# Multiaxial fatigue testing of composite tubes

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**ABSTRACT.** In spite of its importance in the design of structural components that are subjected to complex load histories with variability of loading direction and intensity, the fatigue behaviour of composite materials under multiaxial loading has received only little attention by the scientific community. This paper illustrates the first results of a project aimed at investigating the problem through the following steps: monitoring of the evolution of fatigue damage under multiaxial loading conditions, analysis of the mutual influence of the stress components and understanding of the associated damage mechanisms and, eventually, development of a life prediction model suitable to incorporate these damage mechanisms. As a first step, the fatigue behaviour of glass/epoxy 90° tubes, produced by wrapping and then autoclave moulding, under tension-torsion fatigue loading is investigated. This specific lay-up allows us to quantify the influence of the shear stress component on the transverse strength in the absence of the longitudinal stress. Results are discussed in terms of S-N fatigue curve, stiffness trends and damage evolution observed with optical microscopy, for four different values of biaxiality ratio $\sigma_6/\sigma_2$, ranging from pure tension to pure torsion. The presence of a shear stress component turned out to have a significant influence, with a 40% drop in the fatigue strength at 2 million cycles for a biaxiality ratio equal to 2.0. On the other hand, the stiffness is found not to change significantly, showing a sudden drop at failure. This is quite in agreement with the absence of stable crack propagation observed during the tests.

**KEYWORDS.** Multi-axial fatigue; Damage mechanisms; Composite tubes.