Mesoscopic modelling of the shear stud-concrete interface

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Abstract: Composite steel/concrete construction comprises a concrete slab constrained to behave compositely with a supporting steel beam, typically through the use of welded, headed shear studs. The behaviour of the shear stud-concrete interface is very complex at all levels of loading and this behaviour significantly affects the overall performance of steel-concrete composite beams. Internal forces are transferred through the stud-concrete interface between the concrete and steel, so as soon as the interface starts to fracture or crush, the load carrying capacity of the composite beam changes. Accurate numerical modelling is essential to capture this behaviour. This paper presents a detailed finite element model of the stud-concrete interface, conducted on a mesoscopic level. The model consists of a single shear stud surrounded by concrete. The aim of this paper is to provide information on the behaviour of the shear stud-concrete interface that is unavailable from experimental testing, hence deepening the understanding of composite behaviour.

In developing this model, first, a comprehensive numerical concrete model has been created. This numerical concrete is comprised of the three main phases, coarse aggregates, mortar matrix and the interfacial transition zone (ITZ). The numerical concrete model has been analysed first to ensure crack and stress distribution are realistic for concrete with given properties, via calibrating against experiments. This numerical concrete model has then been applied to the shear stud-concrete (composite) model, where the behaviour of the interface has been analysed and compared with experimental testing. Results show that the model is successfully able to replicate the behaviour of a composite beam under shear loading. It is able to predict the deformation and failure mode of the composite, including force transfer, stress distribution, damage evolution and crack propagation between the shear stud and concrete. The results of the model have been validated from experimental work undertaken in a specially developed push-off rig.