International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 11, November-2018

RESPONSE OF MULTI-STORY R.C STRUCTURAL FRAMED SYSTEM WITH VERTICAL PLAN IRREGULARITIES SUBJECTED TO SEISMIC EXCITATION

[1]Mohammed Gulam Ahmed, [2]Abdul Rahman Khan,
[3] Mohammed Safiuddin, [4]Mohammed Khaja Moinuddin,

[1]M.Tech Structures, Lords Institute of Engineering and Technology, Hyderabad, India
[2]Asst. Professor, Lords Institute of Engineering and Technology, Hyderabad, India
[3]H.O.D Civil Engineering, Lords Institute of Engineering and Technology, Hyderabad, India
[4]Asst. Professor, AL- Habeeb College of Engineering and Technology, Hyderabad, India

Abstract - Multi-storey buildings are nowadays common in the urban and semi urban region where land value is of huge cost. In regions like Mumbai, Delhi, Chennai etc. have a problem of land, but these regions are considered to be financially rich cities in India. But these regions are seismically active where earthquake forces will govern the design. Generally in these cities buildings are of irregular configuration and vertically irregular, showing unacceptable responses due to seismic forces due to which structure may collapse since Bhuj earthquake is a great example where majority of the structures have been collapsed due to improper flow of inertia forces. Columns and shear walls are the major elements which are responsible to transfer the lateral forces safely to the ground. IS 1893:2002 and 2016 gives the guidelines for plan irregularity and vertical irregularity great concentration have to be given when this situation arises in the seismic prone regions. To study the effect of plan irregularity and vertical irregularity simultaneously 9 different mathematical models have been generated in E-Tabs 2015. To evaluate the seismic response equivalent static analysis and response spectrum method have been used as specified by IS 1893:2002 and 1893:2016.

I. INTRODUCTION

Tremor is distinct as the moment among the two tectonic plates in the soil layer. It is an unexpected collision or moment of the ground layer which naturally occurs under the surface. It also prohibits shock waves which may caused by man-made explosions and nuclear test etc. The intersection among two plates is known as fault. When two plates moves; the rocks which are exposed to stress unsettled to the moment suddenly develops fracture in the soil curst which is termed as earthquake. Tremors are mostly the overwhelming and unpredictable natural disasters, which is extremely complicated to look after the engineering properties and human life against it. Thus, sequentially to conquer we require scrutinizing the seismic exploit of the engineering environment by developing a range of methodical measures which resists. The edifice to withstand during the minor earthquake and develops sufficient warning every time subjected to major shaking events. As a result it can save human life & worthless possessions of the society.

The deeds of the edifice for an extent of an tremor depends on quite a few factors, inflexibility, adequate lateral strength and ductility, uncomplicated and usual prototype of the building. The edifice with usual geometry and consistently spread mass and inflexibility in plan moreover in altitude suffers very less damages when match up to the irregular configuration. But the current scenario is; architects and engineers are predictable towards planning of irregular geometry due to boost in demand and growth in population. Earthquake does not kill the humans but the engineering structures do; owing to inadequacy of design criteria used while designing the structure. Therefore it is the foremost duty of the Structural Engineer to lengthen the parameters from earlier practices and consider all the probable hazards that the building is subjected to in the near upcoming, for the intention of safety and secure figures of the construction. With aspire of improving the recital of the building exposed to earthquake structural engineers have urbanized the F.E.M with help of computer software, which capably replica and examine the edifice and display the outcome in specific manner.

Vertical irregularities are moreover essential origin intended behind the breakdown of the edifices during the earthquakes. For instance the edifices with soft stories are the mainly extraordinary edifice which distorted. So the conclusion of perpendicularly abnormality in the seismic deed of structures behaves to be truly vital. In IS 1893 the narration of perpendicularly asymmetrical edifice: The abnormality in the buildings possibly due to irregular allocation in their mass, strength and inflexibility next to the altitude of structure.

While such structures are build in high seismic region, the investigation and design produced to be more complex. There are 2 forms of abnormalities in the structures:

- Plan Irregularities.
- Vertical Irregularities.

The main aim of the current study is:

1. To evaluate the seismic response equivalent static analysis and response spectrum method.

2. How different types of shear wall reduces the effect of storey and how it can enhance the seismic performance of High rise Structures.

II. METHOD OF ANALYSIS

LINEAR STATIC ANALYSIS: Linear static analysis spring is a clad suggestion of flexibility of the construction and specific where initial elastic will increase. The linear still techniques of analysis are limited to stunt to consistent buildings. Structural investigation is the progression to assess a structural classification to predication its come back with action by using substantial policy and mathematical calculation. The leading apart of structural investigation is to control core forces, stress and deformation of structures beneath plentiful weight cause. Then the edifice performed is acknowledged by spreading the lateral masses substitute at every stage in X&Y path.
This lateral loads are premeditated by manner in observing a miscellany of features alike the response reduction factor (R), zone factor (Z), importance factor (I), horizontal acceleration co-efficient (Ah), structural retort aspect (Sa/g) and total seismic influence of building (W) as stated by IS code 1893:2002.

LINEAR DYNAMIC ANALYSIS:
Dynamic investigation of construction is a wedge of structural scrutiny in which posture of elastic structure cause danger to vigorous loading is studied. Vibrant load frequently changes with time. Vibrant load contains of wind, live load, tremor load etc. Thus, in all-purpose we can utter practically all the real life problems can be studied dynamically.
Mathematically $F = M X a$
Where F = inertial force
M = Inertial Mass and
a = Acceleration

Therefore utmost grave part of structural investigation is to engender a computer model, with the predictable amount of mass less member and finite number of shift of nodes which feigns the authentic deeds of structures. Another tough fragment of dynamic analysis is to analyze energy degeneracy and to boundary condition. Therefore it is extremely problematic to investigate structure for seismic load. This exertion can be considered using several programming systems.

RESPONSE SPECTRUM ANALYSIS: It is a lively motionless investigation practice which deals the motivation from equivalent usual approach of shaking to specify the likely utmost seismic retort of a mainly elastic structure response spectrum analysis by gauging pseudo-spectral acceleration, velocity or displacement as a usefulness of structural period for a precise Time History level of curbing. It is practical to wrap response spectra such that a smooth curve signifies the crowning response for every gratitude of structural period. It is preferable for design decision making as it relays structural type selection to dynamic show. Response spectrum aids to attain the top most edifice retort under the linear range which can practice to acquire lateral forces advanced owning to tremor, thus facilitates in seismic unreceptive devise of edifice. As stated by IS 1893:2002.

III. DESCRIPTIONS OF MODELS

For the current study nine different models of eleven (11) storey's has been considered each model has five bays in both X&Y direction with a plan dimension of 15mX20m respectively, Special moment resisting frame is used for modeling of the structure, typical storey height of 3m, size of the columns considered are 300X600mm and 300X750mm, size of beams considered are 300X450mm, slab thickness of 150mm, Thickness of Brick wall 200mm, shear wall width considered are 350mm for Floor 1-2, 300mm for floor 3-5, 230mm for floor 6-11, unit weight of R.C.C 25KN/m^2, unit weight of masonry 20KN/m^2, Live Load considered is 4KN/m^2, Floor Finishes of 1KN/m^2, Earthquake loads as per IS 1893, Seismic Zone II, Importance Factor of 1.5, Response Reduction Factor of 5, grade of concrete is M40 and grade of rebar is Fe500.
Different models considered with different configuration are as follows:
Model – 1: Diamond with Vertical Irregularity. 1ststorey to 5thstorey the plan has diamond shape without perpendicular abnormality & shear partition with openings, and then 6thstorey to 11thstorey the plan has diamond shape with vertical abnormality & shear partition with openings.

Model – 2: Diamond without Vertical abnormality. 1ststorey to 11thstorey the plan has diamond shape without vertical abnormality & shear partition with openings.

Model – 3: I-Section with Vertical Irregularity. 1ststorey to 5thstorey the plan has I- shape without vertical abnormality & shear partition with openings, then 6thstorey to 11thstorey the plan has I-Shape configuration with vertical abnormality & with shear partition openings.

Model – 4: I-Section without Vertical abnormality. 1ststorey to 11thstorey the plan has I- shape without vertical abnormality & shear partition with openings.

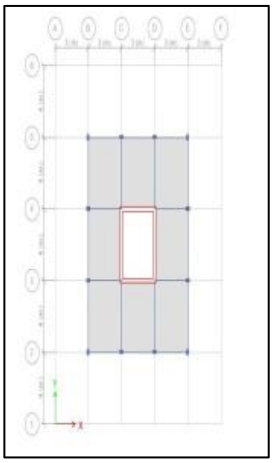
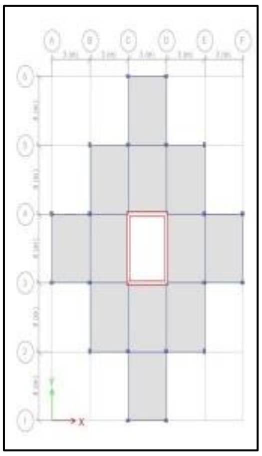
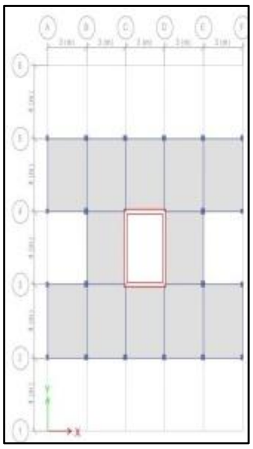
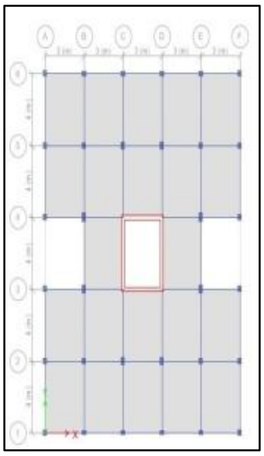
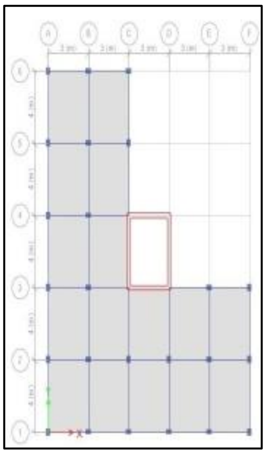
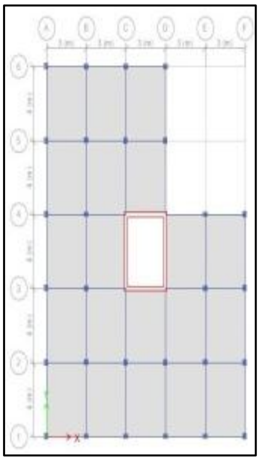
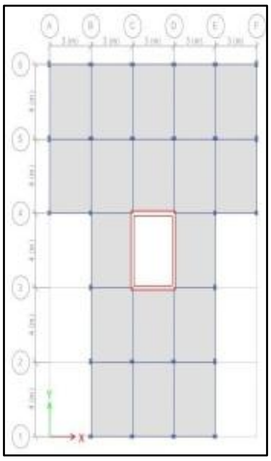
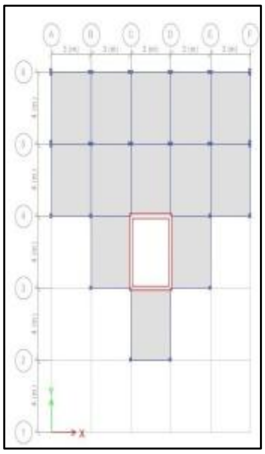
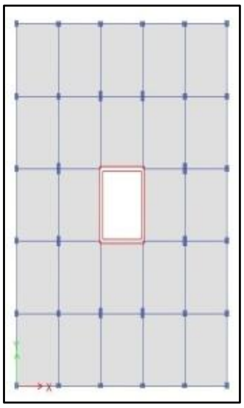
Model – 5: L-Section with Vertical abnormality. 1^{st}storey to 5^{th}storey the plan has L- shape without vertical irregularity & shear partition with openings, then 6^{th}storey to 11^{th}storey the plan has L-Shape configuration with vertical abnormality & with shear partition openings.

Model – 6: L-Section without Vertical abnormality. 1^{st}storey to 11^{th}storey the plan has L - shape without vertical abnormality & shear partition with openings.

Model – 7: T-Section with Vertical Irregularity. 1^{st}storey to 5^{th}storey the plan has T- shape without vertical abnormality & shear partition with openings, then 6^{th} storey to 11^{th} storey the plan has T-shape configuration with vertical abnormality & with shear partition openings.

Model – 8: T-Section without Vertical abnormality. 1^{st}storey to 11^{th}storey the plan has T - shape without vertical abnormality & shear partition with openings.

Model – 9: Bare Frame with block partitions & shear partition with openings.

TIME PERIOD & MODAL MASS PARTICIPATION

	Model	TIME PERIOD (SEC)	Modal Mass Participation in %		
			UX	UY	RZ
MODEL1	1	0.959	64	0.00	0.00
	2	0.858	0.00	63	0.00
	3	0.638	0.00	0.00	78
MODEL2	1	1.142	69	0.00	0.00
	2	1.026	0.00	68	0.00
	3	0.879	0.00	0.00	81
MODEL3	1	1.075	65	0.00	0.00
	2	0.968	0.00	63	0.00
	3	0.893	0.00	0.00	79
MODEL4	1	1.202	60	0.00	14
	2	1.187	12	0.00	69
	3	1.061	0.00	71	0.00
MODEL5	1	1.156	42	4	31
	2	1.052	19	40	12
	3	0.904	9	24	38
MODEL6	1	1.228	52	0.00	23
	2	1.146	16	28	32
	3	1.052	4	41	28
MODEL7	1	1.258	57	0.00	17
	2	1.053	0.00	65	0.00
	3	0.831	9	0.00	61
MODEL8	1	1.314	66	0.00	6
	2	1.152	0.00	69	0.00
	3	1.142	4	0.00	76
MODEL9	1	1.182	1	0.00	83
	2	1.121	73	0.00	1
	3	0.942	0.00	73	0.00

Table No 1: Modal Mass Participation Ratio

The following parameters considered in the current study:

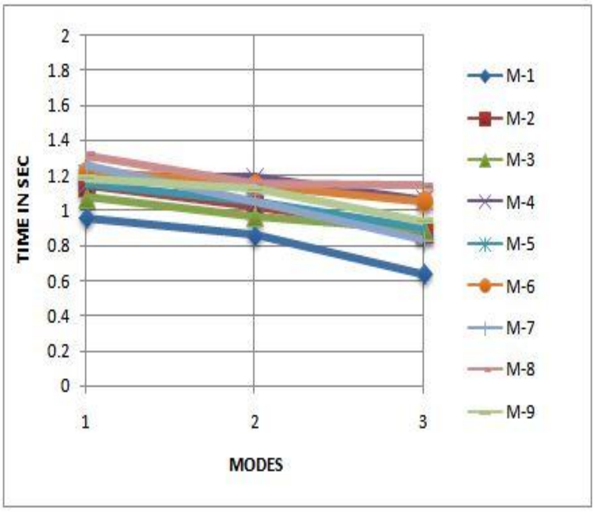


Figure 1: Comparison of Time Period and Modes

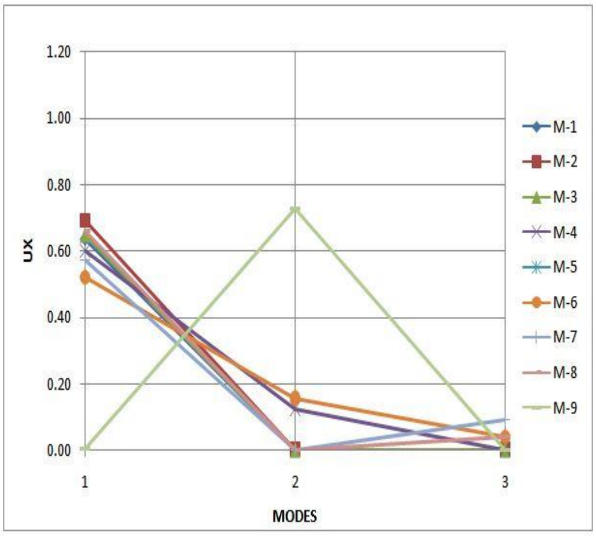


Figure 2: Comparison of UX and Modes

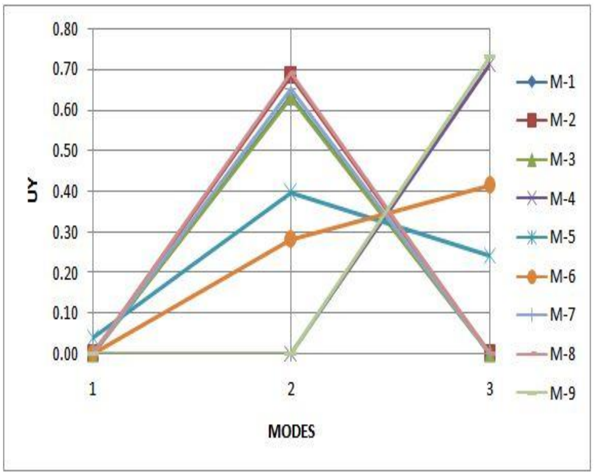


Figure 3: Comparison of UY and Modes

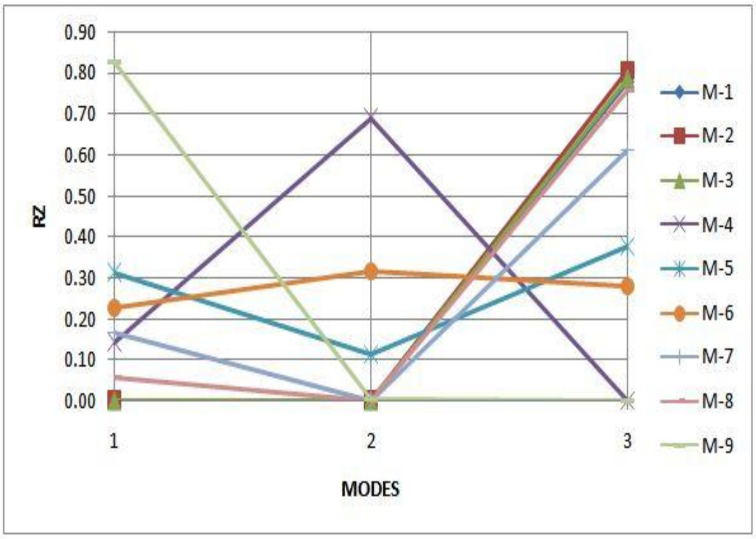


Figure 4: Comparison of RZ and Mode

STOREY DISPLACEMENT:

SPEC X DISPLACEMENT									
STOREY	MODEL1	MODEL2	MODEL3	MODEL4	MODEL5	MODEL6	MODEL7	MODEL8	MODEL9
11	7.59	8.48	30.75	8.71	8.86	9.70	10.37	10.86	8.23
10	6.80	7.64	27.85	8.03	8.33	9.07	9.74	10.05	7.61
9	5.98	6.75	24.75	7.25	7.68	8.31	8.96	9.12	6.90
8	5.13	5.83	21.52	6.40	6.92	7.44	8.05	8.08	6.13
7	4.28	4.89	18.19	5.50	6.08	6.49	7.05	6.97	5.29
6	3.45	3.96	14.86	4.56	5.17	5.48	5.98	5.62	4.41
5	2.66	3.06	11.64	3.63	4.25	4.46	4.92	4.68	3.54
4	1.95	2.22	8.69	2.70	3.32	3.44	3.84	3.56	2.67
3	1.28	1.45	5.84	1.83	2.39	2.44	2.77	2.48	1.63
2	0.71	0.80	3.32	1.05	1.52	1.50	1.75	1.50	1.07
1	0.29	0.32	1.40	0.46	0.78	0.75	0.90	0.72	0.48

Table No 2: Displacement in SPECX Direction

SPEC Y DISPLACEMENT									
STOREY	MODEL1	MODEL2	MODEL3	MODEL4	MODEL5	MODEL6	MODEL7	MODEL8	MODEL9
11	6.80	7.65	27.94	7.87	7.04	7.87	8.94	8.54	6.91
10	6.08	6.84	25.12	7.21	6.51	7.22	7.29	7.68	6.39
9	5.33	6.01	22.14	6.47	5.89	6.50	6.40	6.77	5.78
8	4.56	5.15	19.08	5.68	5.21	5.72	5.49	5.84	5.13
7	3.80	4.28	15.97	4.85	4.49	4.90	4.57	4.89	4.42
6	3.05	3.43	12.91	3.99	3.74	4.07	3.68	3.95	3.67
5	2.34	2.63	9.99	3.14	3.00	3.25	2.83	3.05	2.93
4	1.68	1.88	7.31	2.32	2.30	2.45	2.03	2.20	2.19
3	1.09	1.22	4.81	1.55	1.62	1.69	1.32	1.43	1.49
2	0.59	0.67	2.68	0.87	1.00	1.01	0.72	0.78	0.86
1	0.23	0.26	1.10	0.37	0.50	0.48	0.29	0.31	0.37

Table No 3: Displacement in SPECY Direction

STOREY DRIFT:

SPEC X STOREY DRIFT									
STOREY	MODEL1	MODEL2	MODEL3	MODEL4	MODEL5	MODEL6	MODEL7	MODEL8	MODEL9
11	0.0003	0.0003	0.0021	0.0021	0.0016	0.0020	0.0021	0.0028	0.0017
10	0.0003	0.0003	0.0023	0.0023	0.0019	0.0023	0.0025	0.0030	0.0019
9	0.0003	0.0003	0.0024	0.0025	0.0022	0.0026	0.0028	0.0034	0.0021
8	0.0003	0.0003	0.0025	0.0027	0.0024	0.0029	0.0032	0.0036	0.0023
7	0.0003	0.0003	0.0025	0.0028	0.0026	0.0031	0.0034	0.0038	0.0024
6	0.0003	0.0003	0.0024	0.0028	0.0026	0.0031	0.0033	0.0037	0.0024
5	0.0002	0.0003	0.0022	0.0028	0.0027	0.0031	0.0034	0.0037	0.0024
4	0.0002	0.0003	0.0021	0.0026	0.0026	0.0031	0.0033	0.0035	0.0023
3	0.0002	0.0002	0.0018	0.0023	0.0025	0.0028	0.0031	0.0031	0.0020
2	0.0001	0.0002	0.0013	0.0017	0.0021	0.0023	0.0025	0.0025	0.0016
1	0.0001	0.0001	0.0007	0.0010	0.0016	0.0017	0.0020	0.0017	0.0009

Table No 4: Storey Drift in SPECX Direction

SPEC Y STOREY DRIFT									
STOREY	MODEL 1	MODEL 2	MODEL3	MODEL 4	MODEL5	MODEL 6	MODEL7	MODEL 8	MODEL9
11	0.0002	0.0003	0.0019	0.0018	0.0014	0.0018	0.0022	0.0024	0.0012
10	0.0003	0.0003	0.0020	0.0019	0.0016	0.0019	0.0023	0.0025	0.0014
9	0.0003	0.0003	0.0020	0.0021	0.0018	0.0021	0.0024	0.0026	0.0015
8	0.0003	0.0003	0.0021	0.0022	0.0019	0.0022	0.0024	0.0027	0.0016
7	0.0003	0.0003	0.0020	0.0022	0.0020	0.0022	0.0023	0.0027	0.0017
6	0.0002	0.0003	0.0019	0.0022	0.0019	0.0022	0.0022	0.0026	0.0017
5	0.0002	0.0003	0.0018	0.0021	0.0019	0.0021	0.0021	0.0024	0.0017
4	0.0002	0.0002	0.0016	0.0020	0.0018	0.0020	0.0018	0.0022	0.0016
3	0.0002	0.0002	0.0014	0.0017	0.0016	0.0018	0.0015	0.0018	0.0014
2	0.0001	0.0001	0.0010	0.0013	0.0013	0.0014	0.0011	0.0013	0.0011
1	0.0001	0.0001	0.0005	0.0007	0.0010	0.0010	0.0005	0.0006	0.0006

Table No 5: Storey Drift in SPECY Direction

STOREY SHEAR:

SPEC X BASE SHEAR									
STOREY	MODEL 1	MODEL 2	MODEL3	MODEL 4	MODEL 5	MODEL 6	MODEL7	MODEL 8	MODEL9
11	87.08	107.87	156.24	170.32	122.36	144.11	92.57	131.71	185.34
10	153.92	187.76	277.05	301.12	215.12	252.14	164.99	226.38	332.80
9	200.18	240.43	359.16	389.97	275.93	323.59	214.68	286.24	436.99
8	234.28	278.37	415.80	454.54	317.97	374.77	249.04	328.11	516.00
7	261.77	311.54	460.27	510.09	353.38	419.43	278.38	365.44	583.51
6	285.94	343.64	499.79	562.39	387.28	462.46	308.38	402.76	645.29
5	323.21	375.75	568.45	613.33	428.34	505.12	343.90	441.16	703.67
4	362.44	407.99	645.32	664.12	473.14	548.17	378.96	480.84	759.88
3	398.17	438.46	721.42	712.55	517.60	589.52	412.63	519.20	812.04
2	426.44	461.83	781.94	750.32	552.89	622.09	441.01	549.13	852.30
1	442.62	473.92	815.07	770.93	572.31	639.77	457.77	565.19	874.33

Table No 6: Storey Shear in SPECX Direction

SPEC Y BASE SHEAR									
STOREY	MODEL 1	MODEL 2	MODEL3	MODEL4	MODEL5	MODEL6	MODEL7	MODEL8	MODEL9
11	92.19	115.34	171.84	184.90	131.54	155.66	127.42	151.16	205.31
10	165.22	201.19	304.29	328.01	229.39	270.53	221.81	260.55	373.80
9	217.41	259.50	395.43	428.84	293.34	346.39	284.19	331.87	500.60
8	256.51	303.09	460.44	505.70	338.60	401.58	328.28	383.32	601.84
7	289.01	341.41	513.08	572.64	337.43	450.21	365.58	428.90	689.25
6	317.96	377.58	559.94	634.14	414.19	496.74	400.74	474.16	767.06
5	358.84	412.38	638.26	691.48	458.75	542.34	448.09	517.30	836.67
4	398.86	445.88	721.41	745.69	505.49	587.71	497.72	561.63	899.08
3	435.09	476.44	800.62	794.86	550.42	630.41	544.99	603.27	953.12
2	462.06	499.32	861.64	831.82	585.05	663.23	580.96	634.76	992.86
1	476.23	511.13	894.48	851.54	603.70	680.77	599.91	651.28	1014.15

Table No 7: Storey Shear in SPECY Direction

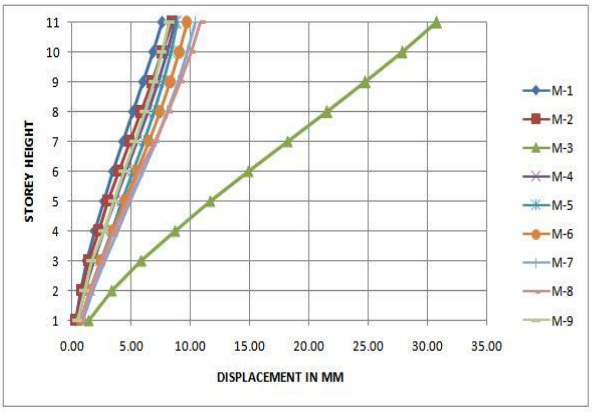


Figure 5: Comparison of Storey Height in SPECX with Storey Displacement

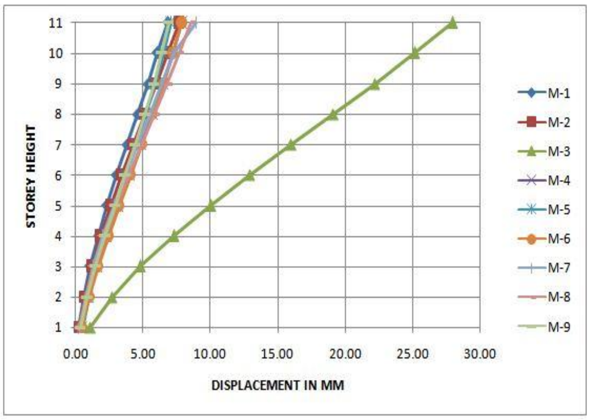


Figure 6: Comparison of Storey Height in SPECY with Storey Displacement

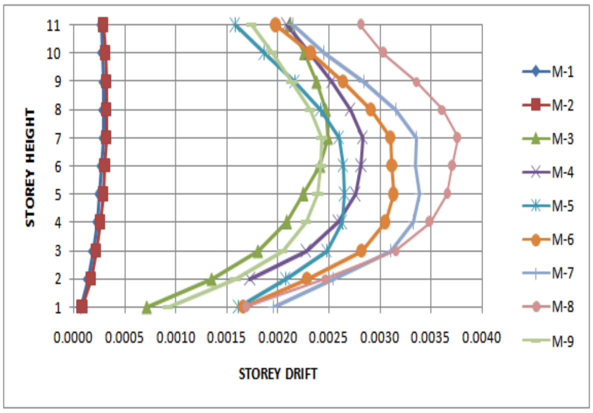


Figure 7: Comparison of Storey Height in SPECX with Storey Drift

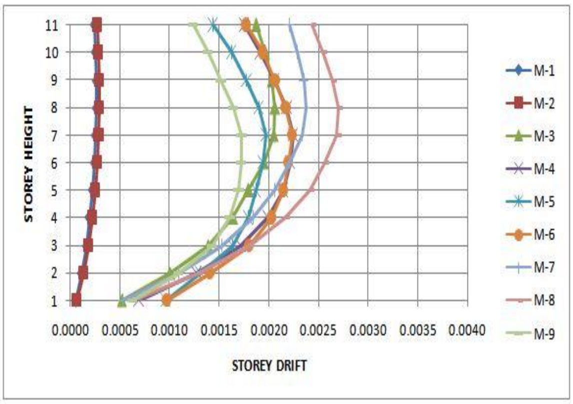


Figure 8: Comparison of Storey Height in SPECY with Storey Drift

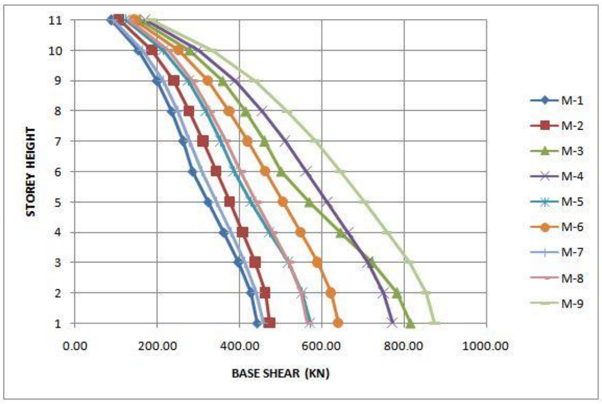


Figure 9: Comparison of storey Height in SPECX with Storey Shear

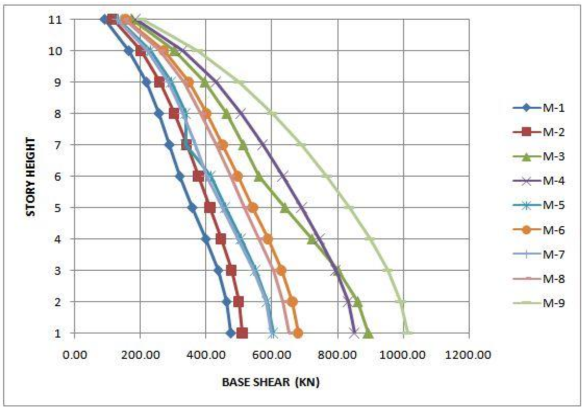


Figure 10: Comparison of Storey Height in SPECY with Storey Shear

IV. CONCLUSION

- Model 1 & 2 demonstrate the least displacement response then it shall be experiential that, these replicas show superior rigidity and strength in association with the remaining building replicas. Displacement restoring capacity or lateral steadiness of asymmetrical edifice models is significantly fewer in association with regular buildings. Therefore irregular configuration is not ample enough to transfer the sideways force generated to earthquake loads.
- When model 3, 4, 5, 6, 7, 8 and 9 compared with model 1and 2, the extent of increase in drift are 85.71%, 88%, 89.21%, 88.88%, 90.33%, 91.18%, 92.11%, 87.51% in that order together with X pathway.
- When model 3, 4, 5, 6, 7, 8 and 9 compared with model 1and 2, the extent of increase in drift are 33.34%, 90.47%, 90.91%, 90%, 90.91%, 91.61%, 92.60%, 88.24% respectively alongside Y path.
- Model with normal geometry and without irregularity showing the good response in association with irregular geometrical models. This shows that abnormality is not the first-class alternative for buildings where earthquake is dominating the design.
- Models with vertical irregularities are not showing first-class deeds, but these replicas are not transferring the loads effectively to the groundwork.
- Plan irregularities are leading the models to torsion which is not superior for the edifice models.
- Modal Mass contribution is very significant parameter to show the proper and accepted lively actions of structure sated by IS Codes. The modal mass should be Maximum in the 1st fundamental modes to learn the vibrant needs of third fundamental modes.

V. REFERENCES

[1] **J.H Casis and E. Cornejo** "Influence of vertical irregularities in the response of earthquake resistant structures" 11th world conference on earthquake engineering in the year 1996.

[2] **P. V. Prasad and T. Rajasekhar** "Effect of Seismic Retrofitting on R.C Building with soft storey and Floating Columns" International Journal of Engineering Trends and Technology (IJETT) Volume 46, Number 7, 2017.

[3] **C.M. Ravi Kumar, K.S. Babu Narayan, M.H. Prashanth, H.B Manjunatha and D. Venkat Reddy** "Seismic Performance Evaluation of RC Buildings with Vertical Irregularity" ISET Golden Jubilee Symposium, October 2012.

[4] **S. Monish and S. Karuna** "A Study on Seismic performance of high rise irregular RC framed building". International Journal of Research in Engineering and Technology (IJRET), Volume 4, Issue 5, May 2015.

[5] **Neha P. Modakwar, Sangita S. Meshram and Dinesh W. Gawatre** "Seismic Analysis of Structures with Irregularities". IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE).

[6] **N.Anvesh, Dr. Shaik Yajdani and K. Pavan kumar** "Effect of Mass Irregularity on Reinforced Concrete Structure Using Etabs". International Journal of Innovative Research in Science, Engineering and Technology Volume 4, Issue 10, October 2015.

[7] **Oman Sayyed, Suresh Singh Kushwah and Aruna Rawat** "Effect of Infill and Mass Irregularity on RC Building under Seismic Loading", International Research Journal of Engineering and Technology (IRJET), Volume 4, Issue 2, February 2017.

[8] **Ravindra N. Shelkel and U. S. Ansari** "Seismic Analysis of Vertical Irregular RC Building Frames". International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 1, January 2017.

[9] **J. Shaikh Sameer and S. B. Shinde** "Seismic Response of vertical Irregular RC Frame with Mass Irregularity". International Journal of Civil Engineering and Technology (IJCIET) Volume 7, Issue 5, September-October 2016.

[10] **Rupesh R. Pawadel and Dr. M. N. Mangulkar** "Influence of Combine Vertical Irregularities in the Response of Earthquake Resistance RC Structure". IOSR Volume 14, Issue 1, January February 2017.

[11] IS 1893(Part1) 2002 **-** Indian Standard criteria for earthquake resistant design of structures.

[12] IS456:2000 Code of Practice for Plain and Reinforced Concrete. Bureau of Indian Standards, New Delhi.

[13] IS800:2007 Code of Practice for Steel Structure. Bureau of Indian Standards, New Delhi.

[14] IS875:1987 Code of Practice for Design Loads (other than earthquake) for buildings and structures part 2 imposed load. Bureau of Indian Standards, New Delhi.

[15] IS13920:1993 Indian Standard Code of Practice for the detailing of Reinforced Concrete Structure subjected to Seismic Force. Bureau of Indian Standards, New Delhi.