Interaction of coplanar 3D cracks in brittle materials under compression

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ABSTRACT

We study the interaction of laterally aligned coplanar penny-shape cracks under compression, in particular the influence on the wing crack growth and coalescence and the stress intensity factors on the crack front.

Under uniaxial loading, brittle materials, such as rock or concrete, are known to break macroscopically along the direction of loading, which has been widely explained by the development and coalescence of inner micro defects. One of the mechanism proposed to explain this phenomenon is the wing crack model[1]. The first studies of compressive failure were based on 2D models, representing the rupture of plates with 2D micro-cracks in uniaxial and biaxial loading, for which extensive growth could be observed. For the 3D case, a single micro-crack cannot lead to the total failure in uniaxial compression, but a network of micro cracks can. Most of three dimensional models are built as extensions to two dimensional models, evaluating the interaction of 3D micro-cracks positioned in a 2D plane. Also, in general only the stress distribution preceding the growth of wing cracks is considered, and some mechanisms such as crack wrapping are neglected. In particular, the interaction between cracks positioned side by side, perpendicularly to the 2D plane, is not accounted for in general, although it has been observed in experiments conducted by Dyskin *et al.*[2].

With the available computational power available today, it is possible to conduct a full simulation of the wing crack growth for several initial cracks in different geometric configurations. In this study, the 3D crack propagation is simulated with PDS-FEM[3], which offers a simple and effective treatment for failure. Our aim is to study the interactions between 3D wing cracks propagating from inclined penny-shaped initial cracks, particularly for the coplanar horizontally aligned cracks case investigated by Dyskin *et al.*. In particular, we aim at evaluating the effects on the stress intensity factors along the secondary cracks front at different stages of crack growth, as a function of the distance between cracks and the friction coefficient between the pre-existing crack surfaces, by comparing with the single crack case. Our preliminary results show that the interaction between two horizontally aligned crack is significant if cracks are situated at a distance lower than their diameter, as observed in Dyskin's experiments. This interaction is also observable for larger distances, but only if wing cracks sufficiently expand laterally which happens for loads that likely exceed the compressive strength of the material. For small distances, the wing cracks starting from adjacent initial cracks join together and create a unique crack front, leading to a relative increase of up to 30% of the mode I stress intensity factors on the crack tip, compared with the single crack scenario.

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