AASHTO LRFD BRIDGE

DESIGN SPECIFICATIONS

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American Association of State Highway and Transportation Officials
444 North Capitol Street, NW Suite 249
Washington, DC 20001
202-624-5800 phone/202-624-5806 fax
www.transportation.org

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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, 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. To accommodate this growth in bridge engineering knowledge, the Subcommittee on Bridges and Structures has been granted authority under AASHTO's governing documents to approve and issue Bridge Interims each year, not only with respect to the Standard Specifications but also to incrementally modify and enhance the twenty-odd additional documents on bridges and structures engineering that are under its guidance and sponsorship.

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). Both WSD and LFD are reflected in the current edition of the Standard Specifications.

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.

With the advent of these specifications, bridge engineers had a choice of two standards to guide their designs, the long-standing AASHTO *Standard Specifications for Highway Bridges*, and the alternative, newly adopted *AASHTO LRFD Bridge Design Specifications*, and its companions, *AASHTO LRFD Bridge Construction Specifications* and *AASHTO LRFD Movable Highway Bridge Design Specifications*. Subsequently, the Federal Highway Administration (FHWA) and the states have established a goal that LRFD standards be incorporated in all new bridge designs after 2007.

Interim Specifications are usually published in the middle of the calendar year, and a revised edition of this book is generally published every four years. The Interim Specifications have the same status as AASHTO standards, but are tentative revisions approved by at least two-thirds of the Subcommittee. These revisions are voted on by the AASHTO member departments prior to the publication of each new edition of this book and, if approved by at least two-thirds of the

members, they are included in the new edition as standards of the Association. AASHTO members are 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 nonvoting member.

Annual Interim Specifications are generally used by the states after their adoption by the Subcommittee. Orders for these annual Interim Specifications may be placed by visiting our web site, bookstore.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 our website or requested from the Publications Sales Office.

Attention is also directed to the following publications prepared and published by the Subcommittee on Bridges and Structures:

AASHTO Guide for Commonly Recognized (CoRe) Structural Elements. 1998.

AASHTO Guide Manual for Bridge Element Inspection. 2011.

AASHTO Guide Specifications for Horizontally Curved Steel Girder Highway Bridges with Design Examples for I-Girder and Box-Girder Bridges. 2003. Archived.

AASHTO Guide Specifications—Thermal Effects in Concrete Bridge Superstructures. 1989.

AASHTO LRFD Bridge Construction Specifications. 2010.

AASHTO LRFD Bridge Design Guide Specifications for GFRP-Reinforced Concrete Bridge Decks and Traffic Railings. 2009.

AASHTO LRFD Movable Highway Bridge Design Specifications. 2007.

Bridge Data Exchange (BDX) Technical Data Guide. 1995. Archived.

Bridge Security Guidelines, 2011.

Bridge Welding Code: AASHTO/AWS D1.5M/D1.5:2010, an American National Standard. 2010.

Construction Handbook for Bridge Temporary Works. 1995.

Guide Design Specifications for Bridge Temporary Works. 1995.

Guide for Painting Steel Structures. 1997. Archived.

Guide Manual for Condition Evaluation and Load and Resistance Factor Rating (LRFR) of Highway Bridges. 2003. Archived but download available.

Guide Specifications and Commentary for Vessel Collision Design of Highway Bridges. 2009.

Guide Specifications for Alternate Load Factor Design Procedures for Steel Beam Bridges Using Braced Compact Sections. 1991. Archived.

Guide Specifications for Aluminum Highway Bridges. 1991. Archived.

Guide Specifications for Bridge Railings. 1989. Archived.

Guide Specifications for Design and Construction of Segmental Concrete Bridges. 1999.

Guide Specifications for Fatigue Evaluation of Existing Steel Bridges. 1990. Archived but download available.

Guide Specifications for Highway Bridge Fabrication with HPS 70W (HPS 485W) Steel. 2003.

Guide Specifications for Seismic Isolation Design. 2010.

Guide Specifications for Strength Design of Truss Bridges (Load Factor Design). 1986. Archived but download available.

Guide Specifications for Strength Evaluation of Existing Steel and Concrete Bridges. 1989. Archived but download available.

Guide Specifications for Structural Design of Sound Barriers. 1989. Archived but download available.

Guide Specifications for the Design of Stress-Laminated Wood Decks. 1991. Archived but download available.

Guidelines for Bridge Management Systems. 1993. Archived but download available.

LRFD Guide Specifications for Design of Pedestrian Bridges. 2009.

The Manual for Bridge Evaluation. 2011.

Movable Bridge Inspection, Evaluation, and Maintenance Manual. 1998.

Standard Specifications for Movable Highway Bridges. 1988. Archived but download available.

Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals. 2009.

Technical Manual for Design and Construction of Road Tunnels—Civil Elements. 2010.

Additional bridges and structures publications prepared and published by other AASHTO committees and task forces are as follows:

AASHTO Maintenance Manual: The Maintenance and Management of Roadways and Bridges. 2007.

Guide Specifications for Cathodic Protection of Concrete Bridge Decks. 1994. Archived but download available.

Guide Specifications for Concrete Overlay of Pavements and Bridge Decks. 1990. Archived but download available.

Guide Specifications for Polymer Concrete Bridge Deck Overlays. 1995. Archived but download available.

Guide Specifications for Shotcrete Repair of Highway Bridges. 1998.

Inspector's Guide for Shotcrete Repair of Bridges. 1999.

Manual for Corrosion Protection of Concrete Components in Bridges. 1992. Archived but download available.

The following bridges and structures titles are the result of the AASHTO–NSBA Steel Bridge Collaboration and are available for free download from the AASHTO web site, bookstore.transportation.org:

Design Drawing Presentation Guidelines, G 1.2. 2003.

Guidelines for Design Constructability, G 12.1. 2003.

Guidelines for Design Details, G 1.4. 2006.

Guidelines for Steel Girder Bridge Analysis, G 13.1. 2011.

Guide Specification for Application of Coating Systems with Zinc-Rich Primers to Steel Bridges, S 8.1. 2006.

Recommendations for the Qualification of Structural Bolting Inspectors, G 4.2. 2006.

Sample Owners Quality Assurance Manual, G 4.4. 2006.

Shop Detail Drawing Presentation Guidelines, G 1.3. 2003.

Shop Detail Drawing Review/Approval Guidelines, G1.1. 2000.

Steel Bridge Bearing Design and Detailing Guidelines, 1st Edition, G 9.1. 2004.

Steel Bridge Erection Guide Specification, S 10.1. 2007.

Steel Bridge Fabrication Guide Specification, S 2.1. 2008.

Steel Bridge Fabrication QC/QA Guide Specification, S 4.1. 2002.

The following have served as chairmen of the Subcommittee on Bridges and Structures since its inception in 1921: Messrs. E. F. Kelley, who pioneered the work of the Subcommittee; 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; and Malcolm T. Kerley. The Subcommittee expresses its sincere appreciation of the work of these men and of those active members of the past, whose names, because of retirement, are no longer on the roll.

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

Suggestions for the improvement of the LRFD Specifications are welcomed, just as they were for the Standard Specifications before them. They should be sent to the Chairman, Subcommittee on Bridges and Structures, AASHTO, 444 North Capitol Street, N.W., Suite 249, Washington, DC 20001. Inquiries as to intent or application of the specifications should be sent to the same address.

PREFACE AND
ABBREVIATED TABLE OF CONTENTS

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

1. Introduction
2. General Design and Location Features
3. Loads and Load Factors
4. Structural Analysis and Evaluation
5. Concrete Structures
6. Steel Structures
7. Aluminum Structures
8. Wood Structures
9. Decks and Deck Systems
10. Foundations
11. Abutments, Piers, and Walls
12. Buried Structures and Tunnel Liners
13. Railings
14. Joints and Bearings
15. Design of Sound Barriers

    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 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 Bookstore, https://bookstore.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, e.g., spaces removed between the letter and number.

CHANGED AND DELETED ARTICLES, 2012

SUMMARY OF AFFECTED SECTIONS

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

2. General Design and Location Features
3. Loads and Load Factors
4. Structural Analysis and Evaluation
5. Concrete Structures
6. Steel Structures
7. Aluminum Structures
9. Decks and Deck Systems
10. Foundations
11. Abutments, Piers, and Walls
12. Buried Structures and Tunnel Liners
13. Railings
14. Joints and Bearings
15. Design of Sound Barriers

SECTION 2 REVISIONS

Changed Articles

The following Articles in Section 2 contain changes or additions to the specifications, the commentary, or both:

2.5.2.6.3

Deleted Articles

No Articles were deleted from Section 2.

SECTION 3 REVISIONS

Changed Articles

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

3.3.2	3.6.1.2.5	3.8.1.1	3.10.9.2	3.16
3.4.1	3.6.1.4.1	3.8.1.2.1	3.11.5.10	
3.4.4	3.6.5.1	3.10.2.1	3.15	

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:

4.2	4.6.1.2.2	4.6.2.2.3c	4.6.3.2.4
4.6.1.1	4.6.1.2.3	4.6.2.5	4.7.6
4.6.1.2.1	4.6.2.1.8	4.6.2.6.4	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:

5.2	5.7.3.3.2	5.9.4.2.2	5.10.4.3.1c	5.13.2.2
5.3	5.8.1.5	5.10.4.3	5.10.4.3.1d	5.14.2.3.2
5.4.2.6	5.9	5.10.4.3.1	5.10.4.3.2	5.14.2.3.4a
5.5.3.1	5.9.1.1	5.10.4.3.1a	5.10.5	5.14.2.3.4b
5.5.4.2.1	5.9.1.6	5.10.4.3.1b	5.10.9.3.7	5.15

Deleted Articles

5.9.4.3

SECTION 6 REVISIONS

Changed Articles

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

6.3	6.6.1.3.2	6.10.11.1.3	6.14.3.3	6.16.2
6.5.4.2	6.7.3	6.11.1.1	6.14.3.4	6.16.3
6.5.5	6.7.4.1	6.11.5	6.14.3.2.1	6.16.4
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6.6.1.2.5	6.10.6.2.3	6.14.3	6.16	6.16.4.4
6.6.1.3.1	6.10.10	6.14.3.1	6.16.1	6.17

Deleted Articles

6.14.3.4 6.14.3.5

SECTION 7 REVISIONS

Changed Articles

The following Articles in Section 7 contain changes or additions to the specifications, the commentary, or both:

7.6.1.2.1

Deleted Articles

No Articles were deleted from Section 7.

SECTION 9 REVISIONS

Changed Articles

The following Articles in Section 9 contain changes or additions to the specifications, the commentary, or both:

9.8.3.4	9.8.3.4.3a	9.8.3.6.2	9.8.3.6.2d	9.8.3.7.4
9.8.3.4.1	9.8.3.4.3b	9.8.3.6.2a	9.8.3.7.1	9.10
9.8.3.4.2	9.8.3.4.3c	9.8.3.6.2b	9.8.3.7.2	
9.8.3.4.3	9.8.3.4.4	9.8.3.6.2c	9.8.3.7.3	

Deleted Articles

9.8.3.5	9.8.3.5.2
9.8.3.5.1	9.8.3.5.3

SECTION 10 REVISIONS

Changed Articles

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

10.6.3.3	10.8.3.6.3

Deleted Articles

No Articles were deleted from Section 10.

SECTION 11 REVISIONS

Changed Articles

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

11.3.1	11.6.5	11.8.6.1	11.10.6.4.3b	A11.1
11.4.1	11.6.5.1	11.8.6.2	11.10.6.4.4b	A11.2
11.5.3	11.6.5.2	11.8.6.3	11.10.7	A11.3
11.5.4	11.6.5.2.1	11.8.6.4	11.10.7.1	A11.3.1
11.5.4.1	11.6.5.2.2	11.9.6	11.10.7.2	A11.3.2
11.5.4.2	11.6.5.3	11.10.1	11.10.7.3	A11.3.3
11.5.5	11.6.5.4	11.10.2.1	11.10.7.4	A11.4
11.5.6	11.6.5.5	11.10.4.2	11.10.10.1	A11.5
11.5.7	11.6.5.6	11.10.6.3.2	11.11.6	A11.6
11.5.8	11.8.1	11.10.6.4.2a	11.12	
11.6.3.3	11.8.6	11.10.6.4.2b	A11	

Deleted Articles

No Articles were deleted from Section 11.

SECTION 12 REVISIONS

Changed Articles

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

12.3	12.7.2.2	12.8.9.2.2	12.8.9.4
12.5.5	12.7.2.5	12.8.9.3.1	12.8.9.5
12.6.6.3	12.8.9.1	12.8.9.3.2	12.14.5.6

Deleted Articles

No Articles were deleted from Section 12.

SECTION 13 REVISIONS

Changed Articles

The following Articles in Section 13 contain changes or additions to the specifications, the commentary, or both:

A13.4.3.1

Deleted Articles

No Articles were deleted from Section 13.

SECTION 14 REVISIONS

Changed Articles

The following Articles in Section 14 contain changes or additions to the specifications, the commentary, or both:

14.3	14.7.5.3.3	14.7.6.1	14.7.6.3.3	14.7.6.3.5b
14.6.3.2	14.7.5.3.6	14.7.6.3.2	14.7.6.3.5a	14.7.6.3.6

Deleted Articles

14.7.6.3.5d

SECTION 15

Section 15 is completely new.

AASHTO Publications Staff
January 2012

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SECTION 1

INTRODUCTION

1.1—SCOPE OF THE SPECIFICATIONS

The provisions of these Specifications are intended for the design, evaluation, and rehabilitation of both fixed and movable highway bridges. Mechanical, electrical, and special vehicular and pedestrian safety aspects of movable bridges, however, are not covered. Provisions are not included for bridges used solely for railway, rail-transit, or public utilities. For bridges not fully covered herein, the provisions of these Specifications may be applied, as augmented with additional design criteria where required.

These Specifications are not intended to supplant proper training or the exercise of judgment by the Designer, and state only the minimum requirements necessary to provide for public safety. The Owner or the Designer may require the sophistication of design or the quality of materials and construction to be higher than the minimum requirements.

The concepts of safety through redundancy and ductility and of protection against scour and collision are emphasized.

The design provisions of these Specifications employ the Load and Resistance Factor Design (LRFD) methodology. The factors have been developed from the theory of reliability based on current statistical knowledge of loads and structural performance.

Methods of analysis other than those included in previous Specifications and the modeling techniques inherent in them are included, and their use is encouraged.

Seismic design shall be in accordance with either the provisions in these Specifications or those given in the *AASHTO Guide Specifications for LRFD Seismic Bridge Design.*

The commentary is not intended to provide a complete historical background concerning the development of these or previous Specifications, nor is it intended to provide a detailed summary of the studies and research data reviewed in formulating the provisions of the Specifications. However, references to some of the research data are provided for those who wish to study the background material in depth.

The commentary directs attention to other documents that provide suggestions for carrying out the requirements and intent of these Specifications. However, those documents and this commentary are not intended to be a part of these Specifications.

Construction specifications consistent with these design specifications are the *AASHTO LRFD Bridge Construction Specifications*. Unless otherwise specified, the Materials Specifications referenced herein are the AASHTO *Standard Specifications for Transportation Materials and Methods of Sampling and Testing*.

C1.1

The term “notional” is often used in these Specifications to indicate an idealization of a physical phenomenon, as in “notional load” or “notional resistance.” Use of this term strengthens the separation of an engineer's “notion” or perception of the physical world in the context of design from the physical reality itself.

The term “shall” denotes a requirement for compliance with these Specifications.

The term “should” indicates a strong preference for a given criterion.

The term “may” indicates a criterion that is usable, but other local and suitably documented, verified, and approved criterion may also be used in a manner consistent with the LRFD approach to bridge design.