Three-Dimensional Modelling of the Concrete-CFRP Bond Behaviour

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The major problems found with external bond reinforcement are the local failure modes. In the last few years, several experimental and analytical studies have been carried out, which contributed to the understanding and quantification of the phenomenon related to the bond behaviour between concrete and fibre reinforced polymers (FRP). However, several issues still need to be clarified to allow an accurate quantification of the adherence between the concrete and the reinforcing material.

To quantify the bond between FRP and concrete, several studies have been developed, in general, by means of two-dimensional tools. In general, the failure occurs by detachment of a thin concrete layer adjacent to the interface. Therefore, several authors presented a relation between the concrete properties and the cohesion. In general, for the most common concrete used in buildings structures, the cohesion is about 5 – 7 MPa. Assuming failure by concrete, the dissipated energy per unit area of cracked surface is defined as fracture energy of concrete. Taking into account 2D analyses, a dispersion of the mode-II fracture energy values greater than the one previously observed for cohesion has been found. In this case, from published works, for the most common concrete used in buildings structures, the ratio between maximum and minimum values of G_F^{II} is almost four. According to several authors, the parameters describing the bond behaviour are dependent on geometrical characteristics. One way of considering such influence is by means of a 3D analysis. Use of 3D models to analyse the bond behaviour between FRP and concrete is considered in few studies. Linear elastic 3D finite element analyses were carried out by [1] to investigate the stress state in a single shear test, in which perfect bond was assumed both between the adhesive and the FRP and between the adhesive and the concrete. Bond-slip laws were implemented in shear models [2, 3, 4].

In this study, based on previous works, a 3D analysis is presented. Pure shear models are defined, using the finite element method, in order to describe the bond behaviour between concrete and sheets of carbon FRP externally glued. Modelling the behaviour of these specimens involves a non-linear phenomenon, namely: shear mode fracture interface behaviour between the concrete and the CFRP. In both models, the bond between the FRP and the concrete is modelled using a discrete crack approach. Interface elements with zero initial thickness are adopted. The shear and peeling stresses developed at these elements are dependent on the relative displacement between the strengthening material and the concrete surface, according to a local softening constitutive relationship. Both Poisson's ratio and the orthotropic behaviour of the CFRP are considered. The relation between adherent and substrate widths is considered in a parametric study. A discussion on the adoption of these parameters is made and some values are proposed.

References

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