Pushover analysis of Irregularity of Multistoried Building For All Zones: A Review

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Abstract- *Among categorizations of seismic behaviour that have been adopted in modern codes is extreme vertical Irregularity. Vertical irregularity is not an unfamiliar concept, having been expressed in codes in various forms for decades. It is an issue that engineers have learned to deal with, particularly in seismically active areas. Extreme vertical irregularity, however, is a somewhat newer concept and subset within the larger issue of vertical behaviour. It is something that can greatly limit and restrict flexibility in choosing seismic force-resisting systems and configurations. In this paper vertical irregular frames are analysed for Pushover analysis and time history analysis for different frames and different zones using ETABS. For time history analysis Bhuj and Koyana data is used.*

Keywords- Vertical irregularity, Push over analysis, Time History analysis, ETABS

I. INTRODUCTION

1.1 General:

During an earthquake, failure of structure starts at points of weakness. This weakness arises due to discontinuity in mass, stiffness and geometry of structure. The structures having this discontinuity are termed as Irregular structures. Irregular structures contribute a large portion of urban infrastructure. Vertical irregularities are one of the major reasons of failures of structures during earthquakes. For example structures with soft storey were the most notable structures which collapsed. So, the effect of vertically irregularities in the seismic performance of structures becomes really important. Height-wise changes in stiffness and mass render the dynamic characteristics of these buildings different from the regular building

A building is said to be a regular when the building configurations are almost symmetrical about the axis and it is said to be the irregular when it lacks symmetry and discontinuity in geometry, mass or load resisting elements. Asymmetrical arrangements cause a large torsion force. IS 1893: 2002 (part1) has explained building configuration system for better performance of RC buildings during earthquakes. The building configuration has been described as regular or irregular in terms of the size and shape of the building, arrangement of structural the elements and mass. There are two types of irregularities 1) Horizontal irregularities refers to asymmetrical plan shapes (L, T, U and F) or discontinuities in horizontal resisting elements such as re-entrant corners, large openings, cut outs and other changes like torsion, deformations and other stress concentrations, 2) Vertical irregularities referring to sudden change of strength, stiffness, geometry and mass of a structure in vertical direction. The main objective of the present work is to study the response of the irregular structures under dynamic loads. In this present study it is proposed to consider the building frames that are irregular in elevation and analyse the response and behaviour of the structures under earthquake and wind loads. For this purpose, Three RC building frames are selected and it is proposed to analyse all the frames that are considered and are modelled. ETABS analysis package is proposed for the analysis of all structures, to get the all nodal displacements. Frames considered in this study are 15,20,25-Storied 3-D frames with symmetrical elevation configuration throughout its height and three other frames with unsymmetrical vertical configuration starting from tenth floor, placed at corner of the plan respectively. It is proposed that the responses of all the above frames are to be determined for all the load combinations. Lateral loads and Storey shears of all the three frames due to earthquake loads is proposed to determine using Time history analysis method, the IS 1893(Part 1) : 2002 has recommended dynamic analysis (linear dynamic analysis).

1. Plan Irregularities
2. Vertical Irregularities.

i. **Stiffness Irregularity**
ii. **Mass Irregularity**
iii. **Vertical Geometric Irregularity**
iv. **In-Plane Discontinuity in Vertical Elements Resisting Lateral Force**

v. **Discontinuity in Capacity**

1.2 Need for Research

Irregular buildings constitute a large portion of the modern urban infrastructure. Structures are never perfectly regular and hence the designers routinely need to evaluate the likely degree of irregularity and the effect of this irregularity on a structure during an earthquake. Need for research is required to get economical & efficient lateral stiffness system for high seismic prone areas. For optimization & design of high rise building with different structural. Framing systems subjected to seismic loads. To improve the understanding of the seismic behaviour of building structures with vertical irregularities.

1.3 Scope:

From the above literature survey it is observed that there is very less research work carried out for seismic performance of irregular structure. Response of base isolated and fix base structure for torsional irregularity is modified by consideration of soil strata. Therefore, this work deals with comparative parametric study of irregular structure with effect of torsion irregularity.

II. REVIEW OF PAPERS

Erik A. Johnson, Juan C. Ramallo, et al. (1998) [1] proposes an intelligent base-isolation system, comprised of low damping isolation bearings and controllable fluid dampers in this paper. The damper employs a agnetorheological (MR) fluid that change its properties in the presence of a magnetic field, resulting in a damper whose characteristics may be modified in real time to adapt to changing excitations in a stable and cost-effective manner. A model of a five-storey building is used to study and compare the efficacy of a passive base-isolation alone, with the addition of an active control device, and with a semi-active MR damper. A preliminary study of active H2/LQG designs shows that mostly dissipative designs exist, which may be implemented using far less power in an approximate manner with an MR damper. Simulations of the semi-active system demonstrate that the ‘smart’ damper can achieve most of the decrease in base displacement and peak acceleration typical of an active device.

H. Yoshioka; J. C. Ramallo; and B. F. Spencer Jr. (2002) [2] states in this paper that one of the most successful means of protecting structures against severe seismic events is base isolation. However, optimal design of base isolation systems depends on the magnitude of the design level earthquake that is considered. The features of isolation system designed for an El Centro-type earthquake typically will not be optimal for a Northridge-type earthquake and vice versa. To be effective during a wide range of seismic events, an isolation system must be adaptable. To demonstrate the efficacy of recently proposed ‘‘smart’’ base isolation paradigms, this paper presents the results of an experimental study of a particular adaptable, or smart, base isolation system that employs magneto rheological ~MR! Dampers. The experimental structure, constructed and tested at the Structural Dynamics and Control/Earthquake Engineering Laboratory at the Univ. of Notre Dame, is a base-isolated two-degree-of-freedom building model subjected to simulated ground motion. A sponge-type MR damper is installed between the base and the ground to provide controllable damping for the system. The effectiveness of the proposed smart base isolation system is demonstrated for both far-field and near-field earthquake excitations.

Sajal Kanti Deb (2004) [3] discusses 3D nonlinear analysis procedure of base isolated building in this paper. Important issues related to design of base isolated building are presented. Shear test for obtaining force-displacement hysteresis loop of isolation bearings is outlined. Other important issues, e.g. (i) effects of soft soil on performance of base isolated building, (ii) effects of near fault motion, and (iii) soil-base isolated building interaction, as reported in the literature have also been discussed.

M Usman, S H Sung, et al. (2009) [4] in this paper evaluates the dynamic performance of a newly proposed smart base isolation system employing Magneto-Rheological Elastomers (MREs). MREs belong to a class of smart materials whose elastic modulus or stiffness can be adjusted by varying the magnitude of the magnetic field. The base isolation systems are considered as one of the most effective devices for vibration reduction of civil engineering structures in the event of earthquakes. The proposed base isolation system strives to enhance the performance of the conventional base isolation system by using controllable MREs. To validate the effectiveness of the MRE-based isolation system, an extensive simulation study has been performed using a five degree-of freedom structure under several historical earthquake excitations. The results show that the proposed system outperformed the conventional system in reducing the responses of the structure in all the seismic excitations considered in the study.

Ahmad Naderzadeh (2009) [5] states in this study that application of base isolation techniques in Iran goes back to hundreds of years ago and even to ancient times. Installing pieces of wood between the foundation and the walls of buildings is among the earthquake resistant construction techniques that have been applied in some areas of Iran in the past. However, contrary to other technologies which are generally adapted soon after their development, modern seismic base isolation technology took almost a quarter of a century to be adapted and utilized in Iran. This paper presents the historical as wells as the modern application of seismic base isolation technology in Iran.

H. Matinmanesh and M. Saleh Asheghabad, et al. (2011) [6] stated that during earthquakes seismic waves propagate from the bedrock through the soil layers and damage structures on the surface. The understanding of local site effects on strong ground motion is of particular importance for the mitigation of earthquake disasters as well as future earthquake resistant design. This paper presents an idealized two dimensional plane strain finite element seismic soil-structure interaction analysis using Abacus V.6.8 program. The analysis performed by considering three actual ground motion records representing seismic motions with low, intermediate and high frequency content earthquakes. Through these analyses, influence of different sub soils (dense and loose sand), buildings height, in addition to the frequency content of the earthquake have been investigated on amplification, acceleration response and stress propagation on the soil-foundation interface. Results illustrate that both sandy soils amplify seismic waves on the soil-structure interface because of the soil-structure interaction effect.

Esteban Saez, Fernando Lopez-Caballero and Arézou Modaressi-Farahmand-] Razavi (2011) [7] study the influence of inelastic dynamic soil–structure interaction (DSSI) on the seismic vulnerability assessment of buildings. The seismic vulnerability is evaluated in terms of analytical fragility curves constructed on the basis of non-linear dynamic finite elements (FE) analysis. An analytical sensibility strategy is introduced in order to define a suitable size of the motion database to be used for computing fragility curves. The fragility curves developed in this study are compared with reference curves. Concerning the effect of the inelastic DSSI, a general reduction of seismic demand when DSSI phenomena are included is found. Derived fragility curve reflects this seismic demand reduction. The importance of the ground motion database is highlighted in terms of the variability of parameters describing derived fragility curves. Comparison with reference curves is satisfactory. Findings illustrate clearly the importance and the advantages of an adequate DSSI effects evaluation.

A. B. M. Saiful Islam1, M. Jameel1, et al. (2011) [8] observes in this work that seismic base isolation is now a days moving towards a very efficient tool in seismic design of structure. Increasing flexibility of structure is well achieved by the insertion of these additional elements between upper structure and foundation as they absorb larger part of seismic energy. However in Bangladesh, this research is still young for building structures. Therefore, this is a burning question to design isolation device in context of Bangladesh. Effort has been made in this study to establish an innovative simplified design procedure for isolators incorporated in multi-storey building structures. Isolation systems namely lead rubber bearing (LRB) and high damping rubber bearing (HDRB) have been selected for the present schoolwork. Numerical formulation and limiting criteria for design of each element have been engendered. The suitability to incorporate isolation device for seismic control has been sight seen in details. The study reveals simplified design procedures for LRB and HDRB for multi-storey buildings in Bangladesh. The detail design progression has been proposed to be included in Bangladesh National Building Code (BNBC).

Miranda Novare Design, Wellington G.A. MacRae & T.Z. Yeow et al. (2012) [9] Stated that, all buildings are subjected to some degree of torsion which in turn changes the member demands from that of translation only. Torsional effects on buildings subjected to earthquakes are not found directly in structural analysis unless full three-dimensional inelastic dynamic time history analysis is conducted. Since design is often conducted using two-dimensional analysis, these effects are not directly considered. There is currently an understanding of how different parameters may influence torsion, however, the degree to which these factors influence torsion is relatively unknown. Currently there are two simple design recommendations by Beyer/Priestley and MacRae; however, these need to be verified to be used in design. To do this, earthquake ground motions are applied in one direction to single storey structures with different in plane wall strength and stiffness, rotational inertia and torsional restraint to obtain the inelastic dynamic response considering torsion. A single multi-storey analysis is performed to verify the response compared to that of the single storey. It is found that an increase in strength on an element does not increase the demand on any critical element. An increase in rotational mass or a decrease in stiffness eccentricity decrease critical wall displacement. Increasing torsional restraint reduces the critical wall displacement. Beyer/Priestley’s prediction is generally non-conservative while McRae’s is conservative. The multi-storey analysis was well approximated by the single-storey response. Both single and multi-storey structures are recommended to be designed by McRae’s method.

H. Gokdemir. H. Ozbasaran, M. Dogan, E. Unluoglu, et al. (July 2013) [10] explains Seismic design Failure analysis Structures experience lateral defections under earthquake loads. Magnitude of these lateral defections is related to many variables such as structural system, mass of the structure and mechanical properties of the structural materials. Buildings should be designed so that they can resist earthquake induced defections and internal forces. Structural irregularities are important factors which decrease the seismic performance of the structures. Buildings which have structural irregularities may experience different drifts of adjacent stories, excessive torsion, etc. according to irregularity type and fail during an earthquake.

In this paper, effects of torsional irregularity on structures are studied. Building models, which have different number of floors and floor areas, are generated by a computer program and calculations are made. Results are compared and precautions are given to prevent damages caused by torsional irregularity under earthquake loads. Also, statements in different earthquake codes about torsional irregularity are compared. Calculations show that separating big building sections from each other with proper separation distances and increasing lateral rigidity on the weak direction of the structures decrease the effect of torsion.

IS CODE PROVISION:-

IS 1893:2002 provides irregularity provision as below

Regular and Irregular Configuration (IS 1893:2002 Part 1 clause7.1 pg. no. 17)

To perform well in an earthquake, a building should possess four main attributes, namely simple and regular configuration, and adequate lateral strength, stiffness and ductility. Buildings having simple regular geometry and uniformly distributed mass and stiffness in plan as well as in elevation, suffer much less damage than buildings with irregular configurations. A building shall be considered as irregular for the purposes of this standard, if at least one of the conditions given in Tables 4 and 5 is applicable, floors.

Table 4 Definitions of Irregular Buildings — Plan Irregularities (Fig. 3)

(*Clause* 7.1)

l No.	Irregularity Type and Description
(1)	(2)
i)	*Torsion Irregularity* To be considered when floor diaphragms are rigid in their own plan in relation to the vertical structural elements that resist the lateral forces. Torsional irregularity to be considered to exist when the maximum storey drift, computed with design eccentricity, at one end of the structures transverse to an axis is more than 1.2 times the average of the storey drifts at the two ends of the structure
ii)	*Re-entrant Corners* Plan configurations of a structure and its lateral force resisting system contain re-entrant corners, where both projections of the structure beyond the re-entrant corner are greater than 15 percent of its plan dimension in the given direction
iii)	*Diaphragm Discontinuity* Diaphragms with abrupt discontinuities or variations in stiffness, including those having cut-out or open areas greater than 50 percent of the gross enclosed diaphragm area, or changes in effective diaphragm stiffness of more than 50 percent from one storey to the next
iv)	*Out-of-Plane Offsets* Discontinuities in a lateral force resistance path, such as out-of-plane offsets of vertical elements
v)	*Non-parallel Systems* The vertical elements resisting the lateral force are not parallel to or symmetric about the major orthogonal axes or the lateral force resisting elements

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