

# Fatigue behaviour of metal-composite hybrid bolted joints

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## Abstract

As composite-metal hybrid structures are increasingly used in aircraft, the fatigue problem in joints between these very dissimilar materials is likely to emerge as a significant issue. Current designs are highly conservative due to a lack of complete understanding of this problem, and the aircraft industry is keen to improve knowledge on this subject in order to allow less conservative approaches and extract the maximum possible benefits from the use of composites. The proposed work involves using the continuum damage method (CDM) to investigate the fatigue behaviour of composite-metal hybrid joints. A generalized user-defined subroutine (UMAT) of the commercial package ABAQUS, developed at the University of Limerick (ULIM) will be used. The first objective is to develop the damage model of the fibre reinforced composite material and metallic material respectively, in order to determine the coupling mechanism characteristic of elastic-plastic hybrid structures. By introducing a residual stiffness-residual strength

coupled model, a nonlinear fatigue damage accumulation model will be established according to the continuity of composite material properties. On the other hand, the metallic CDM model will be developed on the basis of a high cycle damage mechanism. To study the fatigue life of hybrid structures and potential primary damage evolution, two UMAT damage models will thus be combined together. Considering the distinct fatigue evolution of composites and metals, the step size of cycles needs to be under fine control, as it is not realistic to increase the cycles one by one. Eventually, the coupling model will not only estimate the residual strength and life for hybrid structures under constant-amplitude loading conditions, but will also form the foundation of a continuous fatigue degradation model under variable-amplitude loading conditions. However, individual simulations can take days or even weeks to solve on our 160-node computer cluster within the Material and Surface Science Institute (MSSI) at the University of Limerick (UL). Parameter studies like the one proposed here can therefore only be done using the Irish Centre for High End Computing (ICHEC) facilities.