ABSTRACT

Concrete is conventionally assumed to behave in an elastic-brittle manner under tension. However, the validity of this hypothesis depends on the scale of the element and the type of material analysed. In general, concrete behaves as a quasi-brittle material, which is heterogeneous due to the presence of different phases, interfaces, pores and other defects. The failure is, therefore, not brittle but gradual though the toughening is relatively low. The degree of toughening or toughness can be increased significantly by the incorporation of fibres in the concrete.

The principle aim of this thesis is to analyse the effects of cracks and their propagation on the mechanical behaviour in a quasi-brittle material such as concrete. More specifically, the shear failure of Steel Fibre Reinforced Concrete (SFRC) in push-off tests on prisms is studied. Taking into account that shear failure occurs along with cracking opening under tension, the mode of failure is of mixed-mode fracture, as a combination of the pure modes I and mode II. Also, three-point bending tests have been performed on beams to study the failure under mode I fracture.

The shear fracture analyses have been carried out direct shear tests in the push-off configuration using double-notched prisms. In order to study the influence of the lateral restraint on the shear failure, different levels of crack-closing confinement have been applied. Moreover, to ensure appropriate boundary conditions, different test set-ups were designed and tried out.

Using the experimental data obtained from the flexural tests on notched beams loaded under three-point bending, mode I fracture parameters of the different concretes were extracted through an inverse analysis procedure. The parameters have been used to model the push-off test response through the use of finite element analysis based on non-linear fracture mechanics.

Several conclusions have been drawn from the experimental and numerical analyses. Probably, the most important conclusion is that the ductility of the concrete increases significantly as the fibre content in the concrete and the lateral restraint increase. With respect to the different set-ups that have been designed to introduce the lateral confinement on the shear specimen, all of them worked successfully, leading to the determination of the post peak behaviour in a stable manner for different levels of lateral restraint. Moreover, the relationship between tensile and shear stresses during failure has been evaluated.

Lastly, according the results of the numerical modelling of the push-off tests, it is seen that it is not straightforward to modelling the direct shear failure with the discrete crack approach, using the models for the tensile cracking and bulk behaviour available in commercial codes.