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Studying the effects of CFRP and GFRP sheets on the strengthening of self-compacting RC girders

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Abstract. One method of retrofitting concrete structures is to use fiber reinforced polymers (FRP). In this research, the shear, torsional and flexural strengthening of self-compacting reinforced concrete (RC) girders are fulfilled with glass fiber reinforced polymer (GFRP) and carbon fiber reinforced polymer (CFRP) materials. At first, for verification, the experimental results were compared with numerical modeling results obtained from ABAQUS software version 6.10. Then the reinforcing sheets were attached to concrete girders in one and two layers. Studying numerical results obtained from ABAQUS software showed that the girders stiffness decreased with the propagations of cracks in them, and then the extra stresses were tolerated by adhesive layers and GFRP and CFRP sheets, which resulted in increasing the bearing capacity of the studied girders. In fact, shear, torsion and bending strengths of the girders increased by reinforcing girders with adding GFRP and CFRP sheets. The samples including two layers of CFRP had the maximum efficiencies that were 90, 76 and 60 percent of improvement in shear, torsion and bending strengths, respectively. It is worth noting that the bearing capacity of concrete girders with adding one layer of CFRP was slightly higher than the ones having two layers of GFRP in all circumstances; therefore, despite the lower initial cost of GFRP, using CFRP can be more economical in some conditions.

Keywords: CFRP; GFRP; self-compacting reinforced concrete girder; torsion; bending; shear

1. Introduction

Strengthening of concrete structures has been considered recently (Mazloom *et al.* 2018a). In fact, there are novel ways that are worth studying in strengthening of structures (Mazloom et al. 2018b). One considerable way of improvement in constructing structures is to use self-compacting concrete (Djebein *et al*. 2018). Self-compacting concrete (SCC) was introduced for the first time in 1986 in Japan, and then this type of concrete was produced in a laboratory in 1988 (Kamura and Ouchi 1998). It showed acceptable results in physical and mechanical features of concrete (Mazloom *et al.* 2018c, Mazloom *et al.* 2018d). In fact, SCC is a kind of concrete that flows under its own weight (Beygi *et al.* 2014). Considering its high level of flowability, it can easily move through the reinforcement, and fill in the molds (Ghasemi 2018). This type of concrete is quite

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Constr., **5**(6), 587-611.
Mazloom, M. and Hatami, H. (2015), "The behavior of self-compacting light weight concrete produced by magnetic water", *Int. J. Civil, Environ. Struct. Constr. Architect. Eng.*, **9**(12), 1616-1620.
Mazloom, M., Homayooni, S.M. and Miri, S.M. (2018c), "Effect of rock flour type on rheology and strength of self-compacting lightweight concrete", *Comput. Concrete*, **21**(2), 199-207.
Mazloom, M. and Mahboobi, F. (2017), "Evaluating the settlement of lightweight coarse aggregate in self-compacting lightweight concrete", *Comput. Concrete*, **19**(2), 203-210.
Mazloom, M. and Miri, M.S. (2017), "Interaction of magnetic water, silica fume and superplasticizer on fresh and hardened properties of concrete", *Adv. Concrete Constr.*, **5**(2), 87-99.
Mazloom, M., Pourhaji, P., Moosa Farash, A. and Sanati A. (2018a), "Strengthening of concrete structures with buckling braces and buckling restrained braces", *Struct. Monit. Maint.*, **5** (3), 391-416.
Mazloom, M. Ramezanianpour, A.A. and Brooks, J.J. (2004), "Effect of silica fume on mechanical properties of high-strength concrete", *Cement Concrete Compos.*, **26**(1), 347–357.
Mazloom, M. and Ranjbar, A. (2010), "Relation between the workability and strength of self-compacting concrete", *Proceedings of the 35th Conference on our world in concrete & structure*, Singapore, August.
Mazloom, M., Saffari A. and Mehrvand, M. (2015), "Compressive, shear and torsional strength of beams made of self-compacting concrete", *Comput. Concrete*, **15**(6), 935-950.
Mazloom, M, Soltani, A., Karamloo, M., Hassanloo, A. and Ranjbar, A. (2018d), "Effects of silica fume, superplasticizer dosage and type of superplastisizer on the properties of normal and self-compacting concrete", *Adv. Mater. Res.*, **7**(1), 407-434.
Mazloom, M. and Yoosefi, M.M. (2013), "Predicting the Indirect Tensile Strength of Self Compacting Concrete Using Artificial Neural Networks", *Comput. Concrete*, **12**(3), 285-301.
Nunes, S., Figueiras, H., Oliveira, P.M., Coutinho, J.S. and Figueiras, J. (2006), "A methodology to assess robustness of SCC mixtures", *Cement Concrete Res.*, **36**(12), 2115- 2122.
Paultre, P., Khayat, K.H., Cusson, D. and Tremblay, S. (2005), "Structural performance of self-consolidating concrete used in confined concrete column", *ACI Struct. J.*, **102**(4), 560-568.
Saqan, E., Rasheed, H. and Alkhrdaji, T. (2018), "Evaluation of the seismic performance of reinforced concrete frames strengthened with CFRP fabric and NSM bars", *Compos. Struct.*, **184**, 839-847.
Sharif, A., Al-Mekhlafi, G. and Al-Osta, M. (2019), "Structural performance of CFRP-strengthened concrete-filled stainless steel tubular short columns", *Eng. Struct.*, **183**, 94-109.
Shin, M. and LaFave, M.L. (2004), "Reinforced concrete edge beam-column-slab connections subjected to earthquake loading", *Mag. Concrete Res.*, **55**(6), 273-291.
Silva, M., Biscaia, H. and Marreiros, R. (2013), "Bond-slip on CFRP/GFRP-to-concrete joints subjected to moisture, salt fog and temperature cycles", *Compos. Part B: Eng.*, **55**, 374-385.
Taqieddin, Z.N. (2008), "Elasto-Plastic and damage modeling of reinforced concrete", Ph.D. dissertation, Louisiana State University, Baton Rouge LA.
Zhou, L., Zheng, Y. and Taylor, S. (2018), "Finite-element investigation of the structural behavior of basalt fiber reinforced polymer (BFRP)-reinforced self-compacting concrete (SCC) decks slabs in Thompson bridge", *Polymers J.*, **10** (6), 67-702.

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