LMS Seminar

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Towards a micro-macro link for interface cracks

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ABSTRACT

Laminated and bonded structures contain weakness planes in which a crack can easily initiate and propagate. At the macroscopic scale, the crack plane is known, but the energy required for crack propagation depends on the loading conditions, since different mechanisms are activated at the microscopic scale (for laminated composites, this can involve fibres/matrix decohesion, plasti- fication and failure of the matrix, fibres bridging...). A quantitative link between the microscale mechanisms and the macroscopic interface properties has not been established. Its definition would enable a better prediction of crack propagation under the wide range of loading conditions encoun- tered in real structures, as well as the definition of new concepts to delay crack propagation. This talk discusses some issues related to the definition of a micro-macro link for interface cracking. In the first part of the talk, the non trivial link between loading conditions and dissipated energy is highlighted using non-standard delamination tests [1, 2]. In these tests, the symmetry constraints imposed by composite standards are removed at different levels, from the overall geometry of the part, to the crack position, to the local layer orientation: this results in experimental configurations which are closer to real structures, where symmetry is systematically broken. Breaking the symme- try, even at a very local level, turned out to strongly influence the macroscopic dissipated energy, while microscopic observations enabled us to relate such influence to crack path modification. The development of quantitative link is a perspective of this work. In the second part of the talk, we focus on the development of dissipation mechanisms with long characteristic length in order to improve interface ductility [3]. Different design concepts, mainly based on the creation of bridging ligaments, have been proposed in the literature [4, 5]. Here, all of these strategies are interpreted through the prism of Cohesive Zone Models (CZM), which are a good candidate for a synthetic but complete description of macroscopic interface properties. In particular, a two-mechanisms CZM is introduced in order to separately handle the initial crack propagation load, as well as the subsequent progressive failure behaviour. The macroscopic CZM model constitutes a target behaviour to be achieved by introducing specific microstructural features at the interface. Perspectives include the development of microstructural designs, as well as the analysis and mastering of the dynamic response that may develop during propagation.

REFERENCES

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[3] F. Daghia, V. Fouquet, and L. Mabileau. Improving the crack propagation response of layered and bonded structures through dissipation mechanisms at different length scales. International Journal of Solids and Structures, 254-255:111910, 2022.

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