FRP INTERNATIONAL

the official newsletter of the International Institute for FRP in Construction

Vol. 13, No. 2, April 2016

IIFC Best PhD Thesis Award

In order to promote high-quality research on FRP composites for construction, the IIFC has established a PhD Thesis Award to be awarded in association with the Composites in Civil Engineering (CICE) conference series.

Using the CICE cycle, all PhD theses completed within two years of the application deadline are eligible for the award. To be eligible, theses must be nominated by a faculty member from the student's department (typically their advisor) who is a member of the IIFC. The nomination package shall include the following:

- Nominee's name, affiliation and contact information
- Nominator's name, affiliation, contact information and relationship to nominee
- Nominator's statement (2 pages) justifying the significance of the dissertation, novelty, research achievements, and scientific or practical contributions.
- 4-5 page 'extended abstract' summary of the thesis ***prepared by the nominee***

Nominated theses making a 'short list' will be invited to give a presentation at a special session of the CICE conference. The Award Panel will select the Best PhD Thesis based on an evaluation of the nomination package ***and*** presentation made at CICE.

The winner will receive a certificate, $1000 (USD) and a two-year complimentary membership to IIFC. The winner will also be expected to prepare an article for *FRP International*.

The inaugural Best Thesis Award will be awarded at CICE 2016 in Hong Kong. Theses submitted in calendar year 2014 or after will be eligible for the inaugural award.

Nominations for the 2016 IIFC Best PhD Thesis Award should be submitted to Renata Kotynia (renata.kotynia@p.lodz.pl) before 1 July 2016.

More information on the Award may be obtained from Renata Kotynia (renata.kotynia@p.lodz.pl).

International Summer School on Composites in Infrastructure (ISSCI)

The inaugural International Summer School on Composites in Infrastructure (ISSCI) will be held in Wollongong, Australia on 18-22 July 2016. The ISSCI will be hosted by the University of Wollongong and co-organisers The Hong Kong Polytechnic University, Queen's University Belfast, Tsinghua University, University of Queensland and Southern Cross University.

The ISSCI, to be taught by a team of experts, will focus on the structural use of fibre-reinforced polymer (FRP) composites in infrastructure. The ISSCI aims to prepare researchers and postgraduate students for high-quality research in the area and to prepare engineers for practical applications. It will provide a comprehensive and thorough treatment of the behaviour, modelling and design of structures incorporating FRP composites (including both FRP-strengthened structures and FRP-based new structures), with a strong emphasis on fundamental mechanics. The ISSCI will include a one-day symposium which provides an international forum for all attendees to share their recent advances in both research and practice, and to benefit from discussions with the summer school lecturers.

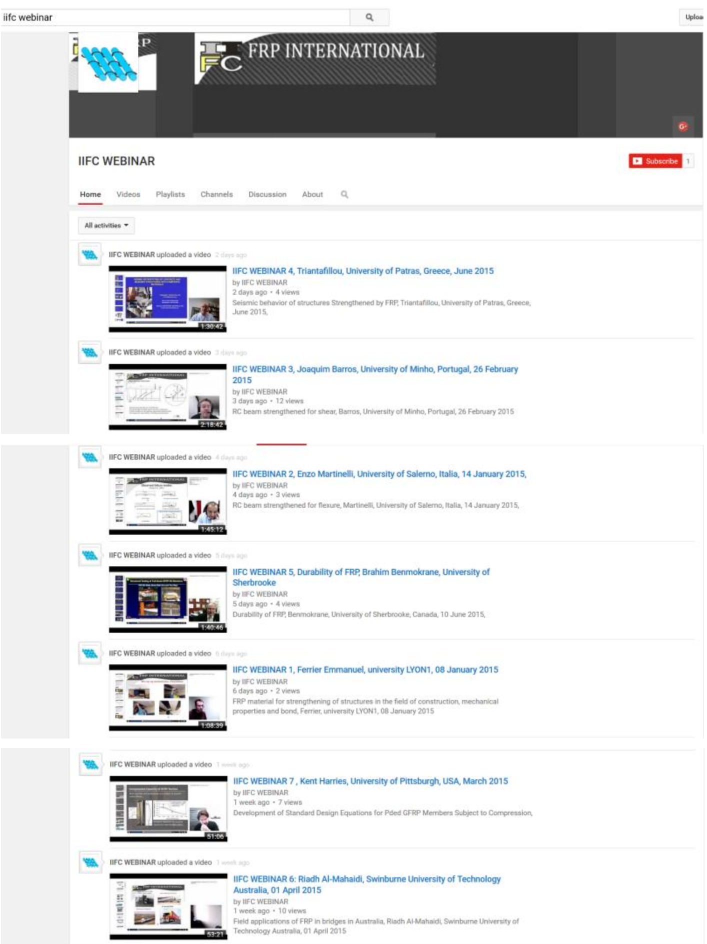
For more information, please contact Dr. Tao Yu by email: taoy@uow.edu.au.

IIFC Webinar Update

Emmanuel Ferrier, Université Lyon 1, France
emmanuel.ferrier@univ-lyon1.fr

IIFC webinars are an excellent opportunity for students and researchers to get an update on focused topics in FRP in construction. These webinars are ***FREE*** and are now available on YouTube:

IIFC WEBINAR Channel:
https://www.youtube.com/channel/UCYmC-3GUIad2P1GdKkZVwkg



Subscribe to the Channel for free and be informed of new webinars all along the year.

If you would like to volunteer to give a webinar, please contact Prof. Ferrier.

...if anyone is counting...

Since being announced in the October 2015 *FRP International*, The IIFC Webinar YouTube page has had over 600 views from all over the world.

New Document

Prospect for new guidance in the design of FRP

CEN TC250 WG4 Science and Policy Report has been published and is freely available in pdf format at the following link:

https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/prospect-new-guidance-design-frp

Abstract

Over the last twenty years, many innovative solutions have confirmed the usefulness of composite structures realized with FRPs (Fibre Reinforced Polymer or Plastic). The need of European standards for use of fibre-reinforced polymer composites in civil engineering was justified in 2007 in the JRC Report EUR 22864 EN. The new European technical rules will be developed using the existing organization of CEN/TC250. The present report has been worked out in the frame of CEN/TC250/WG4 activities. The report encompasses: Part I, which introduces the policy framework and the CEN/TC250 initiative; Part II, which gives a prospect for CEN guidance for the design and verification of composite structures realized with FRPs The report presents scientific and technical background intended to stimulate debate and serves as a basis for further work to achieve a harmonized European view on the design and verification of such structures. This has been the main impulse to include the work item of the Fibre Reinforced Polymer Structures in the Mandate M/515 with high priority.

Authors of Report:

Luigi Ascione, Jean-François Caron, Patrice Godonou, Kees Van Ijselmuijden, Jan Knippers, Toby Mottram, Mattihas Oppe, Morten Gantriis Sorensen, Jon Taby, Liesbeth Tromp, Eugenio Gerardo Gutierrez Tenreiro, Silvia Dimova, Artur Pinto Vieira, Steve Denton

Conference Announcement

8th International Conference on Fibre-Reinforced Polymer (FRP) Composites in Civil Engineering (CICE 2016), 14-16 December 2016, Hong Kong, China

Prof. Jin-Guang Teng and Dr. Jian-Guo Dai, The Hong Kong Polytechnic University, Hong Kong, China

Conference co-chairs

Marking the 15th anniversary of the CICE conference series, the 8th International Conference on Fibre-Reinforced Polymer (FRP) Composites in Civil Engineering (CICE 2016) will be held in Hong Kong, China on 14-16 December 2016. Since its launch in 2001 in Hong Kong, the CICE conference series has been held in Adelaide (2004), Miami (2006), Zurich (2008), Beijing (2010), Rome (2012) and Vancouver (2014). The 2016 conference will be jointly hosted by the Department of Civil and Environmental Engineering (CEE) and the Research Institute for Sustainable Urban Development (RISUD) of The Hong Kong Polytechnic University. Following the well-established tradition of the series, CICE 2016 will provide an international forum for all concerned with the application of FRP composites in civil engineering to exchange recent advances in both research and practice, and to strengthen international collaboration for the future development of the field.

Information on the conference may be found at http://www.polyu.edu.hk/risud/CICE2016/index.html

Conference Topics

The structural use of FRP composites in civil engineering has increased tremendously over the past two decades, primarily for the strengthening of existing structures but also increasingly for the construction of new structures. The following list of topics is not exhaustive, and all papers falling within the general scope of the conference will be considered:

- Materials and products
- Bond behaviour
- Confinement
- Strengthening of concrete, steel, masonry and timber structures
- Seismic retrofit of structures
- Concrete structures reinforced or pre-stressed with FRP
- Concrete filled FRP tubular members
- Hybrid structures of FRP and other materials
- All FRP structures
- Smart FRP structures
- Inspection and quality assurance
- Durability
- Life-cycle performance
- Design codes/guidelines
- Practical applications

Paper Submission

Submission of full papers due 1 May 2016; these will be reviewed before 1 July and final papers will be submitted 1 August 2016.

Mini-Symposia and Special Sessions

Interested researchers are invited to submit proposals for mini-symposia on topics of special interest for approval by the International Organizing Committee.

About Hong Kong

Hong Kong is located within the Pearl River Delta region, which is one of the most developed regions in China. Hong Kong is easily accessible by all means of transport. The international airport of Hong Kong is only 35 minutes away by taxi from downtown Kowloon where the campus of The Hong Kong Polytechnic University is located. Both Chinese and English are official languages in Hong Kong. More information about Hong Kong can be found at the following web site: http://www.discoverhongkong.com/uk/index.jsp

6th Asia-Pacific Conference on FRP in Structures (APFIS 2017)

The IIFC is pleased to announce that APFIS 2017 will be held 19-21 July 2017 in Singapore. The conference will be organised by MCC Singapore and the FRP Application Committee of CCES (Chinese Civil Engineering Society).

More information will follow in subsequent newsletters.

The following paper was awarded Best Paper in the category of repair applications at the joint APFIS-2015 and FRPRCS-12 Conference held in Nanjing in December 2015.

Shear strengthening of cracked RC structures under service loading condition – A case study

T. Imjai, Rajamangala University of Technology, Thailand, thanongsak.imjai@gmail.com

M. Guadagnini, Sheffield University, UK., m.guadagnini@sheffield.ac.uk

Introduction

Rehabilitation and upgrading of existing concrete structures has recently become a major issue which often requires asset and forensic managers to take immediate action. There are a number of situations that might require an increase in the structural capacity of a structure in service, such as change of use, new live load criteria, and impact due to machine loading, damage and deterioration of material. The strengthening or retrofitting of existing concrete (RC) structures to resist an increased applied load, repair deterioration-related damage or increase ductility, has typically been accomplished using conventional materials and construction techniques [1]. The use of externally bonded steel plates, concrete jackets and external post-tensioned reinforcement are regarded as some of the many traditional solution techniques available [2]. Recently, Externally Bonded Fibre Reinforced Polymer reinforcement (EBR) has rapidly emerged as an efficient alternative to conventional steel reinforcement to overcome the problem of corrosion and has opened up another cost-efficient alternative solution for asset and forensic managers. Owing to its superior durability characteristics, the use of FRP reinforcement can extend the lifespan of concrete structures and reduce the need for maintenance or repair [1,3,4].

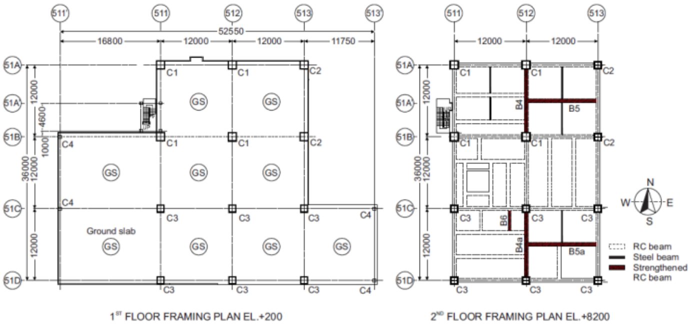
This paper discusses the assessment and strengthening of a deteriorated RC building in Thailand. The as-built design document for the building has been reviewed in detail to assess the residual capacity of the existing RC structural elements and on-site structural inspection has been performed to identify the location and nature of the cracks. Several strengthening solutions, such as externally bonded steel plates (EBS), section enlargement and EBR were proposed. However, an innovative strengthening scheme using EBR as reported by ACI 440.2R [3] and fib bulletin 14 [4], was selected as the preferred strengthening solution. The work reported in this paper sets the scene for identifying the major decisions for a design engineer starting from on-site inspection to the post-construction supervision.

Project Facts

The Pelletizer Building is the main process building of the Linear Low-Density Polyethylene (LLDPE) plant located in Rayong province, Thailand. The building consists of a 6 storey RC structure having beams with a typical span of 12.0 m (Figure 1). It is owned by the Petroleum Authority of Thailand Polyethylene Co., Ltd. (PTTPE) and it was built by Toyo-Thai Corporation PCL (TTCL) and completed in 2009. During construction of the Pelletizer Building, it was found that the in-situ concrete strength (18 MPa) was considerably lower than the specified design strength (30 MPa). Therefore, the capacity of all reinforced concrete (RC) elements in the building had to be re-assessed.

a) view from South

b) view from East



c) floor framing plans

Figure 1 Overview of Pelletizer Building

At the time of inspection, the building had been in operation for three years and annual inspections have been carried out since 2010 (after the construction was completed in 2009). During the inspection in 2013, it was reported that several shear cracks, approximately

0.30 mm wide were observed in RC beams (B4, B4a, B5, B5a and B6 in Figure 2) under normal operating service. This was attributed to the lack of sufficient transversal reinforcement and the low concrete strength as evidenced by the as-built document review. It was proposed to repair the cracked RC elements using epoxy injections prior to carrying out any strengthening work. Several strengthening schemes were proposed including traditional solutions, such as externally bonded steel plate (EBS), concrete sectional enlargement and externally bonded fibre reinforced polymer (EBR) for defected RC beams to resist the actual, increased design live load. An externally bonded system using manual lay-up CFRP laminates was chosen as a repair / strengthening solution to increase the shear capacity of the deficient RC elements. The strengthening design and construction procedure were in accordance to ACI 440.2R [3] and fib 14 [4]. The strengthening work was done and completed in 2014. Currently, the building and the plant are still in operation with a periodic inspection carried out every year.

Structural Damage Assessment

Structural damage assessment of the RC building

The condition survey of structural components for the RC building was implemented to examine and assess the current level of damage and deterioration of the structure, and determine the preliminary serviceability condition of the structural components of the building. The rating point system was used to evaluate serviceability, and to compare the current and newly-built structural condition only, without determining the load capacity of the structural components (see Figures 2 and 3). For damage due to current loading, repair or replacement, terms were added to the criteria for the structure in its current condition, i.e. a structural element that shows small defects, good maintenance and good construction practice was given a condition rating of 2 or “Fair condition”. If the same element had some effects/damages from current loading to the level the replacement of the element will be of more benefit to the whole structure than rehabilitation, then the term “Replacement” was recommended for “Fair condition” (adopted from RILEM Technical Committee 104 [5]).

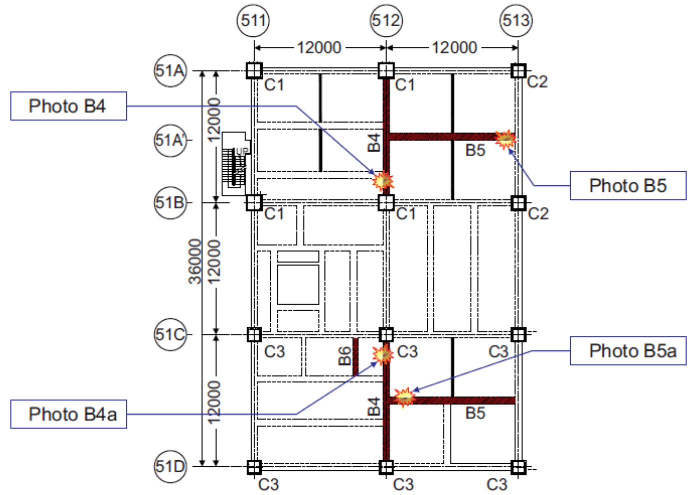


Figure 2 Location of defects found in RC beams at the 2nd floor

Photo B4 (crack width = 0.30 mm)

Photo B4a (crack width = 0.30 mm)

Photo B5 (crack width = 0.30 mm)

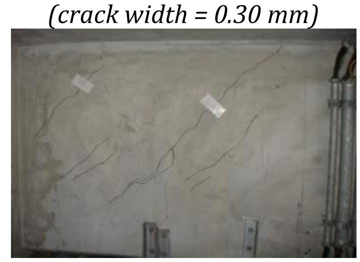


Photo B5a (crack width = 0.35 mm)

Figure 3 Location of shear cracks found in RC beams at the 2nd floor

Design verification according to ACI 318

During the construction of the building, it was found that the concrete strength (18 MPa) was lower than the design value (30 MPa) therefore the in-situ strength of concrete was used to re-assess the actual load capacity. A yield strength of 392MPa was used for the steel reinforcement as per inspection. The original design floor live loads ranged from 5 to 10 kN/m2 and the new live load on the 2nd floor is planned to increase by up to 125% of the original design. The design check considers the factored load i.e (Mu) and nominal strength of the section (Mn) multiplied by the strength reduction factor (Φ) according to ACI 318 [6]. Figure 4 shows a 3D FE model of the Pelletizer building.

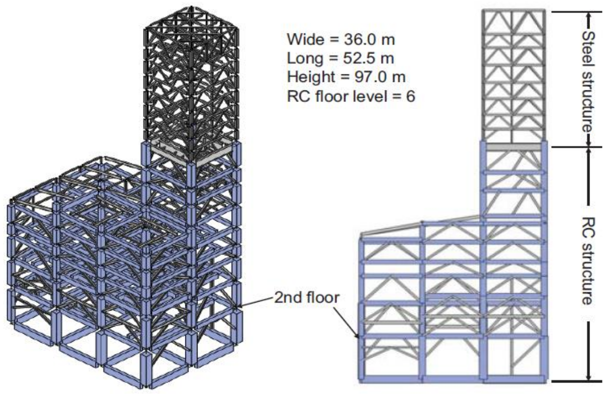


Figure 4 Finite element model of the building

Shear Strengthening Using Externally Bonded CFRP

General design considerations

On the basis of the preliminary structural assessment and detailed engineering analysis of the concrete elements at the 2nd floor, it was found that the shear capacity of the existing beams was smaller than the ultimate shear load due to an increase in the imposed load on the 2nd floor. As a result, shear strengthening using Externally Bonded CFRP was proposed to and agreed by the client. RC beams strengthened in shear using FRP materials exhibit a complex behaviour as both shear strength and failure modes are influenced by many factors, including member geometry, loading condition, method of strengthening and properties of materials. If strains in the FRP are kept at an acceptable level, however, the additive nature of the shear contributions assumed for the design of conventional steel RC elements can still be implemented and Eq. 1 can be used to calculate the shear strength (V_n) of the strengthened RC beams according to existing design recommendations [3,4];

$$V_n = V_c + V_s + V_{frp} \qquad (1)$$

in which V_c is the shear capacity of the concrete, V_s is the shear capacity of steel stirrup and V_{frp} is the contribution of FRP.

CFRP composites

In the strengthening work, a custom, unidirectional CFRP fabric was impregnated in two-parts epoxy resin to form a composite system and was applied externally on the concrete beams at the 2nd floor to increase their total shear capacity. The CFRP fabric sheet is commercially available in the form of a 500 mm width sheet with the thickness of 0.16 mm. The design ultimate tensile strength is 903 MPa with the elastic modulus of 230 GPa and elongation at break of 1.6% according to ASTM D3039 and ASTM D1777. Vertical banded CFRP sheets were applied along the sides of the cracked RC beams as adequate bond could be fully developed according to the design codes [3,4]. Figure 5 shows the EBR CFRP strengthening detail of RC beams.

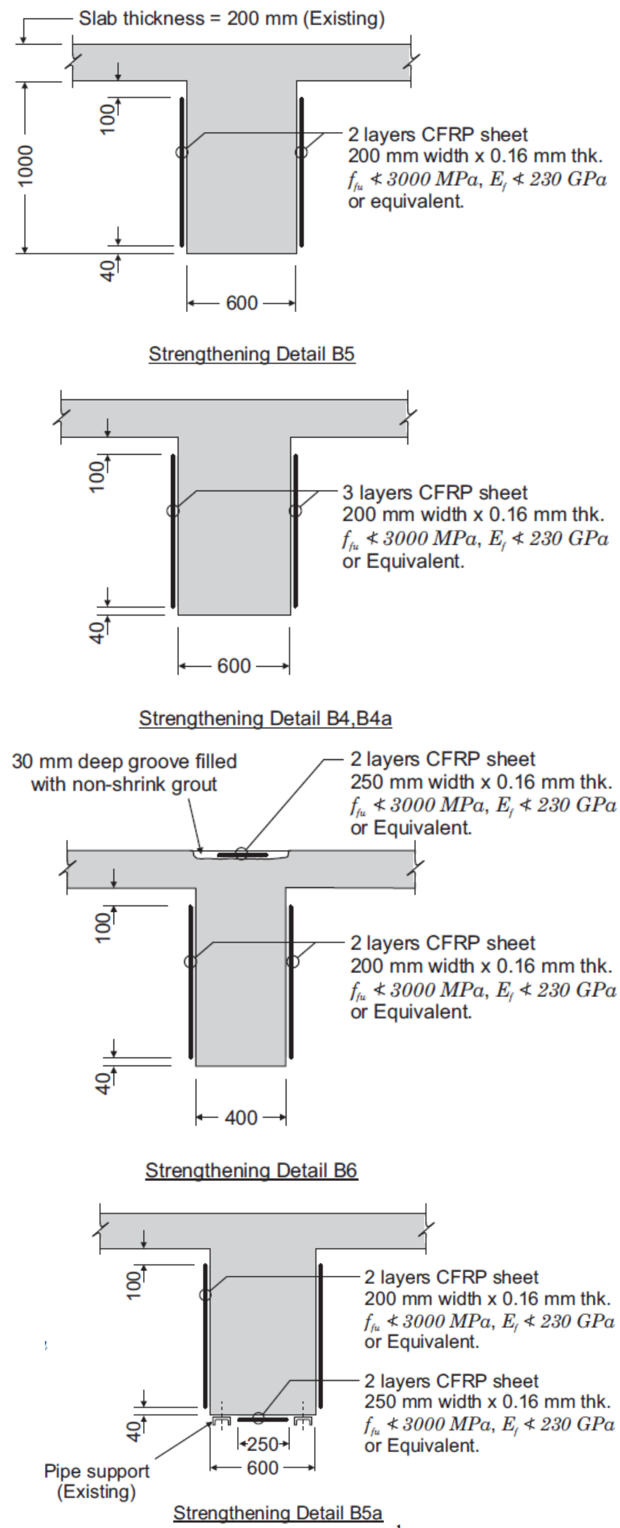


Figure 5 Shear strengthening EBR details for RC beams on the 2nd floor

Construction Quality Control and Fire Protection

Construction details were carried out according to fib 14 [4]. Rules and practical information on detailing aspects can be found in fib 14; chapters 7 and 8 [4]. Figure 6 shows an installation of CFRP fabric on RC beams and a fire protection system.

a) CFRP fabric is impregnated with epoxy by using a roller brush

b) UL approved, Class 1 ASTM E84 flame and smoke spread fire protection system

Figure 6 Construction quality control and fire protection system

Concluding Remarks

Based on the field application discussed in this paper, the following remarks can be made:

- Design verifications based on ACI 318 have shown that the shear capacity of the as-built RC beams was insufficient. The flexural and torsional capacity of the existing RC sections, however, were found to be sufficient to resist increasing live loads of up to 150% on the 2nd floor.
- Externally bonded CFRP systems can be used successfully to increase the total shear capacity of original concrete sections by up to 125% of their original design capacity.
- Design checks according to ACI 318 on RC columns and slabs have shown that original cross-sections were sufficient to sustain up to 150% of the original design live load (LL) on the 2nd floor.

References

[1] Nanni, A. (2004). Fiber reinforced polymer composites for infrastructure strengthening - From research to practice, *VII AIMAT Congress*, Ancona, Italy, June 29 - July 2, Keynote Paper KP2, 10 pp.

[2] Bakis, C.E., Bank, L.C., Brown, V.L., Cosenza, E., Davalos, J.F., Lesko, J.J., Machida, A. Riskalla, S.H., and Triantafillou, T.C (2002). Fiber-reinforced polymer composites for construction – State-of-the-art review, *Journal of Composites for Construction*, **6**(2), 73-87.

[3] ACI 440.2R-08 (2008). *Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures*, American Concrete Institute, Farmington Hills.

[4] *fib* Bulletin 14 (2201). *Externally Bonded FRP Reinforcement for RC Structures*. *fib* Task Group 9.3, Lausanne.

[5] RILEM RC 104 (1991). Damage classification of concrete structures. The state of the art report of RILEM Technical Committee 04-DCC activity. *Materials and Structures*. **24**(142) 253-259.

[6] ACI 318-95/318R-95 (1995). *Building Code Requirements for Structural concrete and Commentary*, American Concrete Institute, Farmington Hills.

Recent Dissertation

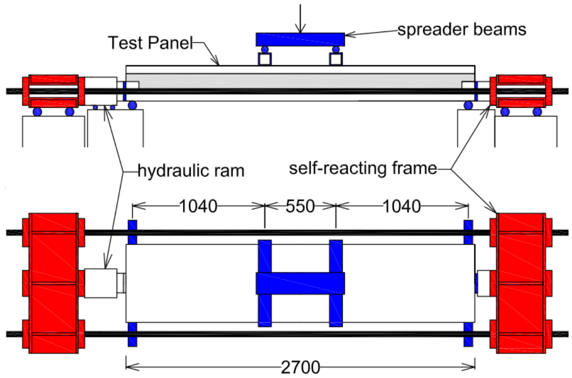
Behaviour of Partially Composite Precast Concrete Sandwich Panels Under Flexural and Axial Loads

Douglas George Tomlinson (2015)
Advisor: Amir Fam
Queen's University, Canada
https://qspace.library.queensu.ca/handle/1974/13745

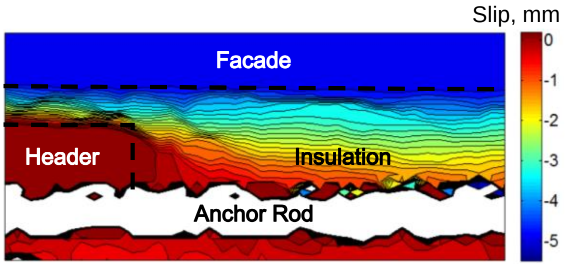
Precast concrete sandwich panels are commonly used as exterior members in buildings. They are typically composed of two reinforced concrete wythes that surround an insulation layer; they are advantageous as they provide both structural and thermal resistance. The structural response of sandwich panels is heavily influenced by shear connectors that link the wythes together.

This thesis presents a detailed study of partially composite non-prestressed precast concrete wall panels. Nine flexure tests were conducted on a preliminary design consisting of walls with concrete studs, that are were not monolithically integrated with either wythe to minimize thermal bridging, and Glass Fibre Reinforced Polymer (GFRP) connectors. The 'floating' studs encapsulate the connectors and stiffen them, thereby reducing shear deformations. The ultimate load increased from 58 to 80% that of a fully composite section as the connectors' reinforcement ratio increased from 2.6 to 9.8%. Insulation contributed about half of this capacity. Though this design adequately resisted design loads, it was made more efficient by reinforcing the studs and integrating them with the structural wythe. Also, new connectors composed of steel or Basalt-FRP (BFRP) were inserted at an angle. The new design was used in subsequent research.

Before studying the new wall design, the load-slip responses of the new connectors were studied through 38 double shear push-through ancillary tests using various connector diameters and insertion angles. Larger connectors were stronger but more likely to pull out. The insulation bond contribution to resistance was independent of connector material, whether BFRP or steel. Seven flexure tests were then conducted on the new wall design reinforced with different combinations of steel and BFRP connectors and longitudinal reinforcement. The degree of composite action varied from 50 to 90% depending on connector material and flexural reinforcement. Also, the individual contribution of each wythe was measured.



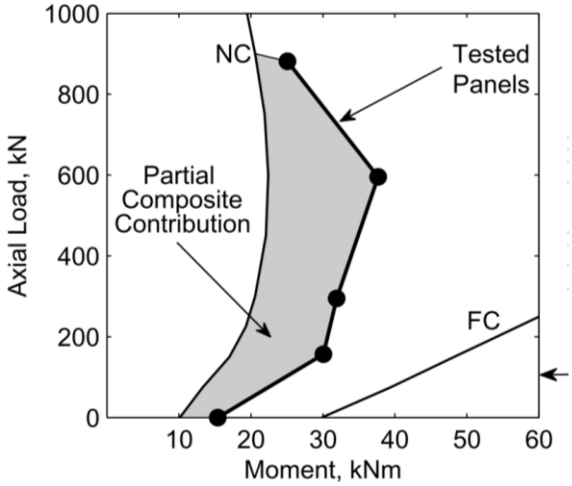
Test Setup



Relative slip of the two wythes at failure in the partially composite panel using Digital Image Correlation (DIC)

Following the flexural study, the axial load-bending moment interaction curves were established for the new wall design, for BFRP and steel connectors and reinforcement. Eight panels were axially loaded to predesignated loads then loaded in flexure to failure. A technique is presented to experimentally determine the effective centroid and stiffness of partially composite sections. This technique is used to develop the interaction diagrams. Composite action decreased as axial load increased. Beyond the classical tension and compression controlled failure regions of the interaction curve, a third region was observed in between, governed by connector failure.

Theoretical models were developed for the bond-slip behaviour of shear connections and to analyze the full panel's flexural and axial behaviour to determine the longitudinal shear force transferred between wythes and account for partial composite behavior. The models were successfully validated against experiments and used to conduct a parametric study covering parameters beyond the limits of the experimental work. Among several interesting findings, the study demonstrated how the degree of composite action increases with the slenderness of axially loaded panels.



Measured partially composite axial load-moment interaction diagram as compared to fully composite (FC) and none composite (NC) cases. Note the three middle data points representing a third distinct region between the classical tension- and compression-controlled regions, governed by shear connection failure in the partially composite panels.

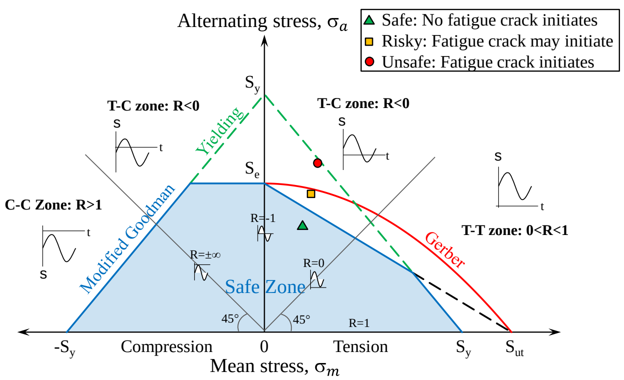
Recent Dissertation

Fatigue Strengthening of Metallic Members using Un-bonded and Bonded CFRP Laminates

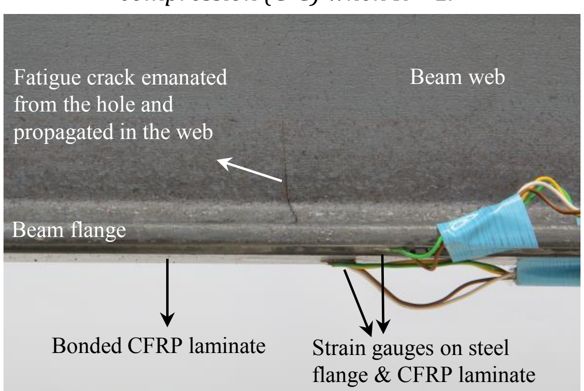
Elyas Ghafoori (2015)
ETH-Zurich, Switzerland
Advisor: M. Fontana
http://e-collection.library.ethz.ch/eserv/eth:47782/eth-47782-02.pdf

There are a large number of aging metallic bridges worldwide that remain operational and must accommodate ever-increasing traffic loadings. Many of these structures are subjected to cyclic loading and are nearing their designed fatigue life. To combat this problem, municipalities often recommend that a retrofit option be considered to extend the remaining fatigue lives of deficient elements before a decision is made to replace the entire bridge. This is because the retrofitting costs are often much cheaper than the costs for demolition and replacement of the entire bridge. Although methods for the strengthening of concrete structures have already been well developed and have been used in many practical cases, this is not the case for metallic structures. There is clearly a need for studies that aim to develop feasible retrofitting methods, along with meticulous design approaches, for the strengthening of metallic members.

One of the main objectives of this research project is to examine the applicability of the constant life diagram (CLD) methodology for the determination of strengthening parameters to prevent fatigue cracks in aging metallic members. The CLD methodology is an approach that predicts the lifetime of materials under high cyclic fatigue. This method uses the combined effect of alternating stress, mean stress and material properties to predict the damage due to cyclic loads. The CLD approach can be used to define the safe, risky and unsafe stress zones ac-cording to the stress ratio (R), as shown in Fig. 1.a. When the stresses are in the unsafe zone, fatigue cracks will initiate from the hot spots in the steel member (see Fig. 1.b). The results of the CLD analysis in this study show that strengthening parameters can be chosen such that the alternating and mean stresses cause only negligible fatigue damage, and, therefore, the lifetime of the aging metallic detail is increased to infinity. The proposed CLD method is particularly valuable when the stress history of the metallic detail, due to prior traffic loadings, is not exactly known. In this research work, different fatigue failure criteria for ductile and brittle metals were described. Analytical formulations were developed to predict the behavior of metallic girders after strengthening with bonded carbon fiber-reinforced polymer (CFRP) laminates. The developed analytical solutions were used to calculate the CFRP properties (e.g., Young's modulus, pre-stress level and dimensions) such that the metallic detail is shifted from an 'at risk' finite fatigue life regime to a 'safe' infinite fatigue life regime (see Fig. 1.a). Extensive experimental studies were conducted to examine the validity of the methodology. The results showed that increasing both the stiffness and pre-stress level of the CFRP laminate can enhance the fatigue resistance of the metal through different mechanisms. The latter mainly preserves the alternating stress and decreases the mean stress level, whereas the former decreases both the mean and alternating stresses proportionally.



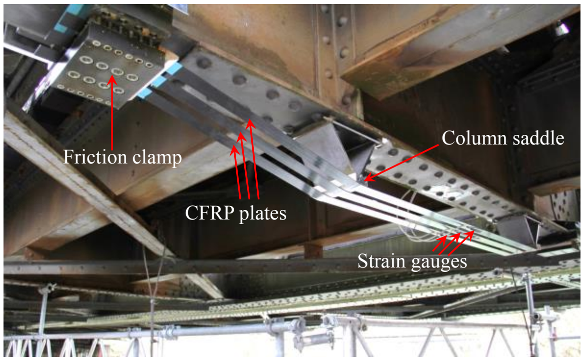
a) Each CLD can be partitioned into three stress regions of tension–tension (T-T) when 0 < R < 1, tension–compression (T-C) when R < 0 and compression–compression (C-C) when R > 1.



b) Fatigue crack initiates in the steel member when stresses are in the unsafe zone.

Figure 1

a) Münchenstein metallic railway bridge with a span length 45.2 m.



b) Each bridge cross-girder was retrofitted using three pre-stressed CFRP laminates.

Figure 2

Another main objective of this study is to develop an un-bonded CFRP strengthening system. Un-bonded CFRP systems are beneficial over traditional bonded CFRP systems as they can be applied to rough or obstructed surfaces (surfaces containing rivet heads or corrosion pitting, for example). Different experimental and numerical studies were carried out to compare the flexural behavior of steel beams retrofitted by bonded and un-bonded systems. The results showed that, when metallic beams are strengthened by pre-stressed CFRP laminates, the fatigue resistance of the specimens is more sensitive to the magnitude of pre-stress level rather than the presence of the bond. After gaining a better understanding of the differences between the bonded and un-bonded strengthening systems, a trapezoidal pre-stressed un-bonded reinforcement (PUR) system was developed. The new un-bonded retrofit system offers fast on-site installation (i.e., no glue and no surface preparation are required) and an adaptive pre-stress level, which substantially reduces the time and work required for onsite bridge strengthening. The performance of the developed trapezoidal PUR system was examined under laboratory static and cyclic loadings. The design criterion based on the CLD approach, which was developed previously for fatigue strengthening using bonded CFRP laminates, was extended for application to un-bonded systems. The accuracy of the developed methodology and the fatigue performance of the trapezoidal PUR system were examined by conducting extensive high-cycle fatigue experiments. Furthermore, the results of the CLD analyses performed in this study showed that the approach currently adopted in many structural standards, which uses the alternating stress as the only parameter affecting fatigue life, is non-conservative for tension-tension cyclic stress patterns (i.e., stress ratios of $0<R<1$). This study therefore proposed a modified version of the Johnson fatigue failure criterion that can reflect the combined effect of the alternating stress, mean stress level and also material properties, and this modified criterion offers a relatively easy design procedure.

Finally, to demonstrate the feasibility and efficiency of the developed PUR system for the strengthening of existing bridges, a 120-year-old railway metallic bridge (see Fig. 2.a) in Switzerland was chosen as a pilot project within this research. In this research work, a comprehensive finite element (FE) analysis was conducted to determine the most fatigue-prone details of the bridge. The results of the numerical studies, along with field measurements, indicated that the cross-girders of the bridge are the most fatigue-prone details. From the experience and knowledge gained through the accomplished experimental, numerical and analytical studies, the trapezoidal PUR system was used for fatigue-strengthening of two riveted cross-girders of the bridge (see Fig. 2.b). The strengthening parameters were chosen to fulfil the requirements of the CLD design approach. The performance of the retrofit system was then monitored using a wireless sensor network (WSN) system. The results of the long-term monitoring showed that the retrofit system could effectively preserve the pre-stress force in CFRP laminates on the coldest and hottest days of a year, which indicates the successful application and the efficiency of the strengthening system.

Upcoming Conferences and Meetings

Concrete Solutions 2016, 5th International Conference on Concrete Repair, June 20-22, 2016, Thessaloniki, Greece. http://www.concrete-solutions.info/

International Summer School on Composites in Infrastructure, 18-22 July, 2016 Wollongong, Australia.

For more information, please contact Dr. Tao Yu by email: taoy@uow.edu.au

7th International Conference on Advanced Composite Materials in Bridges and Structures, August 22-25, 2016 Vancouver, Canada. https://csce.ca/events/7th-international-conference-on-advanced-composite-materials-in-bridges-and-structures-august-22-24-2016/

CICE 2016 *8th International Conference on FRP Composites in Civil Engineering*

December 14-16 2016, Hong Kong

http://www.polyu.edu.hk/risud/CICE2016/index.html

APFIS 2017 6th *Asia-Pacific Conference on FRP in Structures*

19-21 July 2017, Singapore

CICE 2018 *9th International Conference on FRP Composites in Civil Engineering*

July 2018, Paris

IIFC Conference Proceedings Indexed

The IIFC is pleased to announce that Elsevier is now indexing post-2012 IIFC conference proceedings in the Scopus and Compendex indices.

ASTM Committee D30.10 Composites for Civil Structures

This subcommittee of ASTM D30 Composite Materials is responsible for developing standard test methods, practices, terminology, guides, and specifications; sponsoring symposia; stimulating research; and exchanging technical information pertaining to composite materials and reinforcing fibers covered in the scope of the D30 Committee that are used in civil structures. D30.10 presently is responsible for the following active standards:

D7205/D7205M-06(2011) Standard Test Method for Tensile Properties of Fiber Reinforced Polymer Matrix Composite Bars

D7290-06(2011) Standard Practice for Evaluating Material Property Characteristic Values for Polymeric Composites for Civil Engineering Structural Applications

D7337/D7337M-12 Standard Test Method for Tensile Creep Rupture of Fiber Reinforced Polymer Matrix Composite Bars

D7522/D7522M-15 Standard Test Method for Pull-Off Strength for FRP Laminate Systems Bonded to Concrete Substrate

D7565/D7565M-10 Standard Test Method for Determining Tensile Properties of Fiber Reinforced Polymer Matrix Composites Used for Strengthening of Civil Structures

D7616/D7616M-11 Standard Test Method for Determining Apparent Overlap Splice Shear Strength Properties of Wet Lay-Up Fiber-Reinforced Polymer Matrix Composites Used for Strengthening Civil Structures

D7617/D7617M-11 Standard Test Method for Transverse Shear Strength of Fiber-reinforced Polymer Matrix Composite Bars

D7705/D7705M-12 Standard Test Method for Alkali Resistance of Fiber Reinforced Polymer (FRP) Matrix Composite Bars used in Concrete Construction

D7913/D7913M-14 Standard Test Method for Bond Strength of Fiber-Reinforced Polymer Matrix Composite Bars to Concrete by Pullout Testing

D7914/D7914M-14 Standard Test Method for Strength of Fiber Reinforced Polymer (FRP) Bent Bars in Bend Locations

In addition D30.10 is presently developing the following proposed standards:

WK43339 New Specification for Solid Round Glass Fiber Reinforced Polymer Bars for Concrete Reinforcement

WK38604 New Test Method for Bond Strength for FRP Bonded to Concrete Substrate Using Beam Bond Test

Subcommittee D30.10 is chaired by Russell Gentry from the Georgia Institute of Technology; College of Architecture. D30.10 meets jointly with ACI 440K, chaired by Charles Bakis from the Pennsylvania State University.

The entire D30 Committee is responsible for 80 ASTM Standards covering Composite Materials; these are handled by the following subcommittees:

- D30.03 Constituent/Precursor Properties
- D30.04 Lamina and Laminate Test Methods
- D30.05 Structural Test Methods
- D30.06 Interlaminar Properties
- D30.09 Sandwich Construction
- D30.10 Composites for Civil Structures

Information on ASTM may be found at www.astm.org

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/

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