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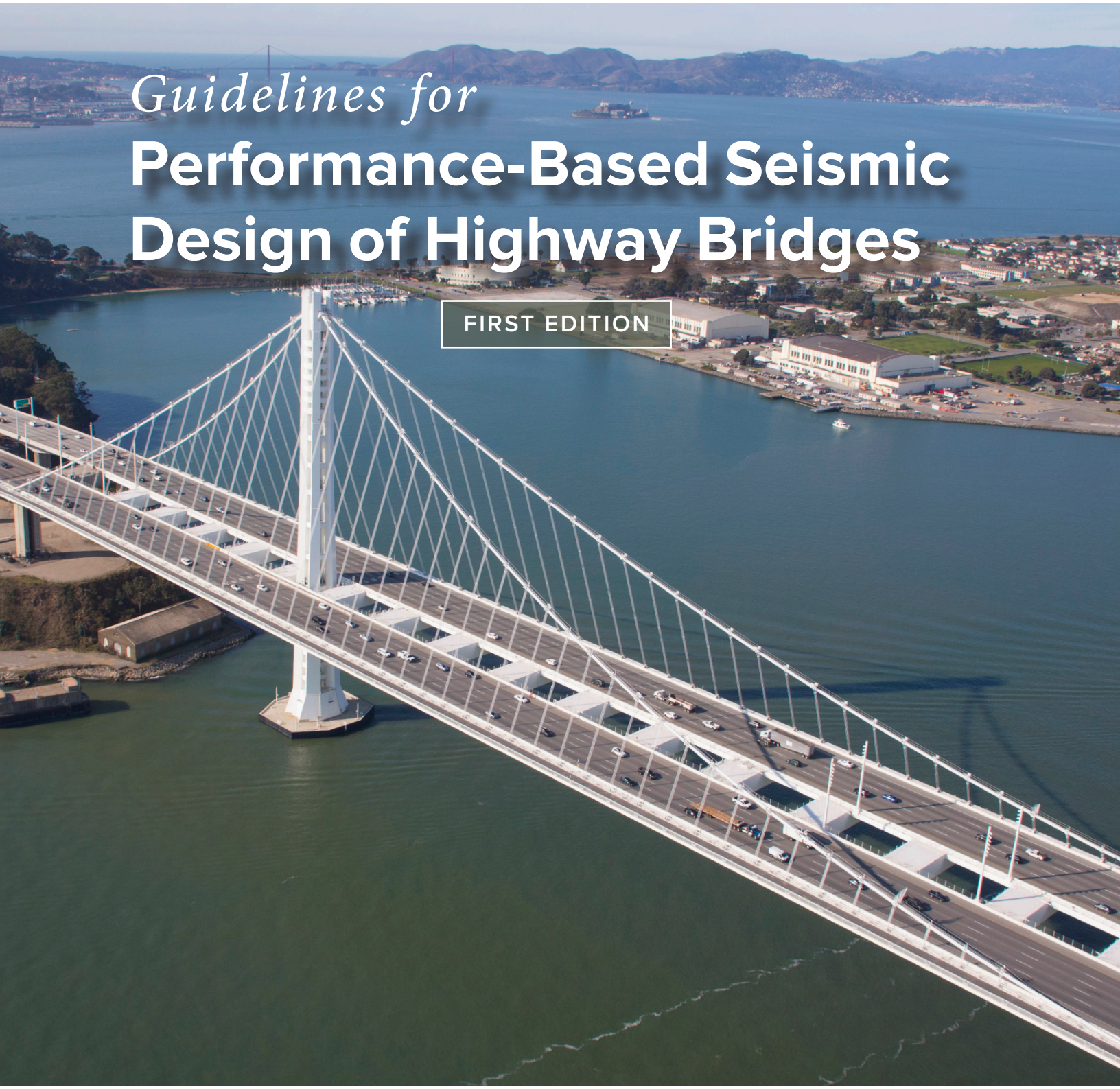

Guidelines for

Performance-Based Seismic Design of Highway Bridges

FIRST EDITION

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SECTION 1
INTRODUCTION

1.1—INTRODUCTION

The concept of life safety design for seismic performance, as implemented in the *AASHTO Standard Specifications for Highway Bridge Design,* and later the *AASHTO LRFD Bridge Design Specifications* and the companion *AASHTO Guide Specifications for LRFD Seismic Bridge Design* (*LRFD Seismic Bridge Design*), has resulted in a dramatic improvement in the performance of bridges during seismic events and has fulfilled the goal of limiting loss of life due to bridge failure. However, as the understanding of seismic bridge performance has improved, there is a need to allow for differing levels of bridge performance during a seismic event, depending on the needs of the Owner and the larger community of bridge users. These Guidelines represent the first implementation, on a national level, of Performance-Based Seismic Design (PBSD) for bridges in the United States. The goal of these Guidelines is to provide Designers and Owners with a methodology for selecting the appropriate level of performance for a given bridge and implementing a design process that will reasonably result in achieving that level of performance under the design ground motions.

The intended use of these Guidelines is as an adjunct to *LRFD Seismic Bridge Design* for the design of new bridges. The minimum requirements of *LRFD Seismic Bridge Design,* based on the life safety performance goal, still apply, and bridges within the scope of those requirements and designed using PBSD still must meet those requirements. Bridges outside the scope of *LRFD Seismic Bridge Design* should be designed using project-specific criteria established in conjunction with the Owner and peer review.

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SECTION 2
MOTIVATION

2.1—MOTIVATION

The motivation behind performance-based seismic design of bridges (PBSD) is to provide Owners and Designers with a better way to influence the performance of a bridge during an earthquake. The current provisions of the *AASHTO Guide Specifications for LRFD Seismic Bridge Design* provide for only one level of performance, that of life safety at a single hazard level. For a variety of reasons, including the importance of a bridge to post-event recovery, economic impacts resulting from closure, and the cost of repair or replacement after an earthquake, Owners need more options for specifying bridge performance objectives at various seismic hazard levels, and Designers need guidance on how to achieve these goals in a reliable way. Satisfying these two requirements is the purpose of PBSD.

Full PBSD allows Owners and Designers to make informed decisions using metrics beyond engineering-based strains, rotations, and displacements. Such metrics can be based on impacts and risks to the public and stakeholders that include direct and indirect losses, cost of construction, cost of repair, and estimates of downtime.

To achieve the goal of full PBSD, the design engineer must be able to characterize the:

1. Seismic hazard at the site for a range of potential ground motions due to the tectonic setting of the region;
2. Structural response of the bridge to these motions;
3. Potential damage to the bridge due to these motions, which may be nonlinear and inelastic; and
4. Potential for loss, which can be expressed in terms of time, resources, or human injury.

With the ability of the Designer to move from earthquake ground shaking through structural response to loss, as illustrated in Figure 2.1-1, decisions can be made regarding the level of structural resistance that must be provided to achieve a potential loss limit state. As with non-seismic loading, it would be ideal to characterize the process from loading through to loss, in a fully probabilistic manner. However, the state-of-the-art and practice is not yet sufficiently advanced to address PBSD probabilistically, and thus deterministic methods are used in these Guidelines. Likewise, the state-of-the-art for linking engineering design parameters (EDPs) to loss metrics, such as construction and repair costs, downtime, and injuries, is immature and not included in the methodology described in the next chapter. Nevertheless, the introduction of EDPs is a significant step forward towards implementation of PBSD. But full probabilistic PBSD is out of reach at this time.

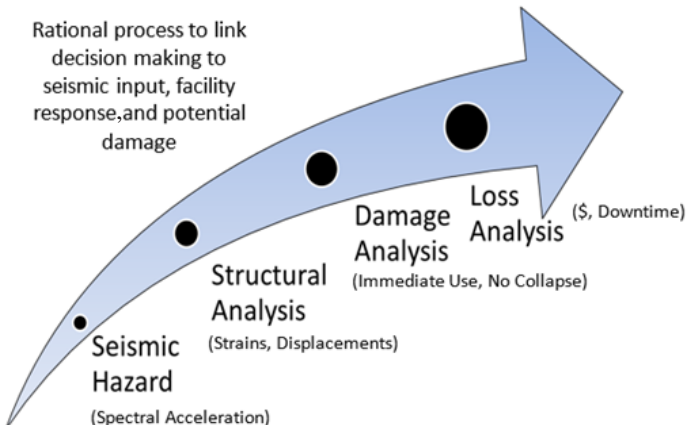

Figure 2.1-1—PBSD Decision-Making Process

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