
Preface

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After visiting areas affected by major natural and manmade disasters during the past several years in the U.S. and abroad, the authors of this report identified a need to consider the development of multi-hazard design principles and guidelines for highway bridges. They began by reviewing existing information with the aim to expand the methods and approaches established in earthquake engineering. During the past two years, a number of exploratory studies have been carried out to define a potential research project that may be accomplished within a period of several years with a moderate but reasonable budget. These pilot studies included the following:

1. Understand the physical conditions of existing bridges and current methods of bridge design, retrofit and inspection.
2. Identify current philosophical approaches to handle multi-hazard (extreme events) load effects on highway bridges.
3. Perform scenario studies of possible damage in a typical highway bridge model due to various extreme hazard loadings.
4. Explore various means to compare some extreme hazards and their load effects.
5. Examine the suitability of using the return period as the basis for comparing different hazards.
6. Conduct uncertainty analysis of extreme hazard models.

The studies revealed the complex nature of establishing multi-hazard design principles and guidelines for highway bridges, since there are so many interrelated parameters to be examined within many different contexts for consideration of importance and priorities. Furthermore, there is insufficient information on hazard occurrences and their load effects on the capacity of bridges, such as damage data, etc. In order to begin to establish a research agenda, the authors organized a special workshop attended by a variety of experts including experienced designers, stakeholders, code authors and researchers. The participants offered their views and opinions on key issues and principles in the multi-hazard design of highway bridges from their unique perspectives. Their papers comprise this report and the central thoughts of these contributions are summarized as follows:

Chapter 1: Importance of and need to pursue a study to establish multi-hazard design principles and guidelines.

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- Chapter 2: The view of an experienced bridge designer advocating that emphasis be given to simplicity, relevance and the need to consider risk from a uniform perspective.
- Chapter 3: The view of an owner and stakeholder that uniform risk-based considerations of extreme events need to be considered. However, mitigation approaches must be developed within the context of normal loadings and functions of bridges.
- Chapter 4: Based on two years of preliminary study, the authors present a case for developing a platform for evaluation, comparison and quantifying extreme hazard events as the first important step toward the establishment of multi-hazard design principles.
- Chapter 5: An approach is proposed to first establish a probability-based seismic hazard table for decision-making, which adopts a design principle by comparing performance with risk, and then expand it to include other extreme events. The table would contain information such as the probability of hazard level vs. vulnerability of bridge and performance (e.g., likely level of collapse).
- Chapter 6: A case study is presented to illustrate the challenges in establishing design principles to predict uncertain future extreme hazard load effects for which only limited historical data is available.
- Chapter 7: This chapter provides an illustrative example on developing simplified design guidelines based on extensive research efforts on LRFD-based earthquake resistant design of highway bridges.
- Chapter 8: This chapter articulates a need to establish a comprehensive bridge failure database on all types of hazards, based on the experience and conclusions of the preliminary studies.
- Chapter 9: The summary outlines a possible roadmap based on the results of the preliminary studies and views of the experts expressed in this volume.

While design against multiple hazards is a complex issue, it is only a small component in the total landscape of bridge engineering design practice, which has well-established codes and specifications based on years of experience and scientifically-based studies. Many concerns and key issues have been raised in the papers presented herein. However, this report should not be viewed as a text that provides answers on multi-hazard load effects to the bridge design community. Instead, its purpose is to provide valuable input to the research community to help plan and design a research program.

We plan to pursue the research path identified from the discussions and the expert advice received at the workshop, and are anticipating that this report will be the first in

a series dedicated to the issues and challenges facing the bridge community in the design of bridges against multiple hazards. Future volumes will address this topic in greater detail, and will include a variety of contributors, such as members of AASHTO T-3, FHWA, MCEER, and other key professionals. “Progress reports” on MCEER research related to this subject will also be included.