International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 07 | July 2022 www.irjet.net p-ISSN: 2395-0072

Performance based seismic design of the multi-storied reinforced concrete building: A review

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Abstract - *The goal of the current project is to better understand performance-based seismic design methodology. We can more effectively design new structures and more realistically evaluate existing structures assess to the performance-based seismic design approach. Performance-based seismic design carefully assesses how a structure is likely to function under a possible earthquake threat. Identification and evaluation of a structure's performance capacity are crucial steps in performance-based design, helping to guide the many options that must be made. In this paper, a brief review is based on a multi-story RCC building with non-linear analysis and performance-based seismic design. In this project work, an attempt is made to fully understand the method and process used in the performance-based design and its implications for producing an earthquake-resistant design.*

Key Words: Performance-based seismic design, Performance objective, Non-linear static analysis, Capacity, Demand.

1. INTRODUCTION

Modern seismic design codes allow engineers to compute design forces and design displacements using either linear or nonlinear analyses. Contains four methods of analysis: linear static analysis, linear dynamic analysis, nonlinear pushover analysis and nonlinear time-history analysis. These methods deal with the design and analysis of framed constructions, primarily buildings, and bridges. For design engineers to fully apply the two nonlinear methods, advanced models and nonlinear procedures are required. In the recent past, the impact of urbanization is very common. In today's generation, the building and development of skyscrapers are much needed, but when an earthquake occurs those structures can be damaged to a very large extent. Earthquake-resistant design of building in India is carried out as per guidelines given in code IS1893:2002. According to this guideline base shear is computed based on perceived maximum seismic risk characterized by a maximum considered an earthquake, the importance of building and reduction in demand depending on perceived seismic damage of the structure. The computed base shear force is then distributed to floor levels which depend on the amount of mass present at the storey level and its height. After that, the building is examined under the lateral force vector, which provides the design forces and earthquake design moments. These forces and moments are combined with forces and moments due to dead and live loads according to load combinations to give design forces and moments in structural members. A frame building's performance during a seismic attack would be improved if it could be guaranteed that plastic hinges only occur in beams and not in columns (Beam mechanism) and that member shear strength is greater than the shear strength corresponding to flexural strength. This can be seen as the actual beginning of performance-based seismic design, where the process of design controls the building's overall performance. Iteratively, performance-based seismic design synthesis starts with selecting a performance objective, then develops a preliminary design, evaluates whether the design satisfies the performance objective, and, if necessary, redesigns and reassesses the design until the desired performance level is reached. As a result, before being constructed, such structures need to be properly analyzed and designed. Every year, an earthquake of about magnitude 3 strikes, leaving thousands of people dead or injured, thousands homeless, and reinforced concrete buildings severely damaged due to irregularities in the structure's mass and design and contradictory seismic responses. Different earthquakes occur in different places and have various intensities and magnitudes, as well as varying levels of destruction. As a result, it is important to investigate the seismic behaviour of RC structures for a variety of responses, including base shear and storey displacement. Calculating the building's seismic response requires seismic analysis, which is a step in the structural design process in areas where earthquakes are common.

2. LITERATURE REVIEW

P.S. Mehare, M. Joshi [1] studied how well buildings perform during earthquakes using performance-based seismic design. In the current study, various sets of reinforcement are made at various levels to study how well buildings perform under the influence of an earthquake. Ultimately, the best possible combination of reinforcement is given, one that is cost-effective and whose damage is minimized to achieve the desired immediate occupancy level. The second is to determine the building's performance point and to assess how the structure responded to earthquakes in terms of base shear, storey drift, spectral acceleration, storey displacement, and spectral displacements.

K.V.Ramana Reddy [2] after conducting research, an analytical study will be made to determine how Pushover analysis will react to regular and irregular structures. It is suggested that ETABS software be used to carry out the analysis for both regular and irregular structures. A variety of quantities, including time, storey displacement, storey drift, base shear, and torsion, will be determined through analysis.

T.A. Ansari, S. Jamle [3] research on the ten-story building's response to soil structure interaction with seismic loads has been compared across different soil conditions. In these kinds of situations, performance-based design principles are necessary because the seismic response of a structure depends on numerous complex factors. It is important to determine the extent of a structure's damage following an earthquake in order to ensure its safety. The study's goal is to suggest a practical and straightforward design approach that will allow designers to take the effects of the interaction between soil and structure into account when analysing earthquakes. As soil base flexibility increases, shear at the performance point increases, displacement decreases, and hinge formation gets closer to ultimate. It is found that a more detailed analysis of the building's response is possible due to the interaction between the soil and the structure in nonlinear static analysis.

D. Shinde, S. Rangari [4] presented a study that analyses of five-story RCC building for zone III using response spectrum analysis and designs the structure based on the analysis's findings. Utilizing pushover analysis in accordance with FEMA 356 and research on the behaviour of plastic hinges, the performance point of this building is assessed. Static pushover curve, displacement, and hinge status are all used to present the results. Design parameters are altered, performance is assessed, and the results are discussed in terms of percentage changes to the design parameters in order to shift the performance of the same building towards the lower side.

Suchita Hirde, Irshad Mullani [5] studied performance-based seismic design synthesis and non-linear analysis of multi-storey RCC buildings. Selecting a performance objective is the first step in the performance-based seismic design synthesis process, which then involves developing a preliminary design, determining whether the design meets the performance objective, and, if necessary, redesigning and reassessing the design until the desired performance level is reached. This paperwork will be carried out for the performance-based seismic design of the multi-story (G+5) RCC building. After the design is complete, seismic performance is studied using non-linear analysis, and the results are compared to the seismic performance of buildings built in accordance with conventional code requirements.

M. Bhandari, S.D. Bharti, et al. [6] presented the base-isolated reinforced concrete building frames for mid-rise (5-story) and high-rise (10-story) buildings were used as examples to illustrate the analysis. Peak storey displacement, maximum inter-storey drift, number of plastic hinges, SRSS of rotations of plastic hinges, maximum base shear, and maximum isolator displacement are the seismic demands that are taken into consideration for comparison.

Meena A. Bhagat [7] after conducting research is done based on the FBD, as earthquake design approaches. While the DDBD uses a specific performance target as the final test in their process, the FBD uses building displacement to assess structural performance. The design process must be recalculated if the final displacement to FBD larger is greater than the value specified by the template. Additionally, DDBD is easier to use than FBD in some situations.

Chetan Ingale and M.R. Nalamwar [8] analysed the multi-story (G+5) RCC building seismic design using performance-based seismic design. After the design is done, a non-linear analysis is carried out to study the seismic performance of the building and determine whether the chosen objective has been met or not. A nonlinear static analysis is performed using auto plastic hinges in this work (G+5) RCC building in accordance with IS code (IS 1893 (Part 1): 2002, IS 456: 2000) for zones 5, 4, and 3 for Maximum Considered Earthquake (MCE) and Design based Earthquake (DBE). The building is imported to the ETABS platform after it has been designed to perform Pushover Analysis. As per the requirements outlined in ATC 40, the Displacement controlled Pushover Analysis was completed and the Pushover Curve was obtained for the building. Using the analysis performed in ETABS 2015, the building's Capacity Spectrum, Storey Displacement, Storey Drift, Demand Spectrum, and Performance Point were found. Determine how the building will perform in various zones by comparing these results for each zone. The building constructed in accordance with Indian standards was discovered to have a life safety performance level that was significantly higher when designed based on an earthquake.

D.J. Chaudhari, G.O. Dhoot [9] presented a paper on a four-story RCC building modelled and designed as per IS 456:2000 and analyzed for life safety performance level in SAP2000 v17. The analysis is carried out as per ATC 40 to find out storey drift, pushover curve, capacity spectrum curve, performance point and plastic hinges as per FEMA 273 in SAP2000 v17. From the analysis, it is checked that the performance level of the building is as per the assumption and for performance-based seismic engineering in contrast to force-based design approaches as studied and the four building performance levels namely operation, immediate occupancy, life safety and collapse prevention were studied. In performance-based design, multi-level seismic hazards are considered with an emphasis on the transparency of performance objectives, thus ensuring better performance and minimum life-cycle cost.

Y. Pratap, P.V S. Neelima [10] In the current study, the authors have examined an effort made to understand the process and methodology used in performance-based design as well as its implications for achieving an earthquake-resistant design. For the case study, a G+4 storey commercial building that is located in seismic zone IV (as defined by IS: 1893 (part1)-2002 is taken into consideration. To calculate the building's capacity, a static nonlinear pushover analysis is used. The building is represented by a pushover curve. Based on the standards for earthquake-resistant resistant design, the building is defined by five performance levels. To achieve the desired performance level, the hinge mechanism obtained at each stage of the pushover is studied.

P. Sairaj, K. Padmanabham [11] presented a paper on a study of the economic aspects of a G+4 multi-story building built with composite braces. Different types of braced frame models are developed in this study, and their structural performance is assessed, because ductility, stiffness, inter-story drift, and lateral displacements are the major concerns in the seismic design of buildings. Geometric models are analysed using an equivalent static seismic analysis method, and the results are compared using the STRAP programme. The goal of this study is to create effective geometric models for new buildings and to provide the necessary structural configuration to prevent retrofitting of existing buildings built in earthquake-prone areas. Models with braced frames are a good way to demonstrate how ductile the structure is and how well it resists lateral loads. For seismic upgrades and retrofits of existing multi-story buildings, this concept is very helpful.

A.M. Mwafy, A.S. Elnashai [12] investigated the scaling and application of each accelerogram one at a time, along with an evaluation of the maximum response up to the achievement of structural collapse. The dynamic pushover envelopes have been developed and compared to the static pushover results with various load patterns using the findings of over one hundred inelastic dynamic analyses conducted for each of the twelve RC buildings using a detailed 2D modelling approach.

Takami Shinji, Yoshioka Kenzo, Eto Hiroaki [13] explained a seismic design approach that the authors, based on structural performance, propose for extremely high-rise reinforced concrete structures. Three building performance levels are established for three earthquake design levels that are expressed in terms of mean recurrence interval. The author's method is used to calculate the ground motions in the structural design. A frame model is used to calculate the damage level and compare it to the detailed seismic criteria that are established to estimate damages to structural members. Concrete's compressive strength is within a range of 100 N/mm2. The authors investigated whether the suggested design approach could be used to create a 60-story RC building. A frame structure and a mega-frame structure made of mega-beams and mega-columns make up its structural system. Through the trial design, the damage for each of the three earthquake design levels is below the threshold. It was demonstrated that a 60-story reinforced concrete building is feasible to design and that the suggested design approach is reasonable and logical for such tall reinforced concrete structures.

3. CONCLUSIONS

After going through all the literature, it is observed that non-linear static analysis of the tall building and RCC buildings, including regular and irregular buildings, have been done by using the pushover analysis method. Not much research has been published on the non-linear dynamic analysis i.e., time-history analysis and the use of energy dissipators for improving the seismic performance of an RCC structure. Therefore, by adding damping to the structure, it is conceivable to lessen the flexural stiffness of the structure to limit seismic base shear. Therefore, in the present dissertation work, it is proposed to carry out a non-linear dynamic analysis of an RCC structure using ETABS software to study the behaviour of RCC structure during earthquake excitations. From the results, it is concluded that storey displacement and storey drift both go on increasing with the increase of zone and are greater in MCE than DBE. Base shear increases and displacement decreases as the zone increases hence load carrying capacity increases as the zone decreases. The performance-based seismic design satisfies the criteria for immediate occupancy, life safety, and collapse prevention of building under various earthquake intensities.

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