MIXED MODE FACE/CORE INTERFACE FATIGUE CRACK PROPAGATION IN SANDWICH COMPOSITES

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Summary. The paper includes a full examination of the mixed mode face/core interface fatigue crack propagation behavior in sandwich composites using the mixed mode bending (MMB) test method modified for sandwich specimens. This test method allows the control of the loading conditions at the debond crack tip, i.e. combinations of mode I and mode II. Sandwich specimens with E-glass/polyester faces and H100 PVC-foam core were examined. The results revealed faster crack propagation rates for specimens where mode I was dominant and the opposite for mode II dominant loading.

ABSTRACT

Face/core interface cracks also named debonds in sandwich specimens/structures may be introduced during the manufacturing processes due to poor face/core bonding in sandwich components or due to accidental overloading during the service life of the structure. Debonds in sandwich structures subjected to static or cyclic loads can result in a reduction in the load carrying capacity of the structure, since tensile and shear loads cannot efficiently be transferred between core and the face sheets. As a result the overall strength and fatigue lifetime of the sandwich structure will be compromised. Thus, investigations of cyclic debond crack propagation behavior in sandwich composite components and structures are of crucial importance for the general application and acceptance of sandwich in primary load carrying structures.

Fatigue crack growth studies of face/core debonds are very scarce [1-2]. Most studies are focused on pure mode I and II fatigue crack growth investigations [2] and very little on mixed mode crack propagation exists with controlled mode-mixity phase angle at the crack tip.
Shipsha [2] performed fatigue crack growth studies using double cantilever (DCB) specimens for mode I and cracked sandwich beam (CSB) for mode II loading. However, the mode-mixity for the DCB and CSB tests carried out were not reported in this study. The mode-mixity at the debond crack tip arises due to elastic mismatch between the face and core at the interface crack tip which leads to mixed mode loading at the crack tip. The DCB and CSB fatigue tests performed in [2] showed higher fatigue crack growth rates under DCB than CSB loadings. However crack propagation under well controlled mode I and mode II ratios has not been studied thoroughly. A limited study with mixed mode loading presented in [1], revealed that the mixed mode bending (MMB) test method is a promising candidate for controlling accurately the mode-mixity at the crack tip of a debonded sandwich specimen.

Analysis of cyclic debonding in sandwich structures is a complex matter due to the presence of multiple crack growth scenarios and fracture mechanism shifts at the crack tip. For instance, static results using the MMB test fixture showed that the debond crack can propagate in the core just below the face/core interface for some configurations, in the face sheet just above the interface for other configurations, and directly at the face/core interface as well [1,3]. Such crack propagation scenarios observed with static loading, are likely to occur as well with cyclic loading which may alter the measured propagation rates and underlining the need for a well controlled mode-mixity phase angle during the characterization test.

Since no consistent methodology for studying face/core fatigue crack growth under well controlled mixed mode loading conditions has been proposed, this manuscript aims at developing a consistent test procedure for fatigue crack growth studies of debonded sandwich composites, and to provide a better understanding of the combined mode I and mode II effects on the fatigue crack growth rates of typical foam-cored sandwich composites. To perform this, the mixed mode bending (MMB) test method is the method of choice.
REFERENCES

