Accepted Manuscript

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PII: S0142-1123(18)30173-7
DOI: https://doi.org/10.1016/j.ijfatigue.2018.05.001
Reference: JIJF 4673

To appear in: *International Journal of Fatigue*

Received Date: 16 March 2018
Revised Date: 1 May 2018
Accepted Date: 2 May 2018

Please cite this article as: Movahedi-Rad, A.V., Keller, T., Vassilopoulos, A.P., Interrupted tension-tension fatigue behavior of angle-ply GFRP composite laminates, *International Journal of Fatigue* (2018), doi: https://doi.org/10.1016/j.ijfatigue.2018.05.001

Interrupted tension-tension fatigue behavior of angle-ply GFRP composite laminates

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Abstract

The effect of load interruptions on the tension-tension fatigue behavior of angle-ply $(\pm 45)_{2S}$ glass/epoxy composite laminates was investigated. The cyclic loading was interrupted for two hours at regular cycle intervals, corresponding to 20% of the fatigue life under continuous loading at the same maximum cyclic stress level. Fatigue stiffness was partially restored after each loading interruption due to the recovery of the viscoelastic polymeric matrix. This repeated material stiffening at the beginning of each loading block delayed crack growth. Crack blunting further delayed damage growth and caused a more uniform damage distribution throughout the specimen volume. By applying interrupted fatigue loading, the rates of stiffness degradation and energy dissipation per cycle decreased due to the delayed damage growth. In addition, more uniform damage growth throughout the specimen volume increased the specimen's capacity to accumulate damage, which led to a lower stiffness at failure, greater energy dissipation per cycle at failure and higher total dissipated energy of specimens subjected to interrupted loading. The specimens loaded under interrupted fatigue therefore exhibited longer fatigue lives than those continuously loaded. This enhancement of fatigue life increased at higher stress levels but almost disappeared at low levels. It was thus concluded that fatigue design allowables, if determined on the basis of continuous fatigue, are conservative in the case of interrupted fatigue.

Keywords:

Fatigue; Interrupted loading; Failure; Damage mechanism; Dissipated energy; Self-generated temperature.

1. Introduction

Engineering structures operating in open-air applications, such as wind turbine rotor blades, airplanes, and bridge decks, are subjected to different irregular loading profiles, in most cases including interrupted loading at high or low stress levels. [1]. If such structures are composed of fiber-reinforced

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