Analysis and Design of Multi Storey Residential Building Using ETABS

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Abstract

Present study represents the analysis and design of ten storey residential building with basement. The building is considered in Ahmedabad (Gujarat) region. The sizes of various structural elements are decided after optimization. For analysis and design, building model is generated in ETABS 2013 software. The various parameters like centre of mass, centre of stiffness, displacement of building, storey drift and rotational displacement are considered for analysis purpose. It is observed that centre of mass and centre of stiffness are depending on the orientation of column. It is also observed that eccentricity in Y-direction is very high as compared to X-direction due to unequal mass distribution at top floor. According to design report provided by ETABS all the values of stresses and storey drift are under limit as mentioned in IS 456:2000 and IS 1893:2002.

Keywords: *Analysis, Design, Storey Drift, Storey Displacement*

INTRODUCTION

ETABS is engineering software which is used to analysis and design multi-storey building. ETABS stands for Extended Three-Dimensional (3D) Analysis of Building Systems. CAD drawings can be converted directly into ETABS models or used as templates in which ETABS objects may be overlaid. Report is generated directly in the software with complete reinforcement details. Many of the floor levels in buildings are similar which reduce modelling and design time. Fast model generation using the concept of similar stories. Different materials can be assigned to the structural elements within the same model such as steel, RCC, composite or any other user-defined material.

Shah H. J. and Jain S. K. have investigated the performance of building during earthquake using different load combination. They have also investigated the performance of building during high wind load. They have also explained the detailing of different structural component using Indian Standard Code. It was concluded that the restoring force is depend on the position of the shear wall [1]. Uma M and Nagarajan (2016) have investigated the optimum structural configuration of a multi storey building by changing the shear wall location. It was concluded that the shear wall placed at the corner of the building shows less displacement and drifts and thus considered as optimum location. It was also shown that the performance of the building is also depending on the material of the shear wall [2]. Lavanya C.V.S., Pailey Emily. P and Sabreen M (2017) have presented multi-storeyed Residential building analysed and designed with lateral loading effect of earthquake using ETABS. They have designed as per Indian Codes- IS 1893:2002 (Part-1) and IS 456:2000. It was concluded that there is a gradual increase in the value of lateral forces from bottom floor to top floor in software analysis [3]. Mallikarjun M. and Surya Prakash P. V. (2016) have studied the analysis and design of a multi storied residential building of (B-2+G+10) by using most economical column method in ETABS. It was concluded that the design of the structure in an economical way by reducing the sizes in the sections. It is also concluded that the height of the structure is increased; the stiffness phenomenon (slenderness effect) i.e. long column effect will come in to the picture. As a result the amounts of deflections are far greater than the codal provisions (IS – 456:2000) [4].

In these paper, analysis and design of (B+G+10) storey residential building is prepared in ETABS. Various parameters like displacement, acceleration, storey drift, etc. are checked according to Indian standard criteria.

MODELLING AND DESIGNING

Generated model is type of residential building. This model is consisting of basement, ground floor, ten storey and terrace with overhead water tank. The location of building is considered at science city road, Ahmedabad (Gujarat). According to IS 1893:2002, this area comes under zoning III. Figure-1 shows the 3D-view of the model in ETABS. Figure 2 shows the structural plan. In Figure 2 Black, yellow and blue line shows the main beam, secondary beam and beam under the landing of stairs respectively. Red line shows the RCC wall for lift section. Table 1 shows the various parameters considered in model. Loads and load combinations are considered according to IS 875:1987 (Part 1 to 5) and IS 1893:2002 (Part-1).

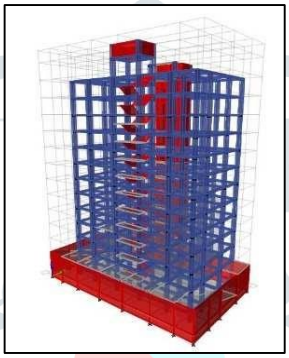

Fig. 1 3D Model

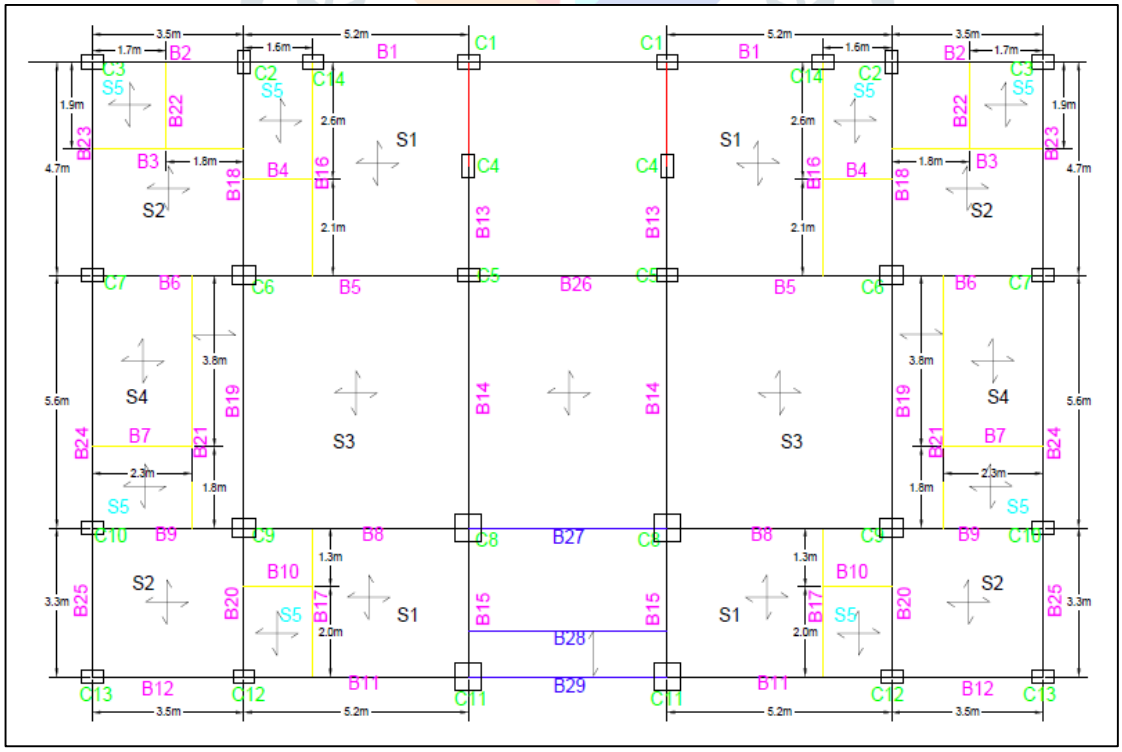

Fig. 2 Structural Plan

Table. 1. Modelling and Design Consideration

Considered Parameters	
Size of column = 500 mm × 300 mm	Thickness of shear wall = 150mm
Size of column = 600 mm × 600 mm	Earthquake Load in X and Y direction
Size of column = 550 mm × 400 mm	Grade of Steel = Fe415
Size of beam = 400 mm × 600 mm	Grade of concrete = M20 (beam) and M25 (column)
Thickness of slab = 150mm	

RESULT AND DISCUSSION

The point representing the mean position of the matter in a body or system is known as centre of mass. The point through which the resultant of the forces of a system acts is known as centre of stiffness [5]. The result of centre of mass and centre of stiffness in both X and Y directions of each floor are mentioned in Table 2. It is observed that eccentricity is maximum at overhead water tank level in Y-direction due to the heavy load and pressure of water at water tank level, eccentricity is 3.05 m which is maximum. In X-direction, the maximum eccentricity is on ground level i.e. 0.91 m due to the storey height i.e. 4m which consist of no wall as it is a parking area. In this direction, eccentricity at water tank level is less due to the orientation of the column. Storey drift is the lateral displacement of one level of a multi-storey building relative to the level below [5]. Table 3 shows the storey drift in X and Y direction. According to the IS 1893:2002 maximum allowable drift is 0.004 h, which is 16 mm for considered building. The results obtain for storey drift is very less as compared to maximum allowable drift. Figure 3 shows the graphical representation of storey drift of each floor in X and Y direction. The storey drift in X direction is more than Y direction. Storey Displacement is total lateral displacement of its storey with respect to ground or base [5]. The graphical representation of storey displacement in X and Y direction are shown in Figure-4.

Table. 2. Centre of Mass and Centre of Stiffness

`	Centre of Mass		Centre of Stiffness		Eccentricity	
Storey	**X**	**Y**	**X**	**Y**	**X**	**Y**
Water Tank	12.00	5.65	11.90	8.70	0.10	3.05
Terrace	12.00	9.18	11.88	8.92	0.12	0.26
Storey 10	12.01	10.63	11.76	8.25	0.24	2.39
Storey 9	12.00	10.72	11.73	8.48	0.27	2.24
Storey 8	12.00	10.72	11.69	8.73	0.31	2.00
Storey 7	12.00	10.72	11.65	8.97	0.35	1.75
Storey 6	12.00	10.72	11.60	9.22	0.40	1.50
Storey 5	12.00	10.72	11.55	9.50	0.45	1.22
Storey 4	12.00	10.72	11.49	9.81	0.51	0.91
Storey 3	12.00	10.72	11.42	10.17	0.58	0.56
Storey 2	12.00	10.72	11.33	10.59	0.67	0.13
Storey 1	12.00	10.72	11.22	11.13	0.78	0.40
Ground Level	12.00	10.74	11.09	11.85	0.91	1.11
Basement	12.00	9.65	11.98	8.47	0.02	1.18
Foundation Level	12.00	9.68	12.00	8.52	0.00	1.17

The result of storey displacement in X and Y direction of each floor for operated load combination i.e. 1.5DL + 1.5EQX in X-direction and 0.9DL − 1.5EQY in Y-direction are mentioned in Table 4.

Table. 3. Storey Drift

Operated load Combination	**0.9DL-1.5EQX**	**0.9DL-1.5EQY**
Storey	**Drift in X**	**Drift in Y**
Water Tank	0.272	0.095
Terrace	0.618	0.382
Storey 10	0.659	0.365
Storey 9	0.717	0.427
Storey 8	0.768	0.505
Storey 7	0.805	0.578
Storey 6	0.825	0.638
Storey 5	0.826	0.685
Storey 4	0.806	0.718
Storey 3	0.761	0.736
Storey 2	0.597	0.737
Storey 1	0.689	0.722
Ground Level	0.565	0.690
Basement	0.060	0.067
Foundation Level	0.049	0.036
Base	0.000	0.000
Maximum Allowable Drift	16 mm	According to IS 1893:2002 Cl. 7.11.1 Page 27

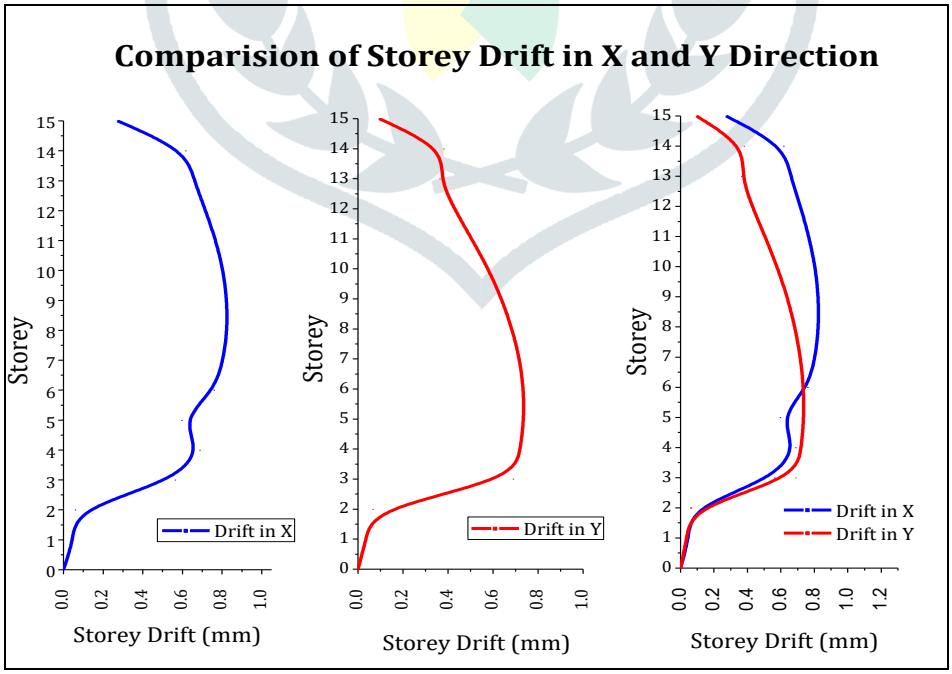

Fig. 3 Comparison of Storey Drift

From the result shown in Table 4, it is observed that maximum displacement is 26.70 mm and 21.80 mm in X-direction and Y-direction respectively at water tank level for observed load combination and minimum displacement at base i.e. 0.00 mm in both X and Y direction for observed load combination.

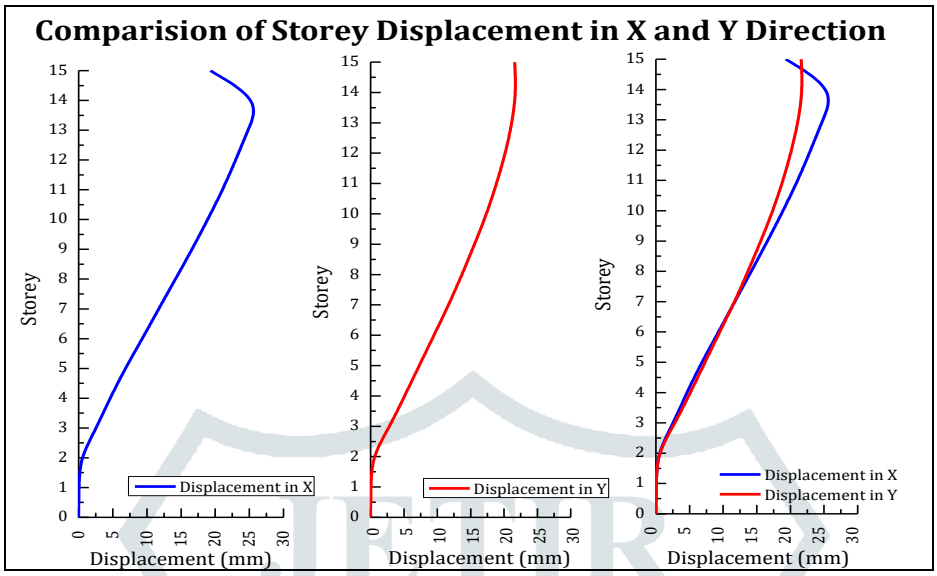

Fig. 4 Comparison of Storey Displacement

Table. 4. Storey Displacement

Operated load Combination	**1.5DL + 1.5EQX**	**0.9DL − 1.5EQY**
	Maximum Displacement in X	**Maximum Displacement in Y**
Storey	**Displacement in X**	**Displacement in Y**
Water Tank	19.30	21.60
Terrace	26.70	21.80
Storey 10	24.80	21.20
Storey 9	23.00	20.20
Storey 8	21.10	18.90
Storey 7	18.90	17.40
Storey 6	16.60	15.60
Storey 5	14.20	13.70
Storey 4	11.70	11.70
Storey 3	9.30	9.50
Storey 2	6.80	7.30
Storey 1	4.60	5.10
Ground Level	2.60	2.90
Basement	0.20	0.20
Foundation Level	0.03	0.03

Rotational displacement of a body is the angle in radians (degrees, revolutions) through which a point revolves around a centre or line has been rotated in a specified sense about a specified axis. The deform shape of building due to rotational displacement in X and Y direction are shown in Figure-5.

The building is asymmetric about both X and Y axis, building is rotated about Z axis. The building is asymmetric about X any Y axis, displacement of the building at one corner is different than other corner of the building. Design of building is performed according to the IS 456:2000. The beams are selected according to the primary and secondary beams and also the location of the beams. Selected beams are B1, B6, B14 and B21.

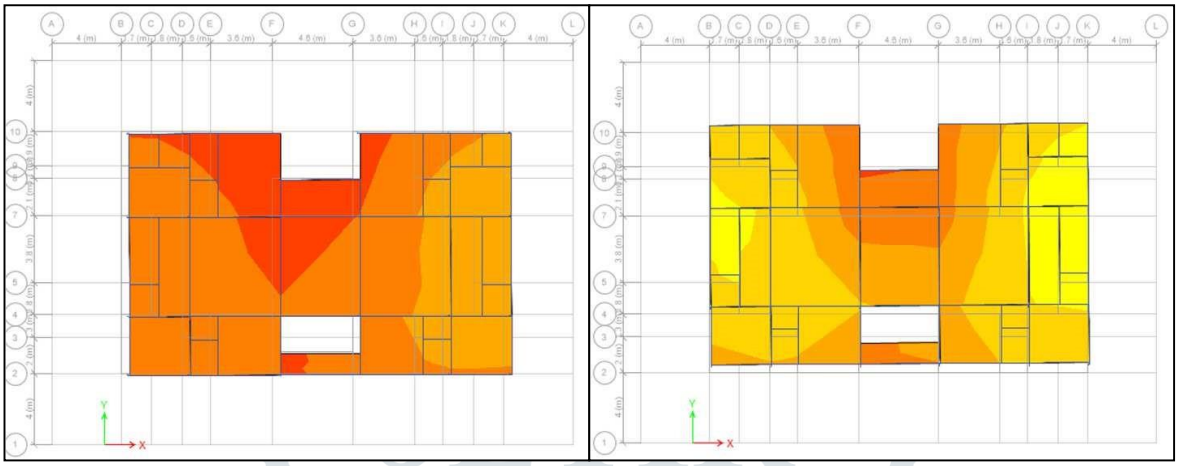

Fig. 5 Rotational Displacement in X and Y direction

CONCLUSION

1. Centre of mass and centre of stiffness of floor are depending on the size and orientation of column as well as shear wall.
2. Eccentricity in Y direction is very high as compared to X direction due to unequal mass distribution at top floor.
3. Maximum storey drift in Y direction is 0.095 mm.
4. Maximum inter storey drift is under limit prescribed by IS 1893:2002.
5. Maximum storey displacement in X-direction is 10.1 percentage higher than Y-direction.

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