GFRP

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AASHTO LRFD Bridge Design Guide Specifications for GFRP-Reinforced Concrete

2ND EDITION

American Association
of State Highway and
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AASHTO

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SECTION 1
INTRODUCTION

1.1—SCOPE

These specifications offer a description of the properties of glass fiber-reinforced polymer (GFRP) reinforcing bars as well as provisions for the design and construction of structural concrete bridge members reinforced with GFRP bars.

C1.1

GFRP materials have emerged as an alternative noncorrosive material for reinforcing bars for concrete structures (Iyer and Sen, 1991; Neale and Labossiere, 1992; White, 1992; Nanni, 1993; Nanni and Dolan, 1993; Dolan et al., 1996; El-Badry, 1996; Humar and Razaqpur, 2000; Burgoyne, 2001; Cosenza et al., 2001; Figueiras et al., 2001; Teng, 2001; Triantafillou, 2007; Bank, 2007; El-Sayed and Benmokrane, 2008; Nanni et al., 2014). GFRP reinforcing bars offer advantages over steel reinforcement due to their noncorrosive nature, which makes them attractive for bridge structures such as beams (Nanni 1993; 2003; Thériault and Benmokrane, 1998; Ashour, 2006; Bentz et al., 2010; Matta et al., 2013), columns (De Luca et al., 2010; Mohamed et al., 2014; Hadhood et al., 2017), decks (Bradberry, 2001; Nanni and Faza, 2002; Benmokrane et al., 2004; 2006; 2007a; 2007b), and traffic railings (Buth et al., 2003; El-Salakawy et al., 2003; Matta and Nanni, 2009; Ahmed et al., 2013; Sennah and Mostafa, 2018). Due to other differences in the physical and mechanical behavior of GFRP materials as opposed to steel, unique guidance on the design and construction of concrete bridges reinforced with GFRP bars is needed.

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 criteria may also be used in a manner consistent with the LRFD approach to bridge design.

GFRP reinforcement shall be in the form of deformed or sand-coated bars, or both, to provide bond with concrete.

Together with straight and hooked GFRP bars used as longitudinal reinforcement, GFRP stirrups in the form of C-shaped bars, spirals, etc., may be implemented to ensure that shear resistance meets safety requirements.

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

The Design Professional shall be familiar with the provisions of the *AASHTO LRFD Bridge Design Specifications* and latest interim specifications, as well as with the design of conventional reinforced concrete structures.

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.

Material specifications and construction specifications consistent with these design specifications are provided in ASTM D7957/D7957M and Section 6, respectively.

1.2—DEFINITIONS

Design Professional—The architect, engineer, architectural firm, or engineering firm responsible for the design of the bridge and issuing Contract Documents or administering the Work under Contract Documents, or both.

Fiber—Any fine thread-like natural or synthetic object of mineral or organic origin. Note: this term is generally used for materials whose length is at least 100 times its diameter.

Fiber, aramid—Highly oriented organic fiber derived from polyamide incorporating into an aromatic ring structure.

Fiber, carbon—Fiber produced by heating organic precursor materials containing a substantial amount of carbon, such as rayon, polyacrylonitrile (PAN), or pitch in an inert environment.

Fiber, glass—Fiber drawn from an inorganic product of fusion that has cooled without crystallizing.

Grating—A two-dimensional (planar) or three-dimensional (spatial) rigid array of interconnected GFRP pultruded shapes other than deformed bars.

Grid—A two-dimensional (planar) or three-dimensional (spatial) rigid array of interconnected GFRP bars that form a con-tiguous lattice that can be used to reinforce concrete.

Lightweight concrete—Concrete containing lightweight aggregate conforming to AASHTO M 195 and having an equilibri-um density not exceeding 0.135 kcf, as determined in conformance with ASTM C567/C567M.

Reinforced concrete—Structural concrete containing no less than the minimum amounts of GFRP reinforcement specified herein.

Structural concrete—All concrete used for structural purposes.

1.3—LIMITATIONS

Prestressed applications; GFRP reinforcement in combination with steel reinforcing bars to resist the same force effect; use of fiber types other than glass, such as carbon, basalt, and aramid fibers; and the use of grid and gratings as well as smooth and hollow-type GFRP reinforcing bars are not covered in these specifications. Assembly of GFRP mats using GFRP bars addressed in these specifications is allowed.

Plain GFRP reinforcing bars used as dowels (that is, devices that transfer shear load across concrete joints), where the intended function requires slip of the dowel, are not covered in these specifications.

The use of lightweight concrete reinforced with GFRP bars is not covered in these specifications and may be specified by the Owner.

The assumed failure mechanism of GFRP-reinforced flexural members shall not be based on the formation of plastic hinges as GFRP materials demonstrate a linear elastic behavior up to failure. Moment redistribution in continuous members shall not be considered for GFRP-reinforced concrete bridge members.

C1.3

GFRP reinforcing bars with a smooth external surface are not covered by these specifications, as their use as concrete reinforcement is restricted due to lack of bond development with concrete. Hollow-type GFRP bars are not considered due to unknown performance as reinforcement for concrete.

The design and construction of lightweight concrete members internally reinforced with GFRP bars is not covered because of the lack of research on this subject. The Owner may specify the use of lightweight concrete based on evidence from physical tests approved by the Owner.

The use of GFRP reinforcing bars in members to be designed for seismic loads is not covered in these specifications.

GFRP reinforcing bars have a significantly lower compressive strength than tensile strength. The strength of any GFRP reinforcing bar in compression shall be ignored in design calculations.

The use of GFRP bars as compression reinforcement of flexural members is not recommended. Placing GFRP reinforcing bars in the compression zone of flexural members is permitted provided that they are not taken into account for the determination of the member flexural resistance.

1.4—DESIGN PHILOSOPHY

These specifications are based on limit state design principles where structural components shall be proportioned to satisfy the requirements at all appropriate service, fatigue and creep rupture, strength, and extreme event limit states. In many instances, serviceability or fatigue and creep rupture limits may control the design.

Provisions related to limit states analysis, general design and location features, loads and load factors, and structural analysis and evaluation shall comply with the *AASHTO LRFD Bridge Design Specifications*.

C1.4

The limit states specified herein are intended to provide for a buildable, serviceable bridge, capable of safely carrying design loads for a specified lifetime.

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