FRACTURE TOUGHNESS OF SKIN/CORE INTERFACES IN SANDWICH MATERIALS UNDER MIXED MODE LOADINGS

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ABSTRACT

Defects in sandwich structures are often inevitable and can originate both from manufacture and use. An important defect type is debonding, i.e. areas with weak or no adhesion between skin and core. In a sandwich structure debondings can arise in production when an area between skin and core has not been wetted properly resulting in a lack of adhesion. In use, damages from loads e.g. impact might result in formation of a debond crack. With debonds present the structure might fail under loads significantly lower than those for the intact sandwich structure. In order to improve the damage tolerance of sandwich structures an increase in the toughness between skin and core is necessary [1].

It is believed that the microstructure of the interface between skin and core can have a large effect on the fracture toughness. It has been shown that the presence of a mat with random oriented and loosely packed fibers between the core and the laminate facilitates the formation of large scale fiber bridging, resulting in a significant increase in crack resistance [2]. The formation of large scale fiber bridging results in a fracture process zone with length several times the skin height. To characterize the crack growth resistance the J integral is deployed since it is valid for handling fracture with large fracture process zone. By analytical derivation the J integral is determined for the special sandwich specimens used in the tests [3].

The aim of the current work is to establish a more fundamental understanding of sandwich fracture and mechanisms taking place during fracture. Several conditions have an influence on the fracture mechanisms and nominal fracture toughness e.g. mode mixity of the loading, skin lay-up, resin type and core density. In the experimental part of this study we measure the fracture toughness of the skin/core interfaces for one material combination by loading specimens under different mode mixities. Observations during experiments are used to identify mechanisms related with variation in fracture toughness for the different mode mixities.

Specimens are manufactured by an industrial partner, with materials and thicknesses similar to those used in structural components. The sandwich consists of 2.5 mm thick glassfiber/polyester skins and 20 mm thick PVC foam core with density 80 kg/m^3. A teflon film strip is placed between skin and core during manufacture to have a well defined start crack. The build-up configuration of the skins is (0/90, Unifilo®, ±45, CSM), where the CSM (chopped strand mat) laminae is located next to the core. The Unifilo and CSM laminaes consist of continuous fibers oriented randomly. The biaxial mat (0/90 and ±45) is 0.7 mm thick and has an area density of 600 g/m^2. The Unifilo and CSM laminaes are 0.7 mm and 0.4 mm thick respectively and have an area density of 450 g/m^2 and 300 g/m^2 respectively. The overall dimensions of the sandwich specimens are 25 mm thick, 30 mm wide and 450 mm in length.

The test method is based on loading the sandwich specimen by uneven bending moments, see Figure 1. By varying the moments the ratio between tangential and normal crack opening displacement can be varied in the full mode mixity range. The loading by moments has the advantage that stable crack growth is accommodated because the J integral value is independent of the crack length. The moments are applied by vertical forces acting on two horizontal arms attached to the top of the specimen. The forces are applied by a roller/wire system mounted in a tensile test machine.

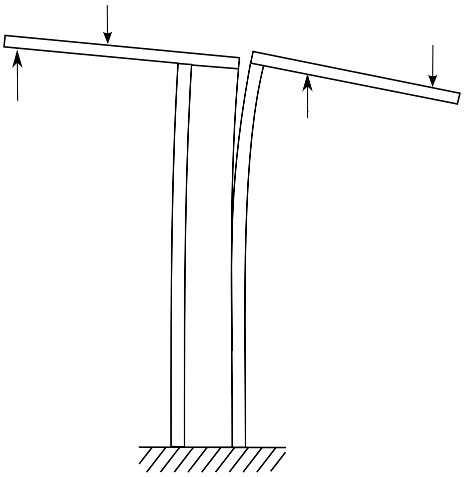

Figure 1. Test specimen loaded by uneven bending moments

As the load exceeds a critical value crack growth is initiated and the right skin separates from the core. Because of the thin skin and increasing crack length large rotations occur, which is critical for the accuracy of the test. The rotations are reduced by adhering a 2 mm thick aluminium strip to the right skin. The stiffening of the skin is taken into account in the analytical derivation of the J integral. Stiffening of the skin furthermore has an effect on the fracture behaviour if mechanisms as fiber bridging occur because the reduced rotation elongates the fracture process zone (see Figure 2).

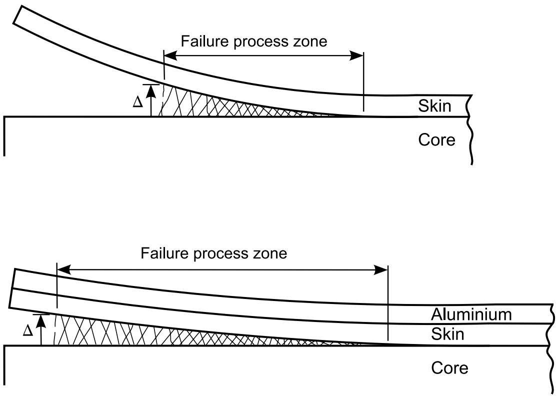

Figure 2. Failure process zone with and without stiffening of the skin

Hereby the spatial material variation is reduced since the fracture process takes place over a larger area and a more homogenous behaviour is measured.

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