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NASA TECH BRIEF

Unidirectional Composite Stiffening

The efficient application of composite materials to structures requires proper selection of the reinforcement pattern and material as well as the overall structural arrangement. Guidelines for the optimum design of such composite structures have been generally lacking, nor are they of such a nature as to be obvious to the designer. The more recent trends towards efficient material configurations have evolved from these conclusions: (1) for high load intensities where strength requirements are important, filamentary composites appear most attractive, particularly when used as unidirectionally reinforced elements; (2) for plate and shell structures which failed because of elastic instability, the most efficient laminate varied with structure and loading condition, but always contained multi-directional reinforcement configurations, (3) the high multi-directional stiffness-to-density ratio of beryllium makes it more efficient than composites for many shell and plate structures—particularly if the load intensities encountered are low and if the stiffness requirements are important.

The problem which arises from these conclusions is whether a combination of the biaxial properties of beryllium or an isotropic composite with the uniaxial properties of one-directional filamentary reinforcement may possibly be the ideal configuration. Based upon the three conclusions, several simple structural elements were explored whose configurations were selected to best utilize composite materials.

An aluminum-alloy circular tube-column with unidirectionally reinforced composite stiffeners was selected as the first model. The structural efficiency curve for the column was evaluated by equating the stress levels for two failure modes; namely, local instability and column instability. Results of the calculations indicate that the addition of boron/epoxy three-point reinforcements permit the tube-column to be made substantially lighter both at high and low loadings. In the elastic stress range, there is apparently an optimum reinforcement ratio beyond which higher percentages of reinforcement do not further increase the efficiency. At the high stresses, the great strength and stiffness of the unidirectional reinforced composite provide an increase in efficiency at reinforcement ratios greater than the elastic optimum ratio.

A study was also made of long supported plates consisting of layers of beryllium on both sides of a uniaxial composite layer. All of the plates had 0° reinforced boron/epoxy cores. An analysis of the results of this study indicate that 0° reinforced material (prestressed if possible) should be used as the strength element to provide the maximum possible elasticity. The material used to provide the plate buckling resistance, the face material in a sandwich, should be selected on the basis of the stresses to be carried out; beryllium should be used at low stresses and composite configurations approaching the 0° configuration should be used at the higher stresses.

Note:

The following documentation may be obtained from:

Clearinghouse for Federal Scientific and Technical Information
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $0.65)

Reference: NASA CR-66518 (N68-13962), Design Criteria and Concepts for Fibrous Composite Structures

(continued overleaf)

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA Code GP, Washington, D.C. 20546.

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