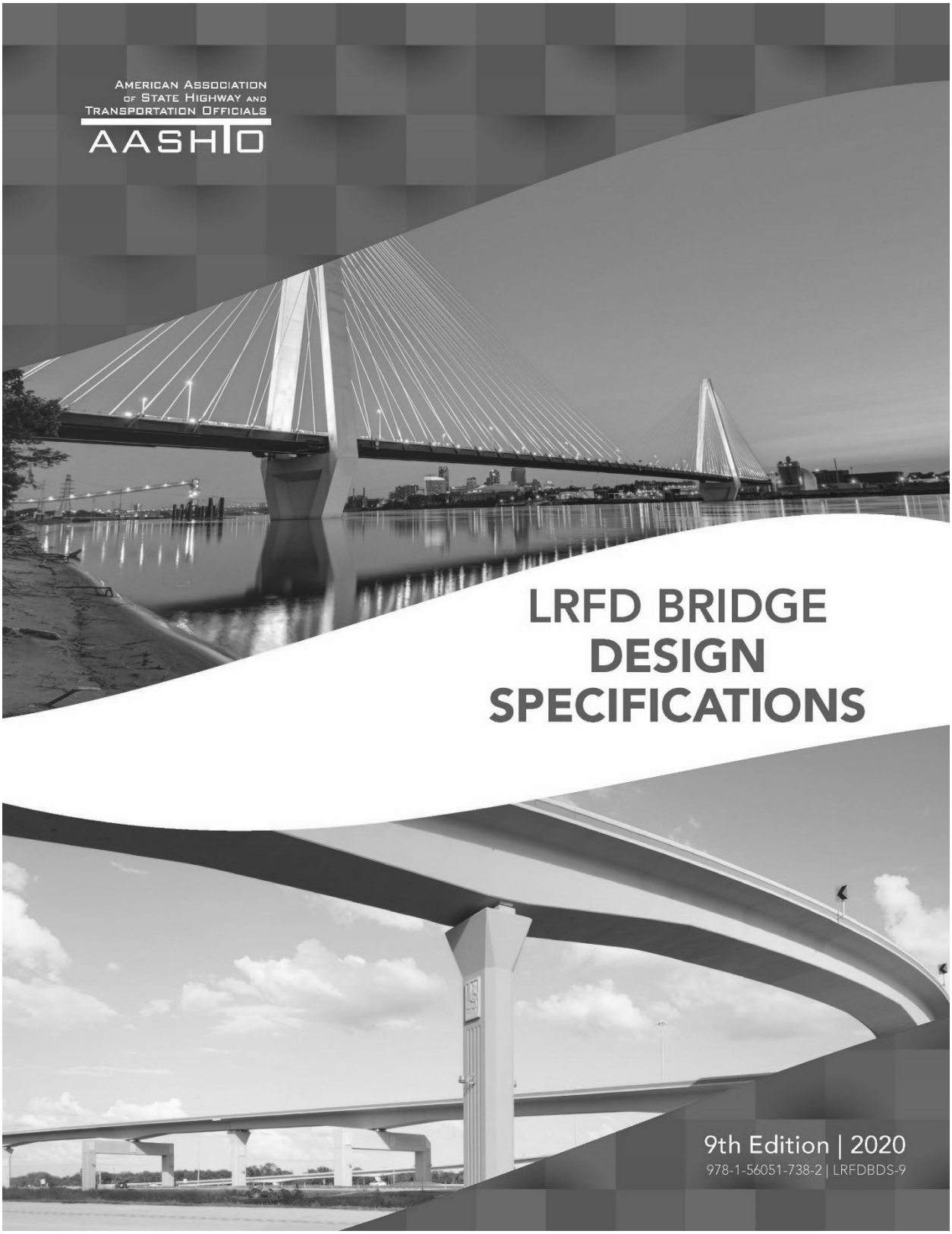

FOREWORD

The first broadly recognized national standard for the design and construction of bridges in the United States was published in 1931 by the American Association of State Highway Officials (AASHO), the predecessor to AASHTO. With the advent of the automobile and the establishment of highway departments in all of the American states dating back to just before the turn of the century, the design, construction, and maintenance of most U.S. bridges was the responsibility of these departments and, more specifically, the chief bridge engineer within each department. It was natural, therefore, that these engineers, acting collectively as the AASHTO Highway Subcommittee on Bridges and Structures (now the Committee on Bridges and Structures), would become the author and guardian of this first bridge standard.

This first publication was entitled *Standard Specifications for Highway Bridges and Incidental Structures*. It quickly became the *de facto* national standard and, as such, was adopted and used by not only the state highway departments but also other bridge-owning authorities and agencies in the United States and abroad. Rather early on, the last three words of the original title were dropped and it has been reissued in consecutive editions at approximately four-year intervals ever since as *Standard Specifications for Highway Bridges*, with the final 17th edition appearing in 2002.

The body of knowledge related to the design of highway bridges has grown enormously since 1931 and continues to do so. Theory and practice have evolved greatly, reflecting advances through research in understanding the properties of materials, in improved materials, in more rational and accurate analysis of structural behavior, in the advent of computers and rapidly advancing computer technology, in the study of external events representing particular hazards to bridges such as seismic events and stream scour, and in many other areas. The pace of advances in these areas has, if anything, stepped up in recent years.

In 1986, the Subcommittee submitted a request to the AASHTO Standing Committee on Research to undertake an assessment of U.S. bridge design specifications, to review foreign design specifications and codes, to consider design philosophies alternative to those underlying the Standard Specifications, and to render recommendations based on these investigations. This work was accomplished under the National Cooperative Highway Research Program (NCHRP), an applied research program directed by the AASHTO Standing Committee on Research and administered on behalf of AASHTO by the Transportation Research Board (TRB). The work was completed in 1987, and, as might be expected with a standard incrementally adjusted over the years, the Standard Specifications were judged to include discernible gaps, inconsistencies, and even some conflicts. Beyond this, the specification did not reflect or incorporate the most recently developing design philosophy, load-and-resistance factor design (LRFD), a philosophy which has been gaining ground in other areas of structural engineering and in other parts of the world such as Canada and Europe.

From its inception until the early 1970s, the sole design philosophy embedded within the Standard Specifications was one known as working stress design (WSD). WSD establishes allowable stresses as a fraction or percentage of a given material's load-carrying capacity, and requires that calculated design stresses not exceed those allowable stresses. Beginning in the early 1970s, WSD began to be adjusted to reflect the variable predictability of certain load types, such as vehicular loads and wind forces, through adjusting design factors, a design philosophy referred to as load factor design (LFD).

A further philosophical extension results from considering the variability in the properties of structural elements, in similar fashion to load variabilities. While considered to a limited extent in LFD, the design philosophy of load-and-resistance factor design (LRFD) takes variability in the behavior of structural elements into account in an explicit manner. LRFD relies on extensive use of statistical methods, but sets forth the results in a manner readily usable by bridge designers and analysts.

Starting with the Eighth Edition of the *AASHTO LRFD Bridge Design Specifications*, interim changes to the Specifications were discontinued, and new editions are published on a three-year cycle. Changes are balloted and approved by at least two-thirds of the members of the Committee on Bridges and Structures. AASHTO members include the 50 State Highway or Transportation Departments, the District of Columbia, and Puerto Rico. Each member has one vote. The U.S. Department of Transportation is a non-voting member.

Orders for Specifications may be placed by visiting the AASHTO Store, store.transportation.org; calling the AASHTO Publication Sales Office toll free (within the U.S. and Canada), 1-800-231-3475; or mailing to P.O. Box 933538, Atlanta, GA 31193-3538. A free copy of the current publication catalog can be downloaded from the AASHTO Store.

For additional publications prepared and published by the Committee on Bridges and Structures and by other AASHTO Committees, please look online in the AASHTO Store (store.transportation.org) under "Bridges and Structures."

Suggestions for the improvement of the *AASHTO LRFD Bridge Design Specifications* are welcomed, just as they were for the *Standard Specifications for Highway Bridges* before them, at www.transportation.org.

The following have served as chair of the Committee on Bridges and Structures since its inception in 1921: E. F. Kelley, who pioneered the work of the Committee; Albin L. Gemeny; R. B. McMinn; Raymond Archiband; G. S. Paxson; E. M. Johnson; Ward Goodman; Charles Matlock; Joseph S. Jones; Sidney Poleynard; Jack Freidenrich; Henry W. Derthick; Robert C. Cassano; Clellon Loveall; James E. Siebels; David Pope; Tom Lulay; Malcolm T. Kerley; Gregg Fredrick; and Carmen Swanwick. The Committee expresses its sincere appreciation of the work of these individuals and of those active members of the past, whose names, because of retirement, are no longer on the roll.

The Committee would also like to thank John M. Kulicki, Ph.D., and his associates at Modjeski and Masters for their valuable assistance in the preparation of the *AASHTO LRFD Bridge Design Specifications*.

PREFACE AND
ABBREVIATED TABLE OF CONTENTS

The *AASHTO LRFD Bridge Design Specifications*, Ninth Edition contains the following 15 sections and an index:

Detailed Tables of Contents precede each section. The last article of each section is a list of references displayed alphabetically by author.

Figures, tables, and equations are denoted by their home article number and an extension, for example 1.2.3.4.5-1 wherever they are cited. In early editions, when they were referenced in their home article or its commentary, these objects were identified only by the extension. For example, in Article 1.2.3.4.5, Eq. 1.2.3.4.5-2 would simply have been called "Eq. 2." The same convention applies to figures and tables. Starting with this edition, these objects are identified by their whole nomenclature throughout the text, even within their home articles. This change was to increase the speed and accuracy of electronic production (i.e., CDs and downloadable files) with regard to linking citations to objects.

Please note that the AASHTO materials standards (starting with M or T) cited throughout the LRFD Bridge Design Specifications can be found in *Standard Specifications for Transportation Materials and Methods of Sampling and Testing,* adopted by the AASHTO Highway Subcommittee on Materials. The individual standards are also available as downloads on the AASHTO Store, https://store.transportation.org. Unless otherwise indicated, these citations refer to the current edition. ASTM materials specifications are also cited and have been updated to reflect ASTM's revised coding system, i.e., spaces removed between the letter and number.

CHANGED AND DELETED ARTICLES, 2020

SUMMARY OF AFFECTED SECTIONS

The revisions included in the *AASHTO LRFD Bridge Design Specifications*, Ninth Edition affect the following sections:

1. Introduction
3. Loads and Load Factors
4. Structural Analysis and Evaluation
5. Concrete Structures
6. Steel Structures
8. Wood Structures
10. Foundations
11. Walls, Abutments, and Piers
12. Buried Structures and Tunnel Liners
15. Design of Sound Barriers

SECTION 1 REVISIONS

Changed Articles

The following Articles in Section 1 contain changes or additions to the specifications, the commentary, or both:

1.3.5

Deleted Articles

No Articles were deleted from Section 1.

SECTION 3 REVISIONS

Changed Articles

The following Articles in Section 3 contain changes or additions to the specifications, the commentary, or both:

3.3.1	3.6.1.2.6a	3.6.5.2	3.11.5.6	3.11.5.9
3.4.1	3.6.5.1	3.11.5.4	3.11.5.8.2	3.16

Deleted Articles

No Articles were deleted from Section 3.

SECTION 4 REVISIONS

Changed Articles

The following Articles in Section 4 contain changes or additions to the specifications, the commentary, or both:

4.5.3.2.2b	4.6.2.2.1	4.6.2.2.2b	4.6.2.10.2	4.9

Deleted Articles

No Articles were deleted from Section 4.

SECTION 5 REVISIONS

Changed Articles

The following Articles in Section 5 contain changes or additions to the specifications, the commentary, or both:

5.3	5.7.2.1	5.8.4.3.5	5.10.4.3	5.12.9.5.2
5.4.3.1	5.7.2.8	5.9.4.3.3	5.10.8.2.5	5.14.1
5.4.6.2	5.7.3.3	5.9.4.5	5.10.8.5.1	5.14.4
5.5.3.1	5.7.3.5	5.9.5.6.1	5.10.8.5.2	5.15
5.5.4.3	5.7.3.6.2	5.10.1	5.12.3.2.1	

Deleted Articles

No Articles were deleted from Section 5.

SECTION 6 REVISIONS

Changed Articles

The following Articles in Section 6 contain changes or additions to the specifications, the commentary, or both:

6.1	6.9.4.1.2	6.10.11	6.12.2.2.2d	6.14.4.4
6.2	6.9.4.1.3	6.10.11.1	6.12.2.2.2e	6.14.4.5
6.3	6.9.4.2	6.10.11.1.1	6.12.2.2.2f	6.14.4.6
6.4.9	6.9.4.2.1	6.10.11.2.2	6.12.2.2.2g	6.16.1
6.5.3	6.9.4.2.2	6.10.11.2.4b	6.12.2.2.3	6.16.2
6.5.4.2	6.9.4.2.2a	6.10.11.3	6.12.2.2.4a	6.16.4.1
6.5.5	6.9.4.2.2b	6.10.11.3.1	6.12.2.2.4b	6.17
6.6.1.2.3	6.9.4.2.2c	6.10.11.3.3	6.12.2.2.4c	A6
6.6.1.2.5	6.9.4.3.1	6.11	6.12.2.2.4d	A6.1
6.6.2.1	6.9.4.4	6.11.1.1	6.12.2.2.4e	A6.2.1
6.6.2.2	6.9.4.5	6.11.3.2	6.12.2.2.5	A6.2.2
6.7.2	6.9.6.1	6.11.5	6.12.2.3.3	A6.3.3
6.7.4.3	6.9.6.2	6.11.6.2.1	6.12.3.2.2	C6.4
6.7.4.4	6.10.1.1.1a	6.11.8.2.2	6.13.2.3.2	C6.4.4
6.7.4.4.1	6.10.1.4	6.11.8.3	6.13.2.5	C6.4.7
6.7.4.4.2	6.10.1.10.1	6.12.1	6.13.2.7	C6.5.1
6.7.4.4.3	6.10.1.10.2	6.12.1.1	6.13.2.9	C6.5.2
6.7.4.5	6.10.2.2	6.12.1.2.1	6.13.2.10.2	D6.2.1
6.7.8	6.10.3.3	6.12.1.2.2	6.13.2.11	D6.3.1
6.8.2.2	6.10.3.4.1	6.12.1.2.3	6.13.3.6	E6.1
6.8.2.3	6.10.3.4.2	6.12.1.2.3a	6.13.3.7	E6.1.1
6.8.2.3.1	6.10.5.2	6.12.1.2.3b	6.13.6.1.3a	E6.1.2
6.8.2.3.2	6.10.6.1	6.12.1.2.4	6.13.6.1.3b	E6.1.3
6.8.2.3.3	6.10.6.2.3	6.12.2	6.13.6.1.3c	E6.1.4
6.8.6.2	6.10.8.1.1	6.12.2.1	6.13.6.1.4	E6.1.5
6.9.2.2	6.10.8.2.3	6.12.2.2.2	6.14.2.4	E6.1.5.1
6.9.2.2.1	6.10.8.3	6.12.2.2.2a	6.14.4.1	E6.1.5.2
6.9.2.2.2	6.10.9.1	6.12.2.2.2b	6.14.4.2	
6.9.4.1.1	6.10.10.2	6.12.2.2.2c	6.14.4.3	

Deleted Articles

6.12.1.2.3c

SECTION 8 REVISIONS

Changed Articles

The following Articles in Section 8 contain changes or additions to the specifications, the commentary, or both:

8.2	8.4.1.2.1	8.4.1.2.3	8.4.4.9	8.14
8.4.1.1.4	8.4.1.2.2	8.4.1.3.1	8.13	

Deleted Articles

No Articles were deleted from Section 8.

SECTION 10 REVISIONS

Changed Articles

The following Articles in Section 10 contain changes or additions to the specifications, the commentary, or both:

10.3	10.5.3.1	10.6.2.4.2b	10.6.3.5	10.9.3.5.4
10.5.2.1	10.5.5.1	10.6.2.4.2c	10.7.2.1	10.10
10.5.2.2	10.5.5.2.1	10.6.2.4.4	10.7.3.1	
10.5.2.2.1	10.6.2.1	10.6.3.1.2a	10.7.8	
10.5.2.2.2	10.6.2.4.1	10.6.3.1.2c	10.8.3.5.1b	
10.5.2.4	10.6.2.4.2a	10.6.3.2.1	10.8.3.5.2b	

Deleted Articles

10.5.2.3	10.6.2.5

SECTION 11 REVISIONS

Changed Articles

The following Articles in Section 11 contain changes or additions to the specifications, the commentary, or both:

11.1	11.6.5.1	11.10.5.2	11.10.6.4.1	11.10.10.3
11.2	11.8.3	11.10.5.6	11.10.6.4.2a	11.10.11
11.3.1	11.8.4.1	11.10.6.1	11.10.6.4.2b	11.11.4.6
11.5.2	11.8.6.1	11.10.6.2	11.10.6.4.3b	11.12
11.5.3	11.9.3	11.10.6.2.1	11.10.6.4.4a	11.12.7.2
11.5.4.2	11.9.4.3	11.10.6.2.1a	11.10.6.4.4b	11.12.9
11.5.5	11.9.4.4	11.10.6.2.1b	11.10.7.2	11.13
11.5.7	11.10.1	11.10.6.2.1c	11.10.7.3	A11.5.3
11.5.8	11.10.2.3.1	11.10.6.2.1d	11.10.7.4	B11.1
11.6.2	11.10.4	11.10.6.2.1e	11.10.8	B11.2
11.6.3.1	11.10.4.2	11.10.6.2.2	11.10.10.1	B11.3
11.6.3.7	11.10.4.3	11.10.6.3.2	11.10.10.2	

Deleted Articles

11.6.2.3	11.8.3.2	11.9.3.2

SECTION 12 REVISIONS

Changed Articles

The following Articles in Section 12 contain changes or additions to the specifications, the commentary, or both:

12.1	12.5.4	12.7.2.7	12.10.2.1	12.12.3.10.2b
12.2	12.6.4	12.8.5.3	12.10.4.3.1	12.16
12.4.2.3	12.6.9	12.8.9.3.1	12.12.2.1	A12
12.4.2.10	12.7.2.1	12.10.1	12.12.3.5	

Deleted Articles

No Articles were deleted from Section 12.

SECTION 15 REVISIONS

Changed Articles

The following Articles in Section 15 contain changes or additions to the specifications, the commentary, or both:

15.9.3	15.9.7	15.9.8

Deleted Articles

15.9.7.1

AASHTO Publications Staff
April 2020

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