FRP INTERNATIONAL

The Official Newsletter of the International Institute for FRP in Construction

Volume 4, Issue 1 ***June 2007***

Editor's Note

It is my great pleasure to introduce myself as the new editor-in-chief of *FRP International*, and to welcome you to the first issue for 2007. On behalf of all IIFC members, I would firstly like to take this opportunity to thank Professor Vistasp Karbhari for his tremendous commitment to this newsletter as the immediate past editor-in-chief.

As you will read in the message from the new IIFC President, Professor Kenneth Neale, CICE 2006 marked the start of a transitional period for the IIFC as an organization. Much of this issue is dedicated to disseminating these changes to the IIFC membership and to introduce the new members of the IIFC Council and Executive Committee.

As the new editor-in-chief, I am also introducing changes to *FRP International*. In this issue, for example, you will find shorter articles and more announcements including updates on technical documents and guides. Profiles of an IIFC Member and an FRP organization, as well as reports from international code committees, will be standing features in future issues. The *FRP International* editorial board is dedicated to making this newsletter a valuable resource for IIFC members and its industry partners. However, we can not do this without the assistance of all members. All suggestions and contributions are welcome and may be submitted electronically to the new newsletter email address: newsletter.editor@iifc-hq.org

Finally, as one of the goals of the Executive Committee is to increase membership, may I challenge each member to encourage a colleague or graduate student to join the IIFC so that we may develop and become a stronger organization. To facilitate this, an IIFC membership form is attached to the last page of this issue.

Rudolf Seracino, Editor-in-Chief
Email: newsletter.editor@iifc-hq.org

Message from the IIFC President

This issue of *FRP International* signals a change in the leadership and administration of the International Institute for FRP in Construction (IIFC). A major challenge for the future of the Institute will be to continue and build on the great success enjoyed in the inaugural years.

Led by the vision and leadership of our founding President, Jin-Guang Teng, IIFC was formed in 2003 with the aim of advancing understanding and the application of FRP composites in civil engineering, in the service of the engineering profession and society. Among the objectives of the Institute are to provide a focal point for the international sharing of knowledge and experience, and to foster international harmonization of design standards and applications. There is no doubt that IIFC is making great strides towards achieving these goals. Arguably, this is due largely to the past efforts and dedication of Jin-Guang Teng; on behalf of IIFC, I wish to express our deepest gratitude for his invaluable service. I would also like to acknowledge the contributions of the members of his Executive Committee, Advisory Committee, IIFC Council, Editorial Committee and various Working Groups.

It is with a great sense of optimism that I embark on this term as incumbent President of IIFC. I am strongly encouraged by the response of the members who have agreed to serve the Institute. In particular, I specifically would like to recognize two individuals who, during their terms of office, will undoubtedly be called upon extensively for their services: Scott Smith as Secretary of IIFC and Rudi Seracino as Editor-in-Chief of *FRP International*. Many thanks are also due to the members of the newly elected Executive Committee and Council for their anticipated contributions.

A major impact of IIFC has been the sponsorship of international symposia and conferences. This will continue with the 1st APFIS and 4th CICE conferences scheduled for 2007 and 2008 in Hong Kong and Switzerland, respectively. Registration fees at such conferences imply that IIFC dues are waived for the year in question. Other advantages of IIFC membership are complimentary copies of conference proceedings. We will strive to enhance the benefits of IIFC membership, and are open to all suggestions and ideas for doing so. I would like to conclude with a request to all members of the Institute: please inform your colleagues of the activities of IIFC and encourage them to join our vibrant organization.

Professor Kenneth W. Neale
University of Sherbrooke, Canada
IIFC President
Email: president@iifc-hq.org

See page 12 for a biographical sketch of Professor Neale.

CICE 2006

The third international conference on Composites in Civil Engineering (CICE 2006), co-organized by Florida International University and the University of Miami, was held in Miami, Florida, December 13-15, 2006. The conference was a great success both in terms of the number of attendees as well as the quality of papers presented.

The conference was sponsored by the American Concrete Institute (ACI), the American Society of Civil Engineers (ASCE) and its Structural Engineering Institute (SEI), the Canadian Society for Civil Engineering (CSCE) and the Intelligent Sensing for Innovative Structures (ISIS) Canada Research Network.

A total of 179 papers were included in the 820 page proceedings, authored by experts in the field from 28 different countries around the world, including Australia, Belgium, Brazil, Canada, Chile, China, Czech Republic, Denmark, France, Germany, Hong Kong, Iran, Ireland, Israel, Italy, Japan, Malaysia, the Netherlands, Oman, Poland, Portugal, Saudi Arabia, South Korea, Sweden, Switzerland, Turkey, United Kingdom, and the United States.

The conference featured 10 enlightening keynote speeches from academe, industry, and funding and government agencies. The conference banquet showed why "F" in FRP stands for fun!

Professor Amir Mirmiran
Florida International University
CICE 2006 Co-chair

CICE 2006 Opening Ceremony.

Fun at the Conference Banquet.

CICE 2006 Best Paper Awards

At the CICE 2006 Conference, three papers were selected among the 179 contributions for Best Papers Awards. One selection was made in the category "FRP in new construction", while two prizes were awarded in the category "FRP for repair and strengthening". The selection committee consisted of Len Holloway, Kenneth Neale (chair) and Tamon Ueda, who were assisted by various subcommittee members in the pre-selection stage.

The winning contributions were:

INDIRECT CRACK CONTROL PROCEDURE FOR FRP-REINFORCED CONCRETE BEAMS AND ONE-WAY SLABS

Carlos E. Ospina[1] & Charles E. Bakis[2]

[1]Project Engineer, Berger/ABAM Engineers Inc., Federal Way, WA, USA

[2]Professor, Dept. of Engineering Science and Mechanics, Pennsylvania State University, University Park, PA, USA

NUMERICAL SIMULATION OF BOND DETERIORATION BETWEEN CFRP PLATE AND CONCRETE IN MOISTURE ENVIRONMENT

Zhenyu Ouyang[1] & Baolin Wan[2]

[1]Ph.D. Student, Marquette University, Milwaukee, WI, USA

[2]Assistant Professor, Marquette University, Milwaukee, WI, USA

STRENGTHENING OF CONCRETE BEAMS IN SHEAR WITH MINERAL BASED COMPOSITES LABORATORY TESTS AND THEORY

Björn Täljsten[1], Katalin Orosz[2] & Thomas Blanksvärd[3]

[1]Professor, Technical University of Denmark, Lyngby, Denmark Luleå University of Technology, Luleå, Sweden

[2]PhD Student, Technical University of Denmark and Norut Teknologi AS, Norway

[3]PhD Student, Luleå University of Technology, Sweden

The award winning papers may be viewed online at:
http://www.IIFC-hq.org

Professor Neale (*l*) presenting Professor Täljsten the Best Paper Award at the CICE 2006 Banquet.

Profiles of the new IIFC Council members and the Executive Committee are given on the following pages.

IIFC Headquarters Moves

IIFC Administrative Center
c/o The University of Manitoba
Agriculture and Civil Engineering Building
A250 - 96 Dafoe Road
Winnipeg, Manitoba, R3T 2N2
Canada
Phone: + 1 204 474 8506
Fax: + 1 204 474 7519

New email addresses:

IIFC President	president@iifc-hq.org
IIFC Secretary	secretary@iifc-hq.org
Newsletter Editor	newsletter.editor@iifc-hq.org

The IIFC website address remains unchanged:
www.IIFC-hq.org

IIFC Organizational Changes

The IIFC General Meeting was held on 14 December 2006 at CICE 2006, where 8 new members were elected to the IIFC Council. The Council now has representatives from 18 countries.

At the Council Meeting, which took place following the General Meeting, the new Executive Committee was elected. The Executive Committee has changed somewhat with a newly elected President in Ken Neale, three new Vice Presidents (Jian-Fei Chen, Vistasp Karbhari, and Zhi-Shen Wu), a new Newsletter Editor (Rudi Seracino) and Secretary (Scott Smith), a new Conference Coordinator (Masoud Motavalli), and two new Members-at-Large (Luke Bisby and Björn Täljsten). The portfolios of Larry Bank (Vice President) and Nemkumar Banthia (Treasurer) remained unchanged.

The new Executive Committee as well as departing Executive Committee members who were present at CICE 2006 met the following day to define responsibilities of individual members of the new Executive Committee. Members of the departing Executive Committee were thanked for their invaluable contributions to IIFC during their term(s) of office. According to the IIFC by-laws, outgoing IIFC president Prof. J.G. Teng automatically became a member of the Advisory Committee.

Dr. Scott T Smith
The University of Hong Kong, China
IIFC Secretary
Email: secretary@iifc-hq.org

Professor Hollaway (*l*) presenting Professor Teng a Thank You gift for his service as IIFC President.

New IIFC Executive Committee

President

Dr. Kenneth W. Neale
Professor
Université de Sherbrooke, Canada
E: Kenneth.Neale@USherbrooke.ca
W: www.usherbrooke.ca/gcivil/personnel/professeur/KennethNeal.html
Research: FRPs for structural strengthening and rehabilitation; solid mechanics and materials; high performance computation.

Vice Presidents

Dr. Lawrence C. Bank
Professor
University of Wisconsin-Madison, USA
E: bank@engr.wisc.edu
W: www.engr.wisc.edu/cee/faculty/bank_lawrence.html
Research: FRP composites in structural engineering; mechanics of composite materials and structures; performance based design of buildings; architecture/engineering/construction integration; paperboard structures; innovative bridge materials and construction.

Dr. Jian-Fei Chen
Reader
The University of Edinburgh, UK
E: j.f.chen@ed.ac.uk
W:
webdb.ucs.ed.ac.uk/see/staff/staff/index.cfm?person=jfchen&CFID=1119473&CFTOKEN=16952750
Research: Strengthening of existing structures; bond behaviour between FRP and concrete; flexural and shear strengthening of concrete members; and strengthening of masonry arch bridges.

Dr. Vistasp M. Karbhari
Professor
University of California San Diego, USA
E: vkarbhari@ucsd.edu
W: www.structures.ucsd.edu/index.php?page=structural_engineering/people/faculty/karbhari
Research: Processing and mechanics of composites; durability of polymers and composites; bio-materials; application of composites to infrastructure renewal and multi-threat mitigation (including blast); impact/damage mechanics and crash energy management; nondestructive assessment of materials and structures; damage prognosis; and structural health monitoring.

Dr. Zhi-Shen Wu
Professor
Ibaraki University, Japan
E: zswu@mx.ibaraki.ac.jp
W: www.civil.ibaraki.ac.jp/civil/strc/wu/
Research: Computational fracture and failure mechanics; FRP technologies; fibre optic sensors; structural health monitoring and control; smart materials and structures; and disaster prevention and mitigation.

Secretary

Dr. Scott T. Smith
Assistant Professor
The University of Hong Kong, China
E: stsmith@hku.hk
W: www.hku.hk/civil/staff/stsmith.html
Research: Behaviour of RC structures strengthened, reinforced or prestressed with FRP composites; strengthening of timber with FRP; strength, ductility and serviceability of RC structures; and local and post-local buckling of steel and FRP in composite steel- or FRP-concrete assemblages.

Treasurer

Dr. Nemkumar Banthia
Professor
University of British Columbia, Canada
E: banthia@civil.ubc.ca
W: www.civil.ubc.ca/faculty/banthia/Banthia.html
Research: Cement-based materials and their fibre reinforced composites; interface characterization and modeling; strain-rate effects and development of experimental techniques for static and impact testing of cement-based materials; permeability measurements; use of FRP in new construction and in repairs; shotcrete, fibre reinforcement, rebound mechanics, kinematic studies, optimization.

Newsletter Editor

Dr. Rudolf Seracino
Associate Professor
North Carolina State University, USA
E: rudi_seracino@ncsu.edu
W: www.ce.ncsu.edu/faculty/seracino
Research: Fundamental intermediate crack debonding behavior of adhesively bonded interfaces; externally bonded and near-surface mounted FRP strips for flexural and shear strengthening of RC flexural members; near-surface mounted FRP strips for repair and strengthening of unreinforced masonry walls subject to out-of-plane loading.

Conference Coord

Dr. Masoud Motavalli
Professor
Swiss Federal Laboratories for Material Research and Testing, EMPA
University of Tehran, Iran
E: Masoud.Motavalli@empa.ch
W: www.empa.ch/plugin/template/empa/357/*/---/l=2/uacc=MM116
Research: Application of advanced materials such as multi layered FRPs and shape memory alloys in civil engineering structures; micro and macro mechanical behaviour of materials; smart wireless sensing systems integrated in advanced materials; seismic retrofitting of existing structures with post-tensioned advanced materials and vibration mitigation systems using adaptive dampers.

Members-at-Large

Dr. Luke Bisby
Assistant Professor
Queen's University, Canada
E: bisby@civil.queensu.ca
W: www.civil.queensu.ca/people/faculty/bisby
Research: FRP for reinforcement, repair, and strengthening of reinforced concrete structures; fire and high-temperature performance of FRP reinforcement and strengthening systems; cold-regions performance and durability of externally-bonded or NSM FRP strengthening systems for concrete; mechanics of FRP confinement; and the use of FRP wraps for strengthening RC columns.

Dr. Björn Täljsten
Professor
Technical University of Denmark, Denmark
E: bt@byg.dtu.dk
W: www.byg.dtu.dk/English/About/staff.aspx?1g=showcommon&id=28878&type=person
Research: Strengthening of civil engineering infrastructure with FRP composites.

New IIFC Council Members

Dr. Joaquim Barros
Associate Professor
University of Minho, Portugal
E: barros@civil.uminho.pt W: www.civil.uminho.pt/composites
Research Interests: Structural rehabilitation; characterization of materials of cement and polymeric matrix by experimental research; fiber reinforced concrete and concrete structures strengthened with composite materials; and numerical modeling of concrete and composite structures.

Dr. Laura De Lorenzis
Assistant Professor
University of Salento, Italy
E: laura.delorenzis@unile.it W: www.dii.unile.it
Research Interests: Strengthening of RC and masonry structures with FRP composites.

Dr. Alper Ilki
Associate Professor
Istanbul Technical University, Turkey
E: ailki@ins.itu.edu.tr W: www.ins.itu.edu.tr/ailki
Research Interests: Assessment of seismic performance of existing RC structures; and seismic retrofitting of existing RC structures with innovative materials.

Dr. Amnon Katz
Associate Professor
Technion-Israel Institute of Technology, Israel
E: akatz@technion.ac.il W: www.technion.ac.il/~civil/katz/
Research Interests: High performance concrete; recycling in construction; construction and environment; FRP in construction; and fiber reinforced cementitious composites.

Dr. Renata Kotynia
Assistant Professor
Technical University of Lodz, Poland
E: Renata.Kotynia@p.lodz.pl W: www.bais.p.lodz.pl
Research Interests: Structural rehabilitation; strengthening of RC and masonry structures with EB and NSM FRP composites; flexural behaviour of RC girders strengthened with pre-tensioned EB laminates; bond behaviour between FRP and concrete; and ductility and serviceability of RC structures.

Dr. Rudolf Seracino
Associate Professor
North Carolina State University, USA
E: rudi_seracino@ncsu.edu W: www.ce.ncsu.edu/faculty/seracino
Research Interests: Fundamental intermediate crack debonding behavior of adhesively bonded interfaces; externally bonded and near-surface mounted FRP strips for flexural and shear strengthening of RC flexural members; near-surface mounted FRP strips for repair and strengthening of unreinforced masonry walls subject to out-of-plane loading.

Dr. Jongsung Sim
Professor
Hanyang University, Korea
E: jssim@hanyang.ac.kr W: http://ace.hanyang.ac.kr
Research Interests: Development and application of GFRP reinforcing bars.

Dr. Scott T. Smith
Assistant Professor
The University of Hong Kong, China
E: stsmith@hku.hk W: www.hku.hk/civil/staff/stsmith.html
Research Interests: Behaviour of RC structures strengthened, reinforced or prestressed with FRP composites; strengthening of timber with FRP; strength, ductility and serviceability of RC structures; and local and post-local buckling of steel and FRP in composite steel- or FRP-concrete assemblages.

Featured Structure

Floodway Bridge
Winnipeg, Canada

The largest single structural use of FRP composites in the world.

The largest single structural use of FRP composites, to date, was completed the summer of 2006 in Winnipeg, Canada: the Floodway Bridge over the Red River.

The foundations of this project were laid by the many research efforts, standards and testing performed by various researchers around the world in the area of "internal reinforcing". The consensus of the "ISIS Canada Winnipeg Principles", whereby leading civil engineers from around the world issued the "proclamation" that bridge decks should be designed as an arch, "steel free" and reinforced with GFRP rebar, further led to the bridge owner taking the step to use internal GFRP bars for crack control and steel straps as ties for the deck to act as an arch. The project is further validation of the work of the Canadian ISIS network and their evaluation of the performance of several existing bridge structures that have internal GFRP reinforcing after up to eight years of service life. At the suggestion of Dr. Urs Meier of EMPA, the ISIS network undertook an extensive evaluation of the performance of several experimental bridge decks that had been built throughout Canada. Results of the seminal work showed NO DEGRADATION of GFRP bars. Clearly there has been proven to be a disconnect between the activation energy of accelerated aging regiments for GFRP internal reinforcing and the realities of field performance. Combined with detailed procurement, qualification and reporting criteria, the publication of the Canadian Highway Bridge Design Code, authoritative test methods such as ASTM D7205, the Floodway bridge project is evidence that internal GFRP reinforcing has moved from research to practice.

UMA Engineering of Winnipeg designed the bridge. It consists of two bridges with eight spans each. Each span is 15.2 m (50 ft) wide by 43.3 m (142 ft) in length. The deck slab is 230 mm (9 in) thick and the NU-Girder spacing is 2.4 m (8 ft). The total length of each bridge is 346.3 m (1136 ft).

MD Steel built the bridge and Bergen Reinforcing were the rebar lathers. The bridge is the largest steel free deck in the world. All concrete above the girders was reinforced with Aslan 100 GFRP bars produced by Hughes Brothers of Seward, Nebraska, USA, and the girders were tied with steel straps. Over 136 metric tons (150 tons) of GFRP bars were used in the bridge. Keeping in mind that GFRP bars are $1/4^{th}$ the weight of steel bars, if traditional steel reinforcing bars had been used there would have been over 544 metric tons (1.2 million lbs) of steel rebar used in the project. The barrier railing was a Canadian type PL-3 barrier reinforced with GFRP bars but incorporating a double-headed stainless steel stud from the deck into the barrier itself.

Quality assurance for the Aslan 100 bars was performed based on the reporting and qualifications of the newly published ISIS Canada criteria which matches fairly closely the soon to be published ACI 440 FRP bar materials and construction specifications. Bars from each production lot were tested in accordance with ASTM D7205 and ACI440.3R-04. Hughes Brothers supplied complete documented material and production lot certs to the bridge owner.

Construction of the bridge was completed without incidence ahead of schedule and the bridge is now open to traffic and performing satisfactorily.

Contributed by:
Mr. Doug Gremel
doug@hughesbros.com

Aslan FRP
Hughes Brothers

Floodway Bridge under construction.
(GFRP deck reinforcement shown)

FRPs in Restoration and Conservation

Dr. Sue Halliwell
ngcc@netcomposites.com

network group for composites in construction
ngcc

The Network Group for Composites in Construction (NGCC) has undertaken a state-of-the-art review of the use of fibre-reinforced polymers (FRP) in restoration and conservation. Experts from UK industry and academia met in London in January 2007 to discuss the latest challenges in the field and present case studies. The workshop was one of a series of public events organised by NGCC which advance understanding in the use of FRP in construction and share the latest developments with construction professionals and clients. The workshop identified the significant potential of FRP in the preservation of historical structures.

In the last two decades, FRPs have gained considerable worldwide interest and growing acceptance in the construction industry. Much work has already been done to enable their advantages to be exploited in the preservation of historic structures, particularly their high strength, durability, cost effectiveness and the potential for minimal aesthetic impacts. Work is now underway to expand the range of potential applications, exploring important issues such as long-term durability, material compatibility, minimising invasiveness, upgrade reversibility and optimising material selection.

The workshop findings have led to the production of a new NGCC technical sheet ***TS06: FRPs in restoration***. The publication and workshop presentations can be downloaded from the NGCC members' e-library on the NGCC website www.ngcc.org.uk

Causes and Modes of Material/Structural Degradation

There are three main causes of deterioration in historic structures:

- ***Environment degradation***: Material decay due to environmental attack caused by moisture, air pollution, corrosion, freeze/thaw cycles, chemical or biological attack, etc. can cause two types of damage:
  - Local damage, as in the case of localised water problems. Localised material damage can lead to long-term structural damage by de-stabilising key structural elements.
  - Global damage, such as the decay of surfaces due to widespread chemical attack on a stone façade.
- ***Displacements***: Over the course of centuries, imposed displacements due to foundation movements, material creep, earthquakes, temperature variations, etc. can destabilise a historic structure. Small changes in geometry can drastically alter the equilibrium conditions and may lead to collapse. For example, foundation movements in a masonry vaulted structure will cause the walls or buttresses to lean outwards, threatening the stability of the masonry vault.
- ***Overloading:*** Extreme loading may be caused by increased road traffic (for bridges), earthquakes, water loading, or structural interventions which have overloaded existing elements.

FRP materials as a repair option

For each type of degradation new materials offer options for repair mechanisms. However, engineers need to exercise caution in applying new technologies to historic structures. Engineers must take a long-term view and must consider the whole life design of an intervention, including the reversibility and the future repair of each intervention. Important historic buildings in the UK are invariably listed either grade 1 or grade 2. Listed building consent would be required to permit the use of any novel or, from the point of view of the statutory bodies, prototypical material for the repair of distressed historic fabric. A clear and detailed technical appraisal of the problem and the properties / life expectancy / reversibility of the intended repair would be needed for attachment to the Conservation Impact Statement that would accompany the listed building consent application.

In addition, hydrophobic materials that are attached to the external, rain-washed surfaces of original hygroscopic ones tend to induce sacrificial decay in the original material as a consequence of moisture being trapped in backgrounds, which then becomes more vulnerable to freeze-thaw destruction and concentration of migrating soluble salt which expands during crystallisation, thus rupturing stone, brick or mortar surfaces.

In cases where materials decay regularly, it is generally accepted that it is better to replace in kind, that is, to use the same materials for the repair. An example is Gothic buildings where masonry pinnacles are replaced approximately every 200 years using the same source of stone each time as it is important to use the same materials and technology to maintain the structure, even if new materials can offer better mechanical properties. However, replacement would depend on the durability or competence of the stone and the degree to which it was subjected to decay processes, such as exposure to dilute sulphuric acid in rainfall.

FRP materials have superior properties compared with steel reinforcement in respect of strength, weight, durability and fatigue. They have many properties that make them suitable for use with historic structures. The most important characteristic of FRP in repair and strengthening applications is the speed and ease of installation. Reduced labour, shut-down costs and site constraints usually offset the material cost of FRP, making FRP strengthening systems very competitive when compared with traditional strengthening techniques, such as steel plate bonding and section enlargement. From a structural preservation perspective, materials and methods are developing rapidly, along with new approaches, such as the use of near-surface mounted (NSM) reinforcement and structural repointing. There are distinct advantages to using NSM or structural repointing for many structures due to the protection that an embedded system provides, and due to the minimal intervention which such a system exhibits.

Masonry structure **Timber beam**

Cast iron girder

Figure 1: Strengthening historic structures.

Monitoring repair in historic structures

Non-destructive evaluation (NDE) procedures are particularly attractive for use with historic preservation projects, where damage to historic materials must be minimised, and in fact often is unacceptable. There have been recent technological advances in applying NDE for evaluation of historic construction, however, challenges remain due to the highly variable nature of these buildings, the many types of materials and construction approaches that have been used over the centuries, the lack of documentation on their construction and their considerable cultural value.

NDE approaches in particular are useful during or immediately following FRP strengthening and repair work as a means to evaluate the adequacy of the repair. Such testing may be conducted for quality assurance (QA) to characterise the completeness of bond or the filling of internal voids, or the detection of improper FRP application as indicated by blisters or pockets of trapped moisture. A secondary purpose for conducting such tests would be for quality control (QC), in which case mechanical testing of bond strength, or the capacity of strengthened wall sections, will likely be required. NDE methods are not currently being used to provide strength-related information.

A major consideration with using FRP for repairing or strengthening historic buildings is the long-term performance of the repair, considering both structural/mechanical performance and durability of the repaired structure. By definition our historic properties have existed for many years and the current philosophy is that we should strive to provide repair/strengthening approaches that have an expected lifetime that matches that of the structure. Until reliable life-cycle information is developed, long-term monitoring must be a requirement of FRP-related projects.

Guidance documents

1. ICE Design and Practice Guides. FRP Composites: Life Extension and Strengthening of Metallic Structures. 2000
2. CIRIA Report C595: Strengthening Metallic Structures using Externally Bonded Fibre-Reinforced Polymers, 2004
3. ISIS (Canada) Design guidance for strengthening steel structures using FRP. To be published 2007.
4. Schnerch D., Dawood M., Rizkalla S. (2006), "Design Guidelines for the use of HM Strips: Strengthening of Steel Concrete Composite Bridges with High Modulus Carbon Fibre Reinforced Polymer (CFRP) Strips", Technical Report No. IS-06-02, North Carolina State University, Constructed Facilities Laboratory.
5. Italian National Research Council (CNR DT200/2004). Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Existing Structures, 2004. (English translation 2006).
6. Step 1 Timber Engineering, Netherlands, Salland De Lange, Deventer, 1995
7. Step 2 Timber Engineering, Netherlands, Salland De Lange, Deventer, 1995
8. Low Intrusion CONservation Systems for Timber Structures (LICONS), CRAFT Project CRAF-1999-71216, visit website: www.licons.org.

Further reading

International Workshop on Preservation of Historical Structures with FRP Composites, National Science Foundation (NSF), USA, 2004.

CFRP-Reinforced Timber Members

Xu Qingfeng, Zhu Lei, Gong Chuncheng
Shanghai Research Institute of Building Sciences,
Shanghai, China
qingfengxu@yahoo.com.cn

The traditional Chinese building is timber, and the oldest in China is the Foguang Temple of the Tang Dynasty. After hundreds of years, these timber buildings have aged and damaged, and are in need of repair and strengthening. Effective repair techniques should be cost efficient and preserve the Chinese architectural style. Many opportunities exist for the use of FRP for repair or strengthening of existing timber buildings in China.

In the past decade, many investigations have been conducted to study the gain in load capacity and performance of timber beams strengthened with FRP [1~3]. However, the timber beams tested did not have obvious knots on the tensile side in the shear-free region. And, only a few investigations have been considered to reinforce round timber columns and glulam columns with FRP [4~5].

CFRP-Reinforced timber beams with obvious knots

Five Douglas Fir timber beams, 4000 mm long with a cross-section of 100*200 mm^2 with obvious knots were tested: no CFRP (B1), one layer of CFRP (B2), one layer of CFRP and U stirrup (B3), one layer of prestressed CFRP (B4), and two layers of CFRP (B5). Tests were executed under four-point bending. The simply supported span was 3600 mm and the load span was equal to 1200 mm.

All the beams ruptured due to cracks prolonged near the knots (see Figs 1 & 2). The load-deflection curves are shown in Fig. 3. The bending capacity of CFRP-reinforced timber beams with knots increased 53-109% over control beam. And the stiffness also increased significantly. From the experimental results, it appears that the presence of CFRP adjacent to the tension zone of the timber arrests crack opening, confines the local rupture, and bridges the defect, especially near knots.

CFRP-Reinforced cracked timber columns

A series of twelve Douglas Fir columns (four groups of three identical columns) 250 mm long with a cross-section of 90*90 mm^2 with an obvious crack along its length were tested: cracked control columns (F_0R_0Cr), uncracked control columns (F_0R_0), one CFRP (F_1R_0Cr), and two CFRP (F_2R_0Cr). The depth of crack was 30-40 mm and the width of crack near the surface was 1-1.5mm. The timber columns were loaded with a WEW-300B test machine.

The failure mode of cracked control columns was compressive buckling with obvious eccentricity, and axial compression for the other three groups. The average increased capacity of F_0R_0, F_1R_0Cr and F_2R_0Cr was 37.8%, 27.6% and 43.9%, respectively, over cracked control columns (F_0R_0Cr). And the ultimate displacement of F_0R_0, F_1R_0Cr and F_2R_0Cr increased by 20%, 186.7% and 196.7%, respectively. The load-deflection curve for a typical timber column of each group is shown in Fig. 4.

Figure 1: Rupture of B2 near knot in tension side.

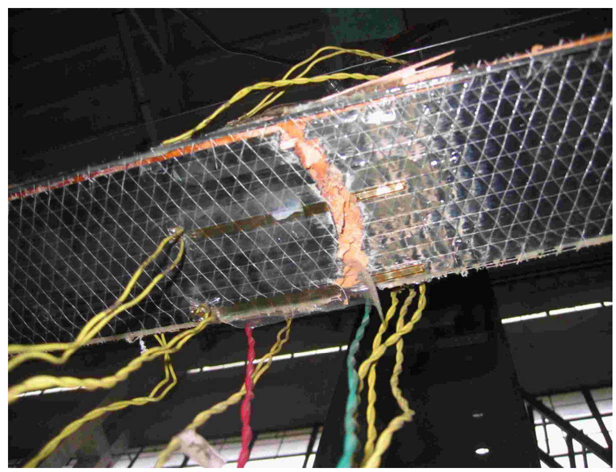

Figure 2: Rupture of midspan CFRP of B3.

CFRP-Reinforced timber columns with different corner radii

Thirty-nine Douglas Fir columns (thirteen groups each with three identical columns) 250 mm long with a cross-section of 90*90 mm^2 were tested. The corner rounding radii included 0 (square), 10, 20, 30, 40 and 45 mm (round). The timber columns were reinforced with either one or two CFRP layers.

Test results show that timber columns are effectively confined by CFRP (see Fig. 5). The mean compressive strength of timber columns confined with one and two CFRP layers were increased 5.2% and 17.4%, respectively, over the unconfined columns. The mean ultimate stress of each group is shown in Fig. 6. The mean ultimate displacement of timber columns confined with one and two CFRP layers was increased 69.8% and 122.1%, respectively, over unconfined columns. The number of layers of CFRP plays an important role in confinement of timber columns, but corner rounding radius has no obvious effect on ultimate stress based on this experimental program and specimen size.

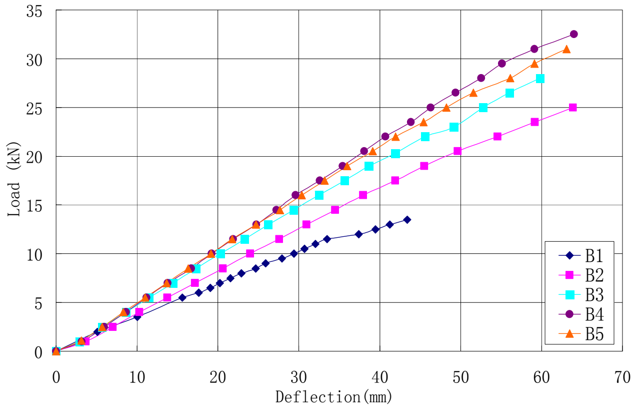

Figure 3: Load-deflection curves of timber beams.

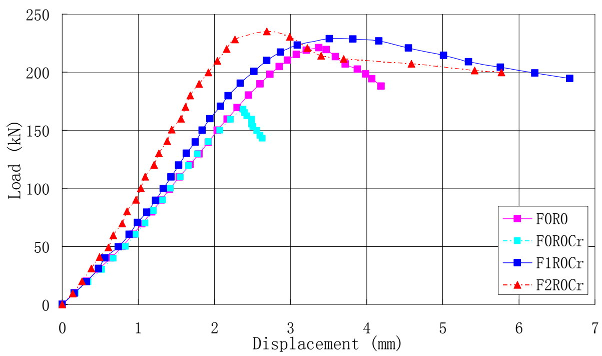

Figure 4: Load-deflection curves of typical columns.

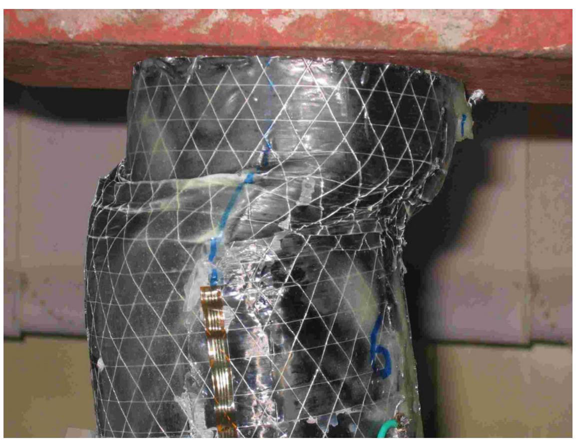

Figure 5: Effective confinement of CFRP.

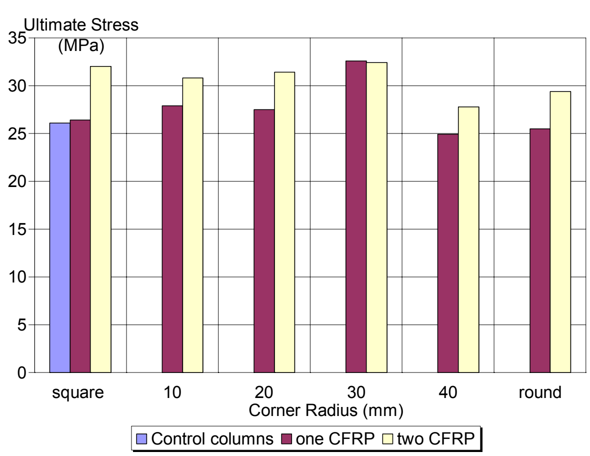

Figure 6: Comparison of ultimate stress.

References

[1] Plevris, N., Triantafillou, T. (1992). FRP-reinforced timber as structural material. Journal of Materials in Civil Engineering, 4(3):300-317.
[2] Johns, K., Lacroix, S. (2000). Composite Reinforcement of Timber in Bending. Canadian Journal of Civil Engineering, 27:899-906.
[3] Borri, A., Corradi, M., Grazini, A. (2005). A method for flexural reinforcement of old timber beams with CFRP materials. Composites Part B: Engineering, 36:143-153.
[4] Ma, J., et al. (2005). Experimental research on axial compressive behaviors for timber columns strengthened with CFRP. Industrial Construction, 35(8):40-44. (in Chinese)
[5] Taheri, F., et al (2005). FRP-reinforced glulaminated columns. FRP International, 2(3):10-12.

Recent Publications

Design Guidelines

The English version of the Italian guidelines on FRP Strengthening of Concrete and Masonry Structures is available *free of charge* on the website of the Italian National Research Council.
www.cnr.it/sitocnr/Englishversion/CNR/Activities/Regulation Certification.html

Research Theses (since previous FRP International issue)

Saha, M.K. "Long-Term Behavior of FRP-Strengthened RC Beams", Doctor of Philosophy, National University of Singapore. May 2007. Advisor: Prof. K.H. Tan.

Zarafshan, A. “A Theoretical and Experimental Investigation of External Reinforcement of Large Scale Square Columns” Master of Science, Faculty of Civil Engineering, University of Tehran, Iran. January 2007. Advisors: Prof. M. Motavalli, Prof. M. Sedegh Marefat, and Dr. O. Huth.

Abraham, E. “Conceptual Investigation of Partially Buckling Restrained Braces” Master of Science, University of Pittsburgh, USA. December 2006. Advisor: Dr. K.A. Harries.

Minnaugh, P. “Experimental Behavior of Steel Fiber Reinforced Polymer Retrofit Measures” Master of Science, University of Pittsburgh, USA. December 2006. Advisor: Dr. K.A. Harries.

Email recent publications to:
newsletter.editor@iifc-hq.com

IIFC Member Profile

Kenneth W. Neale, Ph.D., Eng., FCAE, FCSCE, FIIFC

Kenneth W. Neale was born and educated in Canada. He obtained his B.Eng. degree from McGill University in 1966, followed by M.A.Sc. and Ph.D. degrees in Civil Engineering from the University of Waterloo. He joined the University of Sherbrooke (Sherbrooke, Quebec, Canada) in 1970 where he is currently Canada Senior Research Chair in Advanced Engineered Material Systems. He has also held academic positions at the University of Alberta, Harvard University, McGill University, and the Delft University of Technology in The Netherlands. His research interests include solid mechanics, materials and structures, and the use of fibre-reinforced polymers (FRPs) for civil engineering applications. He has published over 300 technical papers in these areas. Dr. Neale is active in numerous technical societies and code committees. He has participated in the organization of various international conferences, and serves on the editorial boards of a number of technical journals. He is currently Vice President and a Theme Director of the *ISIS Canada* Network of Centres of Excellence, responsible for the theme *Structural Strengthening and Rehabilitation with FRPs*. He is also the incumbent president of the International Institute for FRPs in Construction (IIFC). Dr. Neale is a Fellow of the Canadian Academy of Engineering, the Canadian Society for Civil Engineering, and the IIFC.

Announcements

CARBON-FIBER PIONEER DIES AT 80

If you are flying an airplane that uses carbon fiber, you owe a great deal to physicist and materials scientist **Roger Bacon**, who died in late January in Oberlin, Ohio. While working at Union Carbide in the 1950s, he discovered graphite "whiskers" that were far stronger than steel, according to a New York Times report. He later made fibers by heating rayon to 3,000 degrees Celsius, resulting in a material that resists heat and won't expand when heated. It was used in aerospace and defense applications. He directly supervised later research for the Amoco Corporation using advanced carbon fibers that were used in spacecraft and Navy satellites.

Email general interest announcements to:
newsletter.editor@iifc-hq.com

Calendar of Events

Conferences, Conventions, and Workshops

2007

8th International Symposium on Fiber Reinforced Polymer Reinforcement for Concrete Structures (FRPRCS-8), Patras, Greece, July 16-18, 2007.
www.frprcs8.upatras.gr

1st International Workshop on Performance, Protection & Strengthening of Structures under Extreme Loading (Protect 2007) Whistler, Canada, August 20-22, 2007.
www.civil.ubc.ca/protect2007

Composites and Polycon 2007, Tampa, USA, October 17-19, 2007.
www.acmashow.org/home.cfm

1st Asia-Pacific Conference on FRP in Structures (APFIS 2007), Hong Kong, China, December 12-14, 2007. (APFIS 2007 is the first official Asia-Pacific regional conference of the IIFC.)
www.hku.hk/apfis07/

2008

International Composites in Construction Conference (CCC 2008), Porto, Portugal, April 16-18, 2008.
http://paginas.fe.up.pt/~ccc2008/index.htm

5th Middle East Symposium on Structural Composites for Infrastructure Applications (MESC-5), Hurghada, Egypt, May 23-25, 2008.
www.MESC5-Egypt.com

6th International Conference on Analytical Models and New Concepts in Concrete and Masonry Structures (AMCM 2008), Lodz, Poland, June 9-11, 2008.
www.amcm2008.p.lodz.pl

4th International Conference on FRP Composites in Civil Engineering (CICE 2008), Zurich, Switzerland, July 22-24, 2008. (CICE 2008 is the official conference of the IIFC.)
www.cice2008.org

5th International Conference on Advanced Composite Materials in Bridges and Structures (ACMBS-V), Winnipeg, Canada, September 22-24, 2008.
www.isiscanada.com/acmbs

Committee Meetings

ACI 440 Fiber Reinforced Polymer Reinforcement Committee Meetings, ACI Fall 2007 Convention, Fajardo, Puerto Rico, October 14-18, 2007.
www.concrete.org/Convention/fall-Convention/Front.asp

Email upcoming events to:
newsletter.editor@iifc-hq.com

INTERNATIONAL INSTITUTE FOR FRP IN CONSTRUCTION

COUNCIL

AUSTRALIA	
Professor D.J. Oehlers	University of Adelaide
Professor G.M. Van Erp	University of Southern Queensland
Professor X.L. Zhao	Monash University
BELGIUM	
Professor L. Taerwe	Ghent University
CANADA	
Dr. B. Bakht	JMBT Structures Research Inc.
Professor N. Banthia	University of British Columbia
Professor P. Labossière	University of Sherbrooke
Professor A. Mufti	University of Manitoba
Professor K.W. Neale	University of Sherbrooke
CHINA	
Professor Z.T. Lu	Southeast University
Dr. S.T. Smith	University of Hong Kong
Professor J.G. Teng	Hong Kong Polytechnic University
Professor Q.R. Yue	National Diagnosis and Rehabilitation of Industrial Building Research
Professor L.P. Ye	Tsinghua University
DENMARK	
Professor B. Täljsten	Technical University of Denmark
GREECE	
Professor T. Triantafillou	University of Patras
IRAN	
Dr. M. Motavalli	University of Tehran
ISRAEL	
Dr. A. Katz	Technion-Israel Institute of Technology
ITALY	
Professor E. Cosenza	University of Naples Federico II
Dr. L. De Lorenzis	University of Salento
JAPAN	
Dr. H. Fukuyama	Building Research Institute
Professor A. Machida	Saitama University
Professor T. Ueda	Hokkaido University
Professor Z.S. Wu	Ibaraki University
KOREA	
Professor J.S. Sim	Hanyang University
POLAND	
Dr. R. Kotynia	Technical University of Lodz
PORTUGAL	
Dr. J. Barros	University of Minho
SINGAPORE	
Professor K.H. Tan	National University of Singapore
SWITZERLAND	
Professor T. Keller	Swiss Federal Institute of Technology
Professor U. Meier	Swiss Federal Laboratories for Materials Research (EMPA)
TURKEY	
Dr. A. Ilki	Istanbul Technical University
U.K.	
Dr. J.F. Chen	University of Edinburgh
Professor L.C. Hollaway	University of Surrey
Professor P. Waldron	University of Sheffield
U.S.A.	
Professor C.E. Bakis	Penn State University
Professor L.C. Bank	University of Wisconsin-Madison
Professor I.E. Harik	University of Kentucky
Professor V.M. Karbhari	University of California at San Diego
Professor A. Mirmiran	Florida International University
Professor A. Nanni	University of Miami
Professor S.H. Rizkalla	North Carolina State University
Dr. R. Seracino	North Carolina State University

ADVISORY COMMITTEE

Professor L.C. Hollaway	University of Surrey, UK
Professor A. Machida	Saitama University, Japan
Professor U. Meier	EMPA, Switzerland
Professor A. Mufti	University of Manitoba, Canada
Professor A. Nanni	University of Miami, USA
Professor S.H. Rizkalla	North Carolina State University, USA
Professor J.G. Teng	Hong Kong Polytechnic University, China

EXECUTIVE COMMITTEE

President	
Professor K.W. Neale	University of Sherbrooke, Canada
Vice Presidents	
Professor L.C. Bank	University of Wisconsin–Madison, USA
Dr. J.F. Chen	University of Edinburgh, UK
Professor V. Karbhari	University of California-San Diego, USA
Professor Z.S. Wu	Ibaraki University, Japan
Newsletter Editor	
Dr. R. Seracino	North Carolina State University, USA
Treasurer	
Professor N. Banthia	University of British Columbia, Canada
Secretary	
Dr. S.T. Smith	University of Hong Kong, China
Conference Coordinator	
Dr. M. Motavalli	University of Tehran, Iran
Members-at-Large	
Dr. L. Bisby	Queen's University, Canada
Professor B. Täljsten	Technical University of Denmark

International Institute for FRP in Construction

Application for Membership

Mail to: IIFC Administrative Center • c/o University of Manitoba
Agricultural and Civil Engineering Building • A250-96 Dafoe Road
Winnipeg, Manitoba, R3T 2N2, Canada
Tel: 1 (204) 474-8506 • Fax: 1 (204) 474-7519
Email: iifc@iifc-hq.org • Website: www.IIFC-hq.org

Title: ______________ Gender: ______________ Date of Birth (dd/mm/yy): ______/______/______

Surname: ______________________________ First/middle names: ______________________________

EMPLOYER/COMPANY: ____

CORRESPONDENCE ADDRESS: ____

____

Tel. ______________________ Fax. ______________________ Email ______________________

EDUCATION

Major College/University Graduation date mm/yy Degree

____

____

EXPERIENCE (You may list your personal home page address here for additional information)

____

____

I/we wish to join the International Institute for FRP in Construction (IIFC) as a (please tick one box)

☐ Fellow ($100 US) ☐ Member ($100 US) ☐ Associate Member ($50 US) ☐ Student Member ($25 US)

☐ Collective Member* ($750 US) ☐ Patron Member ($1500 US)

**If applying for a Collective Membership, please nominate two representatives to receive the privileges:*

Representative A Surname: ______________ First/middle names: ______________

Title: ______________ Gender: ______________ Date of Birth (dd/mm/yy): ______/______/______

Tel. ______________________ Fax. ______________________ Email ______________________

Representative B Surname: ______________ First/middle names: ______________

Title: ______________ Gender: ______________ Date of Birth (dd/mm/yy): ______/______/______

Tel. ______________________ Fax. ______________________ Email ______________________

METHOD OF PAYMENT (Payable in US Funds) Cheques and money orders to be made payable to "IIFC"

☐ Check / Money Order ☐ Bank Draft*

**For details on process for bank draft, e-mail choboter@ms.umanitoba.ca*

☐ Visa ☐ Mastercard

☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐ ☐☐☐☐

Credit Card No. *Expiration Date*

____

Name on Credit Card

____

Signature of Cardholder

For Office Use Only

Date of Receipt: ______________

Application Outcome: ______________

Membership Number: ______________

Date of Approval: ______________

Transaction Date: ______________

Amount: ______________

Authorization No: ______________

Invoice No: ______________

Journal Entry No: ______________