

An ACI Standard

# Strengthening of Concrete Structures with Externally Bonded Fiber-Reinforced Polymer (FRP) Materials Using the Wet Layup Method—Specification

Reported by ACI Committee 440

ACI SPEC-440.12-22



American Concrete Institute  
*Always advancing*



## **Strengthening of Concrete Structures with Externally Bonded Fiber-Reinforced Polymer (FRP) Materials Using the Wet Layup Method—Specification**

Copyright by the American Concrete Institute, Farmington Hills, MI. All rights reserved. This material may not be reproduced or copied, in whole or part, in any printed, mechanical, electronic, film, or other distribution and storage media, without the written consent of ACI.

The technical committees responsible for ACI committee reports and standards strive to avoid ambiguities, omissions, and errors in these documents. In spite of these efforts, the users of ACI documents occasionally find information or requirements that may be subject to more than one interpretation or may be incomplete or incorrect. Users who have suggestions for the improvement of ACI documents are requested to contact ACI via the errata website at <http://concrete.org/Publications/DocumentErrata.aspx>. Proper use of this document includes periodically checking for errata for the most up-to-date revisions.

ACI committee documents are intended for the use of individuals who are competent to evaluate the significance and limitations of its content and recommendations and who will accept responsibility for the application of the material it contains. Individuals who use this publication in any way assume all risk and accept total responsibility for the application and use of this information.

All information in this publication is provided “as is” without warranty of any kind, either express or implied, including but not limited to, the implied warranties of merchantability, fitness for a particular purpose or non-infringement.

ACI and its members disclaim liability for damages of any kind, including any special, indirect, incidental, or consequential damages, including without limitation, lost revenues or lost profits, which may result from the use of this publication.

It is the responsibility of the user of this document to establish health and safety practices appropriate to the specific circumstances involved with its use. ACI does not make any representations with regard to health and safety issues and the use of this document. The user must determine the applicability of all regulatory limitations before applying the document and must comply with all applicable laws and regulations, including but not limited to, United States Occupational Safety and Health Administration (OSHA) health and safety standards.

Participation by governmental representatives in the work of the American Concrete Institute and in the development of Institute standards does not constitute governmental endorsement of ACI or the standards that it develops.

Order information: ACI documents are available in print, by download, through electronic subscription, or reprint, and may be obtained by contacting ACI.

ACI codes, specifications, and practices are made available in the ACI Collection of Concrete Codes, Specifications, and Practices. The online subscription to the ACI Collection is always updated, and includes current and historical versions of ACI's codes and specifications (in both inch-pound and SI units) plus new titles as they are published. The ACI Collection is also available as an eight-volume set of books and a USB drive.

**American Concrete Institute**  
**38800 Country Club Drive**  
**Farmington Hills, MI 48331**  
**Phone: +1.248.848.3700**  
**Fax: +1.248.848.3701**

# Strengthening of Concrete Structures with Externally Bonded Fiber-Reinforced Polymer (FRP) Materials Using the Wet Layup Method—Specification

An ACI Standard

Reported by ACI Committee 440

William J. Gold, Chair

Maria Lopez de Murphy, Secretary

Tarek Alkhrdaji  
Charles E. Bakis  
Abdeljelil Belarbi  
Brahim Benmokrane  
Luke A. Bisby  
Gregg J. Blaszak  
Hakim Bouadi  
Timothy E. Bradberry  
Vicki L. Brown  
John P. Busel  
Lijuan Cheng  
Raafat El-Hacha  
Garth J. Fallis

Amir Z. Fam  
Russell Gentry  
Nabil F. Grace  
Mark F. Green  
Doug D. Gremel  
Shawn P. Gross  
Trey Hamilton  
Issam E. Harik  
Kent A. Harries  
Mark P. Henderson  
Tom Hershberger  
Didier Hutchison  
Ravindra Kanitkar

Yail Jimmy Kim  
Michael W. Lee  
Amir Mirmiran  
John J. Myers  
Ayman M. Okeil  
Carlos E. Ospina  
Renato Parretti  
Maria A. Polak  
Max L. Porter  
Andrea Prota  
Hayder A. Rasheed  
Sami H. Rizkalla  
Rajan Sen

Rudolf Seracino  
Venkatesh Seshappa  
Carol K. Shield  
Pedro F. Silva  
Jennifer E. Tanner  
Jay Thomas  
Houssam A. Toutanji  
J. Gustavo Tumialan  
Milan Vatovec  
David White  
Sarah E. Witt\*

## Consulting Members

P. N. Balaguru  
Craig A. Ballinger  
Lawrence C. Bank  
Harald G. F. Budelmann  
C. J. Burgoyne  
Rami M. Elhassan

David M. Gale  
Srinivasa L. Iyer  
Koichi Kishitani  
Howard S. Klinger  
Ibrahim M. Mahfouz  
Kyuichi Maruyama

Antoine E. Naaman  
Hajime Okamura  
Mark A. Postma  
Ferdinand S. Rostasy  
Surendra P. Shah  
Mohsen Shahawy

Yasuhisa Sonobe  
Minoru Sugita  
Luc R. Taerwe  
Taketo Uomoto  
Paul Zia

\*Task Group Chair.

*This Specification covers requirements for strengthening concrete structures using externally bonded fiber-reinforced polymer (FRP) materials using the wet layup method. This Specification includes requirements for surface preparation of the substrate, including applying primers and putties, saturating the dry fabric, installing the fabric on the substrate, identifying and repairing defects, and field testing for quality control of the installation and materials.*

**Keywords:** bond-critical application; contact-critical application; fiber-reinforced polymer (FRP) system; laminate; strengthening; wet layup.

## CONTENTS

### **PART 1—GENERAL, p. 2**

- 1.1—Scope, p. 2
- 1.2—Interpretation, p. 2
- 1.3—Definitions, p. 2
- 1.4—Referenced standards, p. 3
- 1.5—Contractor requirements, p. 3
- 1.6—Submittals, p. 3
- 1.7—Storage and handling, p. 3
- 1.8—Quality assurance, p. 3

ACI SPEC-440.12-22 was adopted and published in December 2022.

Copyright © 2022, American Concrete Institute.

All rights reserved including rights of reproduction and use in any form or by any means, including the making of copies by any photo process, or by electronic or mechanical device, printed, written, or oral, or recording for sound or visual reproduction or for use in any knowledge or retrieval system or device, unless permission in writing is obtained from the copyright proprietors.

**PART 2—PRODUCTS, p. 3**

- 2.1—Materials, p. 3
- 2.2—FRP system design, p. 3

**PART 3—EXECUTION, p. 4**

- 3.1—Surface preparation, p. 4
- 3.2—Temperature, humidity, and moisture, p. 4
- 3.3—Installation, p. 4
- 3.4—Curing, p. 4
- 3.5—Acceptance of Work, p. 4

**NOTES TO SPECIFIER, p. 5**

- General Notes, p. 5

**MANDATORY REQUIREMENTS CHECKLIST, p. 6****OPTIONAL REQUIREMENTS CHECKLIST, p. 6**

- Foreword to checklists, p. 6

**PART 1—GENERAL****1.1—Scope**

**1.1.1** This Specification covers requirements for strengthening concrete structures using externally bonded fiber-reinforced polymer (FRP) materials using the wet layup method.

**1.1.2** This Specification is incorporated by Contract Documents and provides requirements for the Contractor.

**1.1.3** This Specification governs for construction within its scope, except project-specific Contract Documents govern if there is a conflict.

**1.1.4** This Specification governs if there is a conflict with referenced material or testing standards.

**1.1.5** Contractor is permitted to submit written alternatives to any provision in this Specification for consideration.

**1.1.6** Ignore provisions of this Specification that are not applicable to the Work.

**1.1.7** Values in this Specification are stated in inch-pound units. A companion Specification in SI units is available.

**1.1.8** The Notes to Specifier are not part of this Specification.

**1.2—Interpretation**

**1.2.1** Unless otherwise explicitly stated, this Specification shall be interpreted using the following principles:

**1.2.1.1** Interpret this Specification consistent with the plain meaning of the words and terms used.

**1.2.1.2** Definitions provided in this Specification govern over the definitions of the same or similar words or terms found elsewhere.

**1.2.1.3** Whenever possible, interpret this Specification so that its provisions are in harmony and do not conflict.

**1.2.1.4** Headings are part of this Specification and are intended to identify the scope of the provisions or sections that follow. If there is a difference in meaning or implication between the text of a provision and a heading, the meaning of the text governs.

**1.2.1.5** Footnotes are part of this Specification. The meaning of the provision text governs in the event of a difference in meaning or implication between the provision text and a footnote to that provision.

**1.2.1.6** Where a provision of this Specification involves two or more items, conditions, requirements, or events connected by the conjunctions “and” or “or,” interpret the conjunctions as follows:

“and” indicates that all the connected items, conditions, requirements or events apply

“or” indicates that the connected items, conditions, requirements, or events apply singularly

**1.2.1.7** The use of the verbs “may” or “will” indicates that the Specification provision is for information to the Contractor.

**1.2.1.8** The phrase “as indicated in Contract Documents” means the specifier included the provision requirements in Contract Documents.

**1.2.1.9** The phrase “unless otherwise specified” means the specifier may have included an alternative to the default requirement in Contract Documents.

**1.2.1.10** Unless otherwise stated, the inch-pound system of units is applicable to combined standards referenced in this Specification.

**1.3—Definitions**

The following definitions shall govern in this Specification.  
**accepted**—determined by Architect/Engineer to be in compliance with Contract Documents.

**Architect/Engineer**—the architect, engineer, architectural firm, or engineering firm developing Contract Documents, or administering the Work under Contract Documents, or both.

**bond-critical application**—strengthening or repair application that relies on load transfer from the substrate to the fiber-reinforced polymer (FRP) system through bond of the FRP system to the substrate.

**contact-critical application**—strengthening or repair application that relies on load transfer from the substrate to the FRP system through contact or bearing at the interface.

**Contract Documents**—set of documents that form the basis of a contractual relationship between Owner and Contractor or design-builder. These documents are defined by the contractual agreement, and can contain contract forms, contract conditions, specifications, drawings, addenda, and contract changes.

**Contractor**—the person, firm, or entity under contract for construction of the Work.

**drawings**—graphic presentations that detail requirements for Work and may include written notes.

**fiber orientation**—the direction of the principal fibers in a fabric reinforcement.

**FRP manufacturer**—company that makes components of FRP system.

**FRP system**—the fibers and resins used to create the composite laminate and resins used to bond it to the concrete substrate.

**inspection agency**—the person, firm, or entity under contract for providing inspection services.