ON THE ALGORITHMIC FORMULATION OF STRONG DISCONTINUITY APPROACHES

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This paper is concerned with the algorithmic formulation of strong discontinuity approaches. In these approaches, localized deformations are approximated by discontinuous displacement fields (strong discontinuities). Instead of stress-strain relationships, the material response is governed by traction-separation laws. For the modeling of cracking in brittle structures, this idea goes back to Hillerborg [1]. In [1] softening was controlled by an evolution law $t_n = t_n(w_n)$ for the normal component $t_n = (\boldsymbol{n} \otimes \boldsymbol{n}) : \boldsymbol{\sigma}$ of the traction vector $\boldsymbol{t} = \boldsymbol{\sigma} \cdot \boldsymbol{n}$ acting on the crack surface with its normal $\boldsymbol{n}$ in terms of the crack width w_n. The bridging between continuum models (stress-strain relation) and discrete approaches (traction-separation relation) was achieved by Simo, Oliver & Armero [2], [3] using the generalized derivative of the Heaviside function.

In this paper we discuss different algorithmic formulations as well as extensions of the work [2]. In contrast to [2] and in analogy to [4], the singular strains associated with the discontinuous part of the displacement field are integrated exactly, resulting in traction-separation laws. For the numerical analyses of quasi-brittle materials, only mode I failure is considered. On the basis of academic benchmark problems the scope of application of single fixed crack approaches is demonstrated. Since the direction of the micro-cracks does not coincide with the direction of their corresponding macroscopic cracks, stress locking occurs. This drawback of the fixed crack approach can be eliminated by applying the rotating crack concept [5] or by allowing intersecting cracks. For both suggested extensions the advantages and drawbacks are analyzed critically. Particularly, the resulting algorithmic formulations are presented and discussed. The applicability and the performance of the proposed numerical implementation as well as its numerical robustness are investigated by means of a three-dimensional ultimate load analysis of a steel anchor embedded in a concrete block.

References

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