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Performance Based Earthquake Resistance 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 analyzed 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 nonlinear behavior 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. PBSD employs the concept of performance objectives. A performance objective is the Specification of an acceptable level of damage to a building if it experiences an earthquake of a given severity A key to knowing how a building will perform in a given earthquake is having the ability to estimate the damage it will sustain and the consequences of that damage Figure 1 shows a flow chart that presents the key steps in the performance-based design process. 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

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.

LITERATURE REVIEW

SEAOC 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. While the Blue Book itself was not, initially a performance-based design document, its performance expectation statements were the model around which first generation performance-based design standards have been developed. Further, since there are few better descriptions of the expected performance of code conforming buildings available, the Blue Book statements have frequently been proposed by engineers and accepted by building officials as the criterion by which acceptable performance would be judged for alternative performance-based designs.

International Performance Code

In 2001, the first edition of the International Performance Codex was published. Published as a companion document to the model International Building Code, the International Performance Code is specifically a\written to address performance based design. It goes beyond seismic considerations and addresses performance-based design for all disciplines (architecture electrical, mechanical, plumbing, and structural) and for many types of loads (wind, snow, earthquake, fire, flood). The document sets forward minimum performance objectives for buildings of different classes then references a series of authoritative documents, FEMA 356 among them, for procedures on how to demonstrate acceptable performance. The document is noteworthy in that it is the first formal publication by a reputable model building code development agency of a performance-based design code. However, because there are no reference able procedures for many design conditions at this time, it is difficult to implement or enforce and has not yet been adopted by any significant number of jurisdictions.

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. The framework is independent of structural system or facility type and can be used with equal success to determine the performance capability of bridges, buildings, and other types of structures.

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.

Minimum Performance Requirements

There are three basic performance requirements. They are (1) the seismic risk assessment or the retrofit must meet or exceed the minimum requirements for (a) the LDRS, (b) vertical load bearing supports, (c) walls subject to out-of-plane collapse, (d) diaphragms and (e) connections; (2) all buildings not meeting these minimums will require retrofitting; and (3) all building elements that pose an unacceptable risk are assigned a priority retrofit ranking.

PERFORMANCE-BASED SEISMIC DESIGN PROCESS

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. These are based largely on the building stakeholders, namely, the building owner. It is these stakeholders that will determine the initial cost investment in design and construction, and this will drive the level of performance and the associated consequences. **PBD requires more effort in the early phases of design.**

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: 1- Location and nature of the site. 2- 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 3- Presence of any protective technologies, for example, seismic isolators, energy dissipation devices, or damage-resistant elements. 4- Approximate size and location of various structural and non-structural components and systems, and specification of the manner in which they are installed.

Damage functions

Are mathematical expressions of the conditional probability that the building as a whole, or individual structural and non-structural components, will be damaged to different levels, given that different levels of building response occur. Damage functions are generally established by laboratory testing, analytical simulation or a combination of these approaches.

Loss functions

Are mathematical expressions of the conditional probability of incurring various losses, including casualties, repair and replacement costs, and occupancy interruption times, given that certain damage occurs. They are determined by postulating that different levels of building damage have occurred and estimating the potential for injury persons who may be present as well as the probable repair /restoration effort involved.

SEISMIC HAZARD

The way that ground shaking is characterized in the performance assessment process is dependent on the type of performance objective, (i.e., intensity based, scenario-based or time based) that is being used. The simplest form of ground shaking characterization occurs when intensity-based performance objectives are used. In this case, it is only necessary to define a specific intensity of motion that the building will be designed to resist. The parameter used to describe ground motion intensity is termed an intensity measure.

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.

DESCRIPTION OF PUSHOVER ANALYSIS

The non-linear static pushover procedure was originally formulated and suggested by two agencies namely, federal emergency management agency (FEMA) and applied technical council (ATC), under their seismic rehabilitation programs and guidelines. This is included in the documents FEMA-273 [4], FEMA-356 [16] and ATC-40 [32]

Elastic response spectrum:

The 5% damped response spectrum for the (each) seismic hazard level of interest, representing the maximum response of the structure, in terms of spectral acceleration Sa, at any time during an earthquake as a function of period of vibration; T.

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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