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SHEAR BANDING AND CRACK INITIATION IN ZIRCONIA CERAMICS

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- *Introduction*

Experimental results obtained by Chen and Reyes Morel [1,2] show that the behavior of Zirconia ceramics is highly pressure-sensitive and, in particular, fits coherently with the Drucker-Prager plasticity model. This is the macroscopic counterpart of shear banding into grains, interaction of shear bands with grain boundaries and subsequent microcracking. These results have strong implications in the design of Zirconia structural elements. In fact, design philosophy based on yield strength is much different from that based on flaw strength. Moreover, the Drucker-Prager yield criterion predicts a material behavior substantially different from the von Mises based plasticity. In particular, the Drucker-Prager criterion allows for the introduction of a nonassociated flow rule, so giving the possibility of material instabilities (cavitation, surface exfoliations and macro shear banding) in the hardening range. Moreover, material pressure-sensitivity and nonassociativity have strong effects on crack growth [3,4], which may be significant to develop sound design criteria.

- *Experimental results*

Shear banding, crack formation and growth in zirconia ceramics have been experimentally explored. The tensile zone of four point bended TZ-3Y20AB and TZ-3YS zirconia ceramic bars [5] has been investigated, where the material suffers

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inelastic deformations before crack nucleation and collapse. Using scanning electron microscopy, regular microcrack patterns, inclined with respect to the direction of traction were observed. It may be important to note that these cracks were found not to initiate at the free boundary of the bar, but to nucleate in interior points.

In addition to the above-mentioned microcracks, a macroscopic localization of damage, which precedes fracture, was detected. This behavior was observed in pre-cracked popped bars tested for K_{IC} determination by SEPB and was also observed to emerge from the corners of Vickers indentation. The damage localization bands turned out to be orthogonal to the direction of the principal tensile stress.

- Theoretical framework

Possibility of explaining the above-mentioned localization of damage within the mathematical framework laid by Rudnicki and Rice [6] is explored. Material instabilities, as related to macroscopic material behavior of zirconia ceramics are discussed. Non-coaxiality and non-associativity of the flow rule, as well as elastoplastic coupling, are investigated as possible candidates for the constitutive modelling of these materials. Implications of these constitutive features on crack initiation and propagation are investigated.

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