Summary

Aggregate interlocking is a phenomenon occurring when the opposite sides of a concrete crack slide relative to each other. Due to surface roughness, protruding material from one crack-side can engage with the opposite one and thus exchange forces. This affects the load-carrying capacity for structures where the failure is determined by the development of large cracks, like beams and slabs without transverse reinforcement. In such cases, aggregate interlocking contributes significantly to the various shear-transfer actions, allowing forces to traverse cracks.

Aggregate interlocking has been studied for several decades, leading to various experimental and theoretical approaches. However, a number of aspects remain unclear, like the development of new cracks from the initial one and the influence of certain concrete properties on the interlocking forces (e.g. aggregates, crack surface roughness). The present research project comprises three scientific publications focusing on the fundamentals of interlocking and force transfer across concrete cracks and other interfaces related to concrete structures. It is based on the results of an extensive experimental campaign performed with an arrangement allowing to apply precise kinematics upon material discontinuities. The tested specimens include pre-cracked concrete prisms subjected to simultaneous crack opening and sliding and steel-to-concrete interfaces characterized by simple geometries (spheres and rebar-surfaces). Particular attention is given to the roughness properties of the tested cracks and interfaces, several of which were scanned at high resolution.

The experimental results are used to develop a new model for estimating aggregate interlocking forces as a function of crack kinematics. The model is based on the approach originally introduced by Li and Maekawa (1987) with the *Contact Density Model* and allows estimating the contact properties using 2D crack-profiles. Depending on the crack width, two contributions to force transfer are considered. For contacts occurring in wide cracks, contact forces are calculated using an elastic-plastic material law, whereas for small crack opening the effect of residual material soundness is considered. The model can be applied on surfaces corresponding to tests with various failure modes, thus considering different levels of roughness.
Finally, the bond between steel rebar-ribs and concrete is investigated using steel-to-concrete interface specimens, and several similarities with aggregate interlocking are discussed. The previously introduced model is extended to the case of interlocking rebar-ribs, where it can estimate the bond and confinement stresses and the decrease in bond strength for cases where

cracks develop parallel to the rebars.

The thesis ends with an extensive appendix containing details on the performed tests which can be of interest for future researchers.

Keywords: aggregate interlocking, concrete cracks, mechanical modelling, surface roughness, shear transfer, bond