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PII: S0263-8223(17)32116-5
DOI: https://doi.org/10.1016/j.compstruct.2017.11.060
Reference: COST 9126

To appear in: *Composite Structures*

Received Date: 7 July 2017
Revised Date: 13 November 2017
Accepted Date: 21 November 2017

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Abstract

The design of high performance composite structures frequently includes various shape and size discontinuities for various purposes. The zones near to these notches become critical regions under various working loading. The stress concentration factor (SCF), failure process, delamination, and tensile strength degradation of aluminum as well as in E-glass laminated plates are addressed in the current study through a combination of analytical, experimental and numerical studies using finite element (FE) modeling techniques. In the first part of the current work, a series of tensile tests on laminates with various fiber orientation angles and specimens with different notch diameter/width (D/W) ratios are designed and tested to determine the SCF and fracture mechanisms for unnotched/notched specimens. In addition, strain distribution, failure patterns and damage mechanisms of laminated plates with square and rectangular holes with rounded corners have been investigated. The specimens were manufactured from commercially available aluminum and unidirectional E-glass and Medapoxy STR resin epoxy. Digital Image Correlation (DIC) technique is used to obtain full-field surface strain measurements in notched specimens with different fiber orientations and open hole sizes, in order to show their effects on SCF, failure strength and mechanisms. The strain concentration that allowed damage initiation and failure propagation in the notched laminated plates is obtained experimentaly and compared with the simulation details. Furthermore, the effect of the delamination defect around the notch that was unavoidable during hole drilling process was also discussed. In the second part of this study, the experimental data was used to verify the capability of two modified stress criterions models for predicting tensile strength for both materials under consideration. It is shown that the modified models are able to predict tensile strengths of notched samples that display different stress gradients. Compared to experimental data, the accuracy of the predicted strength is within 17%. On the other hand, the numerical outputs from finite element analysis (FEA) compare favorably with experimental results, and give a good estimation for stress distribution compared to the approximate analytical results. This experimental work will be very useful for the validation of new analytical stress calculation models, damage initiation as well as failure propagation models.

Keywords: strain field; stress distribution; notch; strength; DIC technique.

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