Abstract

Bond between reinforcing bars and concrete has been the focus of extensive research over the last century. This is well-justified as the functioning of reinforced concrete intimately depends on the interaction between rebar and concrete, as for example cracking and the development of anchorage forces. The large number of publications on various aspects of bond highlights its complexity. One reason why it is difficult to study bond-related phenomena is that it is a very local mechanism, whose effects are integrated over larger parts of the structure. This can lead to significantly different results for virtually identical tests. Furthermore, bond depends on a large number of parameters. This is probably why studies often address only a few different aspects of bond. Fortunately, recent improvements in measurement techniques have provided additional tools to gain an unprecedented insight on the interaction between rebar and concrete. This has led to new experimental evidence showing that some of the assumptions of current design codes concerning bond need to be improved.

This thesis presents the results of a comprehensive research programme aimed at improving the understanding of the interaction between rebar and concrete. By combining experimental and theoretical investigations, this research aims to add further mechanical considerations to the characterization of bond and to better connect some of the various aspects of this interaction. For this purpose, conventional measurement systems and state-of-the-art measurements were used in simple tests of isolated bars anchored in concrete blocks (pull-out tests), in reinforced concrete tie tensile tests and in full-scale tests on beams.

To investigate the activation of bond stresses in anchorages, an experimental programme of medium-length pull-out tests was performed to study the influence of several parameters commonly appearing in concrete structures. A reference bond-slip relationship based on pull-out test results was proposed. The theoretical work shows that the activation of local bond stresses along the anchorage length can be explained and quantified by a reduction of that reference relationship, caused by the development of cracks along the bar. The second part of this research aims at improving the accuracy and generality of the bond-slip relationship for various conditions. A particular attention was given to provide a mechanical basis for the proposed expressions whenever possible. Lastly, the pertinence of the proposed bond-slip relationship was verified by applying it to cracked concrete elements. For this purpose, an experimental programme composed of reinforced concrete ties and beams was performed. Further data from tests by other researchers was also used for the validation. The proposed relationship satisfactorily describes the activation of bond stresses in the longitudinal and shear reinforcement of the tested members. The experimental results, however, differ from typically assumed values. Given the potential of these new detailed measurement techniques, their pertinence for monitoring cracks in existing structures was also investigated, showing promising results.

Keywords

Anchorage, bond stress, bond-slip relationship, casting conditions, confinement, cracking, Digital Image Correlation, fibre optical sensors, pull-out, splitting, spalling, reinforced concrete