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INTRODUCTION TO THE SPECIAL THEME SESSION ON SEISMIC DESIGN CRITERIA

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ABSTRACT

An overview is presented of design and performance issues discussed in the papers of the Special Theme Session on Seismic Design Criteria.

KEYWORDS

Seismic design, performance based design, inelastic behavior, design spectra, overstrength, reliability, MDOF modifications.

INTRODUCTION

Earthquake resistant design is undergoing a continuous metamorphosis. For many years it consisted of the use of a single lateral load coefficient and the implementation of detailing rules in an elastic design process. In seismic codes one or more performance goals were spelled out, but it was difficult to establish the relationship between these goals and the design process. In most cases a single design level was utilized to fulfill the performance goals, even if more than one goal was specified. The consequence is that engineers have great difficulties explaining to owners what they are buying for minimum code protection and for additional protection that goes beyond the life safety concern expressed in most codes. The general belief is, or was, that explicit code design for life safety provides also adequate protection. for other performance levels that may have to do with damage control or continuing operation of a facility.

There is broad agreement that changes in the seismic design process are needed to fulfill the needs of owners and of society. This demand for changes is driven by several motives, perhaps most important being the realization that present code design procedures often cannot be rationalized sufficiently by first principles to satisfy (a) the designer's desire for a logical explanation of the rules of the game, (b) the owner's desire for a quantitative assessment of the costs and benefits of earthquake protection, and (c) society's needs for informed decision making in the face of uncertain (and often unknown) seismic demands and equally uncertain (and often unknown) seismic capacities of existing and even new man-made construction. Moreover, the realization from recent earthquakes in the U.S. and Japan that monetary damage can surpass expectations by a large amount points out the great importance of damage control. These and other motives, together with recent advancements in knowledge on earthquake occurrences and ground motion and structural response characteristics, set the stage for drastic changes in seismic design procedures.

This Special Theme Session has been organized to promote an international dialogue on critical issues that will shape the future of seismic design methodologies. The purpose is not only an exchange of information, but more so an invitation to find and focus on concepts and ideas that are sufficiently universal to permit implementation on a worldwide basis. Earthquakes don't know boundaries, and neither do basic needs of society. Differences in priorities can always be accounted for in the implementation process, provided that the common concepts are sufficiently general and flexible to permit accommodation of local preferences.

The framework for a unified seismic design approach could be rooted in performance based design. Paraphrasing from Professor Bertero's paper, performance based design implies that at specified levels of ground motion, and with defined levels of reliability, the structure and its content will not be damaged beyond specified limit states. Implicit in this definition is the recognition of several limit states, ranging from damage prevention to collapse, which have to be considered explicitly in the design process. Society has responsibilities in addition to life safety and collapse prevention, including continuing operation of critical facilities, protection against the discharge of hazardous materials, and protection against excessive damage that may have far-reaching consequences for society on a local, regional, national, or international level. Moreover, educated owners want options for maximizing the return on their investment or for providing life safety protection to the inhabitants of their facilities beyond the minimum required by society. These options differ between developers and, for instance, corporate owners whose livelihood may depend on the resumption of operation soon after an earthquake. Implicit is also the concept that the cost of earthquake protection and of expected losses must be quantifiable to provide the tools for cost/benefit analysis. This in turn necessitates life-cycle considerations since costs and benefits should be evaluated over the life span of a facility. In general, performance based design provides the opportunity to society and owners to chose performance goals, and it compels the designer to formulate and implement a design process that fulfills the stated goals.

Several of the papers in this session address general philosophical issues of performance based design, including reliability aspects and conceptual behavior issues at various performance levels. Many of the papers focus on low performance levels concerned with life safety and collapse prevention. These levels receive much attention because of the need to explicitly consider inelastic behavior with all its complexities of predicting seismic demands, formulating a conceptual design procedure that incorporates inelastic concept, and implementing an evaluation procedure in which inelastic demands and capacities need to be assessed with adequate accuracy. Several papers focus on the behavior of inelastic SDOF system whose inelastic strength and displacement spectra, or elastic spectra together with strength reduction factors, can be used as baseline information for the design of MDOF structures. MDOF modifications and code implementations for the design of new structures and the retrofit of existing ones are also discussed.

The message coming through in the papers is that performance based design for multiple performance levels is a desirable and viable concept, but that much research and development is needed before such a design can be implemented. At this time neither imposed demands and acceptable capacities can be evaluated with confidence. There is a scarcity of formulated procedures for predicting seismic demands at the low performance levels and an even greater scarcity of quantitative data on acceptable capacities at all performance levels. The latter scarcity is particularly notable at the high performance levels concerned with damage control and continuing operation since little attention has been paid to these performance levels in the past.

Another message coming through in the papers is that more advanced concepts will have to be incorporated in future design procedures. It must be understood, however, that implementation of advanced concepts is constrained, and rightfully so, by the needs of the profession to keep the design process simple and verifiable in the interest of the public, which must be protected not only from earthquakes but also from consequential design errors. Thus, there needs to be an emphasis on simplifications that make the process feasible and attractive to the engineering profession. This can be achieved only if due consideration is given to the constraints under which the structural engineering profession operates. Structural engineers are not researchers and their activities are driven by the need to deliver in a timely and cost effective manner. They may also be resistive to new concepts unless these concepts are put into the context of their present mode of operation, and the required information is delivered in a ready-to-use package together with tools that facilitate implementation.