RESPONSE SPECTRUM ANALYSIS OF SYMMETRIC AND ASYMMETRIC STRUCTURES IN SEISMIC ZONES

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Abstract - *From past Earthquake it is proved that many of structures are totally or partially damaged due to EQ so it is necessary to determine seismic response of such buildings. There are different techniques of seismic analysis of structure. In this project work seismic analysis of various structures at different storey levels and at various zones are carried using Response Spectrum Analysis method with help of ETABS 2016 software. This project highlights the behaviour of plan irregular buildings at Zone III and Zone IV at different storey levels.*

Key words: Response spectrum, storey drift, Storey shear, Storey displacement, Overturning moment, ETABS 2016.

1. INTRODUCTION

Structural analysis is mainly concerned with finding out the behaviour of a physical structure when subjected to force. This action can be in the form of load due to weight of things such as people, equipment, wind, snow, etc. or some other kind of excitation such as an earthquake, shaking of the ground due to a blast nearby, etc. In essence all these loads are dynamic, including the self-weight of the structure because at some point in time these loads were not there. This distinction is made between the dynamic and the static analysis on the basis of whether the applied action has enough acceleration in comparison to the structure's natural frequency. If a load is applied sufficiently slowly, the inertia forces (Newton's first law of motion) can be ignored and the analysis can be simplified as static analysis. Structural dynamics therefore is a type of structural analysis which covers the behaviour of structures subjected to dynamic (actions having high acceleration) loading.

A dynamic load is one which changes with time fairly quickly in comparison to the structure's natural frequency. Dynamic loads include people, wind, waves, traffic, earthquakes and blasts. Any structure can be subjected to dynamic loading. Dynamic analysis can be used to find dynamic displacements, time history, and modal analysis. The selection of a suitable procedure to evaluate performance of structures under seismic loads is one of the most sensitive issues that structural engineers face. This would be especially important when dealing with irregular structures since the wrong choice of a procedure would lead to results that are far away from the correct solution. One of the most common types of irregularities that found in most buildings is the plan irregularities.

The existence of asymmetry in the plan is usually leading to an increase in stresses of certain elements that consequently results in a significant destruction.

A building is said to be a regular when the building configurations are almost symmetrical about the axis and it is said to be the irregular when it lacks symmetry and discontinuity in geometry, mass or load resisting elements Asymmetrical arrangements cause a large torsion force which makes the structure torsionally irregular based on the structural configuration, each structure shall be designed as a regular, or irregular structure.

Regular Structure: Regular structures have no significant physical discontinuities in plan or vertical configuration or in their lateral force resisting systems.

Irregular Structures: Irregular structures have significant physical discontinuities in configuration or in their lateral force resisting systems. Irregular structures have either vertical irregularity or plan irregularity or both in their structural configurations.

I. Plan irregularities of the structures are

1. Torsion Irregularity
2. Re-entrant corners
3. Diaphragm discontinuity
4. Non-parallel Systems
5. Out of plane offsets

II. Vertical irregularities of the structures are

1. Stiffness irregularity
2. Mass irregularity
3. Vertical geometric irregularity
4. In-plane discontinuity in vertical lateral force-resisting element

5. Discontinuity in capacity (weak storey)

2. OBJECTIVE

- To study the response spectrum method for analysis of symmetric and asymmetric building structures and to study the effect of plan irregularity on the fundamental natural period of the building, its effects on performance of the structure during earthquake for different building models.
- Analysing the regular and irregular structure and Comparing the response parameters for both structures.

3. Methods of Analysis

There are mainly two types of analysis methods :

- Linear method :
  a. Equivalent Static Analysis
  b. Response Spectrum Analysis
  c. Linear response history
- Non Linear method:
  a. Sequential yield analysis
  b. Time history analysis

Dynamic analysis may be performed either by Time history method or by the Response spectrum method. In this project we have adopted Response Spectrum method to analyse both structures.

4. METHODOLOGY

Step 1: Study of seismic zones
Step 2: Literature study (searching codes, methods and techniques)
Step 3: Defining objectives of the study
Step 4: Referring IS codes for loads applications
Step 5: Model generation using Etabs
Step 6: Applying loads and seismic parameters as assumed for this study
Step 7: Analysis of building models to obtain the results
Step 8: Comparison of the results and concluding the work with conclusion

4.1 Modelling of Structure

Regular structure of G+15 and Irregular structures of G+12 and G+15 are modelled using ETABS software as per IS 1893:2000.Total height of the building is 54m in both G+15 cases, for G+12, 42m and loads are applied as per code.

4.2 Loads Applied:

1. Dead Load :IS 875 (part-1)
2. Live Load :IS 875 (part-2)
3. SeismicLoads:IS1893:2000

Building specification

PARAMETERS	VALUE
Column section	0.2mx0.5m
Beam section	0.23mx0.45m
Slab thickness	0.2m
Grade of concrete	M30
Steel	Fe 415
Height of each storey	3.0m
No. of storey	G+15,G+12
Total height	42,54
Zone factor	0.16,0.24
Importance factor I	1.0
Reduction factor R	5.0
Dead Load	1.5KN/M^2

Load combination

The partial safety factor for load combinations are mentioned in the IS Code1893:2000 clause.6.3.1.2.Total 14combinations are considered in this project

1) 1.5 (DL + IL)

2) 1.2 (DL + IL + ELX)

3) 1.2 (DL + IL - ELX)

4) 1.2 (DL + IL + ELY)

5) 1.2 (DL + IL - ELY)

6) 1.5 (DL + ELX)

7) 1.5 (DL - ELX)

8) 1.5 (DL + ELY)

9) 1.5 (DL - ELY)

10) 0.9 DL + 1.5 ELX

11) 0.9 DL – 1.5 ELX

12) 0.9 DL + 1.5 ELY

13) 0.9 DL – 1.5 ELY

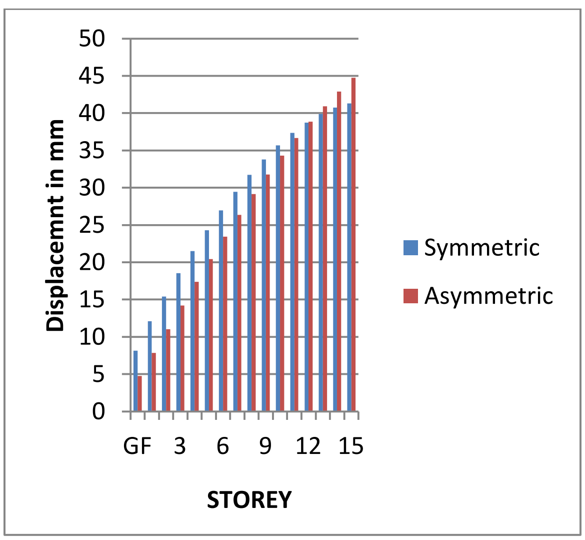
RESULTS AND DISCUSSION

Combined results for both structure

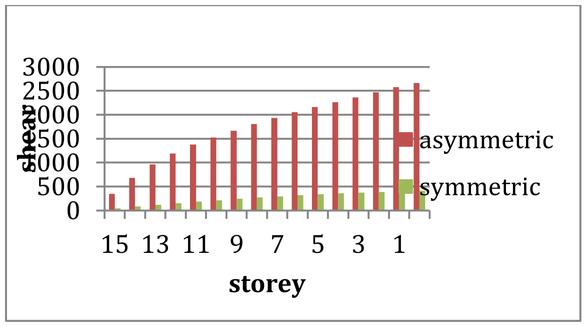
G+15 at Z3

Displacement Varition

Storey	Symmetric	Asymmetric
GF	8.154	4.772
1	12.103	7.845
2	15.418	11.024
3	18.538	14.21
4	21.5	17.361
5	24.306	20.448
6	26.953	23.45
7	29.428	26.348
8	31.718	29.128
9	33.808	31.777
10	35.685	34.285
11	37.336	36.647
12	38.743	38.862
13	39.885	40.935
14	40.737	42.887
15	41.303	44.732



STOREY	ASYMMETRC	SYMMETRIC
15	347.554	43.7902
14	679.6247	84.4122
13	963.0456	119.8466
12	1191.6772	152.0546
11	1373.389	182.9942
10	1525.546	213.1889
9	1665.6871	241.9503
8	1802.6439	268.6796
7	1934.6229	293.5275
6	2055.2664	316.8339
5	2161.9997	338.3647
4	2260.0509	357.4597
3	2359.228	373.841
2	2465.5584	387.8957
1	2573.8036	399.9538
GF	2662.9174	409.4979



Storey Drift

STORY	ASYMMETRC	SYMMETRC
15	0.000231	0.001048
14	0.000362	0.001435
13	0.000485	0.001819
12	0.000585	0.002199
11	0.000664	0.030602
10	0.000731	0.030618
9	0.00079	0.030665
8	0.000847	0.030759
7	0.0009	0.030909
6	0.000949	0.031117
5	0.000995	0.031381
4	0.001037	0.031693
3	0.00108	0.032036
2	0.001139	0.032387
1	0.001343	0.032718
GF	0.002929	0.03299

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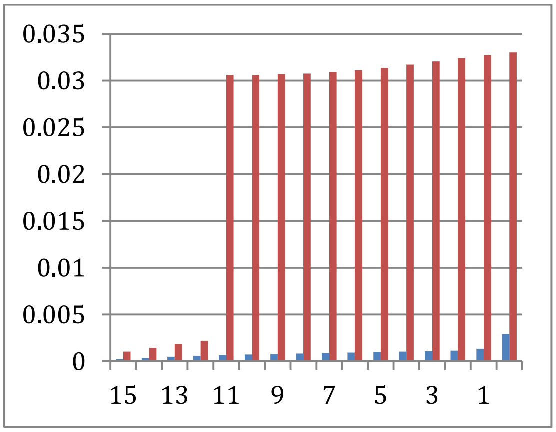
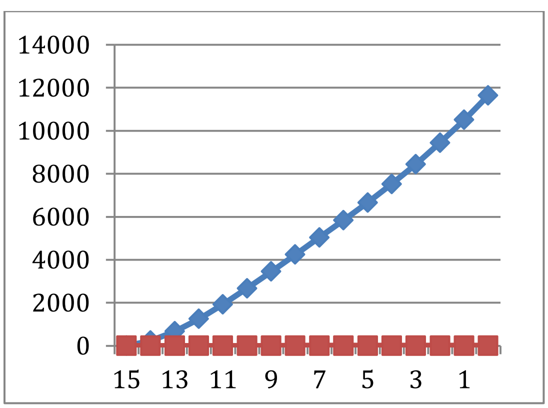


Storey moment

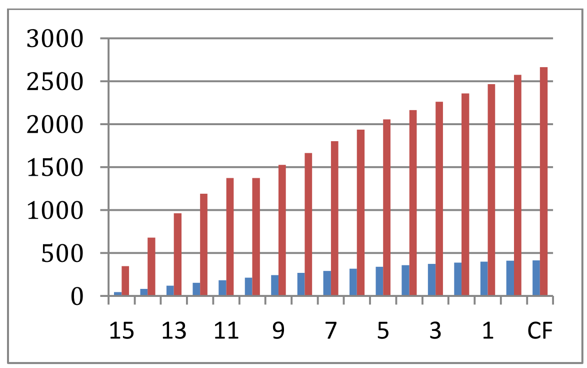
STOREY	SYMMETRIC	ASYMMETRIC
15	0	0
14	234.3	0.08
13	665.54	0.24
12	1245	0.48
11	1927	0.81
10	2673	1.21
9	3451	1.688
8	4242	2.23
7	5036	2.84
6	5839	3.52
5	6663	4.25
4	7526	5.04
3	8448	5.87
2	9440	6.74
1	10509	7.66
GF	11648	8.58



G+15 at Z4:

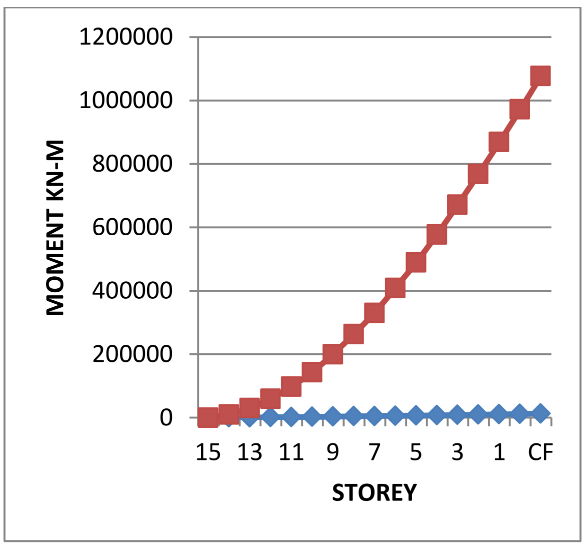
Storey shear

STORY	SYMMETRIC	ASYMMETRIC
15	43.79	347.55
14	84.41	679.62
13	119.84	963.04
12	152.05	1191.67
11	182.99	1373.38
10	213.18	1373.38
9	241.95	1525.54
8	268.67	1665.68
7	293.52	1802.64
6	316.83	1934.62
5	338.36	2055.26
4	357.46	2161.99
3	373.84	2260
2	387.89	2359.22
1	399.95	2465.55
GF	409.49	2573.8
CF	416.44	2662.91



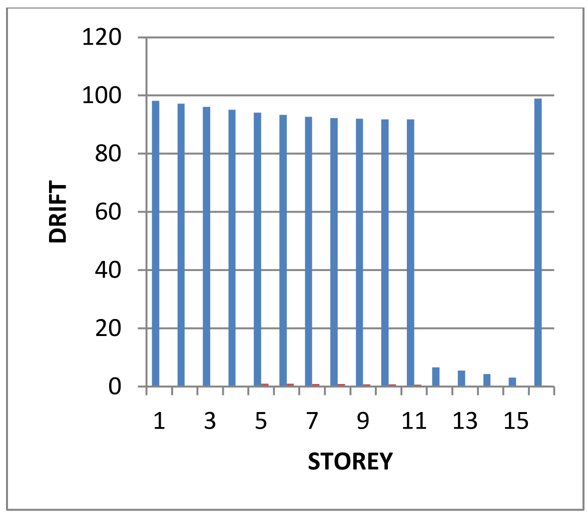
Overturning moment

STOREY	SYMMETRIC	ASYMMETRIC
15	0	0
14	234.3	9584
13	665.54	28965
12	1245.01	57808
11	1927	95685
10	2673.35	140332
9	3451.66	196585
8	4242.19	258590
7	5036.86	325153
6	5839.43	403114
5	6663.2	482534
4	7526.74	569911
3	8448.34	662960
2	9440.97	758715
1	10509	858001
GF	11648	960142
CF	12846	1064321



Storey drift

STOREY	SYMMETRC	ASYMMETRC
1	98.153	0.1343
2	97.162	0.1139
3	96.107	0.108
4	95.078	0.1037
5	94.143	0.995
6	93.35	0.949
7	92.726	0.9
8	92.278	0.847
9	91.996	0.79
10	91.853	0.731
11	91.805	0.664
12	6.596	0.00585
13	5.457	0.00485
14	4.306	0.000362
15	3.145	0.000231
GF	98.969	0.329



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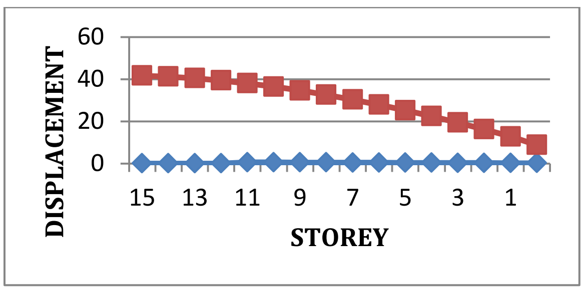
Storey displacement

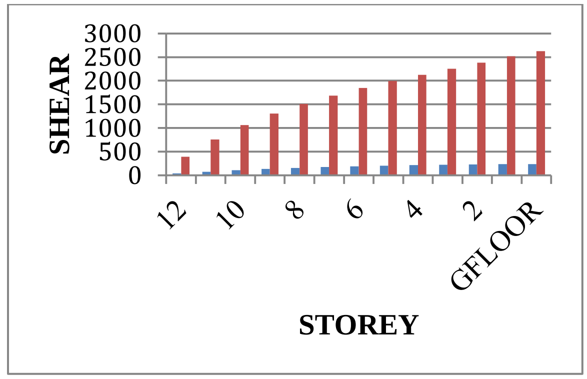
STOREY	SYMMETRIC	ASYMMETRIC
15	0	41.6
14	0	41.15
13	0	40.4
12	0	39.34
11	0.54	38
10	0.49	36.43
9	0.46	34.6
8	0.42	32.56
7	0.38	30.3
6	0.34	27.84
5	0.29	25.19
4	0.26	22.37
3	0.22	19.37
2	0.17	16.2
1	0.13	12.8
GF	0.09	8.78



Storey G+12 at Z3

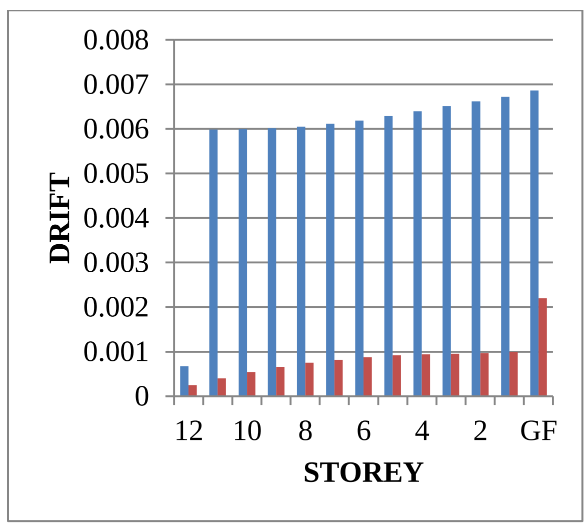
Storey shear

STOREY	SYMMETRC	ASYMMETRC
12	39.091	390.16
11	75.146	757.26
10	106.46	1063.45
9	133.38	1308.06
8	156.28	1507.69
7	175.51	1682.89
6	191.45	1844.62
5	204.45	1992.98
4	214.87	2127.3
3	223.055	2254.21
2	229.34	2383.4
1	234.05	2514.7
GF	237.43	2624



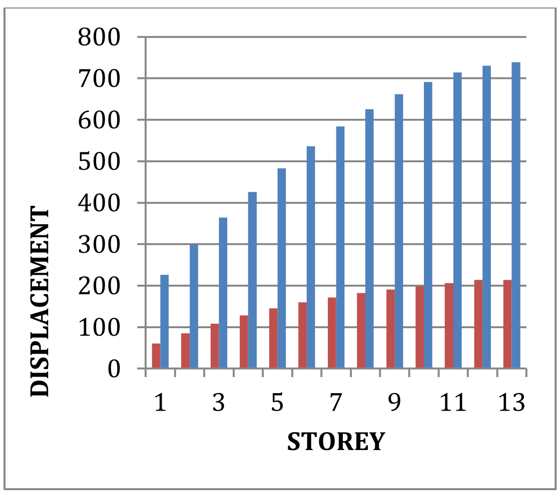
Storey drift

STORY	SYMMETRC	ASYMMETRC
12	0.000674	0.00025
11	0.005992	0.0004
10	0.005999	0.000543
9	0.006019	0.000658
8	0.006057	0.00075
7	0.006115	0.00082
6	0.006193	0.000876
5	0.006288	0.000914
4	0.006397	0.000938
3	0.006511	0.000952
2	0.006624	0.00097
1	0.006726	0.001
GF	0.006867	0.0022



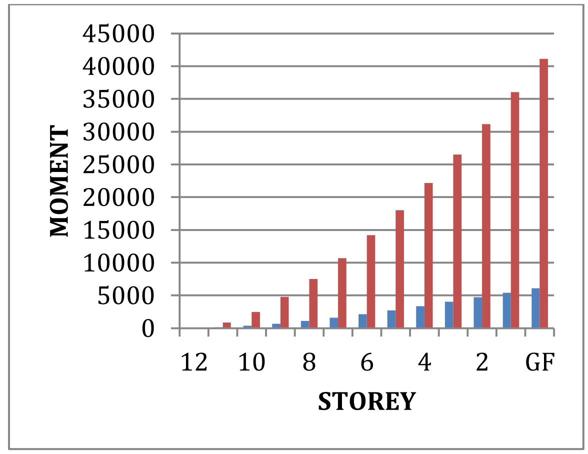
Storey displacement

STOREY	SYMMETRIC	ASYMMETRIC
GF	60.174	226.38
1	85.4	299.18
2	108.09	364.25
3	127.99	425.74
4	145.07	483.17
5	159.51	535.98
6	171.64	583.65
7	181.88	625.71
8	190.73	661.74
9	198.68	691.33
10	206.168	714.18
11	213.48	730
12	213.5	738.72



Overturning moment

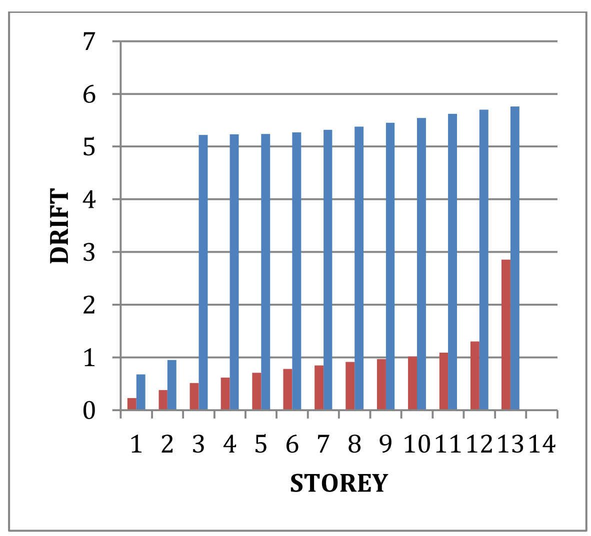
STORY	SYMMETRC	ASYMMETRC
12	0	0
11	122.95	858.78
10	359.01	2499.55
9	692.8	4766.34
8	1110.13	7527.7
7	1597.78	10694
6	2143.8	14209
5	2737.31	18036
4	3368.58	22151
3	4029	26533
2	4711	31165
1	5408.2	36028
GF	6115.26	41113



G+12 at Z4

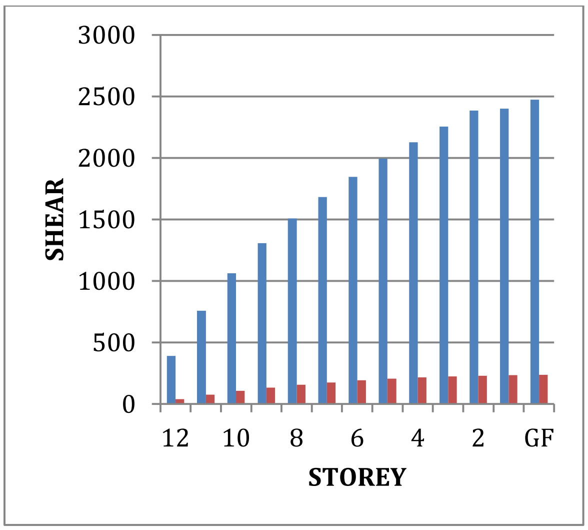
Storey drift

STOREY	ASYMMETRIC	SYMMETRIC
12	0.23	0.675
11	0.377	0.95
10	0.511	5.22
9	0.619	5.23
8	0.707	5.24
7	0.782	5.27
6	0.85	5.32
5	0.912	5.38
4	0.966	5.45
3	1.019	5.54
2	1.089	5.62
1	1.3	5.7
GF	2.852	5.76



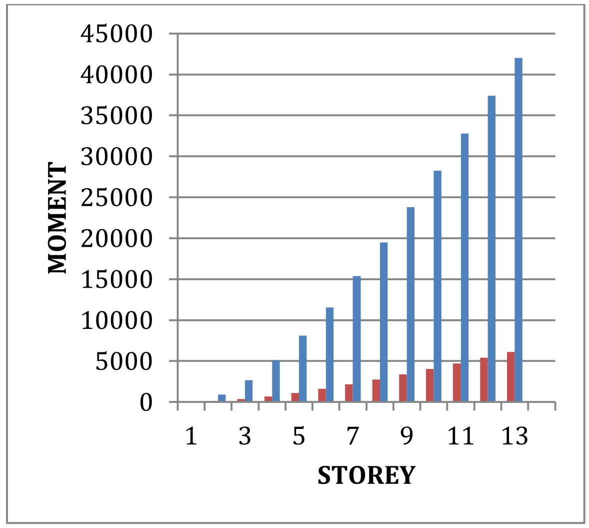
Storey shear

STOREY	ASYMMETRIC	SYMMETRIC
12	390.1606	39.1
11	757.203	75.14
10	1063.451	106.45
9	1308.0605	133.38
8	1507.6901	156.29
7	1682.89	175.54
6	1844.6207	191.49
5	1992.9835	204.5
4	2127.3029	214.92
3	2254.2199	223.12
2	2383.4826	229.42
1	2401.01	234.13
GF	2473.7	237.53



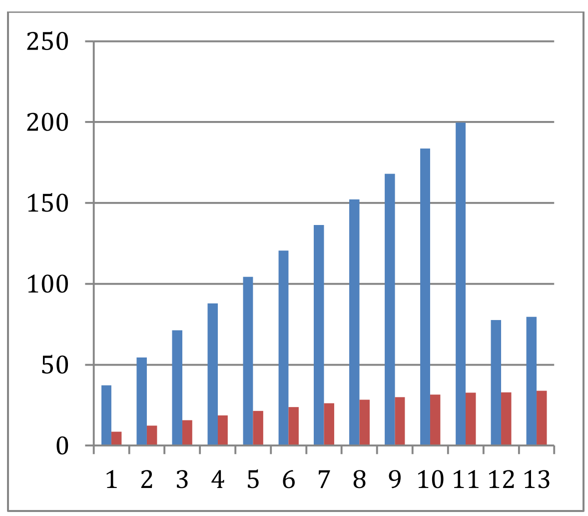
Overturning moment

STOREY	SYMMETRIC	ASYMMETRIC
12	0	0
11	122.98	922.17
10	359.01	2664.58
9	692.76	5096.2
8	1110.04	8097.4
7	1597.7	11560
6	2143.76	15387
5	2737.36	19494
4	3368.76	23805
3	4029.34	28259
2	4711.57	32804
1	5409.03	37400
GF	6116.03	42019



Storey displacement

STORY	SYMMETRIC	ASYMMETRIC
GF	37.35	8.56
1	54.45	12.4
2	71.35	15.7
3	87.94	18.6
4	104.32	21.41
5	120.47	23.9
6	136.44	26.2
7	152.27	28.3
8	168	30
9	183.69	31.57
10	199.65	32.74
11	77.64	33
12	79.66	34



CONCLUSIONS

1. Storey shear has maximum values in all cases in irregular building as compared to regular structure due to earthquake forces in seismic zones.

2. Displacement in X and Y direction increases with increase in height of the structure in both buildings.

3. Displacement is more in asymmetric structures as compared to symmetric structures in all zones.

4. Storey drifts are maximum in symmetric structures G+12 and G+15 and increases with increase in height of the structure in both zones.

5. Overturning moment has maximum values in symmetric structures for G+15 at zone3 due to maximum number of storeys.

6. Moment has maximum values in asymmetric structure for G+12 at zones 3&4 and for G+15at zone4 respectively.

7. From results and graphs observed that maximum displacement, storey drifts, storey shear, and moments occurs in asymmetric structures not in regular building due to earthquake forces and irregularity of structures.

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