Crack Tip Conditions for a Slant Crack in a Symmetrically Loaded Plate

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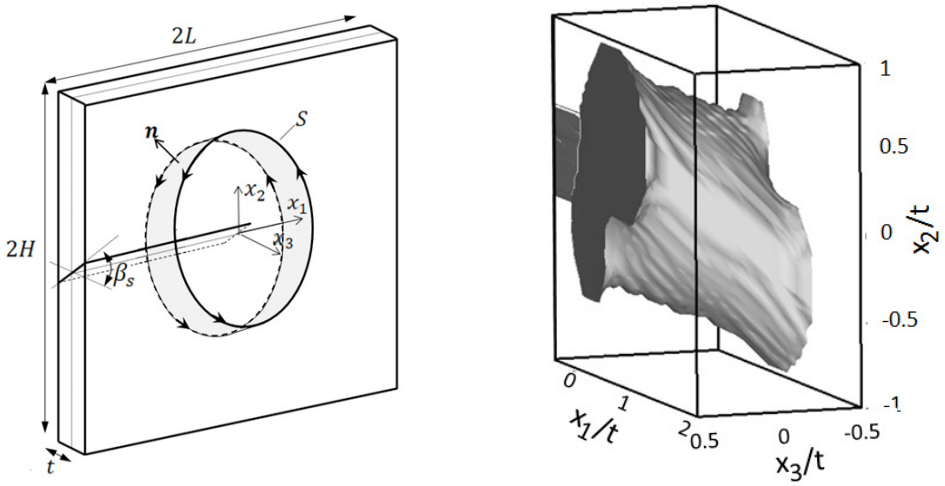
ABSTRACT

Elastic and elastic-plastic results are obtained for a semi-infinite slanted through-crack propagating at steady-state in a symmetrically loaded plate with the aim of providing insight to commonly observed plate tearing behavior. The problem at hand is mode I if the crack remains flat, such that the normal to the crack face remains parallel to the loading direction. However, by introducing a slant crack, that propagates with a 45-degree tilt angle between the loading direction and the crack face normal, the local conditions along the crack front are a combination of mode I and mode III. The problem is first examined in a linear elastic 3D framework, here to; i) reach a basic understanding of the mode III contribution at the crack tip, e.g. the distribution of the mode I and mode III stress intensity factors along the crack front is brought out, and then ii) to highlight the effect of constraining the out-of-plane deflection of the plate that develops with the mode III loading.

In the second part of the work, a full three-dimensional formulation for steady-state crack propagation is employed to generate field distributions (such as effective stress, stress triaxiality, and Lode parameter) near the crack tip (results for a flat crack $\beta_s = 0$ can be found in Sobotka and Dodds [1]). The active plastic zone is then illustrated for slanted cracks propagating at steady-state under varrious intensitives of the loading (see Fig. 1). Keeping the far-field loading at constant level, a clear asymmetry develops in both the fields and the active plastic zone for thick sheets (say $K_R/(\sigma_y\sqrt{t}) < 5$), with K_R being the remote stress intensity, σ_Y the yield stress, and t the plate thickness. However, for thinner plates the asymmetry in the active plastic zone deminishes as it grows to multiple plate thickness.



(a) (b)

Fig. 1: a) A slant crack in a symmetrically loaded plate, and b) Active plastic zone for a 45-degree slant crack loading in far-field Mode I with; $K_R/(\sigma_y\sqrt{t}) = 2$. Axes are normalized by the plate thickness, t.

REFERENCES

[1] J.C. Sobotka, R.H. Dodds Jr., "Steady crack growth in a thin, ductile plate under small-scale yielding conditions: Three-dimensional modeling", *Eng. Frac. Mech.* **78**, 343-363 (2011).