Abstract

Reinforced concrete planar members, as slabs and shells, are structural elements commonly used in the construction technique, which are typically designed without the arrangement of shear reinforcement. Despite the fact that this solution allows for fast and economic construction, the absence of shear reinforcement can give rise to the potential localization of strains within a critical shear crack and eventually to the shear failure of the member before reaching its flexural capacity. In the case of redundant systems, most research on the mechanics of shear failures has been devoted to the strength of the member, neglecting in many cases the development of shear deformations due to inclined cracking as well as the redistributions of internal forces, which are instrumental for the analysis of the response of these members. This situation is to a large extent a consequence of the lack of consistent experimental observations of the strain field of reinforced concrete members. The present thesis addresses the analysis of the mechanics of shear failures in reinforced concrete slabs. The contribution to the state-of-the-art includes a series of theoretical works explaining the observed responses for a series of experimental programmes. These experimental campaigns comprise tests in tension, shear tests in one- and two-way slabs as well as punching tests. For their instrumentation, in addition to classical measurement devices, Fibre-Optic Measurements and Digital Image Correlation were intensively used.

This thesis starts by revisiting the basis of the interaction between reinforcement and concrete. A series of bond tests show the stress concentrations occurring near the ribs and its complex transfer of forces with the surrounding concrete. In addition, tests on beams failing in shear show a complex interaction between bond stresses and kinking on the reinforcement due to the development of dowel action. These phenomena are normally neglected for concrete design due to the ductile nature of reinforcement, but may be relevant for fatigue and negative tension-stiffening effects.
An important step in the knowledge is performed on the understanding of the shear response with respect to the characterization of the deformations in concrete members. Based on a series of test results, a complete description of the deformation field (including shear strains) is presented. On that basis, a rational model is proposed, consistent with the mechanical model of the Critical Shear Crack Theory. This model allows for a precise description of the response and also to describe the through-thickness distribution of the shear deformation.
A general frame for modelling of reinforced concrete slabs is thus presented accounting for the redistribution of internal forces during propagation of the shear crack. This approach is used to investigate a testing programme performed on three wide slabs, analysing in a scientific manner the influence of the width of the member on the shear resistance. The detailed experimental data allow to capture the crack propagation and internal forces redistributions. Clear conclusions and answers are obtained, showing the influence of the shape of the failure surface and of its propagation on the load-carrying capacity.
The research ends with a final investigation on the dowelling action of compression reinforcement, with an application to slabs failing in punching. Based on a large testing programme including eleven axisymmetric punching tests, an analytical approach is developed to estimate the contri-

bution of the dowel action on the load-carrying capacity. This approach is formulated within the frame of the Critical Shear Crack Theory, and is incorporated in a consistent and efficient manner for design purposes.

Keywords: reinforced concrete slabs, shear strength, shear deformations, crack kinematics, shear redistributions, dowel action, Critical Shear Crack Theory, Digital Image Correlation, Fibre Optic Measurements.