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Influence of Recycled Concrete Aggregate Content on the Rebar/Concrete Bond Properties through Pull-Out Tests and Acoustic Emission Measurements

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Abstract : Substituting natural aggregate with recycled aggregate coming from concrete demolition represents a promising alternative to face the issues of both the depletion of natural resources and the congestion of waste storage facilities. However, the crushing process of concrete demolition waste, currently in use to produce recycled concrete aggregate, does not allow the complete separation of natural aggregate from a variable amount of adhered mortar. Given the physicochemical characteristics of the latter, the introduction of recycled concrete aggregate into a concrete mix modifies, to a certain extent, both fresh and hardened concrete properties. As a consequence, the behavior of recycled reinforced concrete members could likely be influenced by the specificities of recycled concrete aggregates. Beyond the mechanical properties of concrete, and as a result of the composite character of reinforced concrete, the bond characteristics at the rebar/concrete interface have to be taken into account in an attempt to describe accurately the mechanical response of recycled reinforced concrete members. Hence, a comparative experimental campaign, including 16 pull-out tests, was carried out. Four concrete mixes with different recycled concrete aggregate content were tested. The main mechanical properties (compressive strength, tensile strength, Young’s modulus) of each concrete mix were measured through standard procedures. A single 14-mm-diameter ribbed rebar, representative of the diameters commonly used in the domain of civil engineering, was embedded into a 200-mm-side concrete cube. The resulting concrete cover is intended to ensure a pull-out type failure (i.e. exceedance of the rebar/concrete interface shear strength). A pull-out test carried out on the 100% recycled concrete specimen was enriched with exploratory acoustic emission measurements. Acoustic event location was performed by means of eight piezoelectric transducers distributed over the whole surface of the specimen. The resulting map was compared to existing data related to natural aggregate concrete. Damage distribution around the reinforcement and main features of the characteristic bond stress/free-end slip curve appeared to be similar to previous results obtained through comparable studies carried out on natural aggregate concrete. This seems to show that the usual bond mechanism sequence (‘chemical adhesion’, mechanical interlocking and friction) remains unchanged despite the addition of recycled concrete aggregate. However, the results also suggest that bond efficiency seems somewhat improved through the use of recycled concrete aggregate. This observation appears to be counter-intuitive with regard to the diminution of the main concrete mechanical properties with the recycled concrete aggregate content. As a consequence, the impact of recycled concrete aggregate content on bond characteristics seemingly represents an important factor which should be taken into account and likely to be further explored in order to determine flexural parameters such as deflection or crack distribution.

Keywords : acoustic emission monitoring, high-bond steel rebar, pull-out test, recycled aggregate concrete
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