Extension of phase field method for predicting fracture path in bi-materials by strong-form meshless method

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Material failure prediction is an essential engineering practice for the life-cycle prediction of components. Present computational fracture mechanics uses, either a discrete or diffused, crack model to predict the fracture path. Traditional discrete methods require an additional ad-hoc criterion for the crack path propagation, making it more computationally intensive for complicated scenarios like crack-branching, crack interaction, crack-path propagation across an interface in composite materials and for three dimensional geometries. On the contrary, continuous approaches like phase-field make these predictions smoother as they use a continuous displacement field with an intrinsic length scale thus controlling the width of transition zone. In the case of phase-field based model, the crack is represented by a scalar field, and the evolution of phase-field evolution equation leads to the modelling of crack path [1, 2].

The present work deals with developing a numerical model for capturing the fracture propagation by phase-field technique in a bi-material (isotropic and specially orthotropic cases). The phase field damage model will be implemented, employing the strong-form meshless local differential quadrature method [3], coupling with the mechanical equilibrium equations.

Strong-form meshless methods can solve governing equations employing lesser discretised nodes without compromising on the accuracy thus making them an ideal candidate for multi-physics problems [3, 4]. The present work implements a strong-form technique called the local differential quadrature (LDQ) method [5]. The LDQ method is capable of solving strong-form governing equations employing uniform, cosine, or random nodes. Despite the advantages offered by LDQ method, solving boundary value problems for bi-material involves an unique challenge of ensuring the traction continuity across the bi-material interface (unlike in finite element method), which is addressed in the present work.

The *novelty* of present work is to demonstrate the numerical implementation results of phase field method with mechanical equilibrium equations, for *bi-material* case, employing LDQ method ensuring a correct traction continuity (currently lacking in the literature).

The present phase-field model will be based on Miehe *et al.* [2] involving a history variable (irreversible damage) and solving the problem using a staggered approach. The capability and the correctness of the formulation will be tested using different benchmark problems, wherein the effect of individual layer material stiffness on the propagation of fracture path is observed.

References

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