

Performance Based Seismic Design of Building

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ABSTRACT

A performance-based design is aimed at controlling the structural damage based on precise estimations of proper response parameters. Performance-based seismic design explicitly evaluates how a building is likely to perform; given the potential hazard it is likely to experience, considering uncertainties inherent in the quantification of potential hazard and uncertainties in assessment of the actual building response. It is an iterative process that begins with the selection of performance objectives, followed by the development of a preliminary design, an assessment as to whether or not the design meets the performance objectives, and finally redesign and reassessment, if required, until the desired performance level is achieved. In this present study one R.C building symmetrical in plan (designed according to IS 456:2000) are analysed using The Displacement controlled Pushover Analysis in this we have assigned auto hinges formation as per FEMA356 in possible location. Then we have found the capacity spectrum, demand spectrum & performance point of the building.

INTRODUCTION

The multi-storey building are designed for earthquake forces which are less than the actual earthquake force corresponding to design response spectrum as a result under the stipulated design earthquake the building undergoes inelastic vibration This inelastic vibration leads to the formation of plastic hinges either in the column or beam ends. The formation of the plastic hinges with the earthquake vibration continues over the duration of the earthquake. During the oscillation a plastic hinge occurs & a reversal may take place at the plastic hinge causing it to close down Thus several plastic hinges may form & close down over the duration of the earthquake during a course of vibration maximum displacement i.e. rotation, drift etc which are caused to be obtained by performing inelastic analysis Since response spectrum method of analysis is elastic in nature the non linear behaviour of the structure during the actual earthquake remains unknown its effect is included in the design by considering ductility factor.

Performance Based Seismic Design

The performance-based seismic design process explicitly evaluates how a building is likely to perform; given the potential hazard it is likely to experience, considering uncertainties inherent in the quantification of potential hazard and uncertainties in assessment of the actual building response.

HISTORY

Performance-based design of buildings has been practiced since early in the twentieth century, England, New Zealand, and Australia had performance-based building codes in place for decades [2]. The International Code Council (ICC) [3] in the United States received a performance code available for voluntary adoption since 2001 (ICC, 2001). The Inter-Jurisdictional Regulatory Collaboration Committee (IRCC) is an international group representing the lead building regulatory organizations of 10 countries formed to facilitate international discussion of performance-based regulatory schemes with a focus on identifying public policies, regulatory infrastructure, training, and technology topics related to implementing and managing these organizations.

Advantages Of Performance-Based Seismic Design

- 1 Design individual buildings with a higher level of confidence that the performance intended by present building codes will be achieved.
- 2 Design individual buildings that are capable of meeting the performance intended by present building codes, but with lower construction costs.
- 3 Design individual buildings to achieve higher performance (and lower potential losses) than intended by present building codes.
- 4 Assess the potential seismic performance of existing structures and estimate potential losses in the event of a seismic event.

5 Assess the potential performance of current prescriptive code requirements for new buildings, and serve as the basis for improvements to code-based seismic design criteria so that future buildings can perform more consistently and reliably.

LITERATURE REVIEW

Different literature

Codes And Standards For Performance-Based Design

Ronald O. Hamburger¹, SE, SECB [7]

There have been no formal statements of the performance standards to which equivalence must be shown nor of acceptable methods of demonstrating equivalence. Therefore, design professionals taking the performance-based route were at risk of being unable to convince to the satisfaction of the authority having jurisdiction that equivalence existed. way into the building codes and their referenced standards. This paper describes some of the major milestones that have occurred in this regard.

Seac Blue Book

The Blue Book published periodically by the Seismology Committee of the Structural Engineers Association of California as the commentary to the structural/seismic design provisions contained in the Uniform Building Code was perhaps the first publication to set forth the explicit performance expectations for buildings designed to the code provisions. These performance statements were made in the form of qualitative description of the design level events, e.g. slight, moderate and major earthquakes; and equally qualitative descriptions of damage and consequences, i.e. moderate repairable damage, significant damage, etc.

PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER

In 1996, the National Science Foundation entered into a 10-year commitment to fund three national earthquake engineering research centres. One of these, the Pacific Earthquake Engineering Research Centre (PEER) adopted a theme of using performance-based engineering procedures to reduce urban earthquake hazards. Though much of the work performed at this centre focused on the behaviour reinforced concrete structures, the centre developed the reliability process contained in the FEMA/SAC guidelines into a formal framework for performance-based engineering that permits rigorous calculation of the probability of incurring various earthquake consequences based on knowledge of the seismic hazard at a site, the response characteristics of the structure, and the vulnerability of the structural and non-structural elements and systems that comprise a building.

Performance Based Seismic Rehabilitation of Non-structural Components

B. E. Kehoe¹ [9]

Little work has been focused on development of comparable procedures for non- structural Components. FEMA 356 includes provisions for evaluating non-structural components, but these provisions are based on building code procedures rather than focusing on a performance-based approach he discussed.

Robert D Hanson, Graham Taylor

The building configuration limitations imposed during this development are (1) 3 story or shorter school buildings, (2) the primary lateral deformation resisting systems (LDRS) provide acceptable life safety risk, (3) heavy partition walls have adequate restraint, (4) non-seismic elements have adequate drift compatibility, and (5) the retrofitted building must have an adequate load path from foundation to roof.

Dhileep. M et al., (2011)

Explained the practical difficulties associated with the non linear direct numerical integration of the equations of motion leads to the use of non linear static pushover analysis of structures. Pushover analysis is getting popular due to its simplicity. High frequency modes and non linear effects may play an important role in stiff and irregular structures. The contribution of higher modes in pushover analysis is not fully developed. The behaviour of high frequency model responses in non linear seismic analysis of structures is not known. In this paper an attempt is made to study the behaviour of high frequency model responses in non linear seismic analysis of structures.

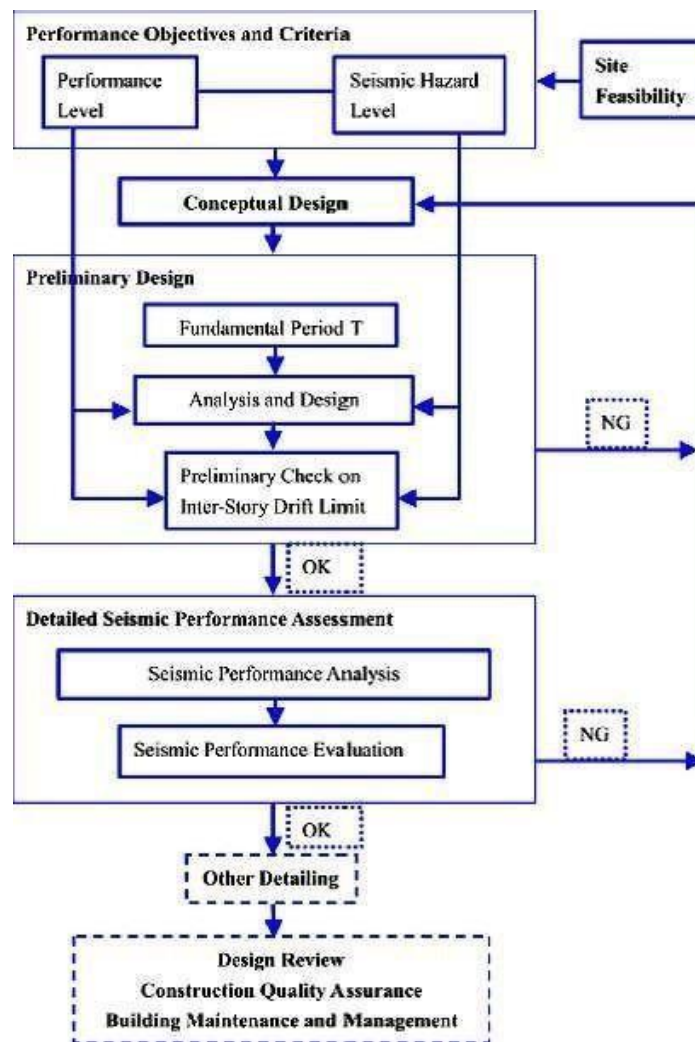


Figure 1 Performance Based Seismic Design For Buildings [6]

Select Performance Objectives

The process begins with the selection of design criteria stated in the form of one or more performance objectives. Performance objectives are statements of the acceptable risk of incurring different levels of damage and the consequential losses that occur as a result of this damage, at a specified level of seismic hazard. Since losses can be associated with structural damage, non- structural damage, or both, performance objectives must be expressed considering the potential performance of both structural and non-structural systems.

An intensity-based performance objective

Is a quantification of the acceptable level of loss, given that a specific intensity of ground shaking is experienced An example of an intensity-based performance objective is a statement that if ground shaking with a 475-year-mean-recurrence intensity occurs, repair cost should not exceed 20 percent of the building's replacement value, there should be no life loss or significant injury, and occupancy interruption should not exceed 30 days.

Develop Preliminary Building Design

The preliminary design for a structure includes definition of a number of important building attributes that can significantly affect the performance capability of the building. These attributes include:

- Location and nature of the site.
- Building configuration, including the number of stories, story height, floor plate arrangement at each story, and the presence of irregularities. Basic structural system, for example, steel moment frame or masonry bearing
- Presence of any protective technologies, for example, seismic isolators, energy dissipation devices, or damage-resistant elements.
- Approximate size and location of various structural and non-structural components and systems, and specification of the manner in which they are installed.

STRUCTURAL PERFORMANCE RANGES

Damage Control Performance Range (S-2)

Structural Performance Range S-2, Damage Control, means the continuous range of damage states that entail less damage than that defined for the Life Safety level, but more than that defined for the Immediate Occupancy level. Design for Damage Control performance may be desirable to minimize repair time and operation interruption; as a partial means of protecting valuable equipment and contents; or to preserve important historic features when the cost of design for Immediate Occupancy is excessive.

Acceptance criteria for this range may be obtained by interpolating between the values provided for the Immediate Occupancy (S-1) and Life Safety (S-3) levels.

Acceleration Time Histories

Time-History Analysis shall be performed with no fewer than three data sets (two horizontal components or, if vertical motion is to be considered, two horizontal components and one vertical component) of appropriate ground motion time histories that shall be selected and scaled from no fewer than three recorded events.

Appropriate time histories shall have magnitude, fault distances, and source mechanisms that are consistent with those that control the design earthquake ground motion. Where three appropriate recorded ground motion time history data sets are not available, appropriate simulated time history data sets may be used to make up the total number required. For each data set, the square root of the sum of the squares (SRSS) of the 5%- damped site-specific spectrum of the scaled horizontal components shall be constructed.

Purpose Of Doing Pushover Analysis

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 reinforced concrete beams, 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 behaviour 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 discontinuous 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.

Analysis & Result Using Sap2000

GENERAL

The main objective of performance based seismic design of buildings is to avoid total catastrophic damage and to restrict the structural damages caused, to the performance limit of the building. For this purpose Static pushover analysis is used to evaluate the real strength of the structure and it promises to be a useful and effective tool for performance based design.

Performance Objective

The following two-level performance objective is suggested for new ordinary structures.

Under DBE, damage must be limited to Grade 2 (slight structural damage, moderate non- structural damage) in order to enable Immediate Occupancy after DBE.

Under MCE, damage must be limited to Grade 3 (moderate structural damage, heavy non- structural damage) in order to ensure collapse prevention after MCE

Description Of Building

Building details are as follows

- Grade of concrete used is M 20 and grade of steel used is Fe 415.
- Floor to floor height is 4 m
- Plinth height above GL is 1.2 m.

- Parapet height is 1.5 m.
- Slab Thickness is 150 mm.
- External wall thickness is 230 mm and internal wall thickness is 150 mm.
- Size of columns is 500mm X 500 mm and size of beams 300mm X 450 mm.
- Live load on floor is 3kN/m² and Live load on roof is 1.5kN/m².
- Floor finishes is 1 kN/m² and roof treatment is 1.5 kN/m²
- Site located in Seismic Zone IV.
- Building is resting on medium soil.
- Take Importance Factor as 1.
- Building frame type is Special Moment Resting Frame (SMRF).
- Density of concrete is 25 kN/m³ and Density of masonry wall is 20 kN/m³

CONCLUSION

After studying all the curves and tables in the result section on push over curve I came to the following conclusion that the Pushover Analysis result show that the Building was able to achieve the performance point along X direction within the elastic limit range in case of Designed Based Earthquake Pushover Analysis is an elegant tool to visualize the performance level of a building under a given earthquake the results in this study show that Indian Standard is very conservative in its approach.

The behaviour of the frame has been observed to be linear up to the value of base shear around 208 KN. After reaching a base shear value of approximately 380 approx KN, the cracks at the base of the columns have been found to open wider and failures at other location like beams and beam – column joints started.

SCOPE FOR FUTURE WORK

The literature review and analysis procedure utilized in this thesis has provided useful insight for future application of SAP2000 for analysis. It helps in comparing the results with experimental results data. Modelling the RCC frame in SAP2000 software gives good results which can be included in future research Site specific response analysis can be carried out for more number of sites at different locations Seismic capacity evaluation of RC framed building can be carried out using site specific response spectra of different sites Program for site specific response spectrum analysis can be developed in C++ Further the work can be extended to study the effect of site specific response spectrum & acceleration time history on tall structure

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