CRACK LOADING

MODES OF CRACK LOADING

There are three types of loading that a crack can experience:

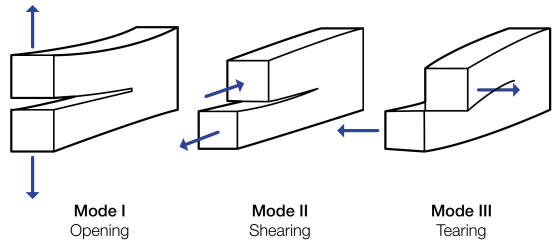
Mode I loading (tearing): the load is opening the two crack faces apart.

Mode II (sliding): the two crack faces slide with respect each other, parallel to the crack propagation direction.

Mode III (shearing): the two crack faces slide with respect to each other in the out-of-plane or transverse direction.

A crack experiences mixed-mode loading when a combination of these three modes is applied. In homogeneous materials, cracks predominantly advance in the most favourable direction, which coincides to pure mode I: under mixed-mode loading the crack will tend to orient itself towards a direction where pure mode I exists.

This is not the case for discontinuous materials such as composites: ply interfaces and fibre alignment act as boundaries which cracks cannot go through. In this case, cracks are forced to propagate under mixed-mode and the growth rate depends on the particular mixed-mode fracture toughness.

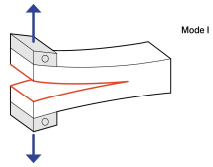


Schematic representations of Mode I, mode II and mode III

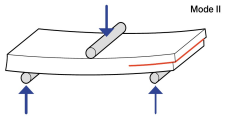
TESTING AND CHARACTERIZATION

Several test methods are available to evaluate the fracture toughness of composite laminates. These tests aim to reproduce the crack deformation shown earlier by applying controlled loads to a specimen. Standards methods are only available for pure mode I, pure mode II and mixed-mode I/II. For mode III the only way to have a stable and measurable crack is by applying a combination of all three modes.

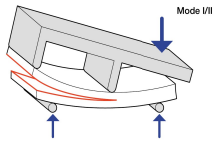
Double Cantilever Beam (DCB) specimen for pure mode I



End Notched flexure (ENF) specimen for pure mode II



Mixed mode Bending (MMB) specimen for mixed mode I/II



Shear-torsion-bending test (STB) specimen for mixed mode I/II/III