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ABSTRACT

The structural behaviour of bolted joints of composite laminates for aerospace applications was modelled comparing the shape, amplitude and phase of stress-strain cycles. This study proposes a model for the bolted joints resulting in a typical load-displacement curve, under cyclic loading, significantly affected by hysteretic effects. From the data gathered though the experimental activities, a constitutive relationship between strain and stress was proposed, starting from simple physical models. The assumption of a rigid shift between the laminates was used to correlate load and displacement curves in the different phases of the load cycle. The hysteretic behaviour was attributed to friction phenomena and interpreted using damping coefficients characterizing the global dynamic response of the structural joint.

KEYWORDS: bolted joints, damping modelling, slack behaviour, fatigue of composite laminates

INTRODUCTION

Aircraft structures must be light, resistant and safe and they are built through the employment of materials able to join these often conflicting requirements. The choice of the optimum material is made comparing figures of merit characterizing the structural performance in each particular engineering case (i.e., modulus E to density ρ ratios such as $E^{1/2}/\rho$, $E^{1/3}/\rho$) and allowing to rank materials able to achieve the minimum weight solution. The solution sought will still have to fulfil the respective strength, stiffness and durability requirements, as well as the cost constraints. This is the reason why aluminium alloys have been employed for aircraft primary structures, in place of other metals over almost seventy years, featuring lower values of the afore mentioned figures of merit. Since their first applications as structural materials, the fibre reinforced composites received a strong attention from the aeronautical industry, essentially for their outstanding specific mechanical properties, and today composites are widely employed for the fabrication of aircraft primary and secondary structures. Not only flaps, ailerons and spoilers but also fuselages and wings are currently designed and built in carbon fibre reinforced composite. Nevertheless, this scenario still exhibits some open scientific and unresolved technical issues. The failure process in composites is very complex, with multiple different mechanisms that may interact, making predicting failure extremely challenging. There is a shortage of reliable experimental data, and even after more than 40 years of research, the issue of failure criteria is still unresolved despite huge efforts on programs such as the World Wide Failure Exercises [1, 2]. Among others, fatigue aspects are of paramount relevance in the aeronautical field since composites show a scatter [3, 4] in the experimental fatigue tests depending on several factors such as lay-up, stacking sequences, processing, assembly methods

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