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Unified brittle failure criteria

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Different failure criteria have been proposed and utilized. For isotropic brittle materials, the maximum normal stress criterion was used frequently, and the failure strength was obtained using a typical dog-bone shape test coupon. However, if the same material has a line crack, the normal stress criterion is not applicable any longer because of the stress singularity at the crack tip, which introduced a new material property called fracture toughness. If the same material has a notch other than a line crack, other failure criteria have been proposed. In other words, depending on the existence of any notch or crack, different failure criteria have been used even for the same material.

This paper is to present a unified failure criteria for brittle materials independent of the existence of any notch or crack. The new failure criteria are based on two set of conditions. The first condition is that the maximum stress should be equal to or larger than the failure strength which was obtained from a dog-bone specimen. This criterion determines the potential locations of failure. However, this condition is necessary but not sufficient to initiate failure. The second condition is based on the stress gradient. This condition provides the failure path. In other words, failure propagates along the path of lowest stress gradient in terms of its absolute value. When both criteria are satisfied, failure are considered to occur. Therefore, the new set of failure criteria provide not only failure initiation location but also failure propagation path. This set of criteria can be applied to the same brittle material regardless of any existence of a notch or crack.

For a specimen like a dog-bone tensile coupon, the first criterion is the controlling condition since second criterion is fully satisfied with zero stress gradient along the width of the specimen. For a specimen with a line crack, the first criterion is always satisfied because of infinite stress at the crack tip. Then, the second criterion is the controlling failure criterion. On the other hand, for a specimen with a hole, none of the criteria are satisfied obviously. Hence, both criteria must be applied. However, when the criteria were applied to specimens with various sizes and shapes of holes, the second criterion was more critical than the first criterion.

References

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