FRP INTERNATIONAL

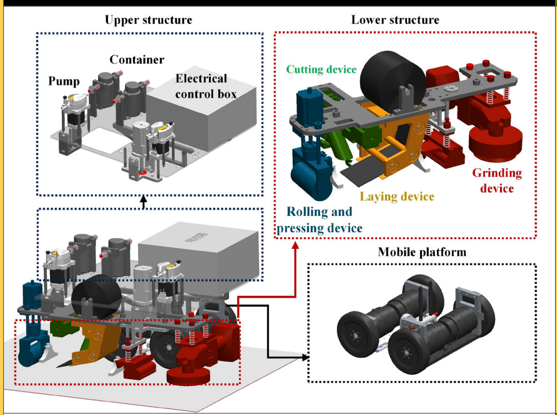
The official newsletter of the International Institute for FRP in Construction

VOL. 23, NO. 2, JUNE 2026

Meet the People

Eric Moussiaux

Page 10



Research

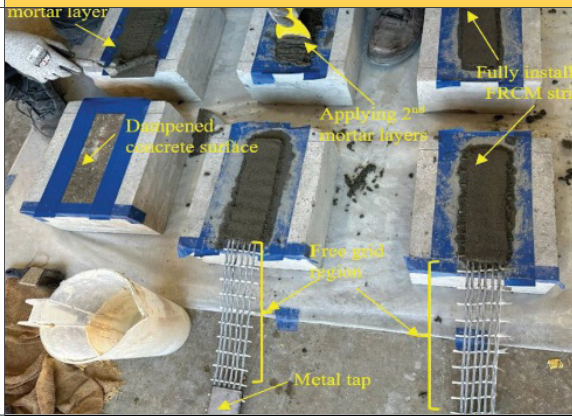
Automated robotic system for FRP application

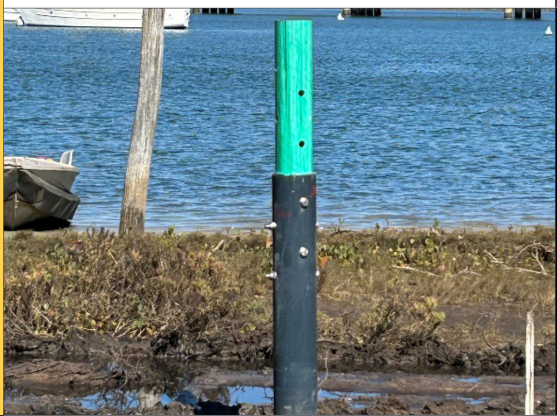
Page 12

Research

Peel angle effect for FRCM

Page 15





Case Study

FRP piles in Gold Coast

Page 19

Table of Contents

MESSAGES

Message from the Editor

The IIFC community continues to be a productive group, and we are pleased to share a snapshot of this activity with you through this newsletter. We hope you find this edition informative; as always, more content is only a click away at www.iifc.org, as well as on LinkedIn and YouTube.

We are quickly approaching this year's flagship event, the FRPRCS-17 conference in Girona, Spain, from July 6-8, which will be closely followed by the Asia-Pacific Conference on FRP in Structures (August 2-5) and the International Summer School on Composites in Infrastructure (August 5-7) in Beijing, China. I am looking forward to seeing many of you there in person! Stay tuned for the next edition of this newsletter where we will share highlights from these gatherings.

In this issue we shine a spotlight on some recent IIFC initiatives, including the relaunched webinar series that is now offered monthly on a rotating regional schedule to encourage broader international participation. All IIFC members are encouraged to browse through our online library of content and connect with our regional webinar coordinators José Sena-Cruz (Europe/Africa), Raafat El-Hacha (Americas), and Lili Hu (Asia/Oceania) to propose a topic.

We also spotlight the first Special Session on Women in FRP that will be held at FRPRCS-17. This session will include a round-table discussion with invited female panelists that will share their perspectives on the valuable contributions of women in our field, as well as challenges and barriers that still need to be addressed. Join us for this important conversation!

This newsletter also continues our series on IIFC task groups by presenting the work of TG-3: FRP in extreme settings, with a look at degradation mechanisms caused by environmental exposure conditions. We also feature research articles looking at the use of robotics to automate the application of FRP for steel structures, as well as the effect of peel angle on debonding of FRCM strengthening systems. Our field case study showcases the use of FRP piles as an efficient and durable solution to support a boardwalk in Gold Coast, Australia. These articles clearly demonstrate that the FRP community continues to push the industry forward through advancements in knowledge and the state of practice.

Our Meet the People feature looks at the contributions of Eric Moussiaux, a pioneer in the field with over 40 years of experience and one of the founders of the European Composites Industry Association. His work spans across disciplines from civil structures to trains, and he has actively contributed to advancements in the use of composite materials in Europe.

I hope you enjoy the read! Please reach out to me or any of the regional editors with ideas for future issues.

Prof. **Martin Noël**
University of Ottawa
Canada

IIFC NEWS & EVENTS

IIFC News

Spotlight on IIFC Webinars: A Decade of Knowledge Sharing in FRP for Construction

The IIFC Webinar Series was created in 2015 by Prof. Emmanuel Ferrier from the University of Lyon 1, France, under the umbrella of the International Institute for FRP in Construction. The initiative was launched with the objective of promoting the dissemination of knowledge related to fiber-reinforced polymer composites in civil engineering and construction.

The IIFC webinars were conceived to provide students, researchers, engineers, and industry professionals with high-level technical presentations on focused topics related to FRP materials and applications, with free access. Through these online seminars, participants from all over the world have been able to stay updated on recent advances, practical applications, innovative technologies, and research developments in the field of FRP for civil infrastructure.

Between 2015 and 2017, a total of 16 webinars were organized. These webinars covered a broad range of important topics, including FRP materials for construction, strengthening of reinforced concrete structures, seismic retrofitting, durability of FRP systems, FRP bridges, confinement of concrete, anchorage systems, fire behavior of pultruded GFRP materials, strengthening of timber structures, and prestressed FRP solutions for new constructions. The webinar series included internationally recognized speakers from leading universities, research institutions, and industry.

In 2024, the IIFC Webinar Series was revitalized by José Sena Cruz from the University of Minho, Portugal, giving new momentum to this important dissemination initiative. Since its relaunch, nine webinars have already been organized, reflecting current challenges and emerging trends in FRP composites and sustainable construction. The IIFC North America Chapter, led by Raafat El-Hacha from the University of Calgary, Canada, also began hosting public webinars in 2024, adding to the IIFC library.

The recent IIFC webinars have focused on highly relevant themes such as fatigue of composites, FRP-reinforced structures, sustainable strengthening solutions with carbon composites, greenhouse gas emission reduction through FRP applications, sustainability in FRP composite structures, natural fiber composites in civil engineering, and innovative applications of basalt fiber reinforced polymer composites in marine engineering.

WWW.IIFC.ORG

Since the beginning of this year 2026, the IIFC webinars have adopted a rolling basis format, with monthly sessions organized across different world regions, namely the Americas (coordinated by Raafat El-Hacha), Europe/Africa (coordinated by José Sena-Cruz), and Asia/Oceania (coordinated by Lili Hu). This new structure aims to strengthen global participation, increase accessibility across time zones, and further enhance the international exchange of knowledge within the FRP community.

Today, the IIFC webinars continue to serve as an important international platform for knowledge exchange and collaboration among academia and industry. All webinars are freely available through the official IIFC website (https://www.iifc.org/publications-resources/iifc-webinars/) and on the IIFC YouTube channel (https://www.youtube.com/@iifc.institute), allowing the global engineering community to access valuable technical content at any time.

IIFC NEWS & EVENTS

IIFC Events

Spotlight: Special Session on Women in FRP in FRPRCS17

Organizers: Lili Hu, Cristina Barris, Rebecca Gravina

As women become increasingly active and make greater contributions in the FRP field, we also face unique challenges tied to our gender. It is against this backdrop that the first "Women in FRP" session is set to take place on the second day of the FRPRCS17 conference, marking a milestone as the first-ever event dedicated to women in the long history of the IIFC conference series. Under the theme "She Reinforces", we aim to create a dedicated space for women in the FRP community.

This 60-minute session has now been officially scheduled as a plenary event at the conference, as follows:

OPENING REMARKS

Lili Hu, University of Science and Technology Beijing, China
Cristina Barris, University of Girona, Spain

SHORT PRESENTATIONS

Qian-Qian Yu, Tongji University, China
Presentation title: How Does It Feel to Be a Young Woman in FRP Research in China?

Francesca Ceroni, University of Parthenope Naples, Italy
Presentation title: Women's research on FRP in Italy.

Maria Lopez de Murphy, Modjeski and Masters, Inc., US
Presentation title: Reflections on mentoring women and young professionals within the FRP community

We welcome students, scholars, and engineers engaged in FRP-related research and applications to join us. Let's support each other, grow together, and realize our full potential.

ROUND TABLE DISCUSSION

Moderator:
Lijuan (Dawn) Cheng, University of California, Davis, US

Panellists:
Qian-Qian Yu, Tongji University, China
Francesca Ceroni, University of Parthenope Naples, Italy
Maria Lopez de Murphy, Modjeski and Masters, Inc., US
Rebecca Gravina, The University of Queensland, Australia

POTENTIAL QUESTIONS TO BE DISCUSSED INCLUDE

1. How Women Are Driving Innovation in FRP
2. How to Move into Leadership Roles
3. Talking About Pay, Getting Resources, and Getting Credit
4. How to Reduce Unconscious Bias in Hiring and Publishing
5. Pausing and Restarting Your Career
6. How Male Colleagues Can Support Women in FRP
7. Measuring Progress: What is truly Gender Balance?
8. Existing Barriers to Achieving Gender Balance
9. Actions Needed in the Near Future

IIFC NEWS & EVENTS

IIFC Task group updates

IIFC TG-3: FRP in Extreme Settings: FRP Degradation Under Various Environmental Exposure Conditions

Daniel Cardoso
Department of Civil and Environmental Engineering, Pontifical Catholic University of Rio de Janeiro

Laura Setti
Department of Civil and Environmental Engineering, Pontifical Catholic University of Rio de Janeiro

Lili Hu
University of Science and Technology Beijing

Anilkumar P M Nair
Institute of Structural Analysis, Leibniz Universität Hannover

Aamir Dean
School of Civil Engineering, Sudan University of Science and Technology

Despite the several advantages of fiber-reinforced polymer (FRP) materials, they are susceptible to chemo-physico-mechanical degradation when exposed to aggressive environments or fire / elevated temperature. Proper understanding of the degradation routes and mechanisms, as well as their influence on mechanical properties, is essential for the development of reliable structural design approaches and effective mitigation strategies. This article presents an overview of the influence of various exposure environments on the behavior of FRP materials and of the available data reported in literature, focusing on systems comprised of typical synthetic fibers (glass, basalt and carbon) and thermoset resins (epoxy, vinyl ester and polyester).

Several peer-reviewed studies have addressed this topic under a wide range of environmental conditions, including hygrothermal aging, exposure to alkaline or acidic solutions, ultraviolet (UV) radiation, freeze-thaw cycles, and fire / elevated temperatures. Studies focused on natural weathering and on the combination of environmental actions and mechanical loading are also available elsewhere [1,2]. Figure 1 summarizes the percentage of peer-reviewed papers published over the last 20 years addressing individually the influence of different environments on the mechanical properties of FRP materials. These papers were collected using a systematic literature review approach [3], considering Scopus and Web of Science databases.

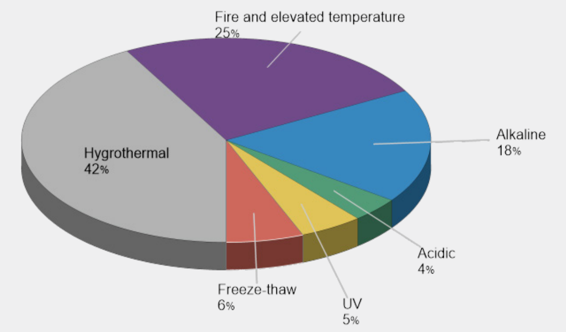


Fig. 1: Percentage of papers published by different exposure environments.

When exposed to high relative humidity or water immersion, moisture penetrates polymer composites through several mechanisms, including diffusion into the bulk matrix (through the free volume of the amorphous phase), capillary transport along fiber/matrix and interlaminar surfaces, and transport through microcracks and voids networks. Moisture absorption may reduce mechanical properties due to matrix plasticization, hydrolysis, and swelling stresses. While the effects of plasticization are fully or partially reversible, hydrolysis and swelling-induced microcracks result in permanent damage. The magnitude of degradation strongly depends on the material formulation and manufacturing process.

Editor's note: IIFC launched six new task groups in March 2025 to promote research and collaboration on emerging topics with widespread interest among research and industry members. This article is part of a regular series in which the various task groups will highlight key trends and opportunities in the field of FRP composites for construction.

For more information, see https://www.iifc.org/publications-resources/task-groups/ or contact Chao Wu.

For example, moisture-induced degradation is generally lower in vinyl ester than in polyester systems due to their denser and less heterogeneous microstructure, and to the lower number of ester groups along the polymer backbone [4, 5]. Nevertheless, after an initial reduction in properties, retention levels often stabilize over time. It is widely acknowledged that moisture-related degradation is thermally activated, meaning that water absorption and associated damage mechanisms may be accelerated at higher temperatures, provided the temperature remains below the glass transition temperature (Tg). Arrhenius-based models are commonly adopted to determine acceleration factors relative to reference conditions [6].

In alkaline environments, FRP degradation is mainly associated with matrix hydrolysis, fiber–matrix debonding, and, in some cases, fiber damage. Glass fibers are particularly susceptible to hydrolysis due to the scission of the Si–O–Si network by hydroxyl ions, leading to more severe degradation – alkali-resistant fibers may be used for this purpose. Since FRP bars are widely used as concrete reinforcement, accelerated aging tests are commonly analyzed also using the Arrhenius law to estimate long-term performance [7,8]. However, moderate temperatures used in these tests may also promote matrix post-curing, especially in partially cured systems, which can temporarily improve some matrix-dominated properties and make the early degradation response more complex [9]. In contrast, exposure to acidic solutions has been less extensively investigated. Existing studies indicate that weak acidic solutions may even improve the fiber–matrix interface, whereas strongly acidic conditions (e.g., pH ≈ 3) can significantly reduce mechanical properties [10].

Degradation may also result from the nucleation and propagation of damage induced by thermal cycling. Such damage is associated with stress concentrations arising from mismatches in thermal expansion or moisture absorption coefficients, coupled with the previously mentioned chemo-physical changes [11]. In these cases, the presence of moisture plays a decisive role. For freeze-thaw cycles, for example, soaked specimens often exhibit significant reductions in mechanical properties due to the freezing and expansion of entrapped water [12]. Conversely, improvements in the fiber–matrix interface have been reported for dry specimens [5]. Similar to hygrothermal aging, degradation during freeze-thaw exposure tends to be more pronounced during the initial cycles and subsequently stabilizes.

UV radiation may cause photo-oxidation, involving the breakdown of chemical compounds due to sunlight exposure. As a result, UV exposure may lead to gloss loss, discoloration such as yellowing, flaking, surface microcracking, gradual matrix–fiber debonding and fiber exposure, and other surface-related damage mechanisms, typically limited to a superficial layer on the order of 10 μm in depth [13].

As the damage is often concentrated in the outer layers of the polymer matrix, the elastic modulus may remain relatively stable, while tensile, flexural, or interlaminar properties can be more sensitive depending on the exposure time and environmental conditions. In general, UV exposure tends to cause relatively small reductions in mechanical properties, often below 10%, although more severe reductions have also been reported in the literature [14].

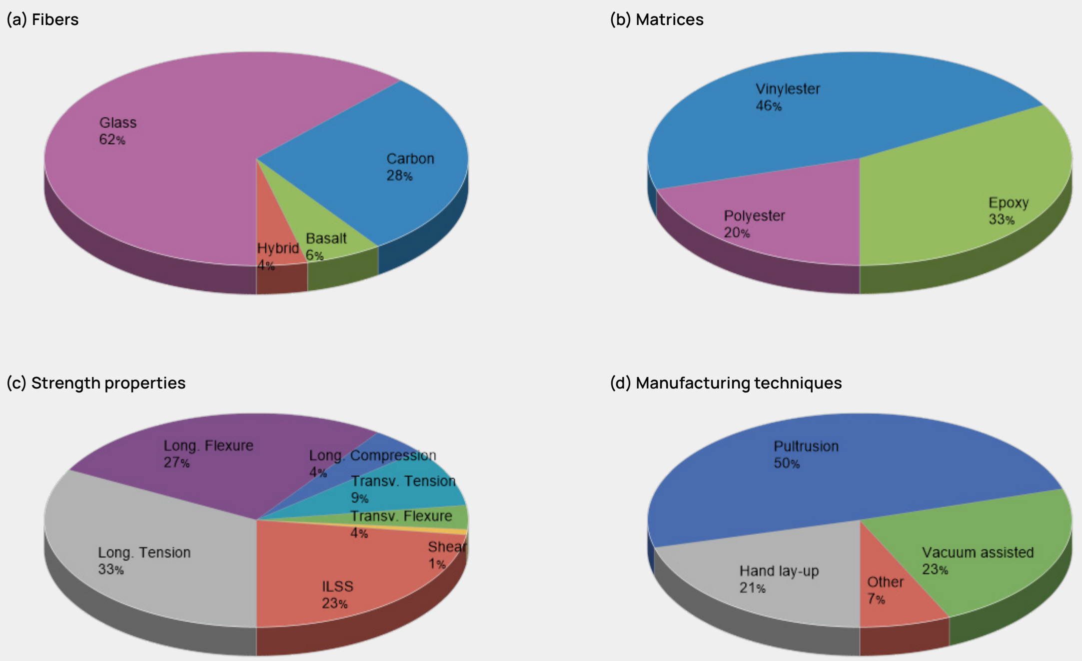
The performance of pultruded FRP materials under fire exposure is also a major concern due to polymer softening and decomposition. Matrix softening occurs at temperatures approaching Tg and more significantly affects matrix-dominated properties, such as shear and compression. As the decomposition temperature (Td) is approached, near-zero property retention is observed for matrix-dominated properties [15]. Both Tg and Td strongly depend on the polymer matrix. For example, unsaturated polyester resins exhibit relatively low thermal stability, with Tg and Td typically ranging from 50–120 °C and 250–350 °C, respectively, whereas phenolic resins are considerably more stable, with Tg and Td commonly ranging from 120–250 °C and 350–500 °C [16-18]. During heating, the heat release rate initially increases due to the ignition of flammable volatile compounds generated by polymer decomposition, followed by a gradual reduction associated with resin consumption and char layer formation. In general, phenolic-based composites exhibit lower contents of combustible volatiles, greater char-forming capability, and lower tendencies for flame spread and smoke generation [17,19]. It is also important to note that partially cured systems may undergo post-curing during heating, resulting in temporary gains in mechanical properties at moderate temperatures [20]. Fibers themselves are also affected by elevated temperatures. Glass fibers, for instance, soften at temperatures ranging from approximately 800 to 900 °C, while carbon fibers may oxidize in air at temperatures around 500–600 °C [21,22]. In general, empirical relationships are used to describe property retention as a function of temperature. Because the thermo-mechanical response is highly dependent on material formulation, a unified model to describe property retention as a function of temperature is still lacking and requires further investigation.

Currently, international codes and guidelines devoted to full-FRP structures, such as the American Standard ASCE/SEI 74-23 [23] – for pultruded FRP – and the European Technical Specification CEN/TS 19101:2025 [24], provide design recommendations for various environmental exposure conditions, particularly moisture and temperature. In most cases, reduction factors are applied to the mechanical properties adopted in design. This approach attempts to condense the influence of complex degradation mechanisms into empirical and easy-to-use knockdown factors. However, the absence of distinctions regarding manufacturing techniques, material formulations, and exposure conditions may result in overly conservative or potentially unsafe predictions. One important contribution of CEN/TS 19101:2025 is the adoption of different reduction factors for matrix- and fiber-dominated properties, recognizing that these properties are differently affected by environmental degradation. These documents also include recommendations for surface protection, such as the use of veils and protective coatings and additives, like UV absorbers and blockers. A previous version of the European Specification provided an annex containing general guidance for fire design – to be addressed in another part of the CEN 19101 –, including recommendation for the use of flame-retardant additives, indicative retention curves for matrix- and fiber-dominated properties and changes in thermo-physical properties with temperature.

The development of more comprehensive design approaches for FRP materials under environmental degradation requires the collection and organization of robust experimental databases. Although numerous review papers are available, they are often focused on specific materials or exposure conditions, which may lead to biased datasets. In practice, such databases must address several challenges, including: (i) the wide variety of material formulations and manufacturing techniques used in FRP production; (ii) the heterogeneous and complex mechanical behavior of FRP composites compared with homogeneous isotropic materials; and (iii) the diversity of accelerated aging and environmental conditioning protocols adopted in the literature.

As an example, Figure 2 shows that, in the case of hygrothermal aging, most available data are related to fiber-dominated properties and composites manufactured with glass fibers, vinyl ester matrices, and pultrusion processes. To address this limitation, IIFC Task Group 3 (FRP in Extreme Settings) is currently working on the development of a transparently curated database that can be continuously updated by engineers and researchers worldwide with peer-reviewed and proprietary data.

Fig. 2: Classifications of collected data for hygrothermal aging.



REFERENCES

1. Rosa, I. C., Castelo, A., Sousa, J. M., Garrido, M., Correia, J. R., Cabral-Fonseca, S., & De Brito, J. (2024). Natural weathering of GFRP structures: Case studies, data survey, and proposal of a moisture conversion factor for durability design. Journal of Composites for Construction, 28(6), 04024063. https://doi.org/10.1061/JCCOF2.CCENG-4869
2. Wang, J., GangaRao, H., Liang, R., Zhou, D., Liu, W., & Fang, Y. (2015). Durability of glass fiber-reinforced polymer composites under the combined effects of moisture and sustained loads. Journal of Reinforced Plastics and Composites, 34(21), 1739–1754. https://doi.org/10.1177/0731684415596846
3. Thomé, A. M. T., Scavarda, L. F., & Scavarda, A. J. (2016). Conducting systematic literature review in operations management. Production Planning & Control, 27(5), 408–420. https://doi.org/10.1080/09537287.2015.1129464
4. Vieira, P. S., da Silva, G. A., Lopes, B. J., D'Almeida, J. R., da Silva, A. H., & Cardoso, D. C. (2023). Hygrothermal aging of steel/FRP pipe repair systems: A literature review. International Journal of Pressure Vessels and Piping, 201, 104881. https://doi.org/10.1016/j.ijpvp.2022.104881
5. Liu, T., Liu, X., & Feng, P. (2020). A comprehensive review on mechanical properties of pultruded FRP composites subjected to long-term environmental effects. Composites Part B: Engineering, 191, 107958. https://doi.org/10.1016/j.compositesb.2020.107958
6. Bank, L. C., Gentry, T. R., Thompson, B. P., & Russell, J. S. (2003). A model specification for FRP composites for civil engineering structures. Construction and Building Materials, 17(6–7), 405–437. https://doi.org/10.1016/S0950-0618(03)00041-2
7. Zhu, D., Yang, J., Chu, K., & Guo, S. (2025). Effect of alkalinity and pre-cracks of seawater sea-sand concrete on the deterioration of BFRP bars in marine environment. Construction and Building Materials, 468, 140356. https://doi.org/10.1016/j.conbuildmat.2025.140356
8. Santos, L. F. O., da Silva Forti, N. C., Cardoso, D. C. T., dos Santos, N. V., Pimentel, L. L., & de Avila Jacintho, A. E. P. G. (2025). Hydrothermal aging of polyester-based GFRP bars in alkaline environment. Materials and Structures, 58, 106. https://doi.org/10.1617/s11527-025-02629-6
9. Delaplanque, N., Tharreau, M., Chataigner, S., Quiertant, M., Benzarti, K., Battais, L., Rolland, A., Gaillet, L., & Bourbon, X. (2024). Durability of partially cured GFRP reinforcing bars in alkaline environments with or without sustained tensile load. Construction and Building Materials, 442, 137603. https://doi.org/10.1016/j.conbuildmat.2024.137603
10. Zhu, X., Guo, Z., & Zhao, L. (2025). Experimental study of the long-term mechanical properties of BFRP bars in a corrosive environment. Materials and Technology, 59, 289–297. https://doi.org/10.17222/mit.2024.1327
11. Hasan, T., Correia, J. R., Garrido, M., Soares, F., Cabral-Fonseca, S., Jorge, M., & Sena-Cruz, J. (2024). Freeze-thaw durability of vacuum infused glass fibre composites with unsaturated polyester and vinyl ester matrices. Construction and Building Materials, 455, 139037. https://doi.org/10.1016/j.conbuildmat.2024.139037
12. Karbhari, V. M. (2004). E-glass/vinylester composites in aqueous environments: Effects on short-beam shear strength. Journal of Composites for Construction, 8(2), 148–156. https://doi.org/10.1061/(ASCE)1090-0268(2004)8:2(148)
13. Tostes, M. V. P. H., & d'Almeida, J. R. M. (2025). Effect of UV radiation exposure and simulated particle erosion damage on the mechanical behavior of carbon/glass hybrid composites. Polymers, 17(7), 861. https://doi.org/10.3390/polym17070861
14. Kim, J., Kang, S., Seong, I., Jeon, J. W., Lee, D., Kim, J.-H., & Kwon, D.-J. (2025). Advancing CFRP durability: Interfacial and weathering performance of epoxy and acrylic matrices. Composites Part B: Engineering, 297, 112315. https://doi.org/10.1016/j.compositesb.2025.112315
15. Correia, J. R., Bai, Y., & Keller, T. (2015). A review of the fire behaviour of pultruded GFRP structural profiles for civil engineering applications. Composite Structures, 127, 267–287. https://doi.org/10.1016/j.compstruct.2015.03.006
16. Laoubi, K., Hamadi, Z., Ahmed Benyahia, A., Serier, A., & Azari, Z. (2014). Thermal behavior of E-glass fiber-reinforced unsaturated polyester composites. Composites Part B: Engineering, 56, 520–526. https://doi.org/10.1016/j.compositesb.2013.08.085
17. Kandola, B. K., Krishnan, L., Deli, D., & Ebdon, J. R. (2015). Blends of unsaturated polyester and phenolic resins for application as fire-resistant matrices in fibre-reinforced composites. Part 2: Effects of resin structure, compatibility and composition on fire performance. Polymer Degradation and Stability, 113, 154–167. https://doi.org/10.1016/j.polymdegradstab.2014.11.002
18. Xu, Y., Guo, L., Zhang, H., Zhai, H., & Ren, H. (2019). Research status, industrial application demand and prospects of phenolic resin. RSC Advances, 9(50), 28924–28935. https://doi.org/10.1039/C9RA06487G
19. Kim, M., Choe, J., & Lee, D. G. (2016). Development of the fire retardant glass fabric/carbonized phenolic composite. Composite Structures, 148, 191–197. https://doi.org/10.1016/j.compstruct.2016.04.003
20. Karbhari, V. M., Xian, G., & Hong, S. K. (2021). Effect of thermal exposure on carbon fiber reinforced composites used in civil infrastructure rehabilitation. Composites Part A: Applied Science and Manufacturing, 149, 106570. https://doi.org/10.1016/j.compositesa.2021.106570
21. Shi, X. H., Li, X. L., Li, Y. M., Li, Z., & Wang, D. Y. (2022). Flame-retardant strategy and mechanism of fiber reinforced polymeric composite: A review. Composites Part B: Engineering, 233, 109663. https://doi.org/10.1016/j.compositesb.2022.109663
22. McKenzie, F., Kandola, B. K., Horrocks, A. R., & Erskine, E. (2024). Carbon fibres: Effect of various thermo-oxidative environments on structural and performance damage, both alone and in composites. Carbon, 230, 119616. https://doi.org/10.1016/j.carbon.2024.119616
23. American Society of Civil Engineers. (2023). Load and Resistance Factor Design (LRFD) for Pultruded Fiber Reinforced Polymer (FRP) Structures: ASCE/SEI 74-23. Reston, VA: American Society of Civil Engineers. https://doi.org/10.1061/9780784415771
24. European Committee for Standardization. (2025). Design of fibre-polymer composite structures: CEN/TS 19101:2025. Brussels, Belgium: European Committee for Standardization.

MEET THE PEOPLE

Eric Moussiaux

Education: Master of Science degree in Civil Engineering from the Free University of Brussels and a Postgraduate Master of Science from Virginia Tech in Composites and Adhesives

Current affiliation: Vice president Technology Exel Composites; Guest professor at MEMC department of the Free University of Brussels (VUB); Member of the Board of the European Composites Industry Association (EuCIA); Member of the Board of the European Pultrusion Technology Association (EPTA); Liaison officer for EuCIA to CEN TC 250 WG4 developing the Eurocode for Composites; Member of the Board of UNIK group of 28 schools in the Brussels area.

Key roles and contributions: EM has been working in the same industry (composites and more specifically pultrusion) and for the same company throughout his career covering most of the functions inside the company (R&D, sales and marketing, business development, general management) while at the same time being active in industry associations for over 30 years.

Eric Moussiaux holds a Master of Science degree in Civil Engineering from the Free University of Brussels and a postgraduate Master of Science from Virginia Tech in composites and adhesives. He is currently vice president technology at Exel Composites, after previous positions in R&D, sales and marketing and business unit management in the field of pultrusion. He fell in love with composites during his student days over forty years ago, and started his career in it back in 1988. Eric Moussiaux is one of the founders and long-term Board Member of the European Composites Industry Association EuCIA. He also serves on the Board of the European Pultrusion Technology Association (EPTA) and, until May 2025, on the board of the Belgian technology federation Agoria Flanders.

He is the liaison officer for EuCIA in CEN TC250 WG4 writing the Eurocode for composites and developing an execution code for composite structures. Eric's involvement in composite industry associations spans over three decades. Privately, Eric Moussiaux has a special interest in education, teaching his own course on 'Design of lightweight composite structures' as Guest Professor at the Free University of Brussels, and having a seat in the Board of a group of 28 schools in the South-West region of Brussels.

Fig. 1: Meeting with Brandt Goldsworthy, the inventor of pultrusion (Nashville 1997)

Fig. 2: Celebrating EN 19101 and ASCE 74 design standards on composite structures with ACMA's John Busel (Chicago 2023)

When and how did your interest on FRP composites first develop?

I fell in love with composites at the end of 1983 in a course by Prof Patrick Dewilde in my civil engineering education at the Free University of Brussels, just weeks before meeting the real love of my life Karina

In your view, what are the main current and future challenges regarding the application of composites in civil engineering?

I am totally convinced that composites have their place besides the other traditional construction materials where designed-in properties really make a difference in 'sustainable lasting performance.

Exel proposed equity story for composites: During their very long service life, composites are strong enablers for even faster decarbonization, by their unique possibilities for innovative design of shapes and by tailoring the material properties towards a worldwide growing need for lightweight solutions. Composites are here to stay and grow, they are designed to perform, and they are made to last. This is our true value proposition: 'Composites designed for sustainable lasting performance'.

As the civil engineering world is very conservative, partly because safety is very important, we need good standards, strong companies and excellent showcases.

Can you describe a particularly impactful project or initiative you have been involved related with FRP composites and its outcomes?

I think I have been one of the pioneers in Europe bringing pultruded composites into buses and trains, starting late eighties, both from a technological as from commercial perspectives.

Being, together with Fiberline of Denmark, the driving force in developing the European Standard for pultrusion EN 13706 and bringing the E23 quality to a worldwide accepted standard (second half of the nineties). The outside body panels of the Bombardier Talent trains in picture 3 were developed in 1997 and still look great 25 years later That has led to contributing to the Eurocode for composites much later.

Can you share the most rewarding moments or achievements in your professional career?

When asked at the beginning of my career for my long-term ambition, my answer was to become a worldwide respected person in composites technology. Now, closing my circle, I think I have achieved that ambition. In 2017 I was asked to become guest professor at the Free University of Brussels teaching composites to the engineering students; I am a respected member of plenty of industry associations.

I was asked by Prof Verpoest to write the chapter on pultrusion in his History of Composites book and I have been an invited speaker in many composite conferences on a worldwide level. Yes, I am proud and happy about all that.

If you were starting your career today as a young engineer/researcher, what advice would you give yourself?

Follow your dreams and interests, never stop learning, never lose your engineering understanding, stay within your personality while not being afraid of new challenges.

Find a good mentor! I will never forget my few meetings with Brandt Goldsworthy, inventor of pultrusion and one of the all-time greatest composites pioneers (who even remembered my name): 'our industry needs young, motivated people like you'.

What is your favourite hobby outside of work?

Outside of work, my greatest passion is spending time with my family. I also greatly enjoy photography, as well as playing cards and snooker with friends.

Currently, I am teaching at the Free University of Brussels while also serving as a Board Member of the UNIK group, which includes 28 schools in the southwest region of Brussels. As I believe it is time for me to give something back, for the last 10 years, I have a growing interest and commitment in education, at all levels.

What is/was your favourite trip?

There have been many memorable trips over the years, but traveling across the Western United States and Canada in an RV with my family has certainly been among the most rewarding experiences. More recently, I visited the Galápagos Islands and Costa Rica, both of which felt like living zoos because of their extraordinary biodiversity and unique wildlife

Which are your favourite songs?

I am particularly fond of rock music from the 1960s and 1970s. Among my favourite bands are The Rolling Stones, Fleetwood Mac, AC/DC, Queen, and The Eagles. My all-time favourite song is Samba Pa Ti by Carlos Santana.

Fig. 3: Bombardier Talent trains still looking great (2024)

COMPOSITES AROUND THE WORLD

Research

Automated Robotic System for FRP Application in Steel Structures

Panlei Chen
School of Ocean and Civil Engineering, Shanghai Jiao Tong University, Shanghai 200240, China

Lili Hu
School of Future Cities, University of Science and Technology Beijing, Beijing 100083, China

Peng Feng
Department of Civil Engineering, Tsinghua University, Beijing 100084, China

ABSTRACT

FRP reinforcement applied through surface bonding can significantly improve the mechanical performance of steel structures. However, current FRP application largely depends on manual operations (Fig. 1), making it difficult to precisely control process parameters and ensure optimal bonding quality. This study developed an automated robotic system for FRP application in steel structures, integrating steel surface grinding, adhesive application, FRP rolling/pressing, laying, and cutting (Fig. 2). The research covers the mechanism design, control system development, and proposed a robotic reinforcement procedure. Parameter studies were conducted through experimental and theoretical analyses to determine the optimal sequence and operation parameters. Validation tests showed that the CFRP-steel interface achieved an ultimate load capacity of 46 kN, 32% higher than the manual result of 35 kN. Moreover, the robotic system applied single-layer FRP sheet 60% faster than manual operations. The development of an integrated end-to-end robotic FRP bonding workflow overcomes the limitations of manual methods and paves the way for intelligent construction technologies.

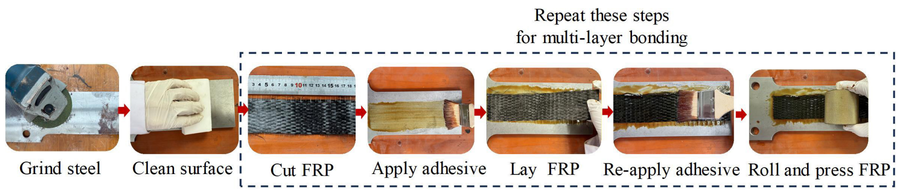


Fig. 1: Manual FRP application process

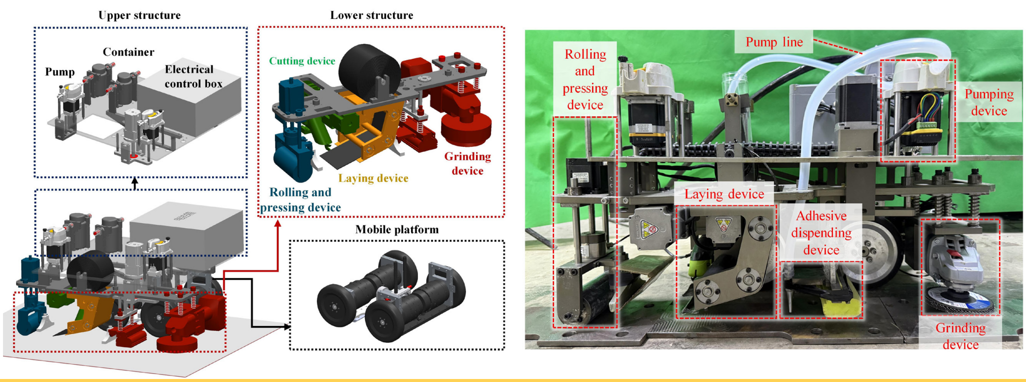


Fig. 2: Structure of robotic system

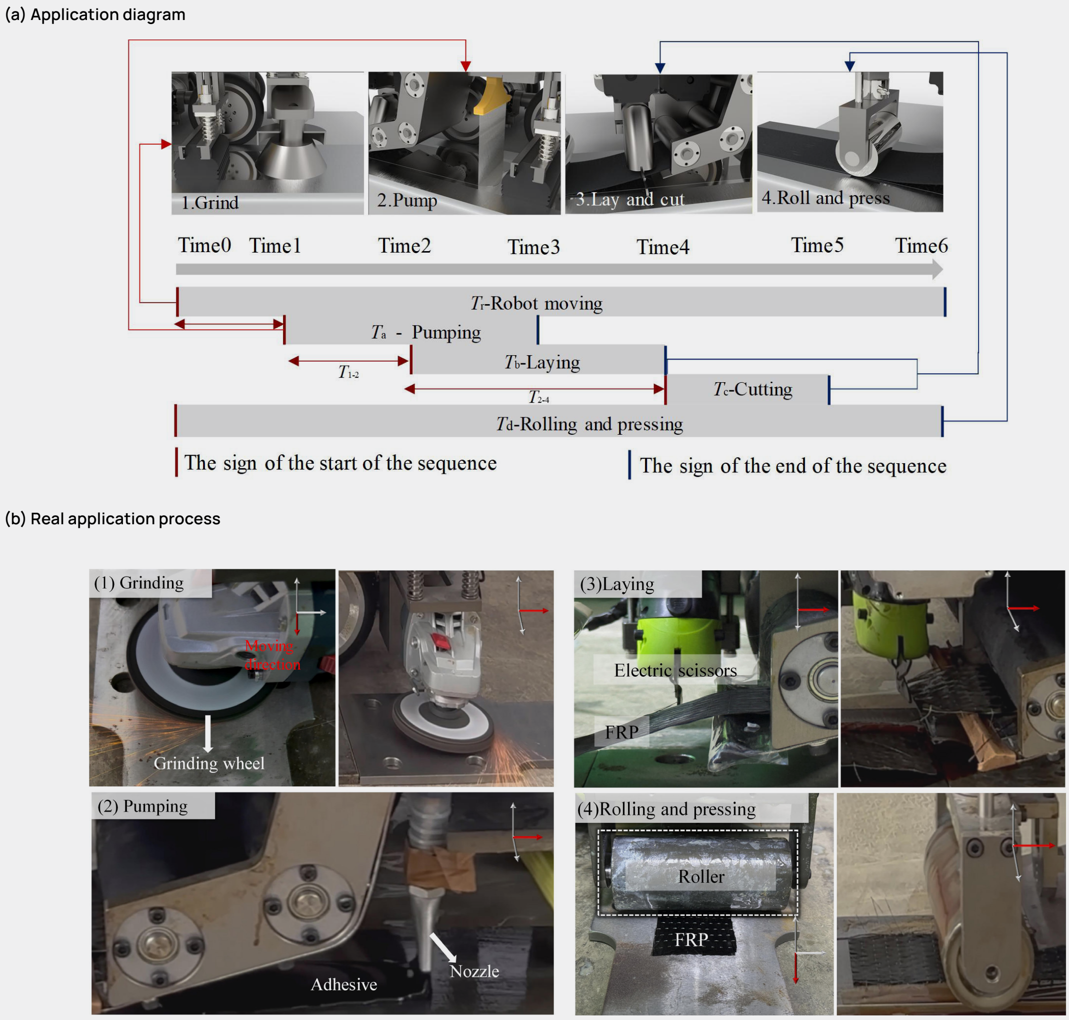


Fig. 3. Robotic system operation

RESEARCH OBJECTIVE

Four key research objectives are as follows: (1) Develop an FRP application automated robotic system integrating mechanism, hardware, and software design. (2) Establish a time sequence for the full robotic FRP bonding process. (3) Conduct a systematic parameter study determining the optimal ones through experimental and theoretical analysis. (4) Validate the whole process using the robotic system and prove bonding quality and operational efficiency.

MECHANISM DESIGN AND FRP BONDING WORKFLOW

The overall structure of FRP application robotic system consists of three main components (Fig. 2): the lower structure, upper structure, and mobile platform. The lower structure integrates all operational devices for FRP application.

The upper structure integrates the electrical control box, adhesive storage bottles, and pump devices. The mobile platform employs a wheeled locomotion system that utilizes powerful permanent magnets at its base to achieve adsorption to steel structures.

Based on this hardware configuration, the entire robotic operation follows a sequential work cycle, as illustrated in Fig. 3. First, the robot performs targeted surface grinding and completes preset roller pressure application. Then, the robot conducts sequential adhesive pumping, FRP laying and continuous rolling pressing, followed by automatic FRP cutting once the preset laying length is fulfilled. Afterwards, the robot moves forward to finish compaction of the residual bonding area and then returns along the original path. The whole working cycle repeats until the preset number of FRP layers is achieved, and the robot stops operation ultimately.

KEY CONSTRUCTION PARAMETERS

To investigate how key construction parameters affect bonding quality, we performed single shear tests using various surface roughness levels and adhesive layer defect tests under different pressing forces and bonding workable times. The relationship between surface roughness (S_a) and bonding capacity are shown in Fig. 4 (a), which reveals an optimal roughness ($S_a \approx 3.7$ μm) maximizing interfacial bonding capacity. Defect detection results are shown in Fig. 4 (b), which reveals that adhesive defects are slightly affected by pressure but highly sensitive to bonding time. The defect area ratio reaches about 25% at 30 min bonding time, but remains below 12% within 15 min, due to increased adhesive viscosity over time.

Based on the above studies, the optimal construction parameters for the robotic system are obtained.

VERIFICATION TEST

A single lap test was conducted to verify the bonding performance and efficiency of the robotic system. The experimental results (Fig. 5) show that the robot-made specimen achieved an ultimate load capacity of 46.19 kN, about 32% higher than the human-made one (35 kN). During the test, the robotic system completed a single layer in approximately 125 s, compared to 201 s for manual operation, representing an approximately 60% increase in speed.

Fig. 4. Effect of key construction parameters on bonding quality

(a) Ultimate loads of specimens with different surface roughness

(b) Defects of specimens with different press and bonding workable time

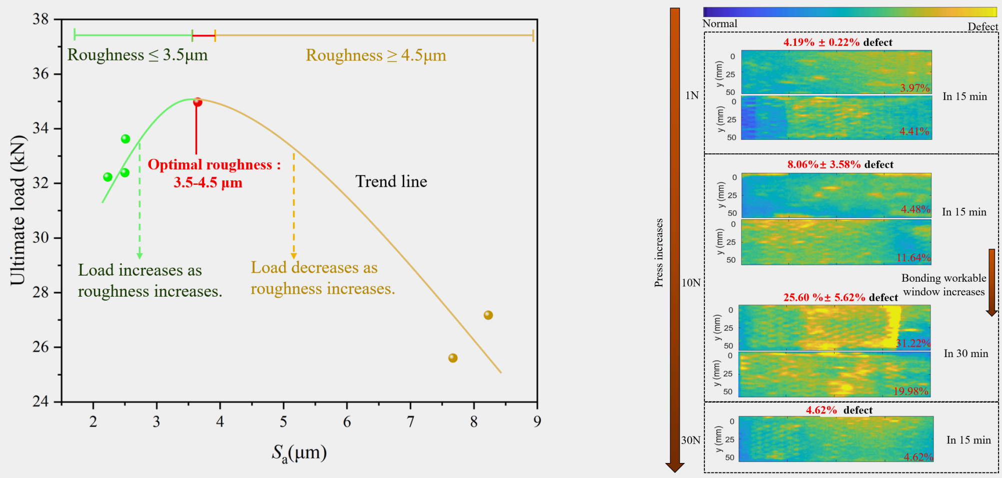
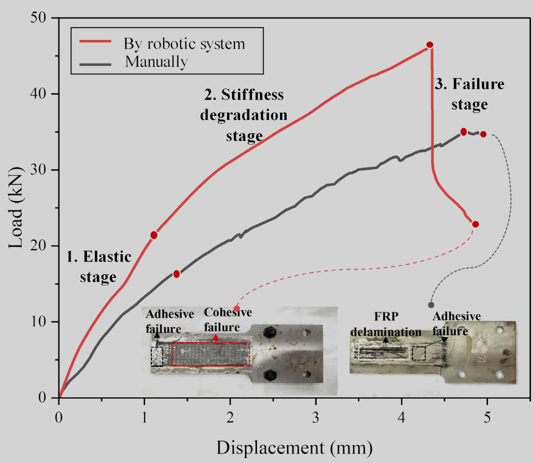


Fig. 5 Comparison of bonding behaviors of robot-made and human-made specimens



NOTE

These findings are drawn from the study presented in: Panlei Chen, Lili Hu, Peng Feng, et al., Automated robotic system for FRP application in steel structures, Automation in Construction, Volume 188, 2026, 106946, https://doi.org/10.1016/j.autcon.2026.106946.

COMPOSITES AROUND THE WORLD

Research

Effects of Peel Angle on the Bond between FRCM Composite and Concrete Substrate

Lucas Robert Gervais
Master of Science, Department of Civil, Construction, and Environmental Engineering
South Dakota State University

Akram Jawdhari, PhD, PEng, M. ASCE
Assistant Professor, Department of Civil, Construction, and Environmental Engineering
South Dakota State University

Hussein Jaaz
PhD student, Department of Civil, Construction, and Environmental Engineering
South Dakota State University

INTRODUCTION

Fabric-reinforced cementitious matrix (FRCM) composites continue to gain attention as a strengthening solution for concrete structures because they combine textile reinforcement with a durable cement-based matrix. Compared with polymer-based fiber reinforced polymer (FRP) systems, FRCM composites are more breathable, more tolerant of heat, and generally better suitable for applications where moisture, fire exposure, or substrate compatibility are important. These advantages make FRCM a strong candidate for the rehabilitation of concrete bridge girders and piers, building columns, beams, walls, and other structural members that need added capacity without major changes to geometry or service conditions.

Despite the growing use of FRCM systems, their performance is controlled not only by the mechanical behavior of the textile and mortar components or the composite, but also by the bond between the composite and the concrete substrate. Bond failure is often a governing limit state in externally bonded strengthening systems, and once debonding begins, the reinforcement can no longer fully contribute to the structural response. For that reason, understanding how the interface behaves is essential for both design and assessment of FRCM-strengthened reinforced or prestressed concrete members.

Although several studies have investigated FRCM–concrete bond behavior, they have primarily focused on Mode II debonding, where the interface is subjected to pure shear stresses. In contrast, mixed mode debonding; where normal (peeling) stresses act in combination with shear and can significantly reduce bond capacity; has received comparatively limited attention.

RESEARCH SIGNIFICANCE

The bond behavior of FRCM systems has been studied extensively under direct shear and other simplified conditions, but real structures rarely behave in such an idealized manner. In practice, strengthened members rarely experience pure shear along the bond line; instead, the interface is subjected to combined shear and normal stresses, particularly near geometric discontinuities (e.g., curved, arched, or tapered soffits) and intermediate shear or flexural-shear cracks.

Even a relatively small peeling component can alter stress distribution, accelerate debonding initiation and propagation, and change the governing failure mode.

The present study systematically investigates the effects of mixed-mode debonding by varying the peel angle in a series of FRCM-to-concrete bond tests. The primary objective is to quantify the reduction in ultimate bond capacity with increasing peel angle and to examine the effects of key variables such as textile reinforcement ratio in strain development, interfacial shear stress distribution, and debonding mechanisms. In addition, the study provides a practical analytical interpretation of the observed behavior, with the aim of informing future bond models and design recommendation

METHODOLOGY

The experimental program included 36 specimens and investigated two main variables: peel angle (θ) and textile reinforcement ratio (ρ). Eight angles were examined, namely: 0°, 2°, 4°, 8.5°, 14°, 19.3°, 26.6°, and 36.9°. Three reinforcement ratios were evaluated, namely: 2.61, 3.93, and 5.23%.

It should be noted that ρ was calculated by finding the smeared area of the C-FRCM strands and then dividing it by the area of the embedding mortar. The main reinforcement ratio was ρ =3.93% which was studied for 20 specimens, evaluating all eight angles above. The two other reinforcement ratios were tested with a subset of four angles: 0°, 4°, 8.5°, 19.3°.

A custom-made test apparatus was fabricated where a concrete block was bonded on one side to a single C-FRCM segment and then loaded at the desired angle.

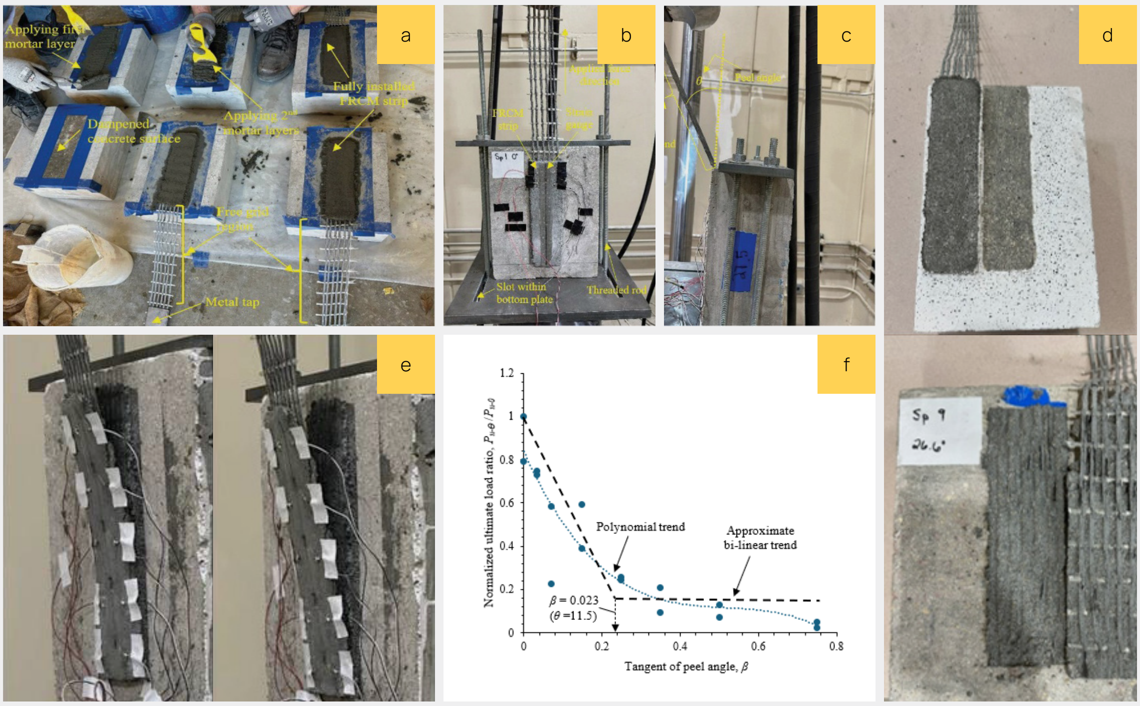
The concrete blocks used in the study were cast and cured according to standard laboratory practice. The substrate had a 28-day compressive strength of 31.71 MPa. The FRCM composite consisted of a carbon textile grid embedded in a cementitious mortar. The mortar had a tensile modulus of 26.8 GPa, a flexural strength of 6.9 MPa, and an average 28-day compressive strength of about 62 MPa based on prior testing. The carbon textile had an equivalent dry thickness of 0.157 mm, an ultimate tensile strength of 450 kN/m, and an ultimate tensile strain of 1.5%.

The specimens were prepared by grinding the concrete surface to remove laitance and improve mechanical interlock. Before applying the FRCM, the substrate was dampened with water. A layer of mortar was first placed on the concrete, the textile grid was embedded into the fresh mortar, and a second mortar layer was applied on top (Figure 1 (a)). The textile extended beyond the bonded region to permit loading during the test. After application, the specimens were wrapped in wet burlap and plastic sheets to ensure a 7-day wet curing period.

EXPERIMENT SETUP

A universal testing machine with a capacity of 245 kN was used to apply the load. The custom jig in Figure 1 (b, c) held the concrete block in place and allowed the unbonded textile segment to be pulled at the chosen angle. The specimen was positioned to achieve the target peel angle by adjusting the horizontal and vertical projections of the unbonded textile segment relative to the vertical, ensuring the specified angle was satisfied.

Figure 1: (a) Installation steps for C-FRCM reinforcement; (b)&(c) Test setup for mixed-mode specimens comprising FRCM-concrete bond joint; (d) & (e) observed debonding modes in experimental tests; (f) normalized bond strength vs. tangent of peeling angle relation



RESULTS AND DISCUSSION

The experimental results showed a clear and consistent trend: the ultimate load (P_u) decreased as the peel angle increased (Figure 1 (f)). Specimens subjected to pure shear (mode II) stress attained the highest bond strength. In general, P_u reduces with the increase of ϴ (and its tangent (β)) for all textile reinforcement ratios. As ϴ increased from 0^0 to 19.30 for ρ = 2.61%, from 0^0 to 36.90 for ρ = 3.93%, and from 0^0 to 19.30 for ρ = 5.23%, P_u at any angle ((P_u-ϴ)), normalized by dividing over the P_u of the specimen tested under pure shear (P_u-0), reduced from 1 to 0.03, from 1 to 0.02, and from 1 to 0.13, respectively. This finding suggests that existing bond models for FRCM-concrete joints, which are often derived based on pure shear interfacial conditions, may need adjustments to incorporate mixed-mode scenarios where both shear and peeling forces are present.

Two debonding failures were observed in the experiments, at the mortar-concrete interface, debonding at the grid-mortar interface (Figure 1 (c, d)), The first failure dominated in specimens with small peel angles, with the second being more observed for larger angles.

The study also found that increasing the textile reinforcement ratio did not produce a simple monotonic increase in ultimate load. Instead, the reinforcement ratio had a stronger influence on the failure mode than on the peak capacity itself. Specimens with lower reinforcement ratios tended to fail by debonding at the FRCM-concrete interface, while higher ratios shifted failure more often to the textile-mortar interface. This shift is likely related to reduced mortar penetration through the textile grid and lower mechanical interlock when the grid openings are smaller.

PRACTICAL IMPLICATIONS

The findings of this study have direct implications for the design and rehabilitation of FRCM-strengthened members. Achieving the intended strengthening capacity requires that the reinforcement be provided with sufficient development length (l_d). Current design provisions, such as those in American Concrete Institute ACI 549.4-20 [7], provide expressions for for l_d; however, these formulations are primarily derived from Mode II (pure shear) bond behavior and may not be applicable in situations where peeling (normal) stresses are present. The results of this study demonstrate that mixed-mode conditions can significantly reduce bond capacity. Accordingly, modifications to existing design approaches are needed to account for the influence of peeling stresses. The proposed relationship between normalized bond strength and the tangent of the peel angle (Fig. 1(f)) may be used to adjust bond strength predictions obtained from Mode II-based formulations.

For practical application, the peel angle associated with service conditions must be estimated, highlighting the need for further research in this area.

In addition, peeling stresses are likely to develop at the tips of shear and shear–flexural cracks near FRCM termination regions, potentially triggering intermediate crack-induced debonding (ICID). While ICID has been extensively studied for FRP systems, with well-established analytical models, its behavior in FRCM systems remains largely unexplored and warrants further investigation.

From a detailing perspective, anchorage and termination design should be carefully considered in the presence of peeling stresses. Strategies such as mechanical anchorage, increased development length, gradual load transfer, and improved surface preparation may enhance bond performance and delay debonding. Furthermore, selection of textile ratio should account not only for strength demands but also for effective mortar penetration and mechanical interlock with the textile grid, as excessively high textile ratios may shift the failure mode toward the textile–mortar interface.

Finally, a simple analytical expression for the bond strength (P_u) of FRCM-concrete joint as a function of the studied parameters, namely: ρ and ϴ (or its tangent β) has been developed based on nonlinear regression of the experimental data. This expression provides a preliminary tool for design-oriented calculations and highlights the governing role of mixed-mode effects in FRCM bond behavior:

$$P_u = \beta^{-0.79} * \rho^{-0.47} * 1.18$$

CONCLUSIONS

An experimental program comprising 36 specimens was conducted to investigate the mixed-mode bond behavior of FRCM–concrete joints, focusing on the effects of peel angle (θ = 0°–36.9°) and textile reinforcement ratio (ρ = 2.61%–5.23%). The results demonstrate that bond capacity is highly sensitive to peel angle, with a pronounced reduction in ultimate load even at relatively small deviations from pure shear conditions; for example, an 88% reduction was observed for ρ = 3.93% as θ increased to 11.5°, beyond which the rate of reduction diminished. While the reinforcement ratio had a limited effect on peak load, it significantly influenced the governing failure mode, with higher ρ values shifting failure from the FRCM–concrete interface to the textile–mortar interface due to reduced mortar interlock. These findings underscore the need to extend current design approaches, which are primarily based on pure shear behavior, to incorporate the influence of peeling stresses in FRCM strengthening systems.

REFERENCES

1. O. Awani, T. El-Maaddawy, and N. Ismail, “Fabric-reinforced cementitious matrix: A promising strengthening technique for concrete structures,” Construction and Building Materials, 2017.
2. L. H. Sneed, T. D'Antino, C. Carloni, and C. Pellegrino, “A comparison of the bond behavior of PBO-FRCM composites determined by double-lap and single-lap shear tests,” Cement and Concrete Composites, 2015.
3. F. M. Mukhtar, A. R. Jawdhari, and A. Peiris, “Mixed-mode FRP-concrete bond failure analysis using a novel test apparatus and 3D nonlinear FEM,” Journal of Composites for Construction, 2022.
4. L. N. Koutas, Z. Tetta, D. A. Bournas, and T. C. Triantafillou, “Strengthening of Concrete Structures with Textile Reinforced Mortars: State-of-the-Art Review,” Journal of Composites for Construction, 2019.
5. M. T. Cristofaro, A. D'Ambrisi, F. Focacci, M. Tanganelli, and M. De Stefano, “Beam tests for the determination of the interfacial properties of FRCM composites,” Case Studies in Construction Materials, 2022.
6. F. Focacci, T. D'Antino, C. Carloni, L. H. Sneed, and C. Pellegrino, “An indirect method to calibrate the interfacial cohesive material law for FRCM-concrete joints,” Materials & Design, 2017.
7. ACI Committee 549. (2020). Guide to Design and Construction of Externally Bonded FRCM and SRG Systems for Repair and Strengthening of Concrete Structures (ACI PRC-549.4-20). American Concrete Institute, Farmington Hills, MI.

FRP INTERNATIONAL
The official newsletter of the International Institute for FRP in Construction
Vol. 23, No. 2, June 2026

COMPOSITES AROUND THE WORLD

Case Studies

Wagners FRP Profiles Redefine Piling – Case Study of Phill Hill Boardwalk

Dr Ali Mohammed, RPEQ, CPEng, IntPE(Aus)
Technical Lead I Wagners CFT

Name of the structure: Phill Hill FRP Boardwalk
Location: Gold Coast QLD Australia
Year of construction: 2025
Owner: City of Gold Coast Council
Designer: Wagners CFT / Kehoe Myres
Contractor: Wagners CFT Install Team

WAGNERS

11 Ballera Court, Wellcamp QLD 4350
PO Box 151 Drayton North QLD 4350
Mobile: +61 (0) 429 036 394
Web: www.wagner.com.au
Email: ali.mohammed@wagner.com.au

INTRODUCTION

Fifteen years after the first commercial installation of Fibre Reinforced Polymer (FRP) piles in Mackay, Queensland, Wagners Composite Fibre Technologies (CFT) has established a proven track record in the design, manufacture and installation of advanced composite piling systems. With thousands of piles now installed across Australia, US, UK and UAE, the FRP piling solutions are helping redefine the industry best practice for lightweight, corrosion-resistant and durable foundation systems. This article presents the FRP piling system adopted for the Phillip Hill Boardwalk replacement project in the Gold Coast region, where more than 120 FRP piles were installed to depths exceeding 10 metres, providing a durable and long-term solution for the harsh coastal environment.

STRUCTURAL CONCEPT

Phill Hill boardwalk is 330m long with a 2m traffic width. It is designed to accommodate a 5kPa live load and 3.6kN point, with the relevant lateral design loads such as flood and wind. The structural design inputs of Phill Hill Boardwalk were taken from local Australian standards, i.e. AS/NZS1170, AS2156, where the loads and serviceability limits of deflections L/250 and vibration 5Hz were considered, and the design/strength checks were as per international FRP codes such as ASCE FRP standard and WCFT Design Guide and testing data. The main structural system of the boardwalk consists of piles/bearers/joist system with a typical longitudinal span of 6m (Figure 1). This design has been adopted for its lightweightness, ease of assembly, and cost-effectiveness. The 6m bay of the boardwalk comprised 250RHS (rectangular hollow section) for the joists and bearers, standard WCFT FRP handrail system and 178CHS FRP piles.

The 178CHS FRP piles are manufactured using advanced pultrusion and pull-winding processes. Unlike traditional FRP materials, the piles are constructed from continuous fibreglass rovings embedded in a vinyl ester resin matrix. The structural system combines longitudinal fibres for axial strength and stiffness with transverse fibre layers that provide confinement and enhanced impact resistance during pile driving. The 178CHS profile contains 9 layers of fibres, with an intricate layup design to optimise both strength and stiffness. This unique fibre architecture enables the piles to absorb installation stresses without exceeding allowable driving limits. The lightweight nature of FRP significantly reduces handling and transport requirements while maintaining structural performance comparable to traditional piling materials.

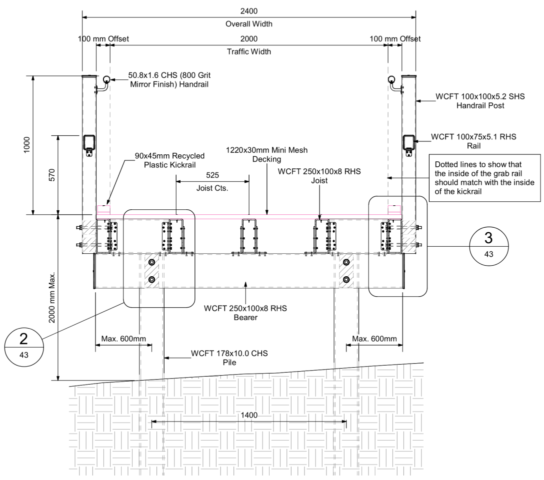


Figure 1. Cross-section of Phill Hill Boardwalk design

FRP INTERNATIONAL
The official newsletter of the International Institute for FRP in Construction
Vol. 23, No. 2, June 2026

FRP PILE DESIGN CONSIDERATIONS

The structural and geotechnical design of the 178CHS FRP piles was undertaken using in-house design tools and spreadsheets, together with structural analysis software, i.e., Space GASS, where Wagners CFT FRP profiles and material properties are predefined in the latest software version. The structural design capacities of the piles and members were established through experimental testing of both full-length and spliced piles.

The challenging part of FRP piles design can be the lack of geotechnical design parameters for FRP materials, especially skin friction and soil plugging effects. So, for simplicity, the skin friction angle is assumed to be similar to that of steel or other traditional pile materials as a conservative approach, as studies show that FRP piles can develop higher interface friction capacity than steel piles, as indicated by Aksoy et al., 2018 (Figure 1).

The soil plugging effect, where soil enters the pile during driving and forms an internal plug that contributes to axial capacity through additional shaft adhesion and end bearing resistance. Gudavalli et al. (2013) showed that this plugging effect can significantly increase pile capacity and may be considered by applying an enhancement factor of approximately 1.1 to 1.6 to the external shaft adhesion, depending on soil conditions and degree of plugging. Alternatively, for smaller diameter FRP piles, the soil plug may be conservatively treated as an additional bearing surface at the pile toe.

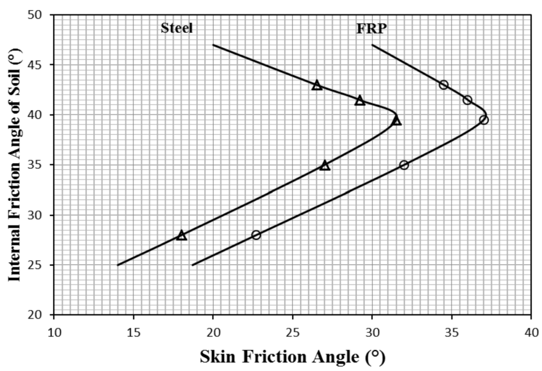


Figure 2. Skin friction chart for steel and FRP (Aksoy et al. 2018)

EXPERIMENTAL TESTING

The structural capacity of the FRP piles was established through a series of experimental tests, including flexural, axial compression and bolted connection testing on both full-length and spliced pile configurations. These tests were undertaken to verify the structural performance and determine the design capacities of the FRP pile system under the expected loading conditions.

Figure 3. Four points flexural tests on 178CHS pile

Field pile testing was also undertaken to verify the geotechnical capacity of the FRP piles under site conditions. The installation process involved driving the piles to a good depth using an impact or vibe hammer, then using a drop hammer for testing while monitoring the pile set per blow. The measured pile sets were then assessed using the Hiley dynamic formula to estimate and confirm the axial pile capacity.

Figure 4. Drop hammer field test on Phill Hill Boardwalk FRP piles

TRANSPORT AND INSTALLATION ADVANTAGES

Construction with FRP piles, at Phill Hill Boardwalk and other structures, offers several practical advantages over traditional materials. The lightweight profiles allow smaller machinery to be used on site, reducing transport and mobilisation costs and improving access in constrained environments. Installation can often be completed faster, improving contractor productivity and reducing project timelines.

FRP piles can also be easily cut and spliced on site using standard tools. Internal splice/FRP sections and bolted connections enable contractors to extend pile lengths as required once subsurface conditions become clearer during installation. This flexibility is particularly valuable in projects where ground conditions vary significantly.

Figure 5. Transport and Install of FRP Piles at Phill Hill Boardwalk and Phill Hill FRP Boardwalk, Gold Coast

CONCLUSIONS

The utilisation of Wagners FRP piling systems, in Phill Hill boardwalk and other strucutres, demonstrate how advanced composite materials can address many of the long-standing challenges associated with traditional marine and civil infrastructure foundations. Through innovative manufacturing process, extensive testing and practical field experience, FRP piles are fully developed as foundation systems capable of delivering long-term durability, corrosion resistance and simplified construction methods.

The use of FRP composites provides several key advantages including lightweight handling, reduced installation costs, improved durability in marine environments, lower maintenance requirements and extended asset life.

As infrastructure owners increasingly focus on whole-of-life value and sustainability, FRP piling systems are emerging as a highly effective alternative to timber, steel and concrete for a broad range of applications.

REFERENCES

1. Aksoy, H.S., Gör, M. and İnal, E., 2018. Determination of friction angles between soil and steel-FRP piles. Turkish journal of science and technology, 13(1), pp.19-23.

PUBLICATIONS

Special Centenary Issue of The Indian Concrete Journal: CALL FOR PAPERS

Composites for Concrete Construction: Advancing Performance, Durability, and Sustainability

As part of its Centenary Celebrations, The Indian Concrete Journal (ICJ – first published in 1927) is pleased to announce a Special Issue on "Composites for Concrete Construction." This issue forms part of the ICJ Centenary Series dedicated to highlighting transformative research directions that will shape the next century of concrete materials, structural systems, and infrastructure development.

Over the past hundred years, concrete has evolved from a conventional construction material into a highly engineered, multifunctional, and sustainable material system. Composite technologies have played a pivotal role in this evolution by enabling enhanced structural performance, improved durability, extended service life, resource efficiency, and reduced environmental impact. Today, composite solutions are increasingly adopted to address critical challenges in infrastructure resilience, climate adaptation, decarbonization, asset aging, and accelerated construction.

The integration of advanced composite materials with concrete—including fiber-reinforced polymers (FRP), textile-reinforced composites, cementitious composites, hybrid material systems, nano-engineered composites, bio-based composites, and multifunctional smart materials—offers unprecedented opportunities for innovation in both new construction and infrastructure rehabilitation.

This special issue aims to bring together cutting-edge research, field applications, design innovations, and critical review papers that advance the science and engineering of composites for concrete construction. Contributions addressing both fundamental mechanisms and practical implementation are encouraged.

TOPICS OF INTEREST

As part of the centenary celebration series, contributions that bridge fundamental research and engineering practice, reflecting ICJ's century-long mission of advancing concrete science and technology through industry–academia collaboration, are particularly welcome.

In this issue, submissions related to the use of composites in concrete structures, materials, and construction technologies are welcome.

Topics may include, but are not limited to:

- Composite materials and constituent technologies
- Composite structural systems and applications in new construction
- Strengthening, rehabilitation, and retrofit of existing structures
- Durability enhancement and service-life extension
- Modeling, design methods, and digital engineering
- Sustainability, circularity, and life-cycle assessment
- Codes, standards, guidelines, and engineering practice

SUBMISSION AND REVIEW

All manuscripts will undergo the standard peer-review process of The Indian Concrete Journal. Authors should prepare manuscripts in accordance with the journal's submission guidelines and clearly indicate "Special Issue: Composites for Concrete Construction" during submission.

IMPORTANT DATES

Manuscript Submission Deadline: July 31, 2026

AUTHOR GUIDELINES

https://www.icjonline.com/assets1/pdf/icj-author-guidelines.pdf

SUBMISSION PORTAL

https://www.icjonline.com/icj-author

We look forward to receiving your contributions and showcasing advances that will drive the next generation of composite-enabled concrete construction systems.

Prof. Saverio Spadea
(Polytechnic University of Bari, Italy)
Guest Editor of the Special Issue

Prof. Vasant Matsagar
(Indian Institute of Technology Delhi, India)
Editor-in-Chief of the Journal

PUBLICATIONS

ACI Structural Journal Special Issue CALL FOR PAPERS

Theme: "Advancing Fiber Composites in Concrete Structures: A Special Issue Celebrating the 25th Anniversary of the International Institute for FRP in Construction"

Guest Editors: Amir Fam, Ph.D., P.Eng., FACI; Jovan Tatar, Ph.D.; Akram Jawdhari, Ph.D., P.Eng.

Original papers are invited for a special issue of the ACI Structural Journal dedicated to advances in fiber-reinforced polymer (FRP) and fiber-reinforced cementitious matrix (FRCM) composites in concrete structures. This special issue is published in recognition of the 25th Anniversary of the International Institute for FRP in Construction (IIFC), the only international professional organization devoted exclusively to composite materials in construction.

Over the past quarter-century, FRP and FRCM systems have evolved from niche solutions into mainstream technologies for both new construction and structural rehabilitation of concrete structures. This special issue will serve as a landmark reference documenting this evolution while charting the innovation pathways that will define the future of composite materials in concrete structures.

All submitted manuscripts must address applications directly relevant to concrete structures. Contributions of particular interest are those providing experimental data, analytical or numerical models, durability and long-term performance assessments, or practical design methodologies for FRP or FRCM systems applied in concrete construction or rehabilitation. Manuscripts offering code-relevant interpretations, comparisons with existing provisions, or proposals for improved design recommendations, particularly those aligned with ACI Committee 440 (Fiber-Reinforced Polymer Reinforcement) and ACI Committee 549 (Thin Reinforced Cementitious Products and Ferrocement), are especially encouraged. Work that strengthens the technical basis for future revisions of ACI documents is strongly welcomed.

ADDITIONAL TOPICS OF INTEREST INCLUDE BUT ARE NOT LIMITED TO THE FOLLOWING:

- Sustainable Fiber Composite Materials — bio-based or low-carbon fibers and resins, natural fiber FRP/FRCM, and life-cycle assessment
- Sustainable End-of-Life FRP Scenarios — recycling, repurposing, and circular-economy approaches
- FRP in Extreme Environments — marine, offshore, high-wind, freeze/thaw, fire, and multi-hazard exposures
- Digitalization of FRP Systems — smart sensing, structural health monitoring, digital twins, AI/data-driven models, and digital fabrication
- Advanced FRP Manufacturing — additive manufacturing, 3D printing, robotic fabrication, and associated testing and standardization

SUBMISSION REQUIREMENTS

The following are required for abstract submission:

1. Paper title
2. Primary (submitting) author name, title, affiliation, and contact information
3. List of co-author names, titles, affiliations, and contact information
4. Abstract of up to 300 words

INSTRUCTIONS

1. Submit abstracts by filling out the online form by July 31, 2026, accessible at https://tinyurl.com/yc62nj8c
2. Notification of acceptance to submit full paper: August 31, 2026.
3. Full paper deadline for peer review: December 31, 2026.

GUEST EDITOR CONTACT INFORMATION

Amir Fam, Ph.D., P.Eng., FACI, FRSC,
Canada Research Chair Professor in Climate Change-Resilient Infrastructure, Vice Dean (Research), Department of Civil Engineering, Queen's University, 58 University Avenue, Ellis Hall, Kingston, ON, Canada K7L 3N6, Email: amir.fam@queensu.ca I Phone: (613) 985-3694

Jovan Tatar, Ph.D. Associate Professor,
Department of Civil, Construction, and Environmental Engineering, University of Delaware, 301 DuPont Hall, Newark, DE 19716, USA, Email: jtatar@udel.edu I Phone: (302) 831-4939

Akram Jawdhari, Ph.D., P.Eng. Assistant Professor,
Department of Civil and Environmental Engineering, South Dakota State University, Crothers Engineering Hall 320, Brookings, SD 57007, USA, Email: akram.jawdhari@sdstate.edu I Phone: (605) 688-5226

PUBLICATIONS

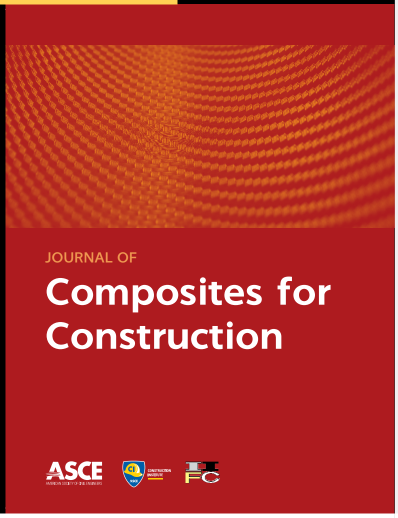
ASCE Journal of Composites for Construction – Recent issues

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: www.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: www.editorialmanager.com/jrncceng



VOLUME 30, ISSUE 3, JUNE 2026

New Strategy for Corrosion Inhibition in RC Columns without Sacrificing Seismic Performance: CFRP Strips Acting as Stirrups and Anodes of ICCP
Biao Hu, Ruibo Liu, Jing He, Kun Wang, Yingwu Zhou, Muhammad Tahir and Xiaoxu Huang
https://doi.org/10.1061/JCCOF2.CCENG-5436

Evaluation of the Durability and Flexural Performance of BFRP-RC Beams in Aggressive Marine Environments
Slim Gassara, Basil Ibrahim, Salaheldin Mousa, Hamdy M. Mohamed and Brahim Benmokrane
https://doi.org/10.1061/JCCOF2.CCENG-5295

Behavior and Predictive Model of Large-Scale Externally Bonded FRP Strips Anchored to Reinforced Concrete Structures
Junrui Zhang, Enrique del Rey Castillo, Tom Allen, Lucas Hogan, Ravi Kanitkar and Aniket D. Borwankar
https://doi.org/10.1061/JCCOF2.CCENG-5513

Rapid Visualization of FRP–Concrete Interfacial Defects Using Scanning Array Infrared Thermography
Xingxing Zou and Fang Jin
https://doi.org/10.1061/JCCOF2.CCENG-5354

Stay-in-Place Permanent Formwork for Concrete Structures Using FRP-Reinforced Ultrahigh-Strength Engineered Cementitious Composites
Ji-Xiang Zhu, Ke-Fan Weng, Wei-He Liu, Bo-Tao Huang, Kai-Di Peng, Ji-Hua Zhu and Jian-Guo Dai
https://doi.org/10.1061/JCCOF2.CCENG-5380

Unified Strength Model for FRP Anchors under Pullout and Concrete-Related Failure Modes
Junrui Zhang, Enrique del Rey Castillo, Ravi Kanitkar, Sheng-Hsuan Lin, Tom Allen, Lucas Hogan and Aniket D. Borwankar
https://doi.org/10.1061/JCCOF2.CCENG-5514

Multiscale Insights into the Electrochemical and Mechanical Performance of CFRP Bars in a Real Concrete Environment under Anodic Polarization
Yingwu Zhou, Guifan Liu, Linlin Zhao, Biao Hu, Ruibo Liu, Xiaoxu Huang and Zhongfeng Zhu
https://doi.org/10.1061/JCCOF2.CCENG-5425

Evaluation of FRCM Shear Strength Contribution in Externally Strengthened RC Beams
Min-Su Jo, Hyeong-Gook Kim, Dong-Hwan Kim, Su-A Lim, Hyun Kong and Kil-Hee Kim
https://doi.org/10.1061/JCCOF2.CCENG-5460

Postheating Compressive Behavior of Carbon Fiber–Wrapped, Geopolymer Concrete–Filled GFRP Composite Tubes after Elevated-Temperature Exposure
Mohsen Ebrahimzadeh, Milad Bazli, Zahir Azimi, Milad Shakiba, Amir Siavoshi and Amin Jahedi Dalivand
https://doi.org/10.1061/JCCOF2.CCENG-5449

PUBLICATIONS > ASCE JOURNAL OF COMPOSITES FOR CONSTRUCTION – RECENT ISSUES

Continuous Model for Postpeak Softening–Rehardening of Circular and Rectangular Concrete Columns with Large Rupture Strain FRP Confinement
Zhongfeng Zhu, Yingwu Zhou, Haixiang Li and Biao Hu
https://doi.org/10.1061/JCCOF2.CCENG-5476

Increasing Remaining Fatigue Life of Steel Plates Using Bonded Ultrahigh-Modulus CFRP Plates: The Effect of Cyclic History and Bond Length
Gavin Li, Joshua E. Woods, Amir Fam and Brahim Benmokrane
https://doi.org/10.1061/JCCOF2.CCENG-5361

Bond Strength of Staggered and Nonstaggered GFRP Lap-Spliced Bars in Normal and Fiber-Reinforced Concrete Beams
Seyed Arman Hosseini, Abolfazl Eslami, Ahmed Sabry Farghaly, Adel ElSafty and Brahim Benmokrane
https://doi.org/10.1061/JCCOF2.CCENG-5391

Seismic Behavior of RC Columns Retrofitted with FRCM Jackets
Moustafa Mansour and Ahmad Rteil
https://doi.org/10.1061/JCCOF2.CCENG-5445

Standard Fire Tests on GFRP-Reinforced Concrete Slabs with End Anchorage, Lap-Splice, and Cutoff Details
Naeim Roshan and Hamzeh Hajiloo
https://doi.org/10.1061/JCCOF2.CCENG-5523

Experimental Study of Glass Fiber–Reinforced Polymer Composite Crossarms for Power Transmission Towers
Burak Talha Kilic, Eray Baran and Serap Ciliz
https://doi.org/10.1061/JCCOF2.CCENG-5296

Deformation Capacity of FRP-Strengthened RC Columns with Lap Splices
Mehmet Emre Unal and John W. Wallace
https://doi.org/10.1061/JCCOF2.CCENG-5520

VOLUME 30, ISSUE 2, APRIL 2026

Axial Compressive Performance of Confined Concrete Columns Reinforced with FRP Grid Cage Stirrups
Chen Chen, Hai Fang, Yun Mook Lim, Laiyun Yang, Zhong Zhang and Juan Han
https://doi.org/10.1061/JCCOF2.CCENG-5360

Experimental Evaluation and Strain-Based Design of Inclined FRP Anchors for RC T-Beam Flexural Strengthening
Abdulaziz Alhelal, Robin Kalfat and Riadh Al-Mahaidi
https://doi.org/10.1061/JCCOF2.CCENG-5368

Shear Strengthening and Anchorage Effects of CFRP U-Wraps in Flexurally Strengthened Reinforced Concrete Beams
Muhammad Ishfaq, Ravi Kanitkar, Kent A. Harries, Eva Oller, Griffith Shapack, Tarek Alkhrdaji and Jovan Tatar
https://doi.org/10.1061/JCCOF2.CCENG-5320

Axial Compression Behavior of Square RC Columns Confined with Textile-Reinforced Ultrahigh-Toughness Cementitious Composite Jackets
Lijun Hou, Yuanda Cai, Zhuwei Zhao, Ting Huang and Yuhao Peng
https://doi.org/10.1061/JCCOF2.CCENG-5345

Innovative UHP-FRCM Systems for Enhanced Flexural Behavior of RC Beams: Addressing Fabric Slippage and Introducing a New Tension Stiffening Model
Yazan Abutahnat, Ahmed El Refai and Luca Sorelli
https://doi.org/10.1061/JCCOF2.CCENG-5382

Effect of Stress Ratio on the Fatigue Behavior of Ribbed Glass Fiber–Reinforced Polymer Bars for Concrete Reinforcement
Islam Elsayed Nagy, Alireza Asadian and Khaled Galal
https://doi.org/10.1061/JCCOF2.CCENG-5307

Deformation Capacity Analysis of Large Rupture Strain FRP-Confined Concrete with Local Stress–Strain Effects
Peng-Da Li and Peng-Cheng Huang
https://doi.org/10.1061/JCCOF2.CCENG-5409

Strength Model for FRP-Confined Concrete: Comprehensive Database and Reliability-Based Partial Factor Calibration
Javad Shayanfar, Sina Baharloo, Joaquim A. O. Barros and Amirhossein Mohammadi
https://doi.org/10.1061/JCCOF2.CCENG-5448

FRP International needs your input...

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 any of the editors. Additionally, please use 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 theses are particularly encouraged.

All announcements are duplicated on the IIFC website (www.iifc.org) and all issues of the FRP International are also available in the archive at this site.

FRP International is yours, the IIFC membership's forum. The newsletter will only be as useful and interesting as you help to make.

FRP INTERNATIONAL
The official newsletter of the International Institute for FRP in Construction
Vol. 23, No. 2, June 2026

From our patron members

For more information on membership, visit our website.

IIFC.ORG/MEMBERSHIP