e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
Volume:02/Issue:05/May-2020 www.irjmets.com

STUDY OF RESPONSE OF STRUCTURE UNDER NON-LINEAR STATIC ANALYSIS: A REVIEW

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ABSTRACT

Now a days, seismic design is considered as a necessary design when it comes to design a multistory building to determine and behavior under seismic excitation forces. Pushover analysis generally gives the idea about the failure of the structure and various factors including ductility can be assessed in order to incorporate the overall performance of the structure and this method implies that the response of the structure is only controlled by the first mode, and the mode keeps constant during time history. Focusing on the pushover-analysis, it becomes important to check the non-linearity of a structure when there is an existing deficiency in seismic resisting capacity due to the omission of seismic design or structure becomes inadequate due to update in design codes. As a pushover analysis is a second stage analysis prior to general seismic analysis and its design, pushover required hinges to be defined in order to assess the approximate formation of hinges at particular displacement corresponding to base shear. Computer Aided Design software's like ETABS, Staad.Pro, SAP are effective for the approximate solution of nonlinear behavior. A review study is conducted in this article in order to incorporate facts regarding the seismic vulnerability of a structure under the variation of its structural property, loading and the structure performance for various targeted displacements and the results are discussed.

KEYWORDS: ETABS, Pushover Analysis, Moment Capacity Ratio, Performance Point, FEMA356.

I. INTRODUCTION

Pushover is a static nonlinear analysis method where a structure is subjected to gravity loading and a monotonic displacement controlled lateral load pattern which continuously increase through elastic and inelastic behavior until an unlimited condition is reached. lateral load may represent the range of base shear induced by loading and its configuration may be proportional to the distribution of mass along building height, mode shapes, or another practical means.

The pushover analysis of a structure is a static non-linear analysis under permanent vertical loads and gradually increasing lateral loads. The equivalent static lateral loads approximately represent earthquake induced forces. A plot of the total base shear versus top displacement in a structure is obtained by this analysis that would indicate any premature failure or weakness. The analysis is carried out up to failure, thus it enables determination of collapse load and ductility capacity. O a building frame, and plastic rotation is monitored, and lateral inelastic force versus displacement response for the complete structure is analytically computed. This type of analysis enables weakness in the structure to be identified the pushover is expected to provide information on many response characteristics that cannot be obtained from an elastic static or dynamic analysis. The following are the examples of such response characteristics:

The realistic force demands on potentially brittle elements, such as axial force demands on columns, force demands on brace connections, moment demands on beam to column connections, shear force demands in deep reinforced concrete spandrel beams, shear force demands in unreinforced masonry wall piers, etc. Estimates of the deformations demands for elements that have to form in elastically in order to dissipate the energy imparted to the structure. Consequences of the strength deterioration of individual elements on behavior of structural system. Consequences of the strength deterioration of the individual elements on the behavior of the structural system. Identification of the critical regions in which the deformation demands are expected to be high and that have to become the focus through detailing. Identification of the strength discontinuities in plan elevation that will lead to changes in the dynamic characteristics in elastic range. Estimates of the inter-story drifts that account for strength or stiffness discontinuities and that may be used to control the damages and to evaluate P-Delta effects. Verification of the completeness and adequacy of load path, considering all the elements of the structural system, all the connections, the stiff nonstructural elements of significant strength, and the foundation system.

II. LITERATURE REVIEW

(Al-jassim and Husssain 2018) has analyzed the structure in Basrah city in Iraq which is not prone to earthquake but has an active fault nearby which makes this area with high damage intensity with liquefaction of soil during earthquakes so the authors performed pushover analysis using capacity spectrum method described in ATC40. Three different frames having six storey was analyzed which consist of regular frame, irregularity in plan and irregularity in height. After analysis they concluded that all the models were over safe in this case and the performance points are near to the elastic state, and all hinges are in immediate occupancy hence safe for design earthquake.

(Kohrangi, Bento, and Lopes 2011) have investigated a set of four structures which consist of two frame structures and two dual frame structures. They have evaluated the need of weak beam strong column in dual frame wall structures. They have included the possibility of spreading plasticity with the inclusion of wall even if the plastic hinges were formed at the column. The comparison of these four-frame structure was done with the help of nonlinear dynamic analysis in which two sets are formed, one for frame structure and another for dual frame structure. Both the sets were designed for two cases, one case is in which only hinges were defined in beams and another on column only. They have suggested a way in which the plasticity spreading in case of hinge formation in column can increase with the help of adding structural wall in the horizontal resisting system of building. Their analysis shows that when the hinge mechanism was formed on top and bottom node of ground storey column and wall has yielded at base they structure didn't fail, or the mechanism was not formed in structure and was spreading plasticity through the column along the height. They have assumed that the wall will only fail at the bottom due overturning moment of wall. One set is further divided for two analyses one for strong beam weak column which is denoted by SB1 and another is strong column weak beam WB1 and another set with dual frame for strong beam weak column SB2 and weak beam strong column WB2. The analysis was done on Drain 2D programmed software. The results show that with the addition of wall there is uniform distribution of damage along the height. Energy dissipating capacity was batter explored by them by analyzing the displacement which results in behavior of wall as a rigid body with hinge with same inter storey drift along the height. In conclusion they have found that the hinges in beam both nodes have led to better seismic performance than hinges at column top and bottom nodes in both simple and dual frame structure. More uniform distribution of inertia forces was possible because they have followed inverted triangle distribution pattern which lead to the concentration of ductility demands in localized areas.

(Verma 2017) has researched on retrofitting of RC buildings in which they have created a model of four storey having three bays with unreinforced masonry infill walls which focuses on their weakness in seismic loading. The frame structure has strong beam weak column concept which was according to me trending at that time which exhibit poor post yield hysteresis behaviour. The unreinforced masonry wall shows cracking at a very low lateral drift of 0.3% and lose their load capacity by drift of between 1 to 2 %. The limit of 2% of lateral drift is expected for maximum lateral deformation capacity which is based upon extensive research and literature review according to author. Full scale pseudo dynamic experiment and tests was tested at European Laboratory of Structural Assessment in Ispra, Italy. At level two 30-40% of degradation of strength and stiffness was noted in concrete frame, this problem is resisted till the masonry infill wall retains its stiffness and strength.

(Ganapati and Mangalgi 2017)concluded that building with provision of floating column at corner on any floor shows the poor performance compared to other cases. Hence provision of floating columns at corner should be considered as critical case, hence special attention is needed. The analysed result shows that storey shear, displacement and storey drift increase in building with floating column as compared with building without floating column. Step back building frames gives greater values of time period as compared with step back-set back building frame with floating column located on sloping ground. In case of step back building maximum storey, displacement increases as compared to step back- set back building frames with floating column on sloping ground. It is observed that in step back-set back building on sloping ground maximum displacement decreases when compared to step back building on sloping ground without floating column. The performance of step back frames during seismic excitation prove to be more vulnerable in comparison with step back-set back building frames, hence step back-set back building frames are desirable then the step back frames. The displacement at performance point of a building with floating column is more compared to building frame without floating column located on sloping ground. The base shear at performance point of building without floating column is more as compared to building with floating column on sloping ground.

(Dey et al. 2015) This paper reviewed the earlier investigations and studies on the seismic response of different building structures under earthquake loadings successfully. The different method of pushover analysis procedure is also observed which can be utilized in various practices of structural engineering. This study led to the following conclusion: For elastic high-rise buildings the regular response spectra analysis can be reformulated as modal pushover analysis (MPA). By the pushover analysis the peak response of an elastic structure subjected to the lateral loading can be predicted. The MPA system can give the estimation of accurate seismic demand in case of unsymmetrical structures. Another study concludes, to analyse the behaviour of beam column joints and failure manner of plastic hinges can be an effective and useful approach of pushover analysis. Study says short buildings are less sensitive than tall buildings, which accomplishes in case sensitivity to residual drift the braced resistant building frames (BRBF) come first than special moment resisting frame (SMRF). The steel braced frames which has capacity of efficient energy dissipation expresses more desirable behaviour than the orthodox frames. In case of nonlinear buildings modal pushover-based scaling (MPS) method is also developed which gives the median values of story drift, plastic rotation, floor displacements etc. It is also obtained from the study that eccentric axial loading is the only reason for the unpredicted distortional buckling of the cold formed steel plate. This buckling can govern the failure of shear walls. In the regions of higher seismicity, the impact of the coupling ratio on the seismic response must check before designing the structure. Shear walls which have the higher stiffness make the dynamic analysis easier and simpler. Stiffness, strength has an effective influence in the seismic behaviour of the structure. Usually vertical irregularities have no influence on the roof displacements, but drift demand has the same. Though the consideration of shear effects and implementation of unbalanced force approach is essential for safe and realistic seismic response.

(Thakur and Chand 2019) The results concluded that the cross section of beam and column matters a lot in designing capacity-based design based on strong column weak beam concept which is systematically represented by the hinges formed during pushover analysis. The moment capacity ratio plays a major role in increasing the ductility of column and moment resistivity of column is increased as per the code guidelines. The frame follows mixed pattern in which only the bottom node of column in ground floor shows hinge formation and rest follows beam mechanism. With the increasing of storey height, the performance point and displacement also increased which implies the need of shear walls for lowering the displacement and increasing the strength of building.

(Kadukar, et.al 2018) With the change of ultimate moment ratio from 2.2 to 0.8, the ductility of structures becomes poor with reduction in ultimate moment ratio. According to analysis results, the method by adjusting the elastic inner force for RC frame cannot give a guarantee to achieve the strong column-weak beam yield mechanism. Based on Experimental and FEM analysis, Slab can change the failure pattern of structure because it contributes in resisting moments from Strong Column-Weak Beam to Weak Column-Strong Beam. Based on codal reviews, there are lot of discrepancies amongst these international codes to achieve strong column weak beam behaviour. Therefore, it’s important to study Strong Column-Weak Beam behaviour of structures.

III. CONCLUSION

1) For elastic high-rise buildings, the regular response spectra analysis can be reformulated as modal pushover analysis (MPA).

2) Study says short buildings are less sensitive than tall buildings, which accomplishes in case sensitivity to residual drift the braced resistant building frames (BRBF) come first than special moment resisting frame (SMRF).

3) Stiffness, strength has an effective influence in the seismic behavior of the structure. Usually vertical irregularities have no influence on the roof displacements, but drift demand has the same. Though the consideration of shear effects and implementation of unbalanced force approach is essential for safe and realistic seismic response.

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