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Mechanical characterization of the fibre/matrix interface and aggregate/matrix (ITZ) in fibre reinforced concrete

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Summary

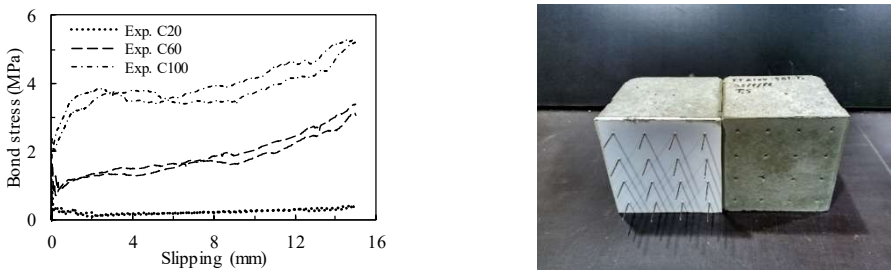
Concrete behaviour is generally well known at the macroscopic level since most of the research and development of this material has been focused on this aspect. Thus, concrete is usually considered a homogeneous material, in which its mechanical properties, essentially the strengths and stiffness, are well studied. However, in order to better understand the concrete behaviour, it is necessary to deepen the study, through a more focused approach to its constituents and the interactions between them, which has been developed in recent years. In this type of analysis, at the mesoscopic level, it is possible to discretize the concrete in several phases. Thus, at this scale, fibre reinforced concrete (FRC) has to be considered a heterogeneous material, composed by three phases: binder matrix; aggregates and/or fibres; and transition (ITZ – Interfacial Transition Zone) and interface zones between the previous. The mechanical properties of the ITZ, namely the aggregate/matrix strengths, and the interface fibre/matrix adhesion are more difficult to evaluate and, especially in the first case, there is a small number of experimental studies. For this reason, this was defined as the main objective of this thesis.

In order to mechanically characterize the aggregate/matrix ITZ and the fibre/matrix interface in FRC, a work plan was elaborated in four stages. In the first one, a bibliographical research was conducted about the concrete, focused particularly on FRC and the properties of the ITZ. In the second, the materials to be used were selected and characterized, the binder matrices were formulated and the specimens and the tests to be performed were defined. In the third, the FRC physical and mechanical characterization tests were carried out. In the fourth and last step, the mechanical behaviour of the aggregate/matrix ITZ and fibre/matrix interface was evaluated, namely the aggregate/matrix strength, when subjected to tension, compression or shear, and the fibre/matrix adhesion.

The analysis and discussion of the test results led to the conclusion that there are several factors that can affect the behaviour of the aggregate/matrix ITZ and fibre/matrix interfaces in FRC. In the case of the fibre/matrix interface, the presence of curved ends in the fibres is determinant to achieve higher levels of strength and ductility. Fibre diameter and length are also fundamental, since they have an important influence when the FRC is subjected to shear actions. With regard to the aggregate/matrix ITZ, it was possible to conclude that the aggregates stiffness is a decisive factor in its mechanical behaviour, which is generally the better the smaller the stiffness difference between the aggregates and binder matrix. The binder matrix strength alone has a great influence on the behaviour of the ITZ, whose strength is usually better the greater the binder matrix. The aggregates roughness also influences the behaviour of the ITZ, especially when it is subject to tension.

Keywords

Fibre reinforced concrete, binder matrix, aggregate stiffness, fibre/paste interface, aggregate / paste ITZ.



Fibre/matrix interface: bond stress-slipping curve (left) and specimen configuration after the test (right).