Review on Pushover Analysis of Building Using Soft Story At Different Level

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Abstract- *The term earthquake can be used to describe any kind of seismic event which may be either natural or initiated by humans, which generates seismic waves. Earthquakes are caused commonly by rupture of geological faults; but they can also be triggered by other events like volcanic activity, mine blasts, landslides and nuclear tests In the Present work three building models of G+15 has been developed for RCC, for different position of shear wall situated in zone V with subsoil Type medium -II were analysed in ETAB software. All the buildings are subjected to same earthquake loading to check their seismic behaviour for same story and story height. For the analysis of these models' various methods of seismic analysis are available but for present work both linear static and non-linear static method is used. So, in this paper discus about pushover analysis with the help of performance levels, pushover curve, and pushover analysis procedure.*

Keywords- Pushover Analysis, Soft Story, Earthquakes, Etab, RCC

I. INTRODUCTION

Generally, loads on these structures are only gravity loads and result in elastic structural behaviour. However, under a Strong seismic event, a structure may actually be subjected to forces beyond its elastic limit. Since. The recent earthquake in last 4 decayed in which many concrete structures have been harshly damaged or collapsed, it has indicated the need for evaluating the seismic suitability of present building or purposed building. Therefore, structure vulnerable to damage must be determined. To make or attain this objective, simplified linear elastic methods are not suitable. Thus, the structural designer has developed a new method of design and seismic procedure that include performance-based structure towards nonlinear technique.

Analysis methods are classified as linear static, linear dynamic, nonlinear static and nonlinear dynamic analysis. In these the first two is appropriate only if the structural loads are low and stress strains within elastic limit. During earthquake the structural loading can reach to collapse load and therefore the material stresses are on top of yield stresses. Therefore, during this case material nonlinearity and geometrical nonlinearity must to be incorporated into the analysis to acquire good results. Pushover analysis provides simple approach to analyse nonlinear static behaviour of the building. So, in this paper discus about pushover analysis with the help of performance levels, pushover curve, and pushover analysis procedure.

II. LITERATURE REVIEW

Sangeetha's et. al. The rapid discharge of energy in the earth's crust forms seismic waves which arrive at various instance of time with different intensity levels are called as earthquake. It causes the random ground motion in all directions, radiating from epicentre, which causes structure to vibrate due to which induce inertia forces in them. Many existing structures are seismically deficient due to lack of awareness regarding seismic behaviour of structures. Due to this, there is vital requirement to converse this situation and do the seismic assessment of existing and proposed structures. The seismic reaction of RCC building frame in terms of performance point and the earthquake forces on Reinforced building frame with the help of pushover analysis is carried out in this project. In this method of analysis, a model of the building is exposed to a lateral load and the force of the lateral load is slowly increased. With the result the series of cracks, yielding, plastic hinge establishment, and failure of numerous structural components is recorded. Pushover analysis can afford a substantial insight into the weak links in seismic concert of a structure and we can know the weak zones in the structure. In the present study an existing building frame is designed and evaluated as per Indian standard and also suggests the recommended retrofitting methods to strengthened the existing structure. The pushover analysis of the RCC building frame is carried out by structural analysis and design software SAP 2000.

Patel Jalap R. et. al. This paper deals with the performance-based analysis of an existing building. The building taken as a case study was Harti apartment, Unihan. It is a G+4 residential building without lifts core and water tank. The typical story height is 3m. The year of construction of

Harti apartment was 2011. The selection of existing building was with an intention of finding capacity of building to check its safety against earthquake. Each floor is having four flats almost equal in its construction. Analysis of building was carried out for different position of shear walls. Typical slab details, terrace slab details, column and foundation details were the four structural drawings available for Harti apartment. The concrete grade was M25 and reinforcement was Fe415. All the beams were 115mm thick and 420 mm depth unless otherwise specified. All the slabs were 115mm thick. Due to symmetry of building in plan the details of beams were same on the either side of the axis of symmetry. Figure 1 shows the column and beam schedule of the building. Column size of the building was taken as 230x460 mm.

Vaishnavi. Dashing et. al. Elastic static analysis, or pushover analysis, has been the ideal method for seismic performance assessment due to its easiness. It is a static analysis that directly includes nonlinear material characteristics. Inelastic static analysis procedures include Capacity Spectrum Method, Displacement Coefficient Method and the Secant Method. Pushover analysis is a static, nonlinear procedure in which the magnitude of the lateral loads is gradually increased, maintaining a predefined distribution arrangement along the height of the building. In this paper, in last 4 decayed experienced the seismic event has major destruction of R.C building as well as human life. Therefore, the question raised about safety of R.C. building in future earthquake "how to make earthquake resistant structure?" there are no of ways to evaluate the building performance up to elastic limit but it is complicated to evaluate beyond elastic limit. So, to assessment the performance of structure in future unpredictable earthquake event a static nonlinear pushover analysis performed. This method gives performance level of building.

Achyut S. Naphade et. al. Due to increase in population, parking spaces is big issue for the apartments in the cities. Hence new trend for utilize the ground story for a parking. Also, for office spaces or conference hall etc., soft story at different levels of structure is constructed. In the past earthquake has shown that the buildings with simple and uniform configurations are subjected to less damage. Regularity and continuity of stiffness in the horizontal planes as well as in vertical direction is very important from earthquake safety point of view. A building with discontinuity is subjected to concentration of forces and deformations at the point of discontinuity which may leads to the failure of members at the junction and collapse of building. Open first story is a typical feature in the modern multistorey constructions in urban India. Such features are highly undesirable in buildings built in seismically active areas; this has been verified in numerous experiences of strong shaking during the past earthquakes. Though multistorey buildings with open (soft) ground floor are inherently vulnerable to collapse due to earthquake load, their construction is still widespread in the developing nations like India. Social and functional need to provide car parking space at ground level and for offices open stories at different level of structure far out-weighs the warning against such buildings from engineering community. With ground soft story for office space open floor is required on different levels of building. In present thesis we are concentrating on finding the best place for soft stories in high rise buildings. With the availability of fast computers, so-called performance based seismic engineering (PBSE), where inelastic structural analysis is combined with seismic hazard assessment to calculate expected seismic performance of a structure, has become increasingly feasible. With the help of this tool, structural engineers too, although on a computer and not in a lab, can observe expected performance of any structure under large forces and modify design accordingly. PBSE usually involves nonlinear static analysis, also known as pushover analysis. Hence in this study vulnerability of RCC building with soft story at GL along with at intermediate floor using nonlinear static analysis. In this project thesis the modelling is done with software SAP 2000 for the analysis. The RCC symmetrical building having G+10 story considers for study. The performance of the building studied considering second floor, fifth floor and eighth floor along with ground floor as a soft story. To find out performance points of building with soft story at these levels with push over analysis is carried out and also analyse the seismic performance of the building by retrofitting with shear wall.

Akshaya V. Raut et. al. This paper highlights the importance of explicitly recognizing the presence of the open first story in the analysis of the building. Many urban multistorey buildings in India today have open first story as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first story. This paper highlights the importance of explicitly recognizing the presence of the open first story in the analysis of the building and also for immediate measures to prevent the indiscriminate use of soft first stores in buildings. Alternate measures, involving stiffness balance of the open first story and the story above, are proposed to reduce the irregularity introduced by the open first story. The structural engineering profession has been using the nonlinear static procedure (NSP) or pushover analysis. Modelling for such analysis requires the determination of the nonlinear properties of each component in the structure, quantified by strength and deformation capacities, which depend on the modelling assumptions. Pushover analysis is carried out for either user-defined nonlinear hinge properties or default-hinge properties, available in some programs based on the FEMA-356 and ATC-40 guidelines. This paper aims to evaluate the zone –II selected reinforced concrete building to conduct the non-linear static analysis (Pushover Analysis). The pushover analysis shows the pushover curves, capacity spectrum, plastic hinges and performance level of the building. This non-linear static analysis gives better understanding and more accurate seismic performance of buildings of the damage or failure element.

Noor Mohammed et. al. Buildings are designed as per the code regulations meeting all specific requirements of code and assuming a linear elastic behaviour for the structural members. Moreover, it is also necessary to know the behaviour of a building that were designed with older codes or which may not have been designed for earthquake forces. During the seismic excitation the building responds well beyond its elastic and linear capacity and enters into non-linear stage. So, the present work is intended to provide a systematic procedure to assess the behaviour of a structure during the seismic excitation. For studying the behaviour, a non-linear static analysis procedure known as pushover analysis is used. The literature pertaining to pushover analysis is reviewed. A Nine story residential building located in the Hyderabad city, which was designed and constructed for gravity loads alone, was considered for analysis. The present structure is studied using the evaluation procedures provided in ATC-40 and FEMA-273 documents. Under detailed evaluation a target displacement for Immediate Occupancy, Life Safety, Collapse Prevention was given and the performance is checked in accordance with IS 1893:2002.

Yousuf Dinar et. al. Nonlinear static pushover analysis provides a better view on the performance of the structures during seismic events. Different configuration of construction may also lead to significant variation in capacity of the same structure. This comprehensive research evaluates as well as compares the performances of bare, different infill percentage level, different configuration of soft story and Shear wall consisting building structures. It will eventually help engineers to decide where generally the soft story could be constructed in the structures. Above all a better of effects of pushover Analysis could be summarized from the findings.

A. Kadir et. al. Recent earthquakes including the last Algerian earthquake have indicated the need for evaluating the seismic adequacy of existing buildings. Seismic rehabilitation of older concrete structures in high seismicity areas is a growing concern. A pushover analysis is a viable method to assess damage vulnerability of buildings, says the study. properly designed frames will perform well under seismic loads, it says. The study was conducted using three framed buildings with 5, 8 and 12 stories respectively. The results obtained from this study show that properly designed frames will performance well under earthquake loads, the study says.

Majid Divina, Murtaza Mad khan et. al. In this study various types of pre-fabricated concrete frames together with pre-fabricated 4 and 8-story shear walls with 1 and 3 bays are studied. The effect of two kinds of uniform and triangular loading on behaviour factor has also been taken into consideration. Non-linear static analysis method (Push-over) has been used in order to determine the behaviour factor. the main section of the seismic design of buildings is done based on equivalent static force method and calculating earthquake force of design from earthquake linear spectrum by applying a reduction coefficient called behaviour coefficient of structure that embrace philosophy of design. So, the necessity of determining behaviour coefficient with respect to its importance in seismic design of structures seems essential. The behaviour coefficient of structure is a coefficient that includes inflexible function of structure and indicates strength and hidden ductility of structure in inflexible stage.

Majid Divina, et. al. In this study various types of pre-fabricated concrete frames together with pre-fabricated 4 and 8-story shear walls with 1 and 3 bays are studied. The effect of two kinds of uniform and triangular loading on behaviour factor has also been taken into consideration. Non-linear static analysis method (Push-over) has been used in order to determine the behaviour factor. the main section of the seismic design of buildings is done based on equivalent static force method and calculating earthquake force of design from earthquake linear spectrum by applying a reduction coefficient called behaviour coefficient of structure that embrace philosophy of design. So, the necessity of determining behaviour coefficient with respect to its importance in seismic design of structures seems essential. The behaviour coefficient of structure is a coefficient that includes inflexible function of structure and indicates strength and hidden ductility of structure in inflexible stage.

Nickname, A. Musleh et. al. This paper deals with Bridges as key elements in the lifeline of each country or urban transportation play a fundamental role economically, politically and militarily. The possibility of severe damage to bridges that are subjected to earthquake leads to the necessity of seismic evaluation of existing bridges, particularly those which have been either designed regardless of earthquake effects or according to moderate earthquake-resistant consideration. The assessment of safety and stability of these bridges while passing increasingly traffic is of high importance in their seismic performance. In this study, an urban steel bridge in metropolitan Tehran which is accounted for as an important structure in the city transportation is studied using nonlinear static procedure at two hazard levels. The hazard levels were obtained by the use of probabilistic seismic hazard analysis (PSHA). Three-dimensional model of the mentioned bridge is developed and analysed using nonlinear static procedure (NSP) thus its seismic performance is evaluated accordingly. The results show the vulnerability of this steel bridge during earthquake and the necessity of retrofitting for improving its seismic behaviour.

Ari Wibowo, et. al. Soft-story buildings are considered to be particularly vulnerable because the rigid block formed by upper levels has limited energy absorption and displacement capacity, thus leaving the columns in the soft-story to deflect and absorb the seismic energy whilst resisting the axial gravity loading. To investigate collapse mechanism of such structures, a unique experimental field testing of a precast soft story building in Melbourne was then undertaken. Four pull-over tests were conducted to measure the drift capacity and load-deflection behaviour of such buildings. Detailed theoretical models were developed that considered rocking behaviour, connection behaviour, P-Delta effects and ground slab interaction effects. The experimental results together with a comparison with theoretical model predictions showed that the precast soft story structure had considerable displacement capacity beyond the traditional definition of failure used in high seismic regions, where failure is deemed to occur when the horizontal resistance capacity of the system is reduced to 80% of the nominal capacity. It is recommended that the nominal failure point could be reduced to a displacement limit set at the lesser of the displacement associated with 40% of the peak strength or 60% of the column width to allow for some conservatism. This preliminary definition is considered more realistic, particularly for regions of lower seismicity where the ground shaking is more modest in terms of displacement demand and duration and P-delta effects are not as significant.

Djamel Yahia, Tayebi Branchia, et. al. It is found that the height and the capacity factor of frame have a profound effect on the BF and the value of this factor recommended by the EC8 is underestimated, mostly for low-rise frames. EC8 does not indicate accurately criteria for define the failure mode or quantitative definition of the ultimate limit state corresponding to which values of BF frames are recommended. Moreover, the evaluation of the seismic strength of structures of buildings is usually carried out by the capacity design approach taking into account the nonlinear response of structure through the BF and in seismic design codes actual seismic load is reduced by this factor that takes into account several parameters including the capacity to dissipate energy, reserve strength and redundancy. Thus, the need for identifying BF in relation to its importance in the seismic design of frames seems indispensable. In this study, results of standard nonlinear static pushover analysis (NSPA) using SAP2000 program for steel moment-resisting frames (SMRFs) of different stories and bays were analysed and compared and conclusions regard the effect of the structural performance limits and the capacity factor and other parameters on BF and its components are presented. It is found that the height and the capacity factor of frame have a profound effect on the BF and the value of this factor recommended by the EC8 is underestimated, mostly for low-rise frames

Sofiane. Y. Ahmed, et. al. Design of civil engineering structures is typically based on prescriptive methods of building codes. Normally in the static case, the loads on these structures are low and result in elastic structural behaviour. However, under a strong seismic event, a structure may actually be subjected to forces beyond its elastic limit. Although building codes can provide a reliable indication of actual performance of individual structural elements, it is out of their scope to describe the expected performance of a designed structure as a whole, under large forces. With the availability of fast computers, so-called Performance-Based Seismic Engineering (PBSE), where inelastic structural analysis is combined with seismic hazard assessment to calculate expected seismic performance of a structure, has become increasingly feasible Nonlinear time history analysis is a possible method to calculate structural response under a strong seismic event. However, due to the large amount of data generated in such analysis, it is not considered practical and (PBSE) usually involves nonlinear static analysis, also known as pushover analysis. Furthermore, modern building codes such as International Building Code (IBC 2006) and Federal Emergency Management Agency (FEMA 356-2000) favour more accurate procedures (as pushover analysis) over traditional linear-elastic methods for a more thorough analysis. Recently many researchers decide how to improve, optimize and control the performance-based seismic design of structures. BAI Jilin and OU Jining combined the failure path and the probability of occurrence for plastic hinges to strengthen the columns and beams, then considered it is a feasible way to improve the seismic capacity of the frame structure. Vijayakumar A. and Venkatesh Babu D. L. analysed three existing buildings using pushover analysis, these buildings were previously designed according to Indian standards, they concluded that these buildings were inadequate in seismic performance, and they suggested before rehabilitation work, it was necessary to check the ultimate capacity of these buildings to determine the strengthening volume.

Alghamdi Farfalle et. al. The modern world demands the construction of multi-story buildings due to fast growing population and increasing urbanization. Earthquakes have a potential of causing major damages to such tall structures. Reinforced concrete multistorey buildings are modelled using finite beam elements as two dimensional or three-dimensional frames. We know that earthquake forces are unpredictable and random in nature and therefore, for doing the analysis of structures, engineering tools should be sharpened. The real behaviour of a structure can be assessed by modelling the earthquake loads and keeping in mind that the damage is expected and it has to be regulated. Load carrying capacity, mass, stiffness, ductility and damping are the main parameters as far as seismic analysis is concerned. Firstly, we perform linear analysis and structure's functionality is ensured after minor earthquakes and then we control the behaviour of structure during strong earthquakes by the help of nonlinear methods.

Venkata Ramana r. L., et. al. Vulnerability evaluation of response reduction factor of RC framed buildings by pushover analysis Vulnerability of buildings to seismic hazards is more drastic in developing countries with high seismicity, as compared to developed countries which is primarily due to the lack of seismic design guidelines. Response Reduction Factor (R) is an essential seismic design tool, which is typically used to describe the level of inelasticity expected in structure during an earthquake. The concept of R factor is based on the observations that well detailed seismic framing systems can sustain large inelastic deformations without collapse through excess of lateral strength over design strength and ductility. Developed countries like United States and Europe, defining R factor with component wise like over strength factor and redundancy factor. Where as in IS 1893 (Part-II) 2002, the R factor which is arrived at empirically based on engineering judgment and perceived earthquake damage with little technical basis. This research focuses on estimating the actual value of R factor of RC framed buildings designed and detailed following the Indian standards and comparing these values with the value suggested in the Indian code. The main focus of this study is to evaluate component wise computation of R factor and effect of number of stores on this factor using Pushover analysis. Performance level considered in this study is corresponding to global performance level (at 2% story drift) and local performance level (life safety level) whichever occurs first. From this study, it was found that Indian seismic code giving conservative R value for regular RC framed buildings as per considered performance level. Also found that overstrength factor is decreasing and ductility factor is increasing as the number of sorrels increases.

Ms. Nivedita N. Raut et. al. A large number of multi-story reinforced concrete (R/C) framed building structures inurbane India are constructed with masonry in fills for architectural, aesthetic or economic reasons. We have investigated the effect of the layout of masonry infill panels over the elevation of masonry in filled R/C frames on the seismic performance and potential seismic damage of the frame under strong ground motions using nonlinear static push-over analysis based on realistic and efficient computational models. From output non-linear analysis, we compare Base shear Nd Displacement in bare frame, in fill wall frame and ground, it seen that at roof level, displacement in bare frame is more than other two frames and displacement at ground floor in weak story is more than other two frames. Mostly hinges are formed in beam than in column

Anju yasmin antony et. al. Earthquakes are the most unpredictable and devastating of all-natural disasters, which are very difficult to save over engineering properties and life. Hence in order to overcome these issues we need to identify the seismic performance of the built environment through the development of various analytical procedures, which ensure the structures to withstand frequent minor earthquakes and produce enough caution whenever subjected to major earthquakes, so that can save as many lives as possible. There are several guidelines all over the world which has been repeatedly updating on this topic. The behaviour of a building during an earthquake depends on several factors, stiffness, and adequate lateral strength, and ductility, simple and regular configurations. The buildings with regular geometry and uniformly distributed mass and stiffness in plan as well as in elevation suffer much less damage when compared to buildings with irregular configurations. But nowadays the need and demand of the latest generation and growing population has made the architects and engineers inevitable towards planning of irregular configurations. Hence earthquake engineering has developed the key issues in evaluating the role of building configurations. One such development is the provision of special columns in buildings. Some special shapes of columns are L-shaped, Tee- shaped and cross (+) shaped which are not commonly used but gives more indoor space than commonly used shapes of column. Special shaped columns avoid prominent corners in a room which increases the usable floor area.

III. CONCLUSION

From the review of literature on, non-linear time history analysis of elevated water tank, the following conclusions are drawn: Circular elevated water tank and rectangular elevated water tank with bracings shows good response under earthquake compared to elevated tanks which have no bracings. Hexagonal bracing and circular bracing show good results under seismic response compared to square bracing. The sloshing of water does not depend on volume of water in tank but depends on staging height. The critical response of elevated tanks does not always occur in full condition, it may also occur under half condition. Sloshing response is affected from the embedment, more in case of soft soil than the stiff soil Earthquake forces decreases at container as staging height increases because structure becomes more flexible. Majority of the researchers have discussed the effect of a particular earthquake at different loading conditions. Results of field studies are also found to be negligible in literature. Behaviour of elevated water tank subjected to different earthquakes in different loading condition is found limited in literature. Future research on the non-linear time history analysis of elevated water tank

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