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Development of a mode I/II/III test fixture for sandwich face/core fracture characterization

Pietro Sabbadin[1], Christian Berggreen[1], Brian Nyvang Legarth[2]
[1]Lightweight Structures Group, Department of Mechanical Engineering, Technical University of Denmark, Nils Koppels Allé Building 404, 2800 Kgs. Lyngby, Denmark.
[2]Associate Professor, Department of Mechanical Engineering, Technical University of Denmark, Nils Koppels Allé Building 322, 2800 Kgs. Lyngby, Denmark.

E-mail: pisabb@mek.dtu.dk, cbe@mek.dtu.dk, bnle@mek.dtu.dk

Pietro Sabbadin is a PhD student and he is part of the *Lightweight structure Group* at Dept. of Mechanical Engineering, DTU. He is working on an ONR project on "Damage tolerance of Sandwich Structures in Naval Vessels operating in Arctic Regions".

Christian Bergreen is Associate Professor and Head of the *Lightweight structure Group* at Dept. of Mechanical Engineering, DTU. His experimental research area includes Damage Tolerance and Integrity of Debonded Sandwich Structures (Macroscale Level).

Brian Nyvang Legarth is associate Professor and Head of Studies of MSc in Engineering Design and Applied Mechanics at at Dept. of Mechanical Engineering, DTU. His research area deals with Fracture and damage, multiphase materials and plasticity.

Abstract

Sandwich structures are considered as key enablers for future and present lightweight structural applications in naval ships because of their superior stiffness/weight and strength/weight ratios compared with traditional metallic concepts as well as monolithic composite materials. Naval vessels are expected to encounter a large variety of load scenarios, which can cause different types of damages within the sandwich structure.

The most common and severe type of damage that a composite sandwich structure can experience is the lack of adhesion (a crack develops) between the face sheets and core known as “debond”. Therefore, the fracture characterization of the face/core surface is fundamental to predict the remaining life of the damaged structure.

The aim of this work consists in developing a test rig and a test procedure which is able to carry out the fracture characterization on a debonded specimen (monolithic or sandwich composite specimen) in the most general loading scenario where all three types of loadings at the crack tip are present (Mode I-II-II).

Introduction

The test rig geometry (Fig. 1) replicates the STB test rig presented in [1] since in that work experimental results agreed with the FEM analyses regarding pure Mode III and multiaxial (Mode I+III, II and II+III) fracture characterization of the debonded surface.

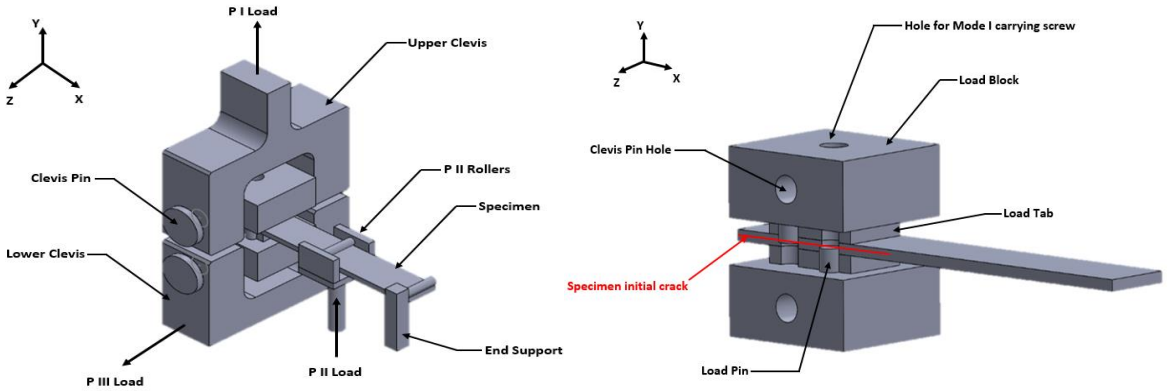

Figure 1: Mode I-II-III test rig.

The STB geometry was analysed by building a 3D FEM model in order both to benchmark the strain energy release rate distributions against the ones found in [1] and to understand how geometric parameters of the specimen influence SERR distributions along the debonded front.

The extraction of SERR values from the debonded front in the FEM model has been carried out by applying the CSDE method [2]. Experimental tests jointly with results from the FEM model will be capable to gain a new and important knowledge regarding pure Mode III and multiaxial fracture characterization of face/core interface in composite sandwich structures.

Numerical Model and Preliminary Numerical Results

A 3D FEM model (Fig. 2) of the specimen was built in order to extract the SERR trend along the crack front under pure mode III load conditions, using the CSDE method [2]. We followed this procedure in order to check if a pure mode III state was present along the crack front with the external load imposed by the test rig.

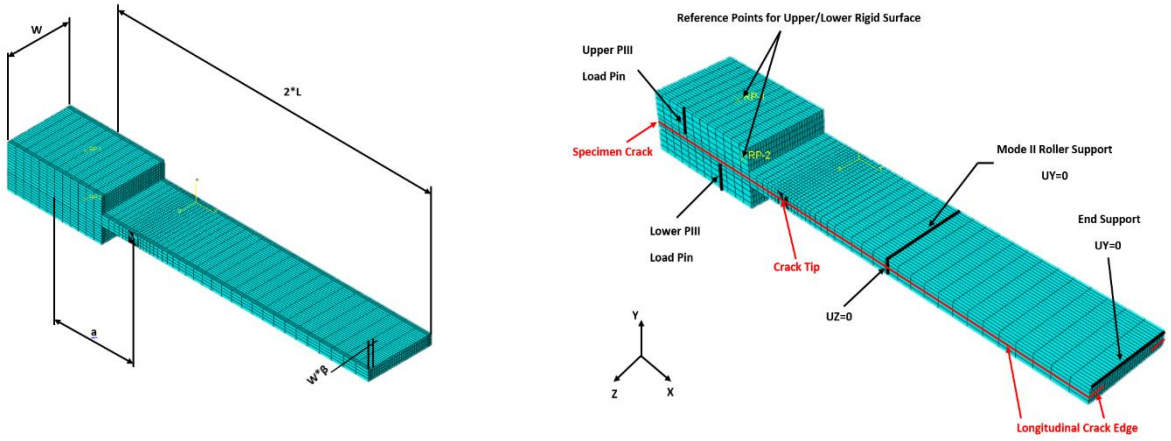

Figure 2: 3D FEM model showing the principle geometrical parameters of the model and the boundary conditions applied.

The SERR values extracted along the crack front with the CSDE method [1] for an unidirectional carbon fiber laminate are reported in Figure 3. The ratio G_{III}/G_{tot} (where G_{tot} account for all modes contribution I-II and III) along the crack front is approximately equal to unity, thus, it means that a pure mode III state is achievable with this preliminary design. Further numerical investigations will be done regarding the introduction of mode I and II before building the real test rig.

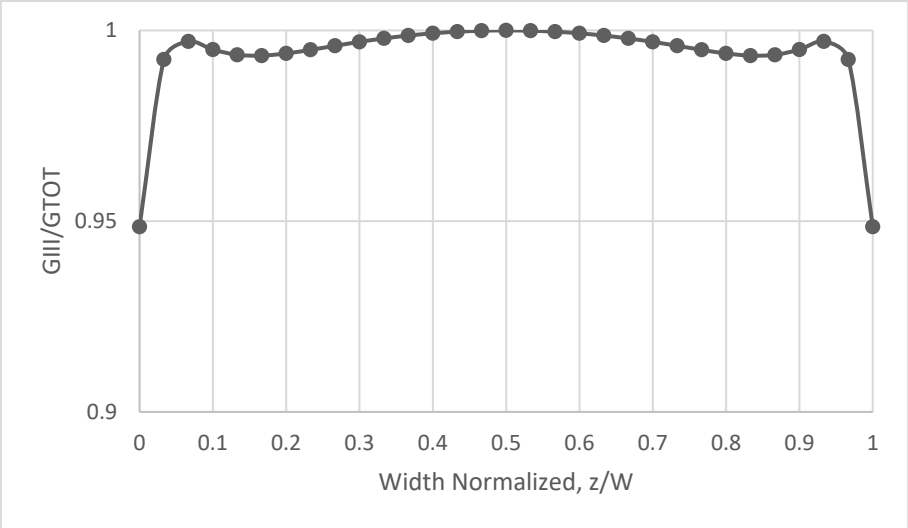

Figure 3: G_{III}/G_{tot} trend along the crack front under pure mode III external load.

Acknowledgements

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References

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