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

Use of XFEM to study fatigue crack propagation



Academic year 2024-2025

Julien Leclec (CENAERO) Ludovic Noels (ULiège)



1. Project

You are requested to study the fatigue crack propagation of a centered crack sample. The geometric description of the sample can be found in appendix. In particular, the parts A to D should be addressed.

The following assumptions will be considered:

- Linear elastic behavior;
- Plane strain state;
- The samples are made of Nitinol, which is a 50% Ni and 50% Ti shape memory alloy (properties listed in Table 1) in austenitic super-elastic regime at 37 ° C, see Table 1.
- The crack propagation curves of Nitinol are available in the paper "AL McKelvey, RO Ritchie, Fatigue-crack growth behavior in the superelastic and shape-memory alloy nitinol, Metallurgical and Materials Transactions A: 32 (13), 731-743, 2001, <u>http://dx.doi.org/10.1007/s11661-001-1008-7</u> (free download from University or pdf on demand).

Material	Young's modulus	Poisson coefficient	Toughness	Yield stress	Fracture strain
NiTinol	48 GPa	0.3	30 MPa m ^{1/2}	400 MPa	17%

Table 1: Material properties

A/ Mode I life prediction using SIF handbook:

Considering the sample with $\beta=0$, with an initial crack length a/W=0.1, and with a cyclic loading σ_{∞} varying between 3 MPa and 30 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 $\beta=0$) 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 β different from zero (one different angle 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 angles β , 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 20th, 2024, at 17:45.

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

Appendix: Test sample



Group	1	2	3	4
β	10°	20°	30°	45°