University of Baghdad
College of Engineering
JE
JOURNAL OF ENGINEERING

Journal of Engineering

journal homepage: www.jcoeng.edu.iq

Volume 30 Number 10 October 2024

Bond Behavior between Externally Bonded CFRP Laminate and Reactive Powder Concrete using Epoxy Adhesive

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ABSTRACT

Reactive powder concrete is an attractive new concrete technology for structural design applications. The technology has been used for different structures with several advantages. Strengthening and retrofitting structures using FRP has grown rapidly in the last decades to upgrade structures because of the gradual material degradation over time. The technique was applied mainly for conventional normal and high-strength concrete and steel. This study is conducted to study the performance of bonding interface among reactive powder concrete substrate and CFRP sheets using different parameters, including bond length, bond width, and bond–slip relations. Concrete prisms with dimensions of (25 x 25 x 75 mm) were adopted in the experimental program. Five groups of three specimens were tested using a single-lap shear test setup, and pull-out loading was applied for testing the specimens. Test results indicated significant bonding properties compared to the normal concrete.

Keywords: Reactive powder concrete, CFRP, Epoxy, Bonding

1. INTRODUCTION

Compared to other retrofitting approaches, FRP composites have evolved in recent decades as a highly practical, economical, and environmentally friendly solution for strengthening aging reinforced concrete structures **(De Lorenzis et al., 2001**; **Ezeldin and Balaguru, 1989; Ferracuti et al., 2007)**. Different strengthening techniques have been used based on the defective members' type and the current understanding of strengthening systems **(Focacci et al., 2000; Mukhopadhyaya and Swamy, 2001; Pilakoutas et al., 2011; Daraj and Al-Zuhairi, 2023)**. Carbon fiber reinforced polymers (CFRP) have become one of the most popular reinforcing materials **(Triantafillou and Plevris, 1992; Sena-Cruz and Barros, 2002; Foster et al., 2017)** because of their excellent mechanical qualities, high strength-to-weight ratio, and unrivalled resistance to corrosion as compared with traditional retrofitting methods. Externally bonded FRP plates or sheets, near-surface

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Peer review under the responsibility of University of Baghdad.
https://doi.org/10.31026/j.eng.2024.10.02

Article received: 25/08/2023
Article revised: 18/09/2024
Article accepted: 23/09/2024
Article published: 01/10/2024

mounted FRP plates or bars **(Tighiouart et al., 1998; De Lorenzis and Nanni, 2002**; **De Lorenzis et al., 2002; El Meski and Harajli, 2013a; Said and Al-Ahmed, 2015; Al-Abdwais and Al-Mahaidi, 2016)** and post-tensioned FRP straps are just some reinforcement methods. It is preferable to use FRP plates that are mounted externally since they are less invasive and the concrete elements can be strengthened while the member is still in use **(Nguyen et al., 2018; Hoult and Lees, 2009; Lee et al., 2012; Hassan and Rizkalla, 2004; Malvar et al., 2003; Salman et al., 2018).**

Epoxy-bonded FRP reinforcement functions compositely, so the bond response is important for transmitting bond stresses through the fiber-concrete bond connection. The type of FRP, bonded area, surface preparation, and FRP thickness significantly affected the bond capability of epoxy-bonded connections. Over the past two decades, extensive research was conducted to determine the optimal bond length, FRP bar diameter, FRP composite thickness, and concrete strength. The results showed that the bond resistance of bond joints increased beyond a certain length of externally bonded reinforcement, while the bond strength did not. This was commonly known as the effective bond or anchorage length **(Ezeldin and Balaguru,1989; Nguyen et al., 2001; Sena-Cruz and Barros, 2004; Novidis and Pantazopoulou, 2008; Mohammed and Ali, 2024; Al-Zuhairi and Sahi, 2013)**. It was also noted that increasing the groove size and cover thickness of the NSM strengthening system could improve the bond strength of the joints **(De Lorenzis and Nanni, 2002; Novidis and Pantazopoulou, 2008; Zheng and Yu, 2012).**

The extraordinary strength, durability, and resistance to various environmental and physical pressures characterize Reactive Powder Concrete (RPC) **(Richard and Cheyrezy, 1994)**. Dense and compact RPC combines very fine powders like silica fume, cement, and quartz powder with steel fibers and a superplasticizer. Steel fiber is sometimes used in addition to the superplasticiser to reduce the water/cement ratio and improve the workability of concrete **(Matte and Moranville, 1999; Parameshwar and Subhash**, **2017)**. Having a compressive strength several times higher than typical types of concrete, RPC is exceptionally resistant to chemical attack and erosion because of its low porosity. Bridges, tunnels, and precast concrete are just some of the many uses for RPC. RPC is a high-performance material, but it is more expensive and labor-intensive to create than regular concrete. Therefore, it is only used in niche contexts that demand it for its particular features. The bond behavior of both regular concrete and concrete reinforced with epoxy-bonded fibers has been extensively studied in several trials **(Razaqpur and Mostafa, 2015; Al-Ahmed and Al-Jbouri, 2016**). However, there has been little focus on the bond response of FRPs on reactive powder concrete (RPC) substrates.

Therefore, the goal of this investigation is to evaluate the bond performance of CFRP-to-RPC bonded joining through the use of an experimental program that takes into account a variety of parameters, such as the influence of bond length, width, and thickness of CFRP plates.

2. EXPERIMENTAL WORK

2.1. Materials

2.1.1. Reactive Powder Concrete

For the compressive testing, cubes were cast from a single batch of the reactive powder concrete mixture. **Table 1** depicts the mix design. Compressive strength was measured using

(AS 1012.9, 1999), and tensile strength was measured using **(AS 1012.10, 2010)** splitting tensile tests. Test outcomes are shown in **Table 2**.

Table 1. Mix ratios of reactive powder concrete (kg/m^3)

Mix type	FS	C	W	SF	SP
Mortar Mix	1070	963	214	107	32
FS: Fine Sand, C: Cement, W: Water, SF: Silica Fume, SP: Super Plasticizer					

2.1.2. Fine Sand

The fine sand was used in this study with a maximum particle size (450 µm) passing from sieve No.40, and a minimum size (150 µm) remaining on sieve No.100. The properties of the fine sand are: The Specific gravity is 2.75, the sulfate content is 0.47%, and absorption is 0.63%.

2.1.3. Silica fume

The use of silica fume was to enhance the bonding properties of the cementitious mortar. The material was supplied from Tasmania.

2.1.4. Superplasticizer

The superplasticizer was used to provide the workability required for the adhesive in this project. The material was supplied by Sika Co.

2.1.5. CFRP laminate strips

The CFRP laminate strips are 1.4 mm thick and have two widths of 25 and 50 mm, which commercial manufacturers use. The mechanical properties were measured using **(ASTM D3039, 2008)**.

2.1.6. Epoxy adhesive

Seka is a commercial manufacturer of epoxy resin. The manufacturer provides details on the product's mechanical qualities in **Table 2.**

Table 2. Materials properties

Material	Compressive Strength (MPa)	Tensile Strength (MPa)	Elastic Modulus (MPa)
Reactive powder concrete	82	6.3	36200
Sika Epoxy adhesive	60	30	4500
CFRP laminate	1200	2500	165,000

2.2 Specimen Details

Fifteen concrete samples measuring 75 mm x 75 mm x 250 mm were used in the experiment. Using epoxy adhesive, CFRP sheets were adhered to the outside of the specimens along the lengthwise axis of the surface. CFRP laminate came in two widths, 25 and 50 mm, and a thickness of 1.2 mm. Four different bond lengths (100, 150, 200, and 250 mm) were used, with three same specimens of each bond length signified as "a," "b," and "c," respectively.

The specifics of the samples are shown in **Table 3**. The samples were evaluated using a single-lap shear test arrangement.

Table 3. Specimen's details

Specimen Designation	Bond length (mm)	Fiber width (mm)	Compressive strength (MPa)	Number of specimens
L100W25	100	25	82	3
L100W50	100	50	82	3
L150W25-SG	150	25	82	3
L150W50	150	50	82	3
L200W50	200	50	82	3
L: Length, W: Width, SG: Strain Gauges				

2.3 Specimens Preparation

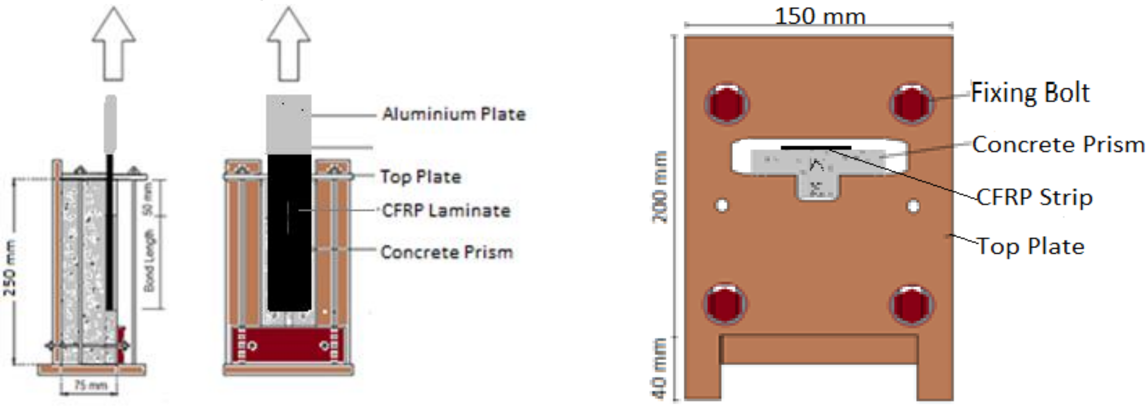
The concrete prisms were allowed to cure for 28 days before the CFRP was bonded to the face of the prisms using adhesive. To prevent premature concrete failure caused by excessive stress concentration, bonding began 50 mm from the left edge of the prism. After 2 weeks of curing, the samples were put through their paces. **Fig. 1** depicts the specimen preparation process.

(a) **(b)**

Figure 1. Specimens preparation **(a)** Bonding of CFRP to the concrete substrate **(b)** Fixing the Aluminum gripping plate

2.4. Testing Set-up

One shear-lap shear test rig was used for all of the specimen testing. **Fig. 2** depicts the arrangement in detail, including its dimensions. The load was applied using displacement-control rate of 0.2 mm/min.



(a) Side view. **(b)** Top view.

Figure 2. Configuration of set-up

With the use of a laser level, we were able to perfectly align the specimens with the loading direction, eliminating any chance of bending moment on the fiber strips and ensuring a pure axial load. Loading cells and extensometers were used to determine the force and distance traveled. Displacement at uniform distances from the bonding end was measured using extensometers placed at the gripping locations. The loading configuration is shown in **Fig. 3**.

Figure 3. Test set-up

3. RESULTS AND DISCUSSION

The consequences of the tests on the specimens with various bonding lengths and widths are presented in **Table 4**. The outcomes were just as effective at bonding as CFRP laminate strips. It has been shown that as bond length increases, average bond stresses drop.

Table 4. Test results

Specimen Designation	Bond length bond length (mm)	Fiber width (mm)	Av. Ultimate force (kN)	Number of specimens
L100W25	100	25	7.2	3
L150W25-SG	150	25	11.9	3
L200W25	200	25	12.2	3
L100W50	100	50	13.9	3
L150W50	150	50	18.1	3
L: Bond Length, W: CFRP Width, SG: Strain Gauges				

The significant effect of the bond length on ultimate load capacity can be indicated in **Fig. 4** with load–displacement curves for three different bonding lengths 100, 150 and 200 mm. The typical ultimate load for three specimens of the L100W25 series with a bond length of 25 mm was 7.2 kN. The load and displacement behavior were linear, which indicates full bonding strength up to 4.5 kN, and beyond this, bonding stiffness reduced gradually, and the behavior became nonlinear until sudden failure. The typical bond stress was 2.88 MPa at this load. **Fig. 4** shows that the bonding stiffness peaked at 4.5 kN before gradually decreasing to failure at the ultimate load. The failure occurred due to delamination at the concrete/adhesive interface, as depicted in **Fig. 5**. This type of failure is typical and mainly occurs in conventional concrete strengthened externally with FRP **(De Lorenzis et al., 2001)**.

With a typical ultimate load of 11.9 kN across all three test specimens, the L150W25 series demonstrated a 65% increase in load compared to the L100W25 series. The average bonding stress at the ultimate load was determined to be 3.17 MPa, representing an increase of 28%. The peeling of the concrete surface is depicted as the failure mode typically occurred at the interface between the concrete and adhesive due to the detachment in the concrete surface as shown in **Fig. 6**. **Fig. 4** shows a load-displacement plot with linear bonding stiffness until about 5.3 kN and then shows nonlinear fluctuation until reaching the ultimate load.

The load-displacement curve **(Fig. 4)** shows that the mediocre ultimate load for the L200W25 specimens was 12.2 kN, with a bonding stress of 2.4 MPa. The bonding stiffness was linear until 5.5 kN and the started to fluctuate reduction until the failure at the ultimate load. The failure was typical of previously tested specimens with delamination at the interface between concrete and CFRP **(Fig. 7).** The ultimate load showed no significant rise with only around 2.5% when the bond length was raised from 150 mm to 200 mm. As the effective bond length is the length beyond which no significant increase in strength is achieved. Therefore, the bond length of 200 mm can be considered as an effective bond length for reactive powder concrete externally bonded with CFRP.

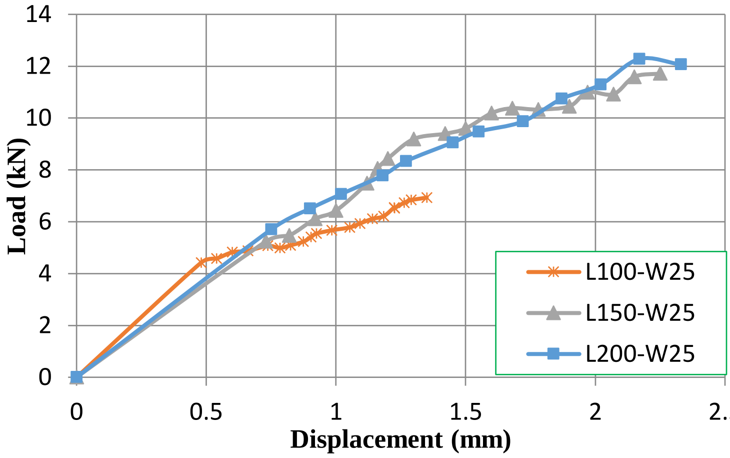


Figure 4. Load-displacement curves of L100,150 and 200W25

Figure 5. The failure mode of L100W25

Figure 6. The failure mode of the L150W25 specimen

Figure 7. The failure mode of the L200W25 specimen

Increasing the width from 25 to 50 mm has significant effect on the bond strength as indicated in **Fig. 8**. With a bonding length of 100 mm and an average ultimate load of 13.9 kN, the average bond stress for 3 Series L100W50 specimens was 2.7 MPa. Compared to the L50W50 series, the increased load is over 95%., which indicates the significant effect of fiber width on the full capacity of the bonding. The failure occurred in a specific pattern because of the interface between the glue and the concrete (see **Fig. 9**). The connections between load and displacement **(Fig. 8)** revealed a steady loosening of the bond's rigidity beyond the loading value of 4.4 kN up to the ultimate stress.

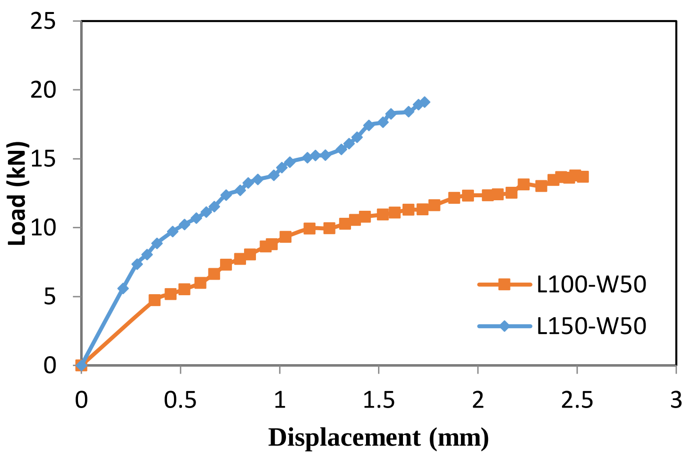


Figure 8. Load-displacement curves of L10&1500W50 specimens

The L150W50 series, as shown in **Fig. 8**, had a mediocre ultimate load of 18.1 kN, achieving an increase of about 30% of the L100W50 specimen with a corresponding average bond stress of 2.41 MPa over three specimens. The bonding stiffness continued linearly up to about 7.6 kN. **Fig. 10** demonstrates that the mode of failure was consistent in the interface region between the concrete and glue.

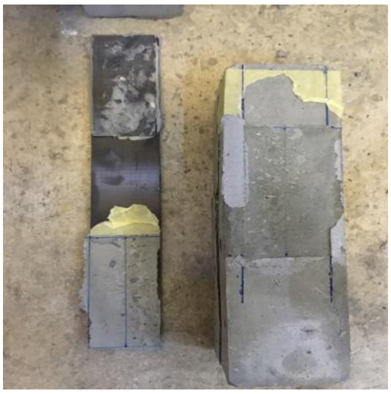


Figure 9. Failure mode of L100W50 specimen

Figure 10. The failure mode of the L100W25 specimen

4. CONCLUSIONS

Extensive research was conducted to learn more about the interfacial bond reaction between RPC substrates and FRPs. Using single-lap shear test configurations, the properties of the bond joints were investigated while taking into account the impact of CFRP bond length and width in samples cast using RPC. The following are the distinguished conclusions drawn from the experimental test results:

- This study examined how the use of reactive powder concrete affected the maximum bond resistance and failure slip. When retrofitting concrete structures cast with RG aggregates, the performance of CFRP reinforcement is significantly impacted by the RPC specimens' poorer aggregates interlocking and lowers concrete surface tensile strength along the bond agent.
- The increase in bond capacity was observed by increasing the width of the CFRP plates from 25 to 50 mm. This resulted from the increase in the bonding area, which consequently acquired greater inter-facial bonding stresses.

- The maximum bond resistance is significantly increased by 65% by increasing the bond length of the CFRP plates from 50 to 150 mm, while the increase in bond strength between 150 to 200 mm was only 2.5%. Hence, the effective bonding length of the PRC molded samples was approximately 150 mm, as confirmed by the fact that using 200 mm bonding of FRP plates did not significantly increase the bonding strength.

Acknowledgements

The authors gratefully acknowledge Al-Nahrain University for supporting this research program.

Credit Authorship Contribution Statement

Ahmed H. Al-Abdwais: Writing - original draft, editing, Validation, Methodology, Proofread Mustafa H. Al-Allaf: Writing - review & editing, Validation. Arafat A Mohammed: Proofreading

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

ACI Committee 440-2R. 2017. Guide for the design and construction of externally bonded FRP systems for strengthening concrete structures. American Concrete Institute

Al-Abdwais A. and Al-Mahaidi R., 2016. Bond behaviour between NSM CFRP laminate and concrete using modified cement-based adhesive. *Construction and Building Materials,* 127, pp. 284-292. https://doi.org/10.1016/j.conbuildmat.2016.09.142

Al-Ahmed, A., H., and Al-Jbouri, M.H., 2016. Behavior of reinforced concrete deep beams strengthened with carbon fiber reinforced polymer strips, *Journal of Engineering,* 22(8). pp. 37-53. https://doi.org/10.31026/j.eng.2016.08.03.

Al-Zuhairi, A.H. and Sahi, W.D., 2013. Numerical prediction of bond-slip behavior in simple pull-out concrete specimens. *Journal of Engineering*, 19(1), pp. 1-12. https://doi.org/10.31026/j.eng.2013.01.01

AS 1012.10., 2010. Methods of testing concrete-determination of indirect tensile strength of concrete cylinders (Brasil or splitting test). Standards Australia.

AS 1012.9, 1999. Methods of testing concrete-determination of the compressive strength of concrete specimens. Standards Australia, Melbourne, Australia.

ASTM D3039/D3039M, 2008. Standard test method for tensile properties of polymer matrix composite materials. ASTM International, West Conshohocken, PA, United States.

ASTM D7205/D7205M-06, 2011. Standard test method for tensile properties of fiber reinforced polymer matrix composite bars. https://doi.org/10.1520/D7205_D7205M-06

Daraj, A.J. and Al-Zuhairi, A.H., 2023. The effect of cohesive debonding elimination on enhancing the flexural performance of damaged unbonded prestressed concrete girders strengthened using NSM CFRP. *Journal of Engineering*, *29*(9), pp.102-116. https://doi.org/10.31026/j.eng.2023.09.08

De Lorenzis, L. and Nanni, A., 2002. Bond between near-surface mounted fiber reinforced polymer rods and concrete in structural strengthening. *Structural Journal,* 99(2), pp.123-132.

De Lorenzis, L., Miller, B. and Nanni, A., 2001. Bond of FRP laminates to concrete. *ACI materials journal*, 98(3), pp.256-264. https://doi.org/ 10.14359/10281.

De Lorenzis, L., Rizzo, A., and La Tegola, A., 2002. A modified pullout test for bond of near-surface mounted FRP rods in concrete. *Composites, Part B*, 33(8), pp. 589–603. https://doi.org/10.1016/S1359-8368(02)00052-5.

El Meski, F., and Harajli, M., 2013a. Flexural behaviour of unbonded post-tensioned concrete members strengthened using external FRP composites. *Journal of Composites for Construction*, 17, pp. 197-207. https://doi.org/10.1061/(ASCE)CC.1943-5614.0000330.

Ezeldin, A., and Balaguru, P., 1989. Bond behavior of normal and high strength fiber reinforced concrete. *ACI Material Journal.*, 86, pp.515–524. https://doi.org/%2010.14359/2141

Ferracuti, B., Savoia, M. and Mazzotti, C., 2007, Interface law for FRP–concrete delamination, *Ccomposite Structures*, 80, pp. 523-531. https://doi.org/10.1016/j.compstruct.2006.07.001

Focacci, F., Nanni, A., and Bakis, C. E., 2000. Local bond-slip relationship for FRP reinforcement in concrete. *Journal of Composite Constructure*, 4(1), pp. 24–31. https://doi.org/10.1061/(ASCE)1090-0268(2000)4:1(24).

Foster, R.M., Brindley, M., Lees, J.M., Ibell, T.J., Morley, C.T., Darby, A.P., and Evernden, M.C., 2017. Experimental investigation of reinforced concrete T-beams strengthened in shear with externally bonded CFRP sheets. *Journal of Composites for Construction*, 21, P. 04016086. https://doi.org/10.1061/(ASCE)CC.1943-5614.0000743.

Golham, M.A. and Al-Ahmed, A.H.A., 2024. Strengthening of GFRP reinforced concrete slabs with openings. *Journal of Engineering*, *30*(01), pp.157-172. https://doi.org/10.31026/j.eng.2024.01.10

Hassan, T. and Rizkalla, S., 2004. Bond mechanism of NSM FRP bars for flexural strengthening of concrete structures. *ACI Structural Journal*, 101(6), pp. 830-839.

Hoult, N.A. and Lees, J.M., 2009., Efficient CFRP strap configurations for the shear strengthening of reinforced concrete T-beams. *Journal of Composites for Construction*, 13(1), pp. 45-52. https://doi.org/10.1061/(ASCE)1090-0268(2009)13:1(4)

Lee, D., Hui, J., and Cheng, L., 2012. Bond characteristics of NSM reinforcement in concrete due to adhesive type and surface configuration. *In 6th International Conference on FRP composites in civil engineering (CICE2012). Rome, Italy*.

Malvar, L.J., Cox, J.V. and Cochran, K.B., 2003. Bond between carbon fiber reinforced polymer bars and concrete. I: Experimental study*. Journal of Composites for Construction*, 7(2), pp.154-163. https://doi.org/10.1061/(ASCE)1090-0268(2003)7:2(154).

Matte, V. and Moranville, M., 1999. Durability of reactive powder composites: influence of silica fume on the leaching properties of very low water/binder pastes. *Cement and Concrete Composites,* 21(1), pp.1-9. https://doi.org/ 10.1016/S0958-9465(98)00025-0.

Mukhopadhyaya, P. and Swamy, N., 2001. Interface shear stress: a new design criterion for plate debonding. *Journal of Composites for Construction*, *5*(1), pp.35-43. https://doi.org/10.1061/(ASCE)1090-0268(2001)5:1(35)

Nguyen, D. M., Chan, T. K., and Cheong, H. K., 2001. Brittle failure and bond development length of CFRP-concrete beams. *Journal of Composites for Construction*, 5(1), pp. 12–17. https://doi.org/10.1061/(ASCE)1090-0268(2001)5:1(12)

Nguyen-Minh, L., Phan-Vu, P., Tran-Thanh, D., Truong, Q.P.T., Pham, T.M., Ngo-Huu, C., and Rovňák, M., 2018. Flexural-strengthening efficiency of CFRP sheets for unbonded post-tensioned concrete T-beams. *Engineering Structures,* 166, pp. 1-15. https://doi.org/10.1016/j.engstruct.2018.03.065

Novidis, D.G. and Pantazopoulou, S.J., 2008. Bond tests of short NSM-FRP and steel bar anchorages. *Journal of Composites for Construction*, 12(3), pp. 323-333. https://doi.org/10.1061/(ASCE)1090-0268(2008)12:3(323)

Parameshwar, H., and Subhash, C.Y., 2017. Investigation on Mechanical Properties of Reactive Powder Concrete under Different Curing Regimes, *Materials Today Journal*, 4(9), pp. 9758-9762. https://doi.org/%2010.1016/j.matpr.2017.06.262

Pilakoutas, K., Guadagnini, M., Neocleous, K. and Matthys, S., 2011. Design guidelines for FRP reinforced concrete structures. *Proceedings of the Institution of Civil Engineers-Structures and Buildings*, 164(4), pp.255-263. https://doi.org/10.1680/stbu.2011.164.4.255.

Razaqpur, G., and Mostafa, A.B., 2015. C-Anchor for strengthening the connection between adhesively bonded laminates and concrete substrates. *Technologies*, 3(4), pp. 238-258. https://doi.org/10.3390/technologies3040238.

Richard, P., and Cheyrezy, M.H., 1994. Reactive powder concretes with high ductility and 200-800 MPa compressive strength. *Special Publication*, 144, pp.507-518.

Said, A.I., Al-Ahmed, A.H.A. and Al-Fendawy, D.M., 2015. Strengthening of reinforced concrete T-section beams using external post-tensioning technique. *Journal of Engineering*, *21*(12), pp.139-154. https://doi.org/10.31026/j.eng.2015.12.09

Salman, W.D., Mansor, A.A., and Mahmood, M., 2018. Behavior of reinforced concrete one-way slabs strengthened by CFRP sheets in flexural zone. *International Journal Civil Engineering Technology*, 9(10), pp.1872–1881. https://doi.org/0976-6308/1872-18871

Sena-Cruz, J. and J. Barros, 2004. Bond between near-surface mounted carbon-fiber-reinforced polymer laminate strips and concrete. *Journal of Composites for Construction*, 8(6), pp. 519-527. https://doi.org/10.1061/(ASCE)1090-0268(2004)8:6(519)

Sena-Cruz, J. M. S., and Barros, J. A. O. 2002a. Bond behavior of carbon laminate strips into concrete by pullout-bending tests. In *Proceedings, Int. Symposium on Bond in concrete-from research to standards (Balázs GL, Bartos PJM, Cairns J, Borosnyói A, eds.)* (pp. 614-622).

Tighiouart, B., Benmokrane, B. and Gao, D., 1998. Investigation of bond in concrete member with fiber reinforced polymer (FRP) bars. *Construction and Building Materials*, 12(8), pp. 453-462. https://doi.org/10.1016/S0950-0618(98)00027-0

Triantafillou, T.C. and Plevris, N., 1992. Strengthening of RC beams with epoxy-bonded fiber-composite materials. *Materials and Structures*, 25, pp. 201-211. https://doi.org/10.1007/BF02473064

Zheng, Y., Li, C., and Yu, G., 2012. Investigation of structural behaviours of laterally restrained GFRP reinforced concrete slabs. *Composites Part B: Engineering*, 43(3), pp. 1586–1597. https://doi.org/10.1016/j.compositesb.2011

سلوك الارتباط بين الواح ال CFRP المرتبطة خارجياً مع خرسانة المسحوق التفاعلية باستخدام لاصق الايبوكسي

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الخلاصة

تعتبر خرسانة المسحوق التفاعلية تقنية خرسانية جديدة جذابة لتطبيقات التصميم الهيكلي. تم استخدام التكنولوجيا لهياكل مختلفة مع العديد من المزايا. أصبح تعزيز وتعديل الهياكل التي تستخدم ال FRP مطلبًا أساسيًا في العقود الماضية لتحسين الهياكل بسبب التدهور التدريجي للمواد بمرور الوقت. تم تطبيق هذه التقنية بشكل أساسي على الخرسانة التقليدية العادية وذات القوة العالية والصلب ولم يتم تسجيل أي بحث في الأدبيات لتعزيز هياكل خرسانة المسحوق التفاعلية باستخدام CFRP. تُجرى هذه الدراسة لدراسة أداء واجهة الترابط بين ركيزة خرسانة المسحوق التفاعلية وألواح CFRP باستخدام معايير مختلفة بما في ذلك عرض رابطة, طول السندات وعلاقات الانزلاق والروابط. تم استخدام الموشورات الخرسانية بابعاد (75X25X25) تم تبنيها في البرنامج التجريبي. النماذج قسمت الى خمسة مجموعات, ثلاث لكل مجموعة. جها القص أحادي اللفة تم اختباره مع تحميل السحب تم استخدامه لفحص العينات. أشارت نتائج الاختبار إلى خصائص ترابط عالية مقارنة بالخرسانة العادية

الكلمات المفتاحية: خرسانة مسحوق تفاعلية، CFRP، إيبوكسي، ترابط.