MODERN STRENGTHENING TECHNIQUES FOR MASONRY STRUCTURES UNDER IMPULSIVE LOADING

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Abstract

Fiber Reinforced Polymers have become a popular material for strengthening of masonry structures. The performance of this technique is strongly dependent on the bond between the FRP and the substrate. This work aims to study the behavior of the bond between different strengthening systems (EBR and NSM), different materials (GFRP and CFRP) and different substrates (Brick and concrete) at different strain rates. A Drop Weight Impact Machine specially developed for pull-off tests (single shear tests) is used with different masses and different heights introducing different deformation rates. The strain rate effect on the failure mode, shear capacity, effective bond length and the bond-slip laws is determined from the experimental results. Empirical relations of dynamic increase factors (DIF) for these materials and techniques are also presented.

1. EXPERIMENTAL SETUP

Different test setups have been used to characterize the bond behavior of concrete-FRP systems [1]. In the case of masonry-FRP systems, due to the lack of standard test setups, similar setups have been used to study this phenomenon [1]. Single-lap shear bond tests consist in imposing a load in the FRP strip, along its longitudinal direction (Fig. 1a). Usually, the composite is applied to one of the faces of the substrate, leaving enough FRP strip free to be connected to the actuators. A drop weight tower specifically developed for single-lap shear bond tests was used for the dynamic testing (Fig. 1c). This tower allows a drop height up to 3 meters and a drop weight with a minimum of 14 kg [1].

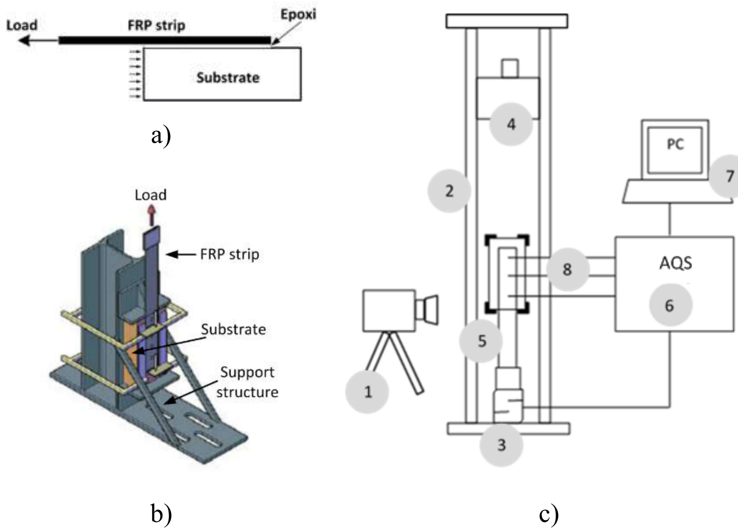
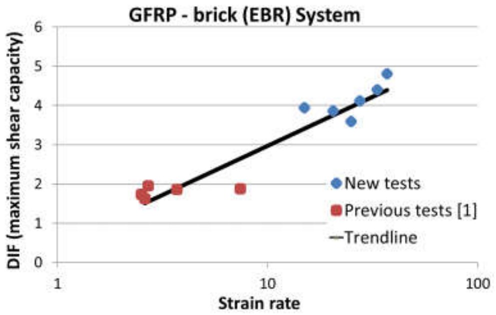


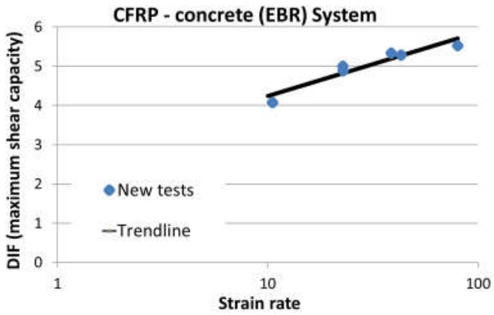
Fig. 1. Single-lap shear bond tests: a) test schematic; b) quasi-static test setup; c) drop weight tower (1) high-speed video equipment; (2) drop weight tower; (3) load cell; (4) hammer; (5) specimen; (6) acquisition system; (7) PC; (8) strain gauges.

2. EXPERIMENTAL RESULTS

From the obtained results, the strain rate clearly influences the bond behaviour of these systems (Fig. 2). In the EBR GFRP-brick system there is an increase of the maximum bond capacity of almost five times the quasi-static value for a strain rate of 37 s^{-1}. Similar increase was obtained for the CFRP-concrete systems but at a strain rate of 80 s^{-1}. For the NSM specimens the observed increase was 3.6 times the quasi-static reference for a strain rate of 20 s^{-1}. The strain gauges placed along the reinforcement allowed to determine the effective bond length of these systems, being the same as the obtained in quasi-static regime. Equations (1) to (3) represent the log-linear empirical relation relations able to translate the influence of the strain rate in the maximum bond capacity of the tested specimens.



a)



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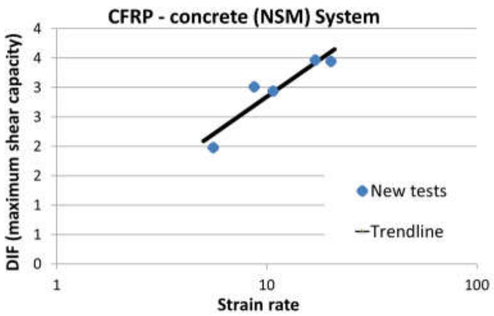

c)

Fig. 2. DIF for shear capacity at different strain rates and different strengthening systems: a) GFRP-brick (EBR); b) CFRP-concrete (EBR); c) CFRP-concrete (NSM).

GFRP-brick (EBR) – $DIF(F_{max}) = 1.0844 ln(\dot{\varepsilon}) + 0.4779$ (1)

CFRP-concrete (EBR) – $DIF(F_{max}) = 0.7151 ln(\dot{\varepsilon}) + 2.6184$ (2)

CFRP-concrete (NSM) – $DIF(F_{max}) = 1.0878 ln(\dot{\varepsilon}) + 0.3382$ (3)

References:

[1] J.M. Pereira, P.B. Lourenço, Experimental Bond Behavior of GFRP and Masonry Bricks under Impulsive Loading, Materials and Structures, 49(11), 4799-4811, 2016

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