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On the development of a plate-finite element framework using the strong discontinuity approach for reinforced concrete components

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ABSTRACT

Damage models, developed in the last decades, allow efficient modeling of fracture zones in quasi-brittle materials like concrete. Recent damage models, based on a continuum description of the media, succeed in representing the main features related to the complex behavior of quasi-brittle materials such as cracking, crack closure effect and permanent strains [1]. However, cracking is described in a diffuse way and quantifying cracking features for instance openings and spacing is a difficult task. Post-processing methodologies are needed to estimate the aforementioned quantities [2].

The recently emerged concept of displacement discontinuities embedded into a standard finite element has come up in the continuity of the smeared crack approach. The kinematics of a traditional finite element is enhanced by a displacement jump which represents the crack opening. In our work, the Embedded Finite Element Method (E-FEM) is used [3]. Numerically, the enhancement related to the displacement jump takes places locally in the element. The non-linear behavior is handled by a tension/separation law characterizing the energy dissipation on the discontinuity.

The objective of our study is the development of a kinematic enhanced damage model to represent cracking patterns of reinforced concrete components subjected to seismic loadings. Within the framework of earthquake engineering in which time-consuming non-linear dynamic analyses have to be carried out to make seismic assessments, the use of reduced kinematic-based elements such as plates and shells is relevant to model reinforced concrete components like slabs or shearwalls. An anisotropic damage model, based on micromechanical assumptions, is used [4]. This model allows accounting, in a natural manner, for particular crack orientations in reinforced concrete membrane elements. A "discrete" damage formulation is considered by introducing p couples of microcrack densities and directional tensors, denoted by $\rho_p \mathbf{N}_p$. Microcrack densities ρ_p are considered as internal variables and the directional tensors $\mathbf{N}_p$ are constructed as the tensor product of the normal to the crack. The model can represent either mode-I and mode-II cracking mechanisms which can be handled independently.

This model is then enhanced with the strong discontinuity kinematics. In order to obtain a consistent enriched model compared to the continuous one, the Dirac distribution is regularized [3]. The enriched constitutive model is then expressed in terms of traction/separation law. The main features of this model will be exposed. Numerical simulations, for instance three point bending test and reinforced concrete tie, will be shown to illustrate the performances of this model and compared to experimental results.

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