A Dynamic Linear Response Spectra Analysis of Multi-Storied Structure Having Special Shapes of Columns With Shear Wall & Without Shear Wall

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Abstract- *Columns are important structural elements in a RC building which are primarily subjected to the moments, axial compressive stresses and to transmit the load to sub-structure. Various special shapes of the columns are considered in the study. The application of special shaped columns more indoor space as compared to normally used shapes of column and also evade barriers in a room which rises serviceable floor area. Walls are usually designed as plain concrete walls, when they are subjected to only compression in the section. Or Else, they have to be designed as reinforced concrete walls. Shear walls are particularly designed as structural walls merged in buildings to withstand the lateral forces which are generated in the wall plane.*

The purpose of this study is to evaluate the seismic performance of structures with Rectangular columns and structures with Specially shaped columns. 16 different building models are analyzed using Equivalent static analysis and Response spectrum analysis in zone IV with medium soil condition. The maximum story displacement story drift base shear and time period of all the models and are calculated. ETABS v2015 software is used for the analytical study. The study has concluded that the seismic performance of the structure having specially shaped columns is superior in comparison with the structure with rectangular columns and also they are economical.

Keywords- Response spectrum analysis, Equivalent static analysis, Special shape of column, Shear wall, ETABS.

I. INTRODUCTION

At present in RCC Construction the building is constructed by connecting various main structural components like footing, columns, beam, and slab. The various loads such as self load of elements, dead load, live load, floor load acts on the building. And load transfer mechanism takes place through slab to beam and from beam to column and finally through column to footing. Columns have a vibrant role in structures for transferring total load from super-structure to sub-structure. Various common shapes of columns are casted in the construction such as rectangular columns, Square columns and circular columns. So, Rectangular, Square and Circular columns are called as Regular columns and T-shape columns, L-shape columns, Cross (+) shape columns are called as specially shaped columns. Columns are structural elements which are mainly exposed to axial compressive stresses and moments. The IS code 456:2000 describes the column as Compression member if the effective height of member surpasses three times the minimum lateral dimension and unsupported length 'L' shall not exceed 60 times of 'b' (least lateral dimension). If it is fixed at both ends. Further, if one end of a column is free, its un-supported length shall not exceed 100b2/D, where D is the larger lateral dimension which is then limited up to 4 times of 'b'. It is called compression member due to compression forces and stresses govern their behavior. Concentrically loaded columns are subjected to pure axial load. Though, such columns hardly occur in practice.

Special shape columns

The RC Building columns are main structural components which are exposed to axial compressive stresses, moments and they carry out the total weight up to sub-structure from super structure. Some common figures of columns are square, rectangular, and circular. columns with certain shapes of L-shaped, Tee-shaped and (+) shape, as presented in Figure 1, which are generally not used. They Provides more indoor space as compare to above general shaped columns , behaves like walls as flexible members. They are generally available in long buildings and is highly used to avoid overall collapse of the construction of the earthquake forces. It is continually desirable to include buildings built in those areas that experience massive earthquakes and a large earthquake. The need for special forces to design these walls for seismic forces is because they should be protected under frequent loads. Generally concrete or masonry wall walls. Usually they are provided between columns, stairs, wells, towels, utility shaft etc.

After the earthquake, the survey of the buildings has shown that due to complete fall, loss of life is lower in some kind of reinforced concrete cabin walls. Although, the most important asset of shear walls for the seismic digestion is different from the design for the air, it should be good flexibility under the ultimate and it should be repeated overload. In planning canvas walls, we should try to reduce the tensile stress. it is likely to load with gravity forces as it can safely take. To avoid the stress of stress, it should be kept equally.

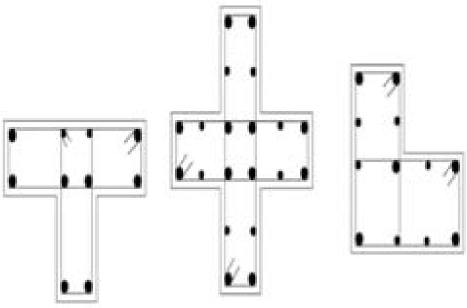

Fig 1. Special shape of column

Shear walls

Details of building:

There is a prominent and considerable growth in the erection of high-rise buildings in both residential and commercial and the current trend of construction is more towards tall and slender buildings. At present the shear wall construction is more generally used as a barrier for lateral loading in tall structures. Shear wall possess considerable in-plane toughness and resistance which in-turn used to consecutively resist heavy horizontal loads and support gravity loads, which considerably deficient lateral sway effect in the building and then reduces harm to structure and its elements. The shear wall location should be so decided that it diminishes the twist and other harmful effect to the building. If the shear walls are located in useful positions in the structure, they could efficiently resist the lateral forces by decreasing lateral deflection for earthquake loads. Hence it’s very crucial to determine proficient and supreme location of these walls.

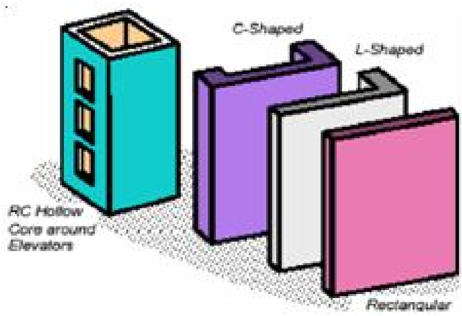

Fig 2. Different shapes of RC shear wall

Table 1- Structural parameters

Sl. no	LOADS	VALUES	UNITS
1	Floor finish	1.5	kN/m²
2	Live load	3	kN/m²
4	Wall load External wall load Partition wall load	13.8 9.0	kN/m kN/m
5	Parapet load	2	kN/m

Table 2 - Loads

Sl. no	P[ARAMETERS	VALUES	UNITS
1	Height of each storey	3.0	m
2	Height of bottom storey	2.0	m
3	Parapet height	1.0	m
4	Beam size	230x500	mm²
5	Thickness of wall External walls Internal walls	230 150	mm mm
6	Thickness of shear wall	230	mm
	Thickness of slab	150	mm
8	Density of concrete f_{ck}	25	kN/m³
9	Characteristic strength of concrete f_{ck}	40	N/mm²
10	Modulus of elasticity of concrete (5000√ f_{ck})	31622.77	N/mm²
11	Grade of steel	415	N/mm²
12	Seismic zone ‘Z’	IV	-
13	Importance factor ‘I’	1.0	-
14	Response reduction factor ‘R’	5.0	-
15	Damping ratio	5%	-

Table 3 - Size of columns

COLUMN NO	SIZES	
	RECTANGULAR COLUMNS in mm	SPECIALLY SHAPED COLUMNS in mm
		EXTERIOR
C1	230x600	Plus (+) shape b=d=400 ; t_w=t_f= 230
C2	300x700	Plus (+) shape b=d=575 ; t_w=t_f=230
C3	450x800	Plus (+) shape b=d=900 ; t_w=t_f=230
C4	230x600	L shape b=d=400 ; t_w=t_f= 230
C5	300x700	L shape b=d=575 ; t_w=t_f= 230
C6	450x800	L shape b=d=900 ; t_w=t_f= 230
C7	230x600	T shape b=d=425 ; t_w=t_f= 23
C8	300x700	T shape b=d=575 ; t_w=t_f= 230
C9	450x800	T shape b=d=900 ; t_w=t_f= 230

DESCRIPTION OF MODELS

Table 4 – Model description

MODEL NO	DESCRIPTION OF MODEL
1	RC bare frame building.
2a	RC frame building with 'plus' (+) shape columns in addition with rectangular column along the Periphery.
2b	RC frame building having only 'plus' (+) shape columns
3a	RC frame building with 'L' shape columns in addition with rectangular columns along the Periphery.
3b	RC frame building having only 'L' Shape columns.
4a	RC frame building with 'T' (Tee) shape columns in addition with rectangular columns along the Periphery.
4b	RC building having only 'T' Shape columns.
5	RC frame building with rectangular columns having 'L' type Shear wall at corners.
6a	RC frame building with 'plus' (+) shape columns in addition with rectangular Columns along the Periphery and also 'L' type shear wall at corners.
6b	RC frame building having only 'plus' (+) shape columns with 'L' type shear wall at corners.
7a	RC frame building with 'L' shape columns in addition with rectangular Columns along the Periphery and also 'L' type shear wall at corners.
7b	RC frame building having only 'L' shape columns with 'L' type shear wall at corners.
8a	RC frame building with 'T' Shape columns in addition with rectangular Columns along the Periphery and also 'L' type shear wall at corners.
8b	RC building having only 'T' shape columns with 'L' type shear wall at corners.
9	RC bare frame building with all special shapes of columns.
10	RC bare frame building with all special shapes of columns having 'L' type shear wall at corners.

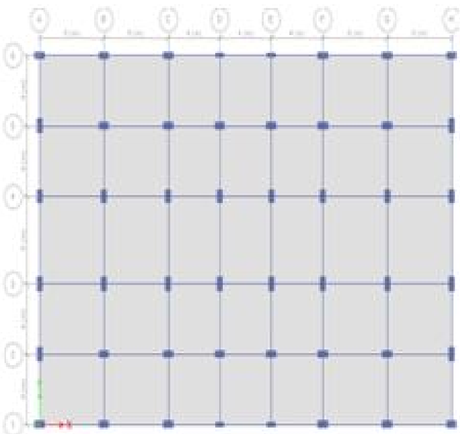

Figure 1. Model 1

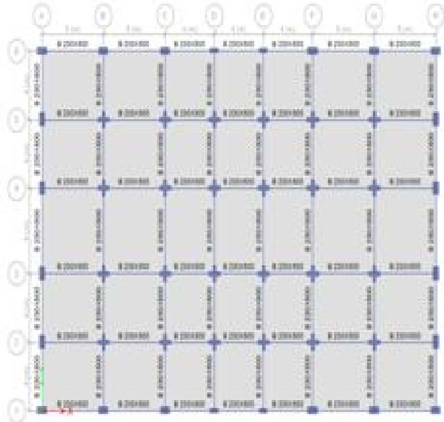

Figure 2. Model 2a

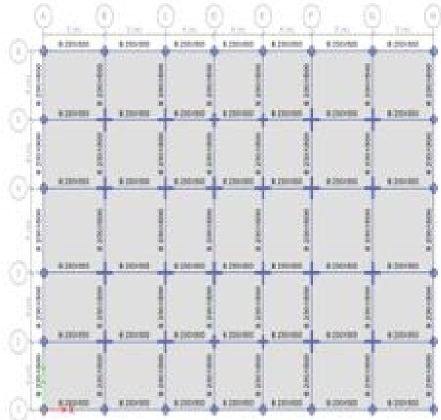

Figure 3. Model 2b

Figure 4. Model 3a

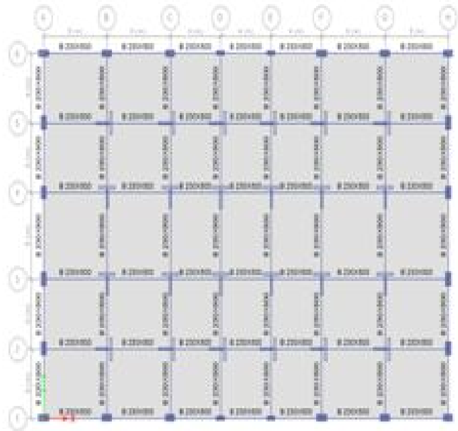

Figure 5. Model 3b

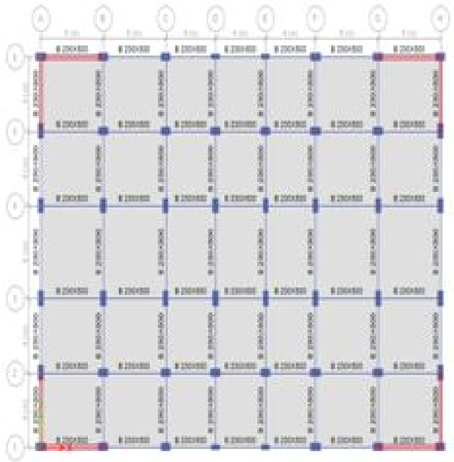

Figure 6. Model 4a

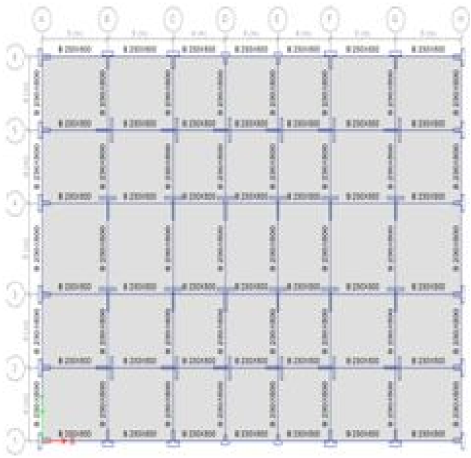

Figure 7. Model 4b

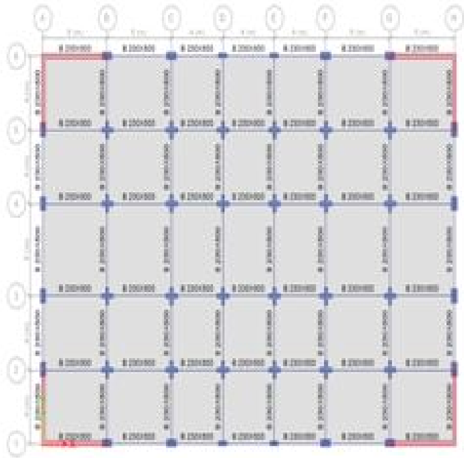

Figure 8. Model 5

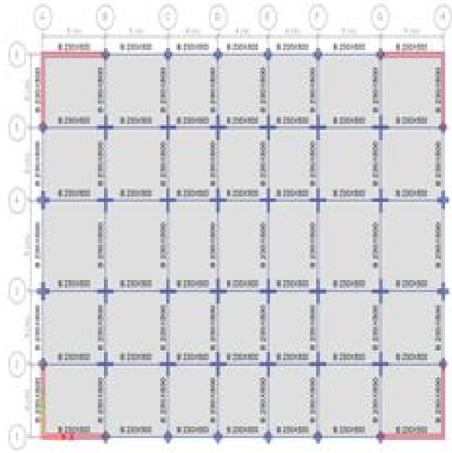

Figure 9. Model 6a

Figure 10. Model 6b

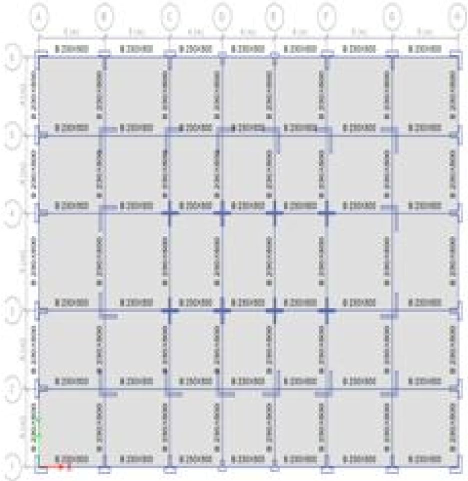

Figure 11. Model 7a

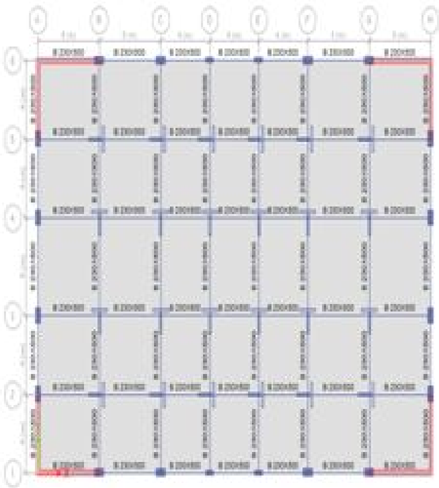

Figure 12. Model 7b

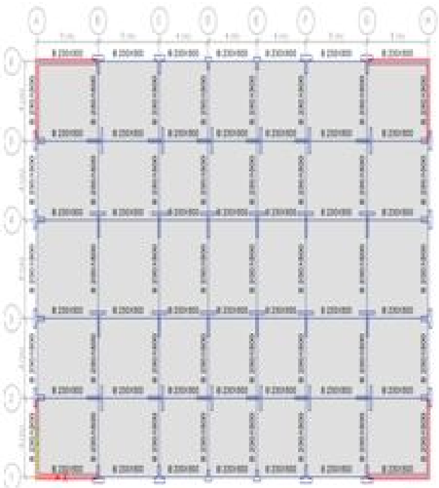

Figure 13. Model 8a

Figure 14. Model 8b

Figure 15. Model 9

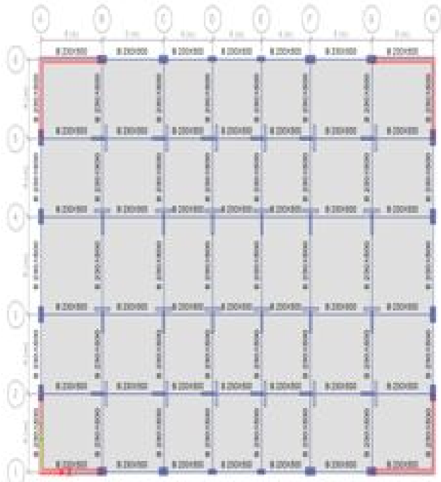

Figure 16. Model 10

II. RESULTS AND DISCUSSIONS

1 Base Shear
2 Time Period
3 Storey Displacement

4 Story Drift

Table 5- Base shear for ESA and RSA

MODEL NO	BASE SHEAR (kN)		
	EQX	EQY	RSX
1	6401.3622	5187.2611	6525.1519
2a	6524.1386	5409.1149	6652.0913
2b	6359.9971	5273.0264	6485.862
3a	6360.4299	5154.0922	6485.8627
3b	6342.4151	5139.4942	6467.2831
4a	6381.8237	5171.4284	6504.9396
4b	6361.3226	5154.8156	6484.5843
5	6819.6932	5526.2502	6953.5265
6a	6891.87	5714.00	7026.6556
6b	6745.0351	5592.2585	6877.3112
7a	6734.4175	5457.1482	6864.7814
7b	6716.5112	5442.6381	6848.0707
8a	6748.0325	5468.1809	6879.4944
8b	6735.0351	5457.6487	6867.3118
9	6359.4166	5153.271	6482.4931
10	6733.5106	5456.4133	6864.3094

Table 6 - Fundamental time period

Model No.	Time period in sec
1	3.391
2a	3.323
2b	3.515
3a	3.144
3b	3.059
4a	3.192
4b	3.171
5	2.526
6a	2.523
6b	2.707
7a	2.461
7b	2.437
8a	2.481
8b	2.486
9	3.159
10	2.487

Chart 1. Base shear of all models for EQX and RSX

Chart 2. Time period for all models

Table 7- Storey displacement

MODEL	DISPLACEMENT in mm
	EQX
1	161.01
2a	151.26
2b	181.56
3a	141.93
3b	138.13
4a	142.71
4b	149.4
5	91.91
6a	89.63
6b	108.6
7a	87.59
7b	87.34
8a	87.84
8b	91.88
9	149.16
10	91.91

Chart 3. Displacement of all models for EQX and RSX

Chart 4. Storey drift for all models

V. DISCUSSION OF RESULTS

1. **Base shear**

The following points are obtained from the result of base shear of the structure.

- The investigation has reviled that base shear is highest for structure which is configured with plus (+) shape of columns along with rectangular columns at periphery having ‘L’ type shear wall at corners i.e. Model 6a
- Whereas base shear is lowest value for Model 9 which has all types of special shapes of columns without shear walls. However it is least stiff among all the models.
- The highest value of base shear in model 6a indicates that this structure is most stiff structure among all the models that are configured in this study.
- Also, as the total seismic weight of the building increases the base shear also increases.

2. **Time period**

The following results are obtained in study of time period of the structure.

- The height of the structure and mass of the structure directly depends on the time period
- As the seismic weight of the structure increases the time period gets decreased.
- The time period is influenced by location of building i.e. zone of building and soil type.
- The implementation of shear wall in the structure has reduce the time period.
- The time period of model-2b is highest among all the values which shows that structure with only plus (+) columns only is most flexible

3. **Storey displacement**

The following observations are made in study of storey displacement and also these results are represented in the graphical form.

- The displacement value is highest for model 2b i,e. building with only plus (+) type of column in comparison with bare frame modeling.
- It is observed from the investigation that model 7b has least displacement and it is a considerable decrement as compared to the displacement of bare frame model.
- Also the displacement is higher at top storey and lesser at bottom storey.
- By introducing shear wall the displacement is reduced to a considerable **value.**

4. **Storey drift**

The following results are observed from the study.

- The storey drift value is inversely proportional to storey stiffness. As the drift increases the stiffness decreases.
- From the results it has been seen that the storey drift is least for model 8a which indirectly shows its stiffness.
- But the storey drift is highest for model 2a.
- The story drift for bare frame model is higher as compared to the structure having only shear walls.

VI. CONCLUSION

The study was ended up with the following conclusions.

1. Among all the models base shear is maximum for model 6a which is modeled with (+) shape of columns and shear walls, thus it concludes that structure configured with (+) column in addition with shear wall is most stiff as compared to other models.
2. Base shear is directly proportional to the stiffness of the structure lower the base shear less will be the structural stiffness.
3. Here base shear is least for model 9 which concludes that structure constructed with all types of special shape column is more economical than the structure constructed with regular shape of columns.
4. Flexibility is dependent on time period of the structure. From the analytical is study it is clear that bare frame model is most flexible.
5. The flexibility of the structure is considerably reduced by introduction of shear wall.
6. The maximum displacement was observed in model 2b in which the rectangular columns are replaced by (+) shape columns.
7. However structure modeled with only 'L' shape column along with shear 'L' type shear wall at corner has minimum deflection when compared with other models.
8. By the study of another seismic parameter it is shown that model 2a is also less stiff and economical
9. The analytical study reveals that the structure modeled with special shape columns are less stiff but they are economical with a considerable decrease in the storey displacement.
10. It is observed that rectangular column of similar equivalent is required upto 10th storey but where as special shape columns of similar equivalent as that of rectangular column are sufficient upto 5th storey only.
11. The study concludes that (+) shape columns are nearly 50% more effective than rectangular columns but with a 10% increase in displacement.
12. As per the study it can be concluded that model 8a is efficient because it has nearly 6% more base shear as compared to model 1 and about 53% less displacement than model 1.

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