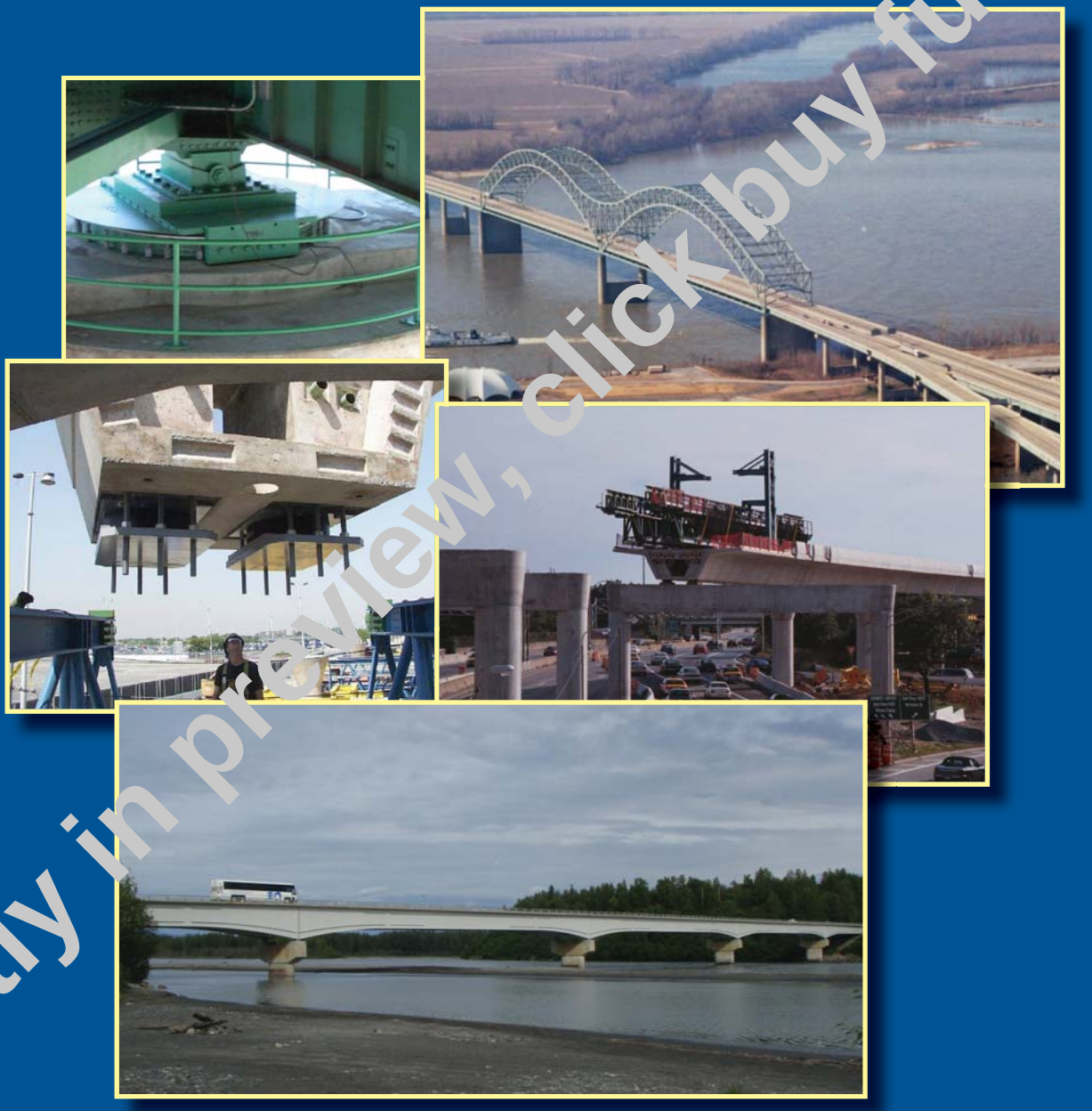
Guide Specifications for Seismic Isolation Design

Third Edition • July 2010



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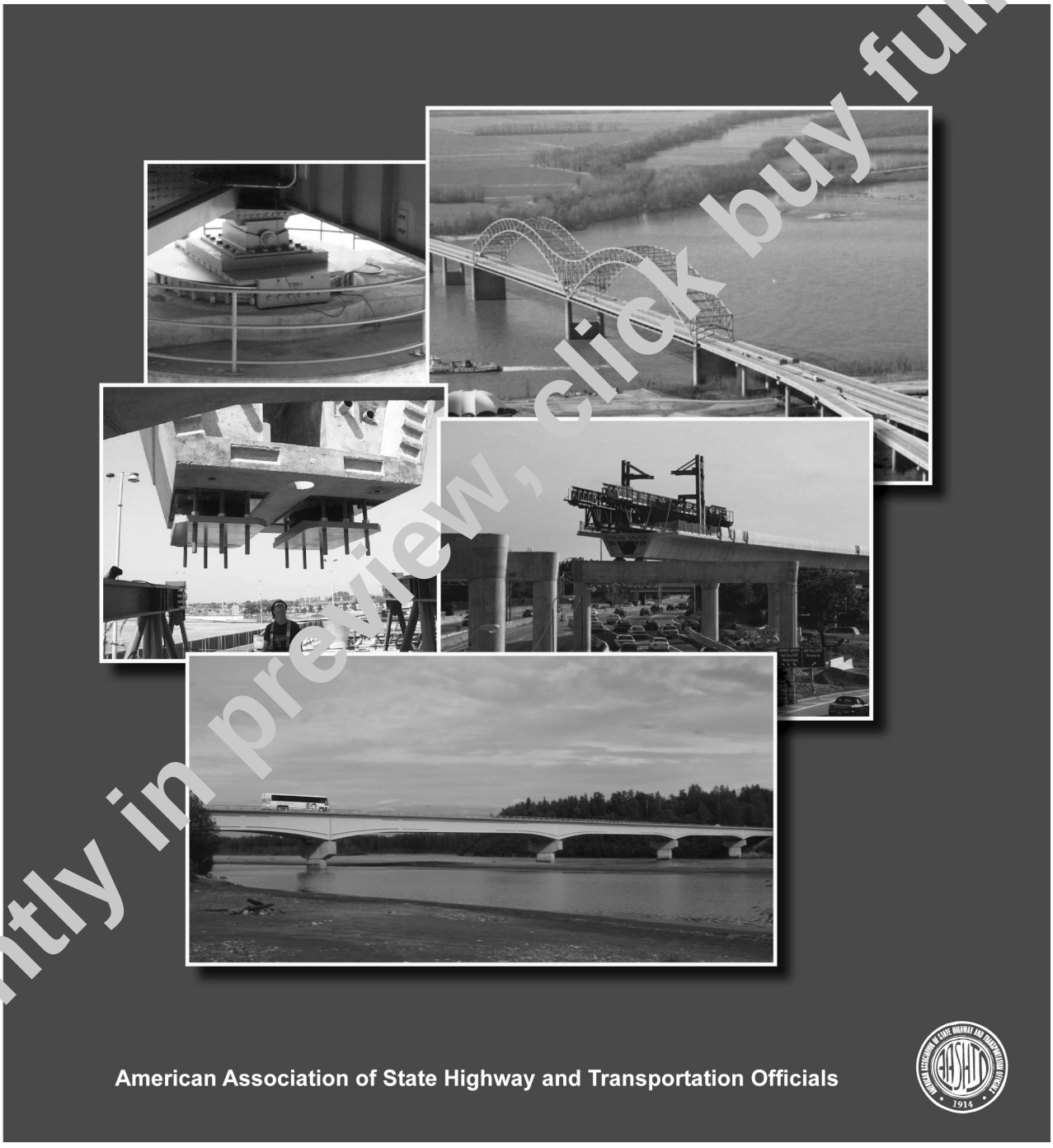

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PREFACE TO THE SECOND EDITION, 1999

In 1995, the American Association of State Highway and Transportation Officials (AASHTO) Subcommittee on Bridges and Structures charged the new T-3 Seismic Design Technical Committee with the task of modifying the 1991 *Guide Specifications for Seismic Isolation Design*. To perform this task, the T-3 Seismic Design Technical Committee formed a task group of three state bridge engineers, three industry representatives, three professors, and one Federal Highway Administration representative. The task group developed the new specifications by considering the current state of practice, results of completed and ongoing technical efforts, and research activities in the field of seismic isolation.

The new Guide Specifications for Seismic Isolation Design contains the following modifications:

- Numerous stylistic changes and additional commentary that make these Guide Specifications consistent with those presented in AASHTO's *Standard Specifications for Highway Bridges, 16th Edition* (hereafter referred to as Standard Specifications).
- Changes in the methods of analysis and, in particular, the uniform load method. This method now accounts for the substructure flexibility. Moreover, some guidelines are provided for analyzing of isolated bridges with added viscous damping devices.
- The single requirement for sufficient lateral restoring force has been changed to two requirements. Of these, the first (lateral force at the design displacement must be at least $^{w}/_{80}$ greater than the lateral force at 50 percent of the design displacement) is provided in order to accommodate imperfections in isolator installation. The second (a requirement on the period based on the tangent stiffness at the design displacement) is provided in order to prevent (1) extreme sensitivity of the displacement response to the seismic input details, (2) the development of cumulative displacement and of significant permanent displacement, and (3) the development of negative stiffness due to column rotations.
- The response modification factors (R-Factors) have been reduced to values between 1.5 and 2.5. This implies that the ductility-based portion of the R-Factor is unity or close to unity. The remainder of the factor accounts for material overstrength and structural redundancies inherent in most structures. The specification of lower R-Factors has been based on the following considerations:
  - Proper performance of the isolation system.
  - Variability in response given the inherent variability in the characteristics of the design-basis earthquake.

  The lower R-Factors ensure, on average, essentially elastic substructure response in the design-basis earthquake. However, they do not necessarily ensure either proper behavior of the isolation system or acceptable substructure performance in the maximum capable earthquake (e.g., described as an event with ten percent probability of being exceeded in 250 yr). Owners may opt to consider this earthquake for the design of important bridges. The California Department of Transportation currently uses this approach for the design of isolated bridges.
- Details are provided for the design of sliding isolation bearings. The increasing number of applications of sliding bearings since the publication of the 1991 Guide Specifications made this addition necessary.
- A procedure for determining bounding values of isolator properties for analysis and design is included. This procedure is based on determining system property modification factors, termed the λ-factors, which multiply the nominal design values of isolator properties. The system property modification factors account for the effects of temperature, aging, travel, contamination, and other conditions.

PREFACE TO THE THIRD EDITION, 2010

This 2009 Edition of the *Guide Specifications for Seismic Isolation Design* updates the 1999 Edition by addressing major changes in the way seismic hazard is now defined in the United States, as well as changes in the state of the art of seismic isolation design for highway bridges. This Edition is based on the work of NCHRP Project 20-7, Task 262.

In summary, this revised edition reflects (a) changes in the definition of the seismic hazard as now defined in the AASHTO *LRFD Bridge Design Specifications* (hereafter referred to as the Design Specifications) and the *Guide Specifications for LRFD Seismic Bridge Design* (hereafter referred to as LRFD Seismic), (b) designer experience in the last 10 yr with the implementation of the current specifications, (c) industry trends in the design and construction of isolators, (d) the sun-setting of the AASHTO *Standard Specifications for Highway Bridges*, and (e) provisions in the Design Specifications that impact the design and testing of isolation bearings, such as in Section 14, Bearings and Expansion Joints. Major changes therefore include:

1. The seismic hazard section has been updated to be compatible with the Design Specifications and LRFD Seismic. Previous Section 3, Acceleration Coefficient, and Section 5, Site Effects and Site Coefficients, have been collapsed into a new Section 3, Seismic Hazard, to make way for a new Section 4, Design Response Spectrum, after moving seismic performance categories to Section 5. This new section presents the design spectrum in a new figure (taken from the Design Specifications and LRFD Seismic), and is used to define spectral accelerations S_{DS}, and S_{D1}. There is one exception to the general rule of compatibility with the Design Specifications. Design Specifications Article 3.10.2 requires a site-specific procedure be used if "long-duration effects are expected in the region." This provision is not in LRFD Seismic and has not been included in these Guide Specifications (Article 3.1).

2. The requirement that the acceleration coefficient (A) for the design of isolated bridges shall not be less than 0.1, has been deleted (Article 3.1).

3. Eq. 3 for displacement, d, (now Eq. 7.1-4) has been changed to be a function of S_1 rather than peak ground acceleration (A) since maps of S_1 are now available. At the same time the site coefficient in the expression for d was updated from S_i to F_v, and the dual units expression has been replaced with one that is independent of the unit of measurement.

4. The previous Table 7.1-1 for the Damping Coefficient B (now labeled B_L), has been replaced by an expression directly relating B_L to the viscous damping ratio ξ. The values for B_L given by this expression, are almost identical to those in Table 7.1-1 over the full range of ξ. The advantage of the expression, however, is that it avoids linear interpolation to find B_L for values of ξ that are not listed in the Table.

5. Eqs. 20 and 21 for the shear strain in a bonded layer of elastomer due to a compressive load, have been replaced by a single equation (Eq. 14.7.5.3-1) that is applicable over the full range of shape factors. This equation is consistent with the recently revised provisions in the Design Specifications for steel-reinforced elastomeric bearings (Design Specifications Article 14.7.5). Likewise, the expression for shear strain due to rotation in Eq. 24 (now Eq. 14.7.5.4-1) has been updated to be consistent with the Design Specifications provisions.

6. The non-seismic requirements for elastomeric bearings (i.e., service limit states) in Design Specifications Section 14 have recently been updated and the corresponding provisions in these Guide Specifications (Article 14.3) now reference the Design Specifications.

7. Some testing requirements for isolation hardware have been deleted or relaxed, if they were judged to be redundant, no longer necessary based on experience with current isolator manufacturers, or unrealistically burdensome and no longer serving a useful purpose.

8. Additional commentary is given to clarify such terms as *design displacement*, which is used for calculating the effective stiffness of an isolator, and *total design displacement* (TDD), which is used for design and specifying the testing requirements for an isolator.

9. Editorial updates/corrections have been made to ensure compatibility with the style and format of the Design Specifications as far as possible. All references to the Standard Specifications have been replaced by corresponding references to the Design Specifications and, where appropriate, to LRFD Seismic.

10. The uniform load method of analysis (Article 7.1) has been renamed the simplified method to better reflect the nature of the method and avoid confusion with the uniform load method given in the Design Specifications and LRFD Seismic.

11. Portions of Article C7 have been determined to be more appropriate to Article 8.1.2 and have been moved accordingly. Portions of Article C7.1 contain mandatory language and have been moved to Article 7.1 in this edition of the Guide Specifications.

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