FRP INTERNATIONAL

the official newsletter of the International Institute for FRP in Construction

Vol. 11, No. 3, July 2014

In addition to being emailed to all IIFC members and available on the IIFC website (www.iifc-hq.org), this issue of *FRP International* will be provided to all delegates at CICE 2014 in Vancouver. On behalf of the IIFC Executive Committee, Welcome to Vancouver!

Kent Harries, Editor

IIFC Business at CICE 2014

As IIFC members prepare to gather in Vancouver for an exciting and dynamic CICE 2014, all should be aware of and plan on participating in the IIFC General Meeting. This will be held during the conference and is open to all delegates. CICE 2014 conference dues include IIFC membership for 2015, so all delegates are members!

The primary purpose of the General Meeting is to report to the membership the state of the Institute, recognise outgoing Council members, and to elect new IIFC Council members.

IIFC Council is the highest body of the Institute. It lays down policies for implementation by the Executive Committee. The widest possible international representation is sought in the composition of the Council (see back cover of *FRP International*), considering both geographical balance and strength of activities in different regions. Members of Council serve for six years. With offset terms, approximately one third of Council is elected at each biennial CICE conference; thus the IIFC membership will be electing up to 13 new Council members from among the membership in Vancouver.

Call for Nominations - IIFC COUNCIL

The IIFC is now seeking nominations of candidates for membership to the IIFC Council. Interested nominees and nominators are strongly encouraged to review the IIFC By-Laws for information on the responsibilities of Council Membership, including the nomination procedure, nomination form, and powerpoint slide template (all available at www.iifc-hq.org). Election from the pool of eligible candidates will be held during the IIFC General Meeting at CICE2014 in Vancouver. The completed nomination form and powerpoint slide are to be received by the IIFC Secretary, Prof. Rudi Seracino, (rudi_seracino@ncsu.edu) no later than **Friday 1 August 2014**.

Call for Nominations - IIFC FELLOWS

The IIFC Executive Committee is now seeking nominations for potential candidates for IIFC Fellowships. A limited number of IIFC Fellows will be elected during the IIFC Council Meeting at CICE 2014 in Vancouver. According to the IIFC By-Laws, nominations must be made by a member of the IIFC Executive Committee. However, via this call for nominations, the Executive Committee is seeking input from all IIFC members. The final selection of candidates will be made by the Executive Committee based on its best judgment, taking into consideration the nominations received. For information on the attributes of an IIFC Fellow and the nomination procedure, please review the nomination procedure and nomination form available at www.iifc-hq.org or from Prof. Seracino. Nominations are to be received by the IIFC Secretary, Prof. Rudi Seracino, (rudi_seracino@ncsu.edu) no later than **Friday 25 July 2014**.

Bohdan Nicholas (Nick) Horeczko 1939 – 2014

It is with sadness that we report the passing of Nick Horeczko on April 8 2014, just days before his 75th birthday. Nick was the long-time Director of Professional Services for ICC Evaluation Service (ICC-ES). With 52 years of civil engineering experience in design, construction, manufacturing, research, building code services and building products evaluation—including 42 of those years with ICC-ES and the legacy organization International Conference of Building Officials (ICBO)—Nick was well-known and highly respected within the industry for his knowledge and warm and inviting demeanour. His contributions to ICC-ES and the industry were immeasurable. For the past 15 years, Nick was an active member of ACI Committee 440, FRP Reinforcement, and its various subcommittees.

Nick was a Fellow of the American Society of Civil Engineers and the Institute for the Advancement of Engineering. Ever the gentleman, Nick will be sorely missed.

[Based on an obituary released by ICC-ES and another appearing at legacy.com.]

Raafat El-Hacha and Khaled Soudki Awarded CSCE Casimir Gzowski Medal

The 2013 Casimir Gzowski Medal is awarded to Dr. Raafat El-Hacha and Prof. Khaled Soudki for their paper entitled "Prestressed near-surface mounted fibre reinforced polymer reinforcement for concrete structures – a review" which appeared in the *Canadian Journal of Civil Engineering* (Volume 40, pp. 1127-1139).


Dr. El-Hacha, the chair of CICE 2014, received the award at the Canadian Society for Civil Engineering (CSCE) annual conference in Halifax in May. Prof. Soudki, regrettably, passed away in September 2013 [*FPP International,* Vol 11, No. 1].

Prestressed near-surface mounted fibre reinforced polymer reinforcement for concrete structures – a review

Abstract

The specialized application of prestressing near-surface mounted (NSM) fibre reinforced polymer (FRP) reinforcement for strengthening reinforced concrete (RC) structures combines the benefits of the FRP reinforcement with the advantages associated with external prestressing. By applying a prestress to the NSM FRP, the material is used more efficiently since a greater portion of its tensile capacity is employed. This paper presents a comprehensive review of the performance of RC members strengthened using prestressed NSM FRP reinforcement. Several techniques and anchorage systems developed to prestress the NSM FRP are presented. The static, flexural, and fatigue performance of RC beams strengthened using prestressed NSM FRP in comparison to non-prestressed NSM is presented. Research on the long-term performance under freeze–thaw exposures and sustained loading is also presented.

As superintendent of public works of the Province of Canada, Colonel Sir Casimir Stanislaus Gzowski (1813-1898) was responsible for improving waterways and canals and constructing roads, harbours and bridges. Later, he was involved in railroad construction and the design and construction of the international bridge at Fort Erie. A founder of the CSCE in 1887, he served as president from 1889 to 1891. Established by Sir Casimir in 1890, the Casimir Gzowski Medal is awarded annually for the best paper on a civil engineering subject.

IIFC Awards presented at...

CICE 2014: 7th International Conference on Fibre Reinforced Polymer (FRP) Composites in Civil Engineering

Vancouver, 20-22 August 2014

IIFC Medal – Prof. Antonio Nanni

The IIFC Medal, the Institute's highest honour, is awarded every two years to an IIFC member who has made distinguished contributions to the field of FRP composites for construction through research or practical applications, or both. Professor Antonio Nanni is the winner of the 2014 IIFC Medal. Professor Nanni is the Lester and Gwen Fisher Endowed Scholar, and Chair of the Department of Civil, Architectural & Environmental Engineering at the University of Miami, USA.

Prof. Nanni is no doubt among the most authoritative and influential world leaders in the composites for construction field. His achievements are comparable with those of the Lifetime Achievement Awardees and the existing IIFC Medalists. Dr. Nanni, as a founding Fellow of IIFC, has also made important contributions to the founding and development of IIFC.

Prof. Nanni has made enormous contributions to the FRP field in many different ways. While his CV is impressive, it is interesting to highlight the following:

1. A search of the Scopus database on November 21, 2013 showed that among the 2,971 Scopus articles found using the keyword combination of "FRP" and "concrete", he is an author/co-author of 73 articles, accounting for 2.4% of the total. He was ranked first in the list of the most prolific authors.

2. His 73 articles received a total of 1889 citations, with an average of 25.9 citations per article, which is significantly higher than the overall average of around 8 citations per article, illustrating the high impact of his publications. The h-index of these articles is 21.

In summary, Prof. Nanni was nominated for the IIFC Medal for being one of the small number of world leaders who have been instrumental in moving composite materials from an exotic object of research to mainstream use in construction over the course of over 25 years through the undertaking of fundamental research, the development of standards and specifications, and the implementation of research findings into meaningful field projects while contributing to the education of the next generation of engineering leaders worldwide.

Professor Nanni will give the IIFC Distinguished Lecture at CICE 2014 on "*Personal Reflections Following 20 years of R&D in FRP Construction*".

Abstract

Personal Reflections Following 20 years of R&D in FRP Construction

Prof. Antonio Nanni
2014 IIFC Medal Awardee
nanni@miami.edu

A keynote address could take several forms, the one selected here is that of a reflection on past and present R&D experiences. The presentation will address five major topics related to FRP composites for construction to revisit our practices with the objective of making our community and industry more relevant and effective.

Materials Science and Engineering. Our scientific community is too insular and needs a closer relationship with the materials researchers. Quantum leaps will only come with the development of new materials transforming performance and durability of existing ones and opening up new construction and installation methods. An example on the role of resins in the case of externally bonded FRP systems is discussed.

Standards. The number one rule in real estate is location, location, location. Similarly, in the construction industry it is all about standards, would they be design codes, materials and construction specifications, inspection protocols, or test methods. We have not fully understood this and when we do it, we lack the ability to remain open to innovation (prescriptive vs. performance standards). We cry foul when we refer to the attitude of the "traditional materials" industry towards composites, but we fall in the same trap when we develop our own standards as discussed in an example related to an ASTM material specification under development.

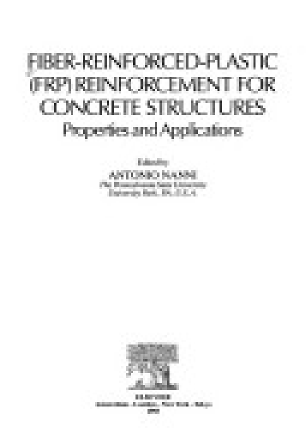
Maturity. As of today, the FRP composites industry is struggling to create a unified strategy to address market needs and opportunities (and barriers). Manufacturers, suppliers and installers are often pitted one against the other focusing on internal competition (the tree) while missing the global opportunity (the forest). Most disturbing is when some resort to misrepresentation of product performance to gain an edge over a perceived competitor as discussed in the case of FRP bars for internal reinforcement of concrete structures.

Research. A very significant portion of the technical literature and research projects being undertaken worldwide is a repetition of what others have done. While it is true that first-hand experience is necessary for progress, we are failing to develop new paradigms for research with an alarming waste of time, talent and resources. There is plenty information available, but little communication. In a world dominated by open access and information technology, we fail to take advantage of what our neighbours have done or are doing as exemplified in the recent case of strengthening with mechanically-fastened FRP laminates.

Technical organizations. Not only peculiar to the FRP composites world is the need to reinvent the role of technical organizations. We need to do more than sponsoring events and publications. Perhaps one unexplored role is that of being a protagonist in the education arena. IFCC is staking the ground with the webinar series. How high can we set the bar?

Conclusions. Discoveries and deployments of the last quarter century have made FRP composites for construction a reality here to stay. This industry is now beyond infancy and with that, the care-free days are gone. We have moved from an outsider role to that of an insider one in the world of constructed facilities thus assuming different responsibilities and facing new challenges. We remain visionaries and innovators at heart and as such, we need to be the champions of transformation of some of the practices of the broader construction industry we are now part of.

20 years of Prof. Nanni…



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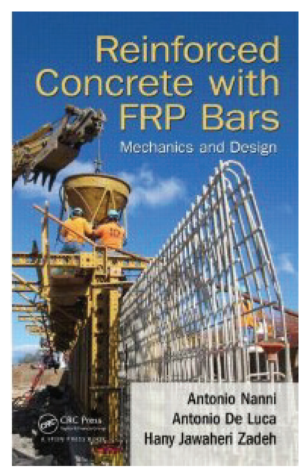

March 2014

Distinguished Young Researcher Award – Prof. Luke Bisby

The Distinguished Young Researcher Award is given every two years to an IIFC member, not older than 40 years of age at the CICE conference, who has distinguished themselves from their peers through research contributions in the field of FRP composites for construction. Professor Luke Bisby is the winner of the 2014 IIFC Distinguished Young Researcher Award. Prof. Bisby is the Arup Chair of Fire and Structures and RAEng Research Chair within the School of Engineering at the University of Edinburgh, UK.

Professor Bisby is an outstanding young researcher, having established himself as an international leader in a number of areas related to FRP materials and their application in civil infrastructure. Prof. Bisby's most notable contributions are in the area of fire effects on structures although his most highly cited work to date (Scopus) is, ironically, on freeze-thaw effects. He is also well established in the areas of confinement effects and structural health monitoring. While prolific, Prof. Bisby's work is always meticulous, well planned, executed and presented. To his great credit, he engrains these same qualities in the students who study under his direction.

Professor Bisby is remarkably active in international codes and standards committees and has made a number of unique contributions to the field of FRP research. Examples include his early work with ISIS Canada and his ongoing activities supporting ACI 440, IIFC and the new TUD COST Action in the EU.

Professor Bisby's research (and indeed teaching) career is impressive by any standard. Having achieved all of this, including a chaired professorship, before reaching 40 years of age is all the more remarkable. It is clear to all that know him that Luke Bisby is today, and will continue to be for decades to come, an exemplary researcher in our field.

Professor Bisby will deliver a keynote lecture at CICE 2014 on "*Fire-Safe Use of FRP Composites in Construction: Myths and Realities*".

Abstract

Fire-Safe Use of FRP Composites in Construction: Myths and Realities

Prof. Luke Bisby
2014 Distinguished Young Researcher Awardee
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Applications of fibre-reinforced polymer (FRP) composite materials for engineering and preserving durable structures have become ever more widespread since fist being seriously considered for such applications in the early 1980s. FRPs are now widely used in certain structural engineering applications; the most common of these in construction are probably:

1) use of externally-bonded FRP sheets or plates for rehabilitation and strengthening of concrete, masonry, steel, or timber structures;

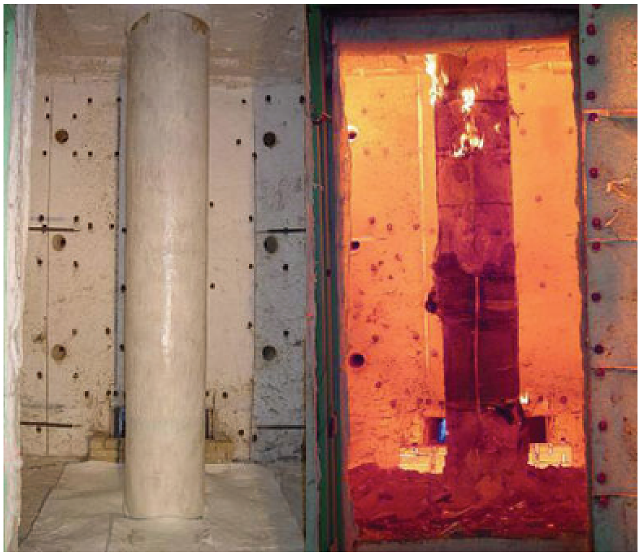
2) application of FRP rods or bars for internal reinforcement or prestressing of concrete structural elements; and

3) use of all-FRP structural sections (pultruded or otherwise) in certain niche structural applications (e.g. marine, offshore, and certain other industrial applications).

Provision of appropriate fire resistance is a major design consideration in virtually all building and construction projects. Thus, when FRPs are considered for use in any of the above applications, questions are invariably (justifiably?) raised around fire safety and the structural fire resistance of all-FRP, FRP-strengthened, or FRP-reinforced or prestressed structural elements. Despite a considerable research effort in this area, particularly during the past decade, there is a persistent and widespread view within the construction industry that "fire and FRPs do not mix"; this has proved difficult to overcome and the perceived poor performance of FRPs in fire continues to discourage their use.

Concerns associated with the use of FRP materials when subjected to possible fire exposure stem from the well-established thermo-mechanical sensitivity of polymer-based materials to elevated temperatures. Deterioration of mechanical and bond properties of FRP materials occurs at temperatures in the range of the glass transition temperature, T_g, of an FRP's polymer matrix. However, the consequences of this

deterioration for the fire-survivability of all-FRP, FRP-strengthened, or FRP-reinforced or prestressed structural elements, under load, are neither well known nor properly quantified. A number of 'reaction-to-fire' considerations are also relevant when applying FRP materials in construction projects, particularly in buildings. These are associated with the combustibility and fire spread properties of the polymers used in FRP manufacture and adhesion, along with associated potential toxicity risks to building occupants.



FRP-RC columns before and after fire resistance tests (National Research Council of Canada)

In an effort to facilitate the widespread application of FRP composites in construction, this paper presents a review of more than a decade's research by the author (and colleagues) on the fire performance and fire safety of FRP composites in construction applications. The available research on FRP materials and systems is summarized and generalized, the myths and realities of the fire performance of FRPs are highlighted, significant remaining research gaps are discussed, and guidance for practicing engineers is presented. This includes research on Polymer adhesives, FRP materials themselves, FRP-strengthened concrete and steel elements, FRP reinforced and prestressed concrete elements, and all-FRP structural elements. Through this review, and by rationally considering the fundamental performance objectives for structures in fire, it is shown that fire-safe use of FRP composites in construction applications is, in many cases, much less problematic than widely perceived.

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

Upcoming Conferences and Meetings

FRP Bridges 2014, September 11-12, 2014, London, UK. www.frpbridges.com

CAMX: Composites and Advanced Materials Expo, October 13-16, 2014, Orlando, USA. www.thecamx.org

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

APFIS 2015 – 5th *Asia-Pacific Conference on FRP in Structures*, 2015, Nanjing, China.

Abstracts due in early 2015

ACIC 2015 – 5th *Advanced Composites in Construction*, September 2015, UK.

info@acic-conference.com

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

Composites Around the World

Polish-Swiss team demonstrate the first application of prestressed CFRP laminates with gradient anchorage for strengthening post-tensioned concrete bridge - The TULCOEMPA Project

Renata Kotynia, Julien Michels, Michał Staśkiewicz, Christoph Czaderski and Masoud Motavalli
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The Polish-Swiss cooperative TULCOEMPA project is collaboration between the Technical University of Lodz (TUL, Poland) and EMPA (Switzerland) in the research and development of innovative methods for structural strengthening of existing bridge infrastructure and subsequent life-long monitoring using with advanced wireless systems.

The first aim of the project is to pioneer the application of innovative strengthening systems with prestressed carbon fibre reinforced polymer (pCFRP) laminates on a bridge in Szczercowska Wieś (Poland). The second goal is to integrate information and communication technologies (ICT) to support the effectiveness of this strengthening technique by continued long-term structural health monitoring (SHM) and environmental monitoring of the structure. The project involved laboratory tests of two girders and a field application of the proposed strengthening technology.

The road bridge over the Pilsia River in Szczercowska Wieś (about 66 km southwest of Lodz; 190 km southwest of Warsaw), built in 1965, needed reconstruction and strengthening to upgrade the road to a higher load class. The existing structure of the bridge consisted of five 18.4 m long post-tensioned precast concrete I-girders supporting a 160 mm reinforced concrete deck (Fig. 1).

Fig. 1 Szczercowska Wieś bridge before reconstruction.

Bridge reconstruction required widening of the structure with two new rectangular-section post-tensioned girders and strengthening of existing girders with externally bonded prestressed carbon fibre reinforced polymer (EB-pCFRP) strips in flexure and EB-CFRP sheets in shear (Fig. 2).

Laboratory tests

Two 18.4 m long full-scale girders based on the original 1965 Szczercowska Wieś bridge plans were fabricated (Figs 3 and 4). Both 1000 mm deep girders were cast with class C35/45 self-compacting concrete (cube compressive strength at testing was approximately 65

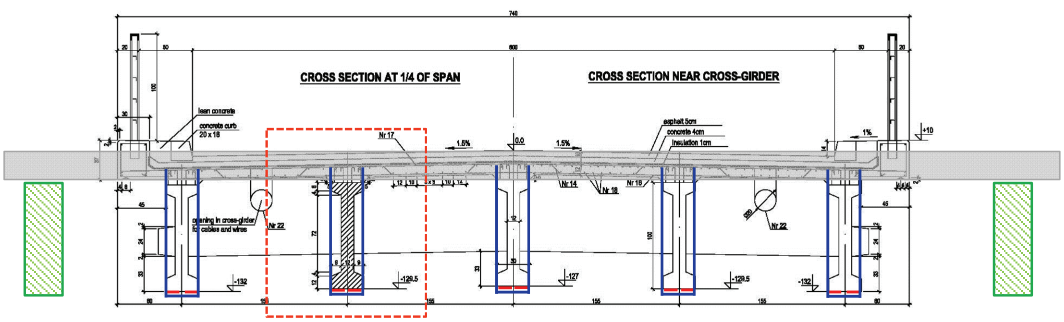

Fig. 2 Bridge reconstruction and strengthening scheme.

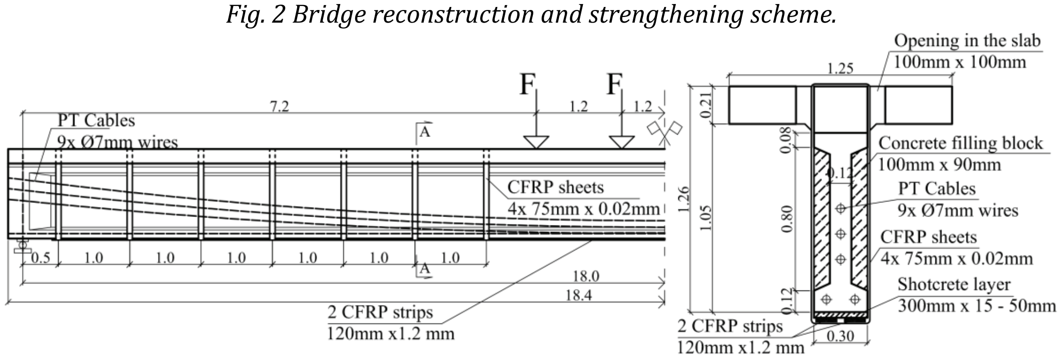

Fig. 4 Strengthening and testing scheme of the laboratory girders.

MPa). After 28 days the girders were post-tensioned with five custom-made prestressing cables consisting of nine 7 mm diameter prestressing steel wires (fu = 1670 MPa) and having square steel anchor heads at each end (Fig. 3). After post-tensioning, a 1250 mm wide, 210 mm deep class C30/37 slab (51 MPa at time of testing) was placed on each girder (Fig. 4).

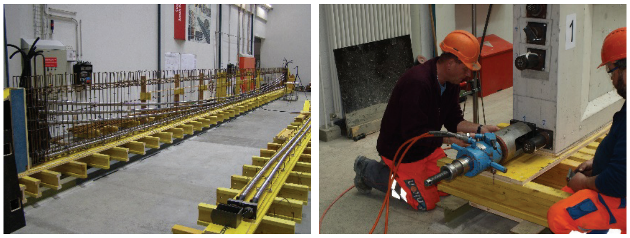

Fig. 3 Fabrication of laboratory girders.

In order to apply the pretensioned CFRP strips, the girder soffit must be straight. To 'correct' for the girder camber, a layer of PCC mortar varying from 15 mm at the girder ends to 60 mm at midspan was applied (Fig. 5). To ensure the proper bond between the girder and filling mortar, the surface of the girder was roughened by a high pressure water-jet. Following mortar application, dry shotcrete with a guaranteed 28-day compressive strength of 60 MPa was applied in order to obtain the flat bottom surface (Fig. 5).

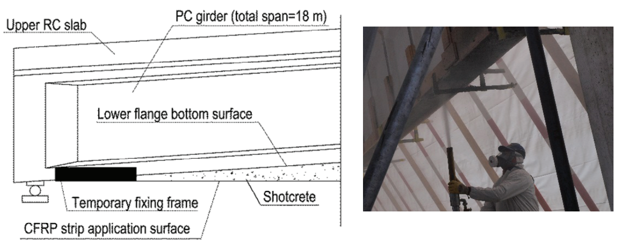

Fig. 5 Soffit levelling and shotcrete application.

Due to the presence of two internal steel tendons in the bottom flange of the girder, it was not possible to install any mechanical anchorage for the CFRP strips. Therefore the test girder was strengthened with two EB-pCFRP strips having a gradient anchorage. This innovative, non-mechanical anchorage method was proposed by Prof. Urs Meier[1] and further developed[2,3] at EMPA. In this method, the ends of the CFRP strips are anchored by sequential epoxy-curing and force-release in three steps, which reduces the prestressing force to zero at the strip ends while maintaining 100% of prestressing force at midspan. Accelerated epoxy cure was achieved using an electronic heating device which produces high temperatures over selected parts of the CFRP anchorage length. This allows for faster adhesive curing and the possibility of a stepwise transfer of shear stress by gradually releasing the prestressing force at different stages of the cure (Fig. 6). Two 100 mm wide, 1.2 mm thick CFRP strips having an elastic modulus of 158 GPa were pre-tensioned with 120 kN force to an initial pre-strain of 0.006 (approximately 34% of ultimate capacity). The gradient anchorage was applied over a length of 800 mm, for which the initial prestressing force was released in three steps. A detailed description of the gradient anchorage is given in Michels et al.[4,5].

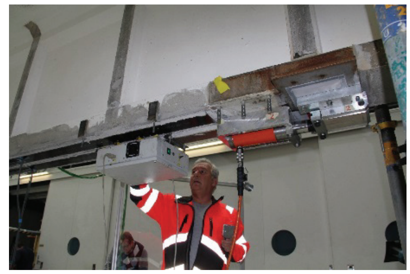

Fig. 6 EB-pCFRP system installation;
prestressing rams and heating box shown.

Shear strengthening required the installation of trapezoid-shaped concrete bolsters in order to locally change the I-shaped girder to a rectangular section (Fig. 7). The girder corners were rounded and holes cut through the slab to permit EB-CFRP sheets to be installed for shear strengthening (Fig. 7). The CFRP sheets were 75 mm wide and 0.9 mm thick and spaced at 1000 mm. The modulus of the CFRP used for shear strengthening was 240 GPa.

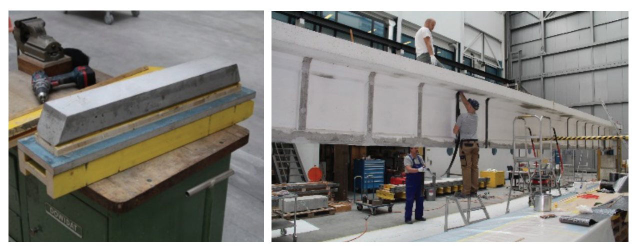

Fig. 7 Concrete bolsters and shear strengthening with EB-CFRP sheets wrapped entirely around girder.

Both the unstrengthened reference Girder 1 and strengthened Girder 2 were tested under displacement control in six-point monotonic bending over an 18 m span (Fig. 4). All girders were extensively instrumented to capture deflections and concrete and CFRP strains. Digital image correlation (ARAMIS system) was used to monitor concrete strains on one side of the strengthened girder in the critical shear span region located between two CFRP wrappings

The test of the reference Girder 1 was stopped at the load of 4 x 193 kN, when the hydraulic rams reached their stroke limit. At this point, midspan deflection was 260 mm (L/69), concrete strains in the compressive zone had reached 0.0023, and tensile strains at the level of the lowermost post-tensioning cables had reached 0.011. Extensive flexural cracks, reaching the level of the concrete slab, were evident across the midspan region of the girder (Fig. 8).

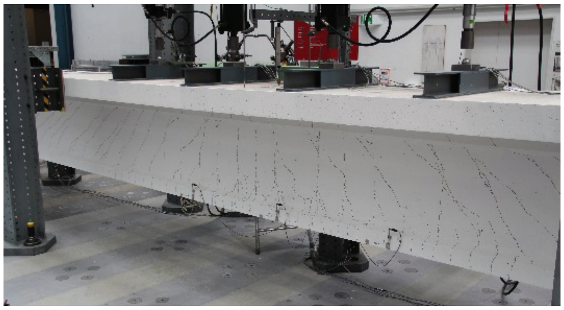

Fig. 8 Laboratory test of reference Girder 1.

Fig. 9 CFRP rupture of strengthened Girder 2.

The strengthened Girder 2 carried an ultimate load of 4 x 240 kN and achieved a mid-span deflection reached 210 mm (L/86) when the EB-pCFRP strips ruptured (Fig. 9). No damage was observed to the CFRP shear reinforcement. Confirming improved serviceability, the strengthened girder exhibited a 22% greater cracking load and greater pre- and post-cracking stiffness (Fig. 10). At the ultimate load, concrete strains were lower than in the reference girder (Fig. 11). The CFRP strain due to load application was 0.010 at rupture, corresponding to an ultimate strain of 0.016 including the prestressing strain.

The laboratory tests demonstrated the efficacy of the EB-pCFRP system and installation procedure. The strengthened girder was stiffer and demonstrated universally lower strains than the reference girder indicating improved serviceability. The transverse CFRP shear wraps effectively arrested longitudinal CFRP debonding (which was observed) allowing the EB-pCFRP to develop its full capacity; failure was indicated by EB-pCFRP rupture.

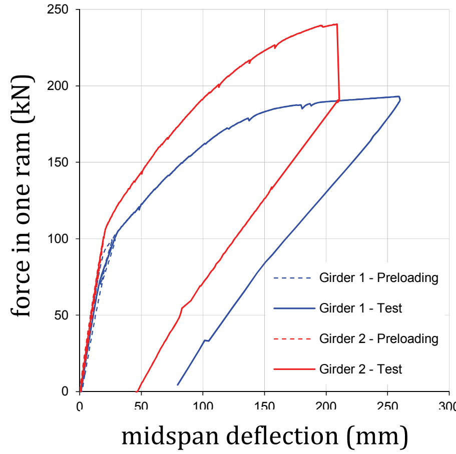

Fig. 10 Load-deflection behaviour of laboratory tests.

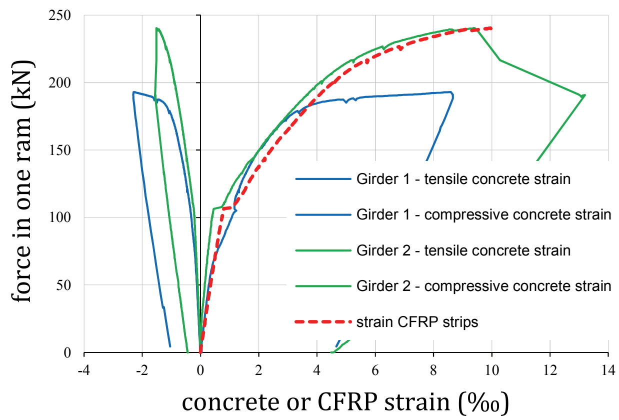

Fig. 11 Load-deflection behaviour of laboratory tests.

Strengthening the bridge in Szczercowska Wieś

The final stage of the TULCOEMPA project was the in situ strengthening of the Szczercowska Wieś bridge girders using the same technique demonstrated in the laboratory; this was done at the end of May, 2014.

As in the laboratory study, the girder soffits were water-jetted and made straight using PCC mortar and dry-shotcrete (Fig. 12). Concrete bolsters were added to the web to allow for the installation of CFRP shear reinforcement.

Fig. 12 Girder preparation.

Structural strengthening of the five existing bridge girders (Fig. 2) also followed the same process as demonstrated in the laboratory program. Over the course of two weeks, ten EB-pCFRP laminates and 90

CFRP sheet wrappings were applied on the girders (Fig. 13). The complete application of one EB-pCFRP strip using the gradient method required less than 4 hours; up to three were applied daily. Due to the use of the gradient anchorage system, all mechanical anchoring devices can be removed immediately and re-used on the next strengthened member.

Fig. 13 Flexural strengthening of the bridge girders.

During the strengthening operation the girders' deflections, concrete strains and CFRP strains were constantly monitored for the evaluation of changes resulting from the application of the EB-pCFRP system. Application of the EB-pCFRP resulted in an additional camber on the order of 0.15 – 0.30 mm. No loss of initial prestressing force in the CFRP laminates was observed during the strengthening. Successful application of bridge strengthening using externally bonded prestressed CFRP (EB-pCFRP) anchored using the gradient method was demonstrated for the first time in the field (Fig. 14); this was the primary goal of the TULCOEMPA project.

Fig. 14 Szczercowska Wieś bridge after reconstruction.

Acknowledgements

The authors acknowledge the financial contribution of the Polish-Swiss Research Programme (PSRP) for the financial contribution to the joint research project TULCOEMPA. Furthermore, the invaluable help of EMPA and TUL staff for related experimental investigation is highly appreciated. Finally, the contribution to the strengthening application of S&P Clever Reinforcement Switzerland and Poland is acknowledged.

The TULCOEMPA team in the lab and on the bridge.

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[2] Czaderski C., Motavalli M. (2007) 40-Year-old full-scale concrete bridge girder strengthened with prestressed CFRP plates anchored using gradient method. *Composites Part B: Engineering,* **38**(7–8), 878–86.

[3] Czaderski, Ch. Martinelli, E., Michels, J., Motavalli, M. (2012) Effect of curing conditions on strength development in an epoxy resin for structural strengthening, *Composites Part B: Engineering*, **43**(2), 398-410.

[4] Michels, J., Sena Cruz, J., Czaderski, C., Motavalli, M. (2013) Structural Strengthening with Prestressed CFRP Strips with gradient Anchorage, *ASCE Journal of Composites for Construction* **17**(5), 651-661.

[5] Michels, J., Martinelli, E., Czaderski, C., Motavalli, M. (2014) Prestressed CFRP strips with gradient anchorage for structural concrete retrofitting: experiments and numerical modeling", *Polymers*, **6**(1), 114-131.

CICE 2014 papers based on this work:

Michels, J., Czaderski, C., Staskiewicz, M., Kotynia, R.. *Large scale testing of two pretensioned concrete girders: comparison between retrofitted and reference beam*

[copy edited by Kent Harries]

Composites Around the World

Composite Houses in Brazil

The Latin American Composite Materials Association (ALMACO) reported in March that at Feicon Batimat (São Paulo, Brazil, March 18-22), the main construction industry trade show in Latin America, it generated $11.5 million (USD) in business. Included was the sale of 611 composite houses manufactured by composites fabricator MVC (Paraná, Brazil). The 611 manufactured composite houses were sold for $7.5 million. The balance of the turnover, came from raw materials required to build the houses, including resins, fiberglass, organic peroxides and structural adhesives.

At Feicon Batimat, ALMACO erected a 330 m2 Composites Neighbourhood. The exhibition featured a house, school, health centre, bus stop, store, leisure area, water tank, sink, bath, doors and stairs, all produced by Brazilian companies. MVC provided the house and school. "The whole exhibition was based on [composite materials]. From power poles, mini wind power generator, traffic signs to bus stop and decor items," says Gilmar Lima, president of ALMACO. The construction systems adopted in both the house and school were approved by Brazilian government programs: the Program My House, My Life and the National Education Development Fund (FNDE), respectively. The neighbourhood was an action based on the same concept as the successful Compocity, a mini-city built by ALMACO in 2012.

[adapted from ALMACO.org.br]

See more about composite housing solutions: *FRP International* Vol. 10, No. 2 (April 2013): STARTLINK Lightweight Building Systems–Wholly Polymeric Structures.

IIFC Education Task Group and Webinars

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Chair, IIFC Education Task Group
emmanuel.ferrier@univ-lyon1.fr

The objective of the IIFC Education Task Group is to promote education and knowledge transfer of IIFC researcher's to students and industry. The IIFC webinar series consists of short online seminars on specialized topics. Students enrol in a virtual classroom and follow the course from their computer. Each webinar contains commentary from the presenting professor, an annotated dashboard, details on calculation methods described and allows participant interaction. The contents of each webinar are approved by the IIFC Education Task Group.

Next Webinar

Fire behaviour of RC structures, case of FRP strengthening will be presented by Prof. Luke Bisby on 11 July 2014 at 14:00 GMT. This webinar may be joined at the following link:

http://spiralconnect.univ-lyon1.fr/b3/join?meetingId=b3_3ad829ac-275e-45fc-8154-19815e3b2b49

A new series of webinars is expected to initiate in October 2014; more details will be given during CICE conference. New topics on FRP in construction will be presented.

Archived 2013-14 Webinars

FRP material for strengthening of structures in the field of construction, was presented by Prof. Emmanuel Ferrier on 20 November 2013.

RC beam strengthened for flexure was presented by Prof. Enzo Martinelli on 8 January 2014.

RC beam strengthened for shear was presented by Prof. Joaquim Barros on 20 February 2014.

At this time the first three webinars are available in the following dropbox:

https://www.dropbox.com/sh/qa8bb5g2u8ljhbt/O1ogdbR_9w

Durability of FRP was presented by Prof. Brahim Benmokrane on 9 April 2014. This webinar is available at the following link (Chrome or Mozilla required):

http://bigbb.univ-lyon1.fr/playback/presentation/playback.html?meetingId=4e2eee83835988e1bac5c2628dad687ae3fdd17d-1398347413102&t=58s

Recent Dissertation

Compressive Strength of Pultruded Glass-Fiber Reinforced Polymer (GFRP) Columns

Dr. Daniel Carlos Taissum Cardoso
COPPE, Universidade Federal do Rio de Janeiro
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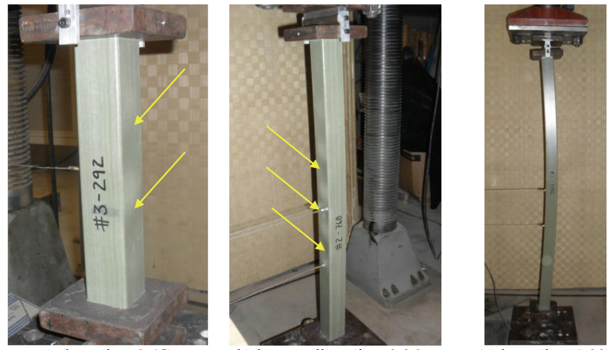
Dissertation Advisors:
Prof. Eduardo de Miranda Batista, UFRJ
Dr. Kent A. Harries, University of Pittsburgh

In this work, performance and strength of pultruded glass-fibre reinforced polymer (GFRP) columns subject to short term concentric compression are studied. To accomplish this task, an extensive review of existing background theory is conducted, including global and local buckling theories for orthotropic material, perfect column failure modes and theories behind 'real' column behaviour. Gaps in the knowledge of and understanding of the behaviour of these members are identified and, to fill them in, rational and comprehensive methods resulting in simple and effective design guidelines are developed and presented. To evaluate the proposed methods, results are compared to those obtained from experimentally and/or from numerical analyses via Finite Strip Method. The experimental programs addressed the compressive strength of GFRP square tube columns having different column and wall slenderness; and the local buckling of I-sections stub columns having different flange-width-to-section-depth and depth-to-thickness ratios. The programs included cross-section geometry measurements, material characterization, experimental determination of critical loads, imperfections and compressive strengths and observations on the failure modes and post-buckling behaviour.



a) short (λ_c = 0.45) b) intermediate (λ_c = 0.96) (c) long (λ_c = 1.39)

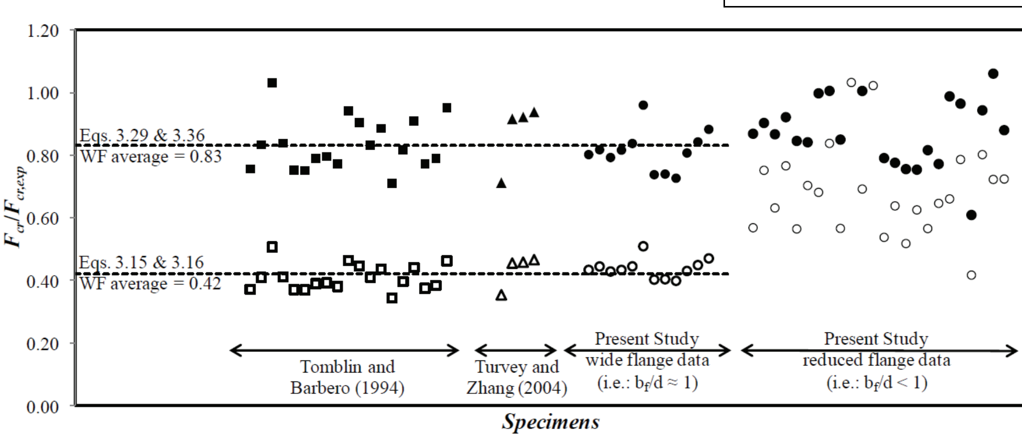
failure modes of short, intermediate and long 50.8x3.2 mm GFRP tubes (arrows indicate local buckling)

The conclusions of this study are directly applicable to approaches promulgated by various international codes/standards. In particular it is demonstrated that considering only simply-supported junctions between web and flange plates (as is commonly recommended), while simple, results in underestimation of the buckling capacity of pultruded I-section by approximately a factor of two. Additionally, this degree of underestimation increases as the flange slenderness increases. Taken together, this has an implication for the 'calibration' of building code material resistance factors (so called φ factors). Using the simply supported assumptions, reliability calibrations will result in relatively high φ factors which misrepresent the material reliability, and may be appropriate for only wide flange shapes. Calibrations using the more rigorous approach proposed in this work will result in more 'representative' and uniformly applicable φ factors.

CICE 2014 papers based on this work:

Cardoso, D., Harries, K.A. and Batista, E.M. *Local Buckling of Pultruded GFRP I-Sections Columns*

Cardoso, D., Harries, K.A. and Batista, E.M. *On The Determination of Material Properties for Pultruded GFRP Sections*



Ratios of predicted-to-experimental critical stresses from literature and present study. Predicted values are based on equations proposed in this study (solid data points) and those commonly used in practice (open data points).

ASCE *Journal of Composites for Construction* Publishes IIFC 10th Anniversary Special Issue

Guest Editors

Prof. Scott T. Smith, Southern Cross University, Australia

Prof. Jian-Fei Chen, Queen's University, Belfast UK

The International Institute for FRP in Construction (IIFC) was formed in 2003 with a mission to advance the understanding and application of fibre–reinforced polymer (FRP) composites in civil infrastructure. Since 2005, IIFC has enjoyed a fruitful association with ASCE via co-sponsorship of the *Journal of Composites for Construction* (*JCC*). Therefore, it is fitting that this present *JCC* issue commemorates the 10th anniversary of IIFC. This is the third special IIFC issue published by *JCC*; the first two issues were in April 2007 ("Recent International Advancements in FRP Research and Application in Construction") and April 2011 ("In Honor of Professor Urs Meier").

The present Special Issue contains 18 invited papers contributed by members of the IIFC Executive, Council and Advisory Committees and their collaborators, addressing a diverse range of topics that are representative of the breadth of activity in the field.

The contributions of numerous individuals are acknowledged in the preparation of this special issue. The authors of the papers in this issue are thanked for preparing high-quality manuscripts. Prof. Charles Bakis, Editor-in-Chief of *JCC*, is thanked for handling the paper review process and ensuring maintenance of the high JCC standard. Professor Bakis is supported by Ms. Renee Lindenberg and a large team of reviewers; their contributions are all acknowledged. The idea of an IIFC 10th anniversary special issue was positively received by Prof. Lawrence Bank, IIFC President, and by the members of the Executive Committee following discussions after CICE 2012. For that, they are all thanked for their support. Finally, all members of IIFC, past and present, are thanked for their various contributions over the years, which have enabled IIFC to move into its second decade on a sound and positive footing.

[adapted from Guest Editor's Note, *ASCE JCC* **18**(3)]

***ASCE Journal of Composites for Construction*, Volume 18, No. 3. June 2014.**

Special Issue on the 10th Anniversary of IIFC

Axial Capacity of Circular Concrete Columns Reinforced with GFRP Bars and Spirals

Mohammad Z. Afifi, Hamdy M. Mohamed, and Brahim Benmokrane

Examining the Presence of Arching Action in Edge-Stiffened Bridge Deck Cantilever Overhangs Subjected to a Wheel Load

C. Klowak, A. Mufti, and B. Bakht

Design of FRP-Strengthened Infill-Masonry Walls Subjected to Out-of-Plane Loading

Dillon S. Lunn and Sami H. Rizkalla

Performance of RC Slab-Type Elements Strengthened with Fabric-Reinforced Cementitious-Matrix Composites

Giovanni Loreto, Lorenzo Leardini, Diana Arboleda, and Antonio Nanni

Flexural Behavior of Preloaded RC Slabs Strengthened with Prestressed CFRP Laminates

Renata Kotynia, Krzysztof Lasek, and Michal Staskiewicz

Effect of Dynamic Loading and Environmental Conditions on the Bond between CFRP and Steel: State-of-the-Art Review

Xiao-Ling Zhao, Yu Bai, Riadh Al-Mahaidi, and Sami Rizkalla

Experimental Investigation on FRP-to-Timber Bonded Interfaces

Jing Wan, Scott T. Smith, Pizhong Qiao, and Fangliang Chen

Integrated Performance of FRP Tendons with Fiber Hybridization

Nageh M. Ali, Xin Wang, and Zhishen Wu

Numerical and Experimental Validation of FRP Patch Anchors Used to Improve the Performance of FRP Laminates Bonded to Concrete

R. Kalfat and R. Al-Mahaidi

Experimental Study on Shear Behavior of Reinforced-Concrete Members Fully Wrapped with Large Rupture-Strain FRP Composites

Tidarut Jirawattanasomkul, Jian-Guo Dai, Dawei Zhang, Mineo Senda, and Tamon Ueda

Fatigue Behavior of Concrete Bridge Decks Cast on GFRP Stay-in-Place Structural Forms

Patrick Richardson, Mark Nelson, and Amir Fam

Comparative Study of Different Cement-Based Inorganic Pastes towards the Development of FRIP Strengthening Technology

Jian-Guo Dai, Sarfraz Munir, and Zhu Ding

Analytical Model for FRP-and-Steel-Confined Circular Concrete Columns in Compression

Hao Hu and Rudolf Seracino

Limits of Application of Externally Bonded CFRP Repairs for Impact-Damaged Prestressed Concrete Girders

Jarret L. Kasan, Kent A. Harries, Richard Miller, and Ryan J. Brinkman

Web Buckling in Pultruded Fiber-Reinforced Polymer Deep Beams Subjected to Concentrated Loads

David T. Borowicz and Lawrence C. Bank

Strengthening of Infilled Reinforced Concrete Frames with TRM: Study on the Development and Testing of Textile-Based Anchors

L. Koutas, A. Pitytzogia, T. C. Triantafillou, and S. N. Bousias

Experimental Investigation of Concrete Shear Walls Reinforced with Glass Fiber–Reinforced Bars under Lateral Cyclic Loading

Nayera Mohamed, Ahmed Sabry Farghaly, Brahim Benmokrane, and Kenneth W. Neale

Postfatigue Monotonic Behavior of RC Beams Strengthened with Prestressed NSM CFRP Strips: Ductility Evaluation

Raafat El-Hacha and Fadi Oudah

Bond Strength Model for CFRP Strips Near-Surface Mounted to Concrete

S. S. Zhang, J. G. Teng, and T. Yu

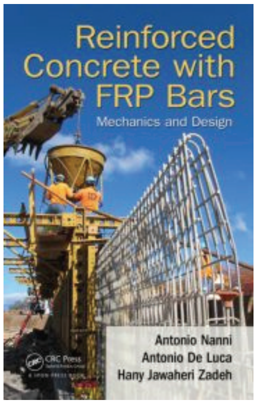
The American Society of Civil Engineers (ASCE) Journal of Composites for Construction (JCC) is published with the support of IIFC. As a service to IIFC members and through an agreement with ASCE, *FRP International* provides an index of ASCE JCC. The ASCE JCC may be found at the following website:

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/

New Publication



Reinforced Concrete with FRP Bars: Mechanics and Design

Antonio Nanni, Antonio De Luca and Hany Jawaheri Zadeh

Corrosion-resistant, electromagnetically transparent and lightweight fiber-reinforced polymers (FRPs) are accepted as alternatives to steel for concrete reinforcement. *Reinforced Concrete with FRP Bars: Mechanics and Design*, a technical guide based on the authors' more than 30 years of collective experience, provides principles, algorithms, and practical examples.

Well-illustrated with case studies on flexural and column-type members, the book covers internal, non-prestressed FRP reinforcement. It assumes some familiarity with reinforced concrete, and excludes prestressing and near-surface mounted reinforcement applications. The text discusses FRP materials properties, and addresses testing and quality control, durability, and serviceability. It provides a historical overview, and emphasizes the ACI technical literature along with other research worldwide. The text:

- Includes an explanation of the key physical mechanical properties of FRP bars and their production methods
- Provides algorithms that govern design and detailing, including a new formulation for the use of FRP bars in columns
- Offers a justification for the development of strength reduction factors based on reliability considerations
- Uses a two –story building solved in Mathcad® that can become a template for real projects

This book is mainly intended for practitioners and focuses on the fundamentals of performance and design of concrete members with FRP reinforcement and reinforcement detailing. Graduate students and researchers can use it as a valuable resource.

Available at:

http://www.crcpress.com/product/isbn/9780415778824

IIFC Working Group on FRP-Strengthened Metallic Structures Announcement

The 2014 list of technical publications on FRP-Strengthened Metallic Structures is now available from Working Group Chair Prof. Xiao-Ling Zhao (zhao.xiao.ling@monash.edu). The list presently contains 572 citations!

International Institute for FRP in Construction

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

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As IIFC grows, we seek to expand the utility and reach of *FRP International*. The newsletter will continue to report the activities of IIFC and focus on IIFC-sponsored conferences and meetings. Nevertheless, we also solicit short articles of all kinds: research or research-in-progress reports and letters, case studies, field applications, book reviews 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. All announcements are duplicated on the IIFC website (www.iifc-hq.org) and all issues of the *FRP International* are also available in the archive at this site.

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