Design with Composite rebar

The mechanical properties of FRP reinforcing bars differ from those of conventional steel rebar in a number of areas. As a result, several issues arise in the development of a design methodology for concrete structures reinforced with such bars. The general design recommendations for flexural concrete elements reinforced with FRP reinforcing bars are presented in ACI 440.1R-06 (2006), Guide for the Design and Construction of Structural Concrete Reinforced with FRP Bars, as reported by the American Concrete Institute (ACI) committee 440.

The design philosophy adopted for FRP bars allows consideration to be given to either FRP rupture or concrete crushing as the mechanism that controls failure. It is based on limit states design principles. An FRP reinforced concrete member is designed based on its required strength, and then checked for fatigue endurance, creep rupture endurance, and serviceability criteria. In most cases serviceability criteria or fatigue and creep rupture endurance limits will control the design.

Design engineers should consider the appropriateness of reinforcing concrete with FRP bars, keeping in mind the following basic points in their designs:

- Direct substitution of FRP bars in a concrete member designed with steel bars is not possible in most cases.
- Lower modulus of elasticity and shear strength of composite rebars may limit the applications where FRP bar can be utilized.
- Glass FRP bar is limited to a maximum sustained stress of 25% of the guaranteed design tensile strength.
- Glass FRP bar applications are limited to the reinforcement of concrete and should not be used as a prestressing or post-tensioning element.

Design Codes/Guidelines

Extensive effort on an international level has resulted in the development of codes and guidelines for FRP composite use in reinforced concrete. Existing publications currently available for such use are as follows:

American Concrete Institute (ACI)

ACI 440R-07 "Report on Fiber-Reinforced Polymer (FRP) Reinforcement for Concrete Structures," ACI Committee 440, American Concrete Institute, Farmington Hills, Mich., (2007), 100p.

ACI 440.1R-06 "Guide for the Design and Construction of Structural Concrete Reinforced with FRP Bars," ACI Committee 440, American Concrete Institute, Farmington Hills, Mich., (2006), 44p.

ACI 440.5-08 "Specification for Construction with Fiber-Reinforced Polymer Reinforcing Bars," ACI Committee 440, American Concrete Institute, Farmington Hills, Mich., (2008), 5p.

ACI 440.6-08 "Specification for Carbon and Glass Fiber-Reinforced Polymer Bar Materials for Concrete Reinforcement," ACI Committee 440, American Concrete Institute, Farmington Hills, Mich., (2008), 6p.

ACI 440.3R-04 "Guide for Test Methods for Fiber Reinforced Polymers (FRP) for Reinforcing and Strengthening Concrete Structures," ACI Committee 440, American Concrete Institute, Farmington Hills, Mich., (2004), 40p.

ACI 440.2R-08 "Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures," ACI Committee 440, American Concrete Institute, Farmington Hills, Mich., (2008), 76p.

ACI 440.7R-10 "Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Unreinforced Masonry Structures" ACI Committee 440, American Concrete Institute, Farmington Hills, Mich., (2010), 46p.

ACI 440.4R-04 "Prestressing Concrete Stuctures with FRP Tendons," ACI Committee 440, American Concrete Institute, Farmington Hills, Mich., (2004), 35p.
Available from: American Concrete Institute - www.concrete.org

American Association of State Highway and Transportation Officials (AASHTO)

"LRFD Bridge Design Guide Specifications for GFRP-Reinforced Concrete Bridge Decks and Traffic Railings," American Association of State Highway and Transportation Officials, Washington, D.C., (2009), 68p.
Available from: AASHTO - www.transportation.org

Canadian Standards Association (CSA)

CAN/CSA-S806-02 "Design and Construction of Building Components with Fibre-Reinforced Polymers", Canadian Standards Association, Toronto, Ontario, Canada, (2007), 218p.

CAN/CSA-S6-06 "Canadian Highway Bridge Design Code" Canadian Standards Association, Toronto, Ontario, Canada, (2006), 1078p.

CAN/CSA-S807-10 "Specification for Fibre-Reinforced Polymers" Canadian Standards Association, Toronto, Ontario, Canada, (2010), 44p.
Available from: Canadian Standards Association - www.shopcsa.ca

Intelligent Sensing for Innovative Structures - Canada (ISIS)

Design Manual No. 3, "Reinforcing Concrete Structures with Fiber Reinforced Polymers", Intelligent Sensing for Innovative Structures Canada Corporation, Winnipeg, Manitoba, Canada, (2001), 158p.
Available from: ISIS Canada - www.isiscanada.com

Japan Society of Civil Engineers

Concrete Engineering Series 23, "Recommendation for Design and Construction of Concrete Structures Using Continuous Fiber Reinforced Materials," Research Committee on Continuous Fiber Reinforcing Materials, Japan Society of Civil Engineers, Tokyo, Japan, (1997), 325 p.

International Federation for Structural Concrete

fib Bulletin No. 40, “FRP Reinforcement in RC Structures”, International Federation for Structural Concrete, Lausanne, Switzerland, (2007), 160p.
Available from: Int'l Federation for Structural Concrete - fib.epfl.ch

Italian National Research Council

CNR-DT 203/2006, "Guide for the Design and Construction of Concrete Structures Reinforced with Fiber-Reinforced Polymer Bars", Italian National Research Council, Rome, Italy, (2007), 35p.
Available from: Italian National Research Council - www.cnr.it