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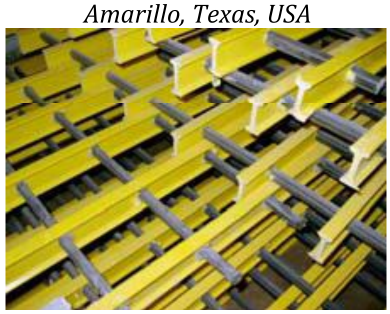
Editor's Note

Winners of the 2005 IIFC Photo Competition…

2005 Winner in Applications Category
Doug Gremel: Laying out an FRP deck in Amarillo, Texas, USA



2005 Winner in Research Category
Steve Preston: FRP bars waiting to be tested

With this issue, I hope to reinvigorate *FRP International* as a venue for reporting research findings and activities to the IIFC membership.

In the first article, Prof. Fam reports on an innovative study of strengthening thin-walled steel HSS moment connections with external FRP. In the second, a team of IIFC and ACI 440 members report on the progress of migrating the test methods developed for ACI Committee 440K, the *Guide Test Methods for Fiber-Reinforced Polymers (FRPs) for Reinforcing or Strengthening Concrete Structures*, into full-fledged ASTM standards. Despite the progress reported, considerably more work is necessary. Those interested in working within ASTM Committee D30 to develop test standards for FRP used in concrete infrastructure are encouraged to contact Prof. Gentry or Prof. Bakis.

I would also like to draw everyone's attention to the announcement for the 2012 IIFC Photo competition on page 2. The winners will be announced at CICE 2012 in Rome.

Kent A. Harries
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Become an *FRP International Author…*

As IIFC grows, we also hope to expand the utility and reach of *FRP International*. The newsletter will continue to report the activities of IIFC and focus on IIFC-sponsored conferences and meetings. Nevertheless, we are also soliciting short articles of all kinds: research or research-in-progress reports and letters, case studies, field applications, or anything that might interest the IIFC membership. Articles will generally run about 1000 words and be well-illustrated. Submissions may be sent directly to the editor. Additionally, please utilize *FRP International* as a forum to announce items of interest to the membership. Announcements of upcoming conferences and abstracts from newly-published PhD dissertations are particularly encouraged. *FRP International* is yours, the IIFC membership's forum. The newsletter will only be as useful and interesting as you help to make it. So, again, *please become an* FRP International *author*.

IIFC Congratulates...

The IIFC Honours Committee is pleased to announce the recipients of the 2012 IIFC Awards:

IIFC Medal

Professor Lawrence C. Bank, Associate Provost for Research at The City College of New York, USA.

The IIFC Medal, established in 2006, is the Institute's highest honour and is awarded to an IIFC member who has made distinguished contributions to the field of FRP composites for construction through research or practical applications, or both.

IIFC Distinguished Young Researcher Award

Dr. Laura de Lorenzis, University of Salento, Italy.

The Distinguished Young Researcher Award, also established in 2006, recognises a member of the FRP research community, not older than 40, who has distinguished himself/herself from his/her peers through research contributions in the field of FRP composites for construction.

Both Prof. Bank and Dr. de Lorenzis will present keynote lectures and receive their awards at the 6th International Conference on FRP Composites in Civil Engineering (CICE 2012) in Rome, June 13-15, 2012.

The members of Honours Committee would like to congratulate the winners of these prestigious IIFC Awards and to thank all the nominees and corresponding and supporting nominators for their careful preparation of all the needed documents. They also would like to motivate all those who were not honoured this time to participate again in the future. Several of the winners in 2010 and 2012 were also nominees in 2008 or 2010.

The IIFC Honours Committee is comprised of past IIFC honourees:

Dr. Renata Kotynia, Technical University of Lodz
Prof. Urs Meier, EMPA (chair)
Prof. Sami Rizkalla, North Carolina State University
Dr. Scott T. Smith, The University of Hong Kong
Prof. Jin-Guang Teng, The Hong Kong Polytechnic University
Prof. Thanisis Triantafillou, University of Patras

Prof. Urs Meier, EMPA, Switzerland
Chair of IIFC Honours Committee

IIFC Announces...

2012 FRP-in-Construction Photo Competition

Competition Categories:

Category 1 – FRP in an engineering project (under construction or completed)

Category 2 – FRP in a research study

Winning Entries:

The winner in each category will receive an award at the 6th International Conference on FRP Composites in Civil Engineering (CICE 2012), Rome, June 13-15, 2012, along with a $200US prize. Also, one of the two winning photographs, selected by the panel of judges, will appear on the cover of the *Journal of Composites for Construction* published by the American Society of Civil Engineers (ASCE) http://ascelibrary.aip.org/cco/.

Runners-up:

The winner and five runners up, in each category, will have their photographs made into posters and displayed (with due acknowledgement) at the CICE 2012 Conference, Rome, June 13-15, 2012.

Competition Rules:

1. Only digital photographs will be accepted. Photographs must be in JPEG format of at least 1205 x 945 pixels, but not larger than 1600 x 1200 pixels. Both color and black and white photographs are eligible.
2. The procedure of submitting photographs will be announced and posted on the IIFC official website: http://www.iifc-hq.org/ prior to the beginning of the entry period (see item 6 below): Each entry must be submitted separately and must include: (i) Title of the photograph, (ii) Name of the photographer, (iii) Month and year the photograph was taken, and (iv) A 25-word (maximum) description of what the photograph shows related to an FRP application or research study. This information will later be posted with the photograph for general viewing at the IIFC official web site.
3. Only two (2) photographs per category per entrant may be submitted.
4. Only photographs taken during or after January 2006 can be entered in this competition.
5. By submitting the photograph to the competition the entrant: (i) Attests that he/she is the person who took the photograph, (ii) Transfers copyright to the IIFC for the photograph, (iii) Gives permission (with due acknowledgement) to the IIFC to use the photograph in publications, literature, and web sites.
6. The competition entry period is from January 1, 2012 to March 31, 2012.
7. The winning photographs will be selected by a panel of judges that will be co-chaired by Professors A. Fam and P. Labossiere, and will include a professional photographer.
8. Top awards winners may be required to submit their photographs in alternative formats as mandated by ASCE for use as the Journal cover photograph. Additional copyright releases may be required by ASCE. IIFC will release permission to ASCE to use the photographs for this purpose.
9. Members of the panel of judges are ineligible to enter the competition.

This article is a technical submission to FRP International. It describes an experimental program assessing the strengthening of thin wall steel tubular joints with GFRP materials.

Strengthening T-Joints of Thin-Walled Rectangular Hollow Steel Sections (HSS) using GFRP Plates

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Rectangular Hollow Steel Sections (HSS) are commonly used in trusses, Vierendeel girders, and frames. The connection between the chord and vertical member (brace) in Vierendeel girders and at the mid-span of N-trusses, or between the beam and column in frames, take the form of a T-joint (Fig. 1). In many cases, the loading capacity of the structure is governed by the strength of its joints. Thus, increasing the strength of joints may be essential in certain structures, especially if the individual members have been strengthened. This becomes even more crucial when thin-walled members are used. In this case, the bearing of the vertical member on the chord member produces web crippling of the thin walls of the chord. Unlike W- and S-sections, it is not possible to install web stiffeners inside the HSS sections. As such, mitigation of web crippling must be carried out through external means.

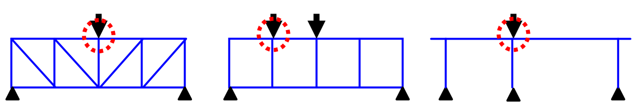


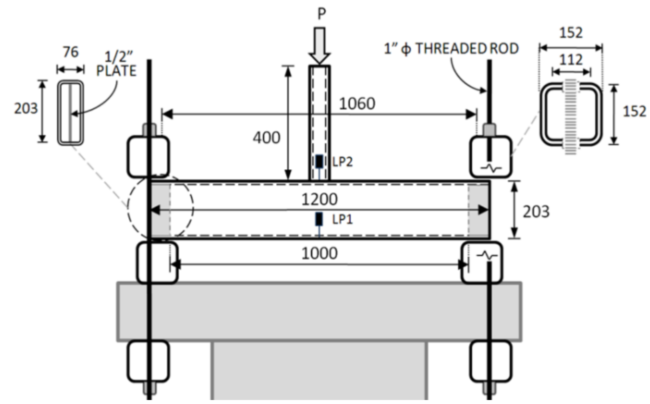
Fig. 1 T-joints in HSS steel structures (trusses, Vierendeel girders and beam-columns)

Experimental Program

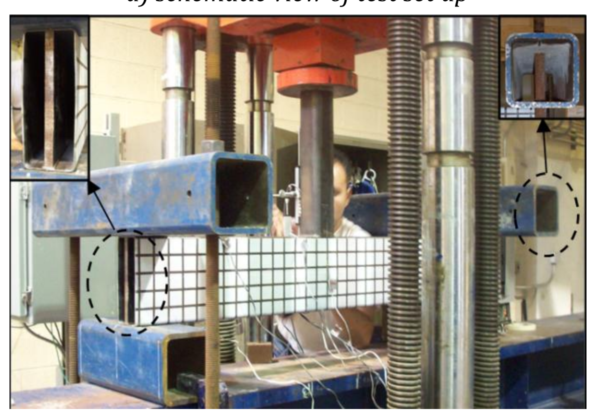
An experimental study has been carried out at Queen's University, Canada, where externally bonded GFRP plates have been used to strengthen the side-walls of HSS T-joints.

Test Specimens and Materials: HSS T-joints were fabricated and tested under brace axial compression load. A Square HSS brace member (76 x 76 x 8.9 mm) was directly welded to a rectangular HSS chord member (76 x 203 x t_o mm), where t_o is the chord wall thickness. Two chord thicknesses were examined (t_o = 3.09 and 5.92 mm). These values result in a web height-to-thickness ratio (h_o/t_o) of 66 and 34, respectively. The lengths of the chord and brace members were 1220 and 400 mm, respectively. Figure 2 shows the T-joint specimens within the test setup.

All the HSS sections were manufactured in accordance with ASTM A500 C. The yield strength of steel was 436 MPa. Pultruded GFRP plates of 9.2 mm thickness were used for strengthening the vertical walls of the HSS chord that are vulnerable to crippling. The tensile strength and modulus of the GFRP plates in the direction parallel to the fibres were 138 MPa and 12.4 GPa, respectively, and in the transverse direction are 69 MPa and 6.9 GPa, respectively.



a) schematic view of test set up

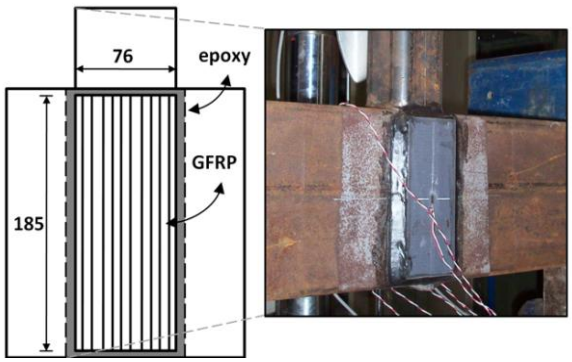


b) test set up

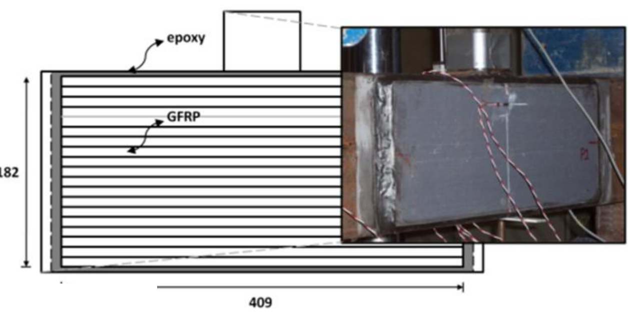
Fig. 2 Test specimens and setup

For each of the two (h_o/t_o) ratios of the HSS chords tested in this study, three specimens were tested (Table 1), namely a control unstrengthened specimen, a specimen with 76 x 185 mm GFRP plate, where the fibres were parallel to the vertical member, configuration (A) (Fig. 3(a)), and a specimen with 108 x 482 mm GFRP plate, where the fibres were parallel to the chord member, configuration (B) (Fig. 3(b)). The steel surface was first sand blasted and cleaned thoroughly before the GFRP plates were adhesively bonded on each side wall of the chord, using Weld-On SS620 Metacrylate adhesive.

The specimens were tested under brace concentric compression loading using a 1000 kN testing machine (Fig. 2). Each end of the chord member was clamped between two heavy HSS sections (150 x 150 x 12 mm) and anchored to the base of the testing machine using two vertical threaded rods to ensure fixity of specimens at both ends. The two supports were set apart to provide a clear span of 1000 mm, which is almost five times the chord depth to exclude the effects of the end supports. Also, at each end, a vertical steel stiffener plate was inserted inside the section to avoid crippling under the clamping force at the support.



a) GFRP 185x76x9



b) GFRP 182x76x9

Fig. 3 GFRP retrofitting configurations of T-joints

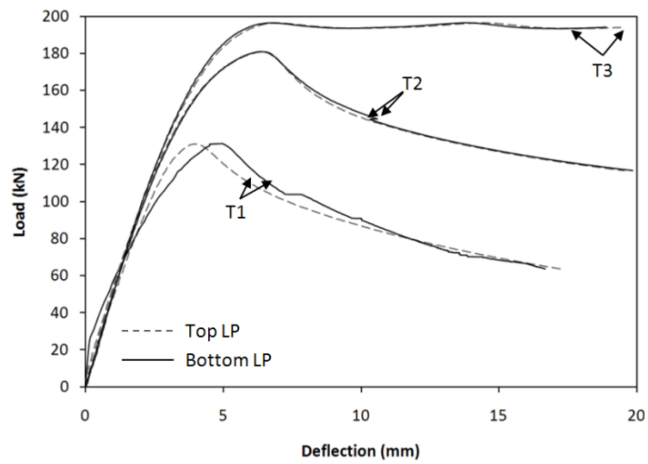
In addition to strain gauges, two linear potentiometers (LP) were mounted to measure the vertical deflections of the upper and lower flanges of the chord member at mid-span, independently. The difference in both deflections is a reflection of the amount of the chord sidewall buckling. The load was applied to the vertical member using stroke control at a rate of 1.0 mm/min up to failure.

Test Results and Discussion

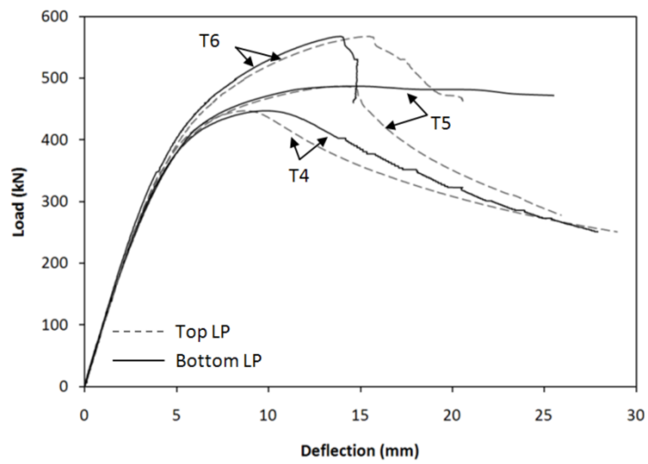
Table 1 provides a summary of test results, including the maximum load capacity of each specimen. The percentage increase in load capacity of joint specimens with (h_o/t_o) ratios of 66 was 38% and 53%, for GFRP configurations (A) and (B), respectively. As for the chord with (h_o/t_o) ratio of 34, the increase in load capacity was 9% and 27% for configurations (A) and (B), respectively.

Table 1 Summary of test results

	chord wall (mm)	GFRP type	GFRP dimensions (mm)	max. load (kN)
T1	3.09	none (control)		131
T2	3.09	A	77x185x9.2	181
T3	3.09	B	407x181x9.2	200
T4	5.92	none (control)		448
T5	5.92	A	77x185x9.2	487
T6	5.92	B	407x181x9.2	568



a) 3 mm specimens



b) 6 mm specimens

Fig. 4 Load-deflection responses of T-join specimens

Figure 4 shows the load-vertical deflection (top and bottom flanges) responses. For control specimens T1 and T4, the load increases to a peak value, where the local instabilities of the webs of the chord occur by outward local buckling (Fig. 5(a)). At this point, the difference in deflection, between the top and bottom flanges become more pronounced and the load dropped gradually. Adding the GFRP configurations (A) and (B) clearly enhanced the strength by elevating the peak loads (Fig. 4). In specimen T2, the GFRP plate shifted the local buckling location to one side of the plate (Fig. 5(b)), whereas in T5 with thicker steel wall, the similar GFRP plate suffered internal delamination within layers of the plate itself at the top, while the bond line remained intact (Fig. 5(c)). In specimen T3, the GFRP was wide enough to shift failure close to the support by a combined diagonal web buckling and end crippling (Fig. 5(d)), whereas in T6 with thicker steel wall, the similar GFRP plate suffered internal delamination at its top edge, while bond to steel was not compromised (Fig. 5(e)).

Figure 6 summarizes the findings of this study by illustrating the variation of percentage gain in joint strength with (h_o/t_o) ratio, for both configurations (A) and (B). It can be concluded that externally bonded GFRP plates are quite effective in strengthening T-joints of HSS members, where thinner HSS sections benefit more from GFRP strengthening than thicker wall sections. Also, increasing the size of the GFRP plate, up to a certain limit, increases the gain in strength.

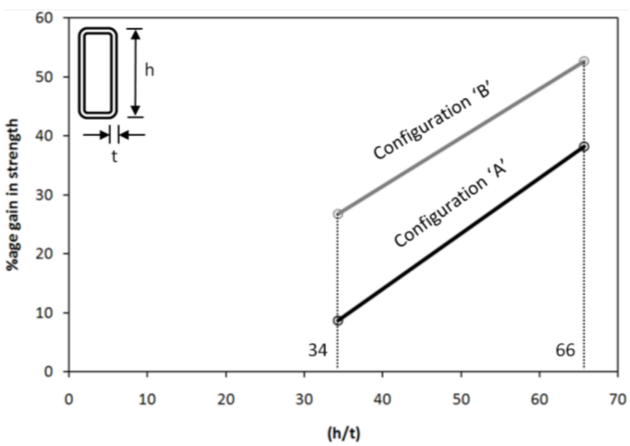
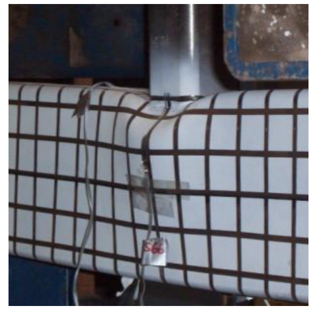
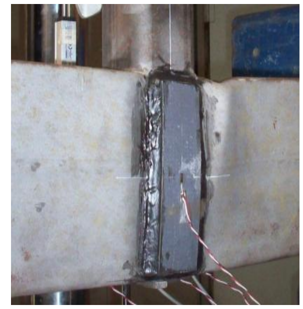


Fig. 6 Effect of tube thickness and GFRP configuration on strengthening effectiveness



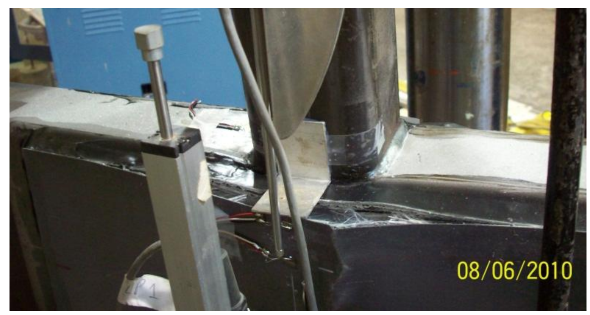
a) T1 and T4



b) T2

c) T5

d) T3



e) T6

Fig. 5 Failure modes

This article is excerpted from the paper of the same title prepared for the Society for the Advancement of Material and Process Engineering Technical Conference (SAMPE-TECH) 2011, held October 17-20, 2011 in Fort Worth, Texas. The paper focuses on test methods that have transitioned from model test methods published by the American Concrete Institute (ACI) to approved ASTM standard test methods under the jurisdiction of ASTM Committee D30, Composite Materials. The authors are members of ASTM Committee D30.

Test Method Development for Infrastructure Composites Applications

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In the civil engineering community, the emergence of new structural material systems necessitates the development of three classes of information: design guidelines, material specifications, and test methods. In the United States, much of this development has taken place within three organizations: the American Society for Civil Engineers (ASCE), the American Concrete Institute (ACI) and ASTM International.

Design guidelines, which outline procedures for calculations of permissible element forces and material stresses, are adopted by the national building codes and act as the mandatory procedures for designing building structures in the given material system. Existing design guidelines for infrastructure composites include the *ASCE Structural Plastics Design Guide*, *ACI Guide for the Design and Construction of Structural Concrete Reinforced with FRP Bars*, and *ACI Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures*. Material specifications identify the type of materials that may be used for a given application, and the tests that must be performed to characterize and qualify the materials. Existing specifications include the *ACI Specification for Construction with Fiber-Reinforced Polymer Reinforcing Bars* and the *ACI Specification for Carbon and Glass Fiber-Reinforced Polymer Bar Materials for Concrete Reinforcement*. In the United States, the development of test methods has generally been the purview of ASTM.

ASTM test methods for polymeric composite materials have primarily been promulgated through technical Committees D20 (Plastics) and D30 (Composite Materials). The D20 standards have focused primarily on the so-called reinforced plastics, which usually use low-modulus fibre reinforcements such as glass. The standards focusing on the manufacturing and testing of pultruded FRP materials, which are commonly used in infrastructure applications, are generally found in D20, and are the responsibility of subcommittee D20.18, Reinforced Thermosetting Plastics. The D30 standards have focused traditionally on aerospace applications, and typically on high modulus fibre composites. At this time, D30 focuses exclusively on the development of test methods and associated guides – and does not publish manufacturing or material specifications.

In the United States, most authoritative work regarding fibre reinforced polymer (FRP) concrete reinforcements has come from American Concrete Institute (ACI) Committee 440: Fiber-Reinforced Polymer Reinforcement. The development of test methods for FRP concrete reinforcements began within Committee 440 in the late 1990's. The first set of guide test methods for FRP concrete reinforcements was published by ACI Committee 440 in 2004: *Guide Test Methods for Fiber-Reinforced Polymers (FRPs) for Reinforcing or Strengthening Concrete Structures*.

Based on an agreement between the two organizations, test method development in the United States for FRP materials has transitioned from ACI to ASTM. To date, this activity has resulted in the publication of the six ASTM standards described in this article. The original ACI guide methods have been revised and improved through the ASTM balloting and revision process, with additional laboratory testing and test fixture development taking place for many of the standards.

Test Methods for Internal Concrete Reinforcements

Internal FRP reinforcements are typically produced as textured bars that are cast within concrete to provide tensile reinforcement to the structure (Fig. 1). In most cases, these reinforcements are used for new construction, but in some cases they are applied as 'near surface reinforcement'.

The primary material and structural characteristics of interest in FRP reinforcing bars are tensile strength, tensile modulus, mechanical bond of the bar to the concrete (a primary function of the texture), ability to carry sustained loading (creep), cyclic loading (fatigue) and the ability to transfer shear across a crack (dowel action).

Fig. 1 Typical installation of composite bars in a reinforced concrete bridge deck slab. (photos courtesy Aslan/Hughes Brothers)

First published in 2006, ***ASTM D7205: Standard Test Method for Tensile Properties of Fiber Reinforced Polymer Matrix Composite Bars*** describes the method for sampling, conditioning, gripping and testing a FRP reinforcing bars in tension. Because these bars have textured coatings or undulating surfaces (from irregular moulds and/or spiral wraps), it is not typically possible to grip them in a collet and still achieve a valid test result. The method therefore provides for an internally-threaded sleeve to be placed over the ends of the bar, and bonded to the bar with either a cementitious or polymeric grout. Once the grout is cured, this anchor is used to fix the specimen into the testing machine. Although this is the recommended anchor, other gripping techniques are permitted as long as consistent stock break failures are achieved.

The method also provides guidance for calculating the cross-sectional area of bars with irregular cross-sections. This so-called nominal cross-sectional area is determined by immersing bars of a known length in a fluid to determine the volume of fluid displaced (Archimedes method). In the United States, steel reinforcing bars are sold in standard sizes, with standard cross-sectional areas. Many manufacturers supply composite reinforcing bars according to this standard, so the method also allows for tensile strength and modulus to be calculated according to these standard areas, as given in ASTM A615. The primary result provided by the method is the tensile strength of the composite bar – calculated using either the nominal or the standard cross-sectional area. The test method also provides the tensile chord modulus of elasticity of the bar.

ASTM D7337: Standard Test Method for Tensile Creep Rupture of Fiber Reinforced Polymer Matrix Composite Bars, first appearing in 2007, assesses the ability of FRP bars to withstand sustained loading by establishing the tensile creep-rupture capacity of these bars. The method relies on the tension testing method (D7205) for test fixtures and anchors, and requires that tension testing be used to establish the baseline tensile strength of the bar. A series of four creep-rupture tests with 5 specimens each are performed – with each subsequent series conducted at a decreasing load level. The series with the highest load level (shortest time to creep rupture failure) must contain at least 4 specimens whose failure time is greater than one hour. The series with the lowest load level (longest time to creep rupture failure) must contain at least 1 specimen whose failure time is greater than 8000 hours. In this way, the creep-rupture times will span at least 3 decades. An annex to the method provides a procedure for a calculation of the extrapolated million hour creep-rupture capacity – which is the primary result of the test method.

ASTM D7617: Standard Test Method for Transverse Shear Strength of Fiber-Reinforced Polymer Matrix Composite Bar was published in 2011 and describes the method of sampling, conditioning, fixturing and testing an FRP reinforcing bar in transverse shear. This method is equally appropriate for use with smooth round rods. In application, composite bars often cross (bridge) a crack, whether unintended (such as a crack in a concrete slab) or intentional (such as an expansion joint in a concrete pavement). Due to the orthotropic nature of the bars, the transverse shear strength is not readily computable from the material tensile strength. The test cradles the bar at each end and subjects the bars to double shear at the central section of the bar (Fig. 2). A pair of blades, machined to fit closely around the bar, supports the bar from below, and a single upper blade is used to apply the force to the bar. The test method provides the transverse shear strength of the composite bar, calculated as one-half the maximum force observed during the test (because the bar is in double shear) divided by the standard or nominal cross-sectional area of the bar (with area calculated according D7205, bar tension).

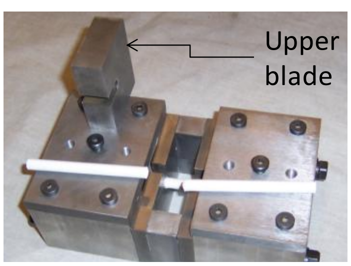


Fig. 2 D7617 test fixture depicting sheared specimen.

Test Methods for Externally-Bonded Concrete Reinforcements

Externally-bonded reinforcements are typically used for strengthening and repairing concrete structures. These materials have also been used for seismic and blast retrofits of concrete structures, and for the strengthening of other materials such as masonry, steel and wood. In some instances, a pre-cured laminate is bonded to the substrate using a separate primer and adhesive system. In other instances, the dry fibre system is saturated in-situ, and the fibre saturant acts as the matrix of the composite and the bonding agent to the substrate material. The primary material and structural behaviours of interest in externally-bonded reinforcements are tensile strength and modulus of the laminate (as a function of angle of orientation between the laminate and the direction of loading), the strength of the bond between the laminate and the substrate, and the strength of splices in the laminates.

The ***ASTM D7565: Standard Test Method for Determining Tensile Properties of Fiber Reinforced Polymer Matrix Composites Used for Strengthening of Civil Structures*** test standard, first published in 2009, describes requirements for sample preparation, tensile testing, and results calculation for wet-layup or pre-impregnated FRP laminates intended to be fabricated and installed in the field. The composite may be a 0-degree unidirectional laminate or a cross-ply (0/90^{o}) laminate with symmetry about the mid-plane. Continuous and discontinuous fibres are permitted. The principal test variables could be, for example, the material constituents and fabrication method, the size of the specimen, or the type of laminate. The test results can be used for material specifications, quality control and assurance, structural design and analysis, and research and development. Laminates may be fabricated in the field (witness panels) or in shop environments. ASTM D7565 provides the tensile force capacity and tensile force-strain characteristics of the composite. Since the thickness of the laminate is not a controlled test variable, the tensile force per unit width of the laminate is calculated. Similarly, if strain data are acquired, the “modulus of elasticity” of the laminate is reported in units of force per unit width divided by strain.

Recently published in 2011, ***ASTM D7616: Method For Determining Apparent Overlap Splice Shear Strength Properties Of Wet Lay-Up Fiber-Reinforced Polymer Matrix Composites Used For Strengthening Civil Structures*** provides a standardized procedure for preparing and testing overlap shear splice samples using wet lay-up composite materials. Overlap shear splices of wet lay-up composite sheets are commonly used in external strengthening applications for reinforced concrete structures. Typical scenarios include cases where the entire surface of the concrete being strengthened is inaccessible or where the overall length of a single saturated laminate would be difficult to manage. A major advantage of strengthening concrete structures with wet lay-up composites is the flexibility these materials provide during installation. Because the composites cure in situ and shear stress can be transferred from one laminate to another without the addition of a supplementary adhesive material, overlap shear splices provide a convenient means for extending the coverage of wet lay-up composites over long spans.

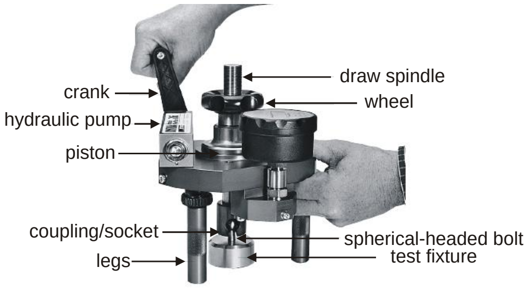
This standard includes guidance for sizing overlap shear splice panels, which are subsequently cut into 25 mm wide specimens for tensile testing. Some latitude is given to the user in specifying the length of the overlap splice, and panel dimensions are specified for 25, 50, 75, 100, 150 and 200 mm overlaps. The standard relies on procedures described in ASTM D7565 for saturating the wet lay-up composites and ASTM D3039 for conducting the tensile testing of the completed specimens. The critical result provided by this method is the force per unit width at failure. For the case of a clean shear failure in the overlap splice itself (bond line), the resulting force per unit width is reported as the apparent shear strength. If the failure occurs away from the overlap splice and involves a tensile failure in one of the plies, the result is reported as the tensile strength for net section failures. The decision to provide results in terms of force per unit width was based on a desire to maintain consistency with D7565 and allow for the direct comparison of overlap shear splice results with tensile strength testing results.

The quality, integrity and overall performance of bonded FRP retrofit systems are largely dependent on adhesion of the FRP system to the concrete substrate. Although a great deal of research has been conducted focusing on bond behaviour, and a number of methods for assessing this have been proposed, few may be practically adapted for in situ quality control/assurance (QC/QA) or acceptance testing. The essence of a QC/QA method appropriate for assessing

FRP-to-concrete bond includes a) simplicity of application; b) the ability to be rapidly deployed with minimal preparatory work; c) easily understood acceptance criteria; and d) excellent repeatability ensuring integrity of data. Adopted in 2009, ***ASTM D7522: Standard Test Method for Pull-Off Strength for FRP Bonded to Concrete Substrate*** provides such a method which is well suited to acceptance testing of bonded FRP systems.

(a) drilled ring isolates sample from substrate

(b) 50 mm disks installed on GFRP substrate



(c) manually operated test apparatus (ASTM D7522)

Fig. 3 Pull-off test application.

The D7522 test method was developed to assess the adhesion of FRP plates or wet lay-up fabrics used for concrete repair. The 'pull-off strength' derived 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. The D7522 test method involves adhering a rigid disk (or dolly) to the surface of the FRP to be tested (Fig. 3b). The test sample is isolated from the surrounding FRP by a circular hole produced using a core drill (Fig. 3a). Using a pull-off test apparatus (an example is shown in Fig. 3c) the disk is subject to gradually increasing direct tension perpendicular to the plane of the FRP until a plug of material is detached exposing the plane of limiting strength within the system. The pull-off strength is computed based on the maximum indicated force and the original surface area stressed. The nature of the pull-off failure is qualified in accordance with the percent of adhesive and cohesive failures, and the actual interfaces and layers through which the failure occurs. Seven failures are possible in a bonded FRP system as described by the method. If bond is sound, the method will result in a cohesive failure in the concrete substrate and thereby provide a lower bound value for the adhesive bond strength. If the bond capacity is deteriorated the resulting failure mode, failure surface and pull-off strength can all provide insight into the bond behaviour and deterioration mechanism. Classification of the failure allows qualitative assessment of the degradation and may help to identify the nature of the degradation.

Current and Future Test Method Development

ACI Committee 440 and ASTM Committee D30 are continuing to develop test methods for FRP reinforcements for concrete. The methods currently under development are briefly described in the following paragraphs.

A current ASTM D30 work item addresses the durability of FRP bars in an alkaline environment. As the pore water chemistry of concrete is highly alkaline and glass fibres are subject to attack in alkaline environments, this test method will act as a material screening procedure to ensure that composite bars are sufficiently resistant to alkaline attack in concrete.

A primary requirement for internal concrete reinforcements is the development of mechanical bond between the bar and the surrounding concrete. Manufacturers of FRP bars have developed various textures and coatings to promote this bond. A number of tests, from simple bar pullout (from a block of concrete) to more realistic beam bond tests are being considered for standardization in Committee D30.

Previously described D7522 provides reliable results for the direct tension capacity of externally bonded FRP and is widely adapted for QA/QC applications. Nonetheless, few (if any) external FRP applications find the interface in direct tension. In-situ, bond stresses are primarily in shear along the interface with a small component out-of-plane in tension. Two parallel efforts are underway to develop appropriate standard tests to determine in situ bond capacity. The first, almost ready for initial balloting, is a standard concrete modulus of rupture test which has been strengthened with a composite laminate. The second approach is a direct shear pull-off test similar to that used in a variety of extant studies of bond.

The current and anticipated test methods involving laminate production generally require the production of test laminates that mimic the production of laminates in the field. A guide to the production of these so-called witness panels has been proposed, so that all of the test methods which depend on the production of field-saturated laminates (or the laboratory equivalent) can refer to the same procedure for specimen preparation.

Conclusions

The publication of test methods for infrastructure composites is evidence that the application of these polymer composite concrete reinforcing materials is maturing. These test methods, along with complementary design guidelines and material specifications, are providing civil/structural engineers with the technical basis to design and rehabilitate concrete structures with composite materials.

ASTM Standards Cited

ASTM A615-09b Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.

ASTM D3039-08 Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials.

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

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

ASTM D7522-09 Standard Test Method for Pull-Off Strength for FRP Bonded to Concrete Substrate.

ASTM D7565-10 Standard Test Method for Determining Tensile Properties of Fiber Reinforced Polymer Matrix Composites Used for Strengthening of Civil Structures.

ASTM D7616-11 Method For Determining Apparent Overlap Splice Shear Strength Properties Of Wet Lay-Up Fiber-Reinforced Polymer Matrix Composites Used For Strengthening Civil Structures.

ASTM D7617-10 Standard Test Method for Transverse Shear Strength of Fiber-Reinforced Polymer Matrix Composite Bar.

All: American Society of Testing and Materials, West Conshohocken, PA.

available at www.astm.org

Upcoming Conferences and Meetings

Meeting of the Polish Group of IIFC, October 18, 2011, INESS HOTEL, Lodz, Poland.

contact Dr. Renata Kotynia: renata.kotyina@p.lodz.pl

KOMPOZYT-EXPO Trade Fair, November 24-25, 2011, Krakow, Poland.

http://targi.krakow.pl/gb/strona-glowna/targi/kompozyt-expo-2011-targi-kompozytow-technologii-i-maszyn-do-produkcji-materialow-kompozytowych/strona-glowna.html

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APFIS 2012 ***Third Asia-Pacific Conference on FRP in Structures,*** February 2-5, 2012, Sapporo, Japan. http://www.eng.hokudai.ac.jp/labo/maintenance/APFIS2012

Final manuscript due: October 31, 2011
Early registration closes: November 30, 2011

ACMBS-VI ***Advanced Composite Materials in Bridges and Structures***, May 22-25, 2012, Kingston, Canada. http://www.acmbs2012.ca/

Papers due: September 15, 2011

CICE 2012 ***6th International Conference on FRP Composites in Civil Engineering***, June 13-15, 2012, Rome, Italy. www.cice2012.it

Papers due: October 31, 2011

4th International Symposium on Bond in Concrete 2012, June 17-20, 2012, Brescia, Italy. http://www.rilem.net/eventDetails.php?event=461

APFIS 2013 ***Fourth Asia-Pacific Conference on FRP in Structures,*** December 2013, Melbourne Australia.

CICE 2014 ***7th International Conference on FRP Composites in Civil Engineering***, August 2014, Vancouver, Canada.

CDCC 2011: 4th International Conference on Durability & Sustainability of Fibre Reinforced Polymer (FRP) Composites for Construction & Rehabilitation

Prof. Brahim Benmokrane, University of Sherbrooke
brahim.benmokrane@usherbrooke.ca

The Fourth International Conference on Durability & Sustainability of Fibre Reinforced Polymer (FRP) Composites for Construction and Rehabilitation (CDCC 2011) was held at Québec City, Québec, Canada from July 20 - 22, 2011. This conference represented a unique opportunity for engineers, researchers and manufacturers from around the world to share their experiences, ideas and projects in the field of durability and sustainability of composite materials for construction.

Opening remarks by Daniel Bouchard, Ministry of Transportation of Québec (left) and Prof. Pierre Labossière, Vice-dean, Faculty of Engineering, University of Sherbrooke (right).

The CDCC 2011 conference was the fourth of its kind focusing on the durability, sustainability and field applications of FRP for construction and rehabilitation of structures (bridges, buildings, marine structures, etc.). The first conference was held in Sherbrooke, Québec in August 1998, followed by Montréal in May 2002 and Québec City in May 2007. The objective of this conference series is to provide a forum for academics, researchers, engineers, structure owners, FRP manufacturers, and delegates from public and industrial institutions to present and exchange views on present and future research on long-term durability and sustainability of FRP composite materials in bridges and other infrastructure systems exposed to harsh environmental conditions. The conference covered some of the important topics related to the durability of FRP such as:

- effect of materials on the durability of FRP products
- effect of environment on the durability of FRP reinforcements, repair patches, and structural shapes
- durability of FRP composites and systems under cyclic and sustained loading (fatigue, creep)
- influence of adhesive type and load on long-term bond between the concrete and FRP reinforcement/laminate
- material resistance factors and design criteria
- fire and thermal cycling
- durability test methods
- durability data from field studies
- monitoring durability performance in field applications
- prediction of long-term durability and modeling
- sustainability of FRP composite structures
- design approaches for durable FRP structures
- FRP field applications and case studies
- blast resistance of FRP reinforced structures
- service life prediction and life cycle cost.

The technical program of the conference included 75 peer-reviewed papers presented in ten single-track sessions over two and half days and was attended by more than 140 attendees. Authors represented experts from 19 different countries, including Algeria, Australia, Canada, China, Egypt, France, Germany, Hong Kong, Iran, Italy, Japan, Netherlands, Portugal, Singapore, South Korea, Switzerland, United Kingdom and USA. The proceedings of the conference was edited by Prof. Benmokrane (University of Sherbrooke), Prof. E. El-Salakawy (University of Manitoba), and Dr. E. Ahmed (University of Sherbrooke). The proceedings volume is available in hard and soft copies and can be purchased from the conference secretary at the Department of Civil Engineering, University of Sherbrooke, Sherbrooke, QC, Canada.

To familiarize the conference attendees with FRP products and services, eleven organizations had exhibits of FRP construction products and fibre optic sensors. Technical exhibitors were: ACMA, BP Composites Ltd, Carbonfibreplus, FiReP Rebar Canada Inc., ISIS Canada Network Association, MagmaTech Ltd, Pultrall Inc., Roctest Ltd, Schoeck Canada Inc., Sika Canada Inc., and Osmos Canada Inc.

At the conference banquet, two awards were presented to John Busel (ACMA Director, USA) and Paul Drouin (ADS Inc., Canada) for their outstanding contribution to the advancement of the FRP composites industry in structures.

ASCE *Journal of Composites for Construction* Abstracts

The American Society of Civil Engineers (ASCE) Journal of Composites for Construction (JCC) is published with the support of IIFC. As a service to IIFC members and through an agreement with ASCE, *FRP International* will begin indexing ASCE JCC. The ASCE JCC may be found at the following website:

http://ascelibrary.org/cco/

ASCE members and those with institutional access are able to obtain full text versions of all papers. Preview articles are also available at this site. The doi (digital object identifier) number is a unique string assigned to each paper that may be used to search and find the paper online. Papers may be submitted to ASCE JCC through the following link:

http://www.editorialmanager.com/jrncceng/

ASCE Journal of Composites for Construction, Volume 15, No. 4, pp 473-662. July/August 2011.

Durability of GFRP Rebars in Simulated Concrete Solutions under Accelerated Aging Conditions

A. S. M. Kamal and M. Boulfiza

doi:10.1061/(ASCE)CC.1943-5614.0000168 (9 pages)

Behavior of CFRP-Prestressed Concrete Beams under High-Cycle Fatigue at Low Temperature

Reza Saiedi, Amir Fam, and Mark F. Green

doi:10.1061/(ASCE)CC.1943-5614.0000190 (8 pages)

Design Approach for Calculating Deflection of FRP-Reinforced Concrete

Peter H. Bischoff and Shawn P. Gross

doi:10.1061/(ASCE)CC.1943-5614.0000195 (10 pages)

Shear Strength of Fiber-Reinforced Polymer Reinforced Concrete Beams Subject to Unsymmetric Loading

A. Ghani Razaqpur, Marwan Shedid, and Burkan Isgor

doi:10.1061/(ASCE)CC.1943-5614.0000184 (13 pages)

Oxygen Permeability of Fiber-Reinforced Polymers Chandra Khoe, Rajan Sen, and Venkat R. Bhethanabotla

doi:10.1061/(ASCE)CC.1943-5614.0000187 (9 pages)

Seismic Behavior of As-Built, ACI-Complying, and CFRP-Repaired Exterior RC Beam-Column Joints

Yousef A. Al-Salloum, Tarek H. Almusallam, Saleh H. Alsayed, and Nadeem A. Siddiqui

doi:10.1061/(ASCE)CC.1943-5614.0000186 (13 pages)

Size Effect of Concrete Short Columns Confined with Aramid FRP Jackets

Yuan-feng Wang and Han-liang Wu

doi:10.1061/(ASCE)CC.1943-5614.0000178 (10 pages)

Analysis of RC Hollow Columns Strengthened with GFRP

Gian Piero Lignola, Fabio Nardone, Andrea Prota, Antonio De Luca, and Antonio Nanni

doi:10.1061/(ASCE)CC.1943-5614.0000192 (12 pages)

Fatigue of Concrete Beams Strengthened with Glass-Fiber Composite under Flexure

Tianlai Yu, Chengyu Li, P.E., Junqing Lei, and Hongxiang Zhang

doi:10.1061/(ASCE)CC.1943-5614.0000189 (8 pages)

Comparison of CFRP and Alternative Seismic Retrofitting Techniques for Bare and Infilled RC Frames

D. Kakaletsis

doi:10.1061/(ASCE)CC.1943-5614.0000196 (13 pages)

In-Plane Lateral Response of a Full-Scale Masonry Subassemblage with and without an Inorganic Matrix-Grid Strengthening System

N. Augenti, F. Parisi, A. Prota, and G. Manfredi

doi:10.1061/(ASCE)CC.1943-5614.0000193 (13 pages)

Development of FRP Shear Bolts for Punching Shear Retrofit of Reinforced Concrete Slabs

Nicholas Lawler and Maria Anna Polak

doi:10.1061/(ASCE)CC.1943-5614.0000188 (11 pages)

Near-Surface-Mounted Composite System for Repair and Strengthening of Reinforced Concrete Columns Subjected to Axial Load and Biaxial Bending

Tamer El-Maaddawy and Amr S. El-Dieb

doi:10.1061/(ASCE)CC.1943-5614.0000181 (13 pages)

Assessing the Strengthening Effect of Various Near-Surface-Mounted FRP Reinforcements on Concrete Bridge Slab Overhangs

Dongkeun Lee and Lijuan Cheng

doi:10.1061/(ASCE)CC.1943-5614.0000182 (10 pages)

Behavior of Beams Strengthened with Novel Self-Anchored Near-Surface-Mounted CFRP Bars

A. Ghani Razaqpur, Marwan Shedid, and David Petrina

doi:10.1061/(ASCE)CC.1943-5614.0000183 (10 pages)

Effect of Existing Structure and FRP Uncertainties on the Reliability of FRP-Based Repair

Kyle T. Wieghaus and Rebecca A. Atadero

doi:10.1061/(ASCE)CC.1943-5614.0000197 (9 pages)

Development of Fiber-Reinforced Polymer Roof-to-Wall Connection

Cetin Canbek, Amir Mirmiran, Arindam Gan Chowdhury, and Nakin Suksawang

doi:10.1061/(ASCE)CC.1943-5614.0000194 (9 pages)

Testing and Modeling of a New Moment Connection of Concrete-Filled FRP Tubes to Footings under Monotonic and Cyclic Loadings

Pedram Sadeghian, Yu Ching Lai, and Amir Fam

doi:10.1061/(ASCE)CC.1943-5614.0000198 (10 pages)

APFIS2012, Sapporo Japan

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http://www.eng.hokudai.ac.jp/labo/maintenance/APFIS2012

The Third Asia-Pacific Conference on FRP in Structures (the Official Asia-Pacific Regional Conference of the IIFC) will be held at Hokkaido University, Sapporo on 2-4 February 2012.

Presently over 70 papers representing 15 countries are scheduled for presentation.

Sapporo has not been affected by the recent earthquake or nuclear power plant incident. While this problem will take some time to be fixed at the site, it seems that radiation will not spread beyond the local area of the plant. APFIS2012 will be unaffected. Travel to and from Japan and to Hokkaido remains safe. What concerns all Japanese is an economic slowdown due to people's perception, both domestically and internationally. A successful APFIS2012 will both directly and indirectly positively affect the restoration of the affected areas and all of Japan.

July 2011 Open Letter to all Appointees to IIFC Council

As most of you have noticed, the look of *FRP International* and the IIFC website (www.iifc-hq.org) have changed in 2011. In 2012, we hope to expand the scope and utility of *FRP International* to better serve the IIFC community and beyond. As part of our commitment to *FRP International,* we have begun to publish only electronically (allowing for greater versatility at reduced cost). We have also recently archived and indexed all 18(!) years of *FRP International* and will begin abstracting the *ASCE Journal of Composites for Construction* with plans to expand this service to the International community.

FRP International has a strong history of publishing brief technical articles highlighting case studies, products, research-in-progress and completed research. IIFC Council has always been a major contributor to this activity. Indeed, Article 2 of the IIFC by-laws states that "each member of the Council, during his [or her] six year term, is expected to contribute at least two articles to the newsletter." This does not necessarily mean that Council members must contribute their own work; soliciting articles from colleagues is encouraged and will hopefully broaden the reach of IIFC (when your colleagues join IIFC!). Of particular interest are articles that may be featured in our new *History of FRP* feature.

FRP International articles will generally not exceed 2000 words, be well illustrated (about 100 word equivalent per figure), and will otherwise conform to typical academic publishing guidelines. Unformatted MSWord format submissions should be sent to *FRP International* editor Kent Harries (kharries@pitt.edu). Authors will have an opportunity to review proofs of their articles prior to publication. Finally, *FRP International* should also be a venue for your announcements. With electronic delivery, we are appending conference announcements to each issue. Please send relevant announcements to Dr. Harries for inclusion in *FRP International*. We appreciate your support of IIFC and *FRP International*.

Lawrence C. Bank IIFC President	Rudolf Seracino IIFC Secretary	Kent A. Harries *FRP International* Editor

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