Paper ID: 5014
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MATERIALS AND STRUCTURES SYMPOSIUM (C2)
New Materials and Structural Concepts (4)

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A COMPARISON OF FATIGUE LIFE PREDICTION MODELS FOR IMPACT DAMAGED CARBON FIBRE REINFORCED EPOXY LAMINATES

Abstract

With the increase in composite material usage in aerospace and space vehicle primary structural components, the prediction of the post-impact fatigue behavior of composites has become a critical concern. Due to the lack of an industry standard analytical fatigue analysis model, extensive physical testing of material coupons, components, and assemblies is conducted to characterize the progression of post-impact fatigue damage. The purpose of this study is to determine an analytical post-impact fatigue assessment methodology applicable to composites. The study focuses on the analysis of four promising models and gives a comparison between their abilities to predict test specimen data generated on damaged carbon fibre reinforced epoxy specimens subjected to fatigue loading. The models are based on a range of methods that include empirical-based parameters, residual strength, and non-destructive evaluation techniques. Although experimental testing has been previously reported to lend validation to individual models, tests have focused on a narrow range of materials, lay-ups, or impact energy levels and moreover, comparisons between the models have not been made. For this analysis, 24-ply quasi-isotropic carbon/epoxy specimens were produced and then damaged at 5 energy levels using a drop-weight impact tester. The damage was characterized using a variety of non-destructive evaluation methods that included ultrasonic C-scan, thermography, and X-ray radiography. The specimens' residual strengths were measured at each impact energy level together with their performance under constant amplitude compression-compression fatigue loading. A strain field-measuring device that uses 3D photogrammetry was used to characterize the growth of damage and the local strain as the test proceeded. These tests were specifically designed to extract the data necessary to apply the analytical models and to highlight the range of the applicability of each model. The paper will present the results of the comparison focusing on balancing accuracy with ease of application. Other insights gained into the post-impact fatigue response of composites through the analysis will be detailed. Finally, a discussion regarding the use of the models in damage tolerant design of space vehicles will be presented.