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CRACK INITIATION FROM ARBITRARY 2D NOTCHES: EFFICIENT MULTI-SCALE MODELS USING THE FINITE FRACTURE MECHANICS CONCEPT

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In a wide range of applications, notches in materials or components are inevitable, and it is crucial to assess how they affect failure. Stress-based criteria like the maximum principal stress criterion are widely used, but for crack-like shaped notches they are too conservative due to the stress concentration.

In this work, a crack initiation criterion is used to predict failure from notches. The crack initiation is predicted by the Finite Fracture Mechanics (FFM) concept [1], where a stress and an energy condition both have to be fulfilled for a crack to initiate. To compute the incremental energy release rate from a given notch, cracks are introduced in Finite Element models. Since the cracks need to be an order of magnitude smaller than the notch geometry, this cannot be done in one single model for the whole notch surface in an efficient way, which is the reason why a multi-scale approach is pursued.

The multi-scale approach consists of a component-, a detail-, and a crack model. Small notches are neglected or homogenized in the component model. The detail model is a submodel of the component model and contains the notch. It is implemented as a voxel model because a voxel mesh can be easily generated from a scanned image of a notch. Furthermore, the detail model is used to compute an estimate of the curvature of the notch and to fit predefined deformation modes along the surface of the notch. The crack model is a generalized model defined in an image space and can therefore be adapted for any location on the notch surface with convex curvature. The model is used to predict crack initiation based on the FFM concept. It is run for a number of predefined deformation modes and a range of curvatures to generate a precomputed meta-model. Linear superposition of the deformation modes as well as scaling laws for the size of the crack model and its stiffness allow us to transfer the precomputed results, stored in the meta-model, to any position on the notch surface in the local model. The approach is applied to an arbitrary-shaped notch and compared to a fully modeled approach in terms of efficiency, accuracy, and applicability.

REFERENCES

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