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Stress Concentration and Strength Prediction of Carbon/Epoxy Composites

Authors : Emre Ozaslan, Bulent Acar, Mehmet Ali Guler

Abstract : Unidirectional composites are very popular structural materials used in aerospace, marine, energy and automotive industries thanks to their superior material properties. However, the mechanical behavior of composite materials is more complicated than isotropic materials because of their anisotropic nature. Also, a stress concentration availability on the structure, like a hole, makes the problem further complicated. Therefore, enormous number of tests require to understand the mechanical behavior and strength of composites which contain stress concentration. Accurate finite element analysis and analytical models enable to understand mechanical behavior and predict the strength of composites without enormous number of tests which cost serious time and money. In this study, unidirectional Carbon/Epoxy composite specimens with central circular hole were investigated in terms of stress concentration factor and strength prediction. The composite specimens which had different specimen wide (W) to hole diameter (D) ratio were tested to investigate the effect of hole size on the stress concentration and strength. Also, specimens which had same specimen wide to hole diameter ratio, but varied sizes were tested to investigate the size effect. Finite element analysis was performed to determine stress concentration factor for all specimen configurations. For quasi-isotropic laminate, it was found that the stress concentration factor increased approximately %15 with decreasing of W/D ratio from 6 to 3. Point stress criteria (PSC), inherent flaw method and progressive failure analysis were compared in terms of predicting the strength of specimens. All methods could predict the strength of specimens with maximum %8 error. PSC was better than other methods for high values of W/D ratio, however, inherent flaw method was successful for low values of W/D. Also, it is seen that increasing by 4 times of the W/D ratio rises the failure strength of composite specimen as %62.4. For constant W/D ratio specimens, all the strength prediction methods were more successful for smaller size specimens than larger ones. Increasing the specimen width and hole diameter together by 2 times reduces the specimen failure strength as %13.2.

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