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Computational and Experimental Investigation of the All Fracture Mode Specimens on Mixed Mode I/III and II/III Fracture

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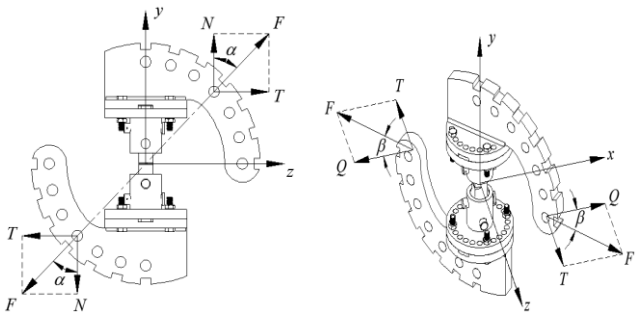
Fracture processes are in various cases of the 3D feature in the real engineering structures. The fracture behaviours in all fracture modes (AFM) specimen with a single edged crack under I/III and II/III loading conditions are investigated by both computational analysis and experimental investigation.

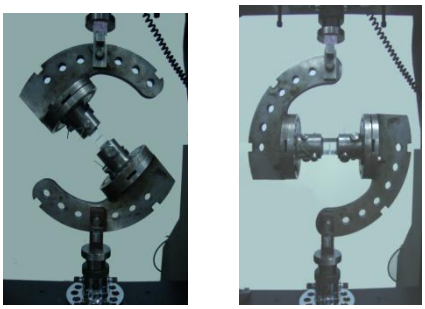
The 3D finite element model of the AFM specimen is assembled of some standard 6-node but predominantly of non-singular, standard 8-node volume elements. The total mesh consists of 14132 six-node or eight-node SOLID45 elements with a total of 17626 nodes. A spider-web-like mesh around the crack front is employed near the crack front to capture detailed stress/strain variations and their singularity behavior. Considering the singular stress behavior at the crack front some mesh refinement is incorporated in the model adjacent to the crack front and with respect to the MVCCI-method the crack front is formed by a homogeneous mesh with elements of constant size ($0.1\times0.1\times0.1\text{mm}^3$ with $\Delta a=0.1\text{mm}$ and $\Delta a/a=0.0074$). The non-dimensional stress intensity factors (Y values) along the crack front of 3D finite element model are calculated by the virtual crack closure method and ANSYS software [1, 2, 3].

The AFM specimen, made of polymethyl methacrylate（PMMA） in this study, is a special type of single edge notched specimen, and the AFM loading device and specimen are developed with Richard method[4]. The AFM specimen with a single edged crack under I+III （α=45°, β=90°） and II+III （α=90°,β=45°）loading conditions are shown respectively in Fig. 1 and Fig. 2.



(a) I+III loading (b) II+III loading

Fig. 1 Schematic diagram of mixed mode fracture test



(a) I+III loading (b) II+III loading

Fig. 2 Experiment device for mixed mode loading

The Fig. 3 and Fig. 4 respectively show the Y_{eff} value along the crack front of AFM model under mixed mode I/III loading and mixed mode II/III loading and the final fractured specimens.

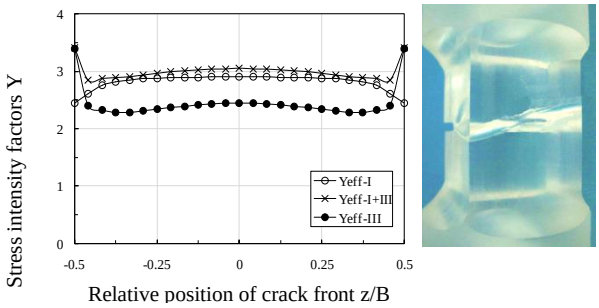


Fig. 3 Y_{eff} values and the fractured specimen for mixed mode I/III loading condition

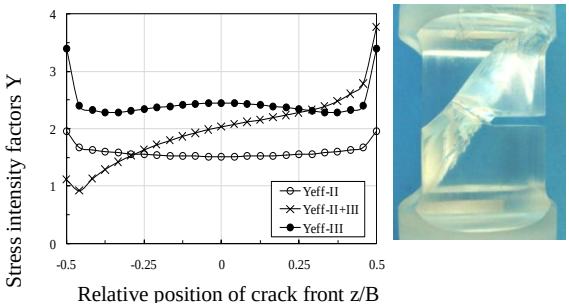


Fig. 4 Y_{eff} values and the fractured specimen for mixed mode II/III loading condition

Fig. 3 shows that the effective Y_{eff} values for mode I/III loading reach the maximum at the free surface of the specimen ($z/B=\pm 0.5$). It can be concluded that for mode II/III loading condition, the fracture will occur at two corners of the crack front firstly and simultaneously.
Fig. 4 shows that the effective Y_{eff} values for mode II/III loading rapidly reach the maximum at the free surface of the specimen ($z/B=+0.5$). It can be concluded that for mode II/III loading condition, the fracture will occur firstly at one corner on the crack front of the AFM specimen.
The observations of the final fractured specimen for I/III and II/III loading tests show clearly that, the fracture occur at two corners of the crack front firstly and simultaneously for I+III loading, and that the fracture occur initially at one corner on the crack front of the specimen for mode II+III loading condition. The computational results and the experimental findings were in agreement with each other.

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