STUDY OF MULTISTOREY TALL STRUCTURE 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

An earthquake is an abrupt and transient motion of the earth's surface. According to geologists, the earth has suffered earthquakes for many years. In terms of the geological time scale, it is only recently (the mid seventeenth century) that an earthquake has been observed as a natural phenomenon driven by the processes of the earth as a planet. Thus succeeding work, particularly in the nineteenth century, led to extremely progress on the instrumental side for the measurement of earthquake data.

Seismological information from numerous earthquakes were gathered and analyzed to map and known the wonders of earthquakes. These information were even used to determine the earth's internal structure to an astounding degree which, all together helped towards the advancement of various hypotheses to explain the reasons for earthquakes. While the assortment of data from the examination of assembled seismological information has helped in the judicious plan of structures to oppose earthquakes, it has likewise found the unsure idea of future earthquakes for which such structures are to be planned. Accordingly, probabilistic musings in overseeing earthquakes and shake safe structures have furthermore created.

II. OBJECTIVES

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

4.1 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

BASIC MODEL

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

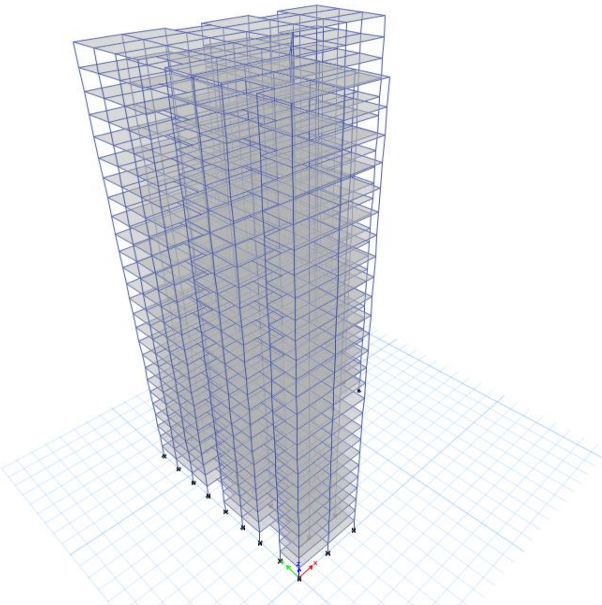

Fig 4.1.1: 3D view

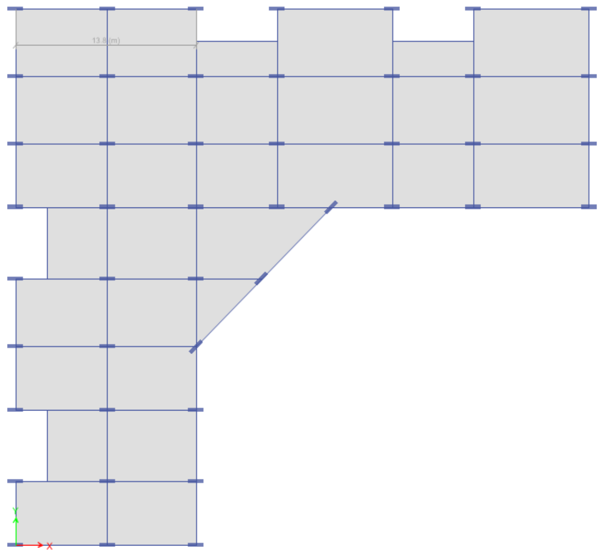

Fig 4.1.2: Plan view

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.

C) **Model 3**: Moment frames with Shear walls in Y-direction and a diagonal shear wall in the core is considered.

D) **Model 4**: Moment frames with Shear walls at the corners of the building and a diagonal shear wall in the core is considered.

E) **Model 5**: Moment frames with cross steel bracings in X-direction and at the diagonal part in the core of the building is considered.

F) **Model 6**: Moment frames with cross steel bracings in Y-direction and at the diagonal part in the core of the building is considered.

G) **Model 7**: Moment frames with cross steel bracings in X-direction and core wall at the centre of the building is considered.

H) **Model 8**: Moment frames with cross steel bracings in Y-direction and core wall at the centre of the building is considered.

I) **Model 9**: Moment frames with alternate cross steel bracings and shear walls in X-direction and core wall at the centre of the building is considered.

J) **Model 10**: Moment frames with alternate cross steel bracings and shear walls in Y-direction and core wall at the centre of the building is considered.

K) **Model 11**: Moment frames with only core wall at the centre of the building is considered.

IV. RESULTS AND DISCUSSIONS

4.1 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

Table 4.1 Base Shears of all models

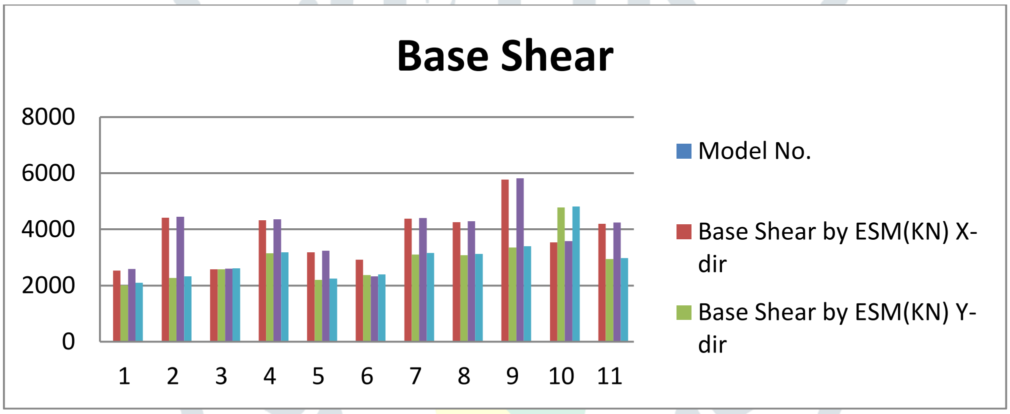

Chart 4.1 Base Shears of all models

4.2 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

Table 4.2 Time Period of all models

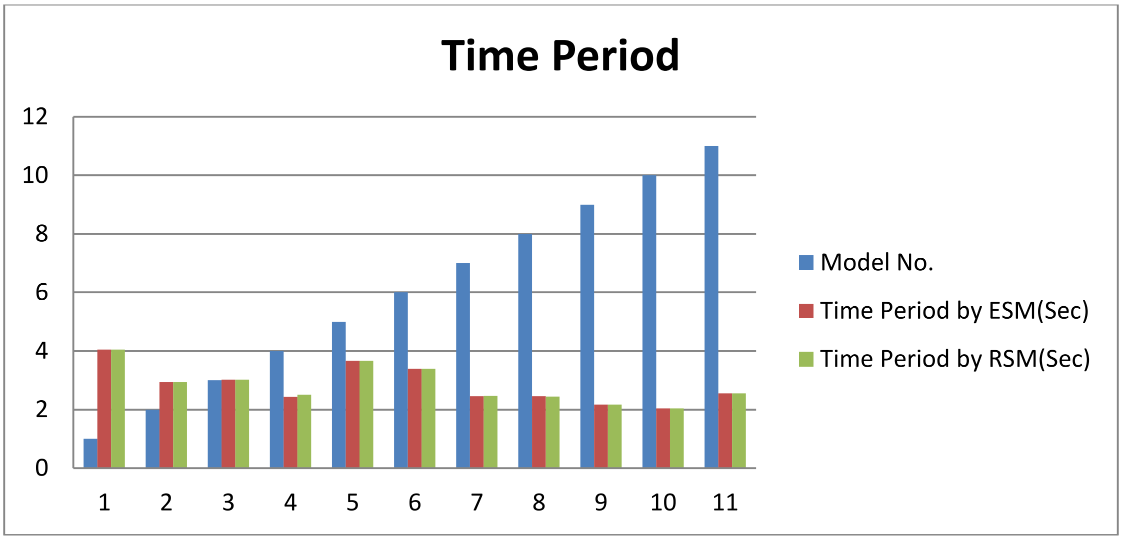

Chart 4.2 Time Period of all models

4.3 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.

Comparison of Maximum storey displacement at the top storey of all models

Model No.	Storey Disp@ top storey by ESM(mm)		Storey Disp@top storey by RSM(mm)	
	X-dir	Y-dir	X-dir	Y-dir
1	57.2	78.7	59.9	86.7
2	47.9	56.3	141	138.5
3	46.7	43.8	45.8	56.2
4	42.4	53.2	44.5	47.6
5	52.8	64.7	44.4	60.7
6	61.7	57.6	56.4	56.3
7	49.1	47.2	40.8	54.7
8	54.7	43.4	51.7	62.2
9	48.1	45.8	57.3	48
10	41.1	44.9	42.1	50
11	51.3	65.2	55	46.1

Table 4.3 : Comparison of Maximum storey displacement

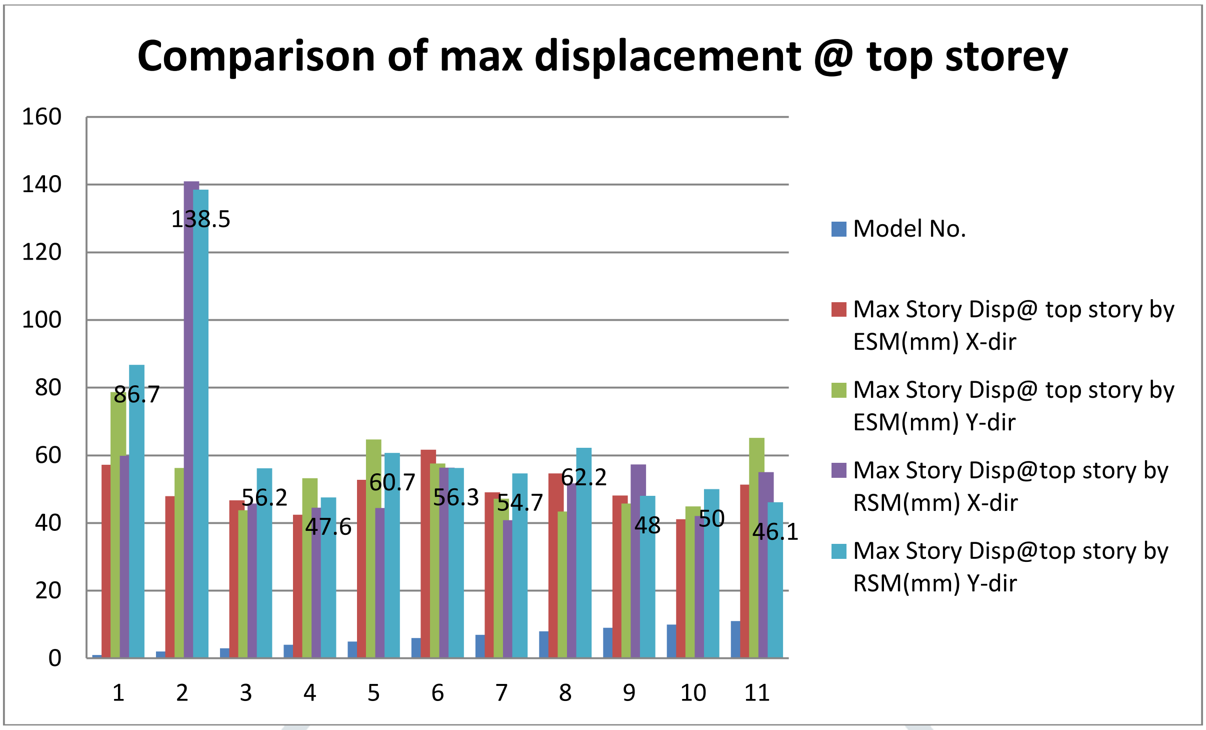

Chart 4.3 Comparison of Maximum storey displacement

V. CONCLUSIONS AND FUTURE SCOPE

5.1 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.

5.2 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.

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