Study Of Multistorey Tall Structure (G+26) With Plan Irregularity Consisting Of Dual Resisting System Subjected To Earthquake Loading

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Abstract : In recent years, there has been a rise in trend of irregular multistorey high rise structures. An irregular building in modern day urban infrastructures adds to a huge portion in the construction industry. Such irregular structures should be taken consideration particularly in high seismic zones. Unforeseen impacts can be seen on irregular structures under different burden examples and it causes additional shear, torsion, story drift and so on. Asymmetry in the arrangement expands stresses of certain basic components.

The case study involves the static and dynamic behavior of multistorey RC structure. A comparative investigation is carried out on a building having plan irregularity. It is done in three phases; the first one includes only the shear walls at various locations on the building. The second phase includes replacing the shear wall in the first case with steel bracing. The third phase includes the combinations of both the shear wall and steel bracings.

The structure has been analyzed in ETABS software, which utilizes FEM based analysis. Indian standard codal provisions have been used to determine different types of loadings on the structure. Various parameters has been taken into account like Storey displacement, Storey drifts, Base shear, Time period, to understand the conduct of the structure under the dynamic loadings.

The results obtained from the analysis are in the form of tables and the same are interpreted in the graphs and charts.

I. Introduction

A tremor is an unexpected and transient movement of the world's surface. As per geologists, the earth has languished quakes over numerous years. Regarding the land time scale, it is as of late (the mid seventeenth century) that a quake has been seen as a characteristic wonder driven by the cycles of the earth as a planet. Consequently succeeding work, especially in the nineteenth century, prompted amazingly progress on the instrumental side for the estimation of tremor information.

Seismological data from various quakes were accumulated and investigated to plan and known the marvels of tremors. These data were even used to decide the world's inward structure to a shocking degree which, all together aided towards the progression of different theories to clarify the explanations behind tremors. While the collection of information from the assessment of amassed seismological data has helped in the prudent arrangement of structures to contradict quakes, it has similarly discovered the uncertain thought of future tremors for which such structures are to be arranged. In like manner, probabilistic insights in administering seismic tremors and shake safe structures have moreover made.

A number of characteristics are significant for the design of buildings and structures to ensure that they will act sufficiently during strong earthquakes.

These include:

1. Stability of Foundations
2. Transfer of loads
3. Adequacy stiffness and strength
4. Regularity
5. Redundancy
6. Ductility and toughness
7. Ruggedness

II. Objective

The following are the main objectives of this study:

1) To perform analysis of G+26 storey RC framed building and to determine its behavior under equivalent static method.
2) Study the behavior of the building by placing the Shear walls at different locations.
3) Study the behavior of the building by replacing the Shear walls with cross steel bracings.
4) To analyze the building with Response spectrum method and to find the behavior of the building under dynamic loadings.
5) To study the different dynamic parameters like Time period, Storey drift, Storey displacement and Base shear.
6) To study the suitability of the present structural system in multi storey tall structures.

III. BUILDING DEFINITION

3.1 DESCRIPTION OF BUILDING

Building Input Data:

- **General**

1)	Plan area	1100 sqm
2)	No. of storeys	G+26
3)	Grade of concrete	M-40 for columns M-30 for beams, slabs, walls
4)	Grade of reinforcement	Fy-500
5)	Size of columns	300 X 900 mm
6)	Size of beams	300 X 600 mm
7)	Slab thickness	150 mm
8)	Storey height	3.35 m
9)	Shear wall	230 mm thick
10)	Steel Bracings	ISMB-300

- **Earthquake Parameters**
  (As per IS1893-2016)

1)	EQ zone	3
2)	Importance factor	1.2
3)	Response reduction factor	3
4)	Diaghpragm	Rigid

- **Loading Parameters**

1)	Live Load	2 KN/sqm (As per IS 875-part 2)
2)	Floor Finish	1.5 KN/sqm
3)	Wall Load	12.6 KN/sqm

GENERAL DESCRIPTION OF MODELS

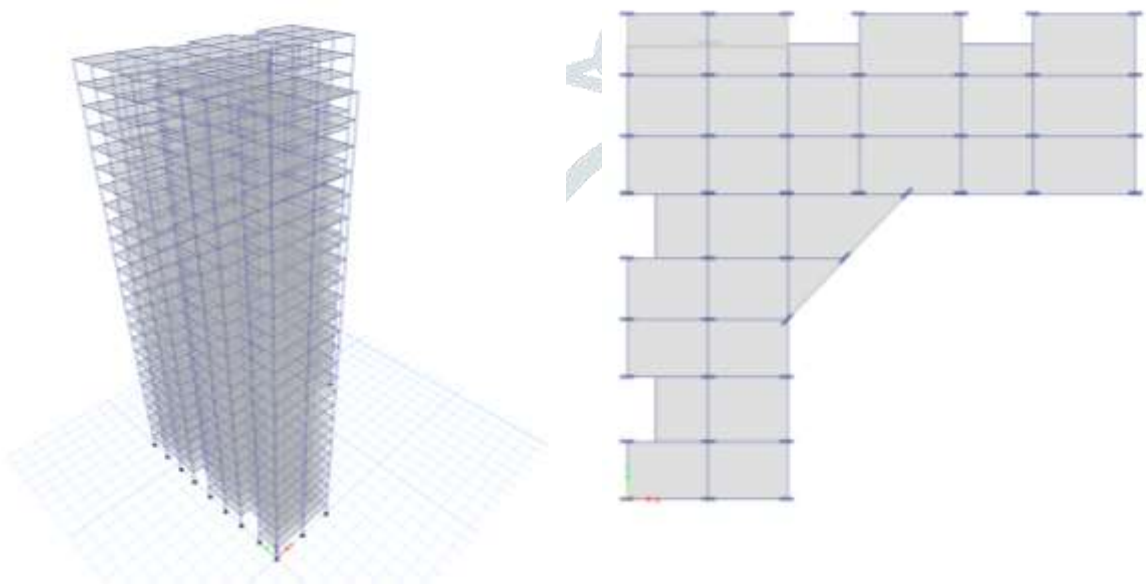
IV. PREPARE YOUR PAPER BEFORE STYLING

The analysis of the models is performed in ETABS. Each model is analyzed using both Equivalent Static Method and Response Spectrum Method. The description of the models is given below:

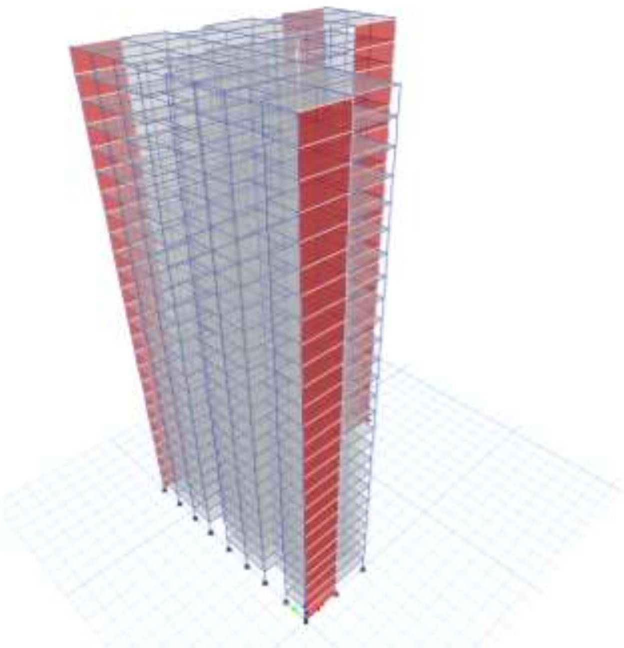
A) **Model 1**: Regular Model, in this model only bare frame model is considered for analysis, consists of simple beams-columns moment frames.

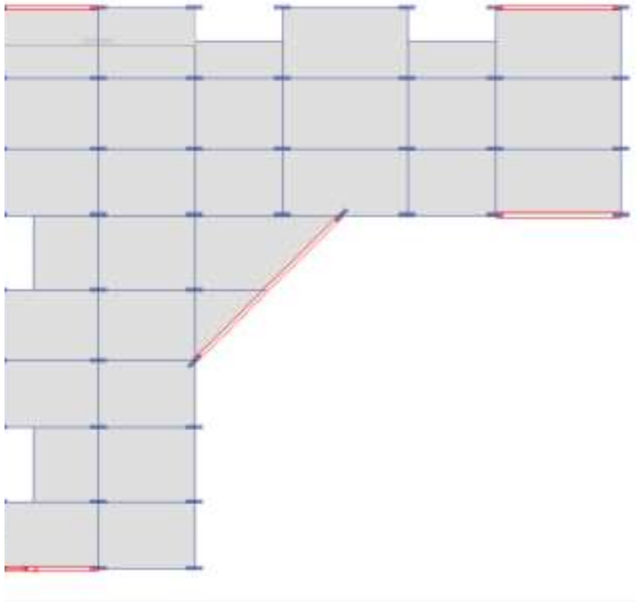
B) **Model 2**: Moment frames with Shear walls in X-direction and a diagonal shear wall in the core is considered.

Model 1:



A) MODEL 2





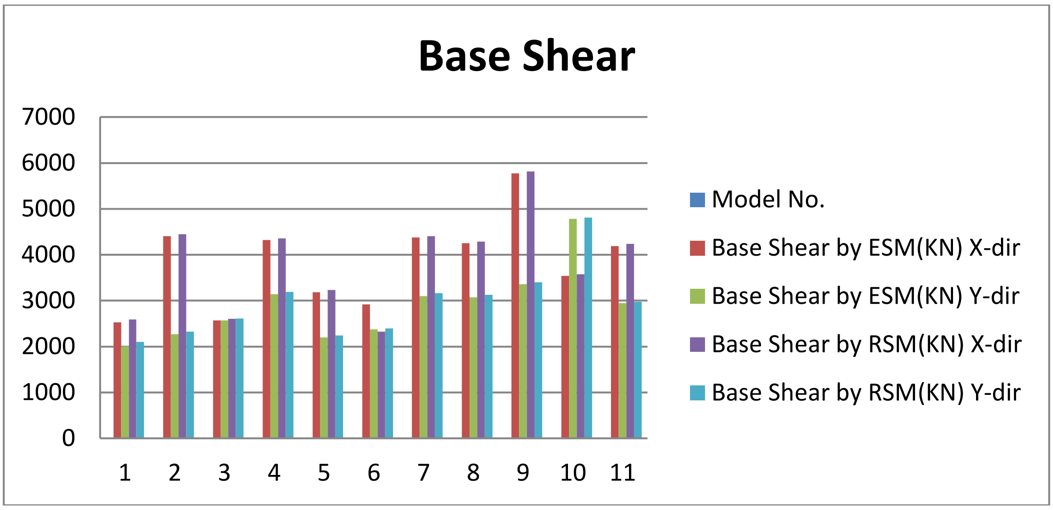
V. RESULTS AND DISCUSSIONS

5.1 BASE SHEAR

It is defined as the Maximum lateral/horizontal force that may be due to wind or Earthquake acting on the base or the foundation level. The base shear depends on the type of soil present and the strata which lies below it.

Following are the Base shear values of differently configured models. These are the values obtained by Equivalent static method and Response spectrum method in X and Y directions respectively.

Model No.	Base Shear by ESM(KN)		Base Shear by RSM(KN)	
	X-dir	Y-dir	X-dir	Y-dir
1	2528	2007	2590	2098
2	4408	2272	4450	2325
3	2572	2572	2605	2608
4	4318	3143	4355	3187
5	3185	2201	3234	2241
6	2919	2375	2328	2397
7	4375	3100	4405	3164
8	4252	3075	4287	3125
9	5770	3356	5812	3397
10	3536	4781	3576	4813
11	4192	2947	4239	2977

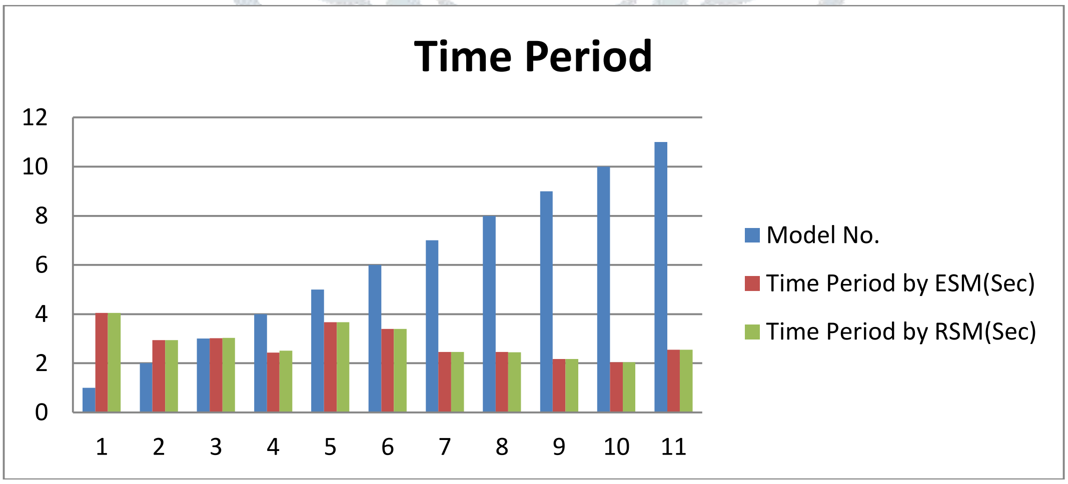


5.2 TIME PERIOD

It is defined as the undamped free vibration in a structure. Every structure has its own natural frequency. When a structure is energized by an earthquake, it starts to vibrate. The lowest natural frequency (f) of structure corresponds to longest Time period of vibration (T), as the frequency and time period are inversely proportional **(T=1/f).**This is also referred to as the first mode of vibration or fundamental period of vibration.

Following are the Time periods of differently configured models analyzed by Equivalent static method and response spectrum method

Model No.	Time Period by ESM(Sec)	Time Period by RSM(Sec)
1	4.044	4.044
2	2.94	2.94
3	3.025	3.026
4	2.434	2.514
5	3.665	3.671
6	3.393	3.394
7	2.457	2.462
8	2.456	2.44
9	2.174	2.173
10	2.043	2.043
11	2.556	2.556

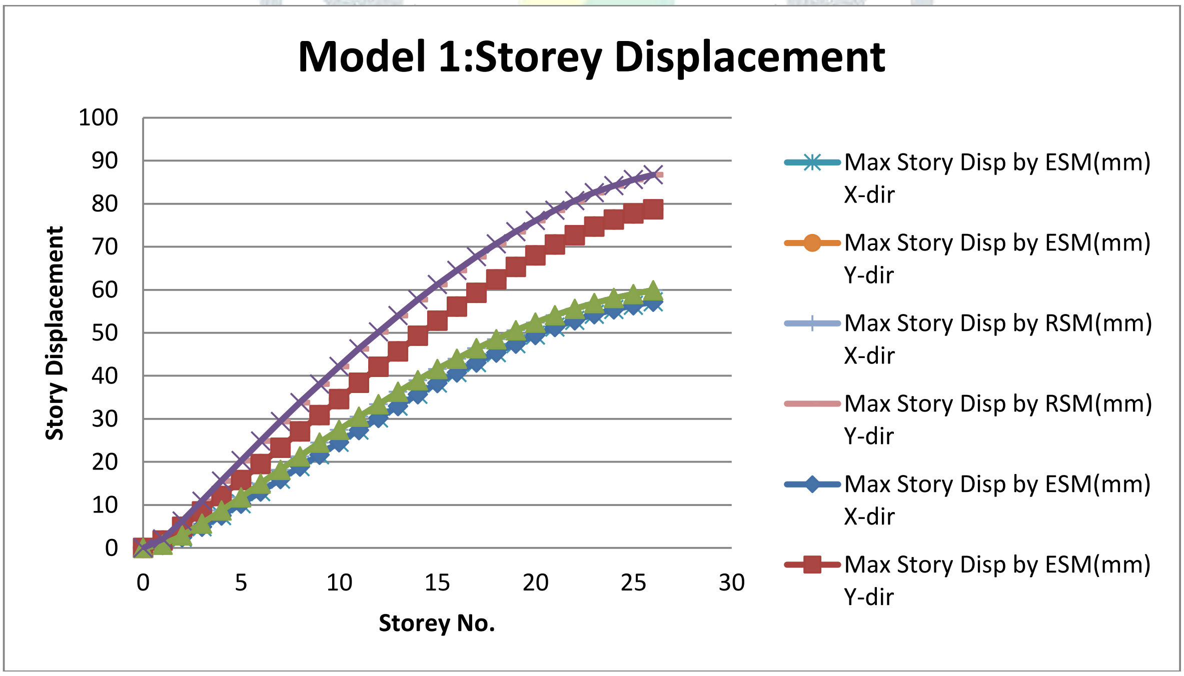


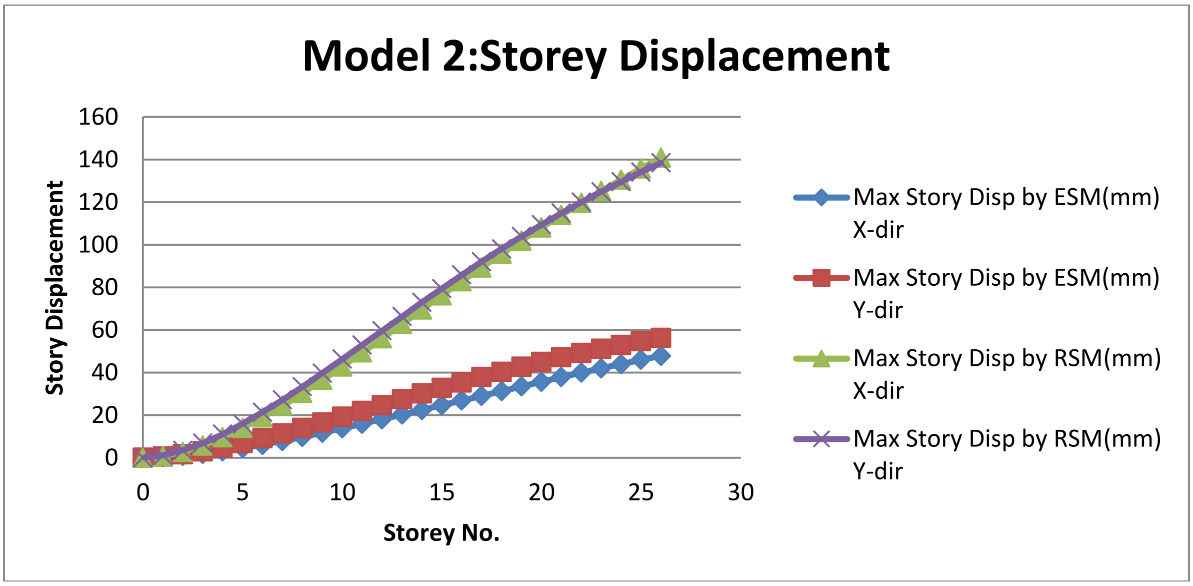
5.3 STOREY DISPLACEMENT

It is defined as the absolute value of displacement of the storey under action of dynamic forces like Earthquake or Wind.

The storey displacements of different models are obtained by analyzing them in ETABS using Equivalent Static Method and Response spectrum method. The values obtained are in the X and Y direction. These are tabulated in the below tables and represented in the Graphs.

Storey No.	Storey Disp by ESM(mm)		Storey Disp by RSM(mm)		Storey No.	Storey Disp by ESM(mm)		Storey Disp by RSM(mm)	
	X-dir	Y-dir	X-dir	Y-dir		X-dir	Y-dir	X-dir	Y-dir
26	57.2	78.7	59.9	86.7	26	47.9	56.3	141	138.5
25	56.4	77.7	59	85.6	25	46	54.7	135.9	134.2
24	55.4	76.3	58.1	84.2	24	44	53	130.6	129.6
23	54.3	74.7	56.9	82.6	23	42	51.1	125.3	124.9
22	52.9	72.7	55.6	80.7	22	40	49.2	119.7	120
21	51.3	70.5	54.1	78.5	21	37.9	47.2	114	114.9
20	49.5	68	52.4	76.1	20	35.7	45	108.1	109.5
19	47.5	65.3	50.6	73.5	19	33.5	42.8	102	103.9
18	45.4	62.4	48.5	70.7	18	31.3	40.4	95.8	98.1
17	43.1	59.3	46.4	67.7	17	29.1	38	89.4	92.1
16	40.8	56.1	44	64.5	16	26.9	35.4	82.9	85.9
15	38.3	52.8	41.6	61.2	15	24.7	32.8	76.3	79.5
14	35.7	49.3	39	57.7	14	22.5	30.2	69.6	73
13	33	45.7	36.3	54	13	20.3	27.5	62.9	66.3
12	30.2	42.1	33.4	50.2	12	18.1	24.7	56.1	59.7
11	27.4	38.4	30.5	46.3	11	16	22	49.5	53
10	24.6	34.6	27.5	42.2	10	13.8	19.3	42.9	46.3
9	21.7	30.9	24.5	38.1	9	11.8	16.6	36.5	39.8
8	18.9	27.1	21.3	33.8	8	9.8	14	30.4	33.4
7	16	23.3	18.2	29.4	7	7.9	11.5	24.5	27.2
6	13.1	19.5	15	24.9	6	6.1	9.2	19	21.4
5	10.3	15.8	11.8	20.3	5	4.5	6.9	14	16
4	7.5	12.1	8.7	15.6	4	3.1	4.9	9.6	11.1
3	4.9	8.5	5.7	10.9	3	1.9	3.1	5.8	6.9
2	2.5	4.9	2.9	6.3	2	0.9	1.7	2.8	3.5
1	0.7	1.7	0.8	2.1	1	0.3	0.6	0.8	1.1
0	0	0	0	0	0	0	0	0	0





5.4 STOREY DRIFT

Drift in building frames is a result of flexural and shear mode contributions, due to the column axial deformations. In low rise braced structures, the shear mode displacements are the most significant and, will largely determine the lateral stiffness of the structure. In medium to high rise structures, the higher axial forces and deformations in the columns, and the accumulation of their effects over a greater height, cause the flexural component of displacement to become dominant.

Storey Drift is defined as Relative difference of design displacement between the top and bottom of a storey, divided by the storey height. Deflections must be constrained during earthquakes for various reasons, and henceforth arrangement of sufficient stiffness is significant. Relative horizontal deflections inside the structure (for example between one story and the following, known as story float) must be restricted. This is on the grounds that non-structural components, for example, cladding, parcels and pipe work must most likely acknowledge the deflections forced on them during an earthquake without failure. Failure of outer cladding, blockage of break courses by firewater pipe work all have genuine security suggestions. In addition, a portion of the sections in a structure may just be designed to oppose gravity loads, with the seismic loads taken by different components, yet in the event that deflections are too incredible they will come up short. In general deflections should likewise be restricted to forestall sway, both crosswise over partition joints inside a structure and (normally more genuinely) between structures.

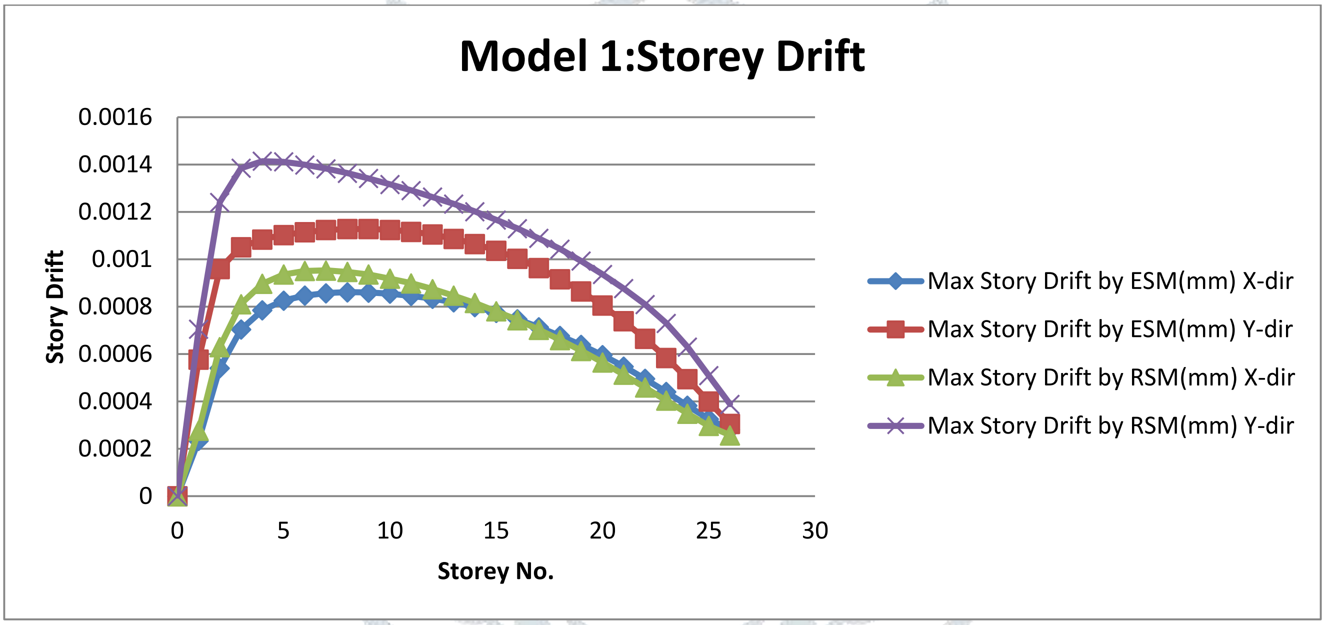
The following are the results of the storey drifts obtained in X and Y direction using Equivalent static method and response spectrum method:

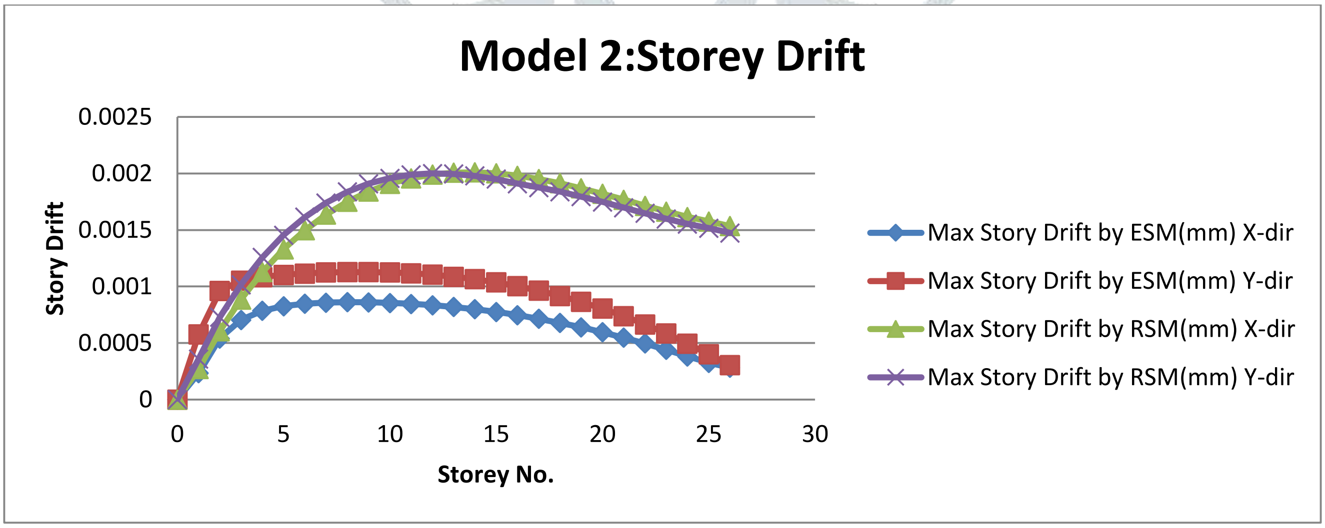
Storey No.	Storey Drift by ESM(mm)		Storey Drift by RSM(mm)	
	X-dir	Y-dir	X-dir	Y-dir
26	0.000281	0.000306	0.000257	0.000388
25	0.000326	0.0004	0.000297	0.00051
24	0.000382	0.000495	0.000349	0.00063
23	0.00044	0.000584	0.000404	0.00073
22	0.000496	0.000665	0.000459	0.00081
21	0.000548	0.000739	0.000513	0.000877
20	0.000596	0.000805	0.000565	0.000937
19	0.000639	0.000865	0.000614	0.000993
18	0.000677	0.000917	0.00066	0.001044
17	0.000714	0.000963	0.000703	0.001089
16	0.000747	0.001003	0.000744	0.00113
15	0.000775	0.001037	0.000781	0.001167
14	0.000799	0.001065	0.000816	0.001202
13	0.000819	0.001087	0.000847	0.001234
12	0.000834	0.001105	0.000875	0.001263

Storey No.	Storey Drift by ESM(mm)		Storey Drift by RSM(mm)	
	X-dir	Y-dir	X-dir	Y-dir
26	0.000281	0.000306	0.001534	0.001474
25	0.000326	0.0004	0.001575	0.001516
24	0.000382	0.000495	0.001615	0.001553
23	0.00044	0.000584	0.001663	0.001599
22	0.000496	0.000665	0.001715	0.001648
21	0.000548	0.000739	0.001768	0.001698
20	0.000596	0.000805	0.00182	0.001748
19	0.000639	0.000865	0.001869	0.001795
18	0.000677	0.000917	0.001913	0.001839
17	0.000714	0.000963	0.001951	0.001876
16	0.000747	0.001003	0.00198	0.00191
15	0.000775	0.001037	0.002001	0.00195
14	0.000799	0.001065	0.00201	0.001979
13	0.000819	0.001087	0.002007	0.001996
12	0.000834	0.001105	0.00199	0.002

11	0.000846	0.001117	0.000899	0.001291
10	0.000855	0.001125	0.000919	0.001317
9	0.00086	0.001128	0.000936	0.001342
8	0.000861	0.001128	0.000947	0.001364
7	0.000857	0.001124	0.000953	0.001383
6	0.000847	0.001115	0.000951	0.001399
5	0.000826	0.001103	0.000936	0.001412
4	0.000785	0.001084	0.000897	0.001415
3	0.000704	0.001052	0.000811	0.001385
2	0.000541	0.00096	0.00063	0.001241
1	0.000234	0.000577	0.000277	0.000706
0	0	0	0	0

11	0.000846	0.001117	0.001958	0.001988
10	0.000855	0.001125	0.001909	0.001958
9	0.00086	0.001128	0.00184	0.001909
8	0.000861	0.001128	0.00175	0.001837
7	0.000857	0.001124	0.001637	0.00174
6	0.000847	0.001115	0.001498	0.001614
5	0.000826	0.001103	0.001329	0.001454
4	0.000785	0.001084	0.001127	0.001258
3	0.000704	0.001052	0.000886	0.001016
2	0.000541	0.00096	0.000606	0.000728
1	0.000234	0.000577	0.000271	0.00036
0	0	0	0	0





VI. CONCLUSION AND FUTURESCOPE

6.1 CONCLUSIONS

From this study the following points can be concluded:

1) For a building with plan irregularity, the presence of lateral load resisting systems at the centre of mass of the building is found to be more effective (Model-11).
2) From the results, the models which have core wall at the centre produces reduced storey displacements, storey drifts.
3) Steel cross bracings on some discrete distances in X and Y directions of building (Model-5,6) yields effective results, showing decreased Storey displacements, Base shear and optimal time period when compared to other models.
4) The models with the shear walls at the edges at discrete locations (Model-2,3) shows increased base shear, storey displacements when compared to the models with steel bracings at their locations.
5) The models with alternate shear walls and steel bracings on the edges in X and Y directions (Models-9,10) produces very effective results in resisting the Earthquake loads. However, they are most uneconomical as they nearly doubles the cost due to the presence of both shear wall and steel bracings.
6) The cost of shear wall per storey when compared to the cost of steel bracings per storey is 30% higher. So the steel bracings are more economical.
7) The combination of both steel bracings and the core wall can be adopted in most of the buildings with plan irregularity, to stabilize the building against lateral loads.
8) Since modern day architecture demands the combination of both RCC and Steel work embedded in the high rise buildings, the steel bracings are a good option in meeting both architectural and structural requirements. Also, these members are slender and easy to install.

6.2 FUTURE SCOPE

This work can be further studied by using wind as the dominant lateral force instead of Earthquake in a high windy area. A different lateral force resisting system can be utilized to study the behavior of the building. This work can also be studied by adopting different kind of irregularities in a high rise building.

REFERENCES

1) Dhaval.N Sorathiya ”Review on Behaviors of diagrids Structural system in high rise buildings” Journal for Research| Volume 02| Issue 11 | January 2017
2) Sudhir K Patel” Effect of number of storey’s to natural time period of building” International Conference on Recent Trends in Engineering & Technology.
3) Raghunath.D.Deshpande “Analysis and comparisons of Diagrid and conventional structural System”IRJET-Volume”02 Issue:03/June -2015
4) Sonali Pandey “A review on Shear Wall in High rise Buildings” IJEI volume 6, Issue 12/Dec 2017
5) Shivekumar Hallale “Seismic Behavior of Buildings with Plan Irregularity with and without Structural infill action”-IJRAET volume-4,Issue-4,2016
6) Abrar Ahmed “Seismic analysis of building with horizontal and vertical irregularities”-IJERD-volume 4,Issue 9,Sept-2017
7) Bourahla N. (2013) “Equivalent Static Analysis of structures subjected to Seismic Actions” -Springer