ACI approach to repair of existing structures with focus on composites: present and near-term future

Antonio Nanni
Presentation and Objective

**Presentation**: code adoption process in the U.S. including the role of model codes (IBC and IEBC), ACI existing and under-development documents (440, 562, 563), and ASTM (D30 .05) standards

**Objective**: to make design professionals aware of activities taking place in the U.S. that have international implications. Focus is on concrete repair and composite reinforcement
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Introduction

Internationally, code officials recognize the need for a modern, up-to-date building code addressing the design and installation of building systems through requirements emphasizing performance. The International Building Code®, in this 2009 edition, is designed to meet these needs through model code regulations that safeguard the public health and safety in all communities, large and small.


The International Building Code provisions provide many benefits, among which is the model code development process that offers an international forum for building professionals to discuss performance and prescriptive code requirements. This forum provides an excellent arena to debate proposed revisions. This model code also encourages international consistency in the application of provisions.
SAMPLE ORDINANCE FOR ADOPTION OF
THE INTERNATIONAL BUILDING CODE
ORDINANCE NO._______

An ordinance of the [JURISDICTION] adopting the 2009 edition of the International Building Code, regulating and governing the conditions and maintenance of all property, buildings and structures; by providing the standards for supplied utilities and facilities and other physical things and conditions essential to ensure that structures are safe, sanitary and fit for occupation and use; and the condemnation of buildings and structures unfit for human occupancy and use and the demolition of such structures in the [JURISDICTION]; providing for the issuance of permits and collection of fees therefor; repealing Ordinance No._______ of the [JURISDICTION] and all other ordinances and parts of the ordinances in conflict therewith.

The [GOVERNING BODY] of the [JURISDICTION] does ordain as follows:

Section 1. That the [GOVERNING BODY] hereby enacts and carries into effect the provisions of this ordinance which are necessary and proper to effectuate the purposes hereinafter stated.

Section 2. The following sections are hereby revised:

Section 101.1. Insert: [NAME OF JURISDICTION]
Section 1612.3. Insert: [NAME OF JURISDICTION]
Section 1612.3. Insert: [DATE OF ISSUANCE]
Section 3412.2. Insert: [DATE IN ONE LOCATION]

Section 3. That Ordinance No._______ of [JURISDICTION] entitled [FILL IN THE COMPLETE TITLE OF THE ORDINANCE OR ORDINANCES IN EFFECT AT THE PRESENT TIME SO THAT THEY WILL BE REFERRED TO DIFFERENT NATION] and all other ordinances or parts of ordinances in conflict herewith are hereby repealed.

Section 4. That if any section, subsection, sentence, clause or phrase of this ordinance is, for any reason, held to be unconstitutional, such decision shall not affect the validity of the remaining portions of this ordinance. The [GOVERNING BODY] hereby declares that it would have passed this ordinance, and each section, subsection, clause or phrase thereof, irrespective of the fact that any one or more sections, subsections, sentences, clauses and phrases be declared unconstitutional.

Section 5. That nothing in this ordinance or in the Building Code hereby adopted shall be construed to affect any suit or proceeding pending in any court, or any rights acquired, or liabilities incurred, or any cause or causes of action acquired or existing, under any act or ordinance hereby repealed or cited in Section 3 of this ordinance; nor shall any just or legal right or remedy of any character be lost, impaired or affected by this ordinance.

Section 6. That the [JURISDICTION'S KEEPER OF RECORDS] is hereby ordered and directed to cause this ordinance to be published. (An additional provision may be required to direct the number of times the ordinance is to be published and to specify that it is to be in a newspaper in general circulation. Posting may also be required.)

Section 7. That this ordinance and the rules, regulations, provisions, requirements, orders and matters established and adopted hereby shall take effect and be in full force and effect [TIME PERIOD] from and after the date of its final passage and adoption.
The *International Building Code*® (IBC®) is a model code that provides minimum requirements to safeguard the public health, safety and general welfare of the occupants of new and existing buildings and structures. The IBC is fully compatible with the ICC family of codes, including: *International Energy Conservation Code*® (IECC®), *International Existing Building Code*® (IEBC®), etc.

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Chapter 19 Concrete. This chapter provides minimum accepted practices to the design and construction of buildings and structural components using concrete—both plain and reinforced. Chapter 19 is formatted to parallel American Concrete Institute (ACI) 318, Building Code Requirements for Structural Concrete. The chapter also includes references to additional standards. Structural concrete must be designed and constructed to comply with this code and all listed standards. There are specific sections of the chapter addressing concrete slabs, anchorage to concrete, shotcrete, reinforced gypsum concrete and concrete-filled pipe columns. Because of the variable properties of material and numerous design and construction options available in the uses of concrete, due care and control throughout the construction process is necessary.

Chapter 22 Steel. Chapter 22 provides the requirements necessary for the design and construction of structural steel (including composite construction), cold-formed steel, steel joints, steel cable structures, and steel storage tanks. The chapter specifies appropriate design and construction standards for these types of structures. It also provides a road map of the applicable technical requirements for steel structures. Steel is a noncombustible building material commonly associated with Types I and II construction; however, it is permitted to be used in all types of construction. The code requires that materials used in the design of structural steel members conform to designated national standards. Chapter 22 is involved with the design and use of steel materials utilizing the specifications and standards of the American Institute for Steel Construction, the American Iron and Steel Institute, the Steel Joist Institute and the American Society of Civil Engineers.

Chapter 23 Wood. This chapter provides guidance for the design of buildings and structures that use wood and wood-based products in their framing and fabrication. The chapter is organized around three design methodologies: allowable stress design (ASD), load and resistance-factor design (LRFD) and conventional light-frame construction. Included in the chapter are references to design and manufacturing standards for various wood and wood-based products; general construction requirements; design criteria for lateral-force-resisting systems; and specific requirements for the application of the three design methods. In general, only Type III, IV or V buildings may be constructed of wood. Accordingly, Chapter 23 is referenced when the combination of the occupancy (determined in Chapter 2) and the height and size of the building (determined in Chapter 2) indicate that construction can be Type III, IV or V.

Chapter 24 Glass and Glazing. This chapter establishes regulations for glass and glazing used in buildings and structures that, when installed, are subjected to wind, snow and dead loads. Engineering and design requirements are included in the chapter. Additional structural requirements are found in Chapter 16. A second concern of this chapter is glass and glazing used in areas where it is likely to have an impact on the occupants. Section 2406 identifies hazardous locations where glazing installed must either be safety glazing or blocked to prevent human impact. Safety glazing must meet stringent standards and be appropriately marked or identified. Additional standards for glass and glazing in guard rails, handrails, elevator hoistways and elevator cars, and athletic facilities are provided.

Chapter 25 Gypsum Board and Plaster. Chapter 25 contains the provisions and referenced standards that regulate the design, construction and quality of gypsum board and plaster. These represent the most common interior and exterior finish materials in the building industry. This chapter primarily addresses quality-control-related issues with regard to material specifications and installation requirements. Most products are manufactured under the control of industry standards. The building official or inspector primarily needs to verify that the appropriate product is used and properly installed for the intended use and location. While often simply used as wall and ceiling coverings, proper design and application are necessary to provide weather resistance and required fire protection for both structural and nonstructural building components.

Chapter 26 Plastic. The use of plastics in building construction and components is addressed in Chapter 26. This chapter provides standards addressing foam plastic insulation, foam plastics used as interior finish and trim, and other plastic veneers used on the
1901.1 Scope. The provisions of this chapter shall govern the materials, quality control, design and construction of concrete used in structures.

1901.2 Plain and reinforced concrete. Structural concrete shall be designed and constructed in accordance with the requirements of this chapter and ACI 318 as amended in Section 1908 of this code. Except for the provisions of Sections 1904 and 1910, the design and construction of slabs on grade shall not be governed by this chapter unless they transmit vertical loads or lateral forces from other parts of the structure to the soil.

1901.3 Source and applicability. The format and subject matter of Sections 1902 through 1907 of this chapter are patterned after, and in general conformity with, the provisions for structural concrete in ACI 318.
SECTION 1908
MODIFICATIONS TO ACI 318

1908.1 General. The text of ACI 318 shall be modified as indicated in Sections 1908.1.1 through 1908.1.10.

1908.1.1 ACI 318, Section 2.2. Modify existing definitions and add the following definitions to ACI 318, Section 2.2.

DESIGN DISPLACEMENT. Total lateral displacement expected for the design-basis earthquake, as specified by Section 12.8.6 of ASCE 7.

1907.7.4 Precast concrete (manufactured under plant control conditions). The minimum specified concrete cover for prestressed and nonprestressed reinforcement, ducts and end fittings in precast concrete manufactured...
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   • ACI (562 and 440)
   • ASTM standards

3. Conclusions
The International Existing Building Code is a model code in the International Code family of codes intended to provide alternative approaches to remodeling, repair or alteration of existing buildings. A large number of existing buildings and structures do not comply with the current building code requirements for new construction. Although many of these buildings are potentially salvageable, rehabilitation is often cost-prohibitive because compliance with all the requirements for new construction could require extensive changes that go well beyond the value of the building or the original scope of the rehabilitation. At the same time, it is necessary to regulate construction in existing buildings that undergo additions, alterations, renovations, extensive repairs or change of occupancy. Such activity represents an opportunity to ensure that new construction complies with the current building codes and that existing conditions are maintained, at a minimum, to their current level of compliance or are improved as required to meet basic safety levels. To accomplish this objective, and to make the rehabilitation process easier, this code allows for options for controlled departure from full compliance with the International Codes dealing with new construction, while maintaining basic levels for fire prevention, structural and life safety features of the rehabilitated building.

### Arrangement and Format of the 2009 IEBC

Before applying the requirements of the IEBC it is beneficial to understand its arrangement and format. The IEBC, like other codes published by ICC, is arranged and organized to follow logical steps that generally occur during a plan review or inspection. The IEBC is divided as follows:

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### Appendix A

Guidelines for Seismic Retrofit of Existing Buildings

The following is a chapter-by-chapter synopsis of the scope and intent of the provisions of the International Existing Building Code:

**Chapter 1 Scope and Administration.** This chapter contains provisions for the application, enforcement and administration of subsequent requirements of the code. In addition to establishing the scope of the code, Chapter 1 identifies which buildings and structures come under its purview. Chapter 1 is largely concerned with maintaining “due process of law” in enforcing the regulations contained in the body of the code. Only through careful observation of the administrative provisions can the code official reasonably expect to demonstrate that “equal protection under the law” has been provided.

2009 International Existing Building Code®
as “an extension or increase in the floor area, number of stories or height of a building or structure.” Chapter 10 contains the minimum requirements for an addition that is not separated from the existing building by a fire wall.

**Chapter 11 Historic Buildings.** This chapter provides some exceptions from code requirements when the building in question has historic value. The most important criterion for application of this chapter is that the building must be essentially accredited as being of historic significance by a state or local authority after careful review of the historical value of the building. Most, if not all, states have such authorities, as do many local jurisdictions. The agencies with such authority can be located at the state or local government level or through the local chapter of the American Institute of Architects (AIA). Other considerations include the structural condition of the building (i.e., is the building structurally sound), its proposed use, its impact on life safety and how the intent of the code, if not the letter, will be achieved.

**Chapter 12 Relocated or Moved Buildings.** Chapter 12 is applicable to any building that is moved or relocated.

**Chapter 13 Performance Compliance Methods.** This chapter, a duplicate of IBC Section 3412, Compliance Alternatives, allows for existing buildings to be evaluated so as to show that alterations, while not meeting new construction requirements, will improve the current existing situation. Provisions are based on a numerical scoring system involving 18 various safety parameters and the degree of code compliance for each issue.

**Chapter 14 Construction Safeguards.** The building construction process involves a number of known and unanticipated hazards. Chapter 14 establishes specific regulations in order to minimize the risk to the public and adjacent property. Some construction failures have resulted during the initial stages of grading, excavation, and demolition. During these early stages, poorly designed and installed sheeting and shoring have resulted in ditch and embankment cave-ins. Also, inadequate underpinning of adjoining existing structures or careless removal of existing structures has produced construction failures.

**Chapter 15 Referenced Standards.** The code contains numerous references to standards that are used to regulate materials and methods of construction. Chapter 15 contains a comprehensive list of all standards that are referenced in the code, including the appendices. The standards are part of the code to the extent of the reference to the standard. Compliance with the referenced standard is necessary for compliance with this code. By providing specifically adopted standards, the construction and installation requirements necessary for compliance with the code can be readily determined. The basis for code compliance is, therefore, established and available on an equal basis to the building code official, contractor, designer and owner.

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**Appendix A Guidelines for the Seismic Retrofit of Existing Buildings.** Appendix A provides guidelines for upgrading the seismic resistance capacity of different types of existing buildings. It is organized into separate chapters which deal with buildings of different types, including unreinforced masonry buildings, reinforced concrete and reinforced masonry wall buildings, and light-frame wood buildings.

**Appendix B Supplementary Accessibility Requirements for Existing Buildings and Facilities.** Chapter 11 of the International Building Code® (IBC®) contains provisions that set forth requirements for accessibility to buildings and their associated sites and facilities for people with physical disabilities. Sections 406, 506, 606, 706, 806, 905, 1004, 1005 and 1308 in the code address accessibility provisions and alternatives permitted in existing buildings. Appendix B was added to address accessibility in construction for items that are not typically enforceable through the traditional building code enforcement process.

**Resource A Guidelines on Fire Ratings of Archaic Materials and Assemblies.** In the process of repair and alteration of existing buildings, based on the nature and the extent of the work, the IIEBC might require certain upgrades in the fire-resistance rating of building elements, at which time it becomes critical for the designers and the code officials to be able to determine the fire-resistance rating of the existing building elements as part of the overall evaluation for the assessment of the need for improvements. This resource document provides a guideline for such an evaluation for fire-resistance rating of archaic materials that is not typically found in the modern model building codes.
CHAPTER 16
REFERENCED STANDARDS

This chapter lists the standards that are referenced in various sections of this document. The standards are listed herein by the promulgating agency of the standard, the standard identification, the effective date and title, and the section or sections of this document that reference the standard. The application of the referenced standards shall be as specified in Section 102.4.

**ASCE**
American Society of Civil Engineers Structural Engineering Institute
1801 Alexander Bell Drive
Reston, VA 20191-4100

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**ASHRAE**
American Society of Heating, Refrigerating and Air Conditioning Engineers
1791 Trolley Circle, NE
Atlanta, GA 30329

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**ASME**
American Society of Mechanical Engineers
3 Park Avenue
New York, NY 10016

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**ASTM**
ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959

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**DOC**
United States Department of Commerce
1401 Constitution Avenue, NW
Washington, DC 20230

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Need for ACI 562
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2. Concrete Repair: sequence/situation of mandatory and non-mandatory language documents
   • ACI (562 and 440)
   • ASTM standards

3. Conclusions
The next section will show the role that different documents have for the development of a concrete repair code with focus on composite reinforcement (this will include a description of the committees developing them):

- ACI (562, 563, 440,)
- ASTM D30.05 standards

A short explanation of the types of documents developed by ACI will precede
ACI Technical Committee Manual
March 2009
Prepared by the ACI Technical Activities Committee

FOREWORD

This manual has been prepared by the Technical Activities Committee (TAC) to guide the operation of ACI technical committees. The success of any committee effort depends largely on the administrative ability and initiative of the Chair. Chairs of ACI technical committees are chosen for their demonstrated ability and knowledge in the field to be covered by the committee as well as for their administrative skills. Many details of committee operations are left to their judgment.

For uniformity of operation and for coordination of activities of the many ACI committees, some mandatory regulations are necessary for compliance with approved policies for the development of standards. These mandatory requirements for committee activities are found throughout the manual. They are stated in the positive language of “shall” or “must,” whereas suggestions are presented as “should” or “may.”

TAC is always looking for ways to improve and streamline committee procedures. Any comments are welcome.

Comments can be e-mailed to:
3.2.1 Mandatory language documents requiring standardization (ACI standards)

3.2.1.1 Codes
   3.2.1.1.1 Code requirements
   3.2.1.1.2 Code cases
   3.2.1.1.3 Acceptance criteria

3.2.1.2 Specifications
   3.2.1.2.1 Reference specifications
   3.2.1.2.2 Guide specifications
   3.2.1.2.3 Material specifications
   3.2.1.2.4 Test methods

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ACI Committee 562 Home

Evaluation, Repair, and Rehabilitation of Concrete Buildings

(Organized 2004)

Chair: Lawrence Kahn  
TAC Contact: Antonio Nanni

Mission

Develop and maintain code requirements for evaluation, repair, and rehabilitation of existing concrete buildings.

Goals

Develop a code and commentary for evaluation, repair, and rehabilitation of existing concrete buildings.

Upcoming Open Meetings

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Documents under Development

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<td>562</td>
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Category: New
ACI 562 – Code Requirements for Evaluation, Repair and Rehabilitation of Existing Concrete Buildings

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Chapter 2 – Notation and Definitions
Chapter 3 – Applicability

Part II – Evaluation of Existing Structures

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9.3 Construction Documents
9.4 Contractor Responsibility
9.5 Structural Testing
9.6 Structural Observations
Specifics on Chapter 7 and Section 7.9, in particular, that introduce and regulate in mandatory language the use of composites for concrete repair and strengthening.
Chapter 7 – Design of Structural Repairs

7.1 Engineering Principles

7.1.1 The design of repairs shall follow substantiated engineering principles.

7.1.1C Engineering principles including, but not limited to force equilibrium and strain compatibility should be considered during design of repairs. Design of repairs should be based on substantiated design methods such those in design standards or on design methods that have been verified experimentally.

7.2 Strength and Serviceability

7.2.1 The design strength of repaired structures shall be determined by the required strengths calculated for the factored loads and forces in such combinations as stipulated in Chapter 5.

Note: C means commentary and not part of the code. This is where non-mandatory language documents can be cited.
7.9 Repair using Fiber-Reinforced Polymer Composites

7.9C FRP can be used to repair existing concrete structures. FRP fabrics, bars or shapes are permitted to be externally and internally bonded and unbonded reinforcement. FRP systems can be used to restore the strength of a deteriorated structural member, add capacity to a sound structural member, or retrofit a structurally inadequate concrete member due to design. FRP can be used as externally bonded reinforcement, internal reinforcement, and as internal or external prestressed reinforcement. Pultruded FRP shapes may be used as additional members to strengthen existing buildings.

Note: Reference to 440.2R is only in the commentary
7.9.1.1 Structural members repaired or upgraded with externally applied FRP composites shall have adequate unstrengthened capacity as defined in Chapter 5 to prevent member failure under the new sustained service load in the absence of the FRP system.

7.9.1.1 To prevent sudden failure of the member in case the FRP system is damaged or becomes ineffective, such as a fire event, the structural member must have adequate strength without the FRP reinforcement to support sustained loads.

7.9.3 Fire protection of FRP systems shall satisfy the requirements of Section 7.11
Design and detailing of internal FRP reinforcement should be achieved in accordance with ACI 440.1R with particular attention to service limits and determination of FRP material design properties. The design professional should determine if internal FRP reinforcement is a suitable repair technique before selecting the type of FRP system based on the level of upgrade required and current condition of the member. Prestressed FRP reinforcement is used the design and detailing should be in accordance with ACI 440.4R.

Note: Reference to 440.1R is only in the commentary
ACI Committee 440 Home

Fiber Reinforced Polymer Reinforcement

(Organized 1991)

Chair: Carol Shield  
TAC Contact: Antonio Nanni

Mission

Develop and report information on fiber reinforced polymer for internal and external reinforcement of concrete.

Goals

1) Report on FRP materials, research, products, and industry practice; 2) Develop design guides, specification, standards, and construction practice for practitioners; 3) Develop educational resources including seminars, technical sessions, and symposiums; 4) Organize, promote, and facilitate product competitions that allow students to apply design with the manufacture of concrete products to learn the principals of FRP composites and concrete technology; 5) Provide a forum for technical exchange of information for FRP composites used with reinforced concrete and masonry structures.

Upcoming Open Meetings

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<tr>
<th>Convention</th>
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<td>New Orleans, LA</td>
<td>11/10/2009 8:30:00 AM - 11:30:00 AM</td>
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11/5/2009 Nanni
<table>
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<tr>
<th>Title</th>
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<tr>
<td>440.1R-06: Guide for the Design and Construction of Structural Concrete Reinforced with FRP Bars</td>
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<td>440.2R-08: Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures</td>
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<td>440.3R-04: Guide Test Methods for Fiber-Reinforced Polymers (FRPs) for Reinforcing or Strengthening Concrete Structures</td>
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<td>440.4R-04: Prestressing Concrete Structures with FRP Tendons</td>
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<td>440.5-08: Specification for Construction with Fiber-Reinforced Polymer Reinforcing Bars</td>
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<td>440.5M-08: Specification for Construction with Fiber-Reinforced Polymer Reinforcing Bars (Metric)</td>
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<td>440.6-08: Specification for Carbon and Glass Fiber-Reinforced Polymer Bar Materials for Concrete Reinforcement</td>
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<td>440.6M-08: Specification for Carbon and Glass Fiber-Reinforced Polymer Bar Materials for Concrete Reinforcement (Metric)</td>
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<tr>
<td>440R-07: Report on Fiber-Reinforced Polymer (FRP) Reinforcement for Concrete Structures</td>
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Note: 440.5-08 and 440.6-08 are in mandatory language and can be incorporated by reference in contractual...
SP-138: Fiber-Reinforced-Plastic Reinforcement for Concrete Structures - International Symposium
SP-188: 4th Intl Symposium - Fiber Reinforced Polymer Reinforcement for Reinforced Concrete Structures
SP-215: Field Applications of FRP Reinforcement: Case Studies
SP-230: 7th International Symposium on Fiber-Reinforced Polymer (FRP) Reinforcement for Concrete Structures
SP-230CD: (CD-ROM) 7th Intl Symposium on Fiber-Reinforced Polymer (FRP) Reinforcement for Conc Struct
SP-245CD: (CD-ROM ) Case Histories and Use of FRP for Prestressing Applications
SP-257CD: (CD-ROM) FRP Stay-In-Place Forms for Concrete Structures
SP-258CD: (CD-ROM) Seismic Strengthening of Concrete Buildings Using FRP Composites

Special Publications under Development

Title
Fiber-Reinforced Polymer (FRP) Reinforcement for Concrete Structures
Serviceability of Concrete Members Reinforced with Internal/External FRP Reinforcement
Table of contents

1. Code adoption process in the U.S.
   • Example for new construction (Model Code IBC 2009 and ACI 318 by reference)
   • Case for existing buildings (Model Code IEBC 2009 and need for ACI 562 by reference)

2. Concrete Repair: sequence/situation of mandatory and non-mandatory language documents
   • ACI (562 and 440)
   • ASTM D30.05 standards

3. Conclusions
Technical Committees / Committee D30/

Committee D30.05 on Structural Test Methods

**ACTIVE** standards under the jurisdiction of D30.05

D7205/D7205M-06 Standard Test Method for Tensile Properties of Fiber Reinforced Polymer Matrix Composite Bars

D7290-06 Standard Practice for Evaluating Material Property Characteristic Values for Polymeric Composites for Civil Engineering Structural Applications

D7337/D7337M-07 Standard Test Method for Tensile Creep Rupture of Fiber Reinforced Polymer Matrix Composite Bars

D7522/D7522M-09 Standard Test Method for Pull-Off Strength for FRP Bonded to Concrete Substrate
ASTM D7205 / D7205M
Significance and Use
This test method is designed to produce longitudinal tensile strength and elongation data. From a tension test, a variety of data are acquired that are needed for design purposes. Material-related factors that influence the tensile response of bars and should therefore be reported include the following: constituent materials, void content, volume percent reinforcement, methods of fabrication, and fiber reinforcement architecture.

Properties, in the test direction, that may be obtained from this test method include:

- Ultimate tensile strength,
- Ultimate tensile strain,
- Tensile chord modulus of elasticity, and
- Stress-strain curve.
ASTM D7522 / D7522M

Significance and Use
The pull-off strength of a bonded FRP system is an important performance property that has been used in specifications, particularly those for assessing the quality of an application. This test method serves as a means for uniformly preparing and testing bonded FRP systems, and evaluating and reporting the results. Variations in results obtained using different devices are possible.

This test method is intended for use in both the field and the laboratory.

The basic material properties obtained from this test method can be used in the control of the quality of adhesives and in the theoretical equations for designing FRP systems for external reinforcement to strengthen existing structures.
Significance and Use

This method for investigating creep rupture of FRP bars is intended for use in laboratory tests in which the principal variable is the size or type of FRP bars, magnitude of applied force, and duration of force application. Unlike steel reinforcing bars or prestressing tendons subjected to significant sustained stress, creep rupture of FRP bars may take place below the static tensile strength. Therefore, the creep rupture strength is an important factor when determining acceptable stress levels in FRP bars used as reinforcement or tendons in concrete members designed to resist sustained loads. Creep rupture strength varies according to the type of FRP bars used.
Significance and Use

This practice covers the procedures for computing material property characteristic values for polymeric composite materials intended for use in civil engineering structural applications. A characteristic value represents a statistical lower bound on the material property structural member resistance factors for civil engineering design codes for composite structures.

This practice may be used to obtain characteristic values for stiffness and strength properties of composite materials obtained from measurements using applicable test methods.
**Proposed New Standards**

**WK17265** Pull-Off Strength for Fiber-Reinforced Polymer Composites Bonded to Concrete Substrate

**WK22346** Determining Overlap Splice Tensile Properties of Fiber-Reinforced Polymer Matrix Composites Used For Strengthening of Civil Structures

**WK22348** Transverse Shear Strength of Fiber-Reinforced Polymer Matrix Composite Bars

**WK22503** Determining Tensile Properties of Fiber-Reinforced Polymer Matrix Composites Used for Strengthening of Civil Structures
Work Item: ASTM WK17265 - New Test Method for Pull-Off Strength for Fiber-Reinforced Polymer Composites Bonded to Concrete Substrate

1. Scope

This test method describes the apparatus and procedure for evaluating the pull-off strength of wet lay-up or pultruded FRP laminate systems adhesively bonded to a flat concrete substrate. The test method determines the greatest perpendicular force (in tension) that an FRP system can bear before a plug of material is detached.

This test method is primarily used for quality control and assessment of field repairs of structures using adhesive-applied composite materials.
1. Scope

This test method describes the requirements for sample preparation and tensile testing of overlap splices formed with fiber-reinforced polymer (FRP) composite materials commonly used for strengthening of structures made of materials such as metals, timber, masonry, and reinforced concrete. The objective of this test method is to determine the apparent shear strength of an overlap splice joint through direct tension. This test method is often used to determine the length of the overlap splice needed to induce stock-break failures. This test method applies to wet lay-up and pre-impregnated FRP material systems fabricated on site or in a laboratory setting.
Work Item: ASTM WK22348 - New Test Method for Transverse Shear Strength of Fiber-Reinforced Polymer Matrix Composite Bars

1. Scope

This test method specifies the test requirements for fiber-reinforced polymer (FRP) composite smooth round rods and textured bars for determining the transverse shear strength in double shear.

This standard is used to assess the dowel strength of FRP concrete reinforcements for use as dowels in pavements and other shear strengthening applications.

1. Scope

This test method describes the requirements for sample preparation, tensile testing, and results calculation of flat fiber-reinforced polymer (FRP) composite materials used for the strengthening of structures made of materials such as metals, timber, masonry, and reinforced concrete. The test method may be used to determine the tensile properties of wet lay-up and pre-impregnated FRP composites fabricated on site or manufactured in a factory setting.
Table of contents

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   • ACI (562 and 440)
   • ASTM standards

3. Conclusions
Conclusions

• The Code implementation process in the U.S. is linear and uses the concept of “adoption by reference”

• Many organizations contribute to the development of codes each with its area of expertise (for repair of concrete mainly: ICC, ACI, ICRI and ASTM)

• A new Concrete Repair Code (ACI 562) will be in-place by 2014 for incorporation by reference in IEBC

• ACI 562 for the first time allows and regulates the use of composites for repair of concrete structures
Conclusions - Continued

• ACI 562 is supported by non-mandatory and mandatory documents. For composites, such documents are generated by ACI 440 & ASTM D30-05

• Design guides (440-1R and 440-2R) in non-mandatory language will remain an important aid for practitioners. Guides will be referenced in the commentary of ACI 562

• Existing mandatory language documents for composites (material specifications, construction specifications and test methods) can be readily incorporated in contract documents
Thanks and Questions?