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A TWO-SCALE STRONG COUPLING FRAMEWORK FOR SOFTENING MATERIALS

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ABSTRACT

Multi-scale analysis of materials is an ongoing research topic which is recently been strengthened by the use of more powerful computational tools. The outcome of these techniques has promising features for the study of highly non-linear heterogeneous materials as well as for the design and assessment of new materials.

Localisation of deformation and fracture, among other phenomena, are considered crucial non-linear processes which have an origin at a highly detailed level. This is, for instance, the case for concrete in which cracks typically originate as the result of coalescence of micro-cracks during mechanical loading. These phenomena can be captured by an appropriate modeling technique at the mesoscopic level where aggregates, matrix, and Interfacial Transition Zone (ITZ) can be distinguished.

In this study a two-scale framework is described which is envisaged to deal with fracture and localisation phenomena in cases where the principle of separation of scales does not hold. For this reason techniques that are based on homogenisation principles [1,2] can not be used. The strategy couples both macro and meso-scales [3] by assigning a certain meso-cell to each macro-element in which a detailed analysis needs to be performed. Both meso-cell and macro-element coincide in terms of shape and dimensions which guarantees that the scales will remain coupled during the computations. The goal is to provide a strategy that is objective with respect of the macroscopic discretisation and flexible in terms of the modeling technique used at meso-scale.

It is shown that the hypothesis chosen to build the boundary value problem at the meso-level is crucial. Macroscopic element size dependence is found when the displacements at the meso-cell boundary are simply interpolated from the displacements of the macro element nodes. A different boundary condition is proposed which is compatible with the deformed configuration of the macroscopic element and, at the same time, allows for localisation to take place at the boundaries of the cell. The new hypothesis proves to be capable of dealing with strain localisation phenomena in a more natural way.

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