Seismic Analysis of A Multi-Storyed RC Building With Horizontal And Vertical Irregularity

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Abstract- *A multistory building has to be designed to resist both lateral loads due to wind or earthquake as well as gravity loads.Lateral load resistance to the structure is provided by both interior and exterior structural system. In this study 3 dimensional analytical models of G+21 storied buildings with 3 soft stories @ different levels with plan 50mx36m have been generated for regular and irregular buildings with all structural members are designed with IS 800:2007 and with load combination taken from 1893(part 1) and analyzed using CSI ETABS software 2016 for zone 5 earthquake of India the modern urban buildings consist of a large portion of Irregular buildings.*

The project focuses on study of structural behavior of tall building to understand irregularity which is due to horizontal & vertical plane thus structures with irregular shapes have been considered. A set of modal consisting of seven different models are considered out of that the first model is with the regular structure, second-fourth with Horizontal irregularities and the remaining fifth-seventh with Vertical irregularities.

The objective of the project is to carry out Equivalent Static Analysis(ESA), Response spectrum analysis (RSA), Time History Analysis(THA) of Horizontal and Vertically irregular RC building. The effect of Horizontal irregularity and Vertical irregularity has been studied by considering the parameter such as Story Displacement, Story Drift, Modal Time Period, Story Forces.

Keywords- Structure design, Irregularity, seismic analysis, Storey Displacement, Time Period, Storey Forces & Response spectrum Analysis etc.

I. INTRODUCTION

GENERAL

Earthquake may be defined as shaking of the ground produced by seismic forces, which results in shaking of structures or building causing damages to building some time leading in human life loss. This has led to a detailed study of structures.

In metro cities tall structure or buildings has more importance in recent years.ie is quit difficulty to avoid irregular shape building construction some time due to space requirement in construction field. Such building must resist both lateral load as well as wind load. The building shape and building structural system has impact on the seismic performance of building. While symmetrical buildings effect in an equally uniform distribution of seismic forces all over its components. Unsymmetrical or irregular buildings results in tremendous indeterminate distribution of forces making the analysis and prediction becomes complicated.

IS 1893 (part-1) :2002 has recommended building configuration system for the better performance of RC building during earthquakes. If the building configurations are almost symmetrical about the axis such building are called Regular buildings or if there is lack insymmetry discontinuity in mass, geometry such building called as Irregular buildings. There are two types of irregularities-

1. Horizontal Irregularities.
2. Vertical Irregularities.

1. Horizontal irregularities refers to asymmetrical plan shapes (L,T,U and H) or discontinuities in horizontal resisting elements such as re-entrant corners, large openings or like torsion, deformations etin vertical.
2. Vertical irregularities referring to sudden change of strength, stiffness, geometry and mass of a structure

A) OBJECTIVES OF STUDY

- To calculate the design lateral forces on regular and irregular buildings using Equivalent Static Analysis, Response Spectrum Analysis, Time History Analysis and to compare the results of different structures.
- To calculate the response of buildings subjected to various types of ground motions namely low,

intermediate and high frequency ground motion using Time history analysis.

- The purpose of this study is to know performance and behavior of R.C.C regular and irregular structures in seismic motion.
- To study about the variations in building properties with different floor plans by carrying out Equivalent Static Analysis, Response Spectrum Analysis, Time History Analysis.
- To study the effects of horizontal and vertical irregularity in high rise buildings considering parameters like displacement, time period, storey drift and story forces.
- To compare the results of linear static analysis with linear dynamic analysis.

B) SCOPE OF STUDY:

- Only RC buildings are considered
- Column was modeled as fixed to the base.
- Both horizontal and vertical irregularity was studied.
- The results of different parameters such as displacement, drift, story forces and time period to be studied.
- Both horizontal and vertical irregularity was studied.

II. MODELING & ANALYSIS METHODS

- 3D modeling for analysis of all models using ETABS 2016 Software package.
- The building is analyzed by using Equivalent Static Analysis (ESA) ,Response Spectrum Analysis (RSA),Time History Analysis(THA)

A) DESCRIPTION OF SAMPLE BUILDING MODELS

Model 1: The model-1 is a rectangular model.
Model 2: The model-2 is a U-shape model with irregularity in horizontal direction.
Model 3: The model-3 is a H-shape model with irregularity in horizontal direction.
Model 4: The model-4 is a L-shape model with irregularity in horizontal direction.
Model 5: The model-5 is with irregularity in vertical direction with same base from 1^{st} -6 th,4 bays are less in x-direction from 7-13^{th},7 bays are less in x-direction from 14^{th}-22^{th}.
Model 6: The model -6 is with irregularity in vertical direction with same base from 1^{st} -6 th,1 bay less in x-direction and 1 bay less in y direction from7^{th}-$12^{th,}$ 2 bay less in x-direction and 2 bay less in y-direction from 13th-17^{th} storey,3 bays less in x-direction and 3 bays less in y-direction from,18^{th} -$22^{th.}$.
Modal 7: The model -7 is with irregularity in vertical direction with same base from 1^{st} -6 th,1 bay less in x-direction and 2 bay less in y-direction from 7^{th} -13^{th} story,2 bay less with in x-direction and 3 bay less in y-direction from 14^{th} -22^{th}.

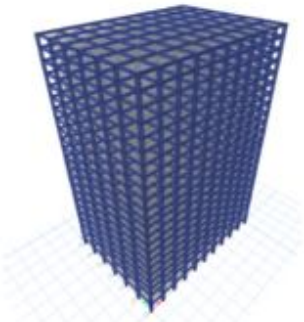


Fig 1:Bare Frame 3d view

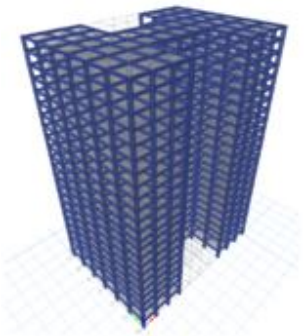


Fig 2:Model 2 3d view

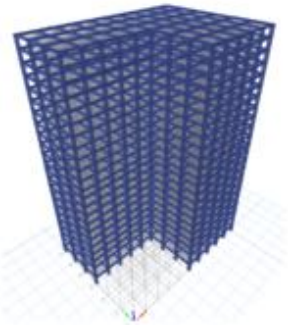


Fig 3:Model 3 3d view

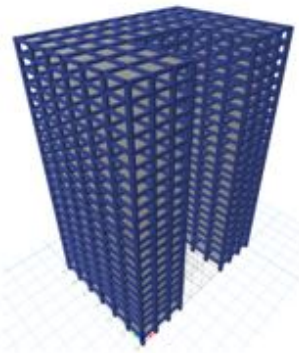


Fig 4:Model 4 3d view

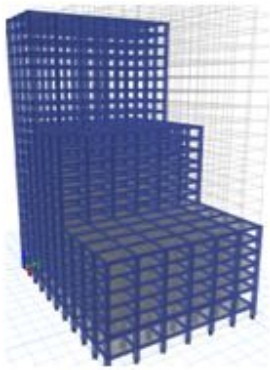


Fig 5:Model 5 3d view

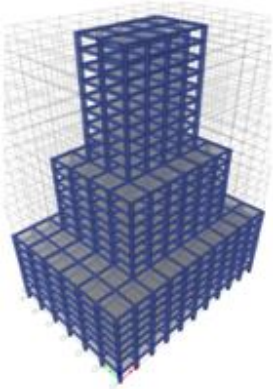


Fig 6:Model 6 3d view

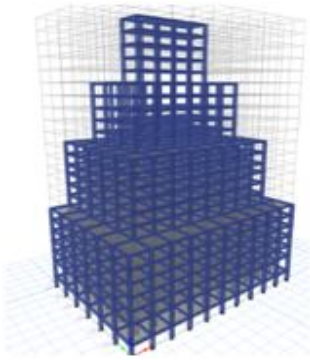


Fig 7:Model 7 3d view

C) DESIGN AND MATERIAL DATA

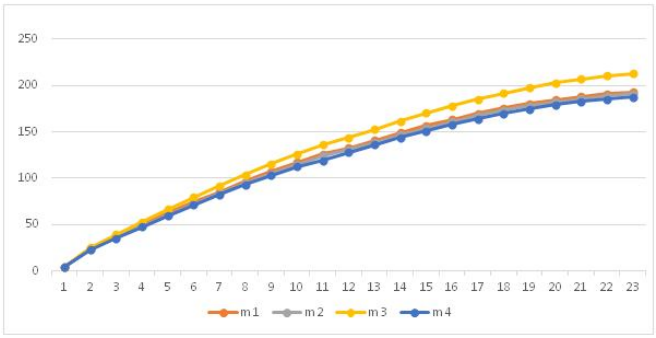
Type of structure	RCCFrame structure
No of storey	G+21
Plan Size	50mx36m
Storey height	3.2m
Bottom soft storey	5m
Intermediate soft storey	2.5m
Top soft storey	3m
Foundation height	3m
Grade of concrete	40N/mm^2
Grade of steel	550N/ mm^2
Seismic Data as per IS 1893:2002	
Seismic zone	V
Response reduction factor	5
Importance factor	1.5
Type of soil	Type 2
Load calculation	
Dead load	
Wall load	11.66 KN
Live load	3 KN/mm^2
FF load	1 KN/mm^2
Section details	
Column size	600x900mm
Beam size	450x530mm
Slab	125mm
Thickness of brick masonry	230mm

III. RESULTS & DISCUSSIONS

The building models has been analyzed using Etabs. The model validation is done to check the safety of members in the structure, lateral displacements, story drifts, time period, story forces of the structure.

A)1.STOREY DISPLACEMENT OF BARE FRAME WITH HORIZONTAL IRREGULAR BUILDING

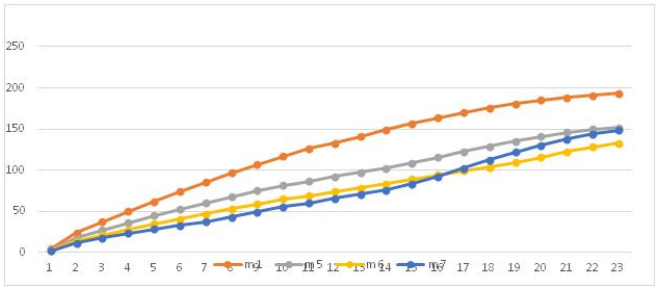
Story Number	MODAL 1	MODAL 2	MODAL 3	MODAL 4
1	4.736	4.591	4.938	4.477
2	24.28	23.601	25.458	23.053
3	37.328	36.387	39.46	35.598
4	50.0.35	48.871	53.137	47.862
5	62.35	60.987	66.451	59.768
6	74.245	72.703	79.358	71.277
7	85.702	83.995	91.828	82.362
8	96.699	94.842	103.836	92.985
9	107.206	105.213	115.345	103.08
10	117.157	115.043	126.283	112.511
11	126.409	124.196	136.489	119.234
12	132.954	130.69	143.809	127.764
13	141.229	138.897	153.016	136.009
14	149.174	146.783	161.897	143.845
15	156.655	154.221	170.305	151.199
16	163.597	161.136	178.154	158.023
17	169.946	167.474	185.385	164.271
18	175.652	173.186	191.942	169.9
19	180.688	178.224	197.772	174.864
20	184.948	182.541	202.822	179.12
21	188.457	186.104	207.055	182.636
22	191.204	188.924	210.479	185.423
23	193.143	190.951	213.096	187.45



Storey vs Displacement.

A)2 STOREY DISPLACEMENT OF BARE FRAME WITH VERTICAL IRREGULAR BUILDING

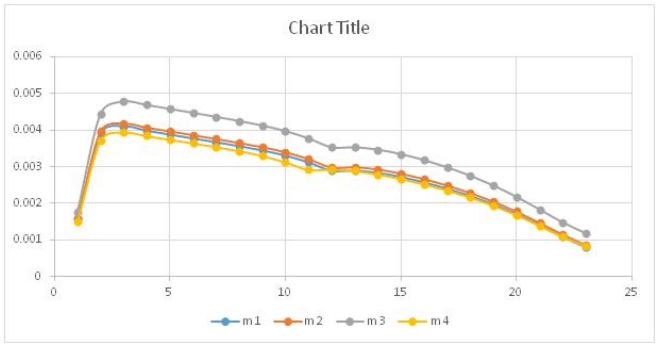
Story Number	MODAL 1	MODAL 5	MODAL 6	MODAL 7
1	4.736	3.527	2.712	2.301
2	24.28	17.935	13.826	11.653
3	37.328	27.346	21.123	17.678
4	50.0.35	36.303	28.073	23.26
5	62.35	44.781	34.624	28.332
6	74.245	52.794	40.78	32.911
7	85.702	60.446	46.732	37.371
8	96.699	67.917	52.953	42.932
9	107.206	75.089	59.188	49.238
10	117.157	81.738	64.977	55.524
11	126.409	86.377	68.95	60.039
12	132.954	92.14	73.76	65.679
13	141.229	97.579	78.361	71.008
14	149.174	102.798	83.6	76.231
15	156.655	108.951	89.162	83.437
16	163.597	115.651	94.464	92.457
17	169.946	122.544	99.236	102.332
18	175.652	129.305	103.585	112.321
19	180.688	135.628	109.23	121.853
20	184.948	141.24	115.898	130.485
21	188.457	145.923	122.505	137.892
22	191.204	149.557	128.352	143.916
23	193.143	152.027	132.937	148.399



Storey vs Displacement.

B)1.STOREY DRIFT OF BARE FRAME WITH HORIZONTAL IRREGULAR BUILDING

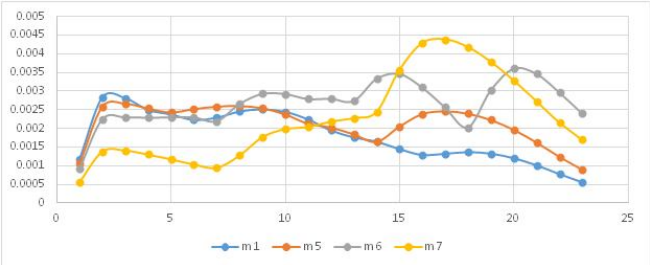
Story Number	MODAL 1	MODAL 2	MODAL 3	MODAL 4
1	0.001988	0.002115	0.002042	0.001987
2	0.004689	0.005037	0.00484	0.004722
3	0.003955	0.00448	0.004195	0.004098
4	0.003618	0.004171	0.003879	0.00378
5	0.003473	0.004031	0.003738	0.003645
6	0.003368	0.003935	0.003635	0.003553
7	0.003274	0.003849	0.003542	0.003469
8	0.003179	0.003762	0.003448	0.003382
9	0.003079	0.003666	0.003347	0.003276
10	0.002959	0.003546	0.003224	0.003102
11	0.002771	0.003354	0.003031	0.002789
212	0.002444	0.003038	0.002705	0.002921
13	0.00256	0.003147	0.002818	0.002901
14	0.002522	0.003116	0.002782	0.002809
15	0.002411	0.003006	0.00267	0.002689
16	0.00227	0.002859	0.002524	0.002548
17	0.002108	0.002684	0.002354	0.002386
18	0.001924	0.002478	0.002158	0.002199
19	0.001711	0.002238	0.00193	0.001981
20	0.001463	0.001957	0.001666	0.001726
21	0.001178	0.001638	0.001363	0.001433
22	0.000865	0.001298	0.001033	0.001111
23	0.000576	0.001012	0.000735	0.000839



Storey vs Drift

B)2.STOREY DRIFT OF BARE FRAME WITH VERTICAL IRREGULAR BUILDING

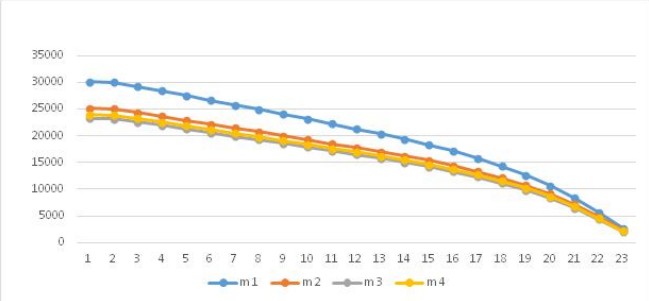
Story Number	MODAL 1	MODAL 5	MODAL 6	MODAL 7
1	0.001173	0.001054	0.000923	0.000565
2	0.002834	0.002588	0.002252	0.001383
3	0.002809	0.002667	0.002302	0.00141
4	0.002496	0.002537	0.00229	0.001301
5	0.002374	0.002431	0.002301	0.001177
6	0.002227	0.002521	0.0023	0.001038
7	0.002287	0.002587	0.002197	0.000949
8	0.002452	0.002603	0.002659	0.001276
9	0.002509	0.002544	0.00293	0.001765
10	0.002444	0.002379	0.002928	0.001981
11	0.002243	0.00213	0.002792	0.002036
12	0.001947	0.002026	0.002799	0.002182
13	0.001761	0.001843	0.00274	0.002275
14	0.001646	0.00164	0.003334	0.00244
15	0.001448	0.002048	0.003465	0.003559
16	0.00129	0.002387	0.003101	0.004279
17	0.001322	0.002461	0.002564	0.00438
18	0.001365	0.002398	0.002029	0.004172
19	0.001326	0.002229	0.003025	0.003783
20	0.001205	0.001966	0.003605	0.003285
21	0.001014	0.001626	0.00347	0.002726
22	0.000779	0.00124	0.002969	0.002162
23	0.00056	0.000893	0.002403	0.001694



Storey vs Drift.

C)1. STOREY FORCES OF BARE FRAME WITH HORIZONTAL IRREGULAR BUILDING

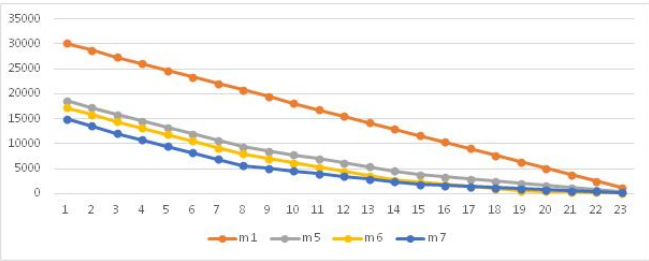
Story Number	MODAL 1	MODAL 2	MODAL 3	MODAL 4
1	30122.412	25135.007	23291.68	23944.9
2	29962.37	24995.839	23166.56	23813.99
3	29232.703	24362.309	22595.85	23217.13
4	28397.034	23641.199	21943.36	22536.36
5	27512.325	22883.82	21252.89	21817.97
6	26636.53	22143.268	20570.79	21110.9
7	25780.621	21428.894	19906.35	20423.29
8	24927.243	20723.454	19246.33	19739.46
9	24054.892	20006.044	18574.05	19042.25
10	23152.676	19266.299	17881.02	18326.83
11	22220.539	18504.656	17167.18	17622.01
12	21289.09	17748.038	16456.43	16951.93
13	20383.931	17018.42	15767.43	16238.18
14	19396.709	16222.893	15014.99	15476.18
15	18322.622	15357.222	14195.19	14643.4
16	17139.261	14402.178	13289.97	13724.83
17	15825.877	13339.639	12282.68	12704.71
18	14347.387	12137.44	11145.47	11552.73
19	12646.265	10741.554	9832.826	10217.65
20	10653.936	9086.5711	8290.41	8637.847
21	8319.311	7122.11	6477.47	6766.146
22	5639.0645	4840.6888	4390.594	4595.507
23	2696.6406	2313.2251	2094.964	2192.543



Storey vs Forces.

C)2. STOREY FORCES OF BARE FRAME WITH VERTICAL IRREGULAR BUILDING

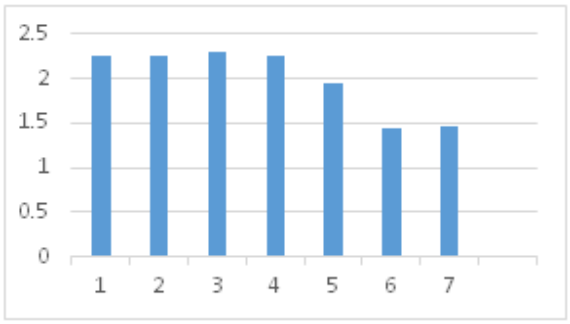
STORY NUMBER	MODAL 1	MODAL 5	MODAL 6	MODAL 7
1	30122.696	18669.38	17257.04	14916.13
2	28721.929	17268.61	15856.28	13515.36
3	27310.251	15856.94	14444.6	12103.68
4	25996.774	14543.46	13131.12	10790.2
5	24683.296	13229.98	11817.65	9476.725
6	23369.818	11916.5	10504.17	8163.248
7	22056.341	10603.03	9190.69	6849.77
8	20742.863	9353.032	7929.359	5631.517
9	19429.386	8544.828	7034.965	5076.796
10	18115.908	7736.624	6140.57	4522.075
11	16802.43	6952.722	5272.958	3984.713
12	15527.142	6168.82	4405.345	3447.35
13	14251.853	5360.616	3510.951	2892.629
14	12938.376	4552.412	2675.505	2337.908
15	11624.898	3791.821	2247.526	1828.532
16	10311.42	3362.572	1819.546	1621.111
17	8997.9428	2933.323	1391.566	1413.689
18	7684.4652	2504.074	963.5867	1206.268
19	6370.9876	2074.826	576.4175	998.8466
20	5057.51	1645.577	456.0327	791.4253
21	3744.0324	1216.328	335.6479	584.004
22	2430.5548	787.0792	215.2631	376.5828
23	1127.9883	361.7981	96.2953	171.287



Storey vs Forces

D) NATURAL TIME PERIODS(T)

MODEL NO	TIME PERIODS IN SEC
MODEL 1	2.262
MODEL 2	2.252
MODEL 3	2.286
MODEL 4	2.245
MODEL 5	1.95
MODEL 6	1.439
MODEL 7	1.454



Storey vs Time period

IV. CONCLUSION

1. Story displacement are max in L shape building and minimum in H shape building.
2. Story displacement are max in bare frame building and minimum in model 6 due to vertical irregularity.
3. Story drift are max for model 3 for horizontal irregular building model and min for model
4. Story drift are max for model 7 for vertical irregular building model and min for model 1.
5. Natural time period is more for model 3 with respect to bare frame for horizontal irregular building whereas time period is more for model 5 with respect bare frame.
6. Story forces are maximum in Bare frame due to horizontal regularity.
7. Hence it can be concluded use regular frame building as far as possible to avoid max damage to the building.
8. Regular structure is stiffer compared to structures with plan and vertical irregularity

V. SCOPE OF FUTURE STUDY

1. Comparative study by providing shear wall at different location.
2. Comparative study by providing bracings and base isolation.
3. Non linear time history analysis can be performed on the structure.
4. Comparative study by providing different shapes of buildings
5. For this analysis we can go for Push Over Analysis.

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