[Volume 5 issue 11 November 2017]
PageNo.1816-1820 ISSN : 2320-7167

INTERNATIONAL JOURNAL OF MATHEMATICS AND COMPUTER RESEARCH

Performance Based Seismic Design: A Review

Harshdeep[1], Kushal Sharma[2], Sumit[3]

[1]Student at Gateway College of Engineering & Technology , Sonipat
[2]Assistant Professor at Mahavir Swami Institue of Technology, Sonipat
[3]Assistant Professor at Gateway College of Engineering & Technology , Sonipat

ABSTRACT: In the last few decades, it is observed that buildings designed using codal procedure of seismic design, doesn't achieve its best performance during earthquake. So, performance based seismic design (PBSD) philosophy comes into picture to improve performance of building during earthquake. The concept of PBSD is to provide engineers capability to design buildings that have reliable performance during earthquake. There are two methods, pushover analysis and inelastic time history, used to evaluate the performance of buildings**.**

KEYWORDS: seismic performance, pushover analysis, N2 method, displacement coefficient method.

I. INTRODUCTION

After several powerful earthquakes that caused major damage in countries with medium and large seismic activity it has been continuously working on improving methods of design.

This led to the development of performance-based engineering, whose framework explicitly addresses life-safety, reparability and functional issues (damage limitation) in building at corresponding levels of seismic motions (events). The design for seismic resistance is changing from "strength" to "performance". Thus, Performance based design is gaining a new dimension in the seismic design philosophy wherein the near field ground motion (usually acceleration) is to be considered. The performance based seismic design approach has become the future direction for seismic design codes. The basic concept of Performance-based seismic design (PBSD) is to provide engineers with the capability to design buildings that have a predictable and reliable performance in earthquake. In this approach, nonlinear analysis procedures become important in determining the patterns and extent of damage to assess the structure's inelastic behavior and failure pattern in severe seismic events.

II. PERFORMANCE BASED DESIGNED APPROACH

Performance-based seismic design explicitly evaluates how a building is likely to perform; given the potential hazard it is likely to experience, consider uncertainties inherent in the quantification of potential hazard and uncertainties in assessment of actual building response. Identifying and assessing the performance capability of a building is an integral part of the design process. It is an iterative process that begins with the selection of performance objectives. Each performance objective is a statement of the acceptable risk of incurring specific levels of damage, and the consequential losses that occur as a result of this damage, at a specific level of seismic hazard.

The goal is to minimize earthquake related costs to the building owner over the life of the building. This is done by considering a set of design objectives. The core of PBSD method is the selection of seismic performance objectives defined as the coupling of expected performance level with expected levels of seismic ground motion. The performance levels are defined:

- Operational level (O): In operational performance level, very light damages occur. Strength and stiffness has less reduction factor. Permanent drift in building occurred. Generally in operational level, displacement in building is very less, so more strength is required to sustain in earthquake. Non-structural component has less damages and other utility of the building in good working condition.
- Immediate Occupancy (IO): In this level, minor cracking allowed. Permanent drifts not allowed. Strength and stiffness has less reduction factor. The displacement in building as compare to operational level is more. Non-structural component has more damages and other utility of the building in working condition.
- Life safety (LS): Moderate cracking and some permanent drifts allowed in life safety level. Strength and stiffness reduced but no any damage to structure which dangerous to human lives. The displacement in building as compare to immediate occupancy is more.
- Collapse prevention (CP): Damages and more Strength and stiffness reductions observed in collapse prevention level but collapse not occurred. The displacement in building as compare to life safety level is more.

A performance design objective couples expected or desired performance levels with levels of possible seismic hazards.

The Structural Engineers Association of California (SEAOC) in their Vision 2000 document defines the performance objective for buildings as the buildings expected performance levels, given a certain level of expected ground motions at a specific site to define the acceptability criteria for the structure. The various performance levels along with their force-displacement characteristics are given below in Fig.1

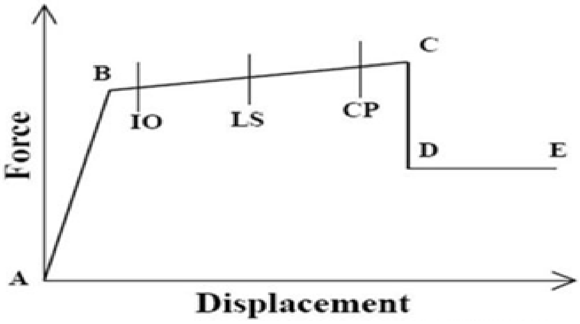

Figure 1: Structural performance level

III. PUSHOVER ANALYSIS

Pushover analysis explained in FEMA 356 and ATC 40. In this method, lateral loads applied in whole-in one shot at a particular point of the structure. In pushover analysis method, structure responses calculated by applying full force or giving target displacement, which is nothing but the 4%, of the height of the structure. Elastic analysis used to determine the lateral seismic forces, which are the reduced to inelastic design force levels by the response modification factor. The pushover analysis has mainly five methods explained in different codes.

IV. CAPACITY SPECTRUM METHOD

The nonlinear method used here to perform seismic analysis is known as N2 method. It combines the pushover analysis of a multi degree of freedom (MDOF) system with the response spectrum of equivalent single degree of freedom (SDOF) system. The method is formulated in the acceleration- displacement format, which enables the visual interpretation of the procedure and of the relations between the basic quantities controlling the seismic response. Inelastic spectra rather than elastic spectra with equivalent damping and period are applied. This feature represents the major difference with respect to the capacity spectrum method. It characterizes the seismic demand initially using a 5% damped linear-inelastic response spectrum and reduces the spectrum to reflect the effects of energy dissipation to estimate the inelastic displacement demand. The point at which the Capacity curve intersects the reduced demand curve represents the performance point at which capacity and demand are equal.

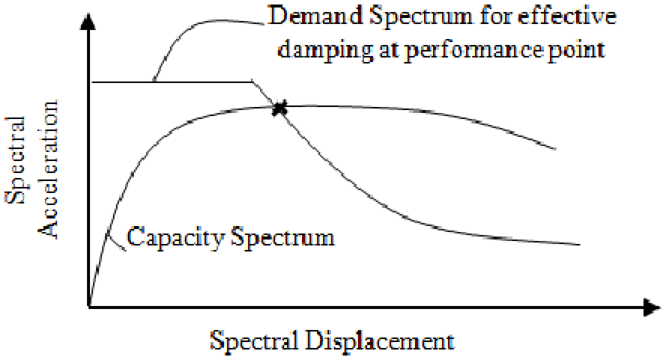

Figure 2: capacity spectrum curve

V. DISPLACEMENT COEFFICIENT METHOD

In this method, the displacement modification factors applied to the maximum deformation of an equivalent elastic single-degree-of-freedom (SDOF) system, to estimate the maximum inelastic displacement demand of the multi degree- of-freedom (MDOF) system. In the FEMA-356 document, the DCM used to characterize the displacement demand. This method primarily estimates the elastic displacement of an equivalent SDOF system assuming initial linear properties and damping for the ground motion. In this method, the demand represented by reducing the elastic demand spectra by the correction factor to the inelastic demand spectra (constant-ductility demand spectrum) which are more accurate than the elastic spectra, with equivalent viscous damping. The FEMA 356 uses the coefficient method, whereby displacement demand calculated by modifying elastic predictions of displacement demand. The FEMA 440 is improvement over the FEMA 356 in which modified coefficients used to calculate displacement demand.

VI. MODAL PUSHOVER ANALYSIS

The pushover analysis has been widely used for analyzing the seismic behaviour of any structures. However, this method has limitation, the assumption that the response of the structure is control by its fundamental mode. A multimodal pushover procedure in which the higher mode effects consider. The procedure comprises several pushover analyses under forcing vectors representing the various modes deemed to be excite in the dynamic response. As higher modes may reveal the failure mechanism not detected by the first mode, a better understanding of the structural performance considering the effect of higher modes becomes mandatory. The Modal pushover curves then plotted and converted to SDOF capacity diagrams, using modal conversion parameters based on the same shapes. Then, the response quantities are separately estimating for each individual mode, and then superimposed using an appropriate modal combination rule.

VII. INELASTIC TIME HISTORY ANALYSIS

Inelastic time history analysis is only method to describe the actual behavior of a structure during an earthquake. It is the most accurate method to predict the force and deformation demands at various components of the structure. The use of the inelastic time history analysis is limited because the dynamic response is very sensitive to the modeling and ground motion characteristics. It requires proper modeling of the cyclic load-deformation characteristics, and careful consideration of the deterioration properties of all the important components. The computation time, the time required for input preparation, and interpreting the voluminous output, makes the use of the inelastic time history analysis difficult for seismic performance evaluation. This method is based on the direct numerical integration of the differential equations of motion by considering the elasto-plastic deformation of the structural element. In this method, the equilibrium equations of motion are fully integrated as a structure is subjected to dynamic loading. Analysis involves the integration of structural properties and behaviors at a series of time steps which are small relative to loading duration. The equation of motion under evaluation is given as follows:

$mx + cx + kx = F(t)$

VIII. CONCLUSIONS

Researchers proposed several approaches in their research work for performance based seismic design. These researches show that PBSD is beneficial over conventional design methods. Inelastic time history analysis is more accurate than the pushover analysis or any methods of seismic analysis but it is less convenient than other methods.

In PBSD multi-level seismic hazards are considered with an emphasis on transparency of performance objectives. Building performance is guaranteed through limited inelastic deformation in addition to strength and ductility. This method design will insure the minimum life-cycle cost of buildings.

The seismic performance shall be verified by comparing the predicted response values with the estimated limit value of structural members and overall buildings. The basic objective of performance-based earthquake engineering is to produce structures that respond in a more reliable manner during earthquake shaking, many engineers PBEE with overall enhanced performance.

Performance-based seismic design concepts provide a suitable framework for future seismic code development. Future seismic design needs to be based on defined multiple performance objectives and associated earthquake hazard levels. That permits considerations of soil-foundation-structure systems including non-structural components.

REFERENCES

1. NEHRP, 2009, “Research Required to Support Full Implementation of Performance-Based Seismic Design”, prepared by The Building Seismic Safety Council of the National Institute of Building Sciences Washington, D.C.
2. ICC, 2001, “International Performance Code for Buildings and Facilities”, International Code Council, Whittier, California.
3. ATC, 1997a, “NEHRP Guidelines for the Seismic Rehabilitation of Buildings”, FEMA 273 Report, prepared by the Applied Technology Council for the Building Seismic Safety Council, published by the Federal Emergency Management Agency, Washington, D.C.
4. SEAOC, 1995, Vision 2000: “Performance-Based Seismic Engineering of Buildings”, Structural Engineers Association of California, Sacramento, California.
5. Fajfar, P., (2000), “A non linear analysis method for performance based seismic design”, Earthquake Spectra, Volume 16, Issue 3/573- 592.
6. ATC, (2006). Next-Generation Performance-Based Seismic Design Guidelines: Program Plan for New and Existing Buildings, FEMA 445, Federal Emergency Management Agency, Washington, D.C.
7. Computers and Structures SAP2000,“Three Dimensional Static and Dynamic Finite Element Analysis and Design of Structures”, Computers and Structures Inc., Berkeley, California, U.S.A.
8. ASCE, 2000, “Pre-standard and Commentary for the Seismic Rehabilitation of Buildings”, FEMA 356 Report, prepared by the American Society of Civil Engineers for the Federal Emergency Management Agency, Washington, D.C.

9. Bertero, VV. 1997, “Performance-based seismic engineering: a critical review of proposed guidelines”, Int. Proceedings of the International Workshop on Seismic Design Methodologies for the Next Generation of Codes. Bled/Slovenia.
10. T Paulay and N J N Priestley 1992, Seismic Design of Reinforced Concrete and Masonry Buildings, John Wiley & Sons.
11. Newmark NM & Hall WJ. 1982. Earthquake spectra and design. Berkeley: Earthquake Engineering Research Institute.
12. Federal Emergency Management Agency-356(FEMA 356); “Pre-standard and commentary for the seismic rehabilitation of buildings”.