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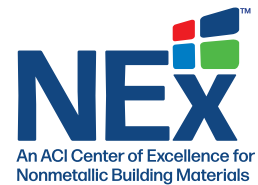
SYMPOSIUM VOLUME



Proceedings of the 16th International
Symposium on Fiber-Reinforced Polymer
(FRP) Reinforcement for Concrete
Structures (FRPRCS-16)

SP-360

Editors:
Ayman M. Okeil,
Pedram Sadeghian,
John J. Myers, and
Maria D. Lopez



American Concrete Institute
Always advancing

Proceedings of the 16th International
Symposium on Fiber-Reinforced
Polymer (FRP) Reinforcement for
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Proceedings of the 16th International Symposium on Fiber-Reinforced Polymer (FRP) Reinforcement for Concrete Structures (FRPRCS-16)

The 16th International Symposium on Fiber-Reinforced Polymer (FRP) Reinforcement for Concrete Structures (FRPRCS-16) was organized by ACI Committee 440 (Fiber-Reinforced Polymer Reinforcement) and held on March 23 and 24, 2024, at the ACI Spring 2024 Convention in New Orleans, LA. FRPRCS-16 gathers researchers, practitioners, owners, and manufacturers from the United States and abroad, involved in the use of FRPs as reinforcement for concrete and masonry structures, both for new construction and for strengthening and rehabilitation of existing structures.

FRPRCS is the longest running conference series on the application of FRP in civil construction, commencing in Vancouver, BC, in 1993. FRPRCS has been one of the two official conference series of the International Institute for FRP in Construction (IIFC) since 2018 (the other is the CICE series). These conference series rotate between Europe, Asia, and the Americas, with alternating years between CICE and FRPRCS. The ACI convention has previously cosponsored the FRPRCS symposium in Anaheim (2017), Tampa (2011), Kansas City (2005), and Baltimore (1999).

This Special Publication contains a total of 52 peer-reviewed technical manuscripts from 20 different countries from around the world. Papers are organized in the following topics: (1) FRP Bond and Anchorage in Concrete Structures; (2) Strengthening of Concrete Structures using FRP Systems; (3) FRP Materials, Properties, Tests and Standards; (4) Emerging FRP Systems and Successful Project Applications; (5) FRP-Reinforced Concrete Structures; (6) Advances in FRP Applications in Masonry Structures; (7) Seismic Resistance of FRP-Reinforced/Strengthened Concrete Structures; (8) Behavior of Prestressed Concrete Structures; (9) FRP Use in column Applications; (10) Effect of Extreme Events on FRP-Reinforced/Strengthened Structures; (11) Durability of FRP Systems; and (12) Advanced Analysis of FRP Reinforced Concrete Structures.

The breadth and depth of the knowledge presented in these papers is clear evidence of the maturity of the field of composite materials in civil infrastructure. The ACI Committee 440 is witness to this evolution, with its first published ACI CODE-440.11, "Building Code Requirements for Structural Concrete with Glass Fiber Reinforced Polymer (CFRP) Bars," published in 2022. A second code document on fiber reinforced polymer for repair and rehabilitation of concrete is under development.

The publication of the sixteenth volume in the symposium series could not have occurred without the support and dedication of many individuals. The editors would like to recognize the authors who diligently submitted their original papers; the reviewers, many of them members of ACI Committee 440, who provided critical review and direction to improve these papers; ACI editorial staff who guided the publication process; and the support of the American Concrete Institute (ACI) and the International Institute for FRP in Construction (IIFC) during the many months of preparation for the Symposium.

Ayman M. Okeil, Pedram Sadeghian, John J. Myers, and Maria D. Lopez
Co-editors

TABLE OF CONTENTS

TOPIC: FRP Bond and Anchorage in Concrete Structures

SP-360-1:

Proposed Design Method for EB-FRP Ties Debond Strain Encompassing Short/Long and Thin/Thick Ties 1-20
Authors: Junrui Zhang, Enrique del Rey Castillo, Ravi Kanitkar, Aniket D Borwankar, and Ramprasath R

SP-360-2:

Review and Analysis of FRP Bond Lengths from Pull-out Testing Database with Reduced Embedment Lengths 21-35
Author: John Myers

SP-360-3:

Evaluation of the Bond Performance of Concrete-Epoxy Interface Using Segmentation-Based Image Processing Techniques 36-49
Authors: Abubakar S. Ishaq, Maria M. Lopez, Charles E. Bakis, and Yoseok Jeong

SP-360-4:

Behavior of Partially Bonded GFRP-Reinforced Concrete Beams 50-63
Authors: Ali Alatif and Yail Kim

SP-360-5:

Bond Performance of CFRP-Concrete Joints Subjected to Freeze-Thaw Cycles: Experimental Study and Analytical Analysis 64-79
Authors: Ahmed Kallel, Radhouane Masmoudi, Benoit Bissonnette, and Marcelin Joanis

SP-360-6:

Model Uncertainty in Reliability Analysis of FRP-to-Concrete Bond with Grooves 80-95
Authors: Zhao Wang and Baolin Wan

SP-360-7:

Fracture Energy of GFRP-Concrete Bonded Interface after Sustained Loading in Natural Environments 96-105
Authors: Jaeha Lee, Kivanc Artun, Charles E. Bakis, Maria M. Lopez, and Thomas E. Boothby

SP-360-8:

Data-Driven Prediction of The Bond Coefficient Between Fibre-Reinforced Polymer (FRP) Bars and Concrete 106-121
Authors: Nadia Nassif, M. Talha Junaid, Salah Altoubat, Mohamed Maalej, and Samer Barakat

TOPIC: Strengthening of Concrete Structures using FRP Systems

SP-360-9:

Effectiveness of Using Dowelled GFRP Bars to Repair Reinforced Concrete Bridge Barriers 122-140
Authors: Juan Torres Acosta and Douglas Tomlinson

SP-360-10:

A New Bond Model for RC Beams Strengthened with Embedded Through-Section Method 141-155
Authors: Sara Mirzabagheri, Andrew Kevin, Kenneth Doyle, Amir Mofidi, and Omar Chaallal

SP-360-11:

Shear Behavior of 60-Year-Old Bridge Girder Strengthened Using CFRP Sheets..... 156-178
Authors: Mohamed Ahmed, Slimane Metiche, Radhouane Masmoudi, Richard Gagne,
and Jean- Philippe Charron

SP-360-12:

Assessment of the Existing Shear Resistance Models for RC Beams Strengthened with
Near Surface-Mounted FRP Reinforcement..... 179-193
Authors: Amirhossein Mohammadi, Joaquim A.O. Barros, José Sena-Cruz, and Salvador J.E. Dias

TOPIC: FRP Materials: Properties, Tests and Standards

SP-360-13:

Physical and Mechanical Properties of Helical Wrap GFRP Bars for Reinforcing
Concrete Structures 194-211
Authors: Girish Narayan Prajapati, Shehab Mehany, Wenxue Chen, and Brahim Benmokrane

SP-360-14:

Interface Shear Transfer Mechanism with GFRP Bars Reinforcement..... 212-224
Authors: Camilo Vega, Abdeldjelil Belarbi, and Antonio Nanni

SP-360-15:

An Effective Simple Fixture for Testing GFRP Rebars in Compression 225-241
Authors: Alireza Sadat Hosseini and Pedram Sadeghian

SP-360-16:

Exploring Strength of Straight and Bent GFRP Bars: Refinements to CSA S807:19 Annex E 242-253
Authors: Ahmed Khalil, Rami A. Hawileh, and Mousa Attom

SP-360-17:

Convertible Bond Test Apparatus for EB FRP, NSM FRP, FRCM, and Allied Systems:
Proof of Concept..... 254-273
Author: Faisal Mukhtar

TOPIC: Emerging FRP Systems and Successful Project Applications

SP-360-18:

Numerical Design Optimization of a New Hybrid-Utility Pole 274-289
Authors: Mohamed Bouabidi, Slimane Metiche, and Radhouane Masmoudi

SP-360-19:

A Novel VOC-Free Epoxy System for High Modulus Glass Fiber Reinforced Polymer Rebar290-298
Authors: Huifeng Qian and Wendell Harriman II

SP-360-20:

Monitoring of RC Beams Using Smart FRP Bonded Material..... 299-317
Authors: Emmanuel Ferrier, Laurent Michel, and Andrea Armonico

TOPIC: FRP-Reinforced Concrete Structures

SP-360-21:

Assessment of the Flexural Bond Stresses of New Generation GFRP Bars.....318-329
Authors: Jesús D. Ortiz, Zahid Hussain, Seyed-Arman Hosseini, Brahim Benmokrane,
and Antonio Nanni

SP-360-22:

Evaluation of ACI 440.11 Shear Strength Provisions for Members without Stirrups330-348
Authors: Stephanie L. Walkup, Eric S. Musselman, Shawn P. Gross, and Hannah Kalamarides

SP-360-23:

Structural and Deformational Behavior of Flexural Concrete Beams Reinforced with GFRP
and BFRP Rebars349-368
Authors: Raphael Kampmann, Tim Rauert, Niklas Pelka, and Bastian Franzenburg

SP-360-24:

Open Issues on the Structural Performances of Concrete Beams Reinforced with
FRP (Fiber Reinforced Polymers) Rebars369-382
Authors: Maria Antonietta Aiello and Luciano Ombres

TOPIC: Advances in FRP Applications in Masonry Structures

SP-360-25:

Experimental Efficiency of FRP Bars as Injected Anchors for Masonry Structures383-394
Authors: Francesca Ceroni, Alberto Balsamo, and Marco Di Ludovico

SP-360-26:

Out-of-Plane Strengthening of Masonry Walls with Inorganic Composites 395-402
Authors: Marta Del Zoppo, Marco Di Ludovico, Alberto Balsamo, and Andrea Prota

SP-360-27:

Discontinuous FRCM-Confinement of Masonry Columns403-412
Authors: Alessio Cascardi, Salvatore Verre, and Luciano Ombres

SP-360-28:

Use of CFRP Rebars as Retrofitting System for Masonry Panels.....413-422
Authors: F. Ferretti, A. R. Tilocca, A. Incerti, S. Barattucci, and M. Savoia

TOPIC: Seismic Resistance of FRP-Reinforced/Strengthened Concrete Structures

SP-360-29:

Modeling Cyclic Response of CFRP Strengthened Fiber Anchored RC Frame
Members to Failure423-441
Authors: Salman Alshamrani, Sama Mohammed Saleem, Hayder A. Rasheed, and Fahed H. Salahat

SP-360-30:

A Comparative Analysis of GFRP- and Steel-RC Columns under Combined Shear,
Flexure, and Torsion Loads.....442-461
Authors: Yasser M. Selmy and Ehab F. El-Salakawy

SP-360-31:

Seismic Strengthening of RC Beam-Column Joints with FRP Systems Applicable from the Exterior of the Building 462-473
Authors: Ciro Del Vecchio, Marco Di Ludovico, Alberto Balsamo, and Andrea Prota

SP-360-32:

Numerical Investigation and Experimental Plan on Seismic Performance of Carbon Fiber-Reinforced Polymer-Reinforced Concrete Columns..... 474-490
Authors: Chaoran Liu, Ligang Qi, Ying Zhou, Guowen Xu, Yan Yang, Zhiheng Li, and Yiqiu Lu

TOPIC: Behavior and Design of Prestressed Concrete Structures

SP-360-33:

Deflection Behavior of Beams Prestressed with Bonded FRP Tendons491-510
Authors: Wassim Nasreddine, Peter H. Bischoff, and Hani Nassif

SP-360-34:

Flexural Behavior of Concrete Beams Prestressed with Hybrid Tendons 511-529
Authors: Adi Obeidah and Hani Nassif

SP-360-35:

Application of FRP in the Rehabilitation of Prestressed Concrete Girder Bridges530-547
Authors: Ramin Rameshni, Reza Sadjadi, and Melanie Knowles

SP-360-36:

The Performance of Prestressed Carbon Fibre Reinforced Polymer (CFRP) Bridge Tendons after 18 Years in Service.....548-562
Authors: Alexandra Boloux, Luke Bisby, Valentin Ott, and Giovanni P. Terrasi

TOPIC: FRP Use in Column Applications

SP-360-37:

Biaxial Interaction Diagrams of Elliptical Concrete Column Sections Reinforced with GFRP Bars.....563-581
Authors: Ahmad Ghadban and Hayder A. Rasheed

SP-360-38:

Stress-Strain Model of Concrete Confined by FRP Laminate and Spike Anchors.....582-601
Authors: Zhibin Li, Enrique del Rey Castillo, Richard S. Henry, Kent A. Harries, and Tongyue Zhang

SP-360-39:

Failure Characterization of GFRP-Reinforced Concrete Walls..... 602-611
Authors: Ju-Hyung Kim and Yail J. Kim

TOPIC: Effects of Extreme Events on FRP-Reinforced/Strengthened Structures

SP-360-40:

Experimental Assessment of Large-Scale FRP-Strengthened RC Shear Controlled Walls Subjected to Cyclic Loads..... 612-627
Authors: Lin S-H, Kim I, Borwankar A, Kanitkar R, Hagen G, and Shapack G

SP-360-41:

Evaluation of Hysteretic Energy and Damping Capacity of GFRP-RC Columns Under Cyclic Loading 628-647
Authors: Yasser M. Selmy, Amr E. Abdallah, and Ehab F. El-Salakawy

SP-360-42:

PBO FRCM Composite System Exposed to Elevated Temperatures: Experimental and Theoretical Investigations 648-662
Authors: Luciano Ombres, Pietro Mazzuca, Alfredo Micieli, and Francesco Campolongo

SP-360-43:

Seismic Performance of Concrete Beam-Column Joints Reinforced with Carbon Fiber-Reinforced Polymer (CFRP) Bars and Stirrups..... 663-677
Authors: Ligang Qi, Guohua Cen, Chaoran Liu, Ying Zhou, Guowen Xu, Yan Yang, Zhiheng Li, and Yiqiu Lu

TOPIC: Durability of FRP Systems**SP-360-44:**

Freeze-Thaw Durability of GFRP and BFRP Rebars.....678-690
Authors: Raphael Kampmann, Carolin Martens, Srichand Telikapalli, and Alvaro Ruiz Empananza

SP-360-45:

Assessment of Crack Spacing and Crack Width Formulations in RC Elements Externally Strengthened with FRP Materials 691-708
Authors: Francesca Ceroni, Cristina Barris, and Alejandro Perez Caldentey

SP-360-46:

Quasi-Static and Fatigue Behavior of GFRP Bars Embedded in Concrete: A Comparison Between Pull-Out Tests and Flexural Tests of Slabs 709-728
Authors: Charles Tucker Cope III, Mohammad Minhajur Rahman, Francesco Focacci, Tommaso D'Antino, Iman Abavisani, and Christian Carloni

SP-360-47:

Fatigue Performance of Real-Scale Precast GFRP Reinforced Lightweight Concrete Arches729-743
Authors: Bartosz Piątek and Tomasz Siwowski

SP-360-48:

Fatigue Behavior of CFRP Sheets Attached to Concrete Surface by Using EBROG Strengthening Method 744-758
Authors: Mehdi Khorasani, Giovanni Muciaccia, and Davood Mostofinejad

TOPIC: Advanced Analysis of FRP Reinforced Concrete Structures**SP-360-49:**

Analysis of Concrete Deep Beams with Fibre-Reinforced Polymer (FRP) Bars by Indeterminate Strut-and-Tie (IST) Method.....759-770
Authors: Shuqing Liu and Maria Anna Polak

SP-360-50:

Effect of Weathering Exposure Time on the Flexural Behavior of FRP Strengthened RC Beams..... 771-790
Authors: Haitham A. Ibrahim, Mohamed F. M. Fahmy, and Seyed Saman Khedmatgozar Dolati

SP-360-51:

Finite Element Analysis of the Interface between FRP and Concrete.....791-803
Authors: Todor Zhelyazov, Eythor Rafn Thorhallsson, and Jonas Thor Snaebjornsson

SP-360-52:

A Review of Strut-and-Tie Models for FRP Reinforced Deep Beams.....804-814
Authors: Taylor J. Brodbeck, Giorgio T. Proestos, and Rudolf Seracino

**Proposed Design Method for EB-FRP Ties Debond Strain
Encompassing Short/Long and Thin/Thick Ties**

Junrui Zhang, Enrique del Rey Castillo, Ravi Kaniitkar, Aniket D Borwankar, and Ramprasath R

Synopsis: A systematic literature review was conducted on pure tension strengthening of concrete structures using fiber-reinforced polymer (FRP), specifically for larger FRP tie applications. This work yielded a dataset of 1,627 direct tension tests, and highlighted the limitation of existing studies on studying thick and long FRP ties, which are typical in real construction scenarios. To overcome this shortcoming, 51 single lap shear tests were conducted on thicker and longer FRP ties, with the dimensions being 0.5 to 6 mm [0.02 to 0.24 in.] thickness, and 300 to 1,524 mm [12 to 60 in.] long. The critical parameters under consideration were concrete compressive strength, FRP thickness, and bond length. The findings demonstrate that thicker and therefore stiffer FRP ties have higher debond force capacity, while longer ties exhibit greater post-elastic deformation capacity but do not affect the debond force capacity. Concrete had a limited effect on either debond force or deformation capacity. A strength model is proposed for FRP systems under axial pure tension, which aligns well with both the published and tested results. This paper focuses on the development of design guidelines and codes to predict the debond strain for EB-FRP systems incorporating thicker and longer FRP ties, aiming to enhance the applicability of FRP to real-world construction scenarios.

Keywords: Externally bonded reinforcement (EBR), Fiber reinforced polymer (FRP), Reinforced concrete (RC), Interfacial bond behavior, Cohesive debonding, Single-lap shear test.