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NONLOCAL APPROCHES TO DUCTILE FAILURE

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Accurate predictions of progressive material degradation related with ductile damage failure is an important issue in practical engineering problems. In this context, modelling complex strain paths requires whether adopting constitutive models within the so-called Continuum Damage Mechanics (CDM) [1] or material laws established from micro-mechanical considerations [2]. In the first case, damage is treated as an internal variable that also participates in the dissipative inelastic process, strongly coupling plasticity and damage effects. On the second case, material degradation is taken into account at the constitutive model level and although damage influences plastic straining indirectly it does not energetically contribute to energy dissipation Many constitutive models established with one of those approaches have proved effective in modelling material internal degradation and predicting failure within a reasonable range of applications. Nevertheless, they are based on local continuum theories, which may not be valid when deformation reaches a critical level and the internal degradation of the material has an important influence on the macrostructural response, typically resulting in a global strain-softening regime. At this phase, heterogeneities in the micro-structure play a crucial role, being responsible for the onset of the failure phenomenon which will lead, eventually, to the appearance of a macro-cracks. Since classical local theories disregard important effects of the micro-structure of the material, they cannot correctly describe the aforementioned localised failure process. Within a typical finite element framework, for instance, the localised zone will have the size of the elements at the critical zone. As the mesh is refined damaged zones concentrate in small layer of elements and in the limit case, the total dissipated energy of the process unrealistically vanishes. Some strategies, as gradient and integral non-local approaches, have been proposed to somehow regularize the solution [3]. The extension of the phase-field concept to the ductile failure problems is also as an alternative approach of dealing, within a continuum framework, with ductile fracture, sharing a similar procedure of adding effects via a characteristic length [4]. In this work an unified approach of these problems is discussed and the proposed methodologies are assessed, resorting to some benchmarking examples.

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