FRP INTERNATIONAL

the official newsletter of the International Institute for FRP in Construction

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Invitation to APFIS 2013

Profs Riadh Al-Mahaidi, Xiao-Ling Zhao and Scott Smith
Co-Chairs of APFIS 2013

On behalf of the Asia-Pacific Conference on FRP in Structures (APFIS2013) Organising Committee, it gives us great pleasure to invite all to APFIS 2013 in Melbourne, Australia from 13 to 15 December 2013.

Melbourne is a vibrant community, typical of many cities in Australia. It has a well-developed infrastructure and a network of roads and bridges which serve a growing demand from users, particularly freight and road-users. Its bridge engineers, who are faced with many maintenance and rehabilitation challenges, will benefit greatly from exposure to the experience and knowledge of international FRP researchers and practitioners.

APFIS 2013 promises to be intellectually engaging and socially enjoyable. The following six keynote speakers will provide perspectives beyond those normally covered within the APFIS series. They come from varying backgrounds and therefore promise to be thought provoking.

Prof. Zdeněk Bažant, Northwestern University, USA
Dr. Jian-Guo Dai, The Hong Kong Polytechnic University, Hong Kong
Prof. Dan Frangopol, Lehigh University, USA
Prof. Hui LI, Harbin Institute of Technology, China
Prof. Alper Ilki, Istanbul Technical University, Turkey
Dr. Geoff Taplin, AECOM, Australia

The conference will be held prior to the end of year summer festive season. You may therefore use this opportunity to spend time in and around Melbourne and the state of Victoria in Australia. You may also use the opportunity to travel to other parts of Australia such as Sydney, Canberra and the Gold Coast.

We look forward to welcoming APFIS2013 delegates to Melbourne in December 2013.

More information is available online at www.apfis2013.org

Melbourne is home to the Westgate Bridge. The city's iconic structure is also of primary importance to the national transportation network. The 38 approach spans of the bridge were recently retrofitted with FRP, making it the world's largest FRP retrofitting project [see *FRP International*, Vol. 8, No. 3; available online at www.iifc-hq.org]. The bridge currently serves approximately 160,000 vehicles per day compared with only 40,000 vehicles when it opened 30 years ago, with future predictions indicating escalating demands. The increased traffic volume is accommodated by the introduction of two additional lanes to the main carriageway. The retrofitting comprised nearly 40 km of carbon fibre laminates and 11,000 m^2 of carbon fibre fabric applied to the structure.

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20th Anniversary of *FRP International*
10th Anniversary of IIFC

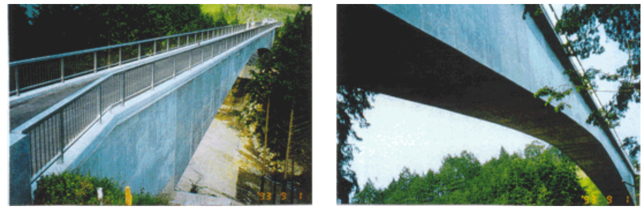
2013 marks the 20th volume of *FRP International* and the 10th anniversary of the founding of IIFC (*FRP International* restarted with Vol. 1 when it became the official newsletter of IIFC). In its first 20 years, the 56 issues of *FRP International* have contained 194 research articles and 283 case studies or product reports. Articles have originated from 29 countries. Interestingly, articles focusing on external FRP reinforcement have outnumbered those addressing either internal FRP reinforcement or FRP structures and shapes by about 2 to 1. A complete index of all *FRP International* articles is maintained on the IIFC website: www.iifc-hq.org.

Considering the milestone anniversaries of both *FRP International* and IIFC, over the course of this year we are featuring a few items from twenty and ten years ago... The use of FRP in construction has come a long way in a very short time. Why it only seems like yesterday...

Twenty Years Ago…

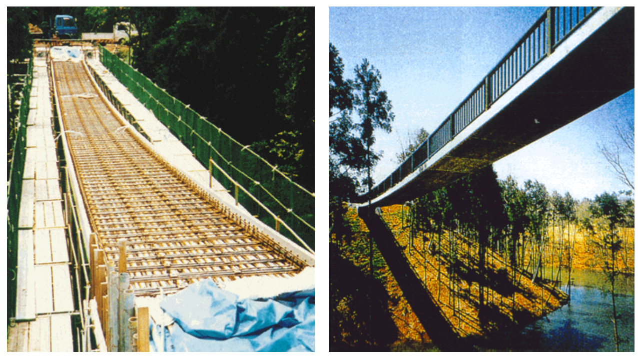
The Fall 1993 (Vol. 1 No. 4) *FRP International* was introduced by Professor Shigeyoshi Nagataki, at the time, the Chairman of the Concrete Committee of the Japan Society of Civil Engineering. Prof. Nagataki was responsible for organising the JSCE subcommittee on Continuous Fibre Reinforced Materials which later developed many highly regarded documents and standards.

Projects described in this issue include the (then) longest carbon fibre composite cable (CFCC) prestressed concrete bridge in the world. A 110 m long pedestrian bridge with a 75 m main span, the Tsukude Country Club Bridge utilised both internal and external cables and was erected using the cantilever method.



Tsukude Country Club Bridge (photo: wtec.org).

A related Japanese bridge – the Birdie Bridge – was also noted for having been awarded 1991 JSCE award. This 54.5 m long stressed ribbon bridge had Leadline ground anchors at the abutments and Arapree pre- and post-tensioning in the bridge slab. The permanent formwork was reinforced with CFCC reinforcement and utilised an advanced vinyl fibre reinforced concrete.



Birdie Bridge, Southern Yard Country Club (photos: wtec.org).

The Fall 1993 issue also announced the publication of a ***new*** book edited by Prof. A. Nanni entitled: *FRP Reinforcement in Concrete Structures: Properties and Applications*. Yes, this book is now 20 years old!

ASCE JCC Special Issue

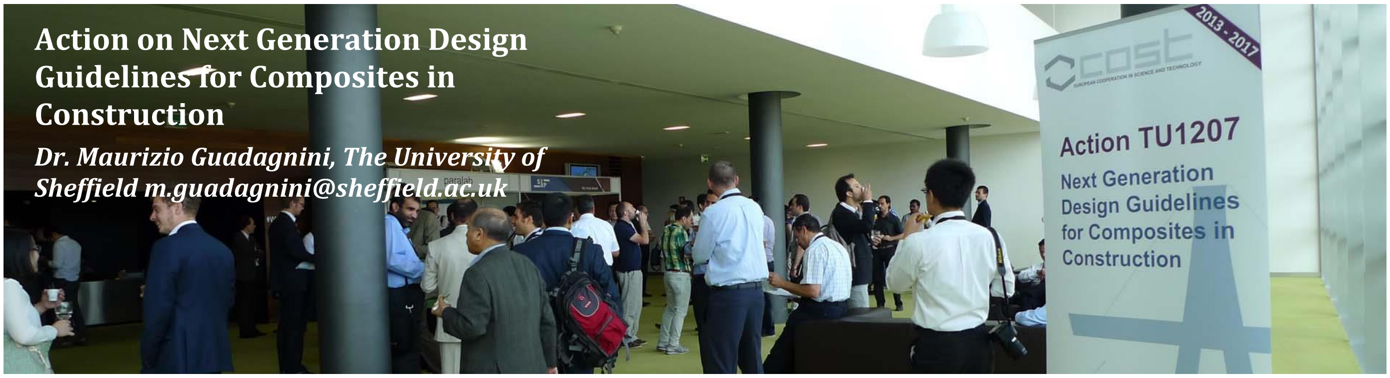
In recognition of IIFC's 10th Anniversary, a Special Issue of the *ASCE Journal of Composites for Construction* is being prepared. Edited by Prof. Scott Smith (IIFC Vice President) and Prof. Jian Fei Chen (IIFC Senior Vice President), the issue is expected to appear in the Spring of 2014.

The ASCE *Journal of Composites for Construction* is published with the support of IIFC. The ASCE JCC may be found at the following website:

http://ascelibrary.org/cco/

Action on Next Generation Design Guidelines for Composites in Construction

Dr. Maurizio Guadagnini, The University of Sheffield m.guadagnini@sheffield.ac.uk



COST (European Cooperation in Science and Technology), whose mission is to enable break-through scientific developments leading to new concepts and products, approved late last year the proposal for a new Action on Next Generation Design Guidelines for Composites in Construction (Action TU1207). Actions are networks centred on nationally-funded research projects and provide support for cooperation activities to bring scientists together and co-ordinate research under a strategic guidance.

Action TU1207 officially started on 12 April 2013 and had its first Meeting in Guimarães, Portugal (Fig. 1) in the days immediately preceding the FRPRCS-11 international conference, one of the most important conferences in the field. The Action already has the support of 23 COST countries and more than hundred researchers from Europe and beyond (Fig. 2).

Figure 1 Official launch of COST Action TU1207, 24-25 July 2013 in Guimarães, Portugal.

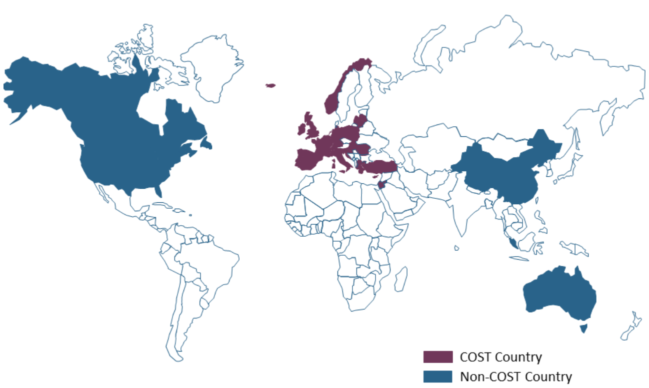


Figure 2 Dimension and impact of COST Action TU1207.

- Action TU1207 leverages the already large amount of work carried out on the use of composite reinforcement for structural applications by individual COST research teams and existing learned groups (fib, RILEM, CEN) and aims to:
- coordinate European research in the field of composite reinforcement for structural applications (new structures and strengthening of existing structures);
- develop and maintain a critical mass of researchers;
- offer a link between academia and industry; and,
- assist in the development of a new generation of design guidelines based on European Standards.

Through the co-ordination and dissemination activities that will be implemented (meetings, workshops, seminars and scientific missions), COST Action TU1207 will also offer a unique one-stop forum that will enable active involvement of major stakeholders (researchers, manufacturers, distributors, contractors, and standardisation committees).

Aim and Objectives

The main aim of the Action is the development of advanced design guidelines that are compatible with European standards. These guidelines will address both new structures reinforced with FRP as well as the rehabilitation and strengthening of existing deficient concrete, masonry, steel and timber structures. The Action will address key scientific and technological challenges in the following four main priority areas: 1) Material Development and Characterisation; 2) New Structures; 3) Strengthening Applications; and 4) Whole-life-costing and life cycle assessments.

The specific objectives of Action TU1207 are:

1. To review the current state-of-the-art and define research priority areas.
2. To assist the European composite industry to identify improvements and new uses for their materials for applications in construction.

3. To transfer the knowledge into design recommendations by facilitating the work of fib TG 9.3, RILEM Technical Committees (223-MSC, 234-DUC and the recently established CSM) and CEN.
4. To disseminate knowledge to young researchers and relevant stakeholders.
5. To inform the general public through outreach activities.

Organisation and Working Groups

Five Working Groups (WG) have been established to coordinate the research and dissemination activities of this Action (Fig. 3). The main scientific themes will be examined by four WGs while WG5 (Knowledge Transfer) will coordinate and promote collaboration and outreach activities. Central to the activities of all WGs will be the preparation of state-of-the-art reports and the creation and maintenance of relevant databases of experimental results, as well as wish lists for future research projects. The activities of each of WG are briefly summarised below.

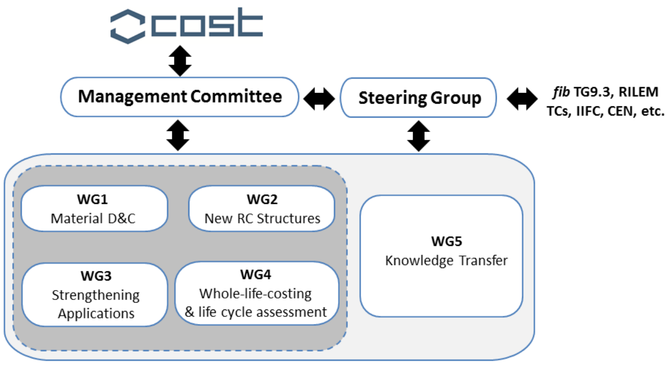


Figure 3 Action TU1207: management structure and organisation.

WG1: Material Development and Characterisation

This Working Group deals with short and long-term material characteristics, the mechanical properties of composites for construction, and their interaction. In particular interaction with concrete and masonry, through bond and anchorage, remain difficult to characterise, due to their vastly different material strength and stiffness. Although a considerable amount of work has already been carried out at various research institutions and by manufacturers, primarily for quality control, reliable standard bond and anchorage tests that are directly relevant to design have yet to be developed.

This WG will provide recommendations on standard procedures for materials testing and create and maintain a large database of experimental results that will be made available to the wider research community. This will enable a more comprehensive assessment of available constitutive models and lead to the development of more accurate predictive equations.

WG2: New RC Structures

This Working Group will coordinate research on the use of composite materials as internal reinforcement for concrete structures. Although in Europe composites were first introduced in Civil Engineering applications primarily for their durability advantages as reinforcement for concrete structures, this is the field that has attracted less attention from building and infrastructure owners. This is partly due to the lack of appreciation of the savings that are possible over the life of a structure. To determine whole life costing, it is necessary to understand the long-term behaviour of FRP materials exposed to a variety of environments, to the alkalinity of concrete, to fire, etc.

FRP reinforcement is much more popular in North America and it is important to understand the reasons behind this. In fact, there is a major difference in approach in dealing with durability between the continents. In Europe the emphasis is placed on ensuring the use of high performance concrete and adequate concrete covers (something which is not always possible), while in North America the emphasis for structures vulnerable to corrosion is on using corrosion resistant reinforcement. Hence, a reassessment of the strategy of the European standards may be necessary in this respect.

WG3: Strengthening Applications

This Working Group will coordinate research on the use of advance materials for the strengthening of existing structures (including concrete, masonry, steel and timber). Strengthening applications have dominated the European market and are still responsible for the largest portion of the research carried out in this field. Although several national committees have been established and design guidelines have been produced, several critical aspects of the behaviour of strengthened structures are not yet fully understood. In particular, ensuring a strong and durable bond between the FRP composite and the original structure, as well as ensuring high ductility in seismically deficient structures remain crucial challenges.

This WG will bring together experts from different fields and will assist in the development of a much needed holistic approach to the rehabilitation and strengthening of existing deficient structures.

WG4: Whole-life-costing and Life Cycle Assessment

Activities of this WG will focus on compiling a database of existing projects and case studies. The industrial participants will be instrumental to the work of this WG. A report on available methodologies to assess the whole-life costing and performance of new and rehabilitated structures will be produced to enable interested stakeholders to compare different solutions using traditional and novel materials.

Join the Action

Additional information on Action TU1207 and how to join the activities can be found on the Action website or by contacting the Action Chair.

Call for Short Term Scientific Missions

Action TU1207 invites researchers to submit proposals for Short Term Scientific Missions (STSM). Applications from Early Stage Researches are particularly encouraged.

STSMs are aimed at supporting individual mobility and at strengthening the Action and fostering collaborations by providing funding to allow scientists to visit an institution or laboratory in another Participating Country. Applicants must be engaged in a research programme as a postgraduate student or postdoctoral fellow, or be employed by or officially affiliated with an institution or legal entity. STSMs can vary from one week to three months and up to six months for Early Stage Researchers. More information on STSMs and how to apply can be found on the Action website.

General Information

Start of Action:	12/04/2013
End of Action:	11/04/2017
Chair of the Action:	Dr. Maurizio Guadagnini The University of Sheffield m.guadagnini@sheffield.ac.uk
Vice Chair:	Prof. Stijn Matthys Ghent University stijn.matthys@ugent.be
Action website:	http://www.tu1207.eu
Domain website:	http://www.cost.eu/tud

Conference Report

FRPRCS11 – 11th International Symposium on Fiber Reinforced Polymer for Reinforced Concrete Structures

Prof. Joaquim A.O de Barros and Dr. Eduardo Pereira, University of Minho, Portugal
barros@civil.uminho.pt, epereira@civil.uminho.pt

The 11th International Symposium on Fiber Reinforced Polymer for Reinforced Concrete Structures (FRPRCS11), an event co-sponsored by IIFC, was held 26-28 June at the Vila Flor Cultural Centre of Guimarães City, in Portugal. Following peer review, 148 extended abstracts and full papers were accepted and published in the proceedings. Approximately 170 delegates representing 38 countries and 137 institutions were in attendance. The distribution of papers by theme is indicated in Table 1, where the tendency for a significant research effort on the "Reinforcement and strengthening performance of FRP systems" is clear, forming about one third of the accepted publications. The FRPRCS11 was composed of 20 sessions of 20 minutes presentations including about 5 minutes for discussion of each. The high technical/scientific level of the publications, and especially the enthusiastic and fruitful discussions which occurred during the presentations were highly remarked upon by the conference participants. Prof. Brahim Benmokrane and Prof. Stijn Matthys provided two stimulating keynote lecturers which provided extraordinary contribution to the motivation and enthusiasm of the delegates, and the scientific quality of FRPRCS11. The closing ceremony ended with the announcement of the chairman of the next FRPRCS conference, Prof. Zhishen Wu, who in 2015 will host FRPRCS12 in Nanjing, China.

Table 1 Distribution of FRPRCS papers.

Theme	Papers
reinforcement and strengthening	46
new FRP materials, systems and techniques	26
bond behaviour	22
durability	14
advanced numerical methods	13
codes, standards and guidelines	11
test methods	7
seismic strengthening	4
field applications	3
health monitoring	2

From FRPRCS11…

…detailed (and fruitful?) discussions of presented papers during breaks…

…celebrity photo opportunities…

…and the conference banquet.

The SC@UM Challenge

Hosted by FRPRCS11 and supported by IIFC and S&P, the SC@UM Challenge gathered researchers, practitioners and institutions in a reflection about CFRP strengthening applied to reinforced concrete (RC) structures. The motif was a T-shaped RC beam, which was pre-loaded to simulate service conditions and then strengthened with longitudinal and transverse NSM-CFRP laminates. The SC@UM Challenge was primarily directed to PhD students working in the field and required accurate predictions characterising the load-deflection response and failure mechanism of an RC beam after strengthening. The initiative was welcomed by many institutions and universities, with 19 teams from 11 countries initially registered to participate.

The Challenge

The strengthening scheme incorporated innovative features relative to the current state of the art, increasing the difficulty of the challenge and increasing curiosity about the outcomes. The competition comprised different stages following the production and characterization of all materials used. After the registration of all teams, the T-shaped RC beam specimens (Figures 1 and 2 in subsequent article) were cast and all materials – concrete, reinforcing steel, CFRP and adhesive – employed were characterised by their Young's modulus and strength. In addition, the load-deflection response of the RC beam during the pre-loading stage was provided to all participating teams to support their estimations and competition reports. The pre-loading of the RC beam was carried out 28 days after casting and consisted of imposing a total deflection of L/350 at a rate of 20 μm/s. The pre-cracked beam was then strengthened using 1.2 x 20 mm CFRP laminates adopting the Near Surface Mounted (NSM) technique for both the flexural and shear strengthening (Figure 1 in subsequent article). The exact dimensions and detailing of the CFRP strengthening were also made available to all teams, together with the accurate positioning of all transverse and longitudinal steel reinforcement elements.

The final competition reports delivered by all teams were composed of three elements: a full paper of approximately 10 pages containing the theoretical background and discussion of their predicted results, a brief presentation summarizing the main results, and a file containing their predicted load-deflection response. Eight teams were able to complete the challenge, submitting their reports and complying with the competition rules. One week after the submission deadline, approximately 90 days after casting, the CFRP strengthened RC T-beam was tested to failure at an imposed deflection rate of 20μm/s (see Figures 1 and 2, this article). The event was broadcast live to the jury members, who were responsible for verifying that all the procedures complied with the competition rules. The jury chairman was Mauricio Guadagnini from the Sheffield University. The jury members were Kent Harries from IIFC, Filipe Dourado from S&P and Eduardo Pereira from ISISE-University of Minho.

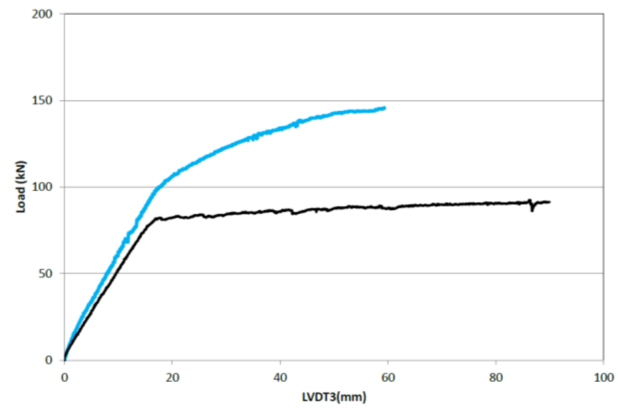


Figure 1 Load-deflection response of the T-shaped RC beam with (blue) and without (black) strengthening using CFRP laminates.

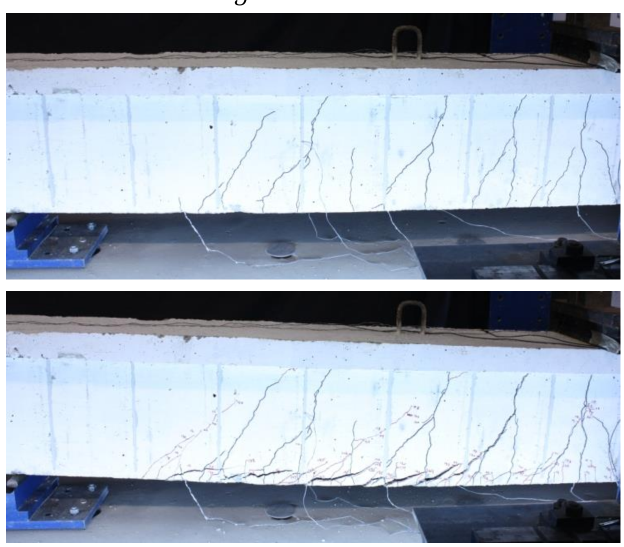


Figure 2 Crack pattern at the left span of the strengthened T-shaped RC beam: (top) at imposed deflection of L/250; (bottom) right before failure.

Evaluation

The multiple parameter evaluation criterion employed was based on the following five parameters with different relative weights: 1) accuracy of the predictions to estimate the load to cause a deflection of

L/250; 2) accuracy of predictions of ultimate load and deflection; 3) overall accuracy of predicted load-deflection response as measured by the area under the response; and 4) a subjective review of the paper assessing the accuracy of the predicted load-displacement responses and of the description of the expected failure mechanism, the innovative character of the proposed model, and the creativity and the theoretical soundness of the model principles described.

Results

Among the eight reports submitted, six teams supported their predictions using finite element method (FEM) models, of which one was a force-based fibrous formulation, two were displacement-based and adopted solid elements, and four used plane stress displacement-based finite element formulations. The remaining two teams adopted purely analytical approaches. The overall shape of the predicted and experimental responses were generally similar as shown in Figure 3.

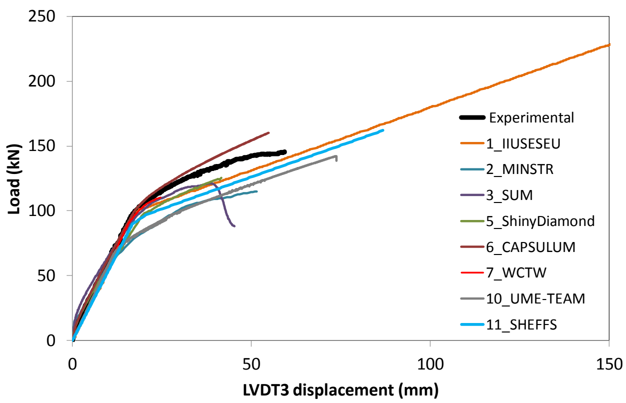


Figure 3 Predicted load-displacement responses by all competing teams and the obtained experimental response.

The four evaluation parameters were generally predicted well by all teams, although teams were more accurate at predicting the strength-related parameters than the ductility/deformability related ones. The type of model used to support the predictions seemed to have an effect on this outcome. The reports also obtained very positive feedback from the Jury members.

Three teams were awarded first, second and third place prizes: CAPSULUM from ISISE-University of Minho (Portugal), UME-TEAM from IUSS Pavia (Italy), and SHEFFS from the University of Sheffield (UK), respectively, were awarded prizes of 1000€, 500€ and 250€, respectively. Considering the excellent quality of the reports, the Jury members also decided to attribute two honorable mentions, the Excellent Report Award, to the two best reports delivered by the teams SUM from the company Simpson Strong Tie (USA) (see subsequent article) and ISISE-University of Minho, and WCTW from ISISE-University of Minho.

Figure 4 Group photo of the SC@M Challenge awarded teams at the closing session of FRPRCS-11.

This initiative was welcomed by all involved members of the scientific community, and received very positive feedback. It was common understanding that the challenge created a unique atmosphere to stimulate the emergence of alternative approaches and creative solutions for FRP strengthening and technology. The contribution of young researchers to the development of the current state-of-the-art can be encouraged in the future through other events and periodic initiatives of this kind.

Competing Teams

IIUSESEU	South East University	China
MINSTR	University of Minho	Portugal
SUM	Simpson Strong Tie and University of Minho	USA and Portugal
ShinyDiamond	University of Minho	Portugal
CAPSULUM	University of Minho	Portugal
WCTW	University of Minho	Portugal
UME-TEAM	IUSS Pavia	Italy
SHEFFS	University of Sheffield	UK

initially 19 teams expressed interest, representing, in addition to those countries listed above: Greece, Taiwan, Iran, Poland, Russia and Saudi Arabia.

This article is condensed from an entry in the SC@UM competition at FRPRCS-11. It was selected for reader interest by the editor.

Simulation of NSM-CFRP Strengthened T-Beam under Flexure Loading

Dr. Frank Ding, Simpson Strong-Tie, California USA fding@strongtie.com

This paper summarises the finite element modeling approach used for the CFRP Strengthening Challenge at FRPRCS-11. The objective of the competition was to predict the behavior of a T-shaped RC beam strengthened in shear and flexural with NSM-CFRP laminates (Fig. 1) spanning 5.7 m (Fig. 2).

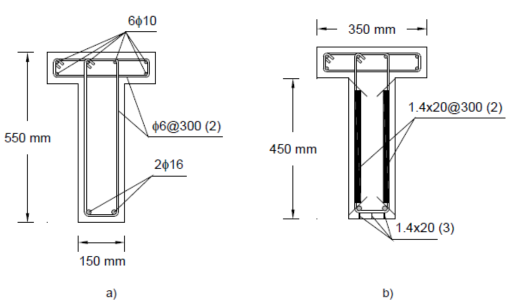


Figure 1 T-beam cross section geometry, a) before and b) after CFRP laminate strengthening.

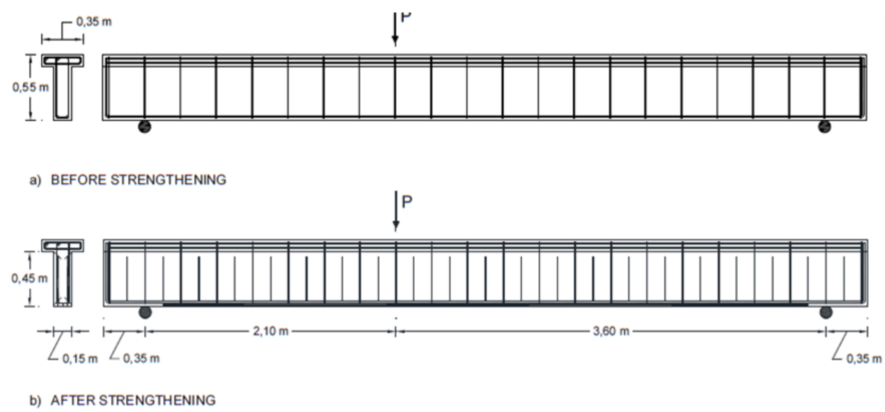


Figure 2 T-beam geometry and steel reinforcement, a) before and b) after CFRP laminate strengthening

An elastic-plastic isotropic material model was used to model the steel reinforcing bars which were subsequently modelled using the Abaqus embedded element technique [2] with a perfect bond. Table 1 shows the material parameters used for the steel bars.

Table 1 Material parameters for steel bars.

Diameter	***Young's modulus E_s(GPa)***	***yield stress F_{sy}(MPa)***	***tensile stress F_{su}(MPa)***
6 mm	211.5	552.6	679.6
10 mm	205.8	529.4	624.6
16 mm	207.2	552.8	657.4

The concrete damaged plasticity model in Abaqus [2] was used to model concrete behavior. The compressive behavior from 28-day test data provided in [1] were used to establish, the modulus: E_c = 35.8 GPa, and the compressive strength f_{cu} = 24.5 MPa. The tensile strength, f_{ct}, was then calculated as:

$$f_{ct} = 0.33\sqrt{f_{cu}} = 1.63 \ MPa \quad (1)$$

To specify the post-peak tension behavior of concrete, the fracture energy method was used. The fracture energy, G_f, is the area under the softening curve, and was assumed to be 70 N/m according to the reported maximum aggregate size of 15 mm [1].

The linear CFRP laminate tensile response is entirely described by the Young's modulus, E_f = 171.6 GPa and the tensile strength, f_{fu} = 2534 MPa. The failure strain was ε_{fu} = 0.0148 [1].

The Adhesive was assumed to be an isotropic elastic-perfectly plastic material. The Young's modulus, E_a = 7.66 GPa, and the yield stress, f_{ya} = 20.7 MPa are based on data provided in [1].

The CFRP-concrete interface was modeled using Abaqus surface-based cohesive behavior based on a traction-separation law. Figure 3 shows a graphic interpretation of a simple bilinear traction-separation law written in terms of the effective traction, τ, and effective opening displacement, δ. The interface is modeled as a rich zone of small thickness with an initial stiffness, K_0, defined as [3]:

$$K_0 = \frac{1}{\dfrac{t_i}{G_i} + \dfrac{t_c}{G_c}} \quad (2)$$

where t_i is the adhesive thickness, t_c is the concrete thickness, and G_i and G_c are the shear modulus of adhesive resin and concrete, respectively. The values used for this study were t_i = 1.7 mm, t_c = 5 mm, G_i = 2.95 GPa, and G_c = 10.8 GPa. Thus K_0 = 0.962 GPa.

The maximum bond shear stress, τ_{max}, was initially set to 18.1 MPa based on CFRP-concrete interface bond experimental data presented by Sena Cruz et al. [4]. The fracture energy, G_{cr} = 90 N/m was used based on the previous work of Obaidat et al. [3].

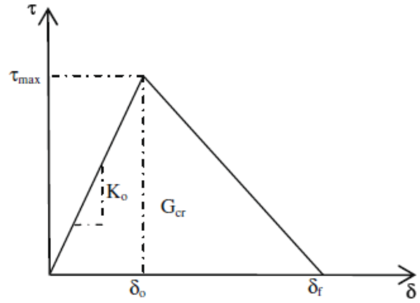


Figure 3 Bilinear traction–separation constitutive law.

The initiation of damage was assumed to occur when a quadratic traction function involving the nominal stress ratios reached unity. This criterion can be represented as:

$$\left(\frac{\sigma_n}{\sigma_n^0}\right)^2+\left(\frac{\tau_s}{\tau_s^0}\right)^2+\left(\frac{\tau_t}{\tau_t^0}\right)^2=1 \qquad (3)$$

where σ_n is the cohesive tension and τ_s and τ_t are shear stresses at the interface, in which n, s, and t refer to the direction of the stress component. The values used for this simulation were σ_n^0 = 41 MPa, and $\tau_s^0 = \tau_t^0$ = 34 MPa. Interface damage evolution was expressed in terms of energy release. The description of this model is available in the Abaqus material library [2]. The dependence of the fracture energy on the mode mix was defined based on the Benzaggah–Kenane fracture criterion [2] given by:

$$G_n^c+\left(G_s^c-G_n^c\right)\left(\frac{G_\varphi}{G_J}\right)^\eta=G^c \qquad (4)$$

where $G_\varphi = G_s + G_t$; $G_J = G_n + G_s$; and η is the material parameter. G_n, G_s and G_t refer to the work done by the traction and its conjugate separation in the normal, and first and the second shear directions, respectively. The values used for this analysis were G_n^c = 9N/m, G_s^c = 90N/m, and η=1.45.

Figure 4 shows a complete 3D Abaqus T-beam model with model translucency. Due to the model size and complicated damage and failure modes involved, Abaqus/Explicit was employed to solve the model on a 32-core Linux cluster.

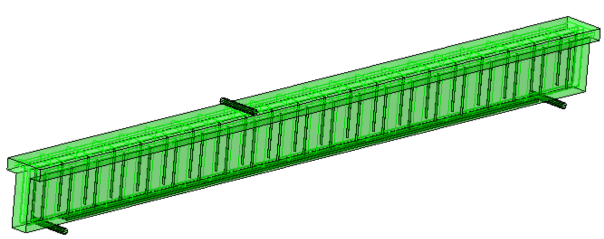


Figure 4 T-beam model built in Abaqus/CAE.

T-beam pre-loading was simulated without CFRP strengthening. Figure 5 shows the load-deflection curve compared with the test result [1]. Figure 6 shows the predicted T-beam crack patterns, and Figure 7 shows the bottom steel reinforcing bars at the loaded section indicating their yield and development of plastic strain.

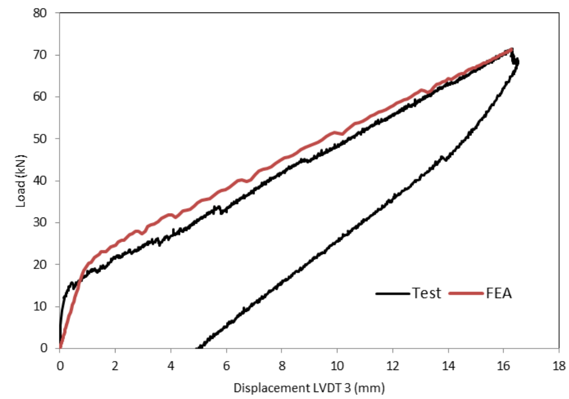


Figure 5 Load displacement response of the T-beam before CFRP strengthening.

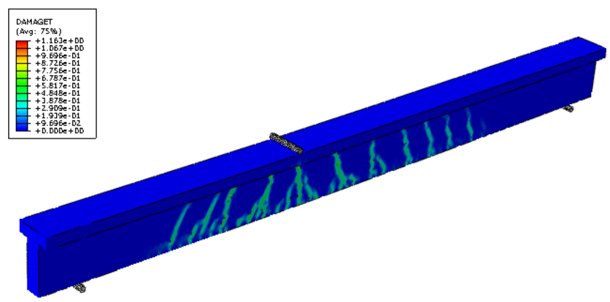


Figure 6 Crack pattern of the pre-loaded T-beam.

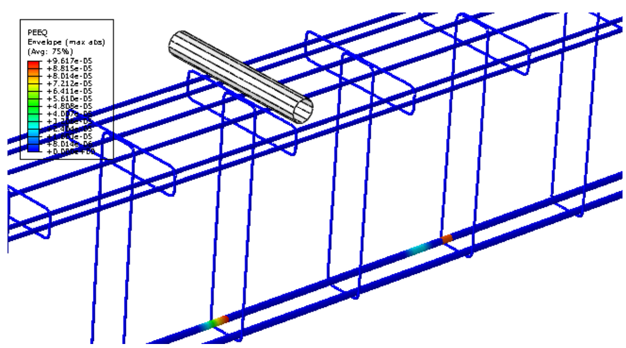


Figure 7 Plastic strain contour plots of the steel bars at the pre-loading peak load.

The final T-beam load displacement curve after CFRP strengthening is shown in Figure 8. The peak load is 121.15 kN at a deflection of 38.6 mm. The load is 107.1 kN at a deflection of L/250 at the loaded section.

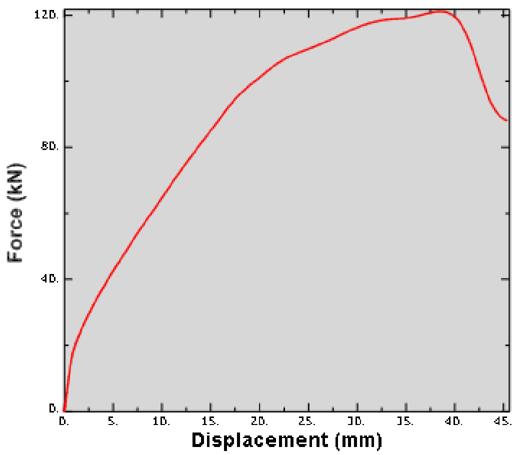


Figure 8 Predicted strengthened T-beam load displacement curve.

At the peak load (Figs 9-12), the CFRP laminates' maximum strain is 0.00726 and maximum stress is 1.24 GPa. The maximum plastic strain at the bottom steel reinforcing bars is 0.0178 (Fig. 10). The failure is predicted to be CFRP-concrete de-bonding plus concrete cracking and crushing at the bottom of the T-beam, starting from the loaded point and propagating to the near support (Fig. 12). The model presented scored as follows in the SC@UM competition:

	experiment	model	mod./exp.
ultimate capacity	145.7 kN	121.2 kN	0.83
ultimate deflection	59.3 mm	38.6 mm	0.65
load at L/250	111.4 kN	107.1 kN	0.96

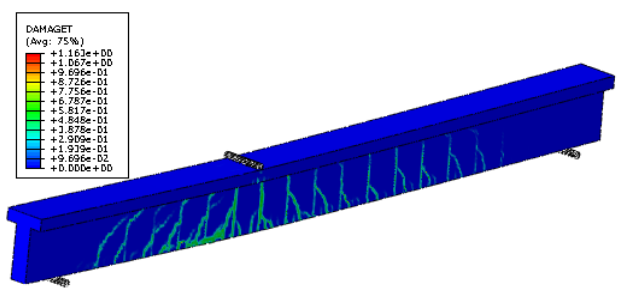


Figure 9 T-beam crack pattern at peak load.

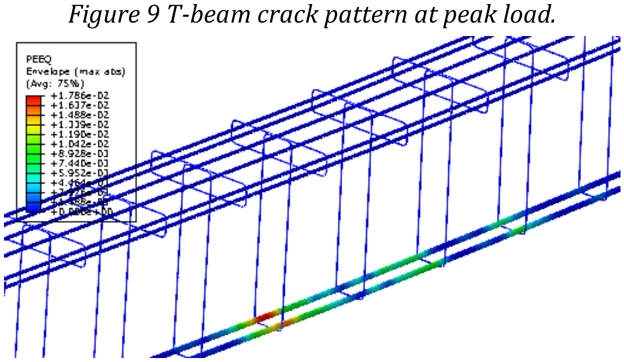


Figure 10: Steel reinforcing bars plastic strain in the loaded section at peak load.

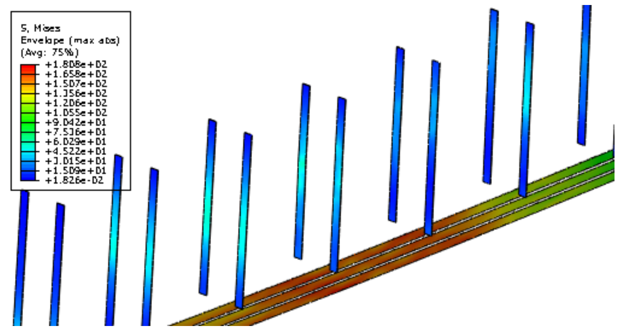


Figure 11 von Mises stress in CFRP laminates at the loaded section at the peak load.

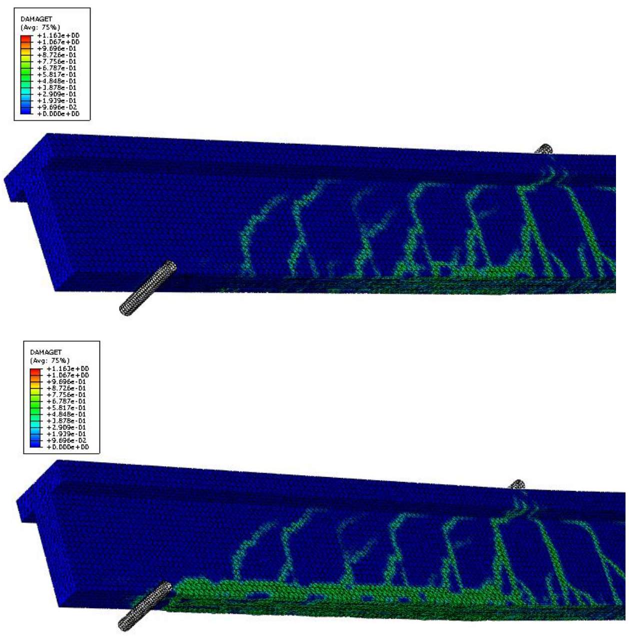


Figure 12 Propagation of CFRP debonding and concrete cracking and crushing failure at peak load.

References

[1] Characteristics of the Materials, *SC@UM Strengthening CFRP Challenge at FRPRCS-11*

[2] Abaqus 6.12 Documentation, SIMULIA, 3DS, 2012

[3] Y. T. Obaidat et al. 2010. The effect of CFRP and CFRP/concrete interface models when modeling retrofitted RC beams with FEM, *Composite Structures* **92**, 1391-1398.

[4] Sena Cruz, J. et al. 2006. Bond Behavior of Near-Surface Mounted CFRP Laminate Strips under Monotonic and Cyclic Loading. *ASCE Journal of Composites for Construction* **10**(4), 295–303.

[copy edited by Kent A. Harries]

Conference Report

ACIC 2013 – 6th Biennial Advanced Composites in Construction Conference

Claire Whysall, NetComposites Ltd, UK
claire.whysall@netcomposites.com

The sixth biennial Advanced Composites in Construction (ACIC) conference took place 10 – 12 September 2013 at Queen's University Belfast hosted by Prof. Susan Taylor.

Organised by NetComposites Ltd in collaboration with the Network Group for Composites in Construction (NGCC), 75 delegates from across the globe gathered to exchange ideas and discussion on current topics within the construction industry, highlighting the use of fibre-reinforced-polymer composite materials in new and existing structures. The conference also looked at topics such as strengthening, refurbishment and reinforcement applications in traditional infrastructure.

Part of the event saw NGCC award Lucian Blaga the winning prize in the Early Career Researchers' Competition for his work on 'Friction Riveting as a New Joining Solution for GFRP Lightweight Emergency Bridges' at Helmholtz-Zentrum Geesthacht, Centre for Materials and Coastal Research. Lucian was chosen as the winner of the competition by the conference attendees from nine entrants, all of whom presented a five minute overview of their current work followed by a networking poster session.

Mr. Brian Bell receiving NGCC Outstanding Achievement Award at conference banquet held in the Great Hall at Queen's University Belfast.

Judging the Early Career Researchers' Competition.

The new NGCC 'Outstanding Achievement' award was a highlight of this year's conference dinner, the winner of which was chosen by the steering group of NGCC. The first recipient was Mr. Brian Bell, formally of UK rail infrastructure company Network Rail, where he worked for 48 years before his retirement in early 2013. Brian was chosen for the award as he has been integral in persuading Network Rail to adopt composites for strengthening existing bridges within the system in the UK. He also helped to introduce all-FRP footbridges into the company's infrastructure inventory. Even in retirement, Brian remains a vital member of the NGCC Bridge Design Guidance committee.

Other 'unprogrammed' conference activities in Belfast: A visit to a National Trust property (seriously).

The next ACIC conference will take place in September 2015, with the venue to be announced. More information on the conference may be found at: www.acic-conference.com; and on the NGCC, at: www.ngcc.org.uk. Conference proceedings containing the 34 presented papers are available by contacting the NGCC.

ASCE *Journal of Composites for Construction*

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* provides an index of ASCE JCC. The ASCE JCC may be found at the following website:

http://ascelibrary.org/cco/

ASCE JCC subscribers and those with institutional access are able to obtain full text versions of all papers. Preview articles are also available at this site. Papers may be submitted to ASCE JCC through the following link:

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

***ASCE Journal of Composites for Construction*, Volume 17, No. 4, pp 421-573. August 2013.**

Bonded FRP Plates for Strengthening Rectangular Hollow Steel Section T-Joints against Web Buckling Induced by Transverse Compression

Jose Aguilera and Amir Fam

Design of FRP Jackets for Plastic Hinge Confinement of RC Columns

Chris P. Pantelides and Domingo A. Moran

Behavior and Design of Slender FRP-Confined Circular RC Columns

T. Jiang and J. G. Teng

Fire Endurance and Residual Strength of Insulated Concrete Beams Strengthened with Near-Surface Mounted Reinforcement

Aniello Palmieri, Stijn Matthys, and Luc Taerwe

Buckling Behavior and Failure of Hybrid Fiber-Reinforced Polymer Pultruded Short Columns

M. M. Correia, F. Nunes, J. R. Correia, and N. Silvestre

Phased Nonlinear Finite-Element Analysis of Precracked RC T-Beams Repaired in Shear with CFRP Sheets

Samir Dirar, Janet M. Lees, and Chris Morley

Behavior of RC Slab-Column Connections Strengthened with External CFRP Sheets and Subjected to Eccentric Loading

Ziad Halabi, Faouzi Ghrib, Amr El-Ragaby, and Khaled Sennah

Flexural Behavior of a Carbon Fiber–Reinforced Polymer Prestressed Decked Bulb T-Beam Bridge System

Nabil Grace, Kenichi Ushijima, Prince Baah, and Mena Bebawy

Size Effect on Shear Strength of FRP Reinforced Concrete Beams without Stirrups

M. S. Alam and A. Hussein

Evaluating the Fire Response of Concrete Beams Strengthened with Near-Surface-Mounted FRP Reinforcement

V. K. R. Kodur and Baolin Yu

Bond Behavior between Basalt Fiber–Reinforced Polymer Sheet and Concrete Substrate under the Coupled Effects of Freeze-Thaw Cycling and Sustained Load

Jiawei Shi, Hong Zhu, Zhishen Wu, Rudolf Seracino, and Gang Wu

Lower Bound Limit Analysis of Masonry Arches with CFRP Reinforcements: A Numerical Method

Silvia Briccoli Bati, Mario Fagone, and Tommaso Rotunno

Strengthening and Retrofitting of RC Flat Slabs to Mitigate Progressive Collapse by Externally Bonded CFRP Laminates

Kai Qian and Bing Li

Resistance Factors for Ductile FRP-Reinforced Concrete Flexural Members

Bashar Behnam and Christopher Eamon

***ASCE Journal of Composites for Construction*, Volume 17, No. 5, pp 575-752. October 2013.**

Unified Shear Design Equation for Concrete Members Reinforced with Fiber-Reinforced Polymer without Stirrups

Md Shah Alam and Amgad Hussein

Simplified Anchor System for CFRP Rods

A. Al-Mayah, K. Soudki, and A. Plumtree

Flexural Behaviors of ECC and Concrete/ECC Composite Beams Reinforced with Basalt Fiber-Reinforced Polymer

Fang Yuan, Jinlong Pan, and C. K. Y. Leung

Seismic Behavior of RC Shear Walls Strengthened with Fiber-Reinforced Polymer

H. El-Sokkary and K. Galal

Strength Reduction Factor for Flexural RC Members Strengthened with Near-Surface-Mounted Bars

Hany Jawaheri Zadeh, Felipe Mejia, and Antonio Nanni

Evaluation of Parameters of Bond Action between FRP and Concrete

Yasmeen Taleb Obaidat, Susanne Heyden, and Ola Dahlblom

Benefits of Grooving on Vacuum-Assisted Resin Transfer Molding FRP Wet-Out of RC Beams

L. Ramos, N. Uddin, and M. Parrish

CFRP Anchor for Preventing Premature Debonding of Externally Bonded FRP Laminates from Concrete

Ahmed Mostafa and A. Ghani Razaqpur

Structural Strengthening with Prestressed CFRP Strips with Gradient Anchorage

Julien Michels, Jose Sena-Cruz, Christoph Czaderski, and Masoud Motavalli

Experimental Study on Full-Scale Pretensioned Bridge Girder Damaged by Vehicle Impact and Repaired with Fiber-Reinforced Polymer Technology

David Cerullo, Khaled Sennah, Hossein Azimi, Clifford Lam, Amir Fam, and Bala Tharmabala

Quantification of Bond-Slip Relationship for Externally Bonded FRP-to-Concrete Joints

Yu-Fei Wu and Cheng Jiang

Modeling of Shear Capacity of RC Beams Strengthened with FRP Sheets Based on FE Simulation

Ahmed M. Sayed, Xin Wang, and Zhishen Wu

Longitudinal Bending and Failure of GFRP Pipes Buried in Dense Sand under Relative Ground Movement

Mohamed Almahakeri, Amir Fam, and Ian D. Moore

Investigation of Various GFRP Shear Connectors for Insulated Precast Concrete Sandwich Wall Panels

Greg Woltman, Douglas Tomlinson, and Amir Fam

Composite Action of Concrete-Filled Rectangular GFRP Tubes

B. E. Belzer, M. J. Robinson, and D. R. Fick

Hybrid Confinement of Concrete by Fiber-Reinforced Polymer Sheets and Fiber Ropes under Cyclic Axial Compressive Loading

Theodoros C. Rousakis

Equivalent Strip Width for FRP Superstructure Design Using Timoshenko Beam Approximation

Wenchao Song, Zhongguo John Ma, and Hyoseon Ji

Upcoming Conferences and Meetings

APFIS 2013 *4th Asia-Pacific Conference on FRP in Structures,* December 11-13, 2013, Melbourne Australia. www.apfis2013.org

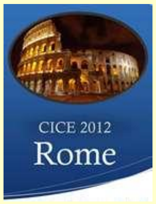
CICE 2014 *7th International Conference on FRP Composites in Civil Engineering*, August 19-22, 2014, Vancouver, Canada. www.cice2014.ca

Accepted papers due: January 1, 2014

FRPRCS-12 *12th International Symposium on Fiber Reinforced Polymer for Reinforced Concrete Structures*, 2015, Nanjing, China.

CICE 2016 *8th International Conference on FRP Composites in Civil Engineering*, June 2016, Hong Kong.

CICE 2012 Proceedings available on IIFC website



The complete Proceedings of CICE 2012 are now available on the IIFC website: www.iifc-hq.org.

All proceedings of official IIFC conferences presently archived on the IIFC website are:

CICE 2012, Rome, Italy, 13-15 June 2012

CICE 2010, Beijing, China, 27-29 September 2010

APFIS 2009, Seoul, Korea, 9-11 December 2009

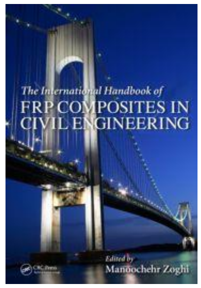
CICE 2008, Zurich, Switzerland, 22-24 July 2008

APFIS 2007, Hong Kong, 12-14 December 2007

CICE 2006, Miami, USA, 13-15 December 2006

BBFS 2005, Hong Kong, 7-9 December 2005

Recent Publication of Interest



The International Handbook of FRP Composites in Civil Engineering

Manoochehr Zoghi (editor),
California State University, Fresno, CA, USA

http://www.crcpress.com/product/isbn/9780849320132

Fiber-reinforced polymer (FRP) composites have become an integral part of the construction industry because of their versatility, enhanced durability and resistance to fatigue and corrosion, high strength-to-weight ratio, accelerated construction, and lower maintenance and life-cycle costs. Advanced FRP composite materials are also emerging for a wide range of civil infrastructure applications. These include everything from bridge decks, bridge strengthening and repairs, and seismic retrofit to marine waterfront structures and sustainable, energy-efficient housing. *The International Handbook of FRP Composites in Civil Engineering* brings together a wealth of information on advances in materials, techniques, practices, non-destructive testing, and structural health monitoring of FRP composites, specifically for civil infrastructure.

With a focus on professional applications, the handbook supplies design guidelines and standards of practice from around the world. It also includes helpful design formulas, tables, and charts to provide immediate answers to common questions. Organized into seven parts, the handbook covers:

- FRP fundamentals, including history, codes and standards, manufacturing, materials, mechanics, and life-cycle costs
- Bridge deck applications and the critical topic of connection design for FRP structural members
- External reinforcement for rehabilitation, including the strengthening of reinforced concrete, masonry, wood, and metallic structures
- FRP composites for the reinforcement of concrete structures, including material characteristics, design procedures, and quality assurance–quality control (QA/QC) issues
- Hybrid FRP composite systems, with an emphasis on design, construction, QA/QC, and repair
- Quality control, quality assurance, and evaluation using non-destructive testing, and in-service monitoring using structural health monitoring of FRP composites, including smart composites that can actively sense and respond to the environment and internal states
- FRP-related books, journals, conference proceedings, organizations, and research sources

Comprehensive yet concise, this is an invaluable reference for practicing engineers and construction professionals, as well as researchers and students. It offers ready-to-use information on how FRP composites can be more effectively utilized in new construction, repair and reconstruction, and architectural engineering.

[Summary by CRC Press, this book has not been reviewed by IIFC]

IIFC encourages the announcement of recently completed theses and dissertations in FRP International*. Announcements should conform to the format shown and be sent directly to the editor at kharries@pitt.edu.*

International Institute for FRP in Construction

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Education/Experience: ***Please attach a current resume or CV (new members only)***

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

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By submitting this application you agree to share your contact information with fellow IIFC members and any conference/organization associated with IIFC.

FRP INTERNATIONAL
the official newsletter of the International Institute for FRP in Construction

FRP International needs your input…

As IIFC grows, we are also expanding 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 also solicit 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***, ***innovative research or products*** 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.

IMPORTANT DATES

Abstract Submission	By 30 NOV 2012
Abstract Acceptance Notification	15 JAN 2013
Full-Length Paper Submission	By 01 MAY 2013
Paper Acceptance Notification	01 AUG 2013
Submission of Final Paper	15 SEP 2013
APFIS 2013 Conference	11 - 13 DEC 2013

REGISTRATION

Early Bird Registration by 15 JUN 2013	AUD 880 (general)
	AUD 440 (students)
Standard Registration	AUD 980 (general)
	AUD 490 (students)

Registering for the APFIS 2013 Conference means :

- attending scientific and professional practice paper presentations.
- learning from international leading keynote lectures.
- joining an event, where both scientific and real business experts are brought together.
- enjoy our social networking events (including: conference reception, banquets, three days catering refeshments and lunches).
- 2014 IIFC membership.

Please visit www.apfis2013.org for more information on the APFIS 2013 Conference, to register and to submit your abstracts.

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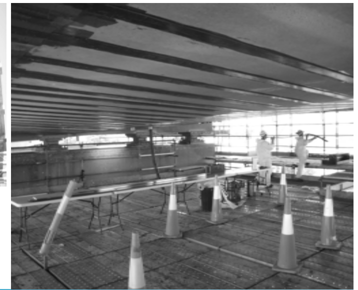
THE FOURTH ASIA-PACIFIC CONFERENCE ON FRP IN STRUCTURES

ANNOUNCEMENT AND CALL FOR ABSTRACTS

APFIS 2013



11 - 13 DECEMBER 2013 MELBOURNE , AUSTRALIA

Towards sustainable infrastructure with FRP composites

Towards sustainable infrastructure with FRP composites

APFIS 2013

THEMES

APFIS 2013 will continue to promote the themes related to basic research and application of **FRP** (*Fibre Reinforced Polymer*) in civil and architectural engineering structures in the Asia-Pacific region and elsewhere in the world.

APFIS 2013 will, however, promote a new overarching theme of **sustainability**. Sustainability issues will be emphasized via special sessions and keynote addresses and will be more comprehensively defined prior to the call for papers.

AIMS AND SCOPE

The aim of APFIS conference series is to provide a forum for young and experienced academics, practitioners, researchers, and research students in the Asia-Pacific region and elsewhere in the world, to share the latest developments in research and application of FRP in civil infrastructure.

In keeping with the tradition of the APFIS conference series, topics will include but are not limited to:

- Materials and products
- Strengthening of concrete, metallic, timber and masonry structures
- Bond behavior and debonding failures
- Confinement and seismic retrofit
- Concrete structures reinforced or prestressed with FRP
- Durability and long-term performance
- Fire, impact and blast loading
- Structural health monitoring and intelligent sensing
- Field applications and case studies
- Codes and standards
- Hybrid structures and all FRP structures

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For more information on members of the Local Organisation Committee and International Scientific Committee, please visit the website **www.apfis2013.org**

CALL FOR ABSTRACTS

Authors or organisations interested in submitting papers are invited to submit an abstract of no more than 300 words outlining the aims, contents and conclusions of their paper. All abstracts will be reviewed by the Conference Committee.

Presentations will be selected to provide a program that offers a comprehensive and diverse treatment of issues related to the conference theme. Authors will be notified by email of the outcome of their abstract submission.

Please note:

1. Abstracts should contain a maximum of 300 words and must be submitted in English.

2. Abstracts can be submitted via the conference website or email (as Ms. Word file) to :

Dr. YU BAI at *yu.bai@monash.edu*

and cc to

Prof. RIADH AL-MAHAIDI at *ralmahaidi@swin.edu.au*

IIFC — SWINBURNE UNIVERSITY OF TECHNOLOGY — The University of Hong Kong — MONASH University

CICE 2014
Vancouver, Canada
August 20-22, 2014

The 7th International Conference on FRP Composites in Civil Engineering

International Institute for FRP in Construction

Call for Papers

INTRODUCTION

After the successful conferences in Hong Kong 2001, Adelaide 2004, Miami 2006, Zurich 2008, Beijing 2010, and Rome 2012, the 7th International conference on Fiber Reinforced Polymer (FRP) Composites in Civil Engineering (CICE 2014), the official conference of the International Institute for FRP in Construction (IIFC), is to be held in Vancouver, British Columbia, Canada from August 20-22, 2014. The conference is co-hosted by the University of Calgary and the University of British Columbia.

OBJECTIVES

CICE 2014 aims to provide an international forum where leaders, engineers, researchers, practitioners and industrial partners in the field of FRP composites in civil engineering can discuss, exchange, and share recent advances and developments and future perspectives of the use of FRP in bridges and other structures.

CONFERENCE TOPICS

Papers are invited in several focus areas including:

- FRP Strengthening
- FRP for Sustainability
- FRP in Seismic Retrofitting
- Hybrid FRP Structures
- Bond and Interfacial Stresses
- Concrete Filled FRP Tubes
- Confinement of Concrete
- All-FRP and Smart FRP Structures
- FRP Internal Reinforcement
- Fire, Impact and Blast Loading
- Prestressing with FRP
- Inspection and Quality Assurance
- Durability/Long-Term Performance
- Codes and Design Guidelines
- Field Applications and Case Studies
- FRP in 2020: Visions and Reality

IMPORTANT DEADLINES

July	15, 2013	Submission of Abstracts (300 words)
August	1, 2013	Notification of Acceptance of Abstracts
January	1, 2014	Submission of Full Papers for Review
April	1, 2014	Notification of Acceptance of Full Papers
May	1, 2014	Final Submission of Revised Full Papers

Abstracts/Papers can be submitted to:

cice2014@ucalgary.ca

SPECIAL JOURNAL ISSUE

Selected papers from this conference will be invited to submit an expanded paper for special issues of the Journal of Construction and Building Materials and the Journal of Composites for Construction.

THE SPECTACULAR BEAUTY OF VANCOUVER

Vancouver is the third largest city in Canada; voted one of the world's premier meeting and convention destinations, and ranked #4 on the list of the world's 10 best places to live. Vancouver is located on Canada's spectacular West Coast, surrounded by mountains and ocean side beaches, and has one of the mildest Canadian climates. Located halfway between Europe and the Asia Pacific region. The city of Vancouver is a cosmopolitan city with a vibrant and multicultural population of two million; it is safe, clean, and pedestrian friendly. Vancouver, the host city of the 2010 Winter Olympics and Paralympics Games, offers an unprecedented range of activities and experiences and unique attractions. The CICE 2014 conference will be held at The University of British Columbia (UBC), only 20 minutes to downtown or the Vancouver International Airport.

REGISTRATION*

Early Registration	$850 (General)	$550 (Students)
Registration after May 1, 2014	$950 (General)	$650 (Students)

* Registration covers attendance at the conference, the conference proceedings, the welcome reception, banquet, all refreshments and lunches, and includes the IIFC membership for 2015. The technical tours and social program are not included.

INTERNATIONAL SCIETIFIC COMMITTEE

This committee consists predominantly of IIFC Council members.

TECHNICAL AND SOCIAL PROGRAM, EXHIBITION

The three-day program will consist of keynote lectures and general sessions. The IIFC member meeting and council meeting will be held during the conference. Technical tours and social programs will be arranged. Products and services exhibition will be open during the conference. If you are interested in having a display booth, please contact the conference secretariat at cice2014@ucalgary.ca.

CONTACT www.cice2014.ca

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University of Calgary

Honorary Chair:
Nemkumar Banthia
University of British Columbia