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# A Review on Economics of Steel Structures using Performance Based Seismic Design Criterion

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**ABSTRACT:** The content of the present work is concerned with identification and quantification of strength and weakness of design practices in India and a dedicated approach for the economics of seismic resistant design of steel building structures using performance based seismic design. Main focus is the Indian condition of hazard control through better framed building structures. In this context, two structural systems: Moment resistant building frames and gravity load frames accompanied with exterior moment resistant frames have been modeled for the specified boundary conditions.

**KEYWORDS:** Steel structure, Performance based seismic design, Life cycle, Cost ratio, Economic evaluation.

## I. INTRODUCTION

Performance objectives are associated with the acceptability of damages with a certain level of seismic hazard. The cost of the structure is being controlled through the level of performance objectives. The role of structural system with the types of the construction materials is of vital important for a reliable PBS. Because of low weight with sufficient strength and stiffness steel building structure has been found suitable to take care of the uncalled seismic demand under varying earthquake ground motions.

On 19<sup>th</sup> September 1985, a major earthquake of magnitude 8.1 occurred, with an epicenter located in Zacatula city, about 350 km from Mexico City, in the south of Micoacan State, Mexico. More than 100 steel buildings were subjected to this earthquake. Among them, 59 buildings were built after 1957, having 7 to 22 stories. This was the first type of verification of the behaviour of the steel structures during a strong earthquake, showing generally a bad performance. The Northridge earthquake of January 17, 1994 at 4:31 a.m. in California, U.S.A., of magnitude 6.7 challenged the well accepted concept of steel as earthquake resisting structure. Following this earthquake, a number of steel moment-frame buildings were found to have experienced brittle fractures of beam-to-column connections. The damaged buildings were of heights varying from one storey to 26 stories and ages of some buildings of 30 years.

The Kobe earthquake, Japan, of January 17, 1995, resulted into collapse of 1,00,000 buildings, caused heavily damage in 90,000 buildings and light damage in 1,50,000 buildings. Out of these buildings, many were steel buildings and most of these suffered beam-to-column fracture.

Performance based seismic design (PBS) developed in the nations known for their leadership in the earthquake resistant design emerged to take care of the damages in the construction practices in India [1-4]. The more important issue is to focus on characteristics of source of demand because no two natural disasters are found having the same effects in the past seismic activities; therefore, their probable effects have been the subject of the concern with the evolution of computer systems with software facility. Extended three dimensional building systems have been used for modeling and simulations under the prescribed loading conditions. RAM Perform 3D, Section Builders has to be further used for the procurement of requisite data base for the accomplishment of validation of the economics of the building structures as and when needed. Controlling behavior of the referred building frames using the concept of transmissibility ratio from one component to the other for desirable mode of action, which is a task in due course of this study. Keeping in view of the background and the present state of art in this area, the main objectives of the present work may be summarized as: (i) To assess the Indian condition of design practices for the seismic resistant design (ii) To ascertain the feasibility of the PBS of the selected structural system in particular and formulation of the present study in this regard in general (iii) To assess the seismic hazards as the basic attributes of problem formulation.



## II. NEED OF PERFORMANCE BASED EARTHQUAKE ENGINEERING

The conventional method of design is based on ensuring that the strength capacity of structural members is greater than the load demand on these members. This method is entirely suited for design against gravity loads and wind loads. However, for earthquakes, a different design philosophy relying on ductile nonlinear behaviour is to be considered. For design of multi-storeyed buildings, building codes recommend the use of response spectrum method, which being based on mode superposition, is only valid for linear behaviour. Performance based seismic design is the modern approach to earthquake resistant design of structures. It implies design, evaluation and construction of engineering structures whose seismic performance meets various economic and safety needs of owner and society. This approach is aimed to improving decision making about seismic risk by choosing the performance goals. This process implies a shift towards a more scientifically oriented design approach with an emphasis on accurate characterization and prediction that employs a higher level of technology than that has been used in the past. The adoption of performance based seismic design requires significant change in current structural engineering and building development practice. It requires the selection of performance objectives for the different classes of structures, development of different analytical procedures as well as direct communication between the engineer and the building users. Finally, the structural engineer will have greater involvement in the overall site selection, buildings layout and conceptual design processes as well as substantially increased oversight of the design and installation of all systems necessary for adequate seismic resistance. A Performance level is described by the physical damage within the building, the threat to life safety of the building's occupants due to the damage and the post earthquake serviceability of the building. These depend on the damage sustained by structural and non-structural members. Structural members are those that carry the gravity and the lateral loads. Other members that do not carry loads are classified as non-structural members. The damage of non-structural members affects the life safety, occupancy and cost of repair. Therefore, the performance of both the structural and non-structural members is considered in PBEE.

## III. ECONOMIC EVALUATION OF PERFORMANCE BASED SEISMIC DESIGN

Benefit and Life Cycle cost ratio is deciding factor for decision making for selection of performance objectives as first task during implementation of seismic design philosophy under the banner of PBSB with the constraint that the life cycle cost is determined considering the cost of death, damage and downtime payment at the post-earthquake event. Hence, therefore, it is pragmatic that damage control under varying earthquakes have been the major concern of seismic resistant design and are the preamble of the concerned seismic design codes. However, only one performance, namely life safety has been in practice. With the developed economy, the Indian construction practices are fully acknowledged for the new technology with better seismic resistant materials. Insurance companies are taking keen interest for the risk coverage for the natural disasters, which may be liable in the life of structure. Further, the know how techniques due to various programs organized throughout the nation is fully enriched for present and future application of seismic resistant design under the banner of performance based seismic design.

## IV. METHODOLOGY

In this study, evaluation of the base shear is being carried using the base shear and seismic weight relation. Steel building frameworks is designed through modeling and simulation using the background of ETABS and the same building structures were assigned the boundary conditions of PBSB using the guidelines of FEMA's.

$$\text{Transmissibility Ratio (T.R)} = \sqrt{\frac{1 + [2\delta(\frac{\omega}{\omega_n})]^2}{(1 - (\frac{\omega}{\omega_n})^2)^2 + [2\delta(\frac{\omega}{\omega_n})]^2}} \quad (1)$$

Transfer of seismic demands has to be controlled through managing damping ratio, forced frequency, and natural frequency in the proportion as mentioned in the above equation.

A series of Nonlinear Static Pushover and Nonlinear Time History is/may be carried out in RAM PERFORM 3D using nonlinear 3D space model for the steel buildings.



## V. CONCLUSION

The scope of the study is limited for some structural systems based on the generalized issues. However, the findings of this study is to be used for further investigations in the light of present study and future infra structure development as is daunting task before engineering community to accept the challenges by the natural disasters in the recent past. Let us understand the ongoing Earthquake disaster mitigation and management through such a kind of innovative research programme.

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