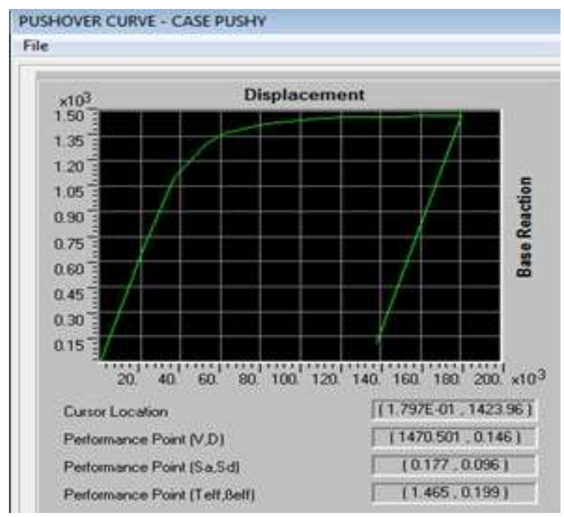


Fig.9 Elevation and 3D view of model M-5 **Fig.10 Pushover curve for model M-5**

STOREY DISPLACEMENT, STOREY DRIFT AND STOREY SHEAR CALCULATION

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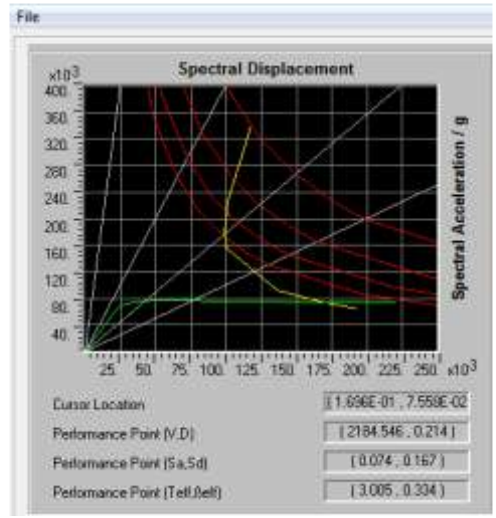
STOREY	STOREY DISPLACEMENT(m)		STOREY DRIFT(m)		STOREY SHEAR(kN)	
	X	Y	X	Y	X	Y
8	0.0214	0.0185	0.00055	0.00048	260.84	302.3
7	0.0198	0.0171	0.00095	0.00082	470.48	545.26
6	0.0169	0.0146	0.00124	0.00106	624.5	723.77
5	0.0132	0.0114	0.00124	0.00107	731.46	847.73
4	0.0095	0.0065	0.00060	0.00051	809.91	938.64
3	0.0077	0.0066	0.00064	0.00054	856.67	992.84
2	0.0058	0.005	0.00075	0.00063	877.46	1016.93
1	0.0035	0.0031	0.00117	0.00103	882.66	1022.96

Table.1. Storey displacement, Storey drifts and Storey shear for model M-1



From the above table it is seen that the maximum displacement of 0.0214 m is occurred in top Storey while the maximum drift of 0.00124 m is occurred in 6th storey. Also shows that the storey shears get increases from top storey to bottom storey.

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Table.2.Storey displacement, Storey drifts and Storey shear for model M-2

STOREY	STOREY DISPLACEMENT(m)		STOREY DRIFT(m)		STOREY SHEAR(kN)	
	X	Y	X	Y	X	Y
8	0.029	0.025	0.001036	0.00066	166.82	177.82
7	0.0259	0.0231	0.001729	0.00113	302.42	322.36
6	0.0207	0.0197	0.002215	0.00147	402.05	428.55
5	0.014	0.0152	0.002016	0.00147	471.23	502.29
4	0.0081	0.0108	0.000699	0.00069	545.35	581.3
3	0.006	0.0088	0.000612	0.00072	602.98	642.73
2	0.0042	0.0066	0.000582	0.00083	640.38	682.59
1	0.0026	0.0041	0.000878	0.00136	649.99	692.84

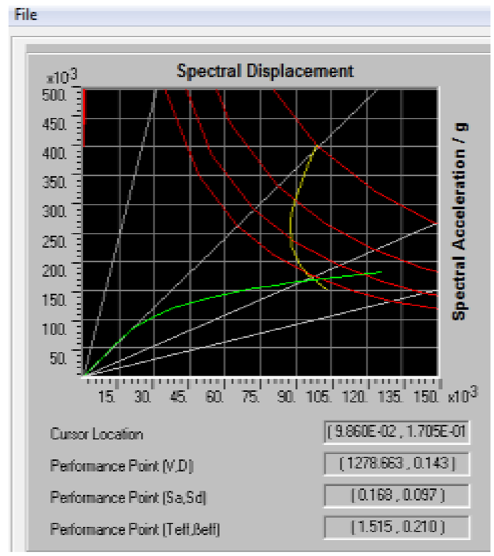

Table.3.Storey displacement, Storey drifts and Storey shear for model M-3

STOREY	STOREY DISPLACEMENT(m)		STOREY DRIFT(m)		STOREY SHEAR(kN)	
	X	Y	X	Y	X	Y
8	0.026	0.0213	0.000979	0.00072	166.65	195.91
7	0.023	0.0191	0.001639	0.00121	302.12	355.16
6	0.0181	0.0155	0.001825	0.00111	401.64	472.16
5	0.0126	0.0109	0.001287	0.00114	532.35	625.81
4	0.0088	0.0076	0.000673	0.00558	630.6	741.31
3	0.0068	0.0059	0.000654	0.00567	689.35	810.38
2	0.0048	0.0043	0.000637	000054	726.71	854.29
1	0.0029	0.0026	0.000982	0.00087	736.32	865.58

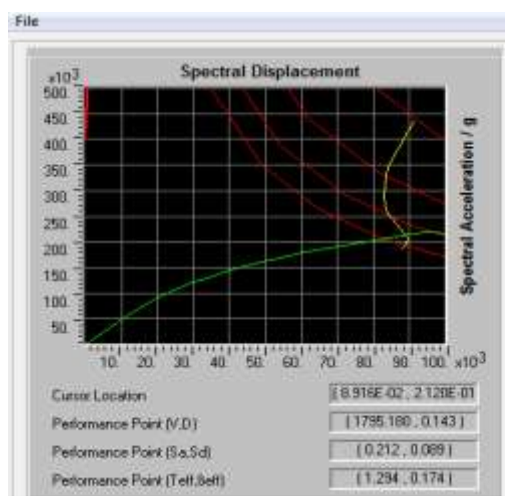

Table.4.Storey displacement, Storey drifts and Storey shear for model M-4

STOREY	STOREY DISPLACEMENT(m)		STOREY DRIFT(m)		STOREY SHEAR(kN)	
	X	Y	X	Y	X	Y
8	0.0257	0.0218	0.000954	0.00068	155.28	183.27
7	0.023	0.0198	0.001586	0.00116	281.49	332.24
6	0.0184	0.0163	0.001934	0.00159	374.22	441.69
5	0.0132	0.0118	0.001543	0.00148	467.31	551.56
4	0.0086	0.0074	0.000734	0.00064	537.1	633.93
3	0.0064	0.0059	0.000651	0.00055	590.75	697.25
2	0.0045	0.0042	0.000652	0.00060	615.08	725.96
1	0.0026	0.0024	0.000864	0.00081	623.78	736.23

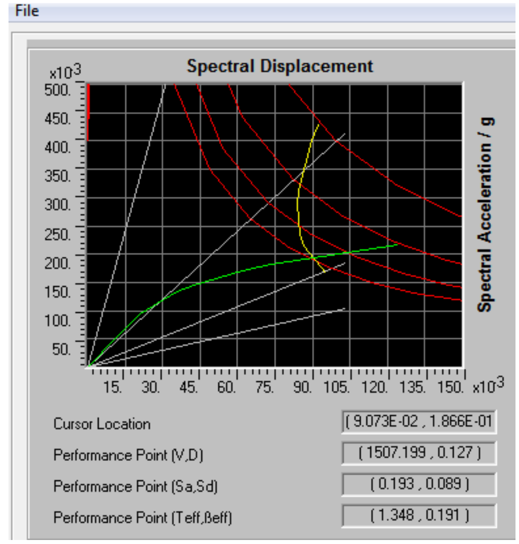

Table.5.Storey displacement, Storey drifts and Storey shear for model M-5

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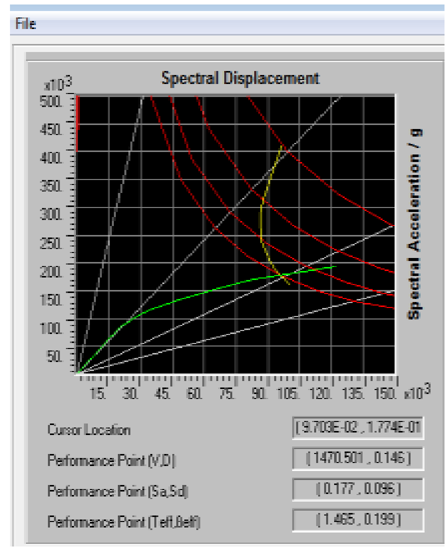
STOREY	STOREY DISPLACEMENT(m)		STOREY DRIFT(m)		STOREY SHEAR(kN)	
	X	Y	X	Y	X	Y
8	0.0294	0.0257	0.00107	0.00068	172.85	183.57
7	0.0262	0.0236	0.00178	0.00116	313.36	332.79
6	0.0208	0.0201	0.00228	0.00151	416.59	442.42
5	0.014	0.0156	0.00199	0.00151	488.28	518.56
4	0.008	0.0111	0.00051	0.00068	635.07	674.45
3	0.0066	0.009	0.00055	0.00073	724.7	769.64
2	0.005	0.0068	0.00066	0.00085	764.54	811.95
1	0.0031	0.0042	0.00103	0.00141	774.5	822.53



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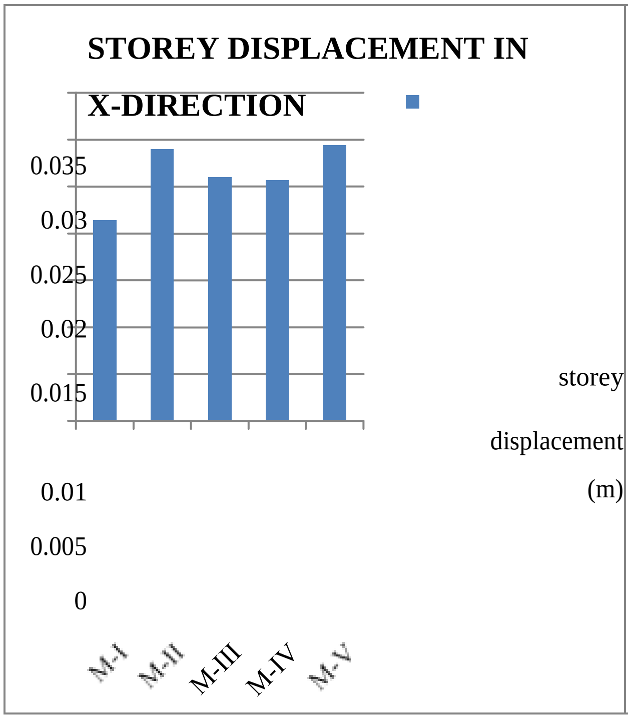
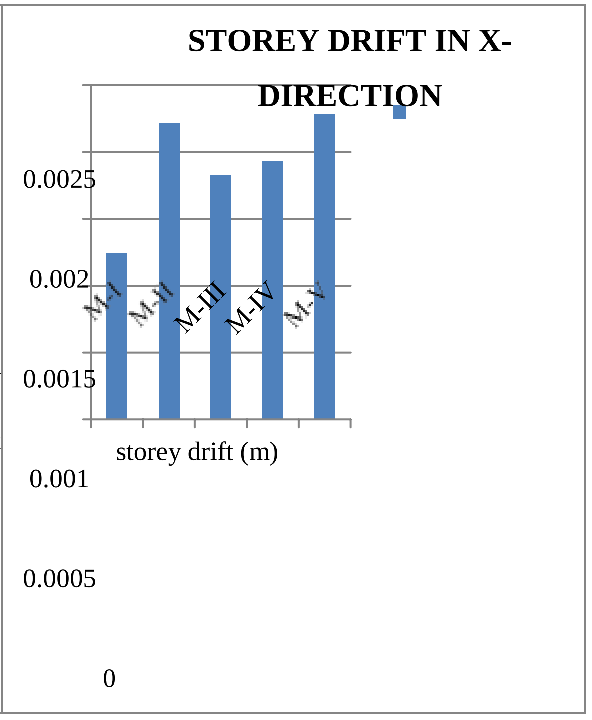
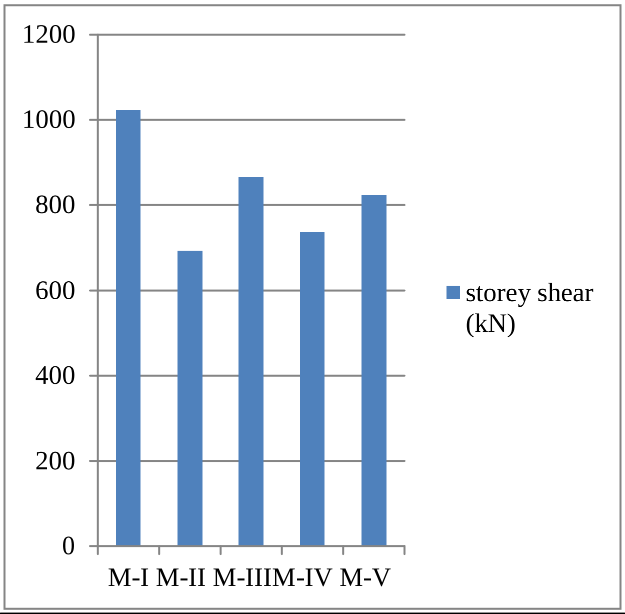
Comparison of building performances

1.Story Displacement ,story drift and story shear







DISCUSSION AND CONCLUSION:

1.a) From the analysis result, it can be seen that the base shear at performance point for building frame without vertical irregularity is 2184.54kN and for building frames with vertical irregularity it is 1278.7kN, 1795.2kN, 1507.2kN and 1470.5kN for models M-2,M-3,M-4,M-5 respectively. Also, it is found that in case of building frames with vertical irregularity there is decrease in base shear at performance point of about 41%, 18%, 31%, and 33% for models M-2,M-3,M-4, and M-5 respectively.

b) From the above result it is seen that the base shear at performance for vertical irregular structure is decreased due to the discontinuity in stiffness,strength and mass.

2.a) In case of building frame without vertical irregularity the displacement at performance point is 0.239 m and the building frames with vertical irregularity it is 0.156m, 0.177m, 0.164m and 0.165m for model M-2,M- 3,M-4,M-5 respectively It can be seen that provision of vertical irregularity reduces the displacement at performance point about 34%, 25%, 30%, 31% for models M-2,M-3,M-4,M-5 respectively.

b) From the above observation, it is seen that the displacement at performance point is reduces. This is because of discontinuity in stiffness, strength and mass.

3.a) Similarly the maximum storey drift for building frame without vertical irregularity is 0.00124m and in case of building frames with vertical irregularity it is 0.0022m, 0.0018m, 0.0019m and 0.0023m for models M- 2,M-3,M-4,M-5 respectively. After comparing the building performance it is found that there is increase in storey drift of about 44%, 31%, 34%, 46% for model M-2,M-3,M-4,M-5 respectively.

b) Due to the discontinuity in stiffness,strength and mass, there is increase in storey drift for irregular structure.

4.a) In case of building frame without vertical irregularity the maximum storey displacement is 0.0214m and in case of building frame with vertical irregularity the max story displacements are 0.029m, 0.026m, 0.026m, 0.029m for models M-2,M-3,M-4,M-5 respectively.So, it is observed that the provision of vertical irregularity increases storey displacement about 27%, 17%, 17%, 27% for models M-2,M-3,M-4,M-5 respectively.

b) As a result of discontinuity in stiffness, strength and mass, the storey displacement is increases for irregular structure.

5. As compared to the building frame without vertical irregularity (M-1) , the spectral acceleration of building frame with vertical irregularity increases of about 55%,65%,61% 58% for model M M-2,M-3,M-4,M-5 respectively. Similarly spectral displacement is reduces of about 39%, 43%, 42%, and 40% for model M- 2,M-3,M-4,M-5 respectively.

b) In case of building frame with vertical irregularity, the spectral acceleration is increases and spectral displacement is decreases. This is due to the discontinuity in stiffness, strength and mass.

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