Parametric Study of Seismic Effect on R.C.C. Structure Considering with And Without Staircase Model at Multiple Location

Chandrashekhar B. Gawalkar[1], Sanjay Bhadke[2]

[1]M-Tech Research Scholar (Structural Engineering), Department of Civil Engineering, Tulsiramji Gaikwad-Patil College of Engineering and Technology, Mohgaon, Nagpur, MH.
[2]Asst. Professor, HOD, Department of Civil Engineering, Tulsiramji Gaikwad-Patil College of Engineering and Technology, Mohgaon, Nagpur, MH.

Abstract:

The importance of earthquake engineering is an emerging field in India ever since high rise structures have become popular. Owing to the ever increasing population & limited space, horizontal expansion is no more a feasible solution especially in big cities & the consultants & civic authorities are compelled to option for vertical development. Thus the effect of lateral loads like winds loads & earthquake forces is acquiring increasing importance and almost every structural designer is faced with the problem of providing adequate strength and stability against lateral loads. High rise reinforced concrete buildings need more attention and more concern while designing so that in case of high winds or any earthquake event they can stand with a lesser amount of damage. For this reason, in recent years, wind and earthquake loadings have become determining factors in high-rise building design. While designing the model of building we can calculate the analytical result and from that result we accordingly design different component of building. These are foundation, column, slab, RCC wall, water tank, staircase etc. Out of this staircase generally not modeled Stair use is essential component of any building the purpose of which is to allow the flow of traffic to be accommodated between floor levels within the building. Staircase is the part of secondary system of the structure and it is one of the essential parts of a building because of its functional importance. Staircase when compared to the modern escalators serves not only better in emergency conditions (such as fire escapes, natural disaster etc.) but also provides considerable stiffness to the building. Due to complex modeling of staircase, it is designed separately for non-seismic and seismic forces. But during earthquake as we construct the structure with staircase monolithically, staircase also contribute its performance to 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 time period and story drift of the building is essential. It can be concluded that the effect of staircase in analysis and design of RC frame buildings cannot be ignored.

Keywords: Staircase, RC frame, Model, earthquake.

I. INTRODUTION

The importance of earthquake engineering is an emerging field in India ever since high rise structures have become popular. Owing to the ever increasing population & limited space, horizontal expansion is no more a feasible solution especially in big cities & the consultants & civic authorities are compelled to option for vertical development. Thus the effect of lateral loads like winds loads & earthquake forces is acquiring increasing importance and almost every structural designer is faced with the problem of providing adequate strength and stability against lateral loads. High rise reinforced concrete buildings need more attention and more concern while designing so that in case of high winds or any earthquake event they can stand with a lesser amount of damage. For this reason, in recent years, wind and earthquake loadings have become determining factors in high-rise building design. While designing the model of building we can calculate the analytical result and from that result we accordingly design different component of building. These are foundation, column, slab, RCC wall, water tank, staircase etc. Out of this staircase generally not modeled Stair use is essential component of any building the purpose of which is to allow the flow of traffic to be accommodated between floor levels within the building. Staircase is the part of secondary system of the structure and it is one of the essential parts of a building because of its functional importance. Staircase when compared to

the modern escalators serves not only better in emergency conditions (such as fire escapes, natural disaster etc.) but also provides considerable stiffness to the building. Due to complex modeling of staircase, it is designed separately for non-seismic and seismic forces. But during earthquake as we construct the structure with staircase monolithically, staircase also contribute its performance to 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 time period and story drift of the building is essential. It can be concluded that the effect of staircase in analysis and design of RC frame buildings cannot be ignored.

1.2. Objectives:

In this work the effects of staircase during the seismic performance R.C frame structure for zone III at different location in plans is considered.

The primary objectives of this project can be summarized as follows:

i. To perform Equivalent Static analysis of RC structure for different stair case location having the same structural height.
ii. To compare the behavior of RC structure with modeled staircase and without modeled staircase.
iii. To analysis the different location of staircase using parameters such as storey drift, storey displacement, column axial load, column bending moment, column shear force, and column area of steel on the building.
iv. To optimized location of stair case is effectively in resisting seismic performance.
v. Comparing the design results for different models on the basis ETABS results.

II. LITERATURE REVIEW

1) Edoardo Cosenza , Gerardo Mario Verderame , Alessandra Zambrano **(2008)**

This paper deals with the seismic performance of existing buildings and in particular on the moment resisting frame structures that could have their critical and weak points in the stair members: columns and beams or slabs. The structural solutions and design practice of stairs in gravity load designed structures are investigated to define their real geometric definition and to understand their performance. Some numerical modal linear and nonlinear push-over analyses are adopted. The author concluded that,

- The presence of stair yields in the transversal direction to an increase of strength and to a reduction in deformation capacity respect to the building without stair. In results need to utilize biaxial bending modeling and for the interaction of the different internal forces that governs the behavior of short columns.
- Shear failure becomes predominant in the short columns and in the reinforced concrete slabs and precedes the conventional ductile failure due to pure flexure.

2) Sang Bum Kim, Young Hack Lee, Andrew Scanlon, Heecheul Kim, and Kappyo Hong, **(2008)**

In this paper author worked on experimental assessment of vibration serviceability of stair systems In this paper they investigate the serviceability performance of the steel and RC stairs. The results of pedestrian induced loading test for the evaluation of vibration are compared. He has done the experimental test in that he done laminated tread board type steel stairs and SFRC tread board type steel stairs are representative of steel stair system. The laminated tread board type steel stair have two laminated 1.6mm thick steel plates for a tread board, supported on 9 mm thick lateral steel plates and tread board is filled with mortar of 40mm thickness. One unit of a stair system connects a floor to a landing at mid-storey height. The setup consists of a RC shear wall and stairs. For steel stair, the system units were connected to the situ cast RC stair landing with M16 Studs Embedded in the stair landing.

3) C. Bellidoa, A. Quiroza, A. Panizoa and J.L. Torerob **(2009)**

In this paper author worked on Performance Assessment of Pressurized Stairs in High Rise Building on this paper they said that Pressurized stair cases are an important part of the Fire Safety Strategy of high rise buildings. Long egress times are compensated by creating safe environments within egress staircases allowing considering the displacement time within those stairs as time where occupants can be considered safe. The main mechanisms by which stairs are "made safe" are by guaranteeing structural protection of the enclosure and by elevating the pressure within the stair to ensure that smoke cannot enter. Despite the critical importance of this element of the Fire Safety Strategy, the analysis and implementation of these systems remain simplified. Simple models have been developed using Bernoulli type formulations that account for static pressure and empirical constants to calculate flows through doors and other leakage areas. Implementation of these systems is even more simplified, consisting mainly of a direct feedback loop that controls a fan output on the basis of a pressure measurement inside the stair. The flow induced by the fan guarantees a minimum pressure. The pressure inside the stair needs to be limited to enable doors to be open, thus pressure dampers are introduced to release airflow in the event the pressure exceeds a specified maximum. Validation of these methodologies was done in the 70's and 80's with very limited field validation in real systems. This study presents an assessment of the performance of pressurized staircases in six high rise buildings. All systems have been designed using a similar methodology but implemented in different ways. In all cases the control mechanism for the fan is a direct feedback loop from a single pressure sensor. The results have been evaluated showing the limitations of the control system in the event of multiple doors being opened and the limitations of the pressure release dampers (as a response mechanism) if the pressure becomes unstable.

4) N Shyamananda Singh and S Choudhury **(2012)**

In this paper author worked on 'effects of staircase on the seismic performance of RCC frame building' on this paper they said that the effects of staircase on the seismic performance of the RCC frame buildings of different heights and different plans have been studied. He said that due to the rigidity of inclined slab and of short columns around staircase, beams and columns are often characterized by a high seismic demand. 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 they presented his paper. For analysis and design, SAP 2000 version 14.0.0 has been used. Performances of both categories of the buildings have been evaluated through push over analyses and nonlinear time historey analysis. Parameter such as time period of the Buildings, Effects on the landing beams and columns, Effect on inter storey drift ratio. The author concluded that,

- In the stair model, columns touching landing beam have been found to be subjected to an increase in axial force by an average of 19% and lateral moment in such columns increased on average by 32%. Shear force in landing beam increased by 36% on average. The inter storey drift ratio has been found to reduce by 33% in short direction and 23% in long direction on average and Dynamically analyzed time period got reduced by about 22.31%

5) Pratik Deshmukh, M.A. Banarase **(2015)**

In the present paper, the effects of staircase on the seismic performance of the RC frame buildings of different heights and different plans have been studied. For analysis and design, Etab v.9 has been used. Performances of both categories of the buildings have been evaluated through Response Spectrum Method. Parameter such as Storey Drift, Storey Displacement .The author concluded that,

- It has been observed that the presence of staircase tremendously influence the peak value of result of beams and columns around staircase obtained after analysis.
- In case of building modeled with staircase, the inter storey drift ratio has been found to reduce approximately by 20% in X and Y-direction, the storey displacement has been found to reduce by 30% in X and Y-direction.

- Columns supporting landing beam have been found to be subjected to an increase in axial force 19%. The lateral moment in such columns increased on average by 32%. The torsional moment in landing beam increased enormously.
- Area of steel decrease in beam supporting staircase flight at top by an average of 80% and at bottom of 13%.
- If building and there components are not design properly by considering diagonal effect of staircases, it may get fail under major earthquakes.

6) Ankit R. Shelotkar, Mayur A. Banarase **(2015)**

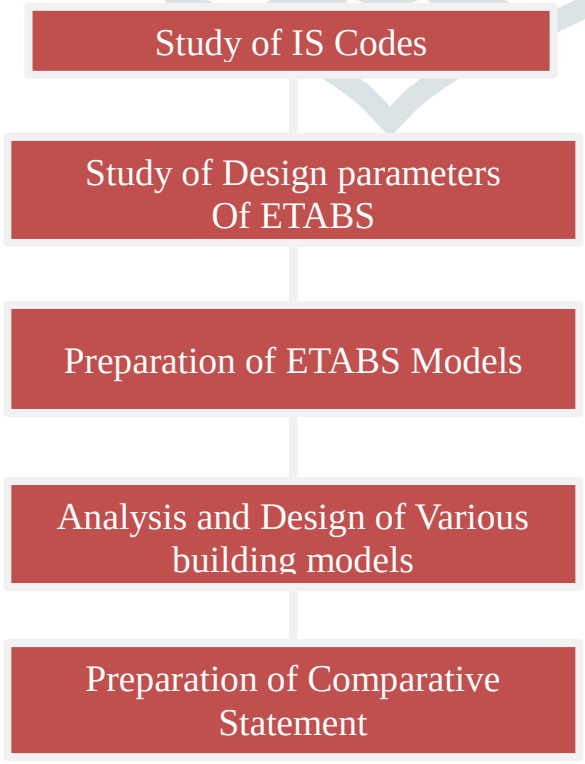
In this paper, the effects of staircase on the seismic performance of the RC frame buildings of different heights and plans have been studied. For analysis and design, Etab v.9 has been used. Performances of all categories of the buildings have been evaluated through Response Spectrum Method. Parameter such as Storey Drift, Storey Displacement .The author concluded that,

- It is observed that the Columns supporting landing beam have been found to be subjected to an increase in moment & beam supporting staircase flight has been found to be subjected to a decrease in area of steel at top.
- The presence of staircase yields in the transversal direction to an increase of strength.
- It is also observed that damage in main structures was due to interactions with stairways and in stairways due to high stiffness and corresponding high force demand, with insufficient strength due to inadequate design.

III. RESEARCH METHODOLOGY

Basic aim of the present work is to study behaviour of with and without stair case model at different location in plan for seismic analysis. In this work the structural system of the public/residential building consists of RC beams, columns and slabs, staircase etc. are performed by equivalent static method.

1) Study of IS code IS 875: (Part I, Part II, Part III, Part IV), IS 456: 2000, IS 1893:2002.
2) Study of Design parameters used in ETABS (i.e drift, displacement, column axial load, column bending moment, column shear force, column area of steel).
3) Preparation of ETABS models for building with stair model and building without stair model with IS codal provisions.
4) Analysis and Design of Various building with stair model and building without stair model depending upon length, span and height.
5) Preparation of Comparative Statement on the basis of Design.



IV. PROBLEM FORMULATION

Research is currently underway. Analysis will be done by using 3-D ETABS models for different types of building configuration. The Span Length varies from 5m to 25m keeping vertical Clear height equal to 45m .The c/c distance between frames varies from 3m to 5m. Different loads such as Dead Load, Live Load, and Earthquake Load will be applied on ETABS models at appropriate location as per codes used for Loading. This model are analyzed by using equivalent static analysis for zones III. Design is done firstly by Indian Codes (i.e IS 456, IS 1893, IS 875). All the results obtain from ETABS are compared with the help of Excel sheets and tabulated.

V. STRUCTURAL MODELING

Introduction of modern electronic digital computer in to engineering has lead to the revolutionary changes in the analysis, design, construction and maintenance of engineering system new mathematical models have been developed to explore the vast computational capabilities the hectic research activity has simultaneously promoted structural engineer to develop a significant application software to automate the analysis and design activities with the least possible input requirement. Most of the analysis packages available today such as SAP, ETAB, STAAD-PRO and ANSYS etc. require a formatted input. Some of these are general purpose program which are not suitable for specific problem like building system.

VI. CONCLUSION

From the study made and the results presented in the previous section, the following important conclusions have been drawn within the preview of the building considered.

- The presences of staircase tremendously influence the peak value of result obtained by equivalent static method for columns around staircase.
- It has been observed that when we compared all structural model under consideration, in case of model AX3 (G+5)& AX6 (G+10), as staircase is along shorter direction the shorter 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 shorter direction (Y-direction) for the model.
- In with stair model it is observed that, columns supporting landing beam have been found to be max axial force. The lateral moment in such columns in landing beam increases enormously, the failure of beam is resolved by not providing the area of steel at negative moment locations and by increasing the depth of beam.
- In absence of staircase in model it is observed that, the force drift, displacement & time period increases due to absence of inclined slab, it is necessary to considering the inclined behaviour of staircase during modelling.
- 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.

VII. REFERENCES

[1] XuanXu[a] and Weiguo Song,(1999) "Staircase Evacuation Modeling and Its Comparison with an Egress Drill", ACI Journals, vol.6, pp 266-278,1999.

[2] C. Bellidoa, A. Quiroza, A. Panizoa and J.L. Torerob, (2009) "Performance Assessment of Pressurized Stairs in High Rise Building", Fire Technology 45 (2), pp. 189-200, 2009.

[3] Edoardo Cosenza, Gerardo Mario Verderame, Alessandra Zambrano(2008) "Seismic Performance Of Stairs In The Existing Reinforced Concrete Building" World Conference on Earthquake Engineering, Beijing, China October 12-17-2008,.

[4] Sang Bum Kim, Young Hak Lee, Andrew Scanlon, Heecheul Kim, and Kappyo Hong, (2008),"Experimental Assessment of Vibration Serviceability of Stair Systems", Journal of CSR, vol. 64 pp 253–259,(2008).

[5] N Shyamananda Singh, And S Choudhury (April 2012), "Effects Of Staircase On The Seismic Performance Of Rcc Frame Building" International Journal of Engineering Science and Technology (IJEST), ISSN: 0975-5462 Vol. 4 No.04 April 2012.

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

[7] Ankit R. Shelotkar, Mayur A. Banarase (2015), "Effect of Staircase on Seismic Performance of Multistoried Frame Structure-A Review" International Journal of Research in Engineering, Science and Technologies (IJRESTs) ISSN 2395-6453 (Online), Volume 1, No. 8, Dec 2016.

[8] Bixiong Li and Khalid M. Mosalam(2013),"Seismic Performance of Reinforced Concrete Stairways During The 2008"Wenchuan Earthquake Journal of Performance of Constructed Facilities ASCE/November/December2013.

[9] Huanjun Jiang, Haiyan Gao and Bin Wang(2012), "Seismic Damage Analyses of Staircases In RC Frame Structure" Advanced Materials Research Vols.446-449(2012)pp 2326-2330 Online Available Since 2012/Jan/24

[10] Zhi-Wei Cao,Chen Bian and Chun-Yi Xu(2014), "Analysis of the Interaction Between Stair and Frame Under Horizontal Earthquake Action Based on ETABS" International Conference on Mechanics and Civil Engineering(ICMCE 2014)