Readers' Forum

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AIAA 81-4280

Comment on "Strength Predictions of Composite Laminates with Unloaded Fastener Holes"

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GARBO and Ogonowski[1] have presented interesting analytical and experimental results relating to the fundamental but complex problem of predicting the strength of composite laminates with holes. However, the following points need to be considered:

1) Interlaminar stresses have been shown[2-4] to be important in the presence of stress-free boundaries. Although these stresses are generally restricted to highly localized regions, their influence on static and fatigue strength can be pronounced. The point-stress characteristic dimension is small compared to the thickness of the laminate, so the boundary-layer effect may have a significant influence on the characteristic dimension. The initial attempt by Whitney and Nuismer[5] to estimate the point-stress characteristic dimension was based on a simple, approximate stress distribution. The present authors have resorted to the more elaborate stress-function approach and, therefore, the analysis can be extended further to include the free-edge effects.

2) Notched tensile specimens with widths ranging from 1.9 cm to 7.6 cm (0.75 in. to 3 in.) are reported in the paper. Prabhakaran[6] has shown that there is an inherent size-effect, reflected in the variation of unnotched tensile strength with specimen width; this size-effect has been shown to be significant when the 0° and 90° plies predominate and has to be filtered out in order to get the true hole-size effect. In comparing the strength of notched specimens with the strength of unnotched specimens, have the authors maintained the widths constant so as to avoid the inherent size-effect? Further, the authors state in one place that only data from tensile loaded tests are reported in the paper, while at another place they mention that the strength values of Table 2 are derived from tests performed on unnotched unidirectional laminate sandwich beams (and rail-shear specimens). This needs to be clarified.

3) The difference between the present paper and the two-parameter models of Whitney and Nuismer[5] is basically twofold: a closed-form analysis is used here to determine the stress field around the hole, whereas an approximate expression is used in Ref. 5; also, the Tsai-Hill failure criterion is used here whereas the maximum normal stress criterion was used in Ref. 5. In view of the more elaborate analysis performed here, it is difficult to understand why the characteristic dimension was calculated empirically for one layup and then used for all layups. It would have been more logical to have calculated a characteristic dimension value for each set of results and then to have compared these values. The scatter in Fig. 5 is not negligible. The scatter in Fig. 7 for the 0° and 90° orientations is not negligible also and three tests cannot provide an acceptable data base for averages. The small number of tests appears incompatible with the elaborate analysis performed.

4) Garbo and Ogonowski have repeated the assertion of Whitney and Nuismer that the characteristic dimension is a constant, although the value obtained in Ref. 1 is different from that suggested in Ref. 5. While a single value "approximately" applicable to different ply-orientations, etc., makes sense, especially for preliminary design purposes, the concept of a constant value is hard to accept. The materials being considered are highly anisotropic and many properties including notch sensitivity[7] have been found to be anisotropic. Even for a single orientation, modification of the two-parameter models has been suggested by Karlak[8] by taking the characteristic dimension to be a function of the hole radius. Confirmation of this dependence on hole size is also given in Refs. 6 and 9. More recently, based on Weibull statistics, Prabhakaran[10] has shown that the point-stress characteristic dimension is not a constant.

5) Finally, it should be pointed out that stress-gradient effects have been a subject of investigation in metals for a number of decades. Attempts to define a constant characteristic dimension or size of an elementary block and to relate it to a structural characteristic of the metal, such as the grain size, have not been wholly successful.

Received July 2, 1980; revision received Dec. 22, 1980.

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