2011

AASHTO Guide Specifications for

LRFD Seismic Bridge Design

2nd Edition

Published by the
American Association of State Highway and Transportation Officials

ISBN: 978-56051-521-0 Publicaton Code: LRFDSEIS-2

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

ISBN: 978-1-56051-521-0 Pub Code: LRFDSEIS-2

EXECUTIVE COMMITTEE
2011-2012

Voting Members

Officers:

President: Susan Martinovich, P.E., Nevada

Vice President: Kirk T. Steudle, P.E., Michigan

Secretary-Treasurer: Carlos Braceras, Utah

Regional Representatives:

REGION I: Beverley K. Swaim-Staley, Maryland One-Year Term
Jeffrey B. Mullan, Massachusetts Two-Year Term

REGION II: Mike Hancock, Kentucky One-Year Term
Robert St. Onge, South Carolina Two-Year Term

REGION III: Thomas K. Sorel, Minnesota One-Year Term
Vacant Two-Year Term

REGION IV: Amadeo Saenz, Jr., Texas One-Year Term
Francis G. Ziegler, P.E., North Dakota Two-Year Term

Nonvoting Members

Immediate Past President: Vacant

AASHTO Executive Director: John Horsley, Washington, DC

HIGHWAYS SUBCOMMITTEE ON BRIDGES AND STRUCTURES, 2011

MALCOLM T. KERLEY, *Chair*
DAVID P. HOHMANN, *Vice Chair*
M. MYINT LWIN, Federal Highway Administration, *Secretary*
RAJ AILANEY, Federal Highway Administration, *Assistant Secretary*
KEITH M. PLATTE, *AASHTO Liaison*
KELLEY REHM, *AASHTO Liaison*

ALABAMA, John F. Black, Eric J. Christie, William "Tim" Colquett
ALASKA, Richard A. Pratt
ARIZONA, Jean A. Nehme
ARKANSAS, Carl Fuselier
CALIFORNIA, Barton J. Newton, Susan Hida, Barton J. Newton, Michael Keever
COLORADO, Mark A. Leonard, Michael G. Salamon
CONNECTICUT, Julie F. Georges
DELAWARE, Jiten K. Soneji, Barry A. Benton
DISTRICT OF COLUMBIA, Ronaldo T. "Nick" Nicholson, L. Donald Cooney, Konjit "Connie" Eskender
FLORIDA, Sam Fallaha, Dennis Golabek, Jeff Pouliotte
GEORGIA, Paul V. Liles, Jr.
HAWAII, Paul T. Santo
IDAHO, Matthew M. Farrar
ILLINOIS, D. Carl Puzey, Tim Armbrecht, Thomas J. Domagalski
INDIANA, Anne M. Rearick
IOWA, Norman L. McDonald
KANSAS, James J. Brennan, Loren R. Risch
KENTUCKY, Mark Hite, Marvin Wolfe
LOUISIANA, Hossein Ghara, Arthur D'Andrea, Paul Fossier
MAINE, David Sherlock, Jeffrey S. Folsom, Wayne Frankhauser Jr.
MARYLAND, Earle S. Freedman, Robert J. Healy, Jeffrey L. Robert
MASSACHUSETTS, Alexander K. Bardow, Shoukry Elnahal
MICHIGAN, Steven P. Beck, David Juntunen
MINNESOTA, Nancy Daubenberger, Kevin Western
MISSISSIPPI, Mitchell K. Carr, B. Keith Carr
MISSOURI, Dennis Heckman, Michael Harms
MONTANA, Kent M. Barnes
NEBRASKA, Mark J. Traynowicz, Mark Ahlman, Fouad Jaber
NEVADA, Mark P. Elicegui, Todd Stefonowicz
NEW HAMPSHIRE, Mark W. Richardson, David L. Scott
NEW JERSEY, Vacant
NEW MEXICO, Raymond M. Trujillo, Jimmy D. Camp
NEW YORK, Wahid Albert, Donald F. Dwyer, Arthur P. Yannotti
NORTH CAROLINA, Greg R. Perfetti, Dan Holderman
NORTH DAKOTA, Terrence R. Udland
OHIO, Timothy J. Keller, Jawdat Siddiqi
OKLAHOMA, Robert J. Rusch, Gregory D. Allen, John A. Schmiedel
OREGON, Bruce V. Johnson, Hormoz Seradj
PENNSYLVANIA, Thomas P. Macioce, Lou Ruzzi
PUERTO RICO, Vacant
RHODE ISLAND, David Fish
SOUTH CAROLINA, Barry W. Bowers, Jeff Sizemore
SOUTH DAKOTA, Kevin Goeden
TENNESSEE, Edward P. Wasserman
TEXAS, Keith L. RamseyDavid P. Hohmann
U.S. DOT, M. Myint Lwin, Raj Ailaney
UTAH, Carmen Swanwick
VERMONT, Wayne B. Symonds
VIRGINIA, Malcolm T. Kerley, Kendal Walus, Prasad L. Nallapaneni, Julius F. J. Volgyi, Jr.
WASHINGTON, Jugesh Kapur, Tony M. Allen, Bijan Khaleghi
WEST VIRGINIA, Gregory Bailey, James D. Shook
WISCONSIN, Scot Becker, Beth A. Cannestra, William C. Dreher
WYOMING, Paul G. Cortez, Michael E.Menghini, Keith R. Fulton
ALBERTA, Lloyd Atkin
KOREA, Eui-Joon Lee, Sang-Soon Lee
NEWFOUNDLAND, Peter Lester
NOVA SCOTIA, Mark Pertus
ONTARIO, Bala Tharmabala
SASKATCHEWAN, Howard Yea
TRANSPORTATION RESEARCH BOARD— Waseem Dekelbab
GOLDEN GATE BRIDGE, Kary H. Witt
MDTA, Dan Williams
N.J. TURNPIKE AUTHORITY, Richard J. Raczynski
N.Y. STATE BRIDGE AUTHORITY, William J. Moreau
PENN. TURNPIKE COMMISSION, James L. Stump
U.S. ARMY CORPS OF ENGINEERS—DEPARTMENT OF THE ARMY, Phillip W. Sauser, Christopher H. Westbrook
U.S. COAST GUARD, Hala Elgaaly
U.S. DEPARTMENT OF AGRICULTURE—FOREST SERVICE, Tom Gillins

FOREWORD

Following the 1971 San Fernando earthquake, significant effort was expended to develop comprehensive design guidelines for the seismic design of bridges. That effort led to updates of both the AASHTO and Caltrans design provisions and ultimately resulted in the development of ATC-6, *Seismic Design Guidelines for Highway Bridges*, which was published in 1981. That document was subsequently adopted by AASHTO as a Guide Specification in 1983; the guidelines were formally adopted into the *Standard Specifications for Highway Bridges* in 1991, then revised and reformatted as Division I-A. Later, Division I-A became the basis for the seismic provisions included in the *AASHTO LRFD Bridge Design Specifications*.

After damaging earthquakes in 1980s and 1990s, and as more recent research efforts were completed, it became clear that improvements to the seismic design practice for bridges should be undertaken. Several efforts culminated in the publication of ATC-32, *Improved Seismic Design Criteria for California Bridges: Provisional Recommendations* in 1996; the development of Caltrans' *Seismic Design Criteria*; publication of MCEER/ATC-49 (NCHRP 12-49), *Recommended LRFD Guidelines for the Seismic Design of Highway Bridges* in 2003; and the development of the South Carolina *Seismic Design* Specifications in 2001. Thus in 2005, with the T-3 Seismic Design Technical Committee's support, work began to identify and consolidate the best practices from these four documents into a new seismic design specification for AASHTO. The resulting document was founded on displacement-based design principles, recommended a 1000-yr return period earthquake ground motion, and comprised a new set of guidelines for seismic design of bridges. During 2007, a technical review team refined the document into the Guide Specifications that were adopted at the 2007 annual AASHTO Highways Subcommittee on Bridges and Structures meeting. The following year, further refinement was completed by the team and was adopted. The 2007 document, combined with the modifications approved in 2008, form the basis of these Guide Specifications.

The scope of these Guide Specifications covers seismic design for typical bridge types and applies to noncritical and non-essential bridges. The title of the document reflects the fact that the Guide Specifications are approved as an alternate to the seismic provisions in the *AASHTO LRFD Bridge Design Specifications.* These Guide Specifications differ from the current procedures in the LRFD Specifications in the use of displacement-based design procedures, instead of the traditional, force-based "R-Factor" method. This new approach is split into a simplified implicit displacement check procedure and a more rigorous pushover assessment of displacement capacity. The selection of which procedure to use is based on seismic design categories, similar to the seismic zone approach used in the *AASHTO LRFD Bridge Design Specifications*. Also included is detailed guidance and commentary on earthquake-resisting elements and systems, global design strategies, demand modeling, capacity calculation, and liquefaction effects. Similar to the LRFD force-based method, capacity design procedures underpin the Guide Specifications' methodology, and these procedures include prescriptive detailing for plastic hinging regions and design requirements for capacity protection of those elements that should not experience damage.

These Guide Specifications incorporate recent experience, best practices, and research results and represent a significant improvement over the traditional force-based approach. It is expected that these Guide Specifications will be revised as refinements or improvements become available.

AASHTO Highways Subcommittee on Bridges and Structures

ACKNOWLEDGMENTS

This work was sponsored by the American Association of State Highway and Transportation Officials, in cooperation with the Federal Highway Administration, and was conducted in the National Cooperative Highway Research Program (NCHRP), which is administered by the Transportation Research Board of the National Research Council. The first edition of any technical publication is especially labor intensive. AASHTO's Highways Subcommittee on Bridges and Structures gratefully acknowledges the contributions of the following people:

AASHTO Technical Committee for Seismic Design

NCHRP Project 20-07, Task 193—Principal Investigator, Roy A. Imbsen of Imbsen Consulting

The technical review team:

- Mark Mahan, CA DOT (Team Leader, 2007)
- Lee Marsh, BERGER/ABAM Engineers (Team Leader, 2008)
- Roy A. Imbsen, Imbsen Consulting
- Elmer Marx, AK DOT
- Jay Quiogue, CA DOT
- Chris Unanwa, CA DOT
- Fadel Alameddine, CA DOT
- Chyuan-Shen Lee, WSDOT
- Stephanie Brandenberger, MT DOT
- Daniel Tobias, IL DOT
- Derrell Manceaux, FHWA
- Tony Allen, WSDOT
- Don Anderson, CH2M Hill

1000-yr Maps and Ground Motion CD Tool—Ed V. Leyendecker, USGS

PREFACE

This second edition of the *Guide Specifications for LRFD Seismic Bridge Design* includes technical content approved by the Highways Subcommittee on Bridges and Structures through 2011. In addition to revising the first edition content, he authors have added Appendix B, "Design Flowcharts."

An abbreviated table of contents follows this preface. Detailed tables of contents precede each Section and Appendix.

AASHTO Publications Staff

ABBREVIATED TABLE OF CONTENTS

TABLE OF CONTENTS