



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

March 2023 | Second Edition





American Association of State Highway and Transportation Officials
555 12th 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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
555 12th Street, N.W., Suite 1000
Washington, D.C. 20004

**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 1/5/2023 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. Armbrrecht, Ruben Boehler,

Jayne Schiff

INDIANA, Andrew Fitzgerald, Jennifer Hart, Anne

M. Rearick, Stephanie Wagner

IOWA, Jim Hauber, James S. Nelson, Michael Nop

KANSAS, Mark Hurt, Karen Peterson, Calvin

Reed

KENTUCKY, Michael Carpenter, Royce

Meredith, Carl Van Zee

LOUISIANA, Arthur D’Andrea, Chris Guidry,

Zhengzheng “Jenny” Fu

MAINE, Jeffrey S. Folsom, Wayne Frankhauser,

Michael Wight

MARYLAND, Maurice Agostino, Jesse Creel,

Jeffrey L. Robert

MASSACHUSETTS, Alexander K. Bardow, Justin

Slack, 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 Hagemeyer, 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, Jeff C. Vigil

NEW YORK, Brenda Crudele, James Flynn, Ernest

Holmberg

NORTH CAROLINA, Brian Hanks,

Scott Hidden, Girchuru Muchane

NORTH DAKOTA, Jon D. Ketterling, Jason R.

Thorenson

OHIO, Alexander B.C. Dettloff,

Timothy J. Keller, Jeffrey Syar

OKLAHOMA, Justin Hernandez, Walter Peters,

Tim Tegeler

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

This page intentionally left blank.

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

This page intentionally left blank.

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 specifications. However, references to North American and international guidelines (ACI 440.2R, CSA S806-12, 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.

NCHRP 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