Fracture Mechanics Homework: Determination of K_c for PMMA

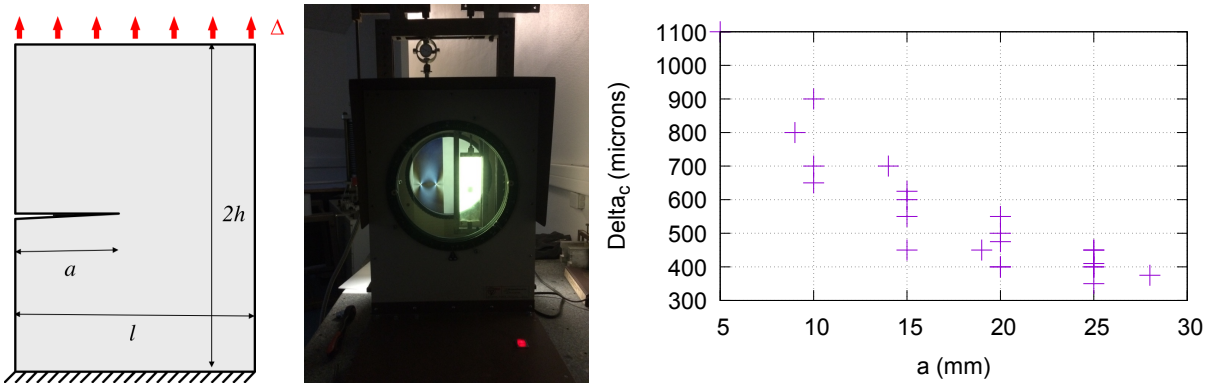

Figure 1: Cracked plate under tension (left). Loading device (center) used to measure the critical displacement Δ_c as a function of a (right).

Consider a PMMA plate ($E = 3000$ MPa, $\nu = 0.4$, width $l = 10$ cm, height $2h = 45$ cm, thickness e =2 mm) containing a crack of length a. We aim to determine the fracture toughness of the material (K_{Ic} and G_c) from the measure of the critical load corresponding to the onset of crack propagation.

The experimental setup is as follows. The lower part of the plate is clamed and the top surface is submitted to a displacement $\Delta \underline{e}_y$. The displacement is increased until the crack propagates. It occurs abruptly for a critical displacement Δ_c depending on a. In Fig. 1, each point corresponds to one test. A movie of a similar experiment (but with two initial cracks) can be found using the link https://mycore.core-cloud.net/index.php/s/GRu0AZZ0zweLjI1.

1. Explain why the elasticity problem can be reduced to the half-plate. Write the corresponding elasticity problem under strong and weak form.
2. Justify why the plane stress ($\sigma_{iz} = 0$ pour $i = x, y, z$) hypotheses is pertinent here.
3. Show by dimensional analysis that
$$K_I = \frac{E\Delta}{\sqrt{\ell}} K^*(a/\ell, h/\ell, \nu)$$
4. Determine numerically $K^*(a/\ell)$ for several values of a/ℓ in the range corresponding to $a \in [5; 30]$.
5. Get the numerical values of all the points of Figure 1 using Webplotdigitizer (https://automeris.io/WebPlotDigitizer/)
6. Determine K_c using the experimental points and $K^*(a)$ obtained numerically. Verify that the value is in line with Ashby's diagram.
7. Determine G_c.

You should submit the homework as a pdf of maximum 4 pages on the moodle.
Dateline: November 15th, 2022.
One pdf for each group of two students.
Name of the file: name1name2.pdf