"EFFECTS OF STAIRCASE ON SEISMIC PERFORMANCE OF RC MULTI-STORIED FRAME BUILDINGS FOR ZONE III & ZONE IV"

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ABSTRACT ***:*** This paper deals with the effects of staircase during the seismic performance of Multistoried RC Frame Building in zone III & zone IV at various location with or without staircase in plans have been studied. During earthquake as we construct the structure with staircase monolithically, staircase also contributes its performance of the building, due to this structural discontinuity, performance of buildings may result in non-linear behavior. Because of this non-linear behavior, modification in various seismic parameters such as a reduction in the time period, displacement, time period and story drift of the building is essential. Due to the rigidity of inclined slab and of short columns around staircase, beams and columns are often characterized by a high seismic demand. It can be concluded that the effect of a staircase in the analysis and design of RC frame buildings cannot be ignored. In the present study, the effect of staircase position on RC frame structures has been carried out by adopting various location of building models with and without staircase along with or without shear wall in longitudinal and transverse direction. Shear wall is used for lift duct in RC multistoried model. The Linear Response Spectrum analysis of the models has been carried out as per IS: 1893 (Part 1) - 2002 and IS: 456 – 2000 with the help of Etab 15.1 software. The Seismic characteristics in terms of Story Drift, Story Displacement and Time period, have been compared with the seismic characteristics of models with and without a staircase along with or without shear wall. Further, the effect of change in location of the staircase on the behavior of the building has also been observed. The identification of the weakest elements of the structure, the failure type considering the presence of the stairs, and their contribution in the nonlinear performance of RC frame buildings are some of the areas on which the present paper has presented. In addition to these, short column effect, variation in moments of beams and columns that are attached to staircase slab, failure and deformation in staircase models have also been studied.

Keywords: Doglegged Staircase, Response spectrum analysis, Shear wall Effect, Short column effect, long column effect. .

1. INTRODUCTION

An earthquake is a spontaneous event and behaves quite differently. The force generated by the seismic action of an earthquake is different than other types of loads, such as gravity and wind loads. It strikes the weakest spot in the whole three dimensional building. Ignorance in design and poor quality of construction result, many weaknesses in the structure, thus cause serious damage to life and property. The staircase is the part of secondary system of the structures and it is one of the essential parts of a building because of its functional importance. Due to the complex modeling of the staircase, it is designed separately for non-seismic and seismic forces. From a geometrical point of view, a stair is composed of inclined element (beam and slabs) and by short column. These elements contribute to increase stiffness of the building. The effect of the staircase on the RC frame structure found in literature may be summarized as imparting discontinuity in the modeling, variation in failure of allied structural elements, contributing in non-linear performance of buildings, modification of various seismic parameters such as reduction in the time period, story drift, and story displacement of the building have been considered in this study. Hence it can be suggested that the effect of a staircase in the analysis and design of RC frame buildings cannot be ignored.

2. BUILDING MODELING & ANALYSIS

The structural system of the Residential building consists of RC beams, columns and slabs, stair etc. Length and thickness of the walls are adjusted in such a way that equal wall area is provided along both directions. The buildings located in Zone III & IV with dog-legged stair of G+7 Storey are referred with stair model as AX1,AX2,AX3,AX4 and the building without stair model as BX1,BX2,BX3,BX4 in longitudinal direction (X-Dirt.) and with stair model as AY1,AY2,AY3,AY4 and the building without stair model as BY1,BY2,BY3,BY4 in the transverse direction (Y-Dirt.). The lift ducts are not considered in models AX1, BX1, AY1 and model BY1. In this paper two case studies are considered for analysis, case -1 with stair model AX1, AX2 are compared with, without stair model BX1, BX2 considering parameters such as drift, displacement, time period. Shear wall is used for lift duct in model AX2 and BX2 . Similarly, in case 2 with stair model AX1, AX2, AX3, AX4, AY1, AY2, AY3, AY4 are compared with, without stair model BX1, BX2, BX3, BX4, BY1, BY2, BY3, BY4 considering parameters such as drift, displacement and time period.

3. THE DETAILS OF THE MODELED BUILDING ARE LISTED BELOW

Plan dimensions	25 X 21.8 m(X*Y)	Grade of concrete & Steel	M30&Fe 415
Length in X- direction	25 m	Seismic zone	III & IV
Length in Y- direction	21.8 m	Soil Type	II
Floor to floor height	3.2 m	Importance factor	1
No. of Stories	8	Building frame type	SMRF
Edge Beam	0.3 X 0.45 m	Density of concrete	25 KN/m³
Total height of Building	25.6 m	Density of masonry wall	20 KN/m³
Slab thickness (S1)	0.155 m	**Loading considered**	
Inclined slab thickness (S2)	0.130 m	Live load on floor	5 KN/m²
Edge Beam	0.3 X 0.45 m	Live load on roof	4 KN/m²
Column size	0.45 X 0.45 m	Floor Finish	2 KN/m²
External and internal wall thickness	0.30 m	Floor finish on roof	4 KN/m²
		Wall Load	16.5 KN/m²
		Parapet Wall Load	6 KN/m²

The structural plans of ground storey in zone III & zone IV for different locations of stair case with or without shear wall are as follows.

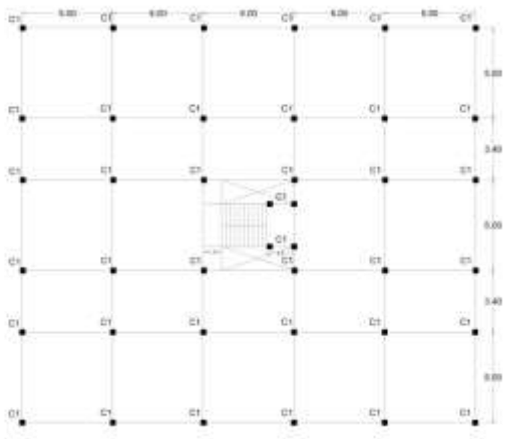

Figure 1: Structural plan for model AX1

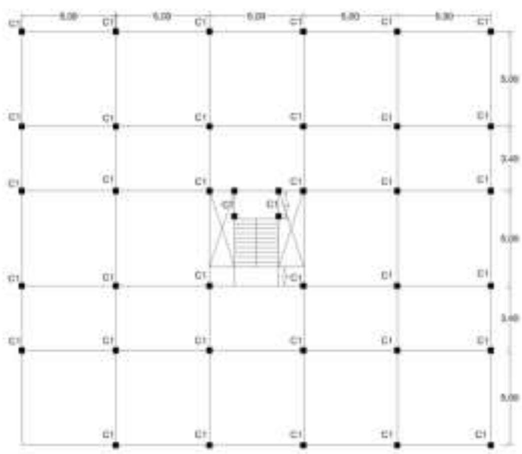

Figure 3: Structural plan for model AY1

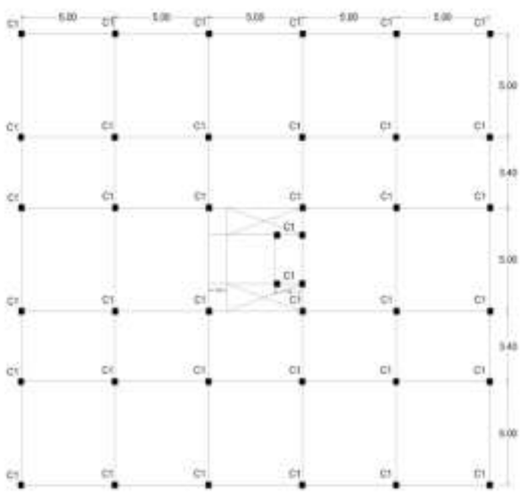

Figure 2: Structural plan for model BX1

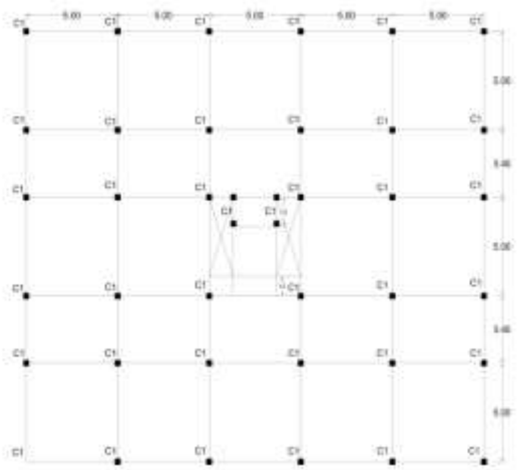

Figure 4: Structural plan for model BY1

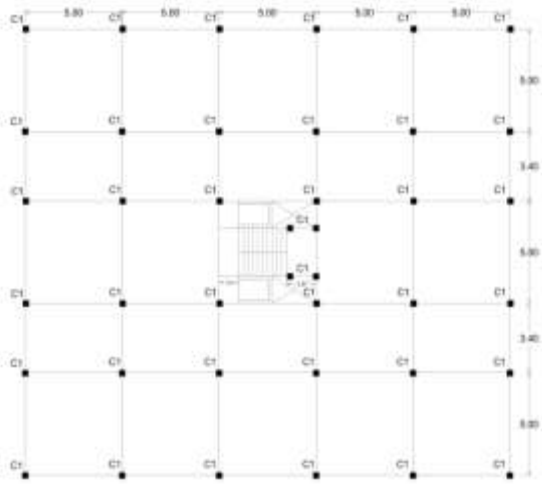

Figure 5: Structural plan for model AX2

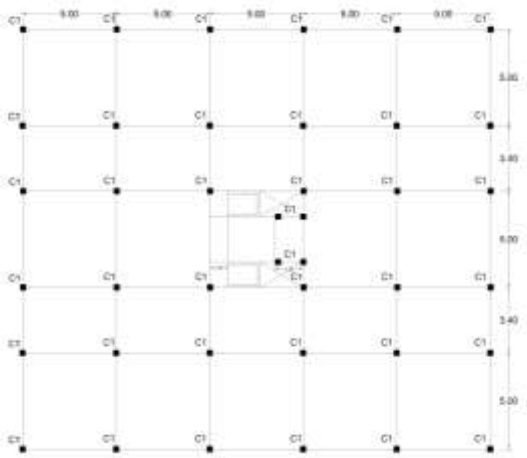

Figure 6: Structural plan for model BX2

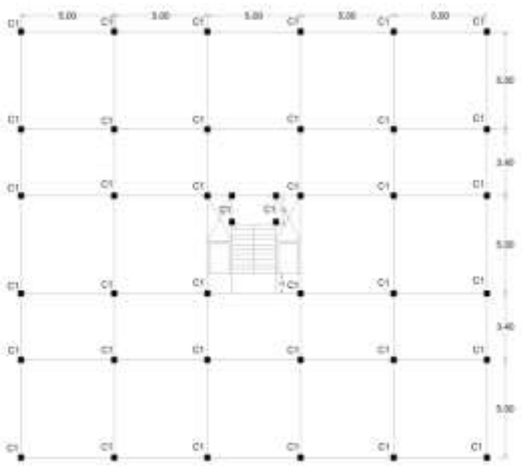

Figure 7: Structural plan for model AY2

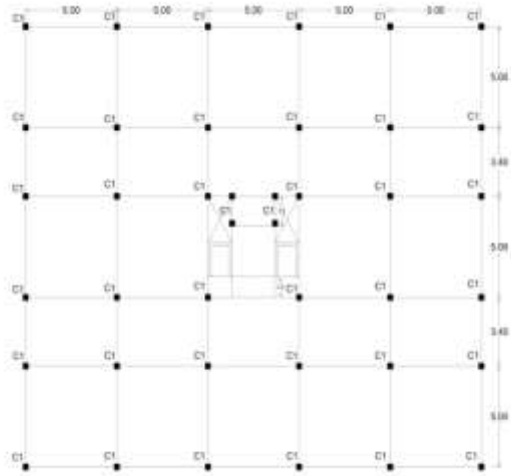

Figure 8: Structural plan for model BY2

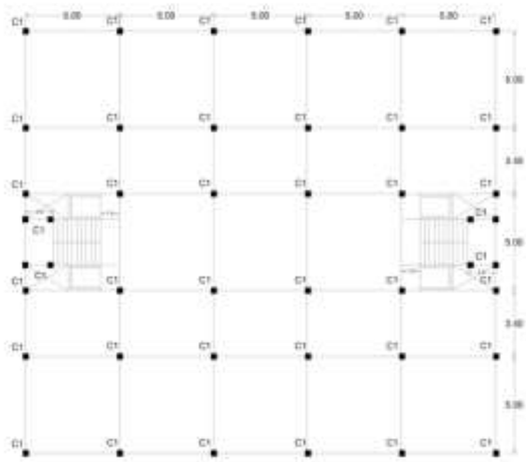

Figure 9: Structural plan for model AX3

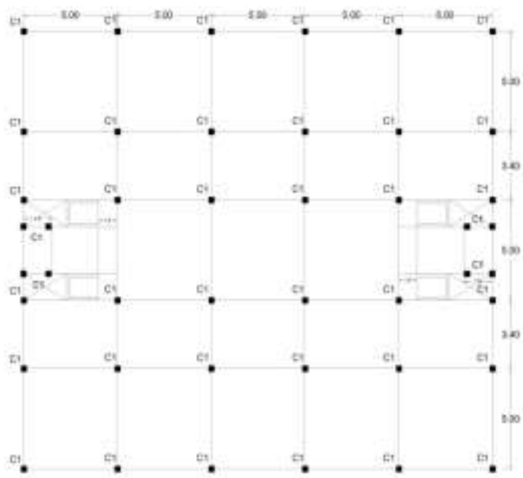

Figure 10: Structural plan for model BX3

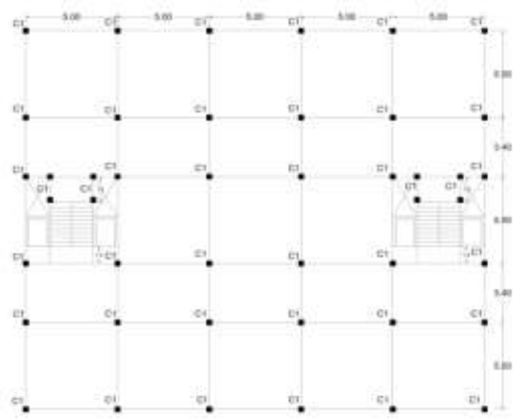

Figure 11: Structural plan for model AY3

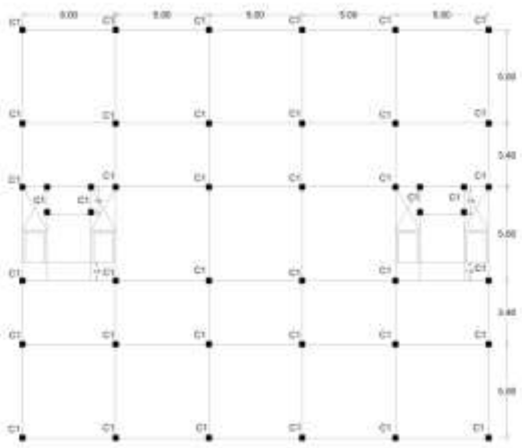

Figure 12: Structural plan for model BY3

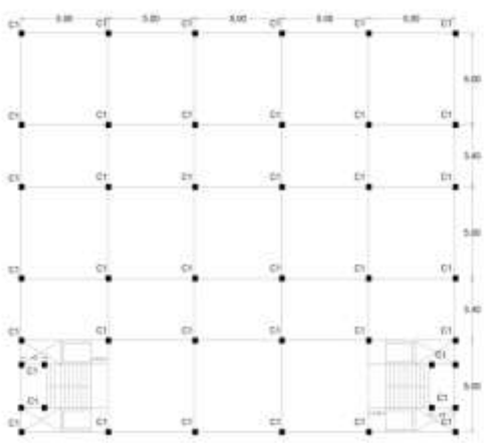

Figure 13: Structural plan for model AX4

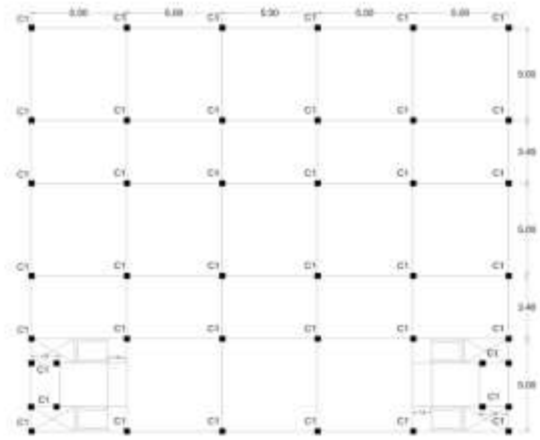

Figure 14: Structural plan for model BX4

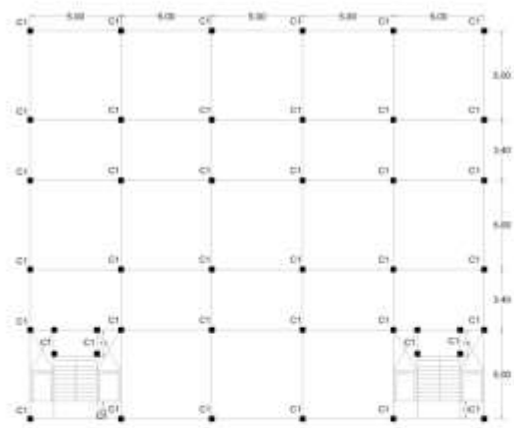

Figure 15: Structural plan for model AY4

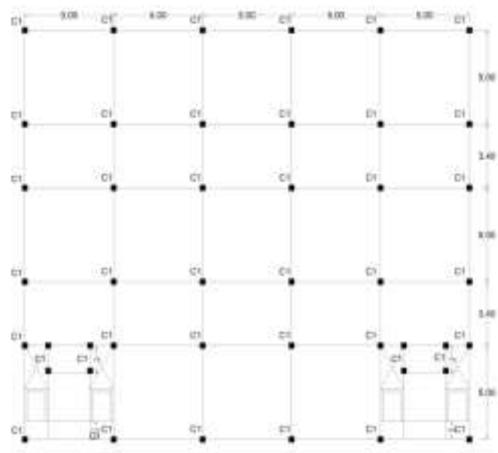

Figure 16: Structural plan for model BY4

4. RESULTS & DISCUSSION

This paper deals with the multistoried building case 1 and case 2. In Case Study 1, with stair model AX1, AX2 are compared with, without stair model BX1, BX2 considering parameters such as drift, displacement, time period. Shear wall is used for lift duct in model AX2 and BX2. Similarly, in Case Study 2S, with stair model AX1, AX2, AX3, AX4, AY1, AY2, AY3, AY4 are compared with, without stair model BX1, BX2, BX3, BX4, BY1, BY2, BY3, BY4 considering parameters such as drift, displacement, time period Comparison of all models prepared in Etab 15.1 carried out with the help of following graphs.

5. RESULTS FOR MODELS AX1, BX1, AY1, BY1, AX2, BX2, AY2, BY2 TYPE OF BUILDING IN ZONE III & ZONE IV (CASE -1):

- Comparison of Storey Drift (X & Y Direction)

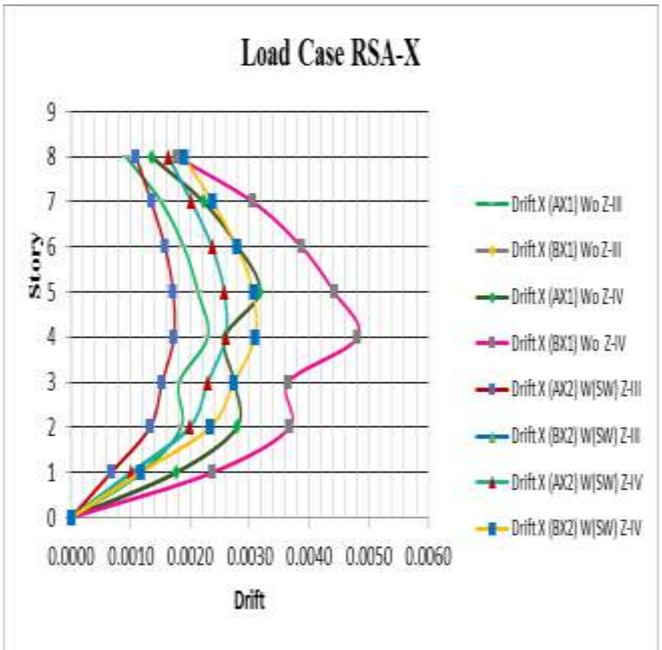

Figure 17: Comparison of Storey Drift. (X-Direction)

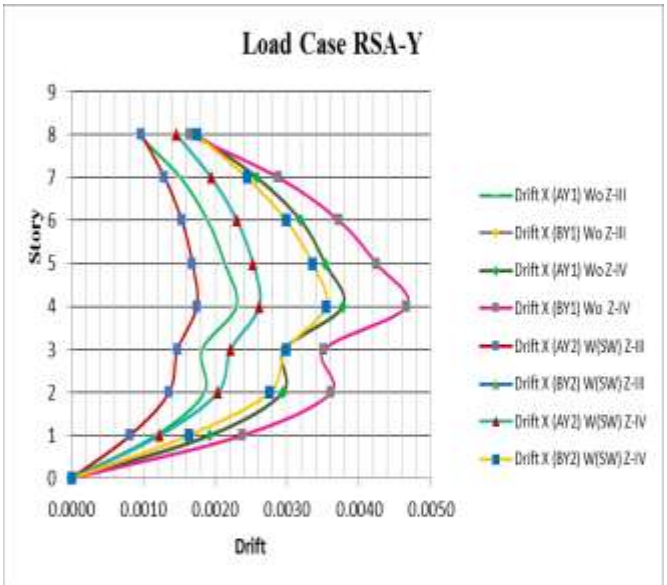

Figure 18: Comparison of Storey Drift. (Y-Direction)

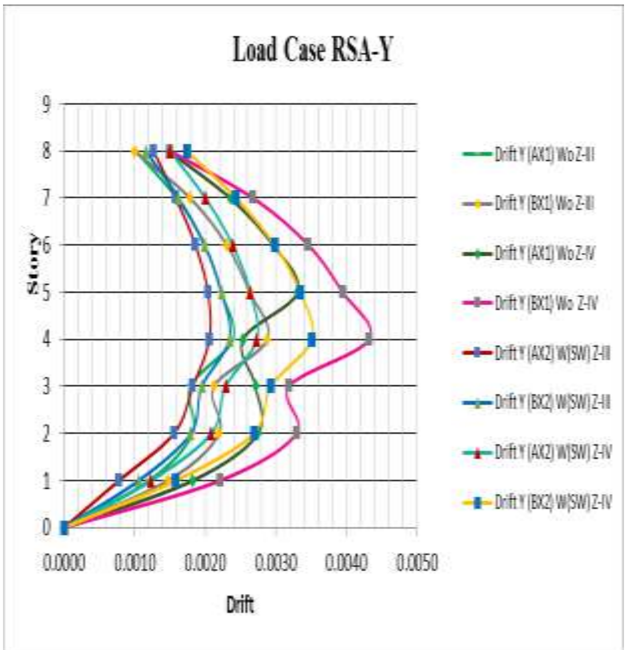

Figure.19: Comparison of Storey Drift. (X-Direction)

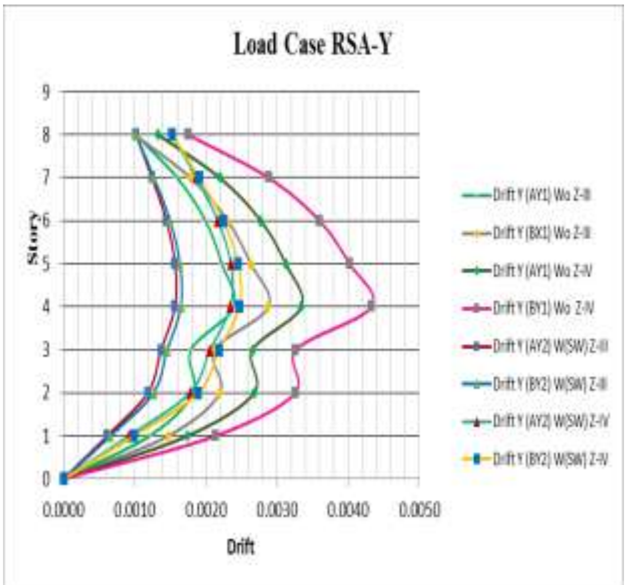

Figure 20: Comparison of Storey Drift. (Y-Direction)

- Comparison of Storey Displacement (X & Y direction):

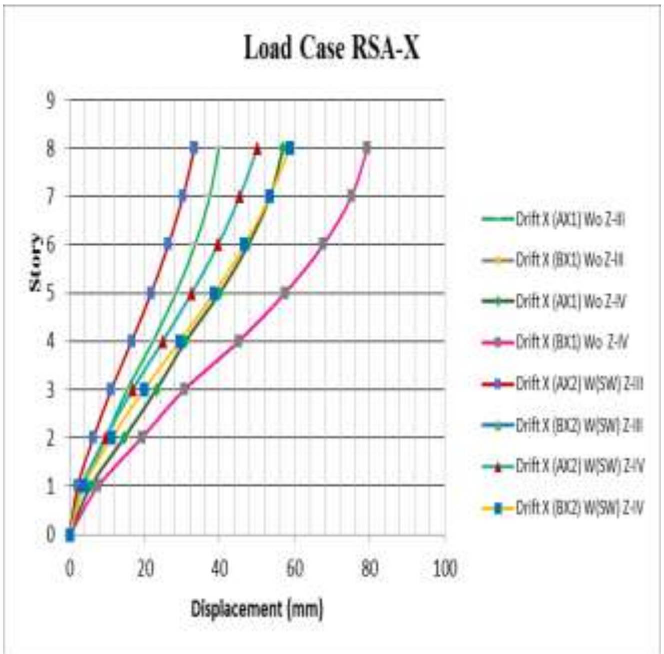

Figure 21: Comparison of Storey Displacement. (X-Direction)

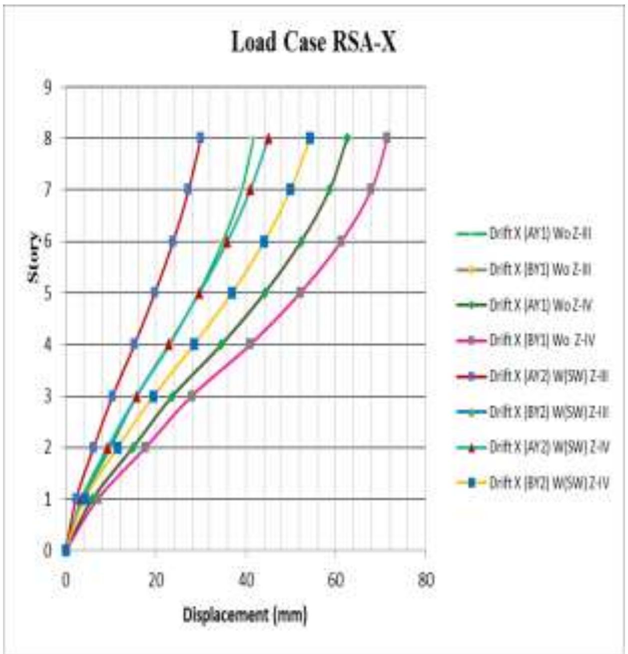

Figure.23: Comparison of Storey Displacement. (X-Direction)

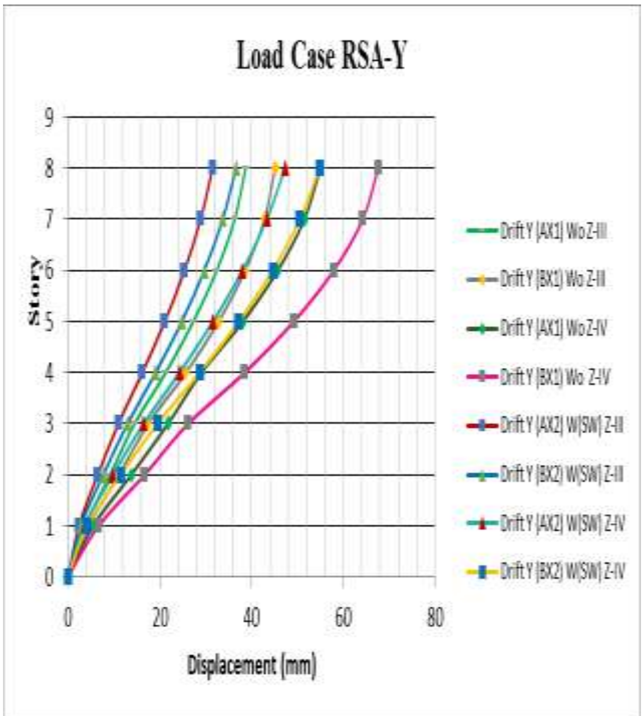

Figure 22: Comparison of Storey Displacement. (Y-Direction)

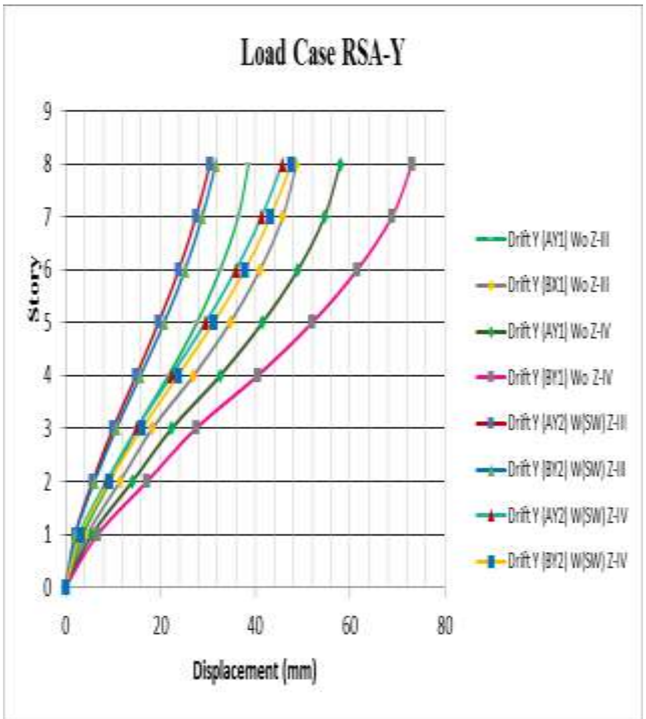

Figure 24: Comparison of Storey Displacement. (Y-Direction)

- Comparison of Time Period (X & Y direction):

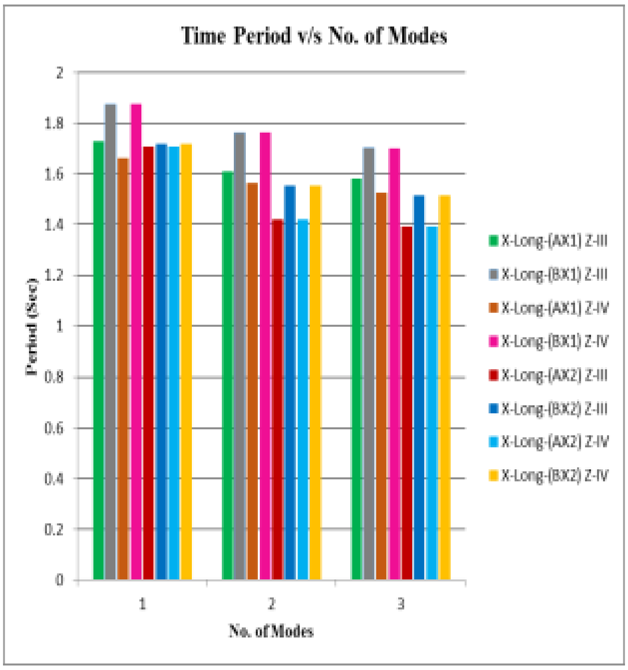

Figure 49: Comparison of Time Period. (X-Direction)

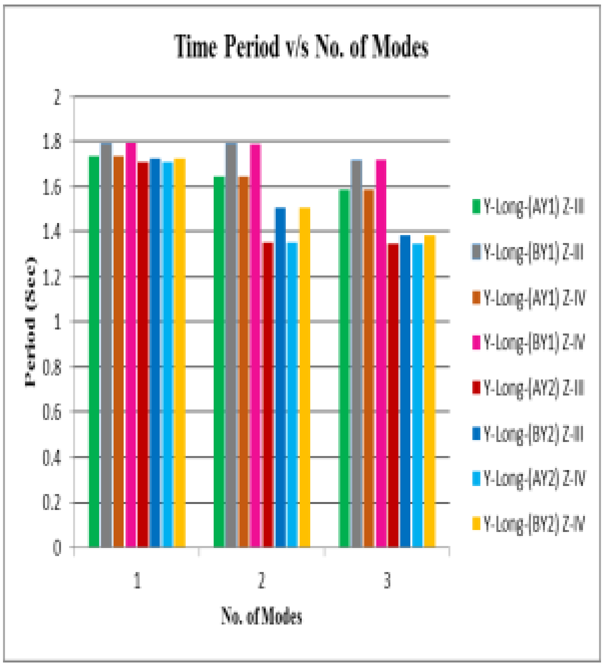

Figure 50: Comparison of Time Period. (Y-Direction)

6. RESULTS FOR MODELS AX1, BX1, AY1, BY1, AX2, BX2, AY2, BY2, AX3, BX3, AY3, BY3, AX4, BX4, AY4, BY4 TYPE OF BUILDING FOR ZONE III & IV (CASE-2):

- *Comparison of Storey Drift (X & Y Direction)*

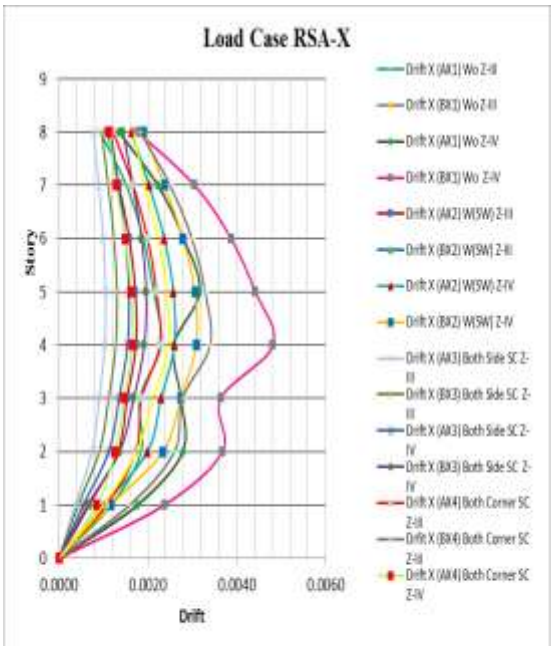

Figure 17: Comparison of Storey Drift. (X-Direction)

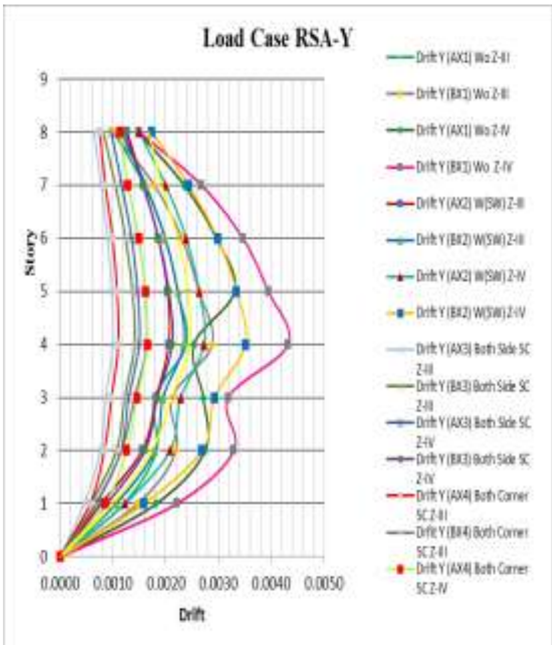

Figure 18: Comparison of Storey Drift. (Y-Direction)

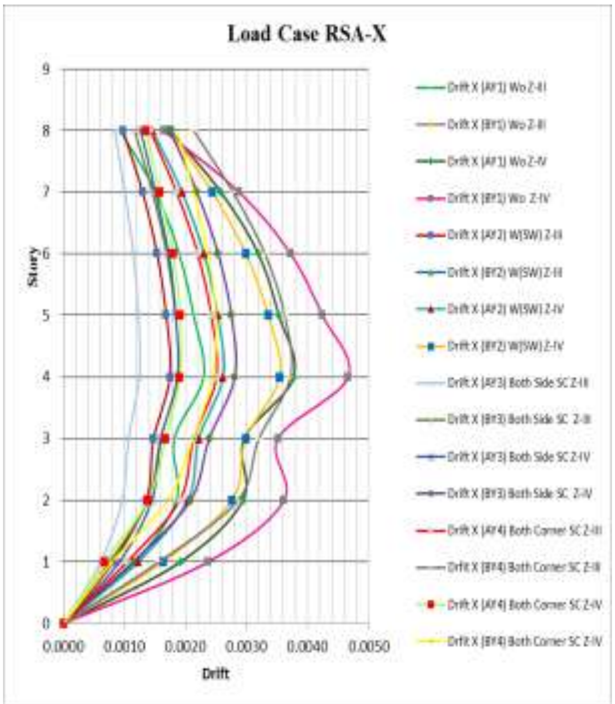

Figure.19: Comparison of Storey Drift. (X-Direction)

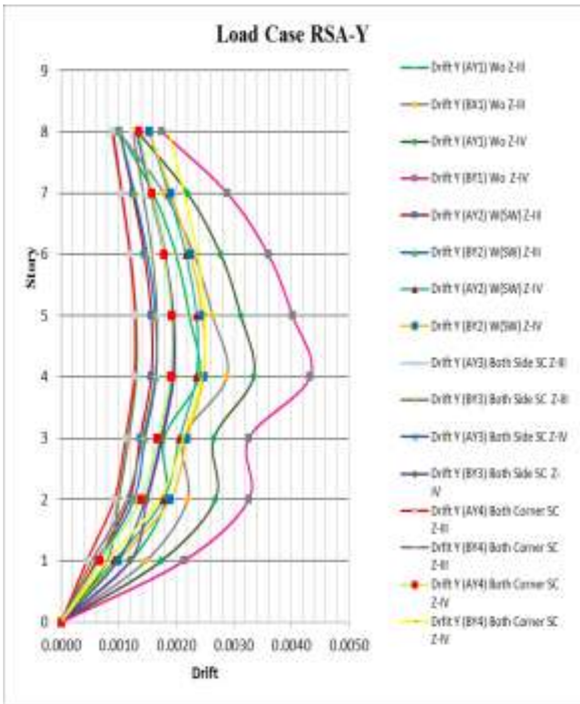

Figure 20: Comparison of Storey Drift. (Y-Direction)

- Comparison of Storey Displacement (X & Y direction):

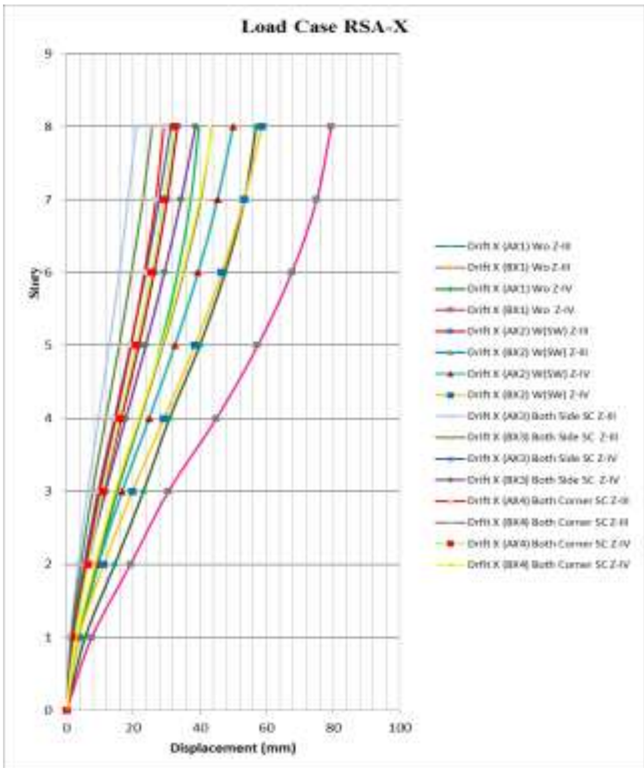

Figure 21: Comparison of Storey Displacement. (X-Direction)

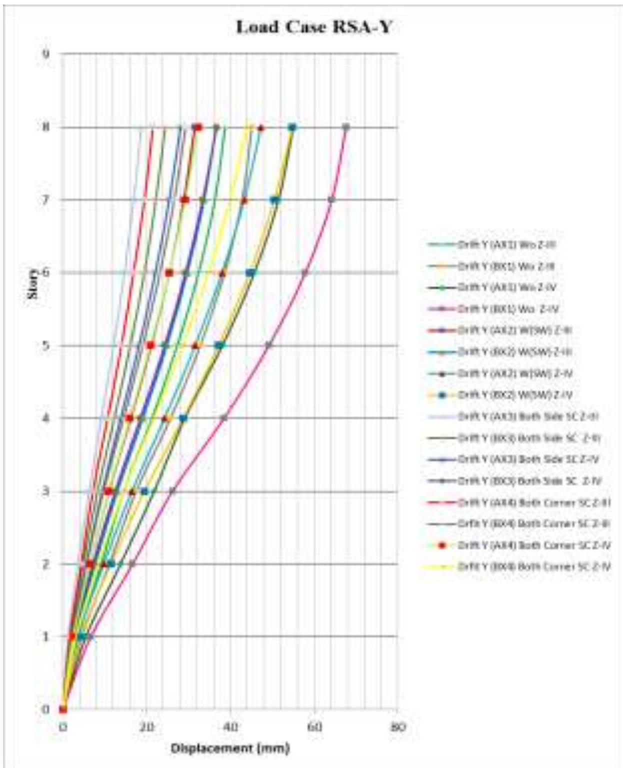

Figure 22: Comparison of Storey Displacement. (Y-Direction)

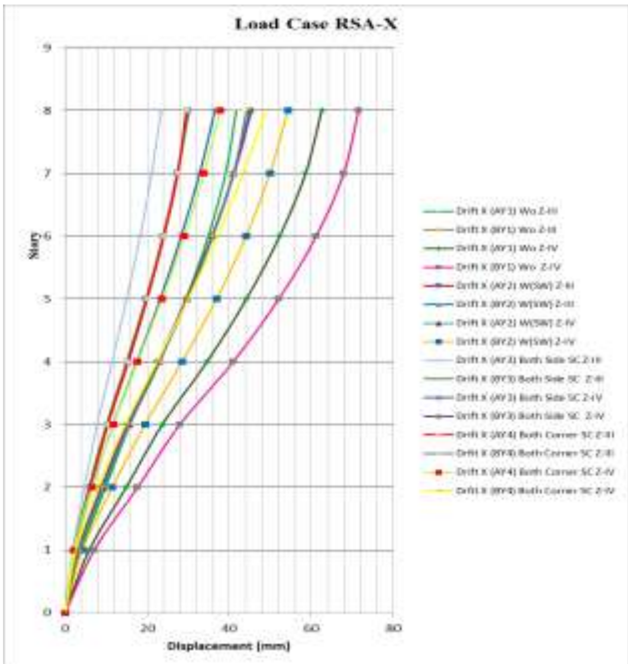

Figure.23: Comparison of Storey Displacement. (X-Direction)

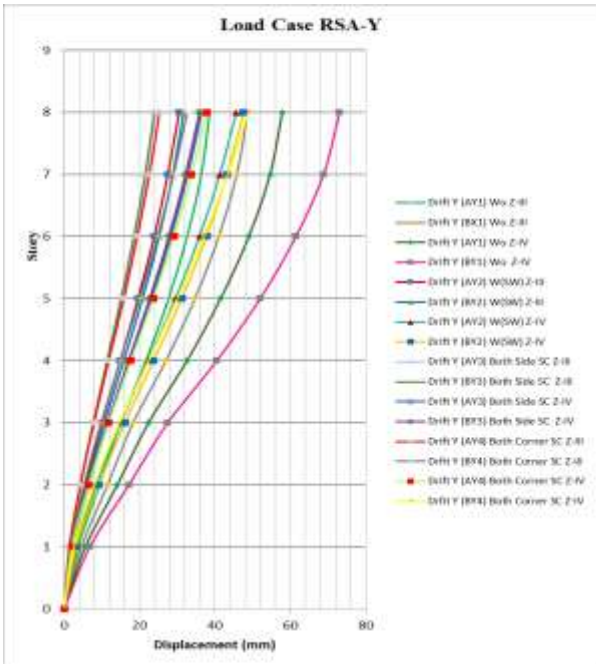

Figure 24: Comparison of Storey Displacement. (Y-Direction)

- Comparison of Time Period (X & Y direction):

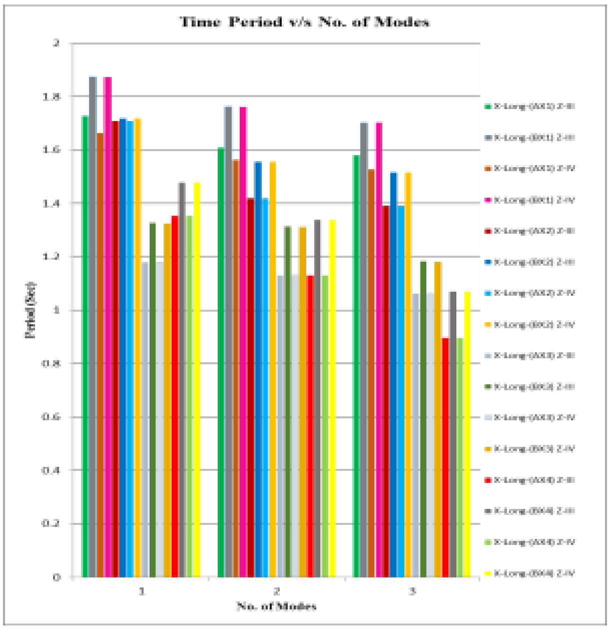

Figure 49: Comparison of Time Period. (X-Direction)

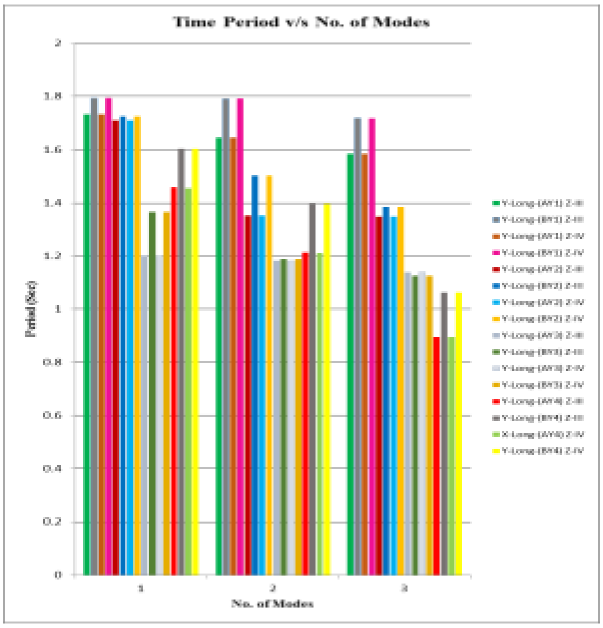

Figure 50: Comparison of Time Period. (Y-Direction)

7. CONCLUSION

- The presences of staircase tremendously influence the peak value of result obtained by response spectrum method for columns around staircase.
- In comparison of all frames for zone III & zone IV without lift duct models i.e (AX1,BX1,AY1,BY1) and all frames with lift

duct models i.e (AX2,BX2,AY2,BY2), the value of drift, displacement and time period is found to be less for model AY2 & AX2. Hence, we can say that it is better to provide stair case in shorter direction (Y-dirt.) & longer direction (X-dirt) for the building plan under consideration.

- It has been observed that when we compared all structural model under consideration, in case of model AX3, as staircase is along longer direction the longer span will divide in two parts. Hence the values for drift, displacement, and time period is observed to be lesser as compared to other models .Hence it is better to provide stair case in longer direction for the model in Zone III & IV.
- In Without stair model it is observed that, columns supporting landing beam have been found to be equal axial force. The lateral moment in such columns get increased due to absence of inclined slab and hence short column and torsional moment in landing beam increases enormously, due to this observation of the failure of member will redesign for better results and stiffness.
- The staircase should not be provided at the corners as well as at the center location in plan for any type of building under consideration as it affects the stability of the building.
- Because of the mid landing the column under the staircase will be act like a short column, as the short column gone through tremendous stresses and forces the beam connecting the short column is failed in the results obtained from ETAB 15. Hence the redesigning of the section is required.
- If building and there components are not design properly by considering diagonal effect of staircases, it may get fail under major earthquakes.

8. FUTURE SCOPE

- The various building models which are analysed in the dissertation work can be further studied by introducing various types of staircase by changing plan and height of the building.
- Stair case +Lift+ Maven technology construction should be studied.
- Use the different software like SAP, STAAD, and EVACENET 50.
- When floors of building are more than 10 than one should use software to analysed the location of stair case or lift.
- Traffic on each floor should be calculated and accordingly the location of staircase or lift should be studied

9. REFERENCES

[1] Edoardo Cosenza1, Gerardo Mario Verderame2, Alessandra Zambrano (2008), “Seismic Performance of Stairs in the Existing Reinforced Concrete Building”, The 14th World Conference on Earthquake Engineering October 12-17, 2008, Beijing, China.

[2] Franz S, “Free Standing Stairs”, ACI Journals, vol.4, 1961, pp 847-870.

[3] Frederick S.M, &Jonathan T. Rictetts, “Building Design and Construction Handbook”, McGraw Hill, New Delhi, sixth edition (2000).

[4] Huanjun Jiang, Haiyan Gao and Bin Wang (2012), “Seismic damage analyses of staircases in RC frame structures”, Advanced Materials Research Vols. 446-449 (2012), pp 2326-2330, Switzerland.

[5] “Indian standard Code of practice for plain and reinforced concrete”, IS 456:2000, (reaffirmed 2005), Bureau of Indian Standards, New Delhi.

[6] “Criteria for earthquake resistance design of structure”, IS 1893:2002, ,(reaffirmed 2005),Bureau of Indian Standards, New Delhi

[7]Kumar S (2009), “Treasure of R.C.C Design”, Standard Book House, Naisarak Delhi, seventeen editions,(2009)

[8] Khose V. N. (2008), “Analysis and Design of Four Storied RC Buildings Using SAP 2000v14”, IIT Roorkee, March 2008, India.

[9]Luis P. S, and Ignacio Martin, “Slab less Tread-Riser Stair”, ACI Journals, vol.10, 1961, pp 353-366.

[10] M. Danish, Zaid M., M. Shariq, A. Masood4and A. Baqi (2013), “Effect of Staircase on RC Frame Structures under Seismic Load”, International Conference on Trends and Challenges in Concrete Structures, Ghaziabad, UP, India, December 19-21, 2013.

[11] Michael J. F, P.E. and John Cutonilli (2008), “Protecting the Stair Enclosure in Tall Buildings Impacted by Stack Effect”, CTBUH 8th World Conference, 2008, pp 1-7.

[12]Phillip L.G, “Analysis and Design of a Cantilever Staircase”, ACI Journals, vol.4, 1963, pp 881-898.

[13]Putul Haldar and Yogendra Singh (2009) ,” Seismic Performance and Vulnerability of Indian Coded Desiged RC Frame Building”, ISET Journal of Earthquake Technology, Roorkee ,Paper No. 502, Vol. 46, No. 1, March 2009, pp. 29–45,India.

[14]Pratik Deshmukh, M.A. Banarase (2015) , "Effects Of Staircase On Seismic Performance Of RC Frame Buildings", International Journal of Current Engineering and Technology, Vol.5, No.3 (June 2015), India.

[15]Prakash Siyani, Saumil Tank, Paresh V. Patel (2009), "Learning of ETAB Software", ETERDCS-Nirma Uni. 25-29 May 2009, India.

[16]Rangwala S.C. (2010), "Building Construction", Charotar Publication Pvt. Ltd., Anand twenty-eight, 2010, India.

[17] Silvia F, Rita Stagni, Angelo Cappello, Alberto Leardini (2005), "Effect Of Different Inertial Parameter Sets On Joint Moment Calculation During Stair Ascending And Descending", Medical Engineering & Physics ,vol.27 2005,pp 537–541, Bologna, Italy.

[18] Xuan Xu and Weiguo Song (1999), "Staircase Evacuation Modeling and Its Comparison with an Egress Drill", ACI Journals, vol.6, 1999, pp 266-278, Washington D.C.

[19]Yahya M Y (2006), "An Analysis of the Effect of Staircase Intermediate Landing Floor on the Evacuation Time", ACI Journals, vol.6, 2006, pp 269-281, Malaysia.