An Overview of Seismic Performance of Reinforced Concrete Frame for Vertically Irregular Buildings

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ABSTRACT
The earthquake phenomenon represents one of the most devastating forces that causes not only loss to human life but cripples the economy of a nation as well. Hence it is necessary to study the characteristics of structures subjected to such seismic excitations to reduce the socioeconomic impact of such a catastrophe. In this report a brief review of seismic performance of reinforced concrete frame vertical irregular buildings is presented. Capacity spectrum method (CSM) is adopted for evaluating seismic performance of reinforced concrete building for medium soils as per IS code 1893(Part 1):2002.SAP 2000 v 18 used.

Keywords
reinforced concrete building, vertical irregularity, Performance, collapse safety, life safety, immediate occupancy.

INTRODUCTION
Structural Irregularity In Buildings
A structure can be classified as vertically irregular if it contains irregular distribution of mass, strength and stiffness along the building height. As per IS 1893:2002, a storey in a building is said to contain mass irregularity if its mass exceeds 200% than that of the adjacent storey. If stiffness of a storey is less than 60% of the adjacent storey, then a storey is termed as „weak storey”’. If stiffness of a storey is less than 70% or above as compared to the adjacent storey, then the storey is termed as „soft storey”. In reality, many existing buildings contain irregularity, and some of them have been designed initially to be irregular to fulfill different functions e.g. basements for commercial purposes created by eliminating central columns. Also, reduction of size of beams and columns in the upper storeys to fulfill functional requirements and for other commercial purposes like storing heavy mechanical appliances etc. This difference in usage of a specific floor with respect to the adjacent floors results in irregular distributions of mass, stiffness and strength along the building height. In addition, many other buildings are accidentally rendered irregular due to variety of reasons like non-uniformity in construction practices and material used.

REVIEW OF LITERATURE
To provide a detailed review of the literature related to assess the seismic performance of reinforced concrete frame vertical irregular buildings of the structures in its entirety would be difficult to address in this paper. A brief review of previous studies seismic performance evaluation of structures is presented is this section. This literature review focuses on evaluation of seismic performance of structures and past efforts most closely related to the needs of the present work.
Literature Review on Seismic Performance Evaluation

Alex H. Barbat (2002) The present study deals with the evaluation of R.C buildings using inelastic method (Pushover Analysis). Finite Element Software ANSYS 5.4 is used to perform the Non Linear Static Pushover Analysis and cracking pattern can also be observed in ANSYS. Firstly, a symmetrical building is analyzed using ANSYS for the procedure development as per ATC-40. Then, Seismic Evaluation is performed on unsymmetrical building (L-shape), which is designed in the first part as without considering seismic effect and in the second part, Analysis is carried out on the same building designed seismically as per IS 1893:2002

Chintanapakdee and Chopra (2004) has studied a number of vertically irregular frame buildings up to 12 stories, which satisfy the strong column-weak beam issue, by using modal pushover analysis method. In their study, irregularity due to the existence of soft story is studied in details.

Murat serdarkircil (2006) the main aim of this study is to develop the fragility curves. 3, 5 and 7 story building were designed according to the Turkish seismic design code. Incremental dynamic analysis were performed for those capacities, fragility curves were developed in terms of PSA,PGA and elastic spectral displacement for yielding and collapse damage levels with lognormal distribution assumption. Furthermore, the maximum allowable inter-story drift ratio and spectral displacement values that satisfy the immediate occupancy and collapse prevention level requirements are estimated with respect to the number of stories of the building using constructed fragility curves and statistical methods.

Mario De Stefano and Barbara Pintucchi (2008) The paper presents an overview of the progress in research regarding seismic response of plan and vertically irregular building structures. Three areas of research are surveyed. The first is the study of the effects of plan-irregularity by means of single-storey and multi-storey building models. The second area encompasses passive control as a strategy to mitigate torsional effects, by means of base isolation and other types of devices. Lastly, the third area concerns vertically irregular structures and setback buildings. Although fewer papers have been published in this last area with respect to the former ones, this state-of-the-art reports extensively on research efforts and progress into the seismic behaviour of irregular buildings in elevation to show the growing interest among specialists in the field.

PavanKumar.A (2010) In this paper fragility functions (curves) are used for the evaluation of the building damage. Firstly he developed a pushover curve for the four story 2d building. The pushover analysis is carried with SAP 2000. The performance evaluation of frame is carried out for three different soil conditions. Secondly, he analyzes the 3D frames and developed a pushover curves. For analysis of the 3D building he used the procedure developed by the (fajfar et al), the method uses inelastic response spectrum and nonlinear static analysis. To validate the pushover procedure model with without shear wall is considered. The pushover analysis is carried with default and user defined properties. Thirdly, he considered a 3 story building with and without infill and he developed fragility curves for 3 story bare frame. Finally he took two buildings and developed a fragility curves.

D.N. Shinde, Nair Veena, Pudale Yojana (2010) The seismic response of RC building frame in terms of performance point and the effect of earthquake forces on multi story building frame with the help of pushover analysis is carried out in this paper. In the present study a building frame is designed as per Indian standard i.e. IS 456:2000 and IS 1893:2002. The main objective of this study is to check the kind of performance a building can give when designed as per Indian Standards. The pushover analysis of the building frame is carried out by using structural analysis and design software SAP 2000.

S.Varadharajan, V.K. Sehgal, and B.Saini (Dec 2012) The present study summarizes the research works done in the past regarding different types of structural irregularities i.e. Plan and vertical irregularities. Criteria and limits specified for these irregularities as defined by different codes of practice (IS1893:2002, EC8:2004 etc.) have been discussed briefly. It was observed that the limits of both Plan and vertical irregularities prescribed by these codes were comparable. Regarding the vertical irregularities it was found that strength irregularity had the maximum impact and mass irregularity had the minimum impact on seismic response.
Regarding the analysis method MPA (Modal pushover analysis) method even after much improvement was found to be less accurate as compared to dynamic analysis.

**Himanshu Bansal, Gagandeep (2012)** The objective of the paper is to carry out Response spectrum analysis (RSA) and Time history Analysis (THA) of vertically irregular RC building frames and to carry out the ductility based design using IS 13920 corresponding to Equivalent static analysis and Time history analysis. Three types of irregularities namely mass irregularity, stiffness irregularity and vertical geometry irregularity were considered. According to our observation, the storey shear force was found to be maximum for the first storey and it decreases to minimum in the top storey in all cases. The mass irregular structures were observed to experience larger base shear than similar regular structures. The stiffness irregular structure experienced lesser base shear and has larger inter-storey drifts.

**S. C. Pednekar, H. S. Chore, S. B. Patil (2015)** The present study gives an effect of increase in number of storey on seismic responses by performing pushover analysis. Reinforced concrete structures of G+4, G+5 and G+6 storey have been modeled and analyzed using CSi ETABS 9.7.4 software. Comparison of seismic responses of the structure in terms of base shear, time period and displacement has been done by performing nonlinear static pushover analysis. From analysis results it has been observed that base shear and spectral acceleration is reduced, whereas displacement, time period, spectral displacement is increased as the number of storey increases. Analysis also shows location of plastic hinges at performance point of the structures with different number of storey.

**S Monish, S Karuna (2015)** In this paper attempt has been made to study the effect of seismic performance of the buildings with vertical irregularity namely vertical geometric irregularity and stiffness irregularity with sloping ground. The irregularities are considered as per clause 7.1 of IS 1893:2002 code. Different irregular models are considered having vertical geometric irregularity and models resting on sloping ground. The methods of analysis considered are static and dynamic method, with parameters like displacement, base shear and fundamental natural period. The modelling and analysis is carried out using ETABS software. From this study the model which is most vulnerable to earthquake under severe seismic zone is found.

**Khalaf, D. Chandra Mouli Sandeep Raad Dheyab Kumar (2016)** In this present work attempt is made to study and investigate the plan irregularities by varying location of shear wall on different asymmetry models. Analysis have been done to estimate the performance of high rise buildings and the effects of structural irregularities in stiffness, strength, mass and combination of these factors are to be going to be considered. The parameters considered are displacement, inter storey drift, and storey stiffness. Dynamic Analysis is carried out using FEM software ETAB v 15 by response spectrum method.

**J. Shaikh Sameer and S.B. Shinde, (2016)** The present paper attempts to investigate the proportional distribution of lateral forces evolved through seismic action in each storey level due to changes in mass of frame on vertically irregular frame. As per the Bureau of Indian Standard (BIS) 1893:2002 (part 1) provisions, a G+10 vertically irregular building is modeled as an simplified lump mass model for the analysis with mass irregularities at third & seventh floor. To response parameters like story drift, story deflection and story shear of structure under seismic force under the linear static & dynamic analysis is studied. The soft computing tool and commercial software CSI-ETABS (version 9.7) is used for modeling and analysis.

**Ravindra N. Shelke and U. S. Ansari (2017)** This paper is concerned with the effects of various vertical irregularities on the seismic response of a structure. The objective of the project is to carry out Response spectrum analysis (RSA) of vertically irregular RC building. Comparison of the results of analysis and design of irregular structures with regular structure was done. Three types of irregularities namely mass irregularity, stiffness irregularity and vertical geometry irregularity were considered. The mass irregular structures were observed to experience larger base shear than similar regular structures. The stiffness irregular structure experienced lesser base shear and has larger inter-storey drifts. The absolute displacements obtained from time history analysis of geometry irregular structure at respective nodes were found to be greater than that in case of regular structure for upper stories but gradually as we moved to lower stories displacements in both structures tended to converge. Lower stiffness results in higher displacements of upper stories.
CONCLUSION
From all the literatures it can be summarized that most of the pushover analysis was carried out on existing structures.
1) Very few studies have considered effect of P-Δ analysis while evaluating response reduction factor.
2) Story height used in analysis are limited.
3) The Buildings will have the following details(G+4,G+8,G+12).
4) These buildings will be designed as per Indian standards IS 456:2000, IS 1893:2002 and IS 13920 and American codes.
5) Analysis will be done by nonlinear static method using “CSI SAP 2000 v.17& some used E_tab.
6) Evaluation of response reduction factor incorporating effects of different load patterns and P-Δ analysis. All these variations will be performed for both SMRF and OMRF with afore mentioned configurations.
7) Base shear will increase when the zones changes from I to IV.
8) Max story drift and story displacement will increase as the vertical irregularities increase in models respectively.

SCOPE FOR FUTURE WORK
The vertical irregular building of various shapes e.g square, rectangle, I shaped in plan having irregularity in elevation will study for different zone and from results of pushover analysis response reduction factor will find for r.c.c structure. Software will be used for nonlinear static analysis Sap 2000V18 having features of performing performance based analysis by going through.

REFERENCES


