



AASHTO



GUIDE SPECIFICATIONS FOR
DESIGN OF BONDED FRP SYSTEMS
FOR REPAIR AND STRENGTHENING
OF CONCRETE BRIDGE ELEMENTS

March 2023 Second Edition

Currently in preview, click buy full version

AASHTO

American Association of State Highway and Transportation Officials
555 14th Street, N.W., Suite 1000
Washington, DC 20004
202-624-5800 phone/202-624-5806 fax
www.transportation.org

Cover photos: Top right courtesy of Matt Chynoweth, Michigan Department of Transportation; top left courtesy of Oregon Department of Transportation; bottom right courtesy of Michael Goff.

© 2023 by the American Association of State Highway and Transportation Officials. All rights reserved.
Duplication is a violation of applicable law.

ISBN: 978-1-56051-807-5

Pub Code: FRPS-2

**EXECUTIVE COMMITTEE
2022–2023**

OFFICERS:

PRESIDENT: Roger Millar, Washington*

VICE PRESIDENT: Craig Thompson, Wisconsin**

SECRETARY-TREASURER: Russell McMurry, Georgia

EXECUTIVE DIRECTOR: Jim Tymon, Washington, D. C.

REGIONAL REPRESENTATIVES:

REGION I: Nicole Majeski, Delaware
Everett Lott, District of Columbia

REGION II: Vacant
Lorie Tudor, Arkansas

REGION III: Nancy Daubenberger, Minnesota
Jack Marchbanks, Ohio

REGION IV: Vacant
Joel Jundt, South Dakota

IMMEDIATE PAST PRESIDENT: Shawn Wilson, Louisiana

***Elected at the 2022 Annual Meeting**

****Elected at the 1/5/2022 Special Virtual Meeting**

AASHTO Committee on Bridges and Structures, 2022

CARMEN SWANWICK, *Chair*

SCOT BECKER, *Vice Chair*

JOSEPH L. HARTMANN, *Federal Highway Administration, U.S. DOT Liaison*

PATRICIA J. BUSH, *AASHTO Liaison*

- ALABAMA**, Eric J. Christie, William “Tim” Colquett, Jeffrey Huner
- ALASKA**, Leslie Daughtery, Elmer E. Marx, Richard A. Pratt
- ARIZONA**, David B. Benton, David L. Eberhart, Pe-Shen Yang
- ARKANSAS**, Charles “Rick” Ellis, Andy Nannemar, Steve Peyton
- CALIFORNIA**, Erol Kaslan, Ruth Fernandes, Gedmund Setberg,
- COLORADO**, Michael Collins, Stephen Harelson, Jessica Martinez
- CONNECTICUT**, Andrew Cardinali, Timothy D. Fields, Bart Sweeney
- DELAWARE**, Jason Arndt, Jason Hastings, Craig A. Stevens
- DISTRICT OF COLUMBIA**, Donald L. Cooney, Konjit C. “Connie” Eskender
- FLORIDA**, Felix Padilla, William Potter
- GEORGIA**, Donn Digamon, Doug Franks, Steve Gaston
- HAWAII**, James Fu, Nicholas Groves
- IDAHO**, Matthew Farrar
- ILLINOIS**, Tim A. Armbrecht, Ruben Boehler, Jayme Schiff
- INDIANA**, Andrew Fitzgerald, Jennifer Hart, Anne M. Rearick, Stephanie Wagner
- IOWA**, Jim Hauber, James S. Nelson, Michael N.
- KANSAS**, Mark Hurt, Karen Peterson, Calvin Reed
- KENTUCKY**, Michael Carpenter, Poyne Meredith, Carl Van Zee
- LOUISIANA**, Arthur D’Andrea, Chris Guidry, Zhengzheng “Jenny” Fan
- MAINE**, Jeffrey S. Folsom, Valerie Frankhauser, Michael Wight
- MARYLAND**, Maureen Agostino, Jesse Creel, Jeffrey L. Robert
- MASSACHUSETTS**, Alexander K. Bardow, Justin Sock, Matthew Weidele
- MICHIGAN**, Matthew Chynoweth, Rebecca Curtis, Richard E. Liptak
- MINNESOTA**, Arielle Ehrlich, Ed Lutgen, Kevin Western
- MISSISSIPPI**, Micah Dew, Bradnado Turnquest, Scott Westerfield
- MISSOURI**, David Hagemeye, Bryan Hartnagel, Darren Kemna
- MONTANA**, Stephanie Brandenberger, Nathan Haddick, Amanda Jackson
- NEBRASKA**, Ross Barron, Fouad Jaber, Kyle Zillig
- NEVADA**, David Chase, Jessen Mortensen
- NEW HAMPSHIRE**, Loretta Doughty, David L. Scott
- NEW JERSEY**, Xiaohua “Hannah” Cheng, Eric Yermack
- NEW MEXICO**, Shane Kuhlman, Jeffrey Vign
- NEW YORK**, Brenda Crudele, James Flynn, Ernest Holmberg
- NORTH CAROLINA**, Brian Franks, Scott Hidden, Girchuru Muciane
- NORTH DAKOTA**, John L. Ketterling, Jason R. Thorenson
- OHIO**, Alexander B.C. Dettloff, Timothy J. Jener, Jeffrey Syar
- OKLAHOMA**, Justin Hernandez, Walter Peters, Tim Peter
- OREGON**, Raymond Mabey, Albert Nako, Tanarat Potisuk
- PENNSYLVANIA**, Richard Runyen, Shane Szalankiewicz
- PUERTO RICO**, (Vacant)
- RHODE ISLAND**, Keith Gaulin, Mary Vittoria-Bertrand
- SOUTH CAROLINA**, Terry B. Koon, Hongfen Li, Jeff Sizemore
- SOUTH DAKOTA**, Steve Johnson, Dave Madden, Todd Thompson
- TENNESSEE**, Ted A. Kniazewycz
- TEXAS**, Graham Bettis, Bernie Carrasco, Jamie F. Farris
- UTAH**, Mark Daniels, Rebecca Nix, Cheryl Hersh Simmons
- VERMONT**, Carolyn Cota, Kristin M. Higgins, Bob Klinefelter, Jim Lacroix
- VIRGINIA**, Kendal R. Walus, Andrew M. Zickler
- WASHINGTON**, Tony M. Allen, Mark A. Gaines, Bijan Khaleghi
- WEST VIRGINIA**, Tracy Brown, Chad Robinson
- WISCONSIN**, Aaron Bonk, Josh Dietsche, William Oliva
- WYOMING**, Jeff R. Booher, Paul G. Cortez, Michael Menghini

Associate Members

CHESAPEAKE BAY BRIDGE AND TUNNEL DISTRICT, Timothy Holloway

MARYLAND TRANSPORTATION AUTHORITY, James Harkness

MULTNOMAH COUNTY TRANSPORTATION DIVISION, Jon Henrichsen

TRANSPORTATION RESEARCH BOARD, Ahmad Abu-Hawash

UNITED STATES COAST GUARD, Kamal Elnahal

U.S. ARMY CORPS OF ENGINEERS, Phillip Sauser

Currently in preview, click buy full version

This page intentionally left blank.

Currently in preview, click buy full version

SECTION 1: INTRODUCTION
TABLE OF CONTENTS

1.1—SCOPE 1-1

1.2—FRP Systems 1-1

1.3—SUBSTRATE REPAIR AND SURFACE PREPARATION 1-2

1.4—INSTALLATION OF FRP 1-3

 1.4.1—Wet Lay-Up FRP Systems 1-3

 1.4.2—Pre-Cured FRP Systems 1-4

 1.4.3—NSM FRP Systems 1-4

1.5—INSPECTION, EVALUATION, AND ACCEPTANCE 1-5

1.6—REPAIR OF DEFECTS 1-6

1.7—REFERENCES 1-7

Currently in preview, click buy full version

This page intentionally left blank.

Currently in preview, click buy full version

SECTION 1:
INTRODUCTION

1.1—SCOPE

These Guide Specifications are intended for the repair and strengthening of reinforced and prestressed highway bridge structures using externally bonded fiber reinforced polymer (FRP) composite systems. These Guide Specifications supplement the *AASHTO LRFD Bridge Design Specifications*, Ninth Edition, 2020 (AASHTO LRFD). Except where specifically provided below, all provisions of AASHTO LRFD shall apply.

These Guide Specifications state only the minimum requirements necessary to provide for public safety and are not intended to supplant proper training or the exercise of judgment by the Engineer of Record. The Owner or the Engineer of Record may require the structural design or the quality of materials and construction to exceed the minimum requirements.

These specifications employ the Load and Resistance Factor Design (LRFD) methodology, in which the load and resistance factors have been developed from structural reliability theory based on current probabilistic/statistical models of loads and structural performance.

Seismic design shall be in accordance with either the provisions in the appropriate sections of AASHTO LRFD or the provisions in the *AASHTO Guide Specifications for LRFD Seismic Bridge Design*.

Except where specifically provided below, all provisions of the *AASHTO LRFD Bridge Construction Specifications* shall apply.

1.2—FRP SYSTEMS

In general, procedures for the installation of FRP systems are developed by the manufacturer and can vary between the available systems. Two optional types of externally bonded FRP systems are available. The first type consists of dry fiber-fabric sheets saturated with an epoxy resin. The second type of system consists of precured laminates (manufacturer fabricated), in the form of plates, shells, and rods.

The dry fiber-fabric sheets are commonly applied using a wet-layup process, where the fiber-fabric sheets are saturated using an impregnating resin on site. Prepreg systems, where the fiber-fabric sheets are saturated off-site but cured

C1.1

This Article discusses the scope of these Guide Specifications, their applicability, and their limitations. This Article is analogous to the opening articles, Articles X.1, of each of the Sections of AASHTO LRFD.

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 specification. However, references to North American and international guidelines (ACI 440.2R, CSA S06-12, 2017; fib technical report bulletin 90, 2019; CNR-DT 200 R1, 2013; Technical Report No. 55, 2012; JSCE, 2001; and AFGC, 2003) as well as relevant research data dealing with externally bonded FRP reinforcement for reinforced and prestressed concrete structures are provided for those who wish to study the background material in depth.

NC CRP Report 609 presents recommended construction specifications concerning the use of externally bonded FRP reinforcement for strengthening concrete structures.

The commentary directs attention to other documents that provide suggestions for carrying out the requirements and intent of these Guide Specifications. However, the commentary and references herein are not part of these Guide Specifications.

C1.2

The wet-layup system is the more versatile of these systems because the fabric/cloth is flexible and can conform to most shapes in the field. Installation procedures may also vary depending on the type and condition of the structure to be strengthened. The application of FRP systems will not stop the ongoing corrosion of existing steel reinforcement. The cause of corrosion to internal steel reinforcement should be addressed and corrosion-related deterioration should be repaired prior to application of any FRP system.

NSM FRP systems are advantageous as they are less prone to delamination and environmental degradation, and allow for effective inspection