JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Torsional Effect In The Pushover Based Seismic Analysis of Building

[1]Vaishnavi Ambatkar, [2]Prof. Shilpa Samrutwar, [3]Prof. Neeraj Singh Bais
[1]Mtech Student, [2]Assistant Professor, [3]Head of Department
[1]Dept. of Structural Engineering and Construction,
[1]Ballarpur Institute of Technology, Ballarpur, India

Abstract: The paper presents a simple computer-based push-over analysis technique for performance-based design of building frameworks subject to earthquake loading. The technique is based on the conventional displacement method of elastic analysis. , the standard elastic and geometric stiffness matrices for frame elements (beams, columns, etc.) are progressively modified to account for nonlinear elastic–plastic behavior under constant gravity loads and incrementally increasing lateral loads . Various approaches in nonlinear static analysis were developed to study the performance of a building. Push over analysis is one of the popular methods to determine the performance level of the building. Based on the results obtained from the pushover analysis whether collapse occurs at member or structure level can be identified. In this analysis both symmetric and asymmetric structures with plan irregularity are compared. Symmetric structures have centre of mass coinciding with the centre of rigidity and the torsion effect in such structures occurs out of accidental eccentricity whereas in asymmetric structures have irregular distribution of mass and stiffness and its centre of mass and centre of rigidity do not coincide and hence causes the torsional effect on the structures which is one of the most important factor influencing the seismic damage of the structure. A simple linear comparison based on eccentricity is also carried out for the structures. Structures with asymmetric distribution of mass and stiffness undergoes torsional motions during earthquake. Equivalent loads and wind loads are considered for the analysis of the structure. The analysis of the structural models is carried out using ETABS 2015 software.

Keyword*:* Pushover analysis , stiffness , earthquake , torsion , nonlinear static analysis

I. INTRODUCTION

Recent earthquakes in which many concrete structures have been severely damaged or collapsed, have indicated the need for evaluating the seismic adequacy of existing buildings. About 60% of the land area of our country is susceptible to damaging levels of seismic hazard. We can't avoid future earthquakes, but preparedness and safe building construction practices can certainly reduce the extent of damage and loss. Design of civil engineering structures is typically based on prescriptive methods of building codes, loads on these structures are low and result in elastic structural behavior . During earthquake ground motions, structures much of the time will encounter torsional vibration in addition to lateral oscillations. A significant torsional reaction hotspot is due to asymmetrical distribution of mass or horizontal load opposing components in the plan of the structure which is Usually refers to eccentricity of mass or rigidity. Pushover analysis is an approximate analysis method in which the structure is Subjected to monotonically increasing lateral forces with an invariant height-wise distribution until a target displacement is reached.

II. Objectives

The case study selected for the investigation is the G+11 RC building comprising a base frame structures with brick infill masonry. The system is regular in plan and asymmetric in elevation in X –direction. Investigation based on pushover analysis is carried out considering following points:

i. To study performance based seismic design of regular building and irregular building in various seismic zones.
ii. To study parameters such as pushover curves, base shear, storey drifts, in various seismic zones.
iii. To study comparative analysis of regular and irregular Building.
iv. To record the fundamental natural period and frequency.
v. To record the sequence of cracks, yielding, plastic hinge formation at failure of various structural components.
vi. To analyse the yield displacement, ductility reduction factor and response reduction factor.
vii. To prepare a computer model for Structural Analysis.
viii. To study the structural response for torsional irregularities.
ix. To understand the behavior of irregular building subjected to lateral loading with the help of time period, frequency ,modal mass participating ratio and the magnitudes of stress resultants

III. Literature Review

Different studies have been carried out for the seismic analysis of RC structures some of them are

S.N.Khante and R.W.Lavkesh, analysed torsional effects of seismic behaviour on base isolated structures and also effects of uneven mass distribution on asymmetric and symmetric structures. Models with eccentricity of mass of variation of 5% of largest dimensions of buildings on uni and bi directions are calculated. By the use of Etabs time history and response spectrum analysis of this model of base fixed.

S.Chandrashekaran et al- conducted a detailed dynamic analysis of 10 story RC frame building using response spectrum method based on Indian codal provisions and different seismic parameters like base shear, story shear, and story drifts are computed.

Alok Madan et al-An analytical evaluation of 14 story RC building frame is analyzed by using the nonlinear dynamic time history analysis and nonlinear static analysis. Here in this paper effect of masonry infill walls in building during seismic performance are analyzed by using masonry infill RC frame and other models by eliminating the infill walls at various floors like ground floor .

N. R. Chandak In this paper the parametric study on RC structural walls and moment resisting frames buildings of structural types using response spectrum method is carried out.in this 6 different buildings models considered with three structural types namely symmetric, monosymmetric, unsymmetrical are considered and analysis is being done.

S Patil et al have conducted the nonlinear dynamic analysis (time history) of ten storied RC frame with and without soft storey by considering the different seismic intensities are carried and responses of such building are studied. Results shows that the seismic parameters like base shear, displacement, story drifts are found to be varied in similar pattern with increased intensities.

Mahmood Hosseini et al have conducted the seismic analysis on how good the IBC 2009 and ACI 318-2014 provide LS PL (life safety performance level) of particular building in Tehran for this they have taken buildings with different storey like 4,7,9,13,16 and analysis is being done for RC special moment resisting frame by taking highest seismic zone.

Rahila Thaskeen, Shinu Shajee (2016) The objective of their work aimed at enhanced understanding of the torsional behaviour of building systems. In the analysis both symmetric and asymmetric structures with plan irregularity were compared. To assess the torsional effect on the structures they modelled 4 types of structures having same outer perimeter area and strengthened by introduction of shear wall cores. A simple linear comparison based on eccentricity is also carried out for G+12 and G+17 structures. The analysis of the structural models is carried out using ETABS software. From their investigation on reviews they concluded that the eccentricity shows the tendency of a structure for torsional effects. Model IV (C- shaped structure) had the maximum tendency for torsional effects with higher value of eccentricity. The highest torsional irregularity ratio was found maximum for model IV which was the C shape structure and it is seen that the rigidity centre of model IV is intense at outside the structure. The drift and displacement values yielded values, indicating the dependence of the stiffness and mass concentration on the structure. Strengthened model yielded shorter-period which permitted smaller drift limits and longer-period structures that is the ideal symmetric structure allowed larger drift limits.

P.S Pajgade, Vipin Guptha (2015) explains that the torsion is the most basic element prompting significant harm or completes collapse of building; therefore it is necessary that symmetric buildings should also be analyzed for torsion. As result the buildings should be designed by considering the design eccentricity and accidental eccentricity. They observed that the irregular profile buildings got larger forces and displacement as compared to regular one. Structures are never consummately consistent and thus the architects routinely need to assess the feasible level of irregularity and the impact of this irregularity on a structure during an earthquake.

Arvindreddy and R.J.Fernandes (2015) presented a review about the Seismic analysis of RC regular and irregular frame structures. They considered 2 types of reinforced concrete structures with regular and irregular 15 story structures and analysed for static and dynamic methods. For time history examination past seismic earth ground movement record is taken to think about reaction of the considerable number of structures. Directly they taken six models. One is of general structure and remaining are unpredictable structural models. From their investigation on reviews they concluded that, the static analysis strategy demonstrate lesser story displacements when compared with response spectrum analysis. This variation may be because of nonlinear distribution of force. In diaphragm irregularity, story displacement and story drift observed to be less when compared with normal structures in both static and response spectrum analysis.

O. A. Mohamed and O. A. Abbass (2015) explain review about the Consideration of torsional irregularity in Modal Response Spectrum Analysis. The motivation behind their work is to determine the impacts of torsional irregularity on seismic reaction as per ASCE 7–10, when MRSA is utilized for count of seismic forces and drifts. They discussed about why torsional irregularity must be represented, notwithstanding when MRSA is utilized. From their investigation on reviews they concluded that the torsional irregularity of building diaphragm or floor frameworks prompts increased structural reactions including bending moments and drift and should be represented in the computational model to maintain a strategic distance from structural failures and building pounding effects.

Turgut Ozturk , Zubeyde Ozturk and Onur Ozturk (2015) presented a review about the seismic behavior analysis of multi-story reinforced concrete buildings having torsional irregularity. The purpose of their work is to understanding of the characteristics of an earthquake and correct determination of the behavior of buildings under earthquake excitation turn out to be the most important requirement to build earthquake resistant buildings. In their study torsional effects that occur during earthquake excitations are analyzed in multi-story reinforced concrete buildings. In that manner the behavior of reinforced concrete structures under earthquake loads are examined and by the way the behaviors of structures having torsional irregularities are enlightened and clarified. From the results they explains that the torsional irregularity can occur in the buildings that have regular geometrical shape and regular rigidity distribution. The reason of this irregularity which is called hidden torsional irregularity, is due to lack of rigidity along the extern axes. In certain cases, torsional irregularity can be lowered or totally removed as a result of decrease shear wall rigidity at central zone. torsional irregularity is more related to the rigidity distribution than the geometrical plan of the building. For this reason, determination of the load carrying system of a structure is the most important issue at the planning stage of the project. It is essential that shear wall locations and cross-sectional areas must be properly selected, and the shear walls must be symmetrical in the plan in order to prevent torsional irregularity.

Rizwan Bhina et.al (2015) presented paper on Assessment of Different Aspects of R.C. Flat-Slab Building and Its Serviceability. In this paper the response of Flat-Slab building and a normal symmetric R.C. frame building of same dimension have been studied for varying seismic intensities and serviceability. Static analysis has been perform on the building to obtain the reinforcement of the structure by using different building codes for example IS 456, ACI 318, NZ code, EURO code. It can be concluded from the result that Indian code IS 456 suggest maximum amount of reinforcement.

A.E. Hassaballa, et.al (2014) presented paper on Pushover Analysis of Existing Four Storey RC Flat Slab Building. In this paper apushover analysis was performed on the four story building using SAP2000 software (Ver.14) and equivalent static method according to UBC 97. They have concluded that the structure will behave poorly during the imposed seismic excitation and need to be retrofitted to avoid future major damage or collapse.

M. A. Ismaeil presented paper on Pushover Analysis of Existing Three Stories RC Flat Slab Building. This paper contents the study of seismic performance of the existing hospital buildings in the Sudan. Plastic hinge is used to represent the failure mode in the beams and columns when the member yields. The pushover analysis was performed on the building using SAP2000 software (Ver.14) and equivalent static method according to UBC 97.

K. S. Sable et.al (2012) presented paper on Comparative Study of Seismic Behaviour of multi-storey Flat Slab and Conventional Reinforced Concrete Framed Structures. This paper investigates the comparison of conventional reinforced concrete building system i.e. slab, beam & column to the flat slab building. These results are compared for different heights of building.The analysis was carried out in STAAD Pro2007 software. Results of conventional R.C.C structure i.e. slab, beam and column and flat slab R.C.C structure for different heights are discussed.

Dhananjay D. Joshi et.al (2014) presented a paper on Performance of Flat Slab Structure Using Pushover Analysis. In this paper A (G+7) frame having 5 bays is considered for analysis. The results obtained by performing pushover.analysis on flat slabs by using most common software SAP2000. It is observed that the performance point of flat slab is more as compared to conventional building.

K. Soni Priya et.al (2012) presented a paper on Non-Linear Pushover Analysis of Flat-slab Building by using SAP2000. In this paper, pushover analysis was performed on (G+2) building with flat slab and resulting pushover curve is plotted. It is concluded that curve is initially linear but start to deviate from linearity as the columns undergo inelastic actions.

Triandas Srikanth presented report on ‘Non-linear Pushover Analysis of Flat Slab Buildings with and without Seismic Retrofitting’. In this report the lateral behaviour of a typical flat slab building which is designed according to IS:456-1978 is evaluated by means of non-linear pushover analysis. The inadequacies of these buildings are discussed by comparing the behaviour with that of the conventional beam-column framing. The effect of retrofitting schemes is also studied.

Ravindra B N et.al. presented paper on ‘Dynamic Analysis of Soft Storey Building with Flat Slab’. For linear and nonlinear analysis 5, 10 and 15 storey buildings modelled by using ETABS software considering response reduction factor, importance factor, zone factor, damping ratio, base shear and hinge reactions are obtained.

Rahiman G. Khan et.al presented paper on Pushover Analysis of Tall Building with Soft Stories at different Levels. In this paper the seismic vulnerability of building is shown with an example of G+20. Earthquake analysis is carried out on RCC moment resisting frame tall building without infill wall on different stories and best position for soft storey is suggested.

Dubey S.K. et.al. [2011] presented paper on Seismic Behavior Of Asymmetric RC Buildings. The main objective of this study is to understand different irregularity, and to analyze “T”-shaped building while earthquake forces acts and to calculate additional shear due to torsion in the columns. Additional shear due to torsional moments needs to be considered because; this increase in shear forces causes columns to collapse. So in design procedures this additional shear must be taken into account.

R.S.More, V. S. Sawant [2013] presented paper on Analysis of Flat Slab. This paper gives information about major issues associated with the flat slab and different method for analysis of flat slab use to confirm the behaviour of flat slab.

IV. References

1. IS1893 (Part 1): 2002, “Criteria for Earthquake Resistant Design of Structures” General provisions and buildings, Bureau of Indian Standards, New Delhi.
2. Thejesh T N1 , B.S.Suresh Chandra2 PG student1 , Professor2 “ Torsional Response on RC Framed Structures Using Response Spectrum Analysis ” International Journal of Engineering Science and Computing, July 2016 volume 6 Issue No. 7.

3. Applied Technology Council, "Seismic Evaluation and Retrofit of concrete Buildings, ATC-40", Volume 1 and 2, Seismic Safety Commission, Redwood City, 1996.
4. Chopra, A. K. and Goel, R. K., "A modal pushover analysis procedure to estimate seismic demands for asymmetry-plan buildings". Earthquake Engineering and Structural Dynamics.33 (2004), pp. 903-927.
5. Raul Gonzalez Herrera1 and Consuelo Gomez Soberon, "Influence of plan irregularity of buildings", 14th World conference on Earthquake Engineering,2008.
6. T. Mahdi and V. SoltanGharaie, "Plan irregular RC frames: Comparison of Pushover with Nonlinear dynamic analysis", Asian journal of civil engineering (building and housing) vol. 12, no. 6 (2011) pages 679-690.
7. Goel, R.K. and Chopra, A.K. (1991). Effects of Plan Asymmetry in Inelastic Seis mic Response of One-Story Systems. Journal of Structural Engineering 117:5, 1492- 1513.
8. Ciongradi, I. and Budescu, M. (2002). Evaluation of the Seis mic Torsion Effects on structures. 3. Fajfar, P., Marusic, D. and Perus, I. (2005). Torsional effects in the Pushover-Based Seismic Analysis of buildings. Journal of Earthquake Engineering 9:6, 831- 854.
9. "Response Spectrum Analysis of Asymmetrical Building", Pravin Ashok Shirule & Bharti V. Mahajan.
10. "Assessment of the Torsion Effect in Asymmetric Buildings Under Seis mic Load", M.D. Bensalah, A. Modaressi, M. Bensaibi.
11. D'Ambrisi A., Stefano M., Tanganelli M. (2009) Use of Pushover Analysis for Predicting Seis mic Response of Irregular Buildings: a Case Study. Journal of Earthquake Engineering 13: 1089-1100.
12. Mahdi & V. Soltangharaie "Static and Dynamic Analyses of Asymmetric Reinforced Concrete Frames" 15 WCEE, LISBOA 2012.
13. Shaikh Abdul Aijaj Abdul Rahman, Girish Deshmukh "Seis mic Response of Vertically Irregular RC Frame with Stiffness Irregularity at Fourth Floor", International Journal of Emerging Technology and Advanced Engineering, Volume 3 Issue 8, August 2013.
14. "Study of Torsion Effects on Building Structures Having Mass and Stiffness Irregularities", Rajalakshmi K R & Harinarayanan S.
15. Erduran E., Ryan K. (2011) Effects of torsion on the behaviour of peripheral steel-braced frame systems. Earthquake Engineering and Structural Dynamics 40(5): 491-507.