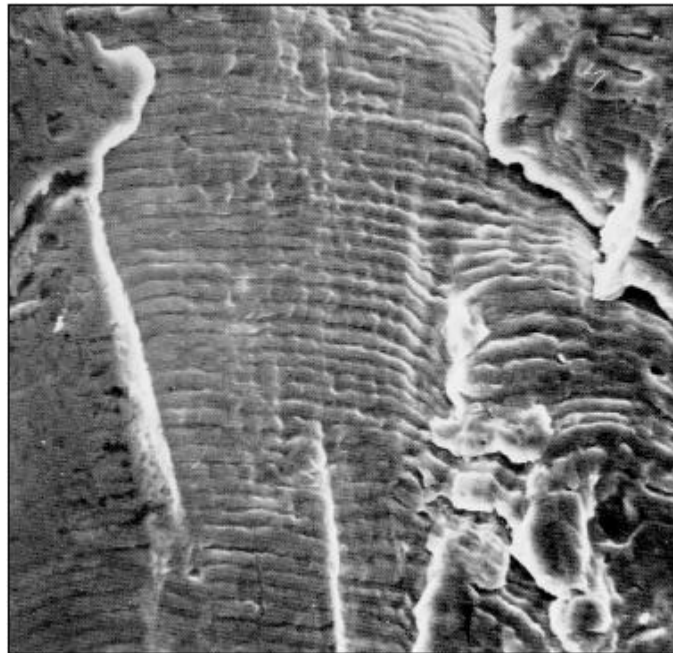


Fracture mechanics, damage and fatigue: project (MECA0058-1)

Use of XFEM to study fatigue crack propagation



Academic year 2025-2026

Julien Leclec (CENAERO)
Ludovic Noels (ULiège)

1. Project

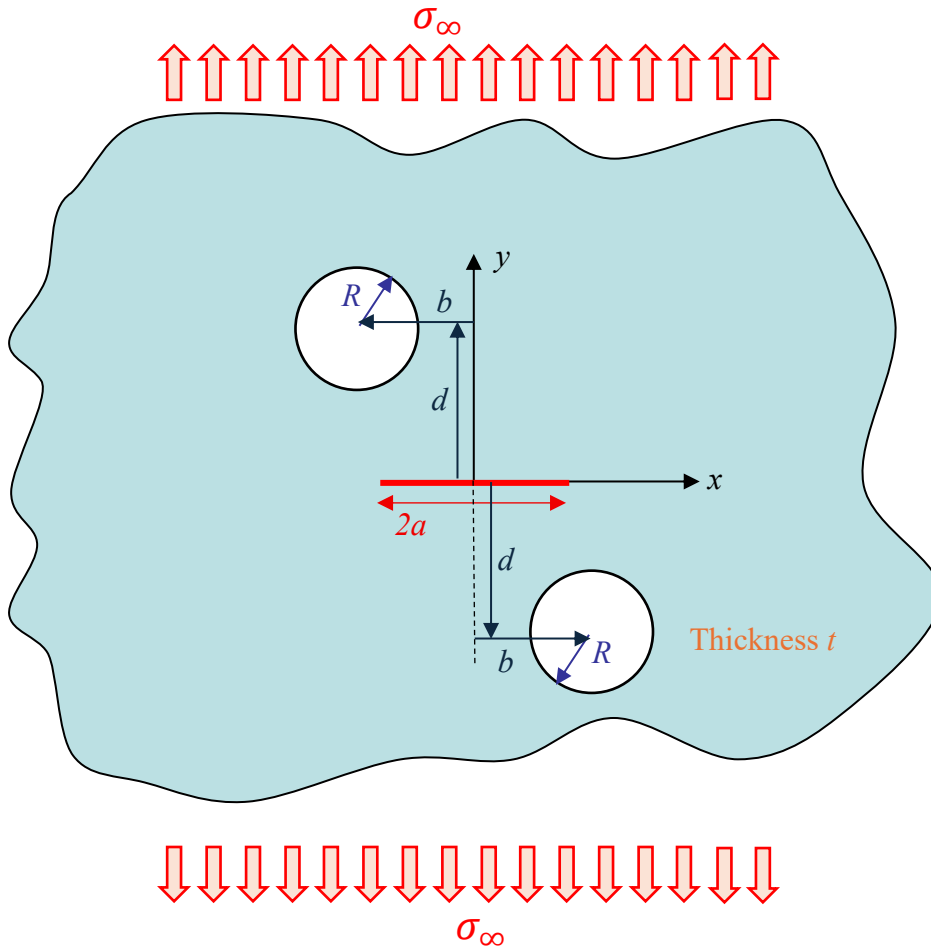


Figure 1: infinite drilled plate with a centered crack of length $2a$

You are requested to study the fatigue crack propagation of a doubly drilled infinite plate with a centered crack. The geometric description of the sample can be found in Figure 1, and the geometrical parameters are reported in Table 1.

Table 1: Geometrical properties

Initial crack length a_0 [m]	Thickness t [m]	Hole radius R [m]	Vertical distance d [m]	Horizontal distance b [m]
0.025	0.01	0.05	0.1	$0 \text{ \& } \left[\frac{d}{2}, d, 2d, \frac{3d}{2} \right]$

In particular, the parts A to D should be addressed. The following assumptions will be considered:

- Linear elastic behavior;
- Plane strain state;
- The material considered is a 7075-type aluminum alloy, with heat treatment 651 (properties in Table 2 and on Figure 2).

Table 2: Material properties (T=25° C)

Material	Young Modulus	Poisson coefficient	Toughness	Yield stress	Critical tensile strain
7075-T651 Aluminum /Zinc	72 GPa	0.33	30 MPa m ^{1/2}	500 MPa	9%

COMPARISON OF FATIGUE CRACK GROWTH RATE DATA FOR ALLOY 7075-T651, 2024-T351 AND 7475-T651 PLATE

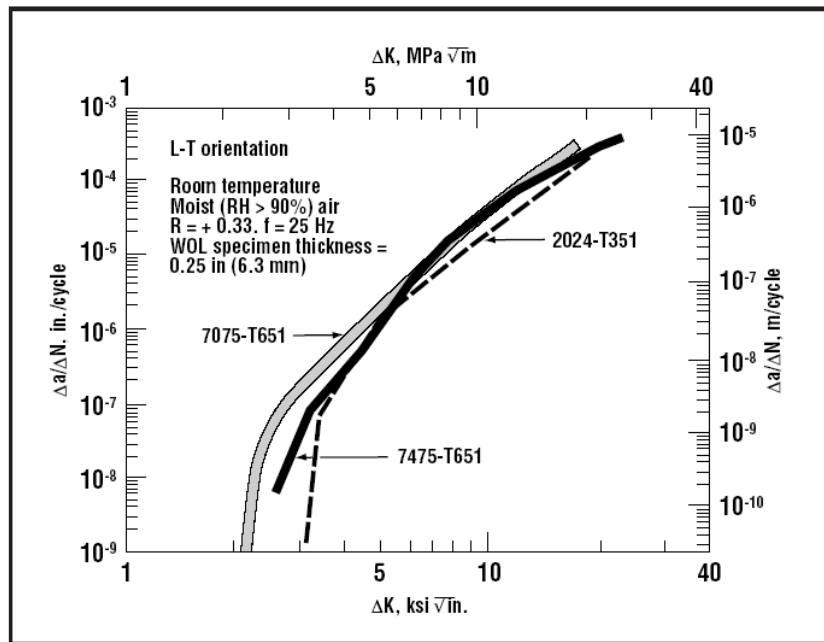


Figure 2: Fatigue curve for aluminum/zinc alloy

A/ Mode I life prediction using SIF handbook:

Considering the sample with $b = 0$, with an initial crack length as reported in Table 1, and with a cyclic loading σ_∞ varying between 20 MPa and 60 MPa, evaluate the time life (in cycle number) using the stress-intensity-factors handbook. In particular, it is asked

- What is the time life?
- To state and justify the assumptions and limits of the method.

B/ Mode I life prediction using the XFEM method:

In the same loading and geometrical conditions (with $b = 0$) as for part A, evaluate the time life (in cycle number) using the XFEM method implemented in MORFEO.

In particular, it is asked

- What is the time life?
- What is the effect of the mesh?
- To compare results with the method of part A.
- To state and justify the assumptions and limits of the method.

C/ Mixed-mode life prediction using the XFEM method:

In the same loading conditions as for parts A and B, for the same alloy but considering a crack orientation $\mathbf{b}$ different from zero (one different value for each student), evaluate the time life (in cycle number) using the XFEM method implemented in MORFEO.

In particular, it is asked

- What is the time life?
- To comment the differences with the part B.
- To state and justify the assumptions and limits of the method.

D/ Mixed-mode life prediction using the XFEM method:

Collecting the results of each student for the different distances $\mathbf{b} = \mathbf{0}$, you are requested

- To comment on the effect of the crack orientation on the behavior and on the time life from the results obtained in C.

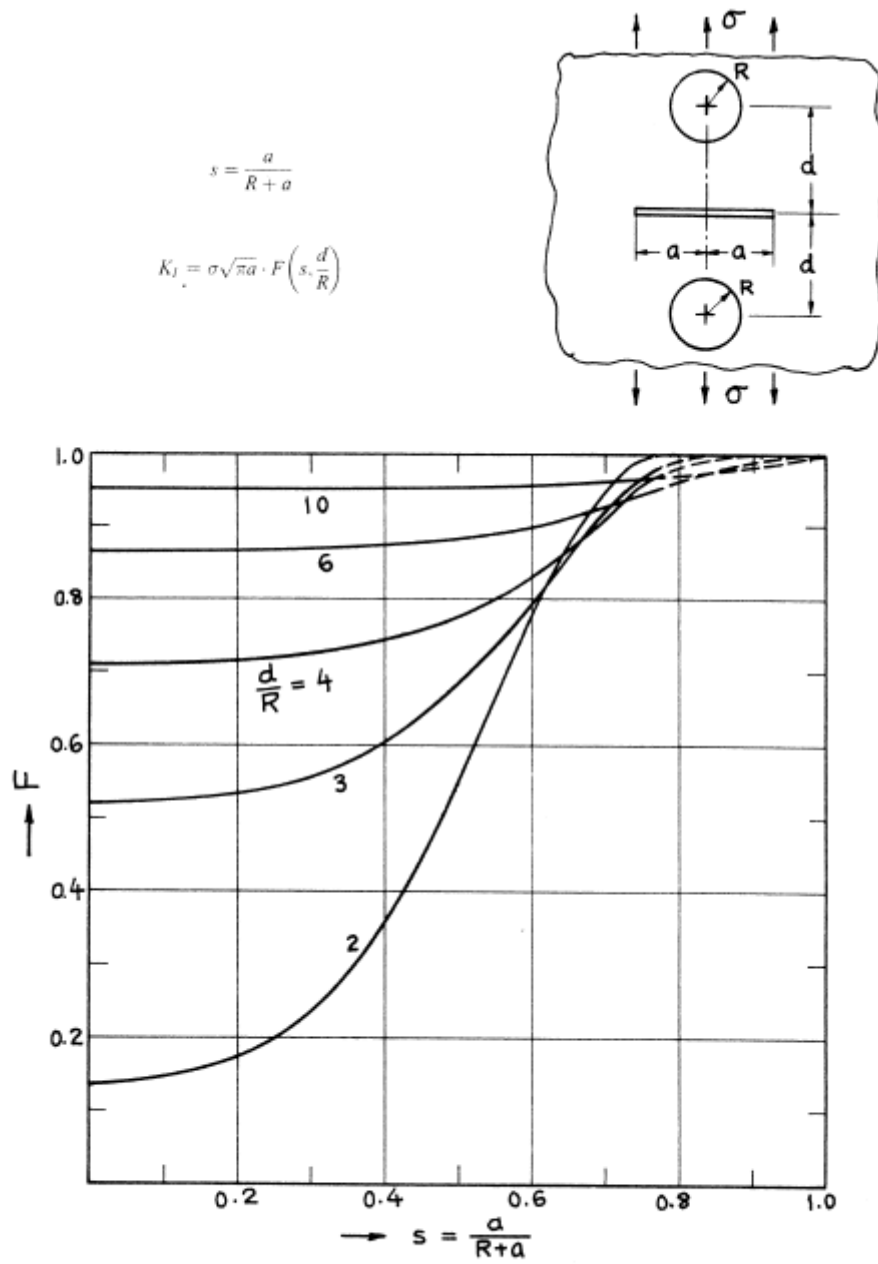
2. Work plan

The project will be achieved by each student (no group).

A (printed and pdf) report containing parts A to D will be printed and given to Ludovic Noels before December the 19th, 2025, at 18:00.

The input files for the XFEM method and the code for part A, will be given in annex of the report.

3. Appendix: SIF Handbook



Method: Boundary Collocation Method

Accuracy: Curves (solid lines) were drawn based on the results having 0.1% accuracy.

Reference: Newman 1971